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FRANK A. TAYLOR

Director, United States National Museum

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Notes on ARADIDAE in the U.S. National Museum, V
(Hemiptera: Heteroptera)¹

By Nicholas A. Kormilev²

For the privilege of studying the unidentified Aradidae in the collections of the U.S. National Museum, Smithsonian Institution, Washington, D.C., and Ohio State University, Columbus, Ohio, I wish to express my sincere appreciation to Dr. Richard C. Froeschner, Curator, Division of Hemiptera, and Dr. Charles A. Triplehorn, Curator of Insects, respectively. All types of new species are deposited at the U.S. National Museum, except two from the author's collection, which he retains.

In the descriptions, 25 units equal 1 mm. In ratios, the first figure represents the length; and the second, the width of measured part.

All species treated in this paper belong to the Neotropical Region.

Subfamily CARVENTINAE Usinger

Described below are two new apterous species, each in a different genus, from Haiti, and a third, belonging to a third genus, from the island of Dominica, B.W.I.

¹ Previous parts of this same series are: I, Kormilev, 1958, Proc. U.S. Nat. Mus., vol. 109, no. 3413, pp. 209-222; II, Kormilev, 1960, Journ. New York Ent. Soc., vol. 68, pp. 36-47; III, Kormilev, 1964, Proc. U.S. Nat. Mus., vol. 115, no. 3483, pp. 245-258; IV, Kormilev, 1966, Proc. U.S. Nat. Mus., vol. 119, no. 3548, pp. 1-25.

² 365 Lincoln Place, Brooklyn, New York 11238.

Drake and Kormilev (1958, p. 243) suppressed the genus *Eretmocoris* Harris and Drake as a synonym of *Acaricoris* Harris and Drake. Usinger and Matsuda (1959, p. 132) separated them and indicated that the former is related more closely to *Aglaocoris* Drake and Maldonado. They further noted that *Acaricoris* is related closely to a new genus that they erected, *Kolpodaptera*. Actually, all four genera are related to each other and, pending a needed revision, I prefer to leave them separate.

Genus *Acaricoris* Harris and Drake

Acaricoris Harris and Drake, 1944, p. 128.

Acaricoris haitiensis, new species

FIGURE 1

FEMALE.—Elongate ovate, rugose, and glabrous; legs with very fine, inclined hairs. Body covered with a very thin layer of whitish incrustation. Apterous.

Head shorter than width across eyes (19:22). Anterior process moderately strong, parallel sided, notched anteriorly; clypeus reaching middle of antennal segment I, much higher than genae, with a small preapical tubercle. Antenniferous tubercles, strong, dentiform, divergent. Eyes globose, protruding, but not pedunculate. Postocular borders strongly converging backward, with a thin, longitudinal carina. Vertex raised in the shape of a trident, with median tooth much shorter than laterals. Laterad of trident with two (1+1) elongate ovate callosities. Antennae slender, one-and-a-half times as long as head width (33.5:22); relative length of antennal segments I to IV 10:7:8.5:8; segments I and II clavate, III slightly tapering toward base, IV fusiform. Labium not reaching base of head; labial groove wide, shallow, open posteriorly.

Pronotum short and wide (12.5:42), separated from mesonotum by a distinct sulcus. Collar thin, straight anteriorly. Anterolateral angles rounded; lateral borders strongly converging forward, slightly sinuate, with two (1+1) small tubercles posteriorly. Posterior border angularly, deeply incised medially, twice (1+1) sinuate laterally. Disc rugose, with two (1+1) subrectangular tubercles anteriorly, separated from each other by a thin median sulcus that becomes much deeper and wider behind them. Along anterolateral borders, from collar to posterior border, extend two (1+1) thin carinae. Mesonotum completely fused with metanotum and terga I-II; the median portion occupied by a spear-shaped elevation with a very thin median sulcus, separated from lateral portions by depressions passing anteriorly into deep sulci. Lateral portions of mesometanotum roundly raised in the middle, discs rugose.

Abdomen almost as long as width across segment IV (64:63), flat; central dorsal plate, consisting of terga III to VI, slightly raised in the middle (area of the first dorsal scent gland scar). Connexivum wide, moderately reflexed. Exterior borders of connexiva straight from II to V, slightly convex on posterior half of VI and VII. Tergum VII with a short, transverse ridge in the middle of posterior border. Spiracles II and III ventral, not visible from above; IV and V sub-lateral and slightly visible; VI to VIII lateral. Paratergites short, subtriangular, reaching middle of tricuspidate segment IX.

COLOR.—Piceous, partially black; labium and tarsi yellow brown.

MEASUREMENTS.—Total length 4.50 mm, width of pronotum 1.68 mm, width of abdomen 2.52 mm.

HOLOTYPE.—Female, Morne Guimby, 22 km southeast of Fond Verrettes, 6500 feet, Haiti, B. and B. Valentine, 20.VII.1956 (USNM type 69611).

REMARKS.—*Acaricoris haitiensis* is related to *A. ignotus* Harris and Drake but differs by lateral borders of pronotum slightly sinuate and provided with a small tubercle posteriorly, by exterior border of connexivum VI forming a rounded angle and connexivum VII rectangular with rounded tip.

Genus *Eretmocoris* Harris and Drake

Eretmocoris Harris and Drake, 1944, p. 130.

Eretmocoris dominicus, new species

FIGURE 2

MALE.—Subrectangular, parallel sided; females ovate; both sexes flat, heavily punctured and with short, erect bristles on head, borders of the body, antennae, and legs; covered with grayish incrustation.

Head as long as width across eyes (σ^7 , 34:34; ρ , 35:35). Anterior process strong, parallel sided, slightly incised in front, reaching middle of antennal segment I. Clypeus much higher and shorter than genae. Antenniferous tubercles robust, dentiform, strongly divergent. Eyes distinctly stalked. Postocular borders strongly converging backward, with four (2+2) small, round tubercles. Vertex with a raised ridge, which is bifurcate anteriorly and separated laterally and in front by deep sulci; laterad of ridge are two (1+1) ovate, raised, rugose callosities. Neck with two (1+1) small tubercles laterally. Antennae short; relative length of antennal segments I to IV: σ^7 , 17.5:9:10:9; ρ , 17:10:11:10; I fusiform, robust; II and III slightly tapering toward the base; IV pyriform. Labium reaching hind border of labial groove; latter deep, wide, closed posteriorly.

Pronotum short, wide (σ^7 , 15:49; ρ , 15:55). Collar strong, raised, separated from disc by a deep sulcus. Anterolateral angles produced

into conical lobes, rounded apically, with a row of small, round tubercles. Anterior border with two (1+1) short ridges placed behind collar, separated from each other by a thin, median sulcus. Behind calli median sulcus becomes wider and deeper. Hind border straight laterally, deeply incised in the middle. Disc rugose, partially deeply punctured.

Mesonotum fused with metanotum and terga I and II. Median portion of this plate triangularly raised, with apex inserted into incisure of hind border of pronotum. Mesometanotal plate laterally depressed between mesonotum and metanotum, and raised on metanotum. Disc densely, deeply punctured, particularly in the middle. Lateral borders of mesonotum produced into two (1+1) lobes similar to those of pronotum; lateral borders of metanotum convex, rounded.

Abdomen as long as width across segment V (σ , 74:75; ρ , 90:91). Terga I and II completely fused with metanotum, but separated from central dorsal plate by a deep sulcus. Central dorsal plate consists of terga III to VI completely fused together, raised in area of dorsal scent gland scars, with carinae dividing disc into a few irregular portions; these portions deeply punctured along carinae; tergum III is punctured on the whole surface. Connexivum wide; segments II and III fused; exterior border of connexivum II roundly produced anteriorly; PE angles III to V angularly produced with blunt tip; PE VI and PE VII produced as conical lobes with rounded tip. Tergum VII raised posteromedially. Paratergites short, reaching middle of hypopygium; latter caudal in position, deeply inserted; disc of hypopygium with a short median ridge. In female, tergum VII conically raised posteromedially; paratergites conically produced as far as segment IX; latter truncated posteriorly. Spiracles II ventral; III sublateral; IV to VIII lateral and visible from above.

COLOR.—Dark brown, shiny, concealed by gray incrustation.

MEASUREMENTS.—Total length: σ , 5.64; ρ , 6.84 mm; width of pronotum: σ , 1.96; ρ , 2.20 mm; abdomen width: σ , 3.0; ρ , 3.64 mm.

HOLOTYPE.—Male, Dominica, W.I., VI.1963, J. Maldonado (USNM type 69612), from Drake collection.

ALLOTYPE.—Female, collected with holotype "in copula"; in the same collection.

REMARKS.—*Eretmocoris dominicus* is related to *E. gigas* Usinger and Matsuda from which it differs by much smaller tubercles on the neck; by absence of thin projections on the foreborder of pronotum; by conical lobes on lateral borders of pronotum and mesonotum; and by progressively produced PE angles of connexiva.

Genus *Aglacoris* Drake and Maldonado

Aglacoris Drake and Maldonado, 1955, p. 291.

FIGURE 3

***Aglacoris drakei*, new species**

FEMALE.—Elongate ovate, shiny; covered with very short, fine bristles, sparse on body and more numerous on head, antennae, and legs. Body completely covered with a thick, whitish incrustation. Apterous.

Head almost rectangular, shorter than width across eyes (27:30). Anterior process moderately strong, incised anteriorly, genae slightly longer than clypeus, reaching middle of antennal segment I. Antenniferous tubercles strong, acute, diverging. Eyes stalked. Postocular borders forming a right angle, with a round tubercle on its tip. Vertex raised as a bifurcate ridge; laterad of which are placed two (1+1) small, ovate callosities. Antennae slender; relative length of antennal segments I to IV: 13:9:-- (two apical segments missing); I fusiform, II tapering toward base. Labium short, reaching hind border of wide, deep labial groove, latter closed posteriorly.

Pronotum short, very wide (14:45). Collar thick, separated from disc by a thin sulcus. Anterior borders laterad of collar sinuate; anterolateral angles slightly produced forward, bordered with a dense row of very fine granules. Hind border deeply incised medially. Disc with a transverse carina behind collar, and with a median sulcus behind carina; laterad of median sulcus two (1+1) round callosities; rest of disc irregularly rugose.

Mesonotum wider than pronotum (55:45), medially fused with metanotum and in combination with terga I-II, forming a subtriangular, elevated plate, with tip entering into incisure of hind border of pronotum. Mesonotum laterally separated from metanotum by transverse depressions, which mesad turn backward along triangular plate; lateral disc of mesonotum with round elevation; mesonotum laterally produced far beyond lateral border of pronotum, forming with the latter a rectangular incisure. Lateral borders of mesonotum straight, parallel, very finely granulate.

Abdomen subrectangular, slightly shorter than maximum width across segment IV (65:67.5). Terga I and II flat, completely fused with metanotum but clearly separated from central dorsal plate, which consists of terga III to VI completely fused; disc slightly raised on median line; two (1+1) zigzag carinae separated outside rows of round, calloused spots from disc. Connexivum wide, reflexed. Exterior borders of abdomen straight and parallel from segment II to V, then converging. Connexiva II and III fused; exterior

border of connexivum VI with an elongate, calloused tubercle bearing spiracle; VII with similar, but larger tubercle. Tergum VII raised posteromedially. Paratergites small, conical, blunt, produced as far as segment IX, latter short, truncate posteriorly. Spiracles II to IV ventral, V to VIII lateral and visible from above.

COLOR.—Uniformly yellow brown; clypeus, tips of antenniferous tubercles, antennae, and legs ochraceous.

MEASUREMENTS.—Total length 5.4 mm, width of pronotum 1.8 mm, width of abdomen 2.7 mm.

HOLOTYPE.—Female, Port-au-Prince, Haiti, II.1956, C. J. Drake (USNM type 69613), from Drake collection.

REMARKS.—This new species is dedicated to the memory of my late friend Dr. Carl J. Drake, an eminent American hemipterologist.

Aglacoris drakei is related to *A. rectangulatus* Usinger and Matsuda from San Domingo but differs by genae with parallel sides; longer antennal segment II (two-thirds as long as I, 9:13); by spiracle VI also placed on a tubercle as is spiracle VII; and by smaller size.

Subfamily ANEURINAE Douglas and Scott

Genus *Aneurus* Curtis

Aneurus Curtis, 1825, pl. 86.

Aneurus haitiensis, new species

FIGURES 4-6

MALE.—Elongate ovate; pronotum finely granulate anteriorly, with a wide, transversely striate band in the middle, and a narrow, striate band along hind border. Scutellum subtriangular, apex broadly rounded.

Head as long as width across eyes (σ , 17:17; ρ , 17:17.5). Anterior process subparallel, rounded anteriorly, reaching to tip of antennal segment I. Genae slightly shorter than clypeus. Antenniferous tubercles short, truncate anteriorly. Eyes semiglobose, protruding. Postocular border forms a right angle, with three minuscule granules laterally. Vertex transversely striate, almost rugose. Two (1+1) large, oblique, ovate callosities mesad of eyes. Antennae moderately slender; relative length of antennal segments I to IV: σ , 5.5:5.5:5.5:12.5; ρ , 6:6:6:12.5; I obovate, II clavate, III tapering toward base, IV cylindrical. Labium short, not reaching hind border of wide, shallow, transversely rugose labial groove.

Pronotum less than half as long as maximum width (σ , 17:39; ρ , 16.5:39). Collar very thin, sinuate in front. Anterolateral angles subangularly rounded with truncate anterior border and slightly convex lateral border. Lateral notch sharp, forming an obtuse angle.

Lateral borders of hind lobe subparallel, slightly convex, converging anteriorly. Hind border sinuate in the middle, convex laterally. Fore-disc with four (2+2) flat callosities; hind disc with two (1+1) ovate, transverse callosities surrounded by striated areas.

Scutellum flat, concentrically rugose, without callosities.

Hemelytra reaching middle (σ) or hind border (φ) of tergum VII. Corium short, reaching basal one-third of scutellum. Membrane very finely punctured.

Abdomen ovate, longer than maximum width across segment IV (σ , 71:56; φ , 72.5:54). Connexivum moderately wide, exterior borders of segments straight; PE angles slightly protruding. Paratergites rounded posteriorly, slightly shorter than hypopygium; the latter small, slightly shorter than wide (5.5:6), not produced beyond exterior borders of connexiva VII. In female, paratergites very short, rounded; segment IX slightly convex posteriorly. Spiracles II, VI, and VII lateral, visible from above; III to V ventral; VIII terminal.

COLOR.—Red brown; disc of scutellum lighter; antennae and membrane darker; labium yellow brown.

MEASUREMENTS.—Total length: σ , 4.92; φ , 4.96 mm; width of pronotum: σ , 1.56; φ , 1.56 mm; width of abdomen: σ , 2.24; φ , 2.16 mm.

HOLOTYPE.—Male, Morne Guimby, 22 km southeast of Fond Verrettes, Haiti, 6500', B. and B. Valentine, 20.VII.1956 (USNM type 69614).

ALLOTYPE.—Female, collected with holotype; Ohio State University collection, Columbus, Ohio.

PARATYPES.—Two males, one collected with holotype, another a day earlier in the same place; in Ohio State University collection and collection of the author.

REMARKS.—*Aneurus haitiensis* is related to the North American *A. pygmaeus* Kormilev from which it may be separated by antennal segment II as long as I or III, antennal segment IV more than twice as long as III, and by larger size.

Subfamily MEZIRINAE Oshanin

Genus *Mezira* Amyot and Serville

Mezira Amyot and Serville, 1843, p. 305.

In my key (1962, p. 260) for American *Mezira* species, 69 of the 71 species were listed. *Mezira horvathi* (Bergroth) and *Mezira novella* Blatchley were excluded because of lack of specimens and insufficient data. Later, three species were described. Now, six new species and one new subspecies are added.

Mezira pusilla, new species

FIGURE 7

FEMALE.—Elongate ovate, with finely setigerous granulations bearing extremely short, curled hairs.

Head almost as long as width across eyes (18.5:19). Anterior process constricted at base, dilated apically; genae forming two (1+1) large, rounded lobes in front of clypeus, reaching to three-fourths of antennal segment I. Antenniferous tubercles acute, strongly divergent. Eyes semiglobose, protruding. Postocular tubercles thin, acute, slightly produced beyond outer border of eyes. Infraocular carinae moderately high, crenulate. Vertex with a U-shaped row of granules. Antennae slender, one-and-a-half times as long as width of head (29.5:19); relative length of antennal segments I to IV: 8:5:9.5:7. Labium reaching to hind border of labial groove, latter closed posteriorly.

Pronotum less than half as long as maximum width (16:36); fore-lobe narrower than hind lobe (29:36). Collar thin, slightly sinuate anteriorly. Anterolateral angles expanded and rounded, produced forward almost as far as collar. Lateral notch deep, forming a slightly obtuse angle. Lateral borders of hind lobe slightly convex, converging anteriorly. Hind border almost straight. Foredisc with four (2+2) granulate ridges. Hind disc roughly granulate.

Scutellum shorter than basal width (14:20); all borders carinate, apex cut out; lateral borders sinuate at apical half; median ridge cross shaped; disc roughly granulate.

Hemelytra reaching to hind border of tergum VI; basolateral borders of corium straight, carinate; apical angle rounded; apical border convex, slightly sinuate interiorly.

Abdomen longer than maximum width across segment V (60:41). Lateral borders slightly convex. Connexivum wide, slightly raised exteriorly; PE angles slightly protruding; PE VII rounded. Paratergites large, rounded, reaching to middle of a moderately long segment IX, latter incised posteriorly. Spiracles II to VI ventral; VII sublateral, barely visible from above; VIII lateral and visible from above.

COLOR.—Testaceous, partly ferruginous; labium and tarsi yellow; membrane fuscous, white at base.

MEASUREMENTS.—Total length 4.4 mm; width of pronotum 1.24 mm; width of abdomen 1.64 mm.

HOLOTYPE.—Female, Cacao, Trece Aguas, Alta v. Paz, Guatemala, Barber and Schwarz, (USNM type 69615).

REMARKS.—*Mezira pusilla* is one of the smallest *Mezira* species known from the Neotropical Region, only *Mezira nana* (Champion)

being smaller. In my key (1962, p. 260) for American *Mezira* species, it runs to *M. angustata* (Champion) but is much smaller, genae are expanded and rounded, apical border of corium more convex, paratergites and segment IX are relatively longer.

Mezira equatoriana, new species

FEMALE.—In general aspect similar to *Mezira pacifica* Usinger but differing from it by: Head longer than width across eyes; anterior process shorter, reaching three-fifths of antennal segment I. Eyes relatively large, semiglobose. Postocular tubercles smaller, blunt, adherent to eyes, not reaching outer border of latter; antennal segment III moderately longer than II (15:12), much longer in *M. pacifica* (17.5:10). Pronotum more sinuate laterally; interior ridges of forelobe less raised. Scutellum relatively shorter, wider at base. Apical border of corium almost straight (sinuate interiorly and convex exteriorly in *M. pacifica*). Paratergites with posterior border convex exteriorly and straight interiorly, reaching as far as a short segment IX; latter truncate posteriorly. All spiracles ventral.

COLOR.—Brown; membrane black; antennae and legs lighter, red brown; labium and tarsi yellow brown.

MEASUREMENTS.—Head longer than width across eyes (30:27.5); relative length of antennal segments I to IV: 15:12:15:15. Pronotum less than half as long as wide (26:66); forelobe narrower than hind lobe (52:66). Scutellum shorter than basal width (25:41). Abdomen longer than maximum width across segment IV (92:87).

Total length 7.08 mm; width of pronotum 2.64 mm; width of abdomen 3.48 mm.

HOLOTYPE.—Female, Esmeralda, south of Mateo, Ecuador, J. Foerster, 5.X.1956, deposited in the collection of the author.

Mezira sanmartini, new species

FEMALE.—Elongate ovate, roughly but sparsely granulate; granules with distinct, yellow, curled hairs.

Head distinctly shorter than width across eyes (21:26). Anterior process dilated anteriorly, rounded and incised in front, reaching three-fourths of antennal segment I. Antenniferous tubercles wide, acute, crenulate outside and slightly divaricating. Eyes large, semiglobose, protruding. Postocular tubercles clawlike, acute, produced slightly beyond outer border of eyes. Infraocular carinae high, crenulate. Vertex with a V-shaped, rough, setigerous granulation. Antennae moderately strong; relative length of antennal segments I to IV: 10:6:—:— (two apical segments missing). Labium reaching to hind border of labial groove, latter closed posteriorly.

Pronotum less than half as long as its maximum width (22.5:50); forelobe narrower than hind lobe (43:50), separated from the latter by a deep depression. Collar moderately wide, angularly incised anteriorly. Anterolateral angles strongly expanded, rounded and crenulate, produced anteriorly as far as collar. Lateral notch deep. Lateral borders of hind lobe rounded and crenulate. Foredisc with four (2 + 2) high, granulate ridges. Hind lobe roughly granulate.

Scutellum shorter than basal width (19:26). All borders carinate, tip incised; lateral borders straight, almost without sinus on apical half; median ridge cross shaped; disc roughly granulate.

Hemelytra reaching three-fourths of tergum VI. Basolateral border of corium carinate and crenulate; apical border straight; apical angle rounded; all veins with a rough, setigerous granulation.

Abdomen longer than its maximum width across segment IV (77:60). Midlateral glabrous areas separated from central dorsal plate by high, crenulate carinae. Connexivum wide and raised exteriorly; disc partially covered with whitish incrustation. PE angles barely protruding; PE VII rounded. Paratergites subtriangular reaching three-fourths of segment IX, with a large, lateral spiracle; segment IX slightly incised posteriorly. Spiracles II to VII ventral, on a tubercle far from the border, VIII lateral.

COLOR.—Ferruginous, partially dark ferruginous; labium and tarsi orange yellow.

MEASUREMENTS.—Total length 5.72 mm, width of pronotum 2.00 mm, width of abdomen 2.40 mm.

HOLOTYPE.—Female, Magdalena, Estado Bolivar, Rio Cauza, Venezuela, P. San Martin, 5.X.1957, deposited in the collection of the author.

REMARKS.—It is a pleasure to dedicate this species to Mr. Pablo San Martin, an Uruguayan entomologist who collected this specimen and donated it to the author.

Mezira sanmartini runs in my key (1962, p. 260) for American *Mezira* species to *M. sangabrielensis* Kormilev from Amazonas, Brazil, from which it differs by anterior process of head rounded anteriorly, not crenulate; by anterolateral angles of pronotum produced forward as far as collar; by lateral notch of pronotum much deeper and angular; by paratergites (♀) produced only to three-fourths of segment IX; and by setigerous granulation with distinct, yellow, curled hairs.

Mezira paraguayensis, new species

MALE.—Elongate ovate, slightly widening backward; covered with a dense and fine granulation bearing extremely short setae.

Head shorter than width across eyes (♂, 23:25; ♀, 25:27). An-

terior process stout, with large, expanded, and rounded anteriorly genae, contiguous in front of clypeus and produced slightly beyond tip of antennal segment I. Antenniferous tubercles narrow, acute, diverging, reaching to the middle of antennal segment I. Eyes semi-globose, protruding. Postocular tubercles small, acute, produced as far as eyes, or slightly beyond. Infraocular carinae high, thin, finely granulate. Vertex with M-shaped group of granulations. Antennae slender; relative length of antennal segments I to IV: ♂, 9:6:12:7.5; ♀, 9:6.5:12:8.5. Labium short, reaching to hind border of labial groove, latter closed posteriorly.

Pronotum half as long as maximum width (♂, 25:51; ♀, 25:54); forelobe narrower than hind lobe (♂, 43:51; ♀, 44:54). Collar thin, slightly sinuate in front. Anterolateral angles expanded, rounded, slightly reflexed, crenulate, produced forward as far as collar. Lateral notch distinct, forming an obtuse angle. Lateral borders of hind lobe subparallel, converging anteriorly, crenulate; hind border feebly sinuate. Foredisc with four (2 + 2) high, granulate ridges; hind disc more roughly granulate.

Scutellum shorter than basal width (♂, 20:25; ♀, 25:27). Lateral borders carinate, sinuate on apical half; apex widely rounded. Median ridge cross shaped, roughly granulate.

Hemelytra reaching to hind border of tergum VI in both sexes. Corium with convex basolateral borders; apical border convex, rounded; apical angle also rounded. Veins of corium densely granulate.

Abdomen ovate in both sexes; longer than maximum width across segment IV (♂, 74:62.5; ♀, 80:65). Connexivum wide, slightly reflexed exteriorly, exterior borders of segments straight, crenulate; PE angles not, or barely protruding; PE VII angularly rounded in both sexes. Paratergites (♂) small, clavate, reaching slightly over two-thirds of hypopygium; latter cordate, shorter than wide (15:20), with a median ovate ridge not reaching tip of hypopygium. Paratergites (♀) large, rounded, reaching middle of segment IX, latter incised posteriorly. All spiracles ventral, not visible from above.

COLOR.—Piceous with rusty brown granulations; genae, antennae, tips of antenniferous tubercles, lateral borders of forelobe of pronotum, PE angles, and hind borders of connexiva, coxae, trochanters, and tarsi, yellow brown to rusty brown. Exterior borders of connexiva on forehalf, black. Round callous spots on connexiva and venter reddish brown.

MEASUREMENTS.—Total length: ♂, 5.80; ♀, 6.12 mm; width of pronotum: ♂, 2.04; ♀, 2.16 mm; width of abdomen: ♂, 2.50; ♀, 2.60 mm.

HOLOTYPE.—Male, Horqueta, 45 m east of Paraguay River,

Paraguay, Alberto Schulz, 4.VII.1933 (USNM type 69616), from Lutz collection in U.S. National Museum.

ALLOTYPE.—Female, collected with holotype; in the same collection.

PARATYPES.—Two males and one female collected with holotype; in the same and author's collection.

REMARKS.—*Mezira paraguayensis* runs in my key (1962, p. 260) for American *Mezira* species to *M. punctiventris* (Stal) but is much smaller, piceous; granulation is rusty brown, connexivum tricolored, brown, black, and yellowish.

Mezira crenulata, new species

FIGURE 8

MALE.—Elongate ovate, with sharp, setigerous granulation; setae short, rusty, curled; lateral borders of pronotum distinctly crenulate.

Head as long as width across eyes (32:32). Anterior process stout, constricted at base, rounded anteriorly, apex incised in the middle, reaching three-fifths of antennal segment I. Antenniferous tubercles blunt, with convex, subparallel outer borders. Eyes semiglobose, protruding; placed behind the middle of lateral border. Postocular tubercles minute, not reaching outer borders of eyes. Infraocular carinae low, with minute, setigerous granulation. Vertex with V-shaped granulation. Antennae moderately stout; relative length of antennal segments I to IV: 20:12.5:15.5:13. Labium short, not reaching to hind border of labial groove, latter closed posteriorly.

Pronotum half as long as maximum width (37:76); forelobe much narrower than hind lobe (60:76). Collar narrow; anterolateral angles expanded, rounded, and crenulate; lateral notch forming a slightly obtuse angle. Foredisc with four (2+2) high, granulate ridges. Lateral borders of hind lobe convex, crenulate; hind disc granulate; hind border shallowly trisinate. Granulations bearing distinct, curled, rusty hairs.

Scutellum shorter than basal width (31:37). All three borders carinate; lateral borders sinuate before apex; median carina cross shaped; disc granulate.

Hemelytra reaching slightly over fore border of tergum VII; basolateral border of corium reflexed, slightly sinuate and crenulate; apical angle rounded; apical border convex outside, sinuate interiorly.

Abdomen ovate, longer than maximum width across segment IV (105:98). Connexivum wide; exterior borders of connexiva barely convex; PE angles slightly protruding; PE VII forming a right angle with rounded tip, reaching to the middle of hypopygium. Paratergites thin, clavate, reaching three-fifths of hypopygium; latter cordate,

shorter than wide (20:30), depressed above, with an elevated ovate median ridge not reaching to hind border. Spiracles small, far from border on II to VII; sublateral, but not visible from above on VIII.

COLOR.—Ferruginous, partly piceous; connexivum concolorous.

MEASUREMENTS.—Total length 8.56 mm, width of pronotum 3.04 mm, width of abdomen 3.92 mm.

HOLOTYPE.—Male, collected in Hoboken, New Jersey, on Orchids imported from Venezuela, 1.VIII.1940 (USNM type 69617).

REMARKS.—*Mezira crenulata*, in my key (1960, p. 260) for American *Mezira* species runs to *M. mexicana* Kormilev but looks more like *M. boliviana* Kormilev from which it differs by spiracles VIII sublateral and not visible from above (lateral and visible in *M. boliviana*); head as long as wide; lateral borders of pronotum distinctly crenulate; hypopygium different: its upper surface produced as far as its lower portion (in *M. boliviana* the upper portion is distinctly shorter than its lower portion).

Mezira placida, new species

MALE.—Elongate ovate, slightly widening backward, then narrowing again; covered with setigerous granulations; setae short and curled. Median ridge of hypopygium reaching to three-fourths its length; paratergites of the female subtriangular with rounded tip, divergent and reaching to one-fourth segment IX. Spiracles II to VII ventral, placed far from border; VIII sublateral, but not visible from above.

COLOR.—Dark ferruginous, connexivum and venter lighter.

MEASUREMENTS.—Head 22.5:25; relative length of antennal segments I to IV: 10:9:11:10; pronotum 21:51; scutellum 19.5:28; abdomen 80:58 across segment V; hemelytra reaching to foreborder of tergum VII; hypopygium 20:24.

Total length 6.0 mm, width of pronotum 2.04 mm, width of abdomen 2.32 mm.

HOLOTYPE.—Male, Hugural Rd., Puerto Rico, J. R. Johnston, 10.IV.1913 (USNM type 69618).

ALLOTYPE.—Female, collected with holotype; in the same collection.

PARATYPES.—Two males and four nymphs of different instars, collected with holotype; in the same collection and collection of the author.

REMARKS.—This species is based on a series of specimens from Puerto Rico and one series from Haiti. The Puerto Rico series has one specimen with a label "*Mezira* n.sp., det. H. G. Barber," and the Haiti series has one specimen with a label "*Brachyrhynchus* sp.?"

very near *B. angustatus* Champ. O. H." (presumably by Otto Heide-
mann).

In my key (1962, p. 260) for American *Mezira* species both series run to *M. granulata* Say. Comparison of both series with a paratype of *M. angustata* (Champion) reveals that they are not related. Comparison with various specimens of *M. granulata* Say shows that they are closely related. The general shape of these two series and *M. granulata* is the same; biometric measurements show the same pattern though the specimens from Puerto Rico and Haiti are slightly larger. The main differences are: postocular tubercles are shorter, not reaching to outer border of eye in specimens from Puerto Rico and Haiti, reaching it in *M. granulata*; lateral notch of pronotum in specimens from Puerto Rico and Haiti is angular, but in *M. granulata* sinuate, rounded, though I have seen specimens of *M. granulata* also with angular lateral notch; paratergites in the female are slightly shorter in specimens from Puerto Rico and Haiti reaching to one-fourth segment IX, while in *M. granulata* they reach to the middle of segment IX; the last but not the least difference is in pilosity: *M. granulata* has setigerous granulation with straight hairs, whereas specimens from both Puerto Rico and Haiti have distinct curled hairs. *Mezira granulata* shows a certain variability in the length of setae; specimens from Texas and Mississippi have setae distinctly longer than specimens from Georgia, or Virginia, but the setae always are straight, never curled.

The differences between specimens from Puerto Rico and Haiti are even smaller. Besides color, which in *Mezira* usually has no specific value, the main difference is the median ridge on the hypopygium: in the specimens from Puerto Rico it reaches three-fourths the hypopygial length, whereas in the specimens from Haiti it reaches to, or almost to, the hind border of the hypopygium.

The best solution is to consider the specimens from Puerto Rico as a new species, herein named *Mezira placida*, new species, and the specimens from Haiti as its geographical subspecies, *M. p. haitiensis*, new subspecies. The following key will separate the two new taxa from each other and from *M. granulata*:

1. Postocular spines produced as far as outer borders of eyes; lateral borders of pronotum mostly roundly sinuate; setigerous granulations with straight setae; paratergites in the female reaching to the middle of segment IX.

Mezira granulata Say, United States

Postocular tubercles not reaching to outer borders of eyes; lateral borders of pronotum with an angular notch; setigerous granulations with curled hairs; paratergites in the female reaching to one-fourth segment IX.

Mezira placida, new species, West Indies

2. Median ridge extending three-fourths length of hypopygium; color dark ferruginous ***M. placida placida***, Puerto Rico

Median ridge of hypopygium reaching almost to its tip; color testaceous.

M. placida haitiensis, new subspecies, Haiti

***Mezira placida haitiensis*, new subspecies**

MALE.—Similar to *Mezira placida placida*, but median ridge of hypopygium reaching almost to the tip of the latter.

COLOR.—Testaceous; membrane fuscous, whitish at base; labium and tarsi yellow.

MEASUREMENTS.—Head 21.5:22.5; relative length of antennal segments I to IV: 10:8:11:9; pronotum 22:46; scutellum 19:26; abdomen 73:54 across segment IV; hemelytra reaching one-fifth tergum VII; hypopygium 17:22.

Total length 5.54 mm, width of pronotum 1.84 mm, width of abdomen 2.16 mm.

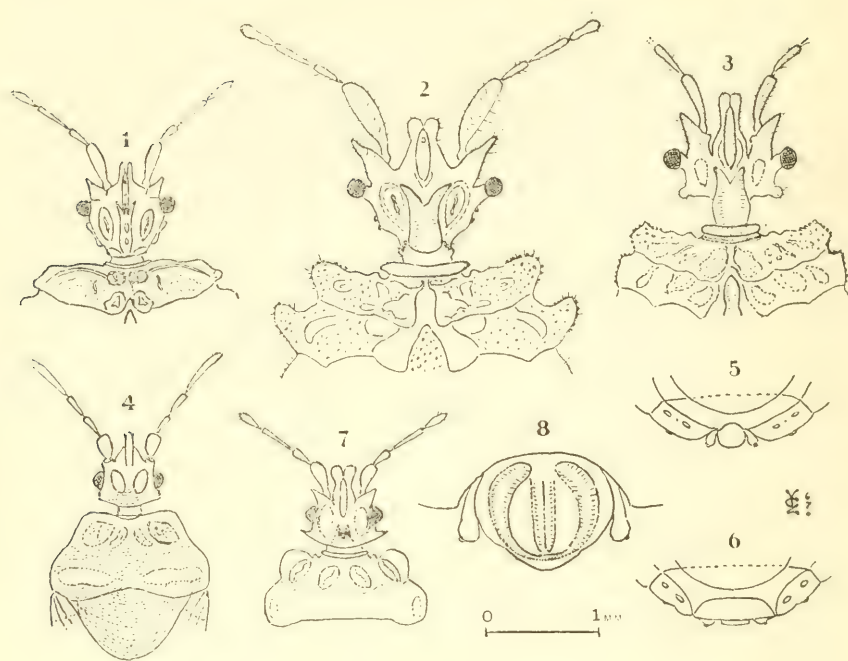
HOLOTYPE.—Male, Port au Prince, Haiti, E. D. Ball, 1940 (USNM type 69619).

ALLOTYPE.—Female, Port au Prince, Haiti, Herbert Osborn, deposited in the collections of Ohio State University, Columbus, Ohio.

PARATYPES.—Six males, collected with holotype, in the collections of U.S. National Museum and in author's collection; seven males, collected with allotype, in the collections of Ohio State University and in collection of the author.

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FIGURES 1-8.—1, *Acaricoris haitiensis*, new species, ♀, head and pronotum; 2, *Eretmocoris dominicus*, new species, ♂, head, pronotum, and mesonotum; 3, *Aglacoris drakei*, new species, ♀, head pronotum, and mesonotum; 4, *Aneurys haitiensis*, new species, ♂, head, pronotum, scutellum, and corium of hemelytra; 5, *Aneurys haitiensis* ♂, tip of abdomen, dorsal aspect; 6, *Aneurys haitiensis* ♀, tip of abdomen, dorsal aspect; 7, *Mezira pusilla*, new species, ♀, head and pronotum; 8, *Mezira crenulata*, new species, ♂, hypopygium, dorsal aspect.

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Isopoda and Tanaidacea from Buoys
in Coastal Waters of the Continental United States,
Hawaii, and the Bahamas
(Crustacea)¹

By Milton A. Miller²

This article is based on collections made during World War II by the author and other biologists employed by Woods Hole Oceanographic Institution on a survey of marine fouling. The research was conducted under supervision of Dr. Alfred C. Redfield and the late Dr. Louis M. Hutchins. It was done under contract with the Bureau of Ships, U.S. Navy, with invaluable logistic support from the U.S. Coast Guard. The author wishes to express deep appreciation to Dr. Redfield for his guidance and encouragement on this and other wartime investigations on the marine fouling problem. The author is indebted to Mrs. Lynn Rudy for illustrations and other assistance in the preparation of this paper. Thanks are due also to Dr. Thomas E. Bowman of the U.S. National Museum for a critical review of the manuscript.

¹ Contribution No. 1816 from Woods Hole Oceanographic Institution, Mass., and a contribution from the Department of Zoology, University of California, Davis.

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Fouling communities include not only various sessile organisms (barnacles, mussels, bryozoans, tube worms, tunicates, sponges, algae, etc.) that attach themselves to submerged structures, but also many free-living forms associated with them. The free-living animals may feed on the sedentary forms, find cover among them, and exhibit various degrees of symbiosis with them. Among the nonsedentary forms commonly found in the fouling association are isopods, tanaidaceans, and other Crustacea.

The isopods and tanaidaceans reported in this paper were extracted from samples of fouling scraped from buoys and their moorings in the coastal waters of the United States. As mentioned above, these collections were made during World War II in connection with a survey of marine fouling conducted by Woods Hole Oceanographic Institution. Biological objectives included determination of the amount and kinds of fouling, rates of accretion, regional and seasonal variation, and ecological factors affecting establishment of fouling organisms. Much valuable systematic, ecological, and distributional data may be derived from investigations of this sort. Such information is needed badly for most invertebrate groups, especially in regions in which the biota has not been investigated adequately.

Besides intrinsic interest, the biological data also might have practical application in the development of more effective methods for control of fouling. Additionally, it was thought that data on buoy fouling could provide clues as to the origin and possibly the course of drifting mines and military flotsam. Cosmopolitan or widely distributed forms obviously would be of little or no value as tracers. Attached forms clearly would serve the purpose better than free-living types. In any event, the distributional limits of species that might be found on buoys would have to be established definitely before any valid conclusions could be drawn. Unfortunately, our present biogeographical knowledge of most invertebrates is too incomplete to be of much help in determining origin or drift.

The results of the marine fouling survey are incorporated in a treatise on marine fouling and its prevention that has been published by Woods Hole Oceanographic Institution (1952). The present paper extends the preliminary account of the Isopoda and Tanaidacea given in that publication.

METHODS.—The buoy fouling survey was initiated in 1943. Biologists were assigned to various naval districts with authorization to accompany buoy tenders of the U.S. Coast Guard in order to investigate fouling on buoys when they were relieved, serviced, or otherwise tended. Generally, at this time, the buoy with mooring chain and anchor were hoisted onto the deck, which gave the biologists an opportunity for observation and sampling.

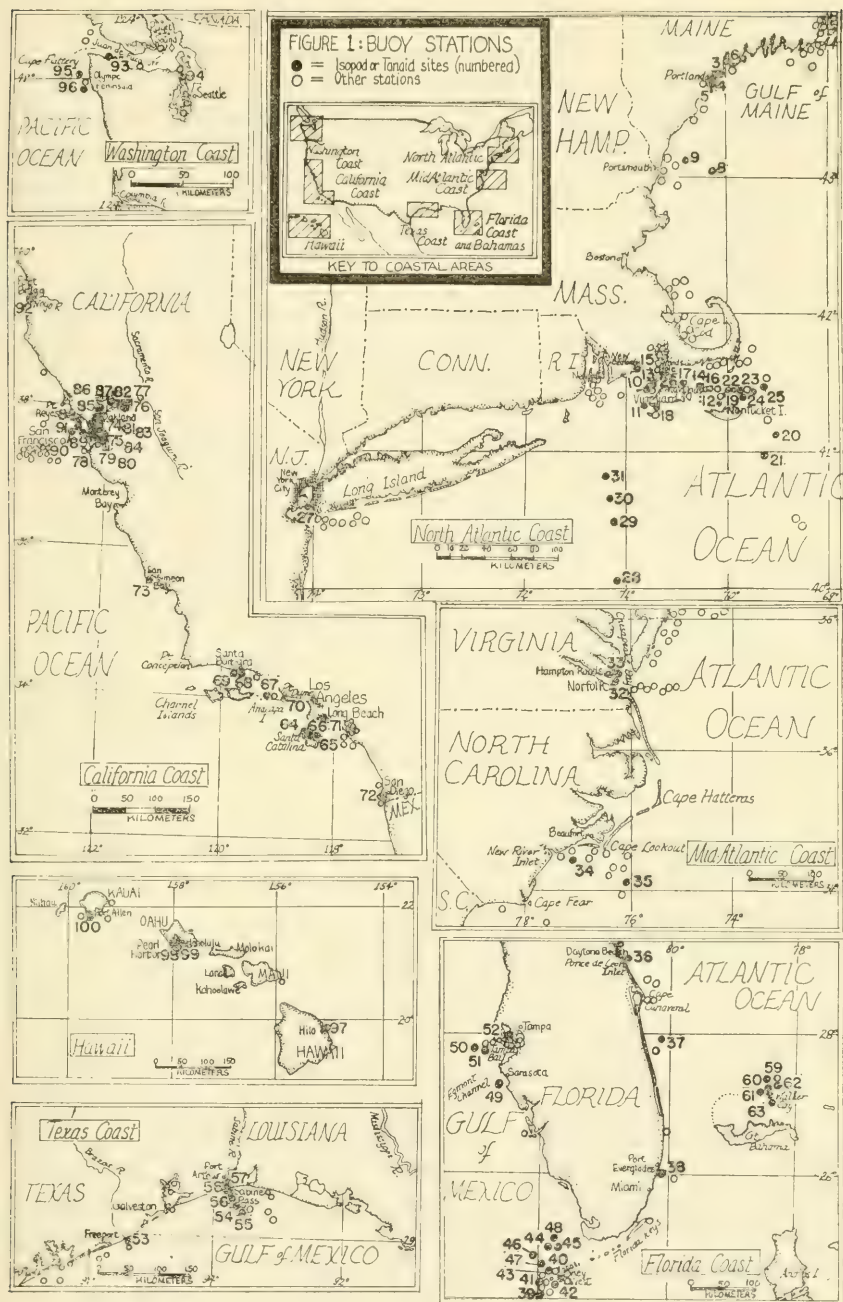


FIGURE 1.—Buoy stations of the fouling survey

The 379 buoys examined (fig. 1) were distributed as follows: 229 along the Atlantic coast from Newfoundland to Florida, 58 in the Gulf of Mexico (south and west coast of Florida and Texas), 77 along the Pacific coast from California to Washington, six in the Bahamas, and nine in the Hawaiian Islands. Owing to lack of opportunity for the biologists to sample the buoys along such a long stretch of coast, the largest gap in the collections lies between central California and northern Washington.

At each station, square foot samples were scraped from the buoy at the waterline, at three and six feet depths and subsequent fathom (6 feet=1.83 meters) intervals below the surface, depending on the size of the buoy. Linear foot scrapings also were made from the bridle and mooring chains at fathom intervals to the bottom. Likewise, a square foot sample was taken when possible from the anchor block. Occasionally, samples were taken from submarine nets or other submerged installations. After weights, volumes, and other data on the fouling were taken, the samples (or aliquots) were preserved and shipped to Woods Hole, Mass., for sorting. At each station, the usual hydrographic data were recorded (water temperature, transparency, etc.) and water samples for salinity determinations were taken.

At Woods Hole, the fouling samples were sorted into major taxonomic groups for later identification by specialists. After large organisms were removed, the residue was scanned with a microscope for small forms. A total of 2028 samples from 379 buoys were sorted, an average of five to six per buoy.

The 100 stations at which isopods and/or tanaidaceans were found are named in table 1. Their location is shown in figure 1, along with buoys in the same area at which none of these crustaceans was found.

RESULTS.—Collection data are presented and summarized in tables 1 and 2 and figures 1 and 2. Isopods were taken from 95 buoys, or about one-fourth of the 379 sampled. Tanaidaceans were found on only 14 buoys, or 3.7 percent of those sampled. Five buoys yielded tanaidaceans but no isopods.

No isopods or tanaidaceans were found in the following vicinities (number of buoy stations sampled in each area in parentheses): Newfoundland (19); Eastport, Me. (12); Mt. Desert, Me. (13); Penobscot Bay, Me. (10); Delaware Bay (24); Chincoteague Bay, Va. (6); Cape Fear, N.C. (2); Cape Romain, S.C. (5); and Amelia Island, Fla. (6). Doubtless, both groups occur in these areas, perhaps even on buoys, but were missed in the sampling.

The collection comprises 26 species of Isopoda belonging to 16 genera distributed among seven families (fig. 2). These represent four of the seven aquatic suborders (Flabellifera, Valvifera, Asellota, and Anthuridea). The three suborders not represented are the Epicaridea,

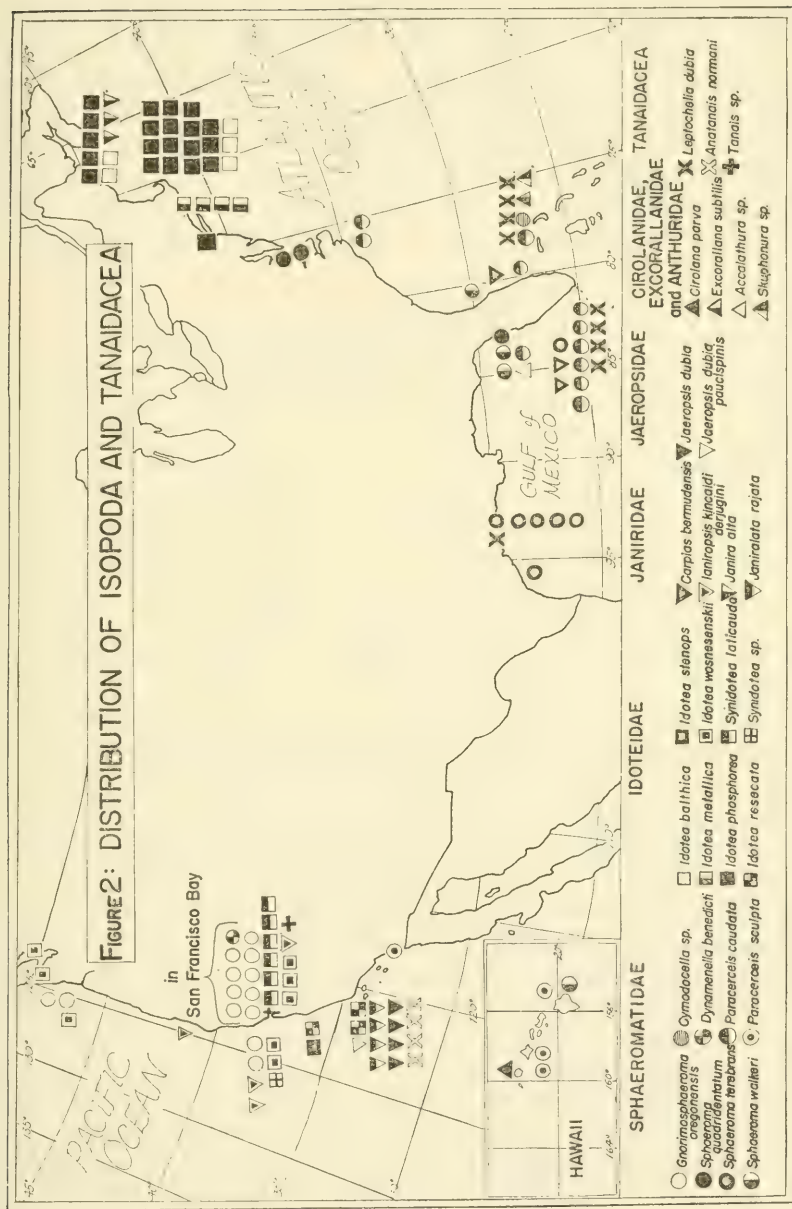


FIGURE 2.—Distribution of Isopoda and Tanaidacea on buoys.

Gnathiidea, and Phreaticoidea—the first parasitic on other Crustacea, the second ectoparasitic in the larval stage on fish, and the third found only in freshwater in Australia and South Africa.

The seven isopod families are represented unequally, both in numbers of species and in occurrences (table 2). To the total of 26 species, the Sphaeromatidae and Idoteidae contributed eight each, the Janiridae four, the Jaeropsidae and Anthuridae two each, and the Cirolanidae and Excorallanidae one each. The inequality is even more evident when the frequency of occurrence is considered with sphaeromids being found on 45 buoys, idoteids on 48, janirids on 13, jaeropsids on five, anthurids only on two, and cirolanids and excorallanids on one each.

The Tanaidacea are represented by only three species belonging to three genera and two families, Paratanaidae and Tanaidae. The one paratanaid species, the cosmopolitan *Leptocheilia dubia*, was found on the Atlantic coast side; the two tanaids were taken on the Pacific coast.

The 29 species in the buoy collection were divided almost evenly by the continent—13 isopod species and one tanaidacean taken on the Atlantic side only (including the Gulf coast and the Bahamas), and 13 isopod species and two tanaidaceans taken only on the Pacific side (including one species found only in Hawaii). No species was found on both the eastern and western coasts, but the widely distributed *Sphaeroma walkeri* were found on buoys in Hawaii and Florida.

Of the 100 buoys from which isopods and tanaidaceans were taken, most (78) contributed only a single species. Two species were taken from 16 buoys, three species from five buoys, and four species from one (Station 48, Florida Keys region).

Considering depth occurrence (table 2), we note that 50 percent of records of capture of isopods (disregarding number of specimens) were within one meter of the waterline on buoys, and that about another 25 percent occurred between 1 to 5 meters from the surface. In the families Sphaeromatidae and Idoteidae, more than half of the records (53 percent and 55 percent, respectively) for each family are at 0 to 1 meter depth, and about three-fourths of their occurrences are within five meters of the surface. Janirids show the greatest range of occurrence, from 0 to 55.4 meters, with *Janira alta* being recorded at the greatest depth for all isopods (on the anchor block set at 55.4 meters depth). None of the Jaeropsidae, Cirolanidae, Excorallanidae, or Anthuridae was found within a meter of the surface, and none of the last three families named was taken at less than five meters of the surface. In fact, the single excorallanid and

the two anthurids were taken from the anchor of buoys set at depths of 14.1, 11.1, and 15.4 meters. Tanaidaceans ranged from the surface to the bottom depths of 10 to 20 meters with the majority of occurrences (10 out of 18) below five meters and the median depth at which buoys were set. The number of species and the occurrences of tanaidaceans and of several isopod families are too small for more than cursory analysis. The possible relationship of motility with depth of occurrence will be discussed later.

In the following systematic review of the collection, the collection sites and previously reported localities for each species are given along with pertinent remarks on their systematics, ecology, and distribution.

Order ISOPODA

Suborder FLABELLIFERA

This sizable suborder (1400 species; Waterman and Chace, 1960) is represented in the fouling collection by 10 species belonging to seven genera distributed among three families—Sphaeromatidae (eight species), Cirolanidae (one species), and Excorallanidae (one species). Sphaeromatids were found on 45 buoys, but each of the other two families was taken from only one buoy.

Family SPHAEROMATIDAE

The sphaeromatids comprise a prominent group in the collection not only in number of species (eight), but also in the abundance of specimens. Swimming ability is relatively well developed in many members of this family, and this doubtless enables them to gain access to buoys. Woodboring sphaeromatids probably have been transported on wooden ship bottoms and in driftwood to new localities.

All the sphaeromatids in the buoy collection fall into two of the three "groups" in Hansen's (1905) subfamily Sphaerominae, namely the *hemibranchiatae* and *eubbranchiatae*. The hemibranchiate genera are *Sphaeroma* (three species) and *Gnorimosphaeroma* (one species). The eubbranchiate genera are *Paracerceis* (two species), *Dynamenella* (one species), and *Cymodocella* (one species). The *Sphaerominae platybranchiatae* are not represented.

Unfortunately, as Monod (1931b) remarked, the systematics of the Sphaeromatidae is in a state of confusion. The confusion stems from the tremendous sexual dimorphism in this family, coupled with parallel adaptations for conglobation. Females and immature males have been described as different species, even in separate genera, from adult males. Variation among individuals of the same size and sex adds to the taxonomic difficulties, as attested by long synonymies. Another complication, especially in widespread species, is that local races or sub-

species probably have developed as a consequence of long geographic or ecological segregation of populations. There is also the possibility of hybridization between related alien and native species. Misidentifications, of course, distort the distributional picture; hence, authors should indicate the uncertainties in their determinations and their reasons for them. Such information also is valuable in systematic revision.

Group Hemibranchiatae

Sphaeroma quadridentatum Say

FIGURE 3

LOCALITIES.—Virginia: near Norfolk (Stations 32, 33). Florida: Tampa Bay (Station 52).

REMARKS.—Richardson (1905b) lists *Sphaeroma quadridentatum* from many localities along the Atlantic seaboard from southern New England to Key West, Fla. Intermediate collection sites include waters in the vicinity of Cape Charles City, Va.; St. Catherine Island, Ga. (type-locality); and Beaufort, N.C. The buoys from which this species was collected lie within its known range. The available ecological data indicate that the species prefers muddy bottoms.

Nierstrasz (1917) reported this species from the Mediterranean, but Monod (1931b) lists the Mediterranean forms in the synonymy of *Sphaeroma serratum* (Fabricius) H. Milne Edwards. Earlier, Monod (1930) following Torelli (1930), also had equated *S. quadridentatum* from the east coast of North America with *S. serratum*. After examining topotypes of the former, however, he concluded that the two were separate species. He pointed out the following three distinctions: (1) In *S. quadridentatum*, there are four well-defined teeth on the outer border of the uropodal exopod, whereas the number of teeth varies in *S. serratum* (occasionally four) and they are often irregular crenulations, making it difficult to determine the precise number. (2) The posterior part of the telson in males of *S. quadridentatum* tends to be excavated dorsally with upturned borders, while in *S. serratum* it is vaulted more regularly. (3) In *S. quadridentatum*, there are fewer setae in the distal row on the propodus of pereopod I than in *S. serratum*. The buoy specimens confirm these observations.

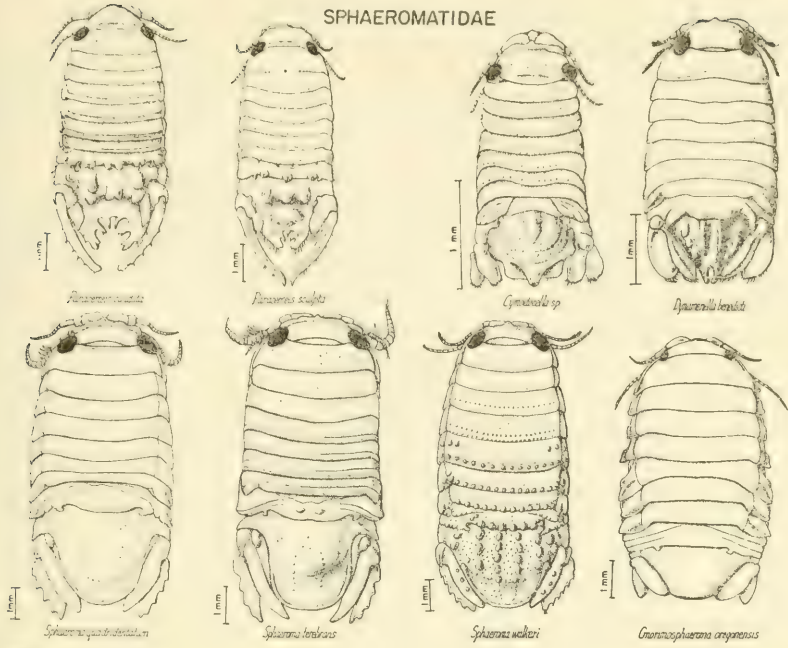
Sphaeroma walkeri Stebbing

FIGURE 3

LOCALITIES.—Florida: Ponce de Leon Inlet (Station 36), Sarasota New Pass (Station 49), Egmont Channel (Station 51). Hawaii: Hilo (Station 97).

REMARKS.—Previous reports indicate that *Sphaeroma walkeri* is widely but spottily distributed as follows. India: Gulf of Manaar (Jokkenpidd: Parr, Marichehukaddi, Cheval Paar, and Galle Harbour,

SPHAEROMATIDAE



IDOTEIDAE

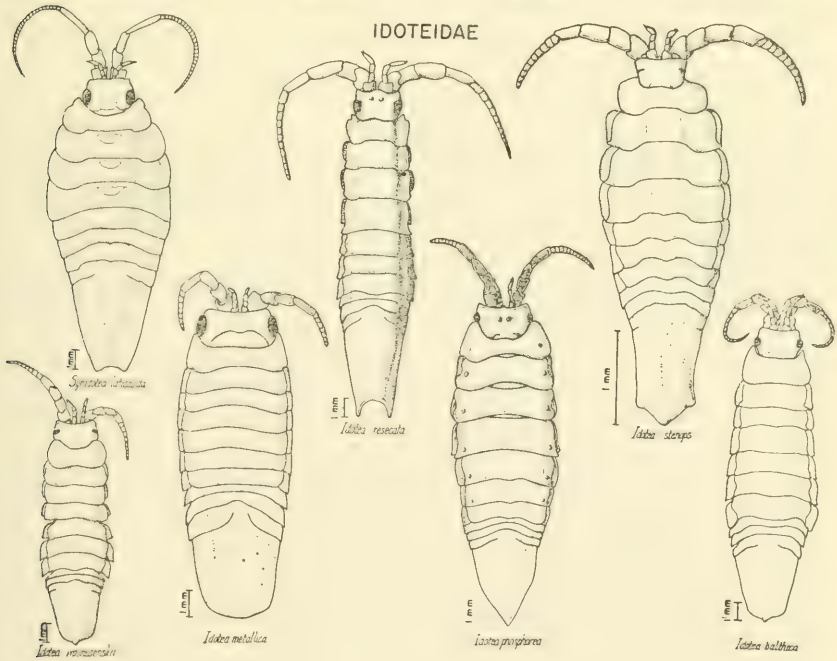


FIGURE 3.—Sphaeromatid and idoteid isopods from buoys

Ceylon—type-localities) (Stebbing, 1905); Travancore (Trivandrum) (Pillai, 1955); Bombay (Joshi and Bal, 1959). Red Sea and Suez Canal (Stebbing, 1910; Omer-Cooper, 1927; Monod, 1933). Africa: Egypt (Alexandria) (Larwood, 1940); Durban Bay (Stebbing, 1917; Monod, 1931b). South America: Brazil (Loyola e Silva, 1962). New South Wales: Blackwattle Bay, Darling Harbour (Baker, 1928).

With the addition of the above-listed localities in Florida and Hawaii, the recorded distribution of *Sphaeroma walkeri* is extended into the central Pacific and the northern hemisphere of the New World. Its spotty, circumglobal distribution and the fact that it has been taken from the hulls of boats (Larwood, 1940; Monod, 1933) strongly suggest dispersal by shipping.

Although the single specimen from Hilo was damaged badly, it was clearly conspecific with intact specimens collected by the author in August 1961 from Hanamaula Bay, Kauai, and no difference could be found between the Hawaiian specimens and those from Florida. The collection of specimens of *Sphaeroma walkeri* from two widely separated Hawaiian islands and from three localities on both the east and west coasts of Florida indicates that this species is fairly well established in these two regions. It would be of great interest to know when and how these isopods were introduced!

The identification of the buoy specimens as *Sphaeroma walkeri* seems certain, although there are some discrepancies between them and Stebbing's (1905) original description. At least they conform as well to his description as do sphaeromatids from other localities that have been assigned to that species by several authors. They show the distinctive pattern of tuberculation, the characteristic number of lateral teeth on the uropodal exopod, and the posteriorly dished telson with a rounded, upturned crenate border.

Our specimens differ from the original description of *Sphaeroma walkeri* primarily in showing epimeral sutures on the first as well as on the six subsequent pereonal segments. Stebbing states unequivocally that the "side plates" (epimera) of the first segment of pereon of this species are "unsutured." His figures, both dorsal and lateral views, agree with the text showing epimeral sutures on all but the first pereonal segment. Twelve years later, however, the same author (Stebbing, 1917) figures a male and female of this species from Durban Bay, South Africa, both lacking epimeral sutures on all seven pereonal segments. (Stebbing's 1910 report of this species from the Red Sea gives no description or figures.) The figures of *S. walkeri* from different localities given by other authors (e.g., Pillai, 1955) clearly indicate epimeral sutures on all pereonal segments including the first, as in our specimens.

One must conclude either that Stebbing did not attach any signifi-

cance to epimeral sutures, or that the sphaeromatids from Durban Bay that he identified as his *Sphaeroma walkeri* might belong to a closely related species, possibly *S. venutissimum* Monod. The fact that his figures of these show other differences from the original description of *S. walkeri* lends credence to the latter view. For instance, the African specimens have tubercles on the head that are not indicated at all in his description or figures of the type. They also have eight or nine teeth on the uropodal exopod instead of the prescribed six or seven. (Although Stebbing's description of *Sphaeroma walkeri* states there are six or seven teeth on the outer margin of the uropod, his figures show only five. He doubtless counted as a tooth the pointed apex of the exopod.) It is difficult to believe that so eminent an authority as Stebbing could erroneously assign specimens to a species he himself described, albeit many years earlier.

Other differences between the buoy specimens and the description of *Sphaeroma walkeri* may be characterized as normal variation. Most specimens had five lateral teeth on the outer branch of the uropod (the typical number), but a few had four or six. Sometimes the number varied between the two sides of a specimen. Most had two tubercles on the dorsal side of the endopod, but several had three and one specimen had only one. The distinctness of the tuberculation, particularly on the thoracic segments, increases with the size of the specimen.

Sphaeroma terebrans Bate

FIGURE 3

LOCALITIES.—Florida Keys (Station 42). Texas coast: near Freeport (Station 53), off Sabine Pass (Stations 54–58).

REMARKS.—The sphaeromatids from buoys off the Texas coast are assigned with some hesitation to *Sphaeroma terebrans*. This is a variable species widely distributed in warm waters (salt, brackish, and fresh) of both the Old and New Worlds (Nierstrasz, 1931; Van Name, 1936). Reported localities include many in India (Stebbing, 1904; Erlanson, 1936; Pillai, 1954); equatorial and southern Africa (Barnard 1920, 1940; Brian and Darteville, 1949; Stebbing, 1910); Australia (Baker, 1926; Calman, 1921; McNeill, 1932); Siam and Sumatra (Chilton, 1926); St. John's River (fresh water) at Palatka, Fla. (Richardson, 1905b); Escambia River, Fla., and Sabine River, Tex. (Wurtz and Roback, 1955); and Brazil (type-locality). Menzies and Frankenberg (1966) report it from Georgia, but as *S. destructor*. Dr. Thomas E. Bowman of the U.S. National Museum informs me (in litt.) that it also has been reported from Virginia by Wass (1963) but apparently was carried there on a ship from Florida. The above-cited Florida location is the type-locality of *S. destructor* Richardson, which has been considered a synonym of *S. terebrans* Bate by most

authors despite Miss Richardson's stout defense for its distinctness. Her *S. peruvianum* from honeycombed wood in oyster beds in Peru and her *S. retrolaevis* from Japan are regarded as distinct from but closely related to *S. terebrans*.

As isopods of this species commonly are found burrowing in decayed wood, bridge and wharf pilings, dead mangrove roots, etc., dispersal by ships and driftwood seems a likely explanation for its widespread distribution. As with other widely distributed species, geographic and/or ecological segregation may result, in time, in reproductive isolation of local populations and subsequent speciation.

The specific identification of the Texas specimens is questioned primarily because the sculpturing of the dorsal surface, as far as this can be determined, does not conform entirely to the descriptions of this feature in *S. terebrans*. According to the descriptions, the dorsal surface on the posterior part of the body is covered with granules and tubercles of various sizes, the larger ones of which bear tufts of minute hairs, and there are tuberculated transverse ridges on the posterior thoracic segments. Well-developed paired tubercles are said to be characteristically present on the last one or two thoracic and on the two pleonal segments. The literature indicates, however, a certain amount of variation in sculpture pattern as well as in other characteristics.

Considerable individual variation in tuberculation was observed in the Texas specimens. The smaller ones were smooth, as in *S. quadridentatum*, or only minutely granular and transverse thoracic ridges were only slightly evident. Larger specimens usually were coated with mud, especially on the hinder part, which obscured the tubercles. Several previous authors mentioned the same difficulty with mud. In our specimens, the coating adhered so tightly that, when attempts were made to remove it, the underlying exoskeleton also peeled off. Nevertheless, it was possible to observe that our specimens had finely tuberculated transverse ridges on the posterior thoracic segments and tubercles on the pleon and pleotelson. Some specimens showed large paired tubercles on the pleon, others did not, and the pattern was not consistent. In some, there was evidence of two paramedian rows of tubercles on the pleotelson, as in *S. quoyana* M. Edwards.

***Gnorimosphaeroma oregonensis* (Dana) Menzies**

FIGURE 3

LOCALITIES.—California: San Francisco Bay area (Stations 74–78, 80, 84–87, 91). Washington: Umatillo (Station 95), Quillayute River (Station 96).

REMARKS.—This species, first described by Dana (1852) as *Sphae-*

roma oregonensis, subsequently has been placed in *Exosphaeroma*, *Neosphaeroma*, and currently, since Menzies (1954), in *Gnorimosphaeroma*. Menzies subdivided it into two subspecies, *G. oregonensis oregonensis* and *G. o. lutea*, but Riegel (1959) on the basis of morphological, physiological, and ecological evidence elevated the two subspecies to full species status.

Menzies states that *G. oregonensis oregonensis* ranges from Alaska to San Francisco Bay, Calif., with the type-locality in Puget Sound, Wash. He lists many records of distribution in this range. It occurs primarily in the intertidal zone to depths of 12 fathoms (20.8 meters) but has been taken at submerged night lights near the surface (Hatch, 1947; Menzies, 1954). It apparently tolerates in nature a wide range of salinities, as it was found on buoys in the upper reaches of San Francisco Bay (Suisun Bay, etc.) near the Sacramento-San Joaquin delta where salinities are low (oligohaline) and on buoys outside the bay and on the open seacoast outside the Golden Gate and along the coast of Washington.

Group Eubranchiatae

Paracerceis caudata (Say) Hansen

FIGURE 3

LOCALITIES.—North Carolina: Cape Lookout region (Stations 34, 35). Florida: Port Everglades (Station 38), Florida Keys (Stations 39–41, 44, 47, 48), Sarasota (Station 49), Tampa Bay (Station 50). Bahamas: Walker Cay (Station 62).

REMARKS.—Richardson (1905b) records many localities for *Paracerceis caudata* (under the name *Cilicaea caudata*) ranging from Egg Harbor, N.J., southward to the Florida Keys, the Bahamas, Porto Rico, Yucatan, and the Bermudas. Reported depths are from the surface to 25 fathoms (46 meters) among algae and grass and from coral reefs. The buoy collections of this species are well within its previously recorded geographic and depth range. It appears to be predominantly a warm water species of the eastern North American coast.

Pronounced sexual dimorphism in this species results in taxonomic difficulty unless samples include mature males. Females alone are notoriously difficult to identify correctly and even have been described as distinct species (e.g., *Dynamene bermudensis* represents the female of *Paracerceis caudata*). Small females of *Paracerceis caudata* in the buoy collection, especially one from Satan Shoal Buoy (Station 39) near Key West, resemble the description of *Dynamene angulata* Richardson (1901). The latter was described only from female specimens found by Mr. Henry Hemphill at No Name Key, Fla. It has

not been reported subsequently from any other locality. The possibility is suggested that, as in the above-cited case of *D. bermudensis*, *D. angulata* is also a junior synonym of *P. caudata*. The fact that Richardson (1905b) reported both *P. caudata* and *D. angulata* from No Name Key, however, indicates that she must have regarded these forms as distinct species. It would be inadvisable, therefore, to relegate *D. angulata* to the synonymy of *P. caudata* without critical comparison of Richardson's types with female and immature male specimens of *P. caudata* from the same region.

***Paracerceis sculpta* (Holmes) Hansen**

FIGURE 3

LOCALITIES.—California: San Diego Harbor (Station 72). Hawaii: Hilo Harbor, Hawaii (Station 97); Pearl Harbor, Oahu (Stations 97, 98).

REMARKS.—Richardson (1905b) reports *Paracerceis sculpta* from only two southern California localities, San Clemente Island and San Diego. In the author's collection there are specimens of this species collected by Marjorie Oakley Brown in Morro Bay, Calif. (unpubl. data), which is more than 200 miles north of the previous known range. The present records of this species in Hawaii greatly extend its distribution. Probably it was transported on the hulls of naval ships plying between San Diego and Hilo and Pearl Harbor.

Several other species of this genus occur along the Pacific coast, but none of these were taken in the buoy survey. One of these is a widely ranging species, *P. cordata* Richardson, which occurs along the Pacific coast of North America from Catalina Island, Calif., to Popoff Island and the Aleutian Islands. (There is a big gap in its recorded distribution, however, between the Alaskan localities and Mendocino County in northern California. Hatch, 1947, does not mention it in Washington and adjacent regions.)

***Dynamenella benedicti* (Richardson) Richardson**

FIGURE 3

LOCALITY.—California: South San Francisco Bay (Station 84).

REMARKS.—Richardson (1905b) lists *Dynamenella benedicti* from Monterey Bay, Calif., its only recorded locality to my knowledge. The present record, therefore, extends its range considerably northward.

***Cymodocella* species**

FIGURE 3

LOCALITY.—Bahamas: Walker Cay (Station 61).

REMARKS.—A single, small female sphaeromatid in rather poor condition is assigned with some uncertainty to the genus *Cymodocella*

Pfeffer. It possesses many of the attributes ascribed to the related genus *Dynamenella*, but the characteristic tubular posterior extension of the pleotelson with a slit along the underside places it in *Cymodocella*.

The generic placement is questionable, however, for several reasons. In Hansen's (1905) key to the *Sphaerominae eubranchiatae*, *Cymodocella* (as well as *Dynamenella*) falls into the section characterized by the exopod of the third pleopod being unjointed; but in the present specimen that structure is biarticulate. The apical tube is not as long as in other species of the genus. The rami of the uropod lamellar, as prescribed, and apically toothed, but subequal in length, whereas in typical *Cymodocella* the exopod is supposed to be considerably shorter than the endopod. Finally, because of the immaturity of the only specimen, the sexual characteristics of generic value could not be ascertained.

Five species of *Cymodocella* are known—the antarctic-antiboreal *C. tubicauda* Pfeffer and four African species from the Cape of Good Hope region; namely, *C. algoensis* (Stebbing) Stebbing, *C. cancellata* Barnard, *C. pustulata* Barnard, and *C. sublevis* Barnard. The facts that the present specimen does not fit the description of any of these and that it is the first record of the genus in the northern and western hemispheres indicate it may represent a new species. Pending examination of additional material—hopefully, mature specimens—of both sexes, it seems best to defer full and formal description.

Family CIROLANIDAE

The family Cirolanidae is represented in the buoy collections by a single specimen.

Cirolana parva Hansen

FIGURE 4

LOCALITY.—Hawaiian Islands: Port Allen, Kauai (Station 100).

REMARKS.—The family Cirolanidae is represented in the buoy collections by a single specimen of *Cirolana parva*. This species has previously been reported from many tropical localities including: Georgia (Menziés and Frankenberg, 1966); Florida, Gulf of Mexico, West Indies, and the Bahamas (Richardson, 1905b); Jamaica (Richardson, 1912); Cameroon and South Africa (Monod, 1931a, 1933); Mozambique (Barnard, 1914); Red Sea and Suez Canal (Stebbing, 1910; Monod, 1931 and 1933); Ceylon (Stebbing, 1905); Siam (Chilton, 1926); Polynesia: Rikitea (Nobili, 1907), Samoa (Hansen, 1890); Indonesia: Timor, Aru, et al. (Nierstrasz, 1931). The present report of this species in the Hawaiian Islands extends its distribution into the central Pacific. The author also has collected it from reefs around

the islands of Kauai, Oahu, and Hawaii. The major gap in the near circumtropical distribution of this species is the eastern Pacific. Its absence there may be due merely to the fact that this area has not been explored sufficiently.

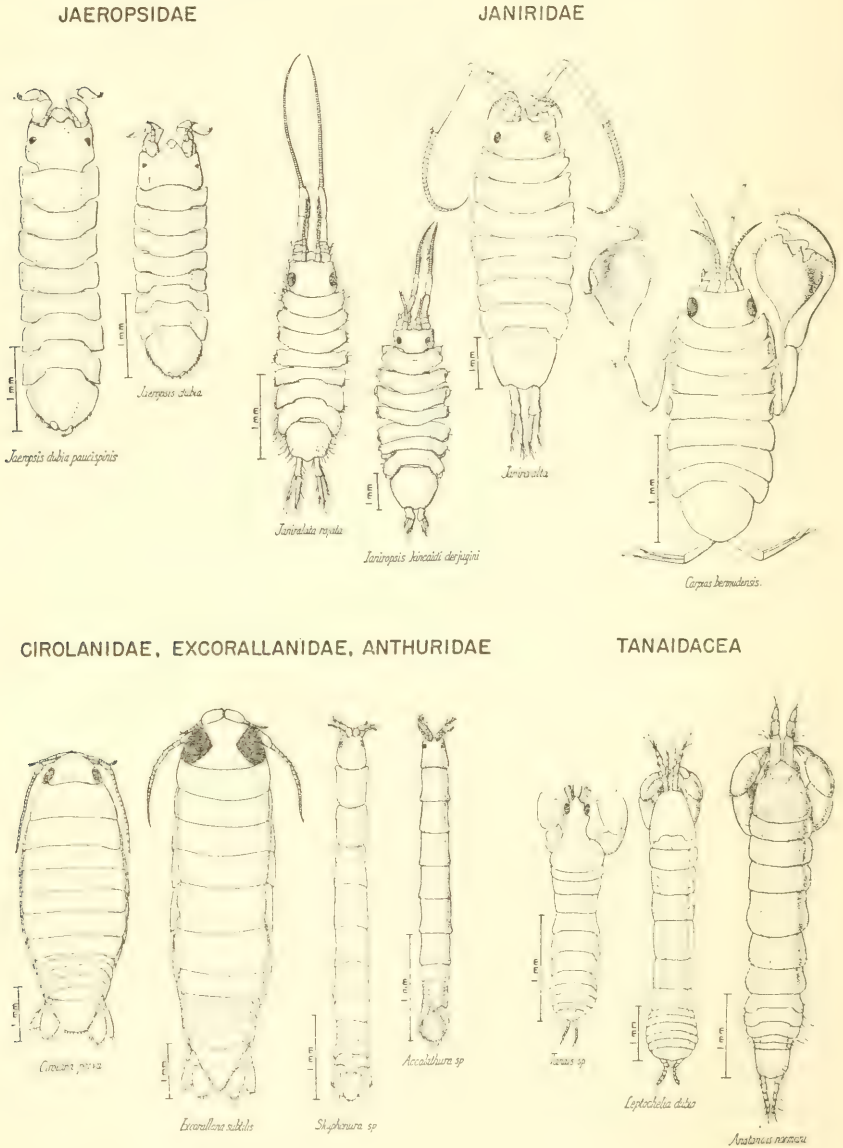


FIGURE 4.—Jaeropsid, janirid, cirolanid, excorallanid, and anthurid isopods, and tanaidaceans from buoys.

Family EXCORALLANIDAE

Excorallana subtilis (Hansen) Richardson

FIGURE 4

LOCALITY.—Florida: Tampa Bay (Station 50).

REMARKS.—Hansen (cited by Richardson, 1905b) records *Excorallana subtilis* from St. Thomas, West Indies. She also hesitatingly refers to this species two male specimens from Florida (specific locality not given) in the collection of the U.S. National Museum. These fit the description except for the lack of the two large tubercles at the base of the terminal abdominal segment. The specimen from Florida, an ovigerous female, agrees nicely with the description except that the two tubercles on the pleotelson are not as large as those figured by Richardson. Probably the presence and size of these tubercles are variable characteristics.

Suborder VALVIFERA

This suborder (containing some 600 species; Waterman and Chace, 1960) is represented in the collection by eight species, all in one family, taken from 48 buoys.

Of the two valviferan families known in North America, the *Astacillidae* (= *Arcturidae*) and the *Idoteidae*, only the latter is represented in the buoy collections. This family occurs mainly in the temperate zone and boreal zones, whereas astacillids are characteristic of still colder waters. Both families, however, have representatives in tropical or subtropical waters and the ranges of some extend into warm waters. Valviferans in general, however, are represented poorly in the tropics. In the buoy collections only one of eight idoteid species (*Idotea resecata*) was found south of 35° north latitude.

Family IDOTEIDAE

Subfamily IDOTEINAE

Only two idoteid genera were found, both in the subfamily Idoteinae to which most idoteids belong: *Idotea*, with six species, and *Synidotea*, with two. The six species of *Idotea* were divided evenly between the Atlantic and the Pacific coasts. They probably are ecological equivalents. Both species of *Synidotea* were found on buoys along the Pacific coast. *Synidotea* is predominantly a North Pacific genus with only two circumarctic or circumboreal species known from the North Atlantic.

As previously mentioned, some idoteids, as well as sphaeromatids, are good swimmers, which accounts for their relatively greater frequency on buoys than the more sedentary isopods. Two species, *Idotea balthica* (= *marina*) and *I. metallica*, have been reported from widely separated localities in both northern and southern hemispheres.

Both species have been taken from floating seaweed, which suggests a possible means of dispersal.

***Idotea phosphorea* Harger**

FIGURE 3

LOCALITIES.—Gulf of Maine (Stations 1–3, 5, 6). Nantucket Sound and vicinity (Stations 11–14, 16–26). New York area (Station 27).

REMARKS.—Richardson (1905b) gives the distribution of *Idotea phosphorea* as “Coast of New England to Halifax, Nova Scotia, and the Gulf of St. Lawrence; Runmarö, Stockholms Skärgörd,” at depths from the surface to 18 fathoms (about 33 meters), among seaweed, and in the stomach of haddock. In the present study, it was taken from 21 buoys from New York to the Gulf of Maine, all within its previously recorded range.

Generally found within three meters of the surface, it also was taken at various depths down to about 23 meters. On one buoy (Station 23), more than 35 specimens were taken. This species was found on the greatest number of buoys in the entire collection.

***Idotea balthica* (Pallas)**

FIGURE 3

LOCALITIES.—Gulf of Maine (Stations 4, 5). Nantucket Sound (Stations 10, 15, 18).

REMARKS.—The nomenclature of this widely distributed and doubtless variable species has had a controversial history. The name *Idotea marina* (L.) has appeared in the literature both as a junior and senior synonym of *I. baltica* (Pallas) (also spelled “*balthica*,” the original spelling of Pallas). Holthuis (1949) reviewed the case and concluded that *I. marina* was correct. He later (1956) reversed himself, however, apparently persuaded by the arguments of Naylor (1955). Hurley (1961) transfers the New Zealand records of *I. baltica* to *I. marina*. Gruner (1965) uses *I. balthica* [sic] and lists among its synonyms *I. marina* of Richardson (1905b) and Holthuis (1949). He does not mention Hurley (1961) but says that the question of occurrence of *I. balthica* [sic] in New Zealand (as well as Java, Brazil, and the Red Sea) must be reexamined.

Richardson’s (1905b) list of localities (given below) for *Idotea baltica* (Pallas) is essentially similar to her earlier list (1901) for *I. marina* (L.) in which the former was included among other synonyms. Both her lists incorporate the distributions given by Miers (1883), Harger (1873), and previous authors. Richardson’s (1905b) list is as follows:

Atlantic coast from Nova Scotia and Gulf of St. Lawrence to North Carolina; Bermudas; Barbados; also Mediterranean, Black and Caspian seas; west coast of Europe to Great Britain; shores of the Netherlands; in German Ocean and

Baltic Sea; Bohusland, Sweden (W. Sachs); Runmarö, Stockholms skärgård (J. Lindahl); on Scandinavian and Finland coasts; South America, at Desterro and Rio Janeiro, Brazil; New Zealand; Red Sea; Java.

Hansen (1916) considers Richardson incorrect in listing this species from Brazil, New Zealand, the Red Sea, and Java. He contends that these localities were listed by Miers (1883) for *I. marina* and under that name Miers "had mixed up at least four and probably five or six species." As previously mentioned, Gruner (1965) also considers these locality records questionable.

Idotea balthica (= *baltica* = *marina*) subsequently has been reported by many authors from many localities: North Sea (Zirwas, 1910); Iceland and the Faroes (Hansen, 1916); Ireland (Tattersall, 1912); Great Britain (Naylor, 1955); the Netherlands (Koumans, 1928; Holthuis, 1949, 1956); Alexandria, Egypt (Larwood, 1940); Australia (Hale, 1924), New Zealand (Hurley, 1961); New Guinea (Nierstrasz and Schuurmans Stekhoven, 1941).

Gruner (1965) summarizes localities mentioned by previous authors and recognizes several subspecies: *Idotea balthica balthica* Dahl (Baltic Sea), *I. b. tricuspidata* Dahl (North Sea), *I. b. basteri* Audouin (Mediterranean), and *I. b. stagnea* Tinturier-Hamelin (Mediterranean, on the coast of Roussillon).

Richardson (1905b) gives depths for *I. baltica* from the surface to 119 fathoms (220 meters) and states it has been found on floating seaweed, among algae and eelgrass, in sand and gravel, and from the stomachs of smelt. Zirwas (1910) found it on floating wood or algae. Hansen (1916) states depth records are misleading as "the animals, which can swim rather well and frequently live among floating algae, have been taken in the instrument when it was hauled up." Gruner (1965) states that this species is euryhaline, sometimes found in water with salt concentrations as low as 3.5 ‰. It is sublittoral, usually does not go deeper than 20 meters, but has been found at depths of 340 meters. In the present study, this species was found on five buoys, all in the New England region, always within a meter of the surface.

Idotea metallica Bosc

FIGURE 3

LOCALITIES.—New York area (Stations 28–31).

REMARKS.—*Idotea metallica*, a widely distributed, nearly cosmopolitan species, has been reported from many localities including the Atlantic coast from Florida Keys to Nova Scotia, Greenland, Iceland, Britain, Ireland, Mediterranean Sea, Indian Ocean, northwestern Australia, New South Wales, New Zealand, Sumatra, Borneo, Sea of Japan, Cape of Good Hope, Antarctic, Montevideo, Straits of Magellan, Chile, and Patagonia (Richardson, 1905b, 1909; Gurjanova,

1936; Dow and Menzies, 1957; Naylor, 1957; Nordenstam, 1933; Thielemann, 1910; Hurley, 1961; Menzies, 1962; Hansen, 1916).

Reported depths for *Idotea metallica* are from the surface to 91 fathoms (166 meters). It has been found on floating fucus. Dow and Menzies (1957) report this species (forma *typica* Cărauşu) as commonly taken in surface plankton tows in the Mediterranean. Their analysis of stomach contents indicates its food consists principally of brown algae, possibly *Sargassum*. They conclude that this form is a pelagic surface-dwelling isopod. Their conclusion is supported by the present study as all specimens of this species were taken at the surface level on four buoys set in open and relatively deep water (59–76 meters) at some distance (50–100 or more kilometers) east of Long Island and south of Massachusetts.

***Idotea (Pentidotea) resecata* (Stimpson) Menzies**

FIGURE 3

LOCALITIES.—California: Anacapa Island (Station 67), Santa Barbara (Station 69), San Simeon (Station 73).

REMARKS.—*Idotea resecata* ranges from southern California to Alaska (Richardson, 1905b; Hatch, 1947; Menzies, 1959) with many localities reported along the coasts of California (San Pedro to Humboldt Bay), Washington, and British Columbia. The author has collected specimens of this species at Los Coronados Islands off San Diego, a locality that extends its known range considerably southward.

According to Richardson (1905b), it is found between tide marks among rocks, seaweed, kelp, eelgrass, etc. at depths from surface to 3.5 fathoms (about 6.4 meters). Dow and Menzies (1959), however, consider it as the Pacific Ocean counterpart of *Idotea metallica*, a truly pelagic species.

The buoy collections of *Idotea resecata* were well within its recorded range of distribution, which extends several thousand miles along the Pacific coast of North America from subtropical to boreal waters. This species apparently has a wide temperature tolerance.

***Idotea (Pentidotea) vosnesenskii* (Brandt) Menzies**

FIGURE 3

LOCALITIES.—California: San Francisco Bay area (inside the bay: Stations 75, 81, 84; outside: Stations 88, 89). Washington: Strait of Juan de Fuca (Station 93), Puget Sound (Station 94), outer coast at Quillayute (Station 96).

REMARKS.—*Idotea vosnesenskii* is common in temperate and cold waters along the entire Pacific coast of North America from central California to Alaska and in the Bering Sea, Sea of Ochotsk, and Kamchatka Sea (Richardson, 1905b; Thielemann, 1910; Gurjanova,

1936; Nierstrasz and Schuurmans Stekhoven, 1941; Hatch, 1947). Richardson (1905b) gives its southern limit as Monterey Bay, Calif., but Thielemann (1910) states it occurs as far south as San Diego. Menzies and Barnard (1959), however, do not list it among the marine isopods of the southern California coastal benthos. The author has specimens from San Simeon, some 100 miles north of Point Conception, which divides the warm water coastal fauna of southern California from the colder water fauna of central and northern California.

Richardson (1905b) records depths from the surface to 9 fathoms (16.4 meters). It is found commonly on kelp exposed at low tide. On buoys, it was found generally at or near the waterline.

***Idotea (Pentidotea) stenops* (Benedict) Menzies**

FIGURE 3

LOCALITY.—California: San Simeon Bay (Station 73).

REMARKS.—*Idotea stenops* has been reported from Monterey Bay, Calif. (Richardson, 1905b); Coos Bay, Oreg. (Hatch, 1947). The author has collected it among algae in the low intertidal zone at several localities along the central California coast from Moss Beach (San Mateo County) to Stockhoff Cove (Sonoma County).

No depths are reported in the literature for this species. On the buoy at San Simeon, it was found at the surface with *Idotea ressecata*.

***Synidotea laticauda* Benedict**

FIGURE 3

LOCALITIES.—California: greater San Francisco Bay (Stations 76, 79, 82, 83, 87).

REMARKS.—The distribution of *Synidotea laticauda* is limited to greater San Francisco Bay, with localities recorded in all three divisions—southern (lower), middle (central), and northern (upper) divisions (Richardson, 1905b; Filice, 1958; author's collection). The northern division includes San Pablo Bay, Carquinez Straits, and Suisun Bay as far inland as Pittsburg near the mouth of the Sacramento-San Joaquin River delta. It has never been collected on the open coast outside the bay.

On buoys, *Synidotea laticauda* was taken at various depths from the surface to 7.4 meters. Richardson (1905b) records it at 12.3 meters. On several buoys, large numbers of these isopods were taken feeding on hydroids *Bimeria franciscana* Torrey.

Many environmental factors, alone or in combination, doubtless limit the distribution of this species to San Francisco Bay. Prominent among these are salinity, temperature, turbidity, oxygen content, and tidal and river currents. Quite as important ecologically as average conditions with regard to these factors are the fluctuations and extremes. Special conditions are created by the geography of this bay

system, which features a narrow entrance (Golden Gate), two long narrow divisions extending northward and southward from the middle section, and the combined discharge into the northern arm of two major rivers—the Sacramento and San Joaquin. In addition to mechanical effects, the complex interaction of the inflow of these and lesser rivers and streams with the diurnal ebbing and flooding tides through the Golden Gate results in significant fluctuations, especially in salinity and temperature.

Salinities at the localities for this species range from polyhaline to oligohaline. At Fort Point, at the Golden Gate entrance to San Francisco Bay and less than a mile seaward from Station 83 (Crissy Field Buoy), salinities average 30–31 ‰. From there, average salinities decrease progressively inland to about 27–29 ‰ in the middle southern division and to about 25 ‰ at the southern end of San Pablo Bay, to 15–16 ‰ at Crockett at the seaward end of Carquinez Straits, to 10 ‰ at Martinez at the other end of the straits, to 1 ‰ at Pittsburg, and to 0.3 ‰ at Antioch (Miller, et al., 1928; Filice, 1954).

As to temperature, the study of Miller, et al. (1928), conducted in July 1923, indicates that the lowest average surface temperatures are found at the entrance to the bay (14.1°C at Fort Point) with increases to 17.8°C at Oakland in the middle bay, to 20.6°C at Dumbarton Bridge in the southern part, and to 19.1°C at Crockett in the northern arm.

As to other factors, turbidity is relatively high at the two ends of the bay system, especially at the northern end owing to silt from the rivers. Toward the mouth of the bay, the water becomes clearer with turbidity normally negligible at the Golden Gate. As might be expected, oxygen content is higher in the colder, less polluted water at the bay entrance. In the upper bay, it is almost invariably below the saturation point (Filice, 1954). Filice could find no evidence, however, that there was a correlation between depressed oxygen values and the presence of wastes, or that the amounts of oxygen present affect the bottom fauna in any way.

Judging from environmental conditions at the various collection sites in San Francisco Bay, I conclude that *Synidotea laticauda* is able to tolerate a wide range of salinities, temperature fluctuations, turbidity, and other estuarine conditions. I will present evidence in a forthcoming paper (with R. J. Menzies) that it probably is a relict of a warm water species that occurred in the bay region in earlier times when warm waters extended far northward along the Pacific coast.

Synidotea species

LOCALITY.—California: San Francisco Bar Channel (Station 90).

REMARKS.—One specimen too badly damaged for positive specific identification was taken from the buoy chain at a depth of 14.8 meters.

It is probably *Synidotea bicuspidata* (Owen), as this is a widely distributed cold water species found along the Pacific coast as far south as San Francisco Bay, on the Atlantic coast as far south as Labrador, in the Arctic Ocean, and in the Sea of Japan. It has been collected frequently both inside and outside of San Francisco Bay.

Suborder ASELOTOTA

The Asellota (comprising 500 species; Waterman and Chace, 1960) were represented in the buoy collections by six species (including one subspecies) in five genera, belonging to the two families, Janiridae and Jaeropsidae. Two janirid species in separate genera were found on Atlantic coast buoys; three species and one subspecies in three genera were taken from Pacific coast buoys.

Family JANIRIDAE

This family contains 35 genera and 136 species, evenly distributed around the world with three-fifths of the species restricted to the continental shelves (Wolff, 1962).

Janira alta (Stimpson) Harger

FIGURE 4

LOCALITIES.—Gulf of Maine (Stations 7–9).

REMARKS.—Richardson (1905b) reports *Janira alta* from the following localities: "Long Island; Massachusetts Bay, near Eastport, Me.; Gulf of Maine; Grand Menan; Bay of Fundy; 120 miles south of Halifax; Grand Banks; Clarke's Ledge; 30 miles east of Sable Island; off Chesapeake Bay." Hansen (1916) reports it as taken by the *Ingolf* at a single station west of Iceland. Richardson (1905b) records depths of 35 to 487 fathoms (64–886 meters), but Wolff (1962) gives a range of 0 to 1384 meters. In the present study, specimens were taken at 40 and 55.4 meters. Apparently it ranges into moderately deep water in the northern and western Atlantic. The buoy collections are well within its recorded range.

Carpis bermudensis Richardson

FIGURE 4

LOCALITIES.—Florida: east coast (Station 37); Key West region (Stations 45, 48).

REMARKS.—Previously reported only from the Bermudas (Richardson, 1902, 1905b), *Carpis bermudensis* was found at three stations off the coasts of Florida. This extension of its known range is not surprising in view of the affinities of Caribbean and Bermudan faunas. It will likely be found elsewhere in the Antilles. Indeed, it

probably originated there and was carried northward to Bermuda by the Gulf Stream. In Bermuda, it occurs in shallow water on submerged reefs, among corals, etc. On one buoy (Station 37) it was found on the anchor at 14.8 meters, but on two others it was found only 1.5 and 2.2 meters from the surface in water 13.8 and 11.1 meters deep, respectively.

Males of this species are distinctive having elongate first pereopods (gnathopods) with distally expanded carpus and propodus, each provided with opposing triangular processes. Females (and immature males) lack this modification of the first leg and superficially resemble females of many other janirid species.

Janiralata rajata Menzies

FIGURE 4

LOCALITIES.—California: Catalina Island (Stations 64, 66); Anacapa Island (Station 67).

REMARKS.—Menzies (1951) described this species from a male specimen in the U.S. National Museum (USNM 43646) that had been collected at Monterey Bay, Calif., by Harold Heath from an egg of *Raja binoculata* at a depth of 20 fathoms (36.4 meters). Deeming its previous identification as *Janiropsis californica* by Richardson to be in error, Menzies redescribed it as a new species assigned to his new genus *Janiralata*. It is known only from the type-locality, Monterey Bay. Thus, the present collection greatly extends its known range.

Menzies (1951) established the genus *Janiralata* with 10 species, including eight transferred from other genera (three from *Janira*, five from *Iolella*) and two new descriptions. Of these, Menzies and Barnard (1959) list two as occurring in southern California, namely, *J. occidentalis* (Walker) and *J. solasteri* (Hatch). The present report adds a third from that region. Kussakin (1962) recently has described six new species, all from the northwest Pacific. He also transfers two other species to *Janiralata*, namely, *Janira tricornis* Krøyer and *Iolella chuni* Thielemann. All known species of *Janiralata* occur in the Pacific except *J. tricornis*, which occurs off Greenland, off Franz Josef Land, and in the Bering Sea. The latter locality is added because Kussakin assigns *J. alascensis* (Benedict) to the synonymy of *J. tricornis* (Krøyer).

Janiropsis kincaidi derjugini (Gurjanova) Menzies

FIGURE 4

LOCALITIES.—California: Alcatraz Island, San Francisco Bay (Station 81); Coast off San Francisco (Stations 88, 89); Noyo River (Station 92).

REMARKS.—Menzies (1952) gives the distribution of *Ianiropsis kincaidi derjugini* as Komandorskie Islands, Bering Sea, to Monterey County, Calif. He states that this subspecies is found under rocks in the middle and lower intertidal zones, whereas the other subspecies, *I. k. kincaidi*, occurs in small pools where the water is supplied by wave splash and is subject to extremes in temperature. The buoy collections of *I. k. derjugini* are within its recorded geographical range. It was taken from buoys at depths from the surface to 1.8 meters.

Of the 17 described species (including subspecies) of *Ianiropsis*, seven occur on the Pacific coast. Of these, five are known only from the central California coast.

Family JAEROPSIDAE

Jaeropsis dubia Menzies and *J. d. var. paucispinis* Menzies

FIGURE 4

LOCALITIES.—*Jaeropsis dubia*: California: Catalina Islands (Stations 64–66), Point Dume (Station 70). *Jaeropsis d. paucispinis*: California: Los Angeles Harbor entrance (Station 71).

REMARKS.—Menzies and Barnard (1959) give the distribution of *Jaeropsis dubia* and its variety *paucispinis* as Marin County, Calif., to the Mexican border. The author's collection contains specimens of this species collected by Lloyd Tevis at Bahia del Tortuga, Mexico, north latitude 27°40', which extends its known range considerably south of the border; hence, the present records are well within this range.

Menzies and Barnard (1959) state that it occurs at depths of 10 to 50 fathoms (18.2–91 meters) but usually at less than 30 fathoms (54.6 meters), associated with algae. They further state that, at depths greater than 30 fathoms, these forms are located in clear water since, in turbid waters, algae rarely are collected below 20 fathoms. In the buoy collections, *J. dubia* was collected at depths ranging from 1.8 to 13 meters, and *J. d. paucispinis* at 5.5 meters. The former was taken in areas with rocky bottom, the latter from an area with sand-shell bottom.

Neither Menzies (1951) nor Menzies and Barnard (1959) indicates any ecological segregation of the two entities, both being collected together in the same localities. The variety is separated solely on morphological grounds, namely, fewer spines on the lateral border of the pleotelson and possibly color pattern. Both are related closely to *Jaeropsis lobata* Richardson described from Monterey Bay, Calif. That species is perfectly smooth, however, lacking spines on the pleotelson and fringed scales on the frontal lamina and antennae, and it has a distinctive color pattern.

Suborder ANTHURIDEA

Only two specimens of this small suborder (only 100 species; Waterman and Chace, 1960) were found in the entire buoy collection, one from the west coast of Florida, the other from the Bahamas. They belong to the same family but in separate genera. The poor representation of anthurids in the fouling samples can be attributed mainly to their benthic mode of life. Both were taken in scrapings from the buoy anchor.

Family ANTHURIDAE

Skuphonura species

FIGURE 4

LOCALITY.—Florida: west coast (Station 48).

REMARKS.—The single female specimen conforms in many important particulars to the description of *Skuphonura laticeps* Barnard (1925a), the type and only known species of the genus. It was described from specimens collected at St. Thomas, St. John, St. Croix and Tobago, West Indies, at depths of 4 to 20 fathoms.

The generic assignment seems fairly certain. Among the characteristics placing it in the genus are: (1) the conformity in mouthparts, notably maxillipeds with four free joints; (2) the complete fusion of the anterior five pleonic segments; (3) the pereopods with the fifth joint of pereopods IV–VII underriding the sixth joint; (4) the thin, subovate telson with paired statocysts; and (5) the nonindurated uropod with exopods not folding over telson. The major differences from the generic description are: (1) the unsutured part of the pleon is nearly as wide as but not wider than the pereon; (2) the sixth (free) pleonal segment is not narrower than the preceding segments; and (3) the flagellum of the second antenna is pauciarticulate, rather than uniarticulate. Since the genus is monotypic, it is not unreasonable to assume that some of the ascribed generic characteristics with which the present specimen differs may prove to be only specific traits when additional species are described. The generic description may be emended accordingly.

Among the specific characteristics of *S. laticeps* shown by our specimen are: (1) a strong, forward-directed, medioventral spine on the first pereonal segment; (2) pereon strongly keeled ventrally; (3) antennae shorter than head; (4) first pereopod with fifth joint apically produced and unguis narrower than finger; (5) uropod with endopod about twice as long as broad with apex subacute and setose, and exopod apically notched, crenulate, and setose. Our specimen differs, however, from the description of *S. laticeps* in the following respects: (1) the anterior part of the head is not expanded laterally; (2) the eyes hardly can be described as small with some 22 ocelli on the dorsal,

lateral, and ventral sides of the head; and (3) the palm of the first pereopod bears a low, blunt tooth.

Since the description of this species is based primarily on the male and the only specimen is a female, the character of the second pleopod can not be compared; moreover, it may be that some of the above-mentioned differences (both specific and generic) may be due merely to sexual dimorphism. Barnard (1925a), for instance, indicates that the head is less expanded in the young, which one also might assume to be the case in females.

The alternatives implicit in the foregoing discussion are (1) to identify the lone specimen as the female of *Skuphonura laticeps* Barnard, (2) to describe it as a new species of *Skuphonura* with an emended diagnosis of the genus, or (3) to identify it only to genus. The first alternative would result in a considerable extension of geographic range of *S. laticeps*, which is ecologically plausible since both occur in warm waters. The second possibility does not seem feasible at this time with the material available; it easily could result in an addition to synonymy. The third possibility seems to be the best decision in this case, leaving the opportunity open for action on the other two when more material is at hand.

Accalathura species

FIGURE 4

LOCALITY.—Bahamas: Walker Cay (Station 59).

REMARKS.—The second of two anthurid species in the buoy collection is represented by a small (3.5 mm) immature specimen that is assigned tentatively to the genus *Accalathura* Barnard (1925a). Its immaturity is indicated by its small size and the presumably incomplete development of the seventh pair of pereopods, which are about half the length of the sixth pair. This makes its determination uncertain and incomplete.

The generic assignment is based on the following characteristics: an unpaired statocyst at the base of the telson; a relatively short, distinctly segmented pleon; the fifth joint of the posterior pereopods not underriding the sixth; and a 4-jointed maxilliped. There are several discrepancies, however, between the generic description and the specimen, probably associated with its immaturity; for instance, the flagella of the first and second antennae are uniaarticulate and pauciarticulate, respectively, rather than both being multiarticulate.

It has not been possible to identify our specimen with either of the two species of *Accalathura* known to occur in the Antillean region, namely, *A. crenulata* (Richardson) and *A. crassa* Barnard. *Accalathura crenulata* has been reported from the Bahamas and other tropical Atlantic localities (Yucatan, Brazil, Danish West Indies, and Cape Verdes) at depths of 5 to 40 fathoms (9–72 meters); *A. crassa* is

known only from St. John, West Indies. The presence of well-developed eyes in this specimen distinguishes it from *A. crassa*, in which eyes are absent. The present specimen differs from the descriptions of *A. crenulata* in several details, although many (if not all) of the variances may be due to age. The buoy specimen is only 3.5 mm in length, whereas Barnard's (1925a) description of *A. crenulata* gives a length of 18 mm. The buoy specimen also differs from the description of this species in lacking crenulations in the telson, in showing only slight crenulations on the margin of the uropodal exopod, in having a more broadly rounded telson, and in having the posterolateral angles of the seventh pereoneal segment only slightly produced backward.

Order TANAIIDACEA

As previously indicated, the Tanaidacea (Chelifera) are represented poorly in the buoy collection. Only three species in as many genera were encountered, two in the family *Tanaidae* G. O. Sars (as emended by Lang, 1949) and one in the family *Paratanaidae* Lang, 1949. They were found on only 14 buoys. Although this is a relatively small order (only 250 species; Waterman and Chace, 1960) compared to the Isopoda (4000 species), tanaidaceans are taken commonly in benthic samples, especially in warm waters. Except for one station in San Francisco Bay, Calif., the buoys from which tanaidaceans were collected were situated in warm coastal waters of the Bahamas, Florida, Texas, and southern California.

Suborder DIKONOPHORA

Family PARATANAIIDAE

Leptochelia dubia (Krøyer) G. O. Sars

FIGURE 4

LOCALITIES.—Bahamas: Walker Cay (Stations 59, 60, 62, 63). Florida: Key West region (Stations 43, 46–48). Texas: Sabine Pass (Station 58).

REMARKS.—Conflicting views regarding the synonymy of *Leptochelia dubia* and related species make it difficult to define its geographic distribution.

Richardson (1905b) gives only three localities for *L. dubia*: Brazil, Bermudas, and "Porto Rico." Her earlier list (1901), however, also includes several other localities: Noank, Conn.; Woods Hole and Provincetown, Mass.; Guernsey, British Channel; Ireland; Atlantic coast from Brittany to Senegal and Teneriffe; and the Mediterranean. The discrepancy is due to Richardson's transferring several names

from the synonymy of *L. dubia* to that of *L. savignyi* (Krøyer) and incorporating their recorded localities in the list for the latter. It is pertinent to the later discussion to note that Richardson (1901, 1905b) regards *L. dubia* and *L. savignyi* as distinct species although the only recognizable difference is in the number of articles in the inner branch of the uropoda, the former having five joints, the latter six.

Monod (1933) regards *L. lifuensis* Stebbing as a junior synonym and concludes that *L. dubia* is a tropical and subtropical cosmopolite. Larwood (1940), however, goes further by adding *L. savignyi*, *L. algicola*, and *L. neopolitana* to the synonymy of *L. dubia*. Accordingly, he gives a much more extended distribution for the latter as follows:

East coast of North America; North-East Atlantic from Brittany and the Channel Islands as far south as Senegal and Madeira and the Azores; Mediterranean: Gulf of Naples, Spezia, Messina, Marseilles, Syracuse, coast of Algeria; Adriatic: Gulf of Trieste; West Indies; Brazil; Indo-Pacific: Loyalty Islands, Isle of Pines, Ceylon and the Red Sea.

Additional recorded localities for *L. dubia* are: Black Sea (Băcescu, 1938), Hawaiian Islands (Miller, 1940), Japan (Shiino, 1951), British Columbia (Fee, 1926), Washington (Hatch, 1947).

Brown (1957), following Barnard (1925b), also considered several species of *Leptochelia* identical, namely, *L. savignyi*, *L. dubia*, *L. edwardsi*, and *L. lifuensis*. Priority is in the order named since the first three were described by Krøyer in 1842 on pages 168, 178, and 191, respectively, and the last was named by Stebbing in 1900. Thus, Barnard and Brown rightly deem *L. savignyi* to be the correct name and assign *L. dubia* and the others to its synonymy. As mentioned above, Larwood also regarded *L. dubia* and *L. savignyi* (among others) as conspecific but erroneously reversed the priority, relegating the latter to the synonymy of the former. In any event, all three authors indicate that the characters on which specific distinctions have been made, particularly the number of joints in the inner branch of the uropod, are too variable to have taxonomic significance.

The present author prefers to suspend judgment on the synonymy of several species of *Leptochelia*, particularly as to whether or not *L. dubia* and *L. savignyi* are conspecific, until more conclusive evidence is available. Certainly indicated is a critical comparison of the species in question based on adequate samples (including individuals of different size and sex) from representative localities. The fact that the forms named *L. dubia* generally have been reported from warmer waters than those named *L. savignyi* supports Monod's opinion that the former is a tropical-subtropical cosmopolite. Theoretically, such ecological segregation of these benthic forms with no apparent means of active dispersal could have resulted in their specific divergence.

Family TANAIIDAE

Anatanais normani (Richardson) Nordenstam

FIGURE 4

LOCALITIES.—California: Catalina Island (Stations 64, 66); Anacapa Island (Station 67); Santa Barbara Harbor (Station 68).

REMARKS.—Richardson (1905a, 1905b) described this species (as *Tanais normani*) from specimens collected at Monterey Bay, central California. It has been reported subsequently from British Columbia (Fee, 1926; Hatch, 1947). The author has collected it intertidally at Moss Beach, San Mateo County, central California. The present report extends its range considerably southward into southern California.

Tanais species

FIGURE 4

LOCALITY.—Central California: San Pablo Bay (Station 87).

REMARKS.—The single tanaid taken in the north end of greater San Francisco Bay was mutilated too badly for specific identification. Antennae and gnathopods were missing and the head was damaged. The three pairs of pleopods and single branched uropod on a 5-segmented pleon are enough to determine that it belongs to the genus *Tanais*. Unfortunately, there is no tanaidacean material from San Francisco Bay or even published records of species in this area available for comparison.

Discussion

INCIDENCE.—In general, Isopoda and Tanaidacea are represented poorly in the buoy collection both in numbers of species and in frequency of occurrence. The 29 species collected represent a small fraction of the isopods and tanaidaceans known to occur in the regions surveyed. On the west coast, for example, Menzies and Barnard (1959) list 36 benthic species of Isopoda in southern California, but only five were found on buoys in that region. Again, in the intertidal zone of central California, Menzies and Miller (1957) list 56 isopod species belonging to the four suborders represented in the buoy collection, but only eight species were taken from buoys in that region. As for tanaidaceans, only one species of the six listed for central California was collected from buoys. Finally, in the northwest Pacific, Hatch (1947) lists 45 flabelliferan, valviferan, and asellote isopods (no anthurideans), and seven tanaidacean species; but only two isopod species and no tanaidaceans were taken from buoys in that region.

As previously noted, isopods were collected from only about 25 percent of the buoys sampled and tanaidaceans were found on less

than four percent of them. By contrast, amphipods (notably caprellids) were found on 98.9 percent of the buoys sampled—about the same incidence as barnacles (Cirripedia). Other crustaceans, such as decapods and copepods occurred in a relatively small fraction of the samples—about the same as isopods. Reasons for these differences will be considered later.

Another feature of the collection is the unequal representation of the seven isopod families (table 2). Between them, the Sphaeromatidae, Idoteidae, and Janiridae contributed 22 of the 26 isopod species and 111 of the total of 115 occurrences by species, not to mention the predominance of individuals belonging to these three families.

Several reasons or combinations of reasons may be advanced to account for the paucity of isopods and tanaiaceans in the collection, their low incidence on buoys, and the differences in frequency of occurrence of various crustacean groups: (1) inadequate sampling, (2) limited harborage presented by buoys, (3) difficulty of access, and (4) varying degrees of motility in different groups.

The necessarily opportunistic sampling program and wholesale collecting methods are partly responsible for the deficiency of isopods and tanaiaceans. In some areas too few buoys could be sampled, and those sampled could not be selected for diversity of local ecological conditions. The number of species and individuals occurring on buoys would depend a great deal on the composition of attached fouling organisms that might serve for food, cover, or a temporary substrate for transient crustaceans. Some doubtless occur by chance encounter, but others may be attracted to the buoy and be induced to remain there by the type of fouling and associated organisms present; for instance, swarms of *Synidotea laticauda* on several buoys in San Francisco Bay doubtless were feeding on colonial hydroids. Species of *Idotea* often were associated with kelp attached to buoys in temperate waters. Sphaeromatids tend to occur on buoys with "soft fouling" (tunicates, bryozoans, hydroids, etc.) in bays and harbors.

Greater variety and numbers also might have been obtained if the time and season of collecting could have been chosen. Buoys sampled a short time after cleaning or replacement, as some were, would not be expected to yield as many kinds and specimens as they might later when more heavily fouled. The season of sampling might also introduce sampling errors since the composition of fouling and associated organisms may vary through the year as a result of seasonal or occasional variations in ambient water temperature, salinity, currents, turbidity, and other factors; hence, periodic sampling of buoys doubtless would give better results than single visits.

The somewhat crude sampling techniques employed also contributed to the paucity of free-living crustaceans and other such creatures in the buoy collections. A major difficulty was that there was no way of preventing unattached forms from deserting the buoy installation while it was being hoisted aboard. Also, it was not possible to screen the samples by using wash bucket and plankton net procedures for extracting small free-living crustaceans from the scrapings. Consequently, many specimens could be lost or destroyed easily, especially if they were small or not abundant.

Besides sampling problems, other inherent difficulties reduced the yield. In the first place, buoy installations obviously comprise an extremely small and rather special vertical extension of the benthic habitat. Buoys are not sited in all habitat types in an area, nor do they necessarily acquire the full complement of species present in their vicinity. Space on buoys is limited, especially on the chain, and access may be difficult, especially for predominantly benthic species. Also, in many instances, chafing or scouring of the lower part of the chain may remove or prevent attachment of fouling and associated organisms. The fact that only a single isopod or tanaidacean species was found on 78 of the 100 buoys from which these crustaceans were taken indicates that buoys present rather limited, unnatural habitats not particularly attractive to these forms.

A possible explanation for the marked differences in incidence of various crustacean groups is the apparent correlation of frequency of occurrence with degree of motility and means of dispersal. Obviously, pelagic forms would stand a better chance of finding and boarding a buoy installation than would benthic types. The high incidence of barnacles and other sessile organisms on buoys can be explained readily by the fact that the sessile adults liberate swarms of pelagic larvae that find buoys to be a convenient substrate for attachment. Peracarid crustaceans, however, including amphipods, isopods, and tanaidaceans, generally lack pelagic larval stages, as the females carry the young in a subthoracic brood pouch until they are relatively well advanced. Liberated young usually resemble adults in habit and appearance, except for size and minor morphological differences, such as undeveloped seventh legs.

The high incidence of amphipods (99 percent) and the lesser frequency of isopods (*c.* 25 percent) the tanaidaceans (less than 4 percent) probably reflects the relative locomotor abilities of these three orders. The greater swimming ability of most amphipods could account for the fact that they are recorded in greater frequency and with greater variety than isopods not only from buoys but from other floating or suspended structures such as ships and test panels (Woods Hole Oceanographic Institution, 1952).

The foregoing comparison is rather crude, as no distinction was made between benthic and pelagic groups of amphipods and isopods. Natatory isopods, notably sphaeromatids and idoteids are represented much better in the buoy collection than predominantly crawling forms such as anthurids and tanaidaceans. Further, it is significant that bottom-dwelling isopods and tanaidaceans were taken generally from the anchor or from lower on the chain than more pelagic species, which were found higher on the chain and on the buoy itself, often at or near the waterline (table 2). More than half of the occurrences of sphaeromatids and idoteids were within the first meter below the waterline, and about three-fourths of them were within the first five meters below the surface. On the other hand, no anthurid was found less than 10 meters from the surface, and more than half of the occurrences of tanaidaceans were below five meters, with only 17 percent within the first meter from the surface. The fairly high incidence of janirid isopods, which are not noted for their swimming ability, may be associated with the fact that they often cling to floating seaweed, as do many of the better swimmers. Currents doubtless transport swimming or floating crustaceans considerable distances and may waft them against buoys.

If locomotor ability were solely responsible for differences between groups in incidence and distribution in buoys, one should expect that benthic caprellids and corophiids would be less abundant than natatory amphipods. Unfortunately, the amphipods of the buoy collections have not been worked up sufficiently for such comparisons. The impression gained from collecting and sorting, however, is that caprellids are as well represented on buoys as natatory gamma-rideans—if not more so.

DISPERSAL.—As was expected, most of the isopods and tanaidaceans taken from buoys belong to indigenous or to cosmopolitan species known to occur in the region. There were, of course, many new locality records within previously established limits. In some instances, however, known geographic ranges were extended, especially in regions that have not been surveyed adequately for these crustaceans. Many extensions were for relatively short distances and of no great biological significance. Some species, however, were found at stations far from any previously recorded locality. Extralimital species are of special interest in relation to means of dispersal and establishment of introduced species in new regions. Several noteworthy examples are discussed below, including *Sphaeroma walkeri* and *S. terebrans*, *Idotea balthica* and *I. metallica*, and *Carpias bermudensis*.

The discovery of *Sphaeroma walkeri* in several widely separated localities in Florida and in the Hawaiian Islands was surprising as this species has never before been reported from the central Pacific

or North America. It was known previously from the coastal regions of India, the Red Sea and Suez Canal, South Africa, South America, and Australia. Now it appears to be a circumglobal, essentially warm water species, but with spotty distribution. Several large gaps remain, however, notably the eastern Pacific and eastern Atlantic. The disjunct distribution of *S. walkeri* might be explained on the basis that the present populations are relicts of a once continuously distributed, circumtropical cosmopolite; however, the alternative explanation that follows seems more plausible.

As previously mentioned, shipping probably has been responsible both for the wide dispersal and for the discontinuous distribution of *Sphaeroma walkeri*. The fact that this wood-boring species has been taken from wooden hulls and that it has a spotty pattern of distribution support this view. It is likely that transport by driftwood or by natural rafts carried by currents has been involved to some extent in the distribution of this species, but it seems unlikely that the vast distances and other barriers between some of its recorded localities could have been traversed by such passive carriers.

Another wood-boring isopod in the buoy collection, *Sphaeroma terebrans*, also has been found on ship bottoms as well as in dead wood. These agencies doubtless have been responsible for the worldwide distribution of this species. A documented case of dispersal of an isopod by ships is given by Chilton (1911). He recovered live females and males of a sphaeromatid (*Cymodoce tuberculata*) from the hull planking of the British Antarctic research vessel *Terra Nova* in dry dock in Lyttelton, New Zealand, after her arrival from Port Phillip, Australia. Since the species was unknown from New Zealand but common in Australia, Chilton concluded that these isopods were transported some 1200 miles between the two ports.

Floating seaweed carried by currents probably has contributed to the wide distribution of two idoteids that are well represented on New England buoys, namely *Idotea balthica* and *I. metallica*. Both species have marked swimming ability and the habit of clinging to floating seaweed.

The new locality records for *Carpis bermudensis* provide a basis for the following hypothesis regarding the origin and dispersal of this species: Hitherto known only from Bermuda, it was found on several buoys on the east coast and Key West regions of Florida. It is now suspected that this species originated and is well established in the Antillean region and that it has been transported northward to Bermuda by the Gulf Stream, possibly clinging to floating seaweed. The well-known affinity of the Caribbean and Bermudan marine faunas support this interpretation. The converse possibility—origin in

Bermuda and transport to the Antillean region, probably by boats—seems less plausible. A crucial point, which can be determined only by more collections, is how well and widely is it established in other parts of the Antillean region.

ESTABLISHMENT OF INTRODUCED SPECIES.—The above-cited examples leave little doubt that isopods and related crustaceans can and have been dispersed considerable distances by various means and that the transported species have become established in new localities. As Hedgpeth (1957) states, establishment requires some minimum population, as well as ecologically favorable conditions.

Enough immigrants of both sexes or a sufficient number of females carrying young in the brood pouch must be introduced to sustain a colony. How many individuals would be required is problematical, but probably more than a single pair or a single ovigerous female would be needed. Predators such as fish easily might wipe out the immigrants or reduce their numbers below the minimum sustaining level. The aliens might not be able to compete with or outbreed native species occupying the same ecological niche. On the other hand, absence of predators or a selective advantage of some sort over competitors would favor establishment of the introduced species. In any event, chance would play an important role in establishment.

One established, introduced species may radiate into different, perhaps unoccupied, ecological niches in the new region. Segregated, populations may undergo speciation as a consequence of reproductive isolation, mutation, genetic drift, and natural selection. Many of the taxonomic difficulties encountered in zoogeographical studies may be attributed to differentiation of local, isolated races, perhaps incipient species.

Ecological conditions in the new environment must be favorable not only for survival but also for reproduction of the introduced species. As Hutchins (1947) points out, within the survival limits for any ecological factor, there is a somewhat narrower range of conditions over which reproduction and repopulation can be completed. For temperature, he shows that maximal and minimal values for survival and/or reproduction are the critical parameters limiting the north-south distribution of many species. That temperature is an important limiting factor for isopods is evident from the latitudinal zonation shown by many species and even higher taxa.

Likewise, extremes (more so than averages) of other factors such as salinity may be limiting. Whether or not these conditions operate directly on the survival and reproduction of the animals themselves, or indirectly through their influence on other organisms on which

they depend, or through a combination of both, is difficult to say without experimental evidence.

GEOGRAPHICAL DISTRIBUTION.—On the basis of their recorded distributions (including the localities herein reported), the species represented in the buoy collection may be grouped geographically as follows.

Five isopod and one tanaidacean species (about 20 percent of the total) are widely distributed, occurring at least in both the Atlantic and Pacific oceans: *Cirolana parva*, *Idotea balthica*, *I. metallica*, *Leptochelia dubia*, *Sphaeroma terebrans*, and *S. walkeri*. It should be noted, however, that the distribution of this group in the Pacific is rather skewed. Only one of these (*Leptochelia dubia*) has been reported from the eastern Pacific, three of them (*L. dubia*, *Cirolana parva*, and *Sphaeroma walkeri*) are now known from the central Pacific, but all six occur in the Indo-Pacific region. Interestingly, *Leptochelia dubia* is the only species in the collection known to occur on both the Atlantic and Pacific coasts of the United States, as well as in the Bahamas and Hawaiian Islands. Two other cosmopolitan species taken in Hawaii, *Cirolana parva* and *Sphaeroma walkeri*, also occur off the Florida coast but not on the Pacific coast. Present knowledge of the isopod and tanaidacean faunas of the vast Pacific is much too incomplete as yet for safe generalization.

The remaining 80 percent (approximately) of the species are separated by the continental barrier—nine on the eastern side and 14 on the west coast (fig. 2; table 2). In at least one case, an eastern and western species comprise a "species pair," that is, morphologically closely related species occurring under similar ecological conditions on opposite sides of a major barrier. Fitting this definition are *Paracerceis caudata* found on buoys in warm waters of the Atlantic, Caribbean, and Gulf of Mexico, and its close morphological relative, *P. sculpta*, taken from buoys in tropical-subtropical waters in southern California and Hawaii (fig. 3). The Atlantic and Pacific coast species of *Idotea* also may be ecological equivalents in temperate waters.

On both sides of the continent, the species may be divided roughly into northern and southern groups, although a few species have extended north-south ranges along the coast. The locality data are too limited for precise definition of boundaries between northern and southern faunas and certainly for any subdivision of these groups. For sake of analysis, however, two well-known temperature and biotic break-points were selected—Cape Hatteras, at 35½°N latitude on the Atlantic coast and Point Conception at 34½°N latitude on the Pacific coast (Hutchins, 1947).

Although the two break-points are nearly at the same latitude, the temperature changes they signify and the temperature zones they

divide on the opposite coasts are not exactly comparable. According to Dana's (1852) isocrymal chart, Cape Hatteras lies at the point at which the isocryme of 62°F leaves the Atlantic coast, whereas Point Conception is about the intercept of the isocryme of 56°F on the Pacific coast. Cape Hatteras thus divides the warm Temperate Zone waters that extend southward along the Atlantic coast to Cape Kennedy (Canaveral), Fla., from the colder temperate waters that range northward from it. On the Pacific coast, however, Point Conception separates the Temperate Zone waters of southern California and northern Baja California from the Subtemperate Zone waters of the central California coast. Moreover, the warmer coastal waters of Florida, the Bahamas, and Gulf coast lie in the Subtorrid Zone (bounded by the isocrymes of 68°F and 74°F), but this zone is not represented along the Pacific coast of the United States. Although the west coast waters south of Point Conception are colder than those of corresponding latitudes along the Atlantic coast, the coastal waters of the northwest Pacific coast are warmer than those of the New England coast. The Subfrigid Zone (bounded by isocrymes of 35°F and 44°F) extends as far south as Cape Cod on the Atlantic coast but only to the Straits of Juan de Fuca on the Pacific coast.

The northern Atlantic group comprises *Janira alta* and *Idotea phosphorea* plus the widely distributed *I. balthica* and *I. metallica*. All these were collected from buoys north of Cape Hatteras and are not known to occur south of it.

The southern Atlantic coast species merge with those of the Caribbean and Gulf of Mexico and include: *Accalathura* species,* *Carpis bermudensis*, *Cymodocella* species,* *Exocorallana subtilis*, *Paracerceis caudata* and *Skuphonura* species,* plus the widely distributed *Cirolana parva*, *Sphaeroma walkeri*, and *Leptocheilia dubia*. Three of these (asterisks) were found only in the Bahamas.

Another Atlantic coast species, *Sphaeroma quadridentatum*, cannot be assigned to either northern or southern group as its range extends from southern New England to Key West, Fla. In the present study it was collected both north of Cape Hatteras in the mouth of Chesapeake Bay and well south of it in Florida. As most of its recorded localities are south of Cape Hatteras, this species is associated more closely with the southern group.

The northern Pacific group comprises *Dynamenella benedicti*, *Gnorimosphaeroma oregonensis*, *Ianiropsis kincaidi derjugini*, *Idotea vosnesenskii*, *Idotea stenops*, *Synidotea laticauda*, *Synidotea* species, and *Tanais* species. None of these occurs south of Point Conception. Two are quite common along the entire Pacific coast north of Point Conception—*Gnorimosphaeroma oregonensis* and *Idotea vosnesenskii*. By contrast, *Synidotea laticauda* is restricted to San Francisco Bay. There

it has become adapted apparently to the lower salinities, higher temperatures, greater turbidity, currents, and wider fluctuations in environmental factors prevailing in the bay as compared to the open seacoast.

The southern Pacific group is poorly defined in this survey. Although six species were taken only from buoys along the southern California coast, only one has never been reported north of Point Conception, namely, *Paracerceis sculpta*. Of the remaining five species, three are known from both southern and central California (*Jaeropsis dubia*, *J. d. paucispinis*, and *Janiralata rajata*); one has been found in southern and central California and British Columbia (*Anatanais normani*); and one is known to be distributed along the entire Pacific coast from southern California to Alaska (*Idotea resecata*). The latter two species actually should not be assigned either to the southern or to the northern Pacific group. It should again be emphasized that the buoy collections do not sample adequately the long Pacific coast or even the included section between San Diego and Puget Sound and that knowledge of the systematics and distribution of isopods and tanaidaceans of the Pacific is incomplete.

As indicated above, the latitudinal zonation on both coasts is definite for two isopod families, the Idoteidae and Sphaeromatidae. All eight idoteids in the collection were found on northern buoys, generally associated with kelp, whereas all but one of the eight sphaeromatids were taken from warm water buoys, usually associated with muddy or sandy bottoms often with soft fouling (tunicates, etc.). Several exceptions may be noted in both families. As previously mentioned, *idotea resecata* ranges from Los Coronados Islands (off San Diego, Calif.) to Alaska, and in the present survey it was collected on buoys as far south as Santa Barbara. Two other idoteids (*Synidotea harfordi* and *S. magnifica*) are known only from southern California (they were not taken in the buoy survey). Conversely, two sphaeromatids in the buoy collection from cold waters are *Gnorimosphaeroma oregonensis*, a common species along the entire Pacific coast north of Point Conception but absent in southern California, and *Sphaeroma quadridentatum*, which ranges both north and south of Cape Hatteras on the Atlantic coast. Many other sphaeromatids (not taken in the collection) also occur in northern waters; nevertheless, as a rule, idoteids (and other valviferans) generally are found in cold waters and sphaeromatids in warm waters.

Not only are idoteids poorly represented in tropical-subtropical regions, but also those found there are relatively small (e.g., *Colidotea edmondsoni* of Hawaii) compared to more northern species. Indeed, valviferans seem to follow Bergmann's rule (for homiotherms) as they tend to increase in size poleward with some frigid zone species

being remarkably large (e.g., *Glyptonotus* species in the Antarctic and *Saduria* species in the Arctic region). The paucity of valviferans in the tropics, however, runs contrary to the abundance of warm water species in other isopod suborders and in invertebrates generally.

Only three isopod species and no tanaidaceans were found on Hawaiian buoys, a scanty representation of the fauna there. Two are cosmopolitan, *Cirolana parva* and *Sphaeroma walkeri*; the other, *Paracerceis sculpta*, probably was introduced into Hawaiian waters by naval shipping from southern California.

The Bahaman fauna was represented only slightly better with four isopod and one tanaidacean species. The tanaidacean was the cosmopolitan *Leptocheilia dubia*. Of the isopods, *Paracerceis caudata* is a common sphaeromatid along the Atlantic and Gulf coasts and in Bermuda. The remaining three—*Cymodocella* species, *Accalathura* species, and *Skuphonura* species—were found only in the Bahamas but doubtless have wider distribution in the Antillean region.

Regarding generic distribution, half of the 16 isopod genera represented in the present study are known to occur along both the Atlantic and Pacific coasts of North America. They are *Cirolana*, *Dynamenella*, *Excorallana*, *Idotea*, *Janira?*, *Paracerceis*, *Sphaeroma*, and *Synidotea?*. Actually, however, species of only two genera, *Idotea* and *Paracerceis*, were collected from buoys on both coasts. All three tanaidacean genera represented in the collection have species on both coasts, but *Leptocheilia* was taken only on Atlantic coast buoys and *Anatanais* and *Tanais* only on Pacific coast buoys.

The above listing of *Janira* and *Synidotea* as genera common to both coasts is questionable for the following reasons. According to Wolff's (1962) tabulations, only one species of *Janira* occurs on the Pacific coast. He gives Vancouver Island and western Canada among the localities for *Janira maculosa* (along with Greenland, Morocco, and Corsica), apparently on the basis of Fee's (1926) and Hatch's (1947) reports. Menzies (1951, p. 123) states, however, that he personally has examined the specimens reported by Hatch and is of the opinion that they belong in the genus *Ianiropsis* G. O. Sars. He thinks the same is probably true of the specimens reported by Fee. All other Pacific coast forms previously assigned to *Janira* by earlier authors have been transferred to *Janiralata* Menzies, *Ianiropsis* G. O. Sars, or *Bagatus* Nobili (Menzies, 1951; Kussakin, 1962; Wolff, 1962); hence, the occurrence of *Janira* in the Pacific, at least the eastern part, is doubtful. The listing of the predominantly North Pacific genus *Synidotea* as occurring both on the Atlantic and Pacific coasts is also tenuous, but two circumboreal species (*S. bicuspida* and *S. nodulosa*) have been reported in the far North Atlantic near Greenland, Labrador, and Halifax. These are the only reports of *Synidotea* in the North

Atlantic. It might be mentioned, however, that species of this genus occur on the South Atlantic coasts of South America (*S. marplatensis* and *S. sphaeromiformis*) and Africa (*S. hirtipes*).

The remaining eight isopod genera are divided evenly between the two coasts. The east coast genera are: *Accalathura*, *Carpias*, *Cymodocella*, and *Skuphonura*. The following four genera are represented on the Pacific coast but not on the Atlantic: *Gnorimosphaeroma*, *Ianiropsis*, *Jaeropsis*, and *Janiralata*. Although absent from the Atlantic coast, *Ianiropsis* and *Jaeropsis* are represented elsewhere in the North Atlantic (Wolff, 1962). *Ianiropsis breviremis* occurs in the northeastern Atlantic (British Isles, Denmark, western Norway). As for *Jaeropsis*, one species (*J. brevicornis brevicornis*) occurs on the northwest coast of France and on the Channel Islands, and another (*J. rathbunae*) is found in Bermuda.

Six of the seven isopod families and both tanaidacean families represented in the buoy collections occur on both the Atlantic and Pacific coasts. The one exception, the monogeneric family Jaeropsidae, is absent from the Atlantic coast, but, as previously mentioned, it is represented by a species in Bermuda and by another on the Atlantic coast of Europe; hence, the continent is no barrier to distribution, at least of the isopod and tanaidacean families in the present study. As indicated above, the continental barrier is progressively more effective for lower taxonomic categories—about 50 percent at the generic level and about 80 percent at the specific level.

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TABLE 1.—Buoy stations with Isopoda and/or Tanaidacea

| Station | Water depth (m) | Bottom | Exposure time (months) | Species | Number of specimens | Depth found (m) |
|--|-----------------|-----------|------------------------|--------------------------|---------------------|-------------------|
| NORTH ATLANTIC COAST: | | | | | | |
| Gulf of Maine | | | | | | |
| 1. Explosive Anchorage-Nantucket Roads "B" | 11.1 | - | 12 | <i>Idotea phosphorea</i> | 2 | 11.1 |
| 2. North Cut Buoy #3 | 5.5 | - | 31 | <i>Idotea phosphorea</i> | 2 | 0.6 |
| 3. Black Cove Buoy #2 | 9.2 | mud | 26 | <i>Idotea phosphorea</i> | 1 | 0.9 |
| 4. Fort Preble Channel Buoy #2 | 4 | - | 13 | <i>Idotea balthica</i> | 1 | 0 |
| 5. Fort Preble Channel Buoy #1 | 4 | - | 13 | <i>Idotea balthica</i> | 1 | 0 |
| 6. Northwest Ledge Buoy #3 | 5.5 | - | 13 | <i>Idotea phosphorea</i> | 2 | 0 |
| | | | | <i>Idotea phosphorea</i> | 7 | 0, 5, 5 |
| 7. Cashe Ledge Whistle Buoy CW | 49.8 | hard | 12 | <i>Janira alta</i> | 1 | 40 |
| 8. Jeffrey Ledge Whistle Buoy #2 JL | 55.4 | hard | 12 | <i>Janira alta</i> | 1 | 55.4 |
| 9. Boon Island Lighted Whistle Buoy #22 A Nantucket Sound and vicinity | 28.3 | hard | 12 | <i>Janira alta</i> | 1 | - |
| 10. Quick's Hole Bell #1 | 21.5 | black mud | 31 | <i>Idotea balthica</i> | 1 | 0.6 |
| 11. Can #3—No Man's Land—Old Man #1 | 12.3 | black mud | 32 | <i>Idotea phosphorea</i> | 1 | 1.8 |
| 12. Nantucket Bar Bell Buoy | 8.6 | sand | 5 | <i>Idotea phosphorea</i> | 1 | 1.8 |
| 13. Naushon Lighted Bell Buoy | 18.5 | mud | 25 | <i>Idotea phosphorea</i> | 1 | - |
| 14. Horseshoe Shoal Lighted Buoy #12 A | 16 | hard | 7 | <i>Idotea phosphorea</i> | 4 | 16 |
| 15. New Bedford Channel Lighted Buoy #2 | 8 | sandy mud | 13 | <i>Idotea balthica</i> | 1 | 0.3 |
| 16. Station Buoy for Half Moon Shoal LB Buoy #12 | 13.8 | sand | 12 | <i>Idotea phosphorea</i> | 5 | 3, 7, 9, 2, 13, 8 |
| 17. Hedge Fence LT and GB #16 | 16.6 | mud? | 8 | <i>Idotea phosphorea</i> | 1 | 2.8 |
| 18. Squibucket Shoal Lighted Bell Buoy #1 | 20.3 | hard sand | 8 | <i>Idotea balthica</i> | 1 | 0.9 |
| | | | | <i>Idotea phosphorea</i> | 5 | 0.9, 1.8, 2, 8 |
| 19. Fifteen Foot Shoal Buoy #9 | 10.8 | sandy | 26 | <i>Idotea phosphorea</i> | 1 | 0.9 |
| 20. Great Rip Lighted Buoy #2 | 29.5 | - | 12 | <i>Idotea phosphorea</i> | 4 | 1.8 |
| 21. Davis South Shoal Fishing Buoy #2 | 11.1 | - | 12 | <i>Idotea phosphorea</i> | 2 | 1.8 |
| 22. Point Rip Lighted Bell Buoy #11 A | 15.4 | hard? | 10 | <i>Idotea phosphorea</i> | 1 | 1.8 |
| 23. Great Round Shoal Buoy #8 | 11.1 | hard? | 10 | <i>Idotea phosphorea</i> | 35+ | 1.5 |
| 24. McBlair Shoal Buoy #7 | 15.4 | - | 12 | <i>Idotea phosphorea</i> | 18 | 18.5 |
| 25. Great Round Shoal Buoy #4 | 23.3 | - | 8 | <i>Idotea phosphorea</i> | 1 | 23.3 |
| 26. Newport AS Net New York region | 15.4 | hard | 30 | <i>Idotea phosphorea</i> | 7 | - |

TABLE 1.—*Buoy stations with Isopoda and/or Tanaidacea*—Continued

| Station | Water depth (m) | Bottom | Exposure time (months) | Species | Number of specimens | Depth found (m) |
|---|-----------------|----------------|------------------------|---------------------------------|---------------------|--------------------|
| 27. Craven Shoal Lighted Bell Buoy #19 A | 11.1 | mud | 5 | <i>Idotea phosphorea</i> | 1 | 2.8 |
| 28. Fairway Lighted Whistle Buoy A | 76 | mud | 14 | <i>Idotea metallica</i> | 1 | 0 |
| 29. Block Island Fairway Lighted Whistle Buoy C | 61 | mud | 13 | <i>Idotea metallica</i> | 2 | 0 |
| 30. Fairway Lighted Bell Buoy D | 59 | mud | 13 | <i>Idotea metallica</i> | 3 | 0 |
| 31. Fairway Lighted Whistle Buoy E | 61 | sandy mud | 13 | <i>Idotea metallica</i> | 1 | 0 |
| MID-ATLANTIC COAST: Norfolk, Va. | | | | | | |
| 32. Hampton Roads Obstruction LB B | 20 | hard mud | 13 | <i>Sphaeroma quadridentatum</i> | 6 | 0 |
| 33. Hampton Roads Obstruction LB A | 26 | mud-clay | 5 | <i>Sphaeroma quadridentatum</i> | 7 | 0 |
| Cape Lookout, N.C. | | | | | | |
| 34. New River Whistle Buoy N | 14.7 | sand-shell | 15 | <i>Paracerceis caudata</i> | 7 | 0.9 |
| 35. Cape Lookout Shoal Obstruction Lighted Buoy W | 16.6 | - | 12 | <i>Paracerceis caudata</i> | 2 | 0.9 |
| FLORIDA COAST: East Coast | | | | | | |
| 36. Ponce de Leon Inlet Lighted Whistle Buoy #2 | 14.1 | black mud | 7 | <i>Sphaeroma walkeri</i> | 62 | 0.9, 1.5, 1.8, 3.7 |
| 37. Bethel Shoal Station Buoy | 14.8 | hard | 10 | <i>Carpis bermudensis</i> | 3 | 14.8 |
| 38. Port Everglades Entrance Buoy #1 A | 12.3 | sandy? | 18 | <i>Paracerceis caudata</i> | 1 | 12.3 |
| South Coast (Florida Keys) | | | | | | |
| 39. Satan Shoal Buoy | 4.9 | - | 8 | <i>Paracerceis caudata</i> | 1 | 4.9 |
| 40. Twenty-four Foot Shoal | - | - | 19 | <i>Paracerceis caudata</i> | 1 | 0 |
| 41. Key West north of Station 39 | 11.7 | - | - | <i>Paracerceis caudata</i> | 12 | 11.7 |
| 42. #1 Entrance Lighted Bell Buoy | 27.6 | white clay | 5 | <i>Sphaeroma terebrans</i> | 1 | 0 |
| 43. Middle Ground South End Buoy #11 | 7.0 | - | 15 | <i>Leptocheilia dubia</i> | 1 | 1.8 |
| 44. Anchorage Lighted Buoy #B 5 | 13 | - | 11 | <i>Paracerceis caudata</i> | 1 | 13 |
| 45. Anchorage Lighted Buoy C | 13.8 | - | 11 | <i>Carpis bermudensis</i> | 9 | 1.5 |
| 46. Anchorage Lighted Buoy BB | 15.4 | gray clay-sand | 11 | <i>Leptocheilia dubia</i> | 3 | 15.4 |

TABLE 1.—Buoy stations with Isopoda and/or Tanaidacea—Continued

| Station | Water depth (m) | Bottom | Exposure time (months) | Species | Number of specimens | Depth found (m) |
|--|-----------------|----------------|------------------------|---------------------------------|---------------------|-----------------|
| 47. Northwest Channel Entranced Lighted Bell Buoy #1 | 8.3 | gray clay-sand | 7 | <i>Leptochelia dubia</i> | 7 | 0, 3.7, 8.3 |
| | | | | <i>Paracerceis caudata</i> | 1 | 8.3 |
| 48. Obstruction Lighted Whistle Buoy #6 | 11.1 | gray sand | 15 | <i>Paracerceis caudata</i> | 92 | 1.1, 3.8, 11.1 |
| | | | | <i>Leptochelia dubia</i> | 30 | 11.1 |
| | | | | <i>Carpis bermudensis</i> | 1 | 2.2 |
| | | | | <i>Skuphonura</i> species | 1 | 11.1 |
| West Coast | | | | | | |
| 49. New Pass Sarasota Lighted Buoy #1 | 6.5 | - | 10 | <i>Sphaeroma walkeri</i> | 2 | 0, 0.9 |
| | | | | <i>Paracerceis caudata</i> | 1 | 0.6 |
| 50. Tampa Bay Lighted Whistle Buoy P'S | 14.1 | sand-mud | 13 | <i>Paracerceis caudata</i> | 3 | 14.1 |
| | | | | <i>Excorallana subtilis</i> | 1 | 14.1 |
| 51. Egmont Channel Lighted Bell Buoy #2 | 10.4 | black mud | 17 | <i>Sphaeroma walkeri</i> | 2 | 0, 0.9 |
| 52. Channel Lighted Bell Buoy #4 K | 6.5 | black mud | 10 | <i>Sphaeroma quadridentatum</i> | 1 | 3.7 |
| TEXAS COAST | | | | | | |
| 53. Freeport Entrance Buoy #2 | 8.3 | blue mud | 16 | <i>Sphaeroma terebrans</i> | 2 | 0.9 |
| 54. Sabine Pass Channel Lighted Bell #2 A | 9.2 | gray mud | 14 | <i>Sphaeroma terebrans</i> | 38 | 0, 8.6 |
| 55. Sabine Entrance Lighted Whistle #1 | 10.1 | gray mud | 14 | <i>Sphaeroma terebrans</i> | 33 | 0 |
| 56. Sabine Pass East Jetty Bell Buoy #2 B | 9.2 | gray clay | 15 | <i>Sphaeroma terebrans</i> | 51 | 0, 0.9 |
| 57. Sabine Pass Channel Lighted Buoy #3 | 4.3 | gray clay | 20 | <i>Sphaeroma terebrans</i> | 200 | 0 |
| 58. Sabine Pass Channel Lighted Buoy #9 | 9.2 | gray mud | 5 | <i>Sphaeroma terebrans</i> | 3 | - |
| | | | | <i>Leptochelia dubia</i> | 2 | - |
| BAHAMAS | | | | | | |
| 59. Walker Cay | 15.4 | - | 13 | <i>Leptochelia dubia</i> | 5 | 15.4 |
| | | | | <i>Accalathura</i> species | 1 | 15.4 |
| 60. Walker Cay Lighted Buoy L | 14.7 | sand | 13 | <i>Leptochelia dubia</i> | 1 | 14.7 |
| 61. Walker Cay #3 | 7.4 | sandy | 13 | <i>Cymodocella</i> species | 1 | 7.4 |
| 62. Walker Cay #5 | 5.8 | sandy | | <i>Paracerceis caudata</i> | 1 | 5.8 |
| | | | | <i>Leptochelia dubia</i> | 2 | 5.8 |
| 63. Walker Cay #4 | 7.4 | - | 13 | <i>Leptochelia dubia</i> | 1 | 7.4 |

TABLE 1.—*Buoy stations with Isopoda and/or Tanaidacea*—Continued

| Station | Water depth (m) | Bottom | Exposure time (months) | Species | Number of specimens | Depth found (m) |
|---|-----------------|------------|------------------------|---|---------------------|-------------------------|
| CALIFORNIA COAST: Southern California | | | | | | |
| 64. Catalina Island, Isthmus Cove, Northwest Entrance Buoy #2 | - | rocky | 10 | <i>Anatanais normani</i> <i>Jaeropsis dubia</i> <i>Janiralata rajata</i> | 22 8 20 | 5.5, 9.2 9.2 9.2 |
| 65. Catalina Island, Isthmus Cove, Northwest Entrance Buoy #2 | 33.2 | rocky | 10 | <i>Jaeropsis dubia</i> | 1 | - |
| 66. Catalina Island, Isthmus Cove, North Entrance Buoy #1 | - | rocky | 10 | <i>Anatanais normani</i> <i>Jaeropsis dubia</i> <i>Janiralata rajata</i> | 44 1 12 | 1.8, 5.5 1.8 1.8 |
| 67. Anacapa Island | 16.9 | rocky | 12 | <i>Idotea (Pentidotea) resicata</i> <i>Janiralata rajata</i> <i>Anatanais normani</i> | 35 5 2 | 0.9 0.9, 11.1 0.9 |
| 68. Santa Barbara Harbor #4 | - | sand-mud | - | <i>Anatanais normani</i> | 3 | 1.8, 3.7 |
| 69. Santa Barbara Buoy, Station B | 33.2 | sand-mud | 8 | <i>Idotea (Pentidotea) resicata</i> | 1 | 0 |
| 70. Point Dume #6 | - | - | 8 | <i>Jaeropsis dubia</i> | 1 | 13 |
| 71. Los Angeles Harbor Entrance (temporary) Buoy B | 15.4 | sand-shell | 7 | <i>Jaeropsis dubia paucispinis</i> | 1 | 5.5 |
| 72. San Diego Harbor (inside) | - | - | - | <i>Paracerceis sculpta</i> | - | 0 |
| Central California | | | | | | |
| 73. San Simeon Bell Buoy | - | - | 25 | <i>Idotea (Pentidotea) resicata</i> <i>Idotea (Pentidotea) stenops</i> | 3 1 | 0, 3.7, 5.5 0 |
| 74. Oakland Outer Harbor Lighted Bell Buoy #1 A | - | - | 7 | <i>Gnorimosphaeroma oregonensis</i> | 3 | 0.9, 1.8, 3.7 |
| 75. Yerba Buena Island Lighted Bell Buoy #2 | - | - | 4 | <i>Gnorimosphaeroma oregonensis</i> <i>Idotea (Pentidotea) wosnesenskii</i> | 3 0 | 0.9 0 |
| 76. Point Edith Buoy | 6-9 | - | 12 | <i>Gnorimosphaeroma oregonensis</i> <i>Symidotea laticauda</i> | - - | 0 1.8, 3.7 |
| 77. Suisun Bay Lighted Buoy #4 | - | - | 17 | <i>Gnorimosphaeroma oregonensis</i> | - | 0.9 |
| 78. South San Francisco Lighted Buoy #2 SSF | - | - | 8 | <i>Gnorimosphaeroma oregonensis</i> | 1 | 0.9 |
| 79. San Francisco Buoy #1 | - | - | 11 | <i>Symidotea laticauda</i> | - | 7.4 |
| 80. San Francisco Bay South Channel Lighted Buoy #1A | 8.9 | - | 12 | <i>Gnorimosphaeroma oregonensis</i> | 2 | 0 |

TABLE 1.—*Buoy stations with Isopoda and/or Tanaidacea—Continued*

| Station | Water depth (m) | Bottom | Exposure time (months) | Species | Number of specimens | Depth found (m) |
|--|-----------------|----------|------------------------|---|---------------------|--------------------|
| 81. Alcatraz Bell Buoy | - | - | 11 | <i>Ianiropsis kincaidi derjugini</i> | | 0, 0.9 |
| | | | | <i>Idotea (Pentidotea) wosnesenskii</i> | | 0, 0.9 |
| 82. Carquinez Strait Restricted Area Buoy #1C | - | - | 6 | <i>Synidotea laticauda</i> | 2 | 0, 0.9 |
| 83. Crissy Field Seaplane Station Buoy CF | - | - | 8 | <i>Synidotea laticauda</i> | many | 0 |
| 84. Obstruction Valve Bell Buoy B | - | - | 7 | <i>Gnorimosphaeroma oregonensis</i> | 1 | 3.7 |
| | | | | <i>Idotea (Pentidotea) wosnesenskii</i> | 1 | 0 |
| | | | | <i>Dynamenella benedicti</i> | 1 | 0 |
| 85. Red Rock Bank South End Lighted Bell Buoy #1 | - | - | 7 | <i>Gnorimosphaeroma oregonensis</i> | 3 | 0, 0.9, 1.8 |
| 86. Point San Pedro Mid-Channel Buoy | - | - | 3 | <i>Gnorimosphaeroma oregonensis</i> | many | 1.8 |
| 87. San Pablo Bay Lighted Buoy #10 | 9.2 | mud | 12 | <i>Gnorimosphaeroma oregonensis</i> | 56 | 0, 0.9, 7.4 |
| | | | | <i>Tanais</i> species | 1 | 0 |
| | | | | <i>Synidotea laticauda</i> | 225 | 0.9, 1.8, 5.5, 7.4 |
| 88. Bonita Channel Lighted Whistle Buoy #4 | - | - | 18 | <i>Ianiropsis kincaidi derjugini</i> | 3 | 0, 0.9, 1.8 |
| | | | | <i>Idotea (Pentidotea) wosnesenskii</i> | 1 | 0 |
| 89. Golden Gate Park Bell Buoy #4 | 12.3 | sandy | 11 | <i>Ianiropsis kincaidi derjugini</i> | 12 | 0.9 |
| | | | | <i>Idotea (Pentidotea) wosnesenskii</i> | 1 | 0.9 |
| 90. San Francisco Bar Channel Buoy | - | - | 9 | <i>Synidotea</i> species | 1 | 14.8 |
| 91. San Francisco Bar Channel Lighted Bell Buoy #5 | - | - | 9 | <i>Gnorimosphaeroma oregonensis</i> | many | 0 |
| 92. Noyo River Entrance Bell Buoy | 11.1 | - | 2 | <i>Ianiropsis kincaidi derjugini</i> | 1 | 0 |
| WASHINGTON COAST | | | | | | |
| 93. Clallam Reef Bell Buoy #1 | 24 | rocky | 5 | <i>Idotea (Pentidotea) wosnesenskii</i> | 1 | 0 |
| 94. Double Bluff Lighted Trumpet Buoy #1 | 10.1 | rocky | 8 | <i>Idotea (Pentidotea) wosnesenskii</i> | 1 | 0 |
| 95. Umatilla Reef Lighted Buoy UR | 46.2 | rocky | 13 | <i>Gnorimosphaeroma oregonensis</i> | 12 | 1.8 |
| 96. Quillayute River Jetty Buoy #2 | 6.8 | sand-mud | 14 | <i>Idotea (Pentidotea) wosnesenskii</i> | 2 | 0 |
| | | | | <i>Gnorimosphaeroma oregonensis</i> | 174 | 0, 0.9, 1.8, 2.7 |

TABLE 1.—*Buoy stations with Isopoda and/or Tanaidacea*—Continued

| Station | Water depth (m) | Bottom | Exposure time (months) | Species | Number of specimens | Depth found (m) |
|---|-----------------|--------|------------------------|----------------------------|---------------------|-----------------|
| HAWAIIAN ISLANDS | | | | | | |
| 97. Hilo Harbor, Hawaii, Special Nun #8 | 11.1 | mud | 2 | <i>Paracerceis sculpta</i> | 30 | 1.8 |
| | | | | <i>Sphaeroma walkeri</i> | 1 | 5.5 |
| 98. Pearl Harbor, Oahu, 2nd Class Nun #28 | 15.4 | mud | 1 | <i>Paracerceis sculpta</i> | 82 | 0.9, 5.5, 7.4 |
| 99. Pearl Harbor, Oahu, 2nd Class Nun | 12.9 | mud | 1 | <i>Paracerceis sculpta</i> | 78 | 0, 0.9, 3.7, 8 |
| 100. Port Allen, Kauai, #7 | 9.2 | mud | 8 | <i>Cirolana parva</i> | 1 | 7.4 |

TABLE 2.—Occurrence and depth distribution (in meters) of Isopoda and Tanaidacea on buoys (regions: A=Atlantic coast, B=Bahamas, G=Gulf of Mexico, H=Hawaii, P=Pacific coast)

| Species | Regions | Number of buoys | Bottom depth | | Frequency and depth of occurrence | | | | | |
|--------------------------------------|---------|--------------------|--------------|------|-----------------------------------|-----|------|-------|-------|-------|
| | | | Range | Mean | 0-1 | 1-5 | 5-10 | 10-20 | 20-40 | 40-60 |
| Sphaeromatidae | | | | | | | | | | |
| <i>Gnorimosphaeroma oregonensis</i> | P | 13 | 8-46 | 15.7 | 13 | 8 | 1 | | | |
| <i>Sphaeroma quadridentatum</i> | A, G | 3 | 6-26 | 17.5 | 2 | 1 | | | | |
| <i>Sphaeroma terebrans</i> | G | 7 | 4-28 | 11.1 | 7 | | 1 | | | |
| <i>Sphaeroma walkeri</i> | A, G, H | 4 | 6-14 | 10.5 | 5 | 3 | 1 | | | |
| <i>Cymodoella</i> species | B | 1 | - | 7.4 | | | 1 | | | |
| <i>Dynamenella benedicti</i> | P | 1 | - | - | 1 | | | | | |
| <i>Paracerceis caudata</i> | A, B, G | 12 | 5-17 | 10.8 | 4 | 3 | 3 | | 5 | |
| <i>Paracerceis sculpta</i> | P, H | 4 | 11-15 | 13 | 4 | 2 | 3 | | | |
| Idoteidae | | | | | | | | | | |
| <i>Idotea balthica</i> | A | 5 | 4-20 | 11.6 | 5 | | | | | |
| <i>Idotea metallica</i> | A | 4 | 59-76 | 64.3 | 4 | | | | | |
| <i>Idotea phosphorea</i> | A | 21 | 4-30 | 13.7 | 6 | 10 | 2 | 4 | | 1 |
| <i>Idotea resicata</i> | P | 3 | 17-33 | 25.1 | 3 | 1 | 1 | | | |
| <i>Idotea stenops</i> | P | 1 | - | - | 1 | | | | | |
| <i>Idotea wosnesenskii</i> | P | 8 | 7-24 | 13.3 | 9 | | | | | |
| <i>Synidotea laticauda</i> | P | 5 | 8-9 | 8.4 | 4 | 3 | 3 | | | |
| <i>Synidotea</i> species | P | 1 | - | - | | | | | 1 | |
| Janiridae | | | | | | | | | | |
| <i>Carpjas bermudensis</i> | A, G | 3 | 11-15 | 13.2 | | 2 | | 1 | | |
| <i>Janiropsis kincaidi derjugini</i> | P | 4 | 11-12 | 11.7 | 6 | 1 | | | | |
| <i>Janira alta</i> | A | 3 | 28-55 | 44.5 | | | | | 1 | 1 |
| <i>Janiralata rajata</i> | P | 3 | - | 16.9 | 1 | 1 | 1 | 1 | | |
| Jaeropsidae | | | | | | | | | | |
| <i>Jaeropsis dubia</i> | P | 4 | - | 33.2 | | 1 | 1 | 1 | | |
| <i>Jaeropsis dubia paucispinis</i> | P | 1 | - | 15.4 | | 1 | | | | |
| Cirolanidae | | | | | | | | | | |
| <i>Cirolana parva</i> | H | 1 | - | 9.2 | | | 1 | | | |
| Excorallanidae | | | | | | | | | | |
| <i>Excorallana subtilis</i> | G | 1 | - | 14.1 | | | | | 1 | |
| Anthuridae | | | | | | | | | | |
| <i>Accalathura</i> species | B | 1 | - | 15.4 | | | | | 1 | |
| <i>Skuphonura</i> species | B | 1 | - | 11.1 | | | | | 1 | |
| Paratanaididae | | | | | | | | | | |
| <i>Leptochelia dubia</i> | B, G | 9 | 7-15 | 10.5 | 1 | 2 | 3 | 4 | | |
| Tanaididae | | | | | | | | | | |
| <i>Anatanais normani</i> | P | 4 | - | 16.9 | 1 | 3 | 3 | | | |
| <i>Tanais</i> species | P | 1 | - | 9.2 | 1 | | | | | |



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Caligoid Copepods Parasitic on *Isurus oxyrinchus*
With an Example of Habitat Shift

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Several recent collections of parasitic copepods from 17 specimens of the mako shark, *Isurus oxyrinchus*, have made possible redescrptions of certain species of these parasites commonly found on this shark. These, plus 15 collections from the Indian and Atlantic Oceans previously reported (Cressey, 1967a and 1967b), form the basis of this paper.

Ten species of caligoid copepods are reported herein. Both sexes of *Nemesis lamna* Risso and the males of *Dinemoura producta* (Müller) and *D. latifolia* (Steenstrup and Lütken) are redescrbed. The last copepodid instar and three chalimus stages of *Phyllothereus cornutus* (Milne-Edwards) males are described for the first time. The remaining species have been redescrbed recently by various workers (Shiino, 1955; Lewis, 1966; and Cressey, 1967a), and no further redescrption of these species is considered necessary.

All drawings have been made with the aid of a camera lucida. All specimens are preserved in 70 percent alcohol and deposited in the U.S. National Museum.

Station data for the R. V. *Anton Bruun* stations cited in this paper are as follows:

| station number | date | latitude | longitude |
|----------------|---------|----------|-----------|
| 552 | 2/17/66 | 33°02'S | 77°02'W |
| 553 | 2/19/66 | 33°24'S | 79°00'W |
| 554 | 2/20/66 | 32°58'S | 81°31'W |
| 558 | 2/24/66 | 30°28'S | 89°31'W |
| 564 | 3/ 7/66 | 20°37'S | 83°20'W |
| 567 | 3/10/66 | 12°50'S | 83°31'W |
| 568 | 3/11/66 | 10°33'S | 83°38'W |
| 569 | 3/12/66 | 08°49'S | 83°33'W |
| 571 | 3/14/66 | 08°47'S | 81°20'W |
| 572 | 3/15/66 | 10°28'S | 79°36'W |

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Pandarus satyrus Dana

Pandarus satyrus.—Lewis, 1966, p. 74.

Pandarus cranchii.—Hewitt, 1967, p. 249 [not *P. cranchii* Leach].

For earlier synonymy, see Cressey, 1967a, p. 6.

MATERIAL.—Four collections from off the west coast of South America, R. V. *Anton Bruun*, Cruise 14, Stations 553, 564, 569, and 571; two collections from the Indian Ocean previously reported (Cressey, 1966b); one collection from off New Jersey.

This copepod has been well figured and described in recent literature, and no further description is included here except as related to the remarks below.

REMARKS.—In the seven collections reported above, this copepod was found in the mouth or on the gill arches of the host. *Pandarus satyrus* is a common parasite on the body surface of *Prionace glauca*. In all cases the egg-bearing females of *P. satyrus* from *I. oxyrinchus* were pigmented less noticeably than individuals of the same species when they occur on the body surface of blue sharks. The record of *P. cranchii* cited by Hewitt from the "jaws and skin" of *I. oxyrinchus* appears to be *P. satyrus* according to his figures (figs. 141–147).

Pandarus smithii Rathbun

Pandarus smithii.—Lewis, 1966, p. 91.

For earlier synonymy, see Cressey, 1967a, p. 11.

MATERIAL.—Three collections from the North Atlantic (two off New Jersey, one at 35°N–70°W): one collection from the Indian Ocean, R. V. *Anton Bruun*, Cruise 5, Station 282.

As in *P. satyrus*, this copepod has been redescribed recently (Cressey 1967a), and no further description will be given here.

REMARKS.—The copepods of this species from the Atlantic were found in the mouth of the host. The single female representing the Indian Ocean collection from this host was on the body surface. Like *P. satyrus*, this copepod is a common parasite on the body surface of sharks, primarily carcharinids. Also, as in *P. satyrus*, those specimens from inside the buccal area of the host are not pigmented as heavily as individuals of the same species occurring on the body surface of other sharks.

Pandarus katoi, Cressey

Pandarus katoi Cressey, 1967a, p. 17.

MATERIAL.—Four collections from off the west coast of South America, R. V. *Anton Bruun*, Cruise 14, Stations 567, 568, 569, and 571.

REMARKS.—*Pandarus katoi* has been reported previously from the body surface of carcharinid sharks in the eastern Pacific (Cressey, 1967a). The collections recorded above from *I. oxyrinchus* were removed from the mouths and gill arches of the hosts. The specimens in collections of this species from the body surface of other sharks are not pigmented as heavily as most other species of the genus *Pandarus*; nevertheless, the *P. katoi* from the mouths of makos are pigmented still less than those on the body surface of other sharks, consistent with the situation with *P. satyrus* and *P. smithii* reported above. The change in habitat for these three species is discussed at the end of this paper.

Gangliopus pyriformis Gerstaecker

For earlier synonymy, see Cressey, 1967a, p. 28.

MATERIAL.—One collection off the west coast of South America, R. V. *Anton Bruun*, Cruise 14, Station 552 (1 ♀ specimen only).

REMARKS.—The single specimen from the 32 sharks examined indicates a low incidence of this parasite. This copepod is more common on *Prionace glauca* and, since these two sharks often are found in the same waters, this may be a reflection of that association.

Phyllothereus cornutus (Milne-Edwards)

FIGURES 1-26

Phyllothereus cornutus.—Lewis, 1966, p. 96.—Hewitt, 1967, p. 233.

For earlier synonymy, see Cressey, 1967a, p. 25.

MATERIAL.—Four collections off the west coast of South America, R. V. *Anton Bruun*, Cruise 14, Stations 553 (two collections), 554, and 572.

Many immature stages including the last copepodid stage were collected from the sharks off South America. When some of these copepodids were cleared in KOH and lactic acid, the first chalimus stage could be seen within. By carefully splitting open the copepodid, I teased out the developing chalimus. These chalimus stages were identical to first chalimus stages collected free in the gill chamber of the shark. Two successive chalimus stages also were found. These immature stages are described below. For a description of the adults of this species, see Cressey (1967a).

LAST COPEPODID.—Body form as in figure 1. Total length 6.77 mm (6.23–7.43) based on an average of 240 specimens, greatest width 4.07 mm (3.78–4.38) based on an average of 20 specimens (all measured specimens taken from a single shark at R. V. *Anton Bruun* Station 554).

Dorsal surface unornamented. Two "eye spots" with more heavily pigmented area surrounding and between them in anterior third of cephalon. Posterior corners of first free thoracic segment produced, extending nearly to end of second free thoracic segment. Genital segment slightly longer than wide (1.3 x 1.1 mm in one specimen). Abdomen 1-segmented, somewhat triangular, wider than long (.3 x .4 mm in one specimen). Caudal ramus (fig. 2) 536 μ wide, 590 μ long at outer edge, 295 μ long at inner edge (based on one specimen); armed with six plumose setae, four long terminal and two short subterminal. Adhesion pad present on ventral surface immediately posterior to first antenna.

First antenna (fig. 3) 2-segmented: basal segment with several short plumose spines, proximal two more heavily spinose; terminal segment with seven setae, posterior four plumose. Second antenna (fig. 4) with terminal segment in form of a claw, tip of claw twisted. Mouth tube and mandible of usual caligoid form, mandible with 10 teeth. First maxilla (fig. 5) a small lobe with three short setae and posterior projection bearing process with rugose tip. Second maxilla (fig. 6) with two terminal claws and subterminal hirsute process, claws ornamented as in figure 7. Maxilliped (fig. 8) stout, bearing bladellike claw opposed by striated area on basal segment.

Legs 1–4 (figs. 9–12) biramose. Rami of legs 1–3 2-segmented. Exopod of leg 4 1-segmented, endopod 2-segmented (see spine and seta formula below). Leg 5 (fig. 13) a knob bearing two setae, one naked and one plumose, on lateral margin of genital segment. Leg 6 absent.

Color in life: dark mahogany brown.

CHALIMUS I, MALE.—Body form as in figure 14. Total length 6.6 mm, greatest width 3.1 mm (all measurements based on a single specimen taken from the same shark as copepodids).

Dorsal surface unornamented. Eye spots less obvious than in copepodid. Outer posterior corners of first free thoracic segment produced, extending nearly to end of second free thoracic segment. Genital segment as wide as long (1.4 x 1.4 mm), posterior corners produced to form short rounded lobes. Abdomen 2-segmented; each segment about same length but second segment somewhat wider than first and triangular (widest posteriorly). Caudal rami triangular; with four long terminal and two short subterminal plumose setae. Adhesion pad on ventral surface posterior to base of first antenna.

First antenna (fig. 15) 2-segmented, similar to copepodid except that segments longer, bearing more setae. First maxilla (fig. 16) similar to copepodid except rugose process of copepodid is short pointed process in chalimus I. Second maxilla of chalimus I and all subsequent stages with plumose processes at base of two terminal spines (see Cressey, 1967a, fig. 129). Maxilliped (fig. 17) with pointed claw, seta on inner margin of claw. Legs 1-4 biramose. All rami 2-segmented. Leg 1 exopod with four spines equal in length on outer terminal margin of second segment, endopod of first segment with adhesion pad on inner distal corner. Leg 2 exopod with four outer spines, distalmost about twice length of proximalmost spine. Leg 3 exopod with four outer spines, proximalmost very small; other three becoming progressively longer, distalmost twice length of next longest. Leg 4 exopod with four spines, lengths as in leg 3. Leg 5 consisting of spine and two plumose setae at notch at posterior three-fourths of genital segment. Leg 6 a single spine near junction of abdomen and genital segment.

Color in life: cream.

CHALIMUS II, MALE.—Body form as in figure 18. Total length 8.6 mm, greatest width 4.6 mm (all measurements based on single specimen). Clear fringe around cephalon and outer corners of first free segment (not seen in previous stage). Principle changes in body form from previous stage are proportionately wider cephalon, elongation of genital segment, and more prominent caudal rami. Adhesion pads present ventrally on cephalon, one posterior to base of first antenna and a small one on basal segment of second antenna.

First antenna (fig. 19) with both segments longer and with increased ornamentation over previous stage. Second antenna (fig. 20) with well-developed claw; bearing two short setae, one at base of claw and one median. Maxilliped (fig. 21) with well-developed claw. Other head appendages as in previous stage.

Legs 1-4 biramose (see pls. 1-4). Spine and seta formula for legs 1-4 of last three immature stages and adult male are as follows (Roman numerals refer to spines, arabic to setae):

| leg | seg. | copepodid | | chalimus I | | chalimus II | | chalimus III | |
|-----|------|-----------|------|------------|------|-------------|------|--------------|------|
| | | exo. | end. | exo. | end. | exo. | end. | exo. | end. |
| 1 | 1 | I:0 | 0:0 | I:0 | 0:0 | I:0 | 0:0 | I:0 | 0:0 |
| | 2 | IV:3 | 3 | IV:3 | 3 | IV:3 | 3 | IV:3 | 3 |
| 2 | 1 | I:1 | 0:1 | I:1 | 0:1 | I:1 | 0:1 | I:1 | 0:1 |
| | 2 | IV:5 | 7 | IV:5 | 8 | IV:6 | 8 | IV:6 | 8 |
| 3 | 1 | I:0 | 0:1 | I:1 | 0:1 | I:1 | 0:1 | I:1 | 0:1 |
| | 2 | III:4 | 4 | IV:5 | 5 | IV:5 | 6 | IV:5 | 6 |
| 4 | 1 | IV:3 | 0:1 | I:0 | 0:1 | I:1 | 0:1 | I:1 | 0:1 |
| | 2 | | 3 | IV:5 | 4 | IV:5 | 5 | IV:5 | 5 |

Leg 5 (fig. 22) consists of single stout spine and three short plumose setae at notch in margin of genital segment (an increase of one seta over previous stage). Leg 6 a short spinelike process with plumose seta near junction of abdomen and genital segment.

The lengths in mm of each of the free body segments for the last five developmental stages of the male are as follows (specimens measured along mid-dorsal, anterior-posterior axis):

| | copepodid | chalimus I | chalimus II | chalimus III | adult |
|------------------------------|-----------|------------|-------------|--------------|-------|
| cephalon | 2.4 | 2.6 | 3.2 | 3.6 | 5.3 |
| first free thoracic segment | .9 | .6 | .7 | .9 | .9 |
| second free thoracic segment | .7 | .6 | .8 | .8 | 1.2 |
| third free thoracic segment | .9 | .8 | .9 | .9 | 1.3 |
| genital segment | 1.3 | 1.4 | 1.7 | 2.3 | 3.8 |
| abdomen | .3 | .3 | .5 | 1.0 | 1.4 |
| caudal ramus | .1 | .6 | .8 | .9 | 2.0 |
| total body length | 6.6 | 6.6 | 8.6 | 10.4 | 15.9 |

CHALIMUS III, MALE.—Body form as in figure 23. Total length 10.4 mm, greatest width 4.9 mm (measurements based on single specimen). This form is ornamented in all respects like chalimus II. There is a general increase in size and further elongation of genital segment. Cephalic appendages show elongation of terminal segments when compared with previous stage (claw of second antenna, maxilliped and terminal segment of first antenna are proportionally longer). Other than subtle changes in proportions, appendages are the same as in chalimus II. For comparison of legs 1-4, see plates 1-4.

ADULT MALE.—Total length 15.9 mm, greatest width 7.2 mm (measurements based on one specimen). The appendages of the adult do not differ significantly from the previous stage except for subtle changes in lengths of terminal segments of cephalic appendages, the adult appendage is somewhat longer in proportion (compare adult first maxilla, fig. 24 with fig. 16). The maxilliped of the adult male (fig. 25) bears two striated pads opposing the claw instead of just one as in previous stages.

Changes in ornamentation and proportionate lengths of the segments of the first antenna of all stages of the male are as follows:

| | segment 1 | | | segment 2 | | |
|--------------|-----------|----------------------------|-------------------------------|-----------|----------------------------|-------------------------------|
| | length | percent total length | no. spines and setae | length | percent total length | no. spines and setae |
| copepodid | 266 μ | 66 | 14 | 136 μ | 34 | 5 |
| chalimus I | 342 μ | 68 | 23 | 165 μ | 32 | 12 |
| chalimus II | 413 μ | 64 | 27 | 236 μ | 36 | 14 |
| chalimus III | 472 μ | 61 | 27 | 307 μ | 39 | 14 |
| adult | 531 μ | 58 | 27 | 378 μ | 42 | 14 |

ADULT, FEMALE.—Body form as in figure 27. For a complete description of the female of this species, see Cressey (1967a).

REMARKS.—The description of the copepodid instar of this species is the first to be linked conclusively to a known species of pandarid copepod. Similar forms have been described as the males of the genus *Nesippus* (Dana, 1852; Steenstrup and Lütken, 1861; Beneden, 1892; Gnanamuthu, 1949; and Hewitt, 1967). This description substantiates my previous remarks regarding these *Nesippus* males (1967a, p. 59). Since no forms intermediate between chalimus III and the adult male were found, it is assumed that there are only three chalimus stages. A few immature females were collected but not enough to determine their stage of development. Description of these forms has been deferred until more material can be collected.

The copepodids were found either on the body surface of the host or within the gill chamber, usually just inside the gill slit. The chalimus stages and adults all were found within the gill chamber but not usually on the filaments themselves. Most often these forms were found near the tips of the filaments, firmly attached to the epidermis. The females often cause the tissue to swell, almost covering the cephalon. Males were not observed to produce this host reaction.

This parasite is not restricted to *Isurus* but also is found commonly on other lamnid sharks and *Prionace glauca*.

Dinemoura latifolia (Steenstrup and Lütken)

FIGURES 26-27

Dinemoura latifolia.—Lewis, 1966, p. 102.—Hewitt, 1967, p. 195.
For earlier synonymy, see Cressey, 1967a, p. 42.

MATERIAL.—Three collections in the western North Atlantic (two previously reported by Cressey, 1967a); one collection from the Caribbean Sea, 13°38'N, 75°50'W; five collections from the Indian Ocean, previously reported by Cressey (1967b); eight collections from off the western coast of South America, R. V. *Anton Bruun*, Stations 553, 554, 564, and 567); one collection from the central Pacific, vicinity of Christmas Island.

REMARKS.—Both sexes of this copepod have been described, most recently by Lewis (1966). In my pandarid revision (1967a), I noted the lack of information regarding the male of this species. Lewis provides a good description of this sex in his 1966 paper. My material conforms to his description in every way except in regard to the first antenna (antennule in Lewis). According to Lewis, the first segment bears 14 setules and the second segment, five setae. In my material I have found each segment with more setae than described by Lewis (25 on the first segment, 12 on the second). A figure of the male (fig. 26) and its first antenna (fig. 27) is provided to supplement the description by Lewis.

This copepod is a common parasite on the body surface of mako sharks. Large clusters of females often occur in the posterior half of the body and usually on the ventral surface. Males generally are fewer in number and are scattered over the body surface.

Dinemoura producta (Müller)

FIGURES 28-42

Dinemoura producta.—Hewitt, 1967, p. 204.
For earlier synonymy, see Cressey, 1967a.

MATERIAL.—A single collection previously reported from the North Atlantic (Cressey, 1967a); three collections from off Scripps Pier, La Jolla, Calif.; 12 collections off Chile and Peru, R. V. *Anton Bruun*, Stations 552, 553, 554, 567, 568, 569, 571, and 572.

FEMALE.—A good description of the female of this species was given by Shiino (1957). Additions to his description were provided by Cressey (1967). Further description of the female will not be included herein.

MALE.—The male of this species was described by Wilson (1923) but a redescription of this sex is needed and is provided below.

Body form as in figure 28. Total length 8.25 mm, greatest width 3.6 mm (measurements based on a single specimen from Station 567). Lengths in mm of each of the body segments measured along the mid-dorsal line are as follows:

| | |
|-----------------------------|------|
| cephalon | 2.55 |
| first free thoracic segment | .37 |
| second " " " | .60 |
| third " " " | .75 |
| genital segment | 2.18 |
| abdomen (2 segments) | .90 |
| caudal ramus | .90 |

No dorsal plates present. Abdomen 2-segmented, second segment about twice as long as first. Genital segment (fig. 29) nearly twice as

long as wide (2.18 x 1.30 mm). Caudal rami (fig. 30) conspicuous, longer than wide (.90 x .52 mm); armed with four prominent plumose setae and two small subterminal plumose setae, inner margins of rami with row of short hairs.

First antenna (fig. 31) 2-segmented; basal segment with 26 short spines and setae, terminal segment with 12 short naked setae. Second antenna (fig. 32) stout; terminal claw with accessory process near base and two setae, one short and one long; appendage armed with number of adhesive areas as indicated in figure. First maxilla (fig. 33) with 3-segmented terminal ramus, basis bearing group of three short setae. Second maxilla (fig. 34) terminal claw with rows of fine hairs; second segment bearing short stout spine covered with fine spinules, patch of hairs on outer distal corner. Maxilliped (fig. 35) well developed; terminal claw opposed by two adhesion areas on basal segment.

Legs 1-4 biramous. Leg 1 (fig. 36) both rami 2-segmented. Exopod first segment large, bearing spine on outer distal corner; second segment with fringe of digitiform processes along outer edge and bearing three short spines and four setae. Endopod first segment unarmed, distal end produced to form broad lamella overlapping base of terminal segment; terminal segment with three stout setae and patch of hairs on outer edge. Leg 2 (fig. 37) both rami 3-segmented. Exopod first two segments of each with spine and seta on outer and inner distal corners respectively, terminal segment with two lateral spines and six setae. Endopod first segment with seta on inner distal corner, second segment with two setae at inner distal corner, terminal segment with six setae. Leg 3 (fig. 38) both rami 3-segmented. Exopod with same armature as leg 2. Endopod with last two segments modified as in figure 39. Leg 4 (fig. 40) rami 2-segmented. Exopod first segment with spines on outer distal corner, second segment with spine on outer and seta on inner distal corners, terminal segment with two spines and five setae. Endopod with one, two, and three setae on the inner margin of each segment respectively.

Spine and seta formula of legs 1-4 is as follows:

| seg. | leg 1 | | leg 2 | | leg 3 | | leg 4 | |
|------|-------|------|-------|------|-------|------|-------|------|
| | exp. | end. | exp. | end. | exp. | end. | exp. | end. |
| 1 | 1:0 | 0:0 | I:1 | 0:1 | I:1 | 0:1 | I:0 | 0:1 |
| 2 | III:4 | 3 | I:1 | 0:2 | I:1 | 0:2 | I:1 | 0:2 |
| 3 | | | II:6 | 5 | II:6 | I:4 | II:5 | 3 |

Leg 5 (fig. 41) represented by process on ventral surface of genital segment bearing one outer fringed spine and two inner plumose setae (see fig. 29); a fourth plumose seta internal to process. Leg 6 (fig. 42) a process near posterior corner of genital segment bearing one outer naked spine and one short inner plumose seta.

REMARKS.—This copepod normally is found on the fins of the host, most frequently on the trailing edges of the dorsal and pectoral fins.

Echthrogaleus denticulatus Smith

Echthrogaleus pellucidus Shiino, 1963, p. 357.

For earlier synonymy, see Cressey, 1967a, p. 56.

MATERIAL.—One collection from off Scripps Pier, La Jolla, Calif.; one collection from the central Pacific in the vicinity of Christmas Island; six collections off Chile and Peru, R. V. *Anton Bruun*, Stations 553, 554, 568, 569, and 571; and four collections from the Indian Ocean previously reported (Cressey, 1967b).

REMARKS.—No description of either sex of this copepod will be given herein as that of Shiino (1963) and of Cressey (1967a) are adequate. I have placed *E. pellucidus* Shiino in synonymy after re-examining the type of *E. denticulatus* Smith deposited in the USNM. The only differences among all the material I have collected recently, the description of *E. pellucidus* by Shiino, and the type-specimen is that the type is larger. The type-specimen was collected in the North Atlantic, whereas all other material has come from the Indo-Pacific. Cressey (1967a, p. 27) reported a similar situation for another species of parasitic copepod, *Phyllothereus cornutus*, where the specimens collected from the colder waters of the Atlantic were larger than those from the relatively warmer Indian Ocean.

These copepods generally are found on the body surface of the host, frequently in the anterior part near the gill slits. Although there was a high incidence of infestation on mako sharks off Chile and Peru, the number of individuals on any one shark was never more than 20. This same species was collected in the Indian Ocean from thresher sharks, *Alopias vulpinus*, and often occurred on that host in clusters of more than 100 individuals.

Anthosoma crassum (Abildgaard)

For earlier synonymy, see Lewis, 1966, p. 66.

MATERIAL.—Four collections from off Scripps Pier, La Jolla, Calif.; four collections from the central Pacific in the vicinity of Christmas Island; one collection from off Sandy Hook, N.J.; two collections from the Indian Ocean, previously reported (Cressey, 1967b); one collection from the North Atlantic taken during a cruise of the M. V. *Delaware*; seven collections from off Chile and Peru, R. V. *Anton Bruun*, Stations 552, 553, 554, 558, 564, 568, and 571.

REMARKS.—This species has been well described by Shiino (1955) and Lewis (1966) and no further description will be given herein. On the mako sharks caught off the western coast of South America, this species was very common and was always found imbedded be-

tween the teeth on either or both the upper and lower jaw. It has been recorded also from other species of lamnid sharks.

Nemesis lamna Risso

FIGURES 43-58

Nemesis lamna Risso, 1826, p. 136.—Roux, 1828, p. 174.—Guérin, 1837, pl. 35.—Krøyer, 1837, p. 199.—Milne-Edwards, 1840, p. 486.—Wilson, 1922, p. 59; 1932, p. 461.—Fage, 1923, p. 282.—Heggaard, 1962, p. 184.—Cressey, 1967b, p. 6.

Nemesis carchariarum Roux, 1828, p. 176.—Krøyer, 1837, p. 199.—Milne-Edwards, 1840, p. 486 [misspelled "carcherium"].

Nemesis mediterranea Heller, 1868, p. 220.—Valle, 1880, p. 66.—Richiardi, 1880, p. 151.—Stossich, 1880, p. 262.—Carus, 1885, p. 365.—Brian, 1898, p. 15; 1899, p. 201; 1902, p. 44; 1905, p. 7.—Bassett-Smith, 1899, p. 476.

Nemesis lamna var. *sinuata*.—Valle, 1878, p. 91.

MATERIAL.—Four collections from the Indian Ocean, previously reported (Cressey 1967b); three collections from off Scripps Pier, La Jolla, Calif.; nine collections from off the Coast of Chile and Peru, R. V. *Anton Bruun*, Stations 552, 553, 554, 558, 564, and 572.

FEMALE.—Body form as in figure 43. Total length 6.61 mm (5.85-7.95), greatest width 2.0 mm (1.73-2.40). Widths of cephalon and four free thoracic segments are as follows: cephalon 1.25 mm (1.19-1.50), first free thoracic segment 1.92 mm (1.80-2.33), second free thoracic segment 2.00 mm (1.73-2.40), third free thoracic segment 1.99 mm (1.73-2.40), fourth free thoracic segment 1.74 mm (1.50-2.25). All measurements are based on an average of 10 ovigerous females randomly selected from the collection at Station 552.

Fourth free thoracic segment (bearing leg 5) with many sclerotized papillae on dorsal surface. Genital segment (fig. 44) about as long as wide (.8 x .8 mm) and subdivided ventrally giving the appearance of two segments. Abdomen (see fig. 44) 2-segmented. Each segment with a few papillae on dorsal surface and armed with short hairs and spinules as in figure. Caudal rami short, about twice as long as wide (363μ x 218μ), bearing rows of short spinules on ventral surface.

First antenna (fig. 45) composed of 13 segments. Each segment armed with short setae as in figure. Second antenna (fig. 46) 4-segmented, basal segment with weak triangular process on inner surface, antepenultimate segment with short seta on inner distal corner, penultimate segment unarmed, terminal segment in form of short claw bearing two setae on inner border. Mouth tube and mandible of usual caligoid type, mandible with eight to nine teeth. First maxilla (fig. 47) biramose; each rami with two setae, anteriormost ramus with one short and one long seta. Posterior ramus with two equal long setae. Tip of second maxilla (fig. 48) with short claw, claw covered with short papillae. Patch of spines present near base of claw

and patch of long hairs on outer corner of segment bearing terminal claw. Maxilliped (fig. 49) in form of stout claw. Penultimate segment with triangular process on inner proximal corner. Claw heavily sclerotized and bearing two short setae on inner margin.

Legs 1-4 biramose, each ramus 2-segmented. All legs with conspicuous patches of spinules as indicated in figures. Leg 1 (fig. 50) exopod first segment long and recurved, second segment small bearing three short spines at tip; endopod first segment with outer distal corner produced to form prominent claw, last segment with two weak setae at tip. Second leg (fig. 51) exopod first segment with inner and outer corners produced to form spines, last segment short, bearing six short spines of about equal length; endopod first segment similar to that of exopod, last segment with five spines. Leg 3 (fig. 52) exopod as in leg 2 except last segment bearing seven short spines; endopod first segment as in leg 2, last segment with prominent spinelike process on outer distal corner and one small outer and four small inner spines. Leg 4 (fig. 53) exopod first segment with spine on outer distal corner only, last segment with six small spines; endopod first segment as in legs 2 and 3, last segment with five spines, next to outermost larger than other four. Leg 5 represented by knob bearing three short setae on outer distal corners of genital segment.

MALE.—Body form as in figure 54. Total length 4.7 mm, greatest width 1.6 mm measured across first free thoracic segment (measurements based on single specimen from Station 552).

Cephalic appendages as in female. Leg 1 as in female. Leg 2 (fig. 55) exopod first segment with prominent spine on outer distal corner and small seta on inner margin, second segment with six small setae on terminus and inner margin; endopod first segment with prominent spine on outer distal corner, second segment with three short but somewhat recurved setae. Leg 3 (fig. 56) exopod first segment with outer prominent spine and small seta on inner distal corner, second segment with six setae, fourth from outer considerably longer than other five; endopod first segment with outer distal corner produced to form prominent spine, endopod with two terminal spines and three small setae on inner margin, spine on inner distal corner strong and somewhat recurved. Leg 4 (fig. 57) exopod first segment with prominent spine on outer distal corner, second segment with six setae, inner three longer than outer three; endopod first segment with outer corner produced to form strong spine and inner margin bearing conspicuous seta, second segment with two terminal spines and two inner short setae, spine on inner distal corner strong and slightly recurved as in leg 3. Leg 5 (see fig. 58) a short free segment bearing three setae plus single seta near base of segment. Leg 6 (see fig. 58) on outer distal corner of genital segment consisting of prominent inner spine

and two outer setae. Spermatophores visible within genital segment.

REMARKS.—Wilson (1932) redescribed both sexes of this species and stated that no description had been presented since Heller (1865). He apparently was unaware of the redescription of the female and description of the male by Fage (1923). Although Fage's description is of more value than that of Wilson, both lack certain details and, thus, a re-description of both sexes has been presented herein.

This species is very common on mako sharks and, as in other members of the genus, the adults are found only on the gill filaments of the host. It has been reported from other lamnid sharks as well.

Habital Shift in the Genus *Pandarus*

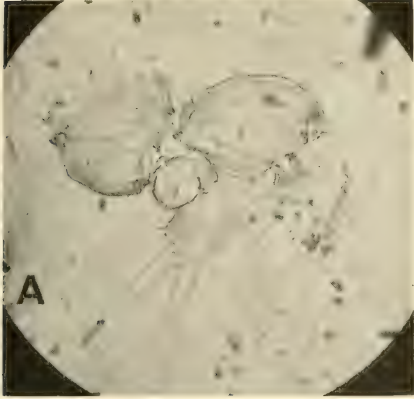
All species of the genus *Pandarus* are found commonly on the body surface of their respective shark hosts. In this paper three species are reported from *Isurus oxyrinchus*. Of the 16 collections of *Pandarus* from this host, only one was taken from the body surface (*P. smithii* in the Indian Ocean). All others were collected from the mouth and/or the gill arches. During the course of my studies with parasitic copepods, it has become evident that there is considerable specificity with regard to the site of infestation on the host. One can predict with a high degree of certainty sites of infestation for any species. Needless to say, any marked deviation from the usual mode of existence presents some interesting problems. Such is the case with the genus *Pandarus* as found usually on *Isurus oxyrinchus*.

While collecting *Pandarus* from the mouths of mako sharks, I suspected that they might represent new species due to the unusual habitat and their noticeable reduction in pigmentation. Subsequent examination, however, showed that they all could be assigned to the known species—*satyrus*, *smithii*, and *katoi*—differing from other members of each species only in the reduced pigmentation. An examination of the collection records showed that in all cases where *Pandarus* was present in the mouth, either *Dinemoura latifolia* and/or *D. producta* were present at the sites where one might expect to find *Pandarus* on other hosts. In the one collection where *Pandarus* occurred on the body surface, *Dinemoura* was not present. Apparently, the presence of *Dinemoura* inhibits *Pandarus* from becoming established in its usual places. The fact that it does become established in a new location is interesting. I suspect that in time, if they continue to be successful in this habitat, they will result in new species of the genus being produced. By the usual criteria of separating the species of the genus, they cannot at present be considered as different species. If, however, their progeny result in forms that will not attach to any other host on the body surface, then they represent something new. A definitive answer to this would come only from experimental evidence and cannot

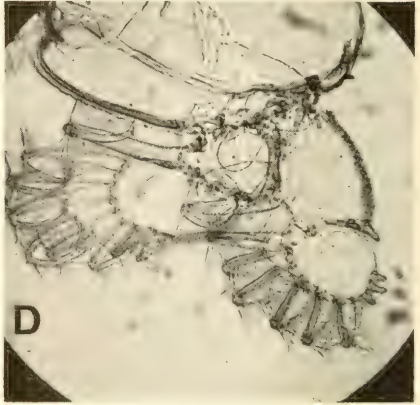
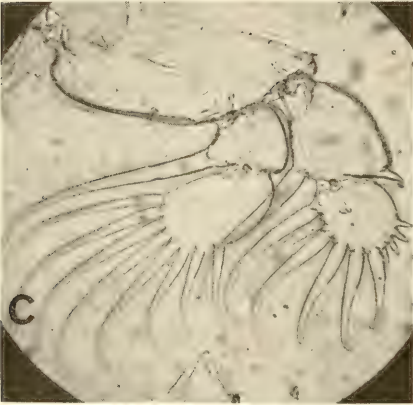
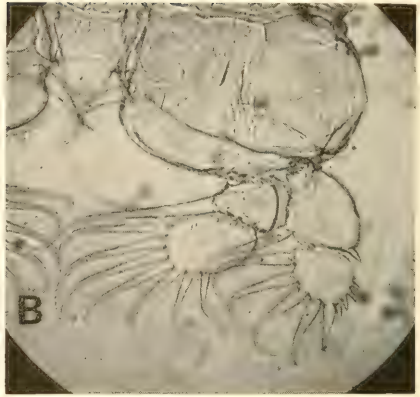
be ascertained at this time. I suspect that this situation represents new species in the early stages of formation.

It is interesting to note that Hewitt (1967) cites two records of *P. cranchii* (which are actually *P. satyrus*) from the "buccal cavity" and "jaws and skin" of *Isurus oxyrinchus* and *Galeorhinus australis*. *Dinemoura latifolia* was collected from both of these sharks.

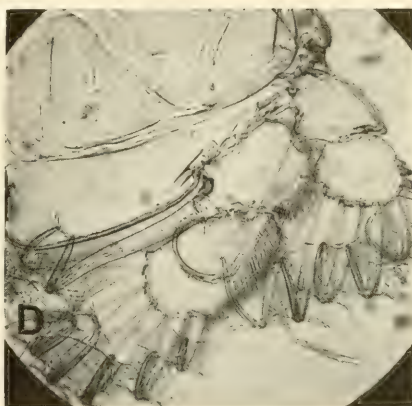
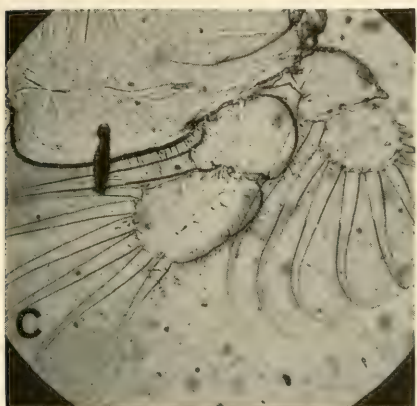
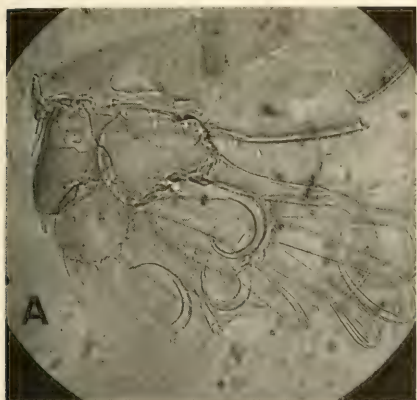
As previously indicated, adult females of the three species in the mouth were pigmented less noticeably than adult females of the same species that occurred on the surface of other hosts. Two possible explanations come to mind. First, the pigmentation may be influenced by the amount of light available to the copepod, those in the mouth receiving less. Second, the pigmentation may be influenced by the amount of pigmentation of the shark at the point of attachment of the parasite. From my own observations of other parasitic copepods, I favor the latter explanation. Often parasitic copepods assume the color of the host tissue to which they are attached, or those parasites with little or no pigment are associated with lighter areas and the pigmented forms are on darker areas. Many questions basic to understanding this departure remain unanswered. Most of these deal with the life history process about which practically nothing is known. No attempt at a definitive explanation is offered here, but rather I have presented the situation in the hope that future investigations will shed more light on this interesting situation.



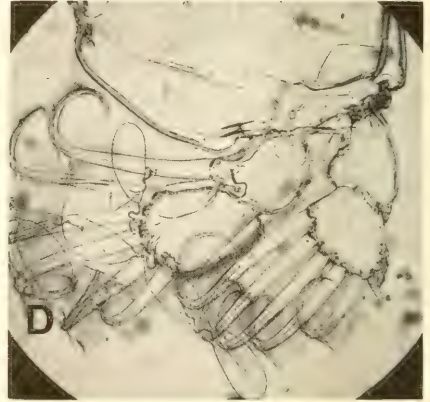
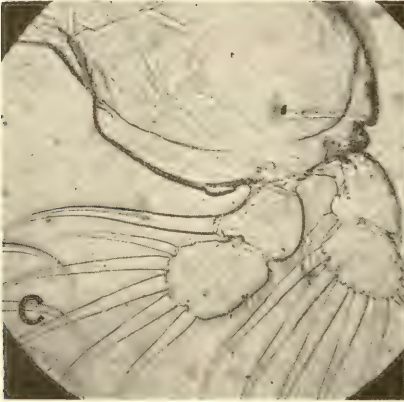
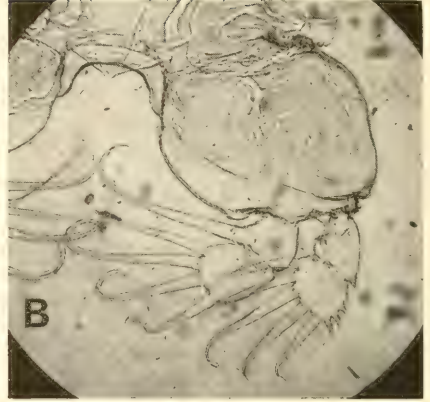
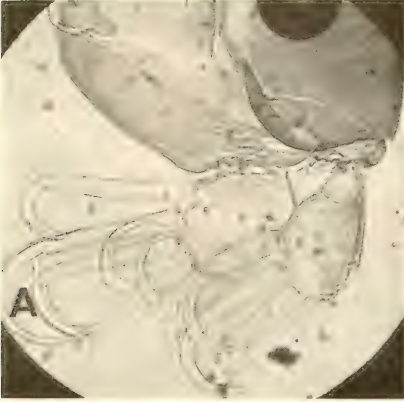
Phyllothereus cornutus, male: a, copepodid leg 1; b, chalimus I leg 1; c, chalimus II leg 1; d, chalimus III leg 1.



Phyllothereus cornutus, male: a, copepodid leg 2; b, chalimus I leg 2; c, chalimus II leg 2; d, chalimus III leg 2.



Phyllothereus cornutus, male: a, copepodid leg 3; b, chalimus I leg 3; c, chalimus II leg 3; d, chalimus III leg 3.

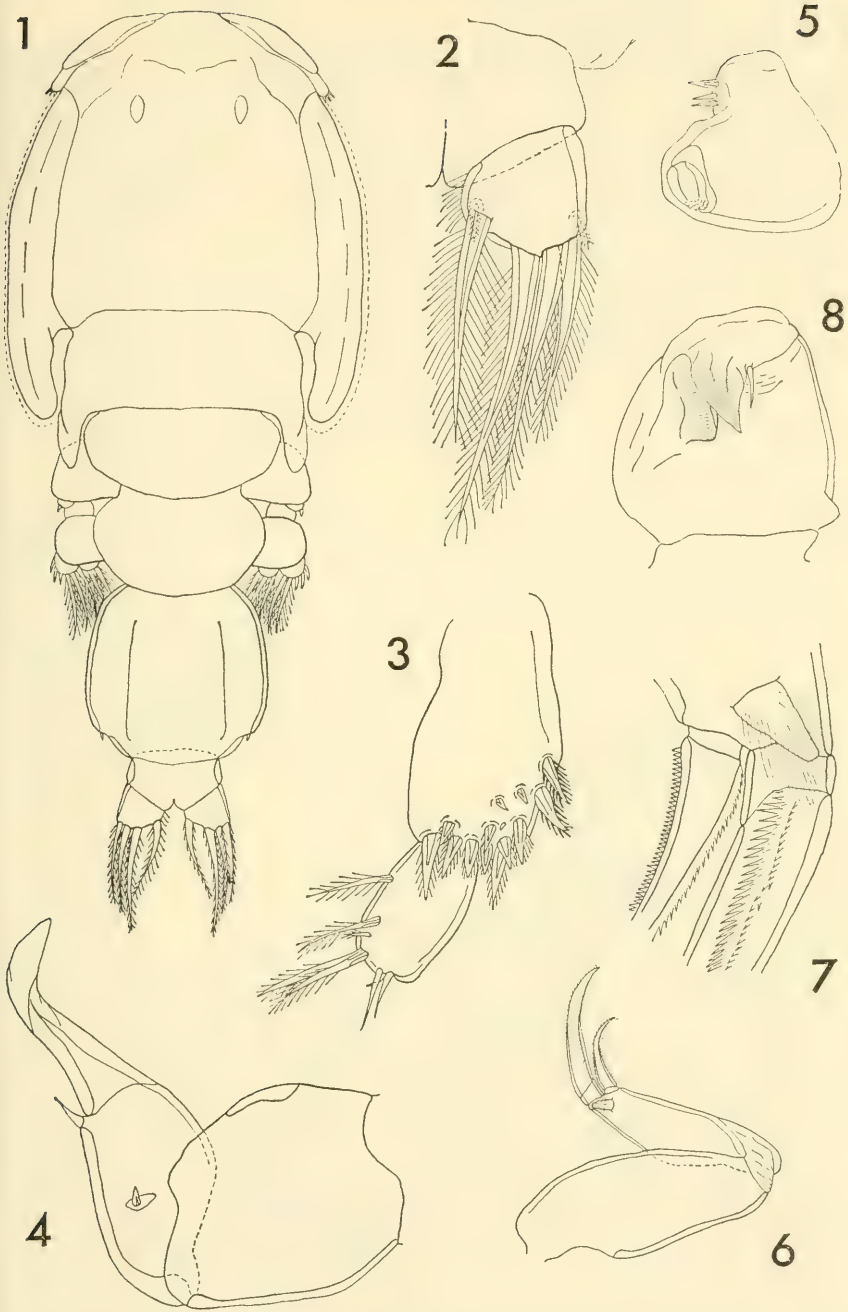


Phyllothereus cornutus, male: a, copepodid leg 4; b, chalimus I leg 4; c, chalimus II leg 4; d, chalimus III leg 4.

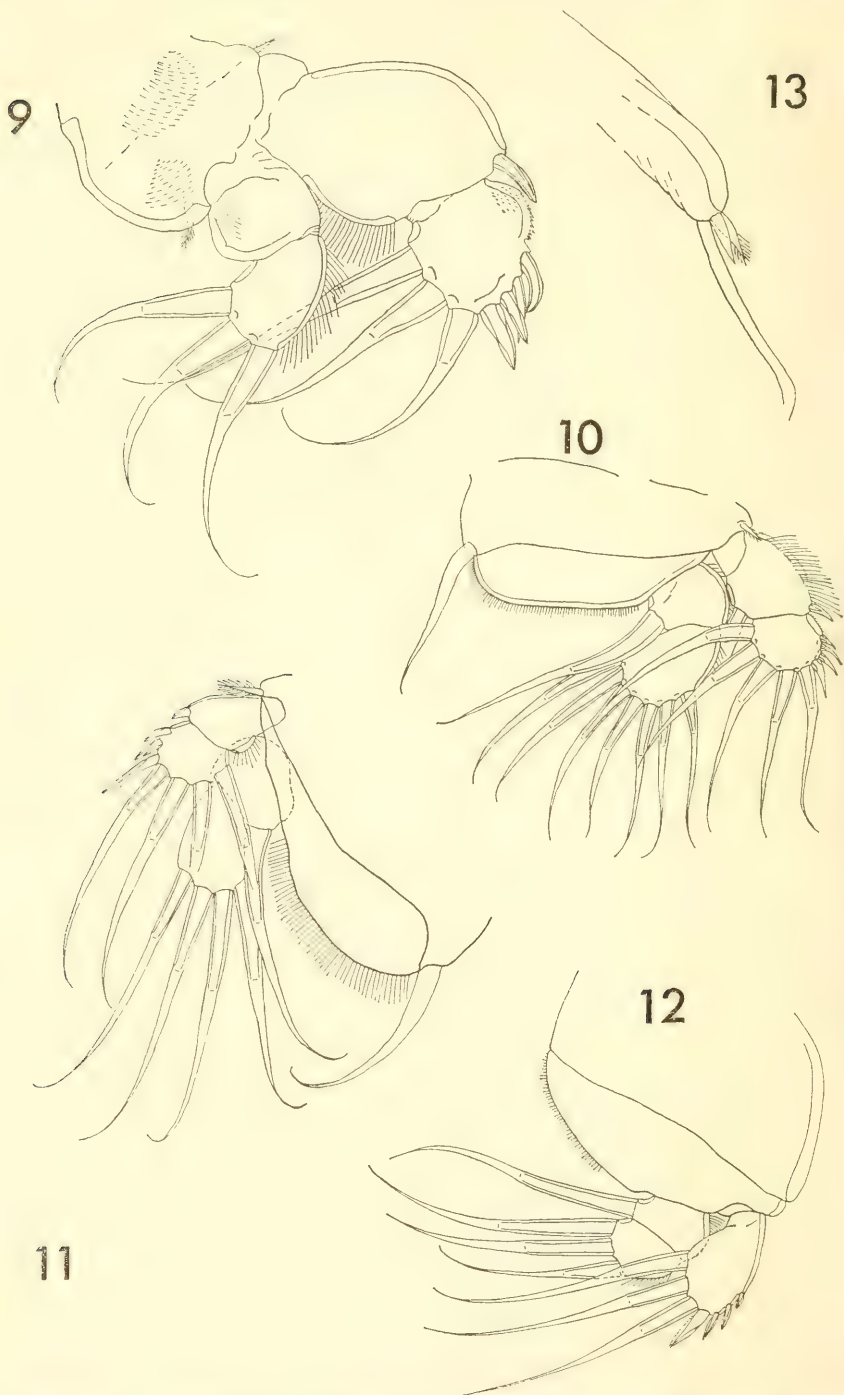
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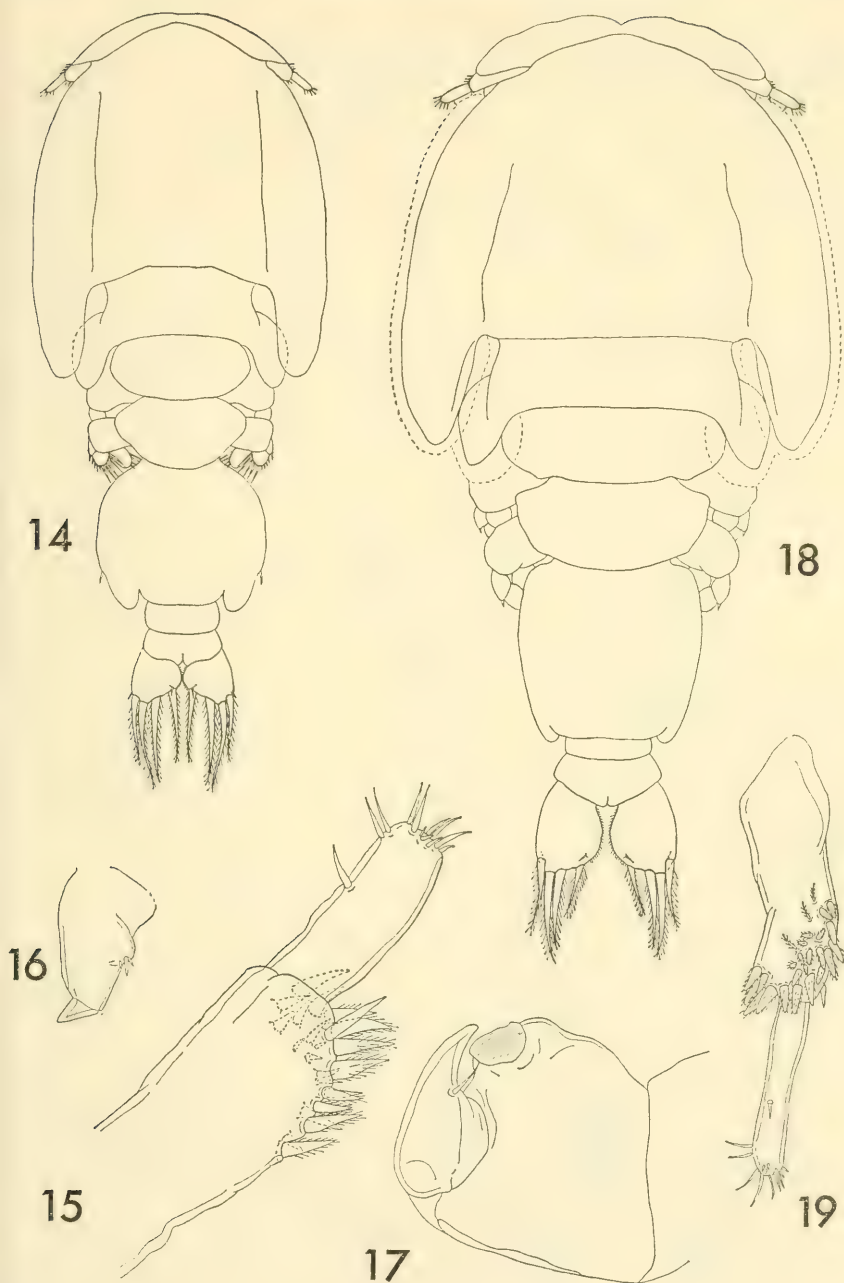
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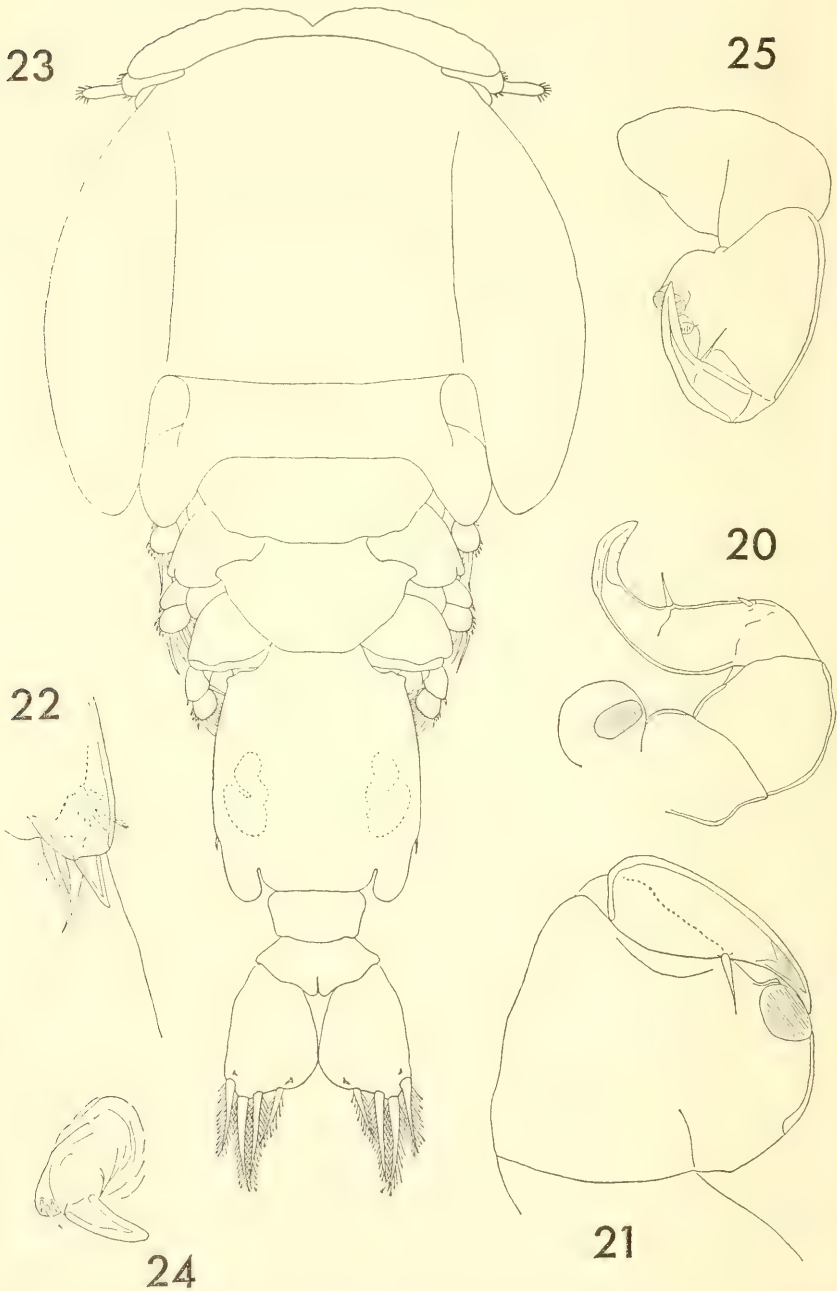
FIGURES 1-8.—*Phyllothereus cornutus*, male copepodid; 1, dorsal; 2, caudal ramus; 3, first antenna; 4, second antenna; 5, first maxilla; 6, second maxilla; 7, base of terminal claws on second maxilla; 8, maxilliped.



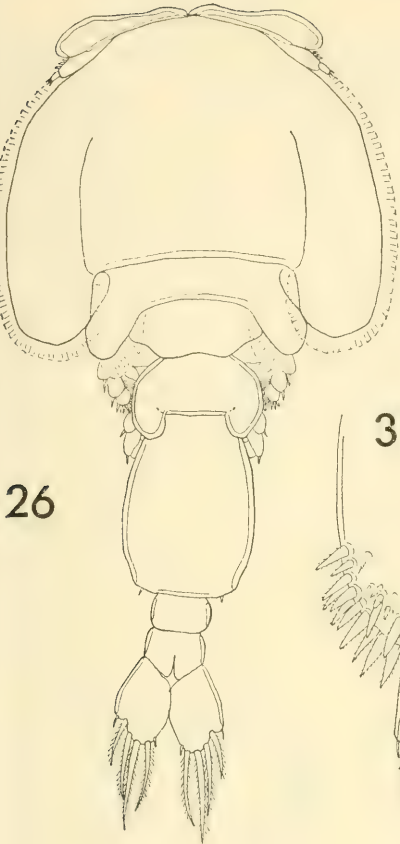
FIGURES 9-13.—*Phyllothereus cornutus*, male copepodid: 9, leg 1; 10, leg 2; 11, leg 3; 12, leg 4; 13, leg 5.



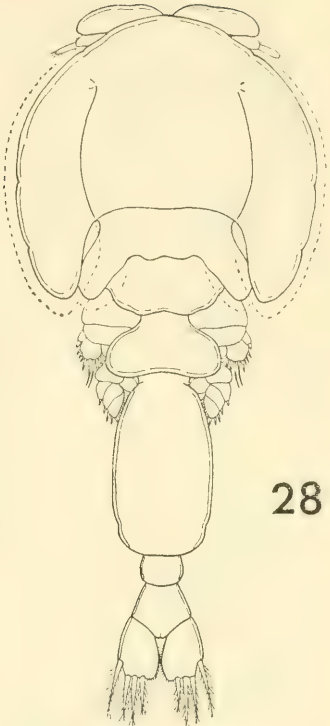
FIGURES 14-19.—*Phyllothereus cornutus*, male chalimus I: 14, dorsal; 15, first antenna; 16, first maxilla; 17, maxilliped. Male chalimus II: 18, dorsal; 19, first antenna.



FIGURES 20-25.—*Phyllothereus cornutus*, male chalimus II: 20, second antenna; 21, maxilliped; 22, leg 5. Male chalimus III: 23, dorsal; 24, first maxilla; 25, maxilliped.



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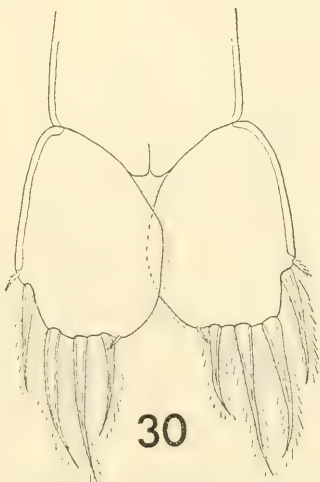
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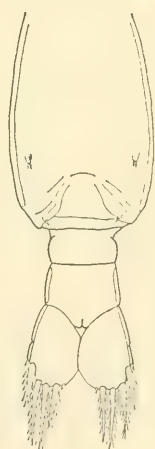
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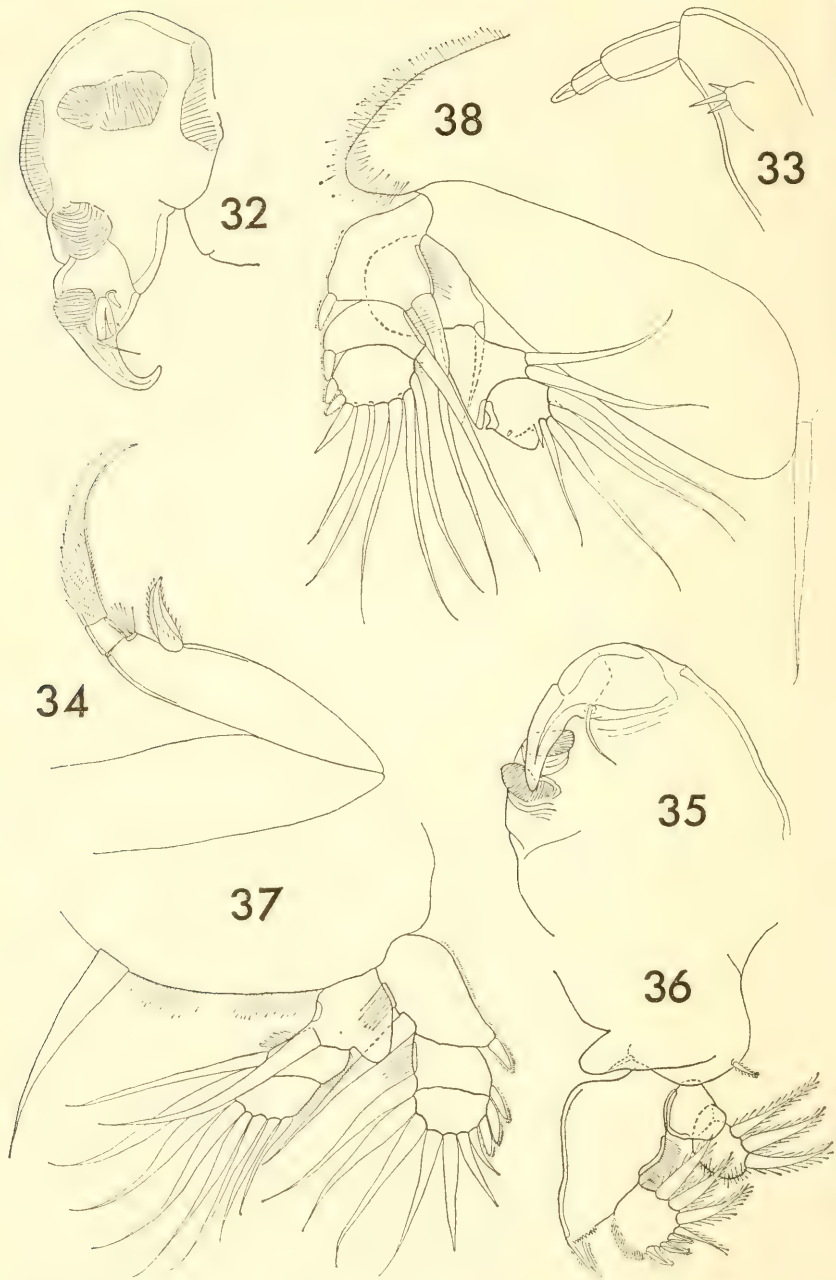


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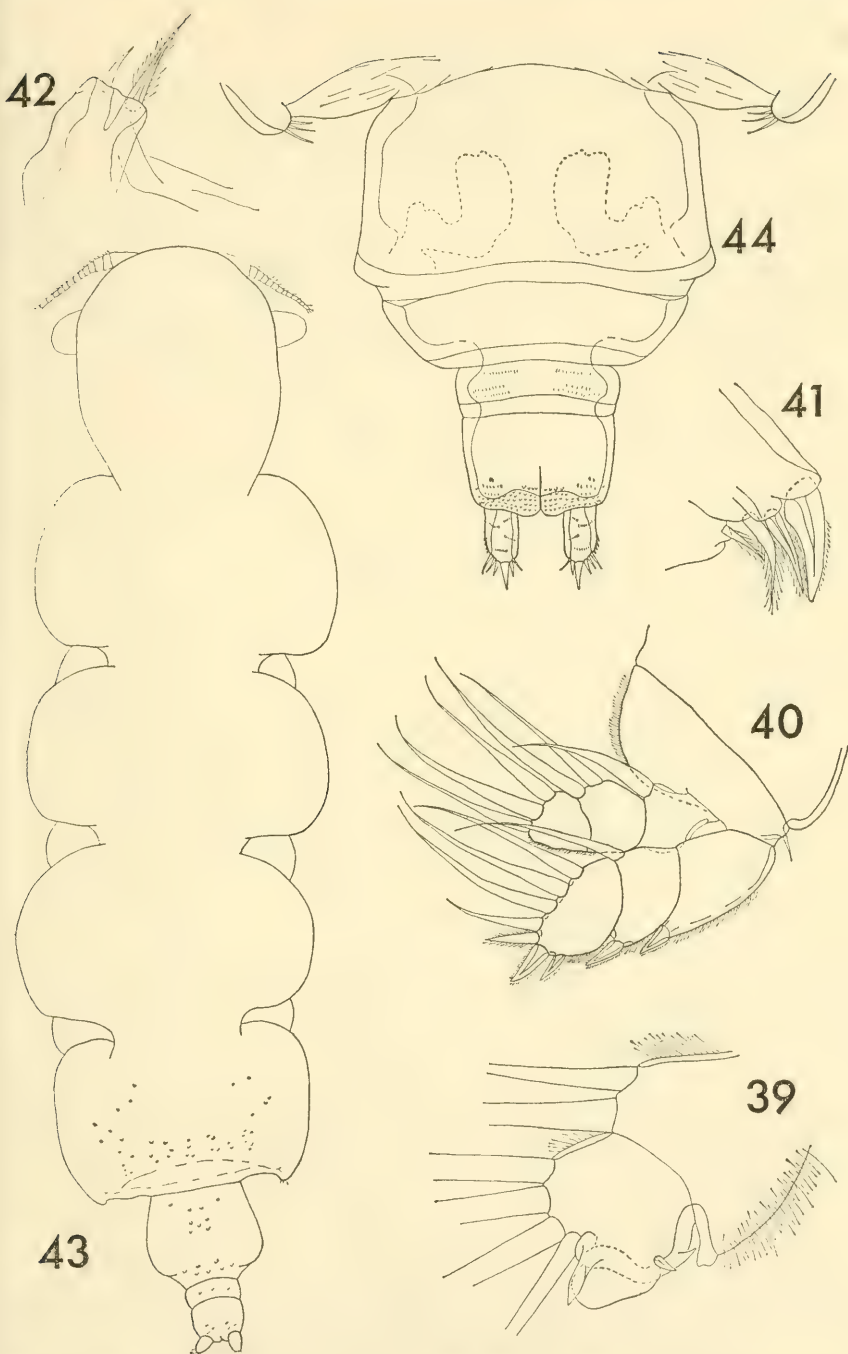


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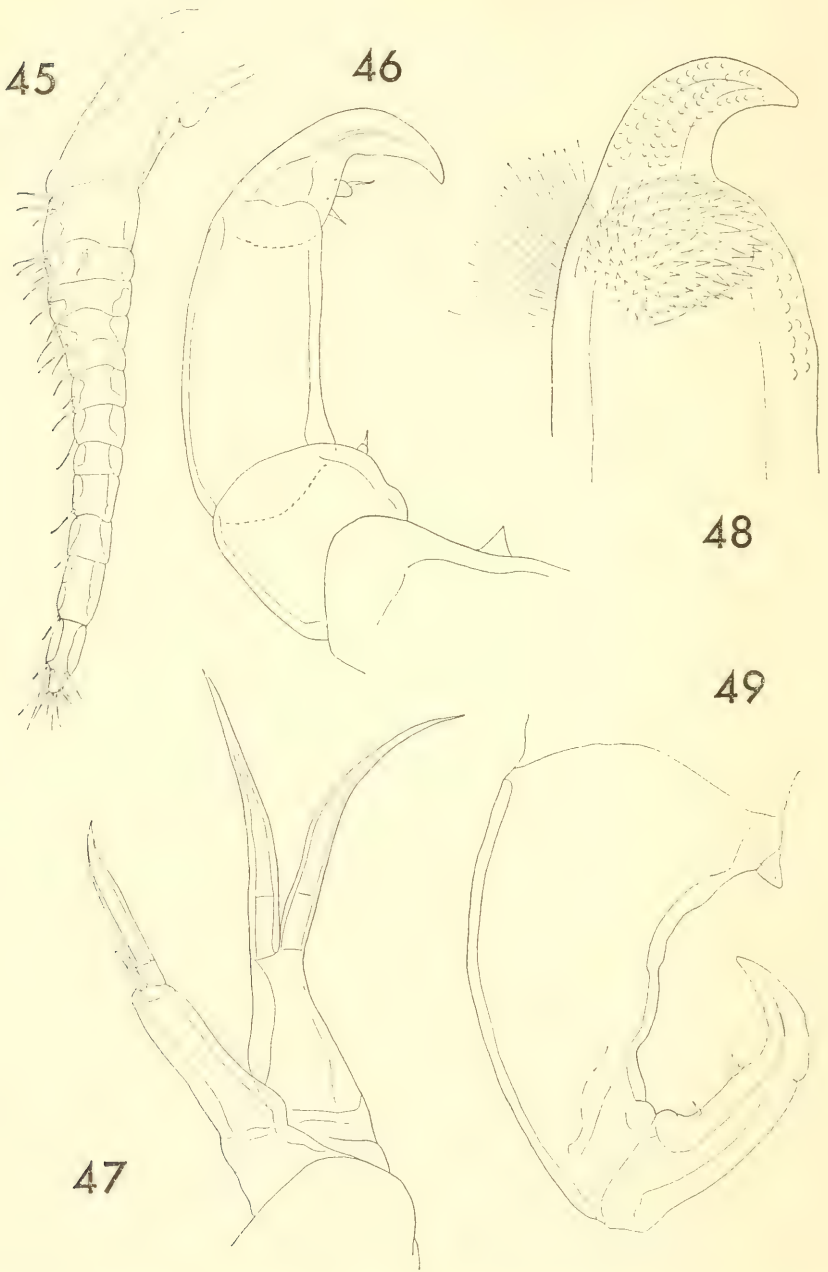
FIGURES 26-31.—*Dinemoura latifolia*, male: 26, dorsal; 27, first antenna. *D. producta*, male: 28, dorsal; 29, genital segment and abdomen, ventral; 30, caudal rami; 31, first antenna.



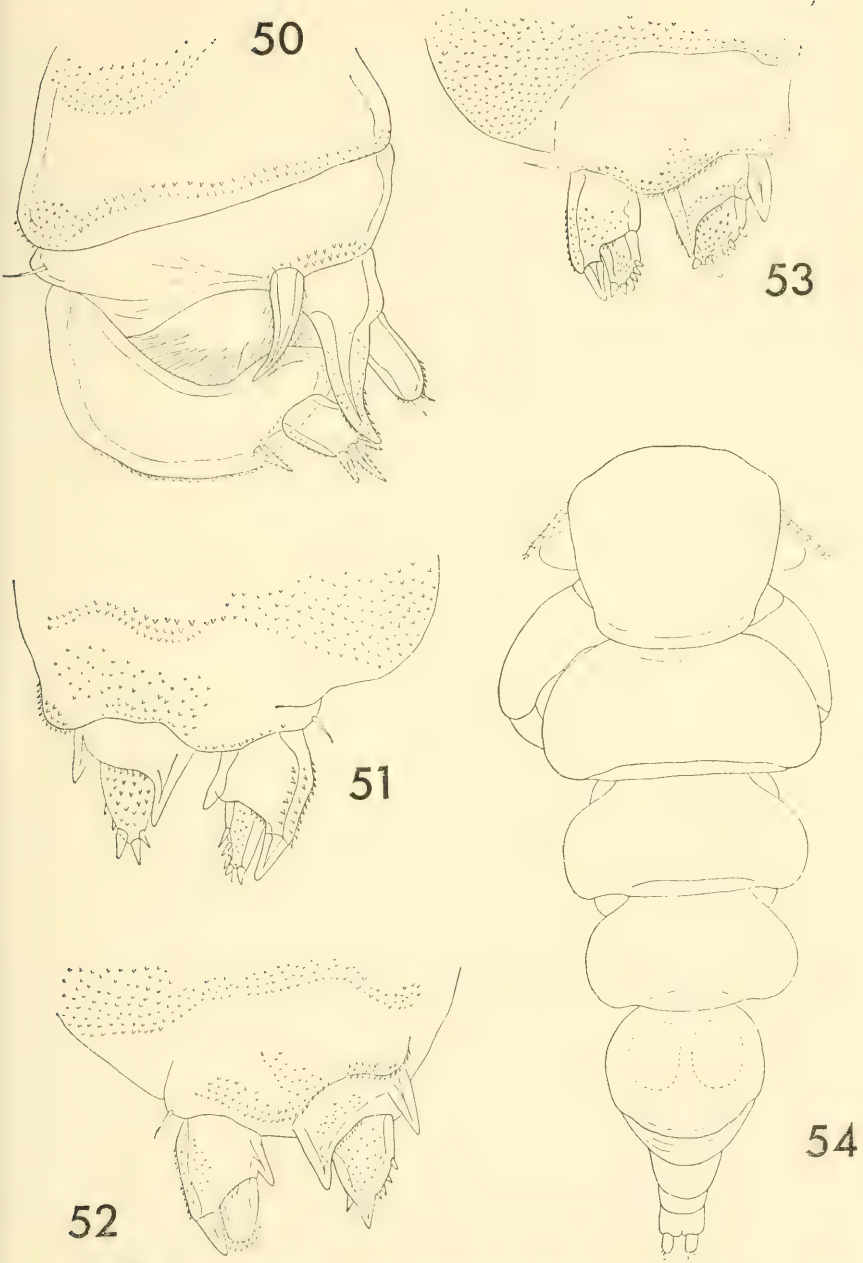
FIGURES 32-38.—*Dinemoura producta*, male: 32, second antenna; 33, first maxilla; 34, second maxilla; 35, maxilliped; 36, leg 1; 37, leg 2; 38, leg 3.



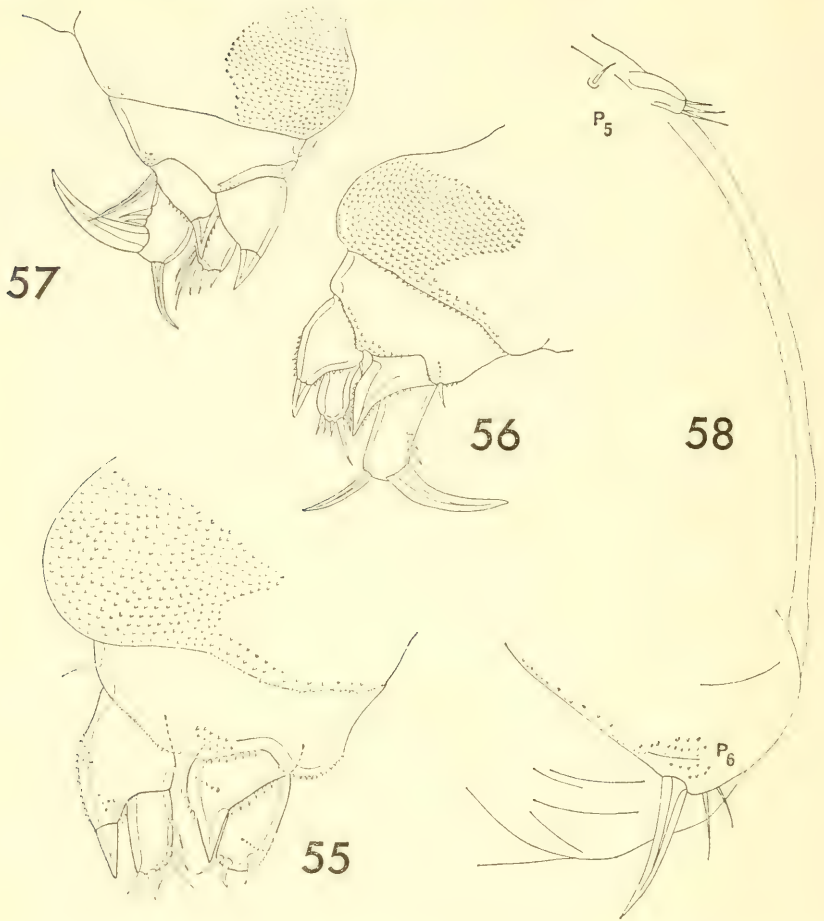
FIGURES 39-44.—*Dinemoura producta*, male: 39, terminal segment on endopod of leg 3; 40, leg 4; 41, leg 5; 42, leg 6. *Nemesia lamna*, female: 43, dorsal; 44, genital segment and abdomen, ventral.



FIGURES 45-49.—*Nemesis lamna*, female: 45, first antenna; 46, second antenna; 47, first maxilla; 48, tip of second maxilla; 49, maxilliped.



FIGURES 50-54.—*Nemesia lamna*, female: 50, leg 1; 51, leg 2; 52, leg 3; 53, leg 4. Male: 54, dorsal.



FIGURES 55-58.—*Nemesia lamna*, male: 55, leg 2; 56, leg 3; 57, leg 4; 58, edge of genital segment showing legs 5 and 6.

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Neotropical Microlepidoptera, XVI¹

A New Genus and Two New Species of Oecophoridae
(Lepidoptera)

By J. F. Gates Clarke

Senior Entomologist, Department of Entomology

The first species described herein was received from Dr. F. Luis Gallego M., Chief, Departamento de Entomología, Facultad de Agronomía e Instituto Forestal, Universidad Nacional, Medellín, Colombia, who states that the larvae of the species damage apple by boring in the twigs. A search of the literature and museum collections failed to reveal any described form that approaches this species. The generic affinities are with the Australian *Sphyrelata* Meyrick.

The second species described herein is noteworthy because it is the only species of the family Oecophoridae—a family exhibiting an enormous development of species in the Neotropical region—recorded from the island of Dominica, British West Indies. The specimens were collected by my colleagues, my wife, and me during the Archbold-Bredin-Smithsonian Biological Survey of Dominica.

The photographs for this paper were made by Mr. Victor Krantz, staff photographer. The drawings of the genitalia of *Gonionota insulana* and those of the head, palpus, wing venation, and leg of *Maesara*

¹ See list at end of paper.

gallegoi were made by Mrs. Elsie H. Froeschner; the genitalia of *M. gallegoi* were drawn by Mr. André del Campo Pizzini.

Maesara, new genus

Type-species: *Maesara gallegoi*, new species.

Antenna about two-thirds the length of forewing, rather stout, not ciliated; scape with pecten. Labial palpus upturned, second segment slightly roughened beneath; third segment acute, in male much shorter than second; in female nearly as long as second. Maxillary palpus short. Tongue well developed, heavily scaled. Head roughened, sidetufts spreading; ocelli absent. Thorax with posterior crest. Posterior tibia heavily clothed with moderately long hairlike scales. Forewing smooth, termen oblique; costal and dorsal edge nearly parallel in female, in male costa strongly arched, 12 veins; 1b furcate, 2 from near angle of cell; 2, 3, and 4 about equidistant; 6 parallel to 7; 7 and 8 long stalked, 7 to apex; 9 approximate to base of stalk of 7 and 8; 11 from near basal third of cell. Hindwing with 8 veins; 2 from well before angle of cell; 3 and 4 short stalked, from angle of cell, 5, 6, and 7 about equidistant.

Male genitalia: Uncus present. Gnathos present, divided. Aedeagus unarmed.

Female genitalia: Signa present.

Maesara is related very closely to the Australian *Sphyrelata* Meyrick and keys to it in Meyrick's key to the genera of Oecophoridae ("Genera Insectorum," 1922, fasc. 180). *Maesara* differs from *Sphyrelata* by the smooth, somewhat shorter antenna, the absence of ocelli, the basad origin of vein 11 of the forewing and the short-stalked veins 3 and 4 of the hindwing.

Maesara gallegoi, new species

FIGURES 1, 2; PLATE 1

Alar expanse 18–36 mm.

Labial palpus light ochraceous buff mottled with brown and fuscous. Antenna ochraceous buff basally shading to chestnut brown distad; extreme apex ochraceous buff; scape ochraceous buff shaded with fuscous. Head ochraceous buff somewhat infuscated; side tufts mixed with blackish fuscous. Thorax ochraceous buff, the ground color obscured by chestnut brown and blackish fuscous. Forewing ground color umber brown; costa broadly edged with chestnut brown, this band of color narrowing toward apex; veins in costal half of wing emphasized by chestnut brown; in cell, at one-third, an ochraceous buff spot mixed with a few black scales; on fold, slightly beyond one-third, a similar spot (absent in some specimens); at end of cell a more conspicuous, well-defined, ochraceous buff spot; ochraceous buff

scales irregularly and sparsely scattered over surface of wing; cilia composed of alternating ochraceous buff and fuscous groups producing a spotted appearance. Hindwing grayish fuscous, thinly scaled basad; cilia grayish fuscous mixed subapically with ochraceous buff. Foreleg ochraceous buff; femur and tibia strongly overlaid fuscous; tarsal segments irregularly marked fuscous; midleg ochraceous buff; femur mottled fuscous on outer side; tibia almost wholly overlaid fuscous on outer side except distally; tarsal segments with ochraceous buff

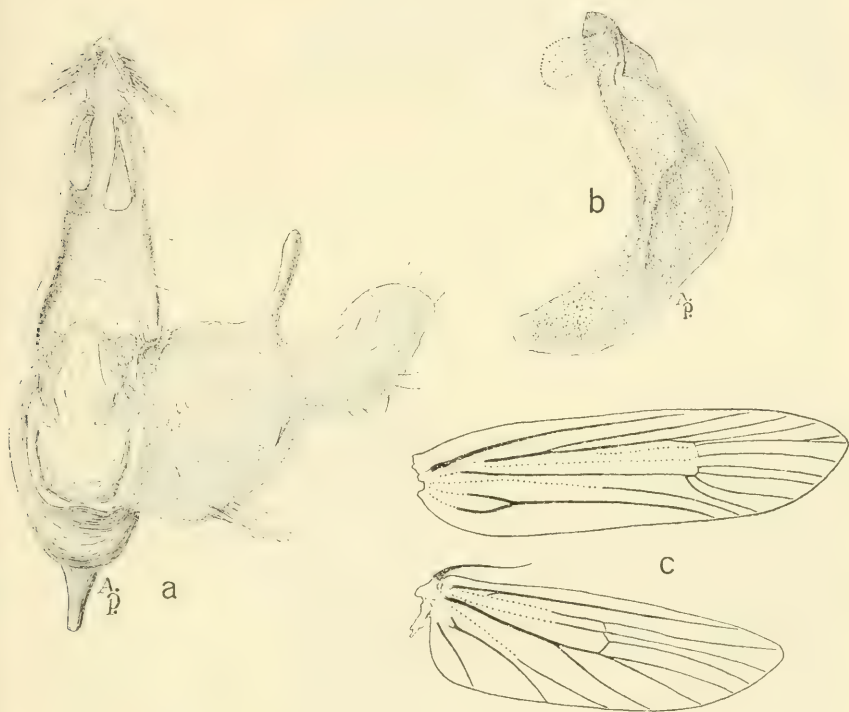


FIGURE 1.—*Maesara gallegoi*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, venation of right wings.

reduced to narrow annulations. Hindleg fuscous except ochraceous buff distally on femur and tibia, and tarsal annulations. Abdomen blackish fuscous with a slightly paler lateral stripe; anal tuft ochraceous buff.

Male genitalia slides JFGC nos. 10582, 11703. Harpe very broad basally, constricted beyond middle, then dilated into a suboval cucullus; costa with a long, curved, digitate projection before constriction, and at base a thick pointed process (triangular in cross section). Gnathos divided, consisting of two long elements flattened

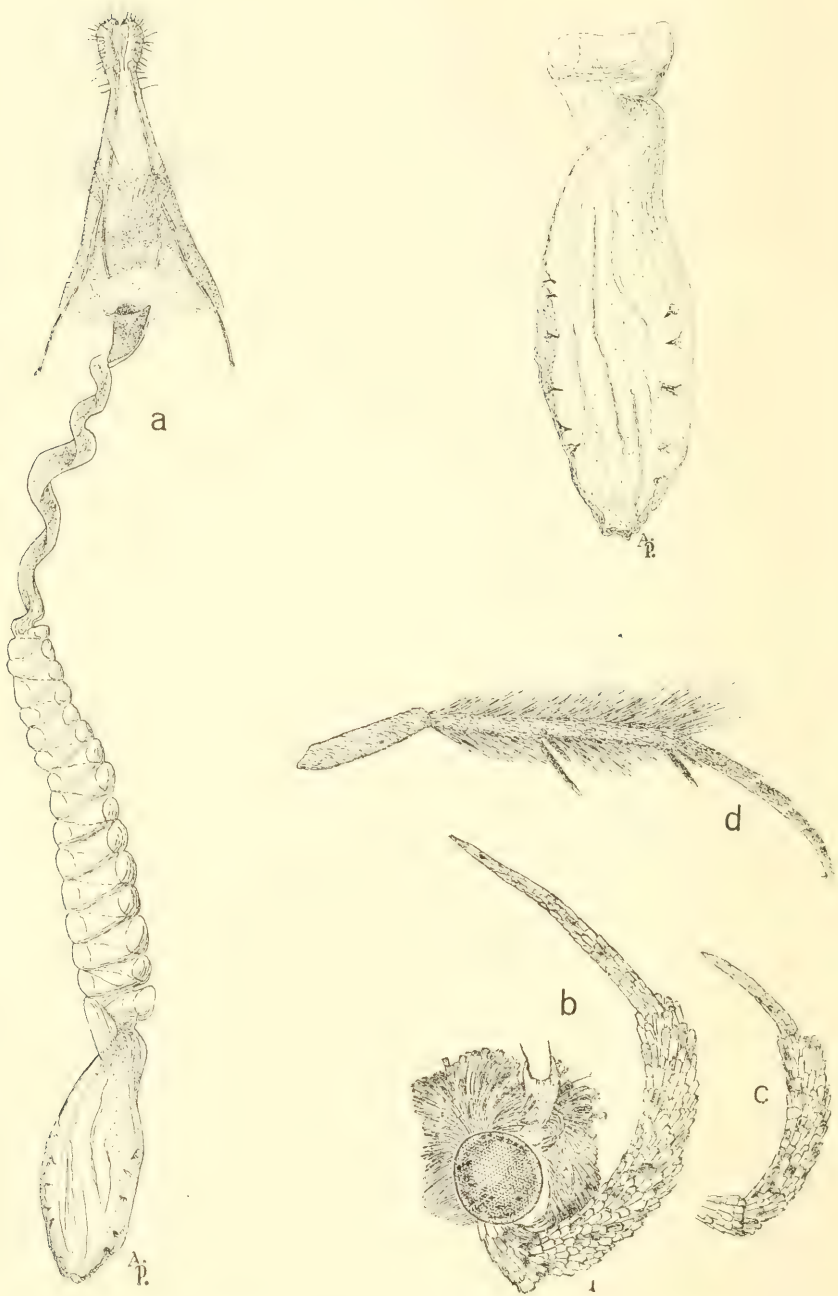
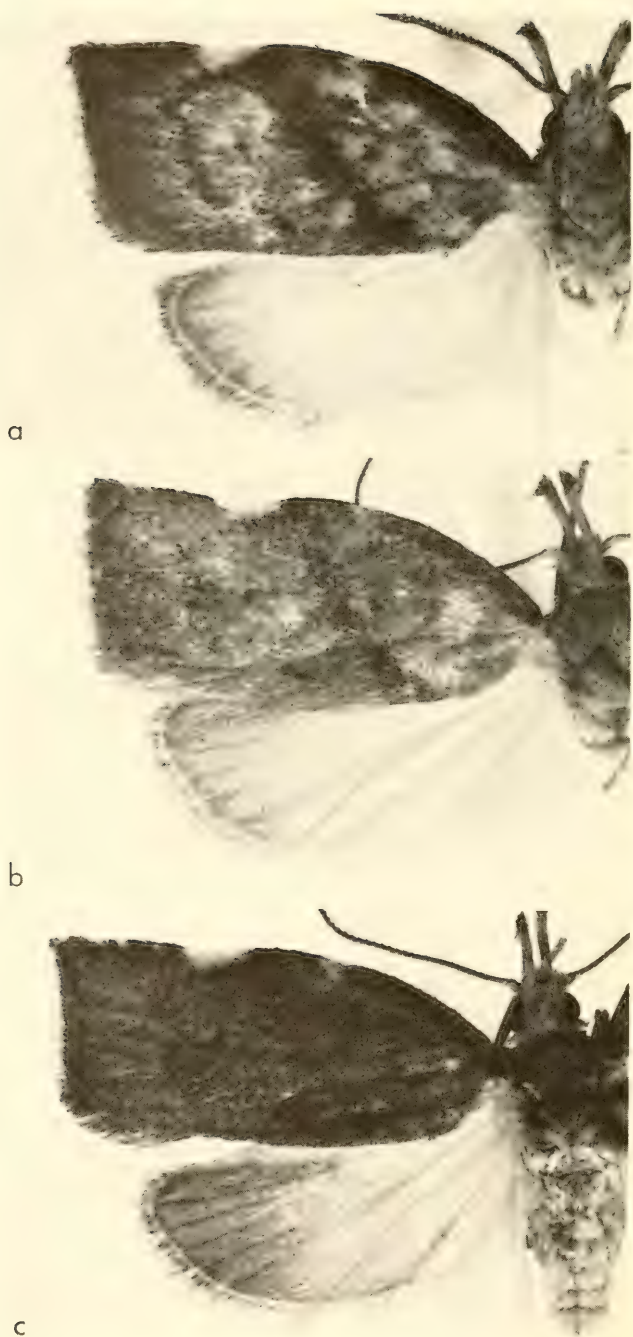


FIGURE 2.—*Maesara gallegoi*, new species: *a*, ventral view of female genitalia with bursa copulatrix at right side; *b*, lateral aspect of head of female showing labial palpus; *c*, labial palpus of male; *d*, hindleg.



Maesara gallegoi, new species: *a*, male (holotype); *b*, female, left wings.



Gonionota insulana, new species: *a*, male (holotype), left wings; *b*, female (light form), left wings; *c*, female (dark form), left wings.

and dilated distally. Uncus triangular, hood shaped, clothed with stiff setae. Vinculum produced into a point. Tegumen narrow, somewhat longer than harpe. Anellus consisting of a narrow ventral band and a strongly developed, broad dorsal tube; laterally, on each edge of the tube a pyramidal process with a granular surface. Aedeagus curved, swollen at middle, unarmed.

Female genitalia slides JFGC nos. 10939, 11704. Ostium transverse, oval. Antrum strongly sclerotized. Ductus bursae long, spiraled; posterior third lined with a narrow, longitudinal scobinate band. Bursa copulatrix membranous. Signa 11, in two longitudinal rows of small thorns; lamella antevaginalis and lamella postvaginalis membranous.

Holotype: U.S. National Museum No. 69716.

Type-locality: Colombia (Antioquia) Rionegro.

Distribution: Of this species, Dr. Gallego states (in litt.): "In several municipalities of Oriente Antioqueno and other departments of Caldas, Boyaca and Cundinamarca (2200-2600 m.)."

Food plant: *Pyrus malus* L. (*manzano*). Larva boring in the twigs.

Described from the holotype male, 7 ♂♂ and 18 ♀♀ paratypes all from the same locality (September and October dates). Paratypes will be placed in the U.S. National Museum; in the Departamento de Entomología, Facultad de Agronomía e Instituto Forestal, Universidad Nacional, Medellín, Colombia; and in the British Museum (Natural History).

Presumably, this moth is a native Neotropical species; it is interesting that it should be found damaging apple, an introduced plant, while its native host is still unknown. The habits and economic significance of this species will be published by Dr. Gallego and his associates.

It gives me very great pleasure to dedicate this species to Dr. F. Luis Gallego M., dean of South American entomology.

Gonionota Zeller

Gonionota insulana, new species

FIGURE 3; PLATE 2

Alar expanse 17-19 mm.

Labial palpus orange yellow irrorate with scarlet and brown scales; apex of third segment ochreous white. Antenna light brown suffused reddish in some examples; scape orange yellow irrorate with scarlet. Head orange yellow with scattered scarlet scales along sides and on frons. Thorax orange yellow mixed with scarlet and brown scales. Forewing ground color orange yellow; costa to three-fifths russet; extreme edge narrowly black interrupted by a white streak at two-fifths; on costa, beyond three-fifths an orange yellow spot with extreme

costal edge white; from basal third to costal three-fifths an outwardly oblique, russet band, confluent with dark costal shade, terminating in point, the latter confluent with an outwardly curved series of black

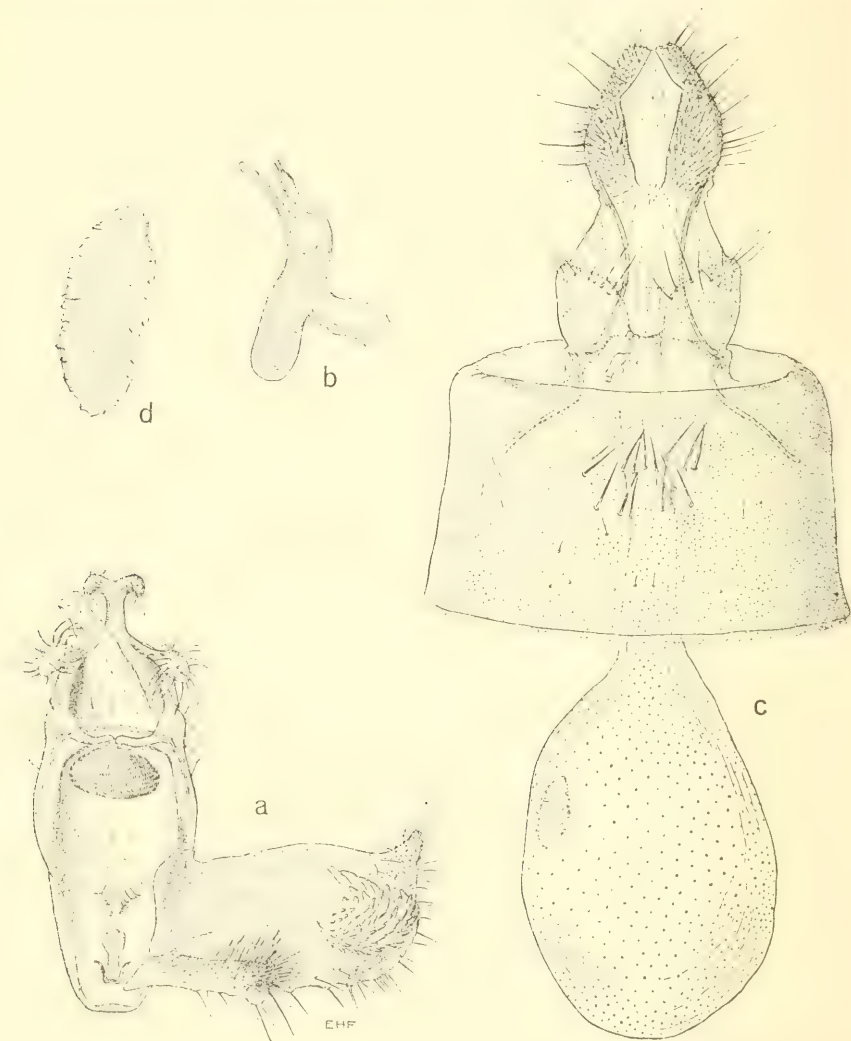


FIGURE 3.—*Gonionota insulana*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia; *d*, signum, enlarged.

spots; terminal area of forewing russet; discal stigmata, two, blackish, at one-third in cell and at end of cell; irregular lines and blotches scarlet; cilia yellow to tornus then fuscous; underside with scarlet and brown and much white scaling. Hindwing buff shaded with brown

and russet toward edges; cilia russet and brown terminally, buff toward anal angle. Foreleg white overlaid with light brown and scarlet on outer side; midleg white; femur with scattered brown and scarlet scales on outer side; tibia with scarlet dash distally on outer side; tarsus shaded with scarlet distally; hindleg white with scattered brown and scarlet scales; tarsus suffused reddish distally. Abdomen ochereous white dorsally, somewhat more yellowish toward middle; ventrally irrorate with ochereous white, scarlet, and fuscous scales.

Male genitalia slide JFGC no. 11681. Harpe subrectangular; cucullus pointed dorsally; at about middle of cucullus a large cluster of heavy spines; sacculus a prominent ridge from base to about middle of harpe. Gnathos an oval, spined knob. Uncus divided into two divergent arms from a central stalk. Vinculum narrow, truncated. Tegumen as long as harpe. Anellus a very narrow plate, dilated distally. Aedeagus stout, curved, with a cluster of bristles distad.

Female genitalia slides JFGC nos. 11678, 11679, 11680. Ostium small, slitlike, membranous. Genital plate membranous. Antrum narrowly and very lightly sclerotized. Inception of ductus seminalis from anterior edge of antrum. Ductus bursae membranous. Bursa copulatrix membranous with a small, slightly sclerotized signum, dentate along the edges.

Holotype: U.S. National Museum No. 69717.

Type-locality: Dominica, .5 mile east of Pont Casse (13 January 1965; J. F. G. and Thelma M. Clarke).

Distribution: Dominica.

Food plant: Unknown.

Described from the holotype male and 7 ♀♀ paratypes as follows: 2 ♀♀, Springfield Est., 20–26 July 1963; 2 ♀♀, .4 mile east of Pont Casse, 23 June 1964, 21 May 1964; ♀, 1.6 miles west of Pont Casse, 16 June 1964 (all collected by O. S. Flint); ♀, 1 mile east of Pont Casse, 1800 feet, 29 January 1965 (J. F. G. and Thelma M. Clarke); ♀, Pont Casse, 7 June 1965 (Don R. Davis).

Only eight specimens of *insulana* came to hand during many nights of collecting over a two-year span. Moreover, all were collected within a radius of three miles although the island was covered, during the two-year period, by many collectors. At best the species is rare.

This is an unusually interesting species for two reasons: First, it is the only representative of the family Oecophoridae and the sole representative of the genus *Gonionota* on the island. Both the family and the genus are highly developed in the neotropics yet only the one species has succeeded in establishing itself on Dominica. Second, it is unusually variable, a characteristic seldom found in the genus *Gonionota*. In plate 2a I have illustrated the only male available that shows a clearly defined pattern and contrasting coloring. Plate 2b illustrates

a female with a less well-defined pattern and suffused coloring. In the female shown in plate 2c practically the whole pattern has disappeared, and the whole upper surface of the wing is overlaid with light brownish scales. Careful examination with a microscope reveals the same markings, though greatly subdued, that are found in the other specimens.

In general, the male of *insulana* appears similar to that of *G. comastis* (Meyrick), but it is much smaller and lacks the conspicuous, white discal spot of forewing of that species. The evenly colored female (pl. 2c) resembles that of *G. isastra* (Meyrick) in color, but it is little more than half the size of that species. In the male genitalia, both *isastra* and *comastis* lack the large disc of coarse spines found in *insulana*. Since the females of *isastra* and *comastis* are unknown, no comparison of the genitalia can be made.

Neotropical Microlepidoptera Series in the *Proceedings*

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Parallel Evolution in
the Small Species of *Indicator*
(Aves)

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One of the aspects of avian taxonomy that inevitably has to wait on the gradual amassing of considerable material is the appreciation, and the consequent elucidation, of sympatric sibling species. Until sufficient numbers of specimens become available, the investigator can only treat the minor differences that he may notice as inconsistent, but apparently individual, variations in a not completely homogeneous taxon.

The genus *Indicator* presents an unusual array of sympatric, closely similar species distinguished primarily by size. In the Acacia grasslands of much of eastern Africa there are three similar species (in descending order of size): *minor*, *meliphilus*, and *narokensis*. In the forests of western and central Africa there are *conirostris* (a race of *minor*), *exilis*, *willcocksii*, and *pumilio*. Not only are the species of the two groups similar in appearance, but their habits vary but slightly. Chapin (1962) found *pumilio* and *exilis* (*pachyrhynchus*) together at Tshibati and saw no difference in their behavior. We can infer that *minor* and *meliphilus* also must be extremely similar in their actions and vocalisms, or variances would have been recorded by the numerous observers who

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have written about them. Some collectors were not aware that there were two species involved until they studied the dried specimens after their field experience.

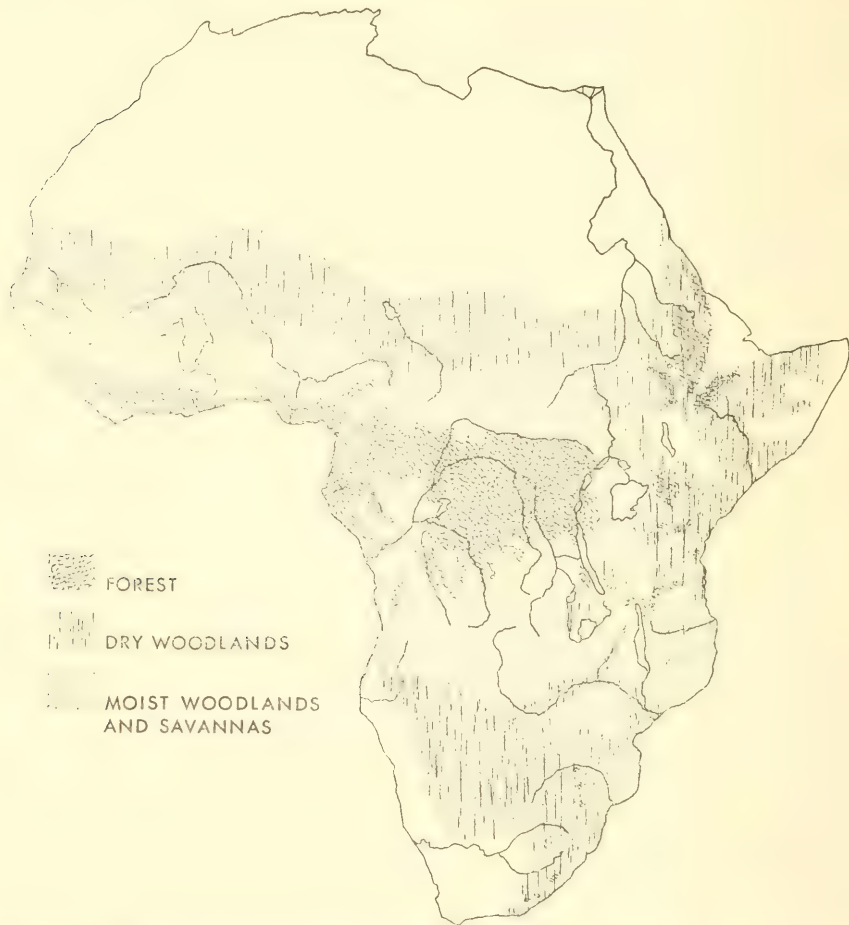


FIGURE 1.—Simplified vegetation map of Africa. The large equatorial forest area is the home of the following honeyguides discussed in this paper: *maculatus*, *conirostris*, *exilis*, *willcocksii*, and, at its eastern end, chiefly at higher altitudes, of *pumilio*. The woodlands and savannas are the home of *variegatus*, *minor*, *meliphilus*, and *narokensis*.

Through the cooperation of the American Museum of Natural History, the Field Museum, and the National Museums of Rhodesia, together with the now considerable holdings of the Los Angeles County Museum of Natural History, plus earlier study of the specimens in the Royal Museum of Natural History in Brussels, the British Museum (Natural History), the Musée d'Histoire Naturelle of La Chaux-de-Fonds, Switzerland, and the United States National Museum, I have

been able to study in depth the morphology and distribution of the smaller *Indicator* species. Some of the specimens were collected under National Science Foundation Grant GB-5107.

The *exilis-willcocksii* Relationship

The small west African forest honey-guides, *exilis* and *willcocksii*, were considered conspecific prior to Chapin's 1962 study when, for the first time, the specific identity of the latter sibling form was elucidated. Until then *willcocksii* had been treated as a western race (Ghana and Togoland) of *exilis*; the fact that *willcocksii*-like individuals occurred here and there throughout the range of nominate *exilis* was, if anything, looked upon as evidence that the latter race provided the variational trends that had become "solidified" in *willcocksii*.

A good number of specimens of *willcocksii* collected in 1966 and 1967, along with those of *exilis* (*pachyrhynchus*) in extreme western Uganda (Kibale and Impenetrable Forests), clearly upholds Chapin's conclusions in regard to the distinctness of the two sympatric species. When series are laid out, the differences between the species is more marked than that suggested by single examples.

Chapin's attention was brought to bear on the *exilis-willcocksii* situation as a result of his discovery and description of the still smaller, partly sympatric *pumilio*. While the validity of *pumilio* as a species distinct from its sympatric congeners is clear as has been universally accepted by all students of African birds, Chapin (1958, p. 47) did not pursue the question of its relation to the paler, small *Indicator* species of the open country of eastern Africa beyond commenting that the very small beak of *pumilio* caused him to think at first that it might be conspecific with *meliphilus*. The striking difference in coloration of the two species persuaded him to name *pumilio* binomially, but he felt constrained to add that he was still of the opinion that "its small beak may well indicate relationship with *meliphilus*"

The *meliphilus-narokensis* Relationship

Just as *willcocksii* had been looked upon as a part of the variational limits of *exilis* until sufficient series of specimens became available for study, *meliphilus* too has been assumed to comprise within its extremes, the species *appellator* Vincent (1933) and *narokensis* Jackson (1906). Ever since Chapin's discovery of *pumilio* in the Kivu forests I have wondered whether or not *meliphilus*, like *willcocksii*, might also have a smaller, sympatric sibling form. The description and dimensions of *appellator*, described from Zobu  on the border of Mozambique and Malawi, were too close to those of *meliphilus* to

cause any concern, but *narokensis* was described as much smaller than the average *meliphilus* as *pumilio* was than the average *exilis* (or *wilcocksii*). As long as *narokensis*, however, was known from only one or two odd specimens, to decide if it was a taxon in its own right or merely the smallest specimens of *meliphilus* was impossible. Accordingly, in three different publications (1954, 1955, 1958) I could treat it only as a probable synonym of *meliphilus*, which, until 1958, was still considered to be an eastern, pale, gray-breasted race of *exilis*.

As long ago as 1938 Grant and Mackworth-Praed (pp. 143-144) examined van Someren's pair of *narokensis* from Mt. Moroto and found that the two specimens agreed with Jackson's type from Mt. Doinyo Narok and with Granvik's specimen from Kacheliba. Grant and Mackworth-Praed concluded that comparison with examples of *meliphilus* "clearly show that *I. narokensis* is a distinct species having a smaller bill and a smaller wing measurement It is a very remarkable fact that there are two birds so very similar in coloration . . . and, although they both occur in the same general area in Kenya Colony, it may be found that they inhabit different types of country, as Granvik records *I. narokensis* in tall acacias in dry open country, and Moreau records *I. e. meliphilus* in the vestiges of coastal forest"

I now feel certain that only lack of critical specimens in most of the large museums caused Grant's and Mackworth-Praed's conclusion to be overlooked. In the absence of such material, it had been impossible to test it. At the time of their report, their conclusion seemed too remarkable to be likely, and I left *narokensis* in the unverified synonymy of *meliphilus*. White (1965) does not even mention *narokensis*, either as a valid taxon or as a synonym—an indication that he was content to go along with current disbelief in it. The remarkable, and hence unlikely aspect of a distinct species, *narokensis*, being sympatric with *meliphilus* has, of course, been changed completely by Chapin's findings of three sympatric sibling *Indicator* species in the Congo. In the light of his results, it is not surprising that a comparable situation should exist among the small *Indicator* species of eastern Africa.

In 1957 Mackworth-Praed and Grant (p. 745) again treated *narokensis* as a species, smaller and generally paler in color than *meliphilus*, and listed a number of specimen-based locality records: Mt. Moroto in eastern Uganda; Kacheliba in Turkanaland, northwestern Kenya; Mt. Doinyo Narok, Sokoke Forest, and Malindi, all in southern Kenya; and Lushoto, in northeastern Tanzania. Subsequently, I have seen other records that have reported the species from Shimba Hills, near Kwale, and southern Guaso Njero, in southern Kenya, and from Sigor, West Pokot, western Kenya. With these

last three examples, it became obvious that there were indeed two very similar species living side by side in eastern equatorial Africa. This caused me to assemble as complete a series as possible in order to review the situation again and to seek new conclusions.

Although very similar to each other, *narokensis* and *meliphilus* should be treated as specifically distinct. In *narokensis*, the wing length varies from 65 to 70 mm in four females, 67 and 69 mm in two males; in *meliphilus*, 18 females have wing lengths from 69 to 78.5 mm, 18 males, from 73.5 to 85.5 mm. The bill is "stubbier" to the eye in *narokensis*, more so than actual measurements reveal; length from distal end of nostril to tip of culmen is 4.2 to 4.8 mm (4.7 to 5.9 mm in *meliphilus*), the exposed culmen is 5.7 to 7 mm (7.1 to 8.5 mm in *meliphilus*). Actually, the bills of *narokensis* are very similar to those of *pumilio*. This supports Chapin's comment, cited above, that *pumilio* may be related not merely, as he put it, to *meliphilus*, but even more closely to that part of *meliphilus* (*olim*) now separated as *narokensis*.

In my 1958 paper I explored the question of the status of the western race of *meliphilus*, which Monard (1934, p. 55) had designated *angolensis* as a subspecies of *minor*! I still believe that there are two recognizable races of *meliphilus*, although they are based on average differences and not on more trenchant characters; *angolensis* is usually paler gray, especially on the throat, breast, and upper abdomen than nominate *meliphilus*. Chapin (1954, p. 633; 1962, p. 44) considered *angolensis* indistinguishable from *meliphilus*, but he also put *narokensis* in this category. More recently, Traylor (1963, p. 108) has supported the belief that *angolensis* is the southwestern race of *meliphilus*, and I may add that the additional specimens I have seen since my 1958 paper also have supported this division. The removal of *narokensis* from *meliphilus* increases the average duskiness of the residual nominate *meliphilus* since the palest members of that taxon, as formerly treated, are all *narokensis*.

The *narokensis-pumilio* Relationship

The relationship of *narokensis* and *pumilio* parallels very closely that of *meliphilus* and *exilis* and that of *minor* and *conirostris*. Inasmuch as *meliphilus* and *exilis* have been found to overlap sympatrically in the Mwinilunga district, Zambia, and in the Upemba Park, in the Congo (Verheyen, 1953, pp. 406-407), their specific distinctness has to be granted. The situation between *minor* and *conirostris*, however does not include this convenient sympatry, and they usually are still considered to be races of one species. While *conirostris* is a dark-colored forest-inhabiting form with a discontinuous range from western Kenya (Kakamega and Kapenguria) west to southern

Cameroon and Gabon, typical *minor* is the bird of the open country of southern and eastern Africa, west and south of the Congo forest to Angola. It now seems that *pumilio* is the dark forest counterpart (from the eastern Congo, discontinuously to Kakamega, in western Kenya) of the pale *narokensis*, which is now known to occur from Turkanaland south to northeastern Tanzania and west to the Upemba Park in the Congo.

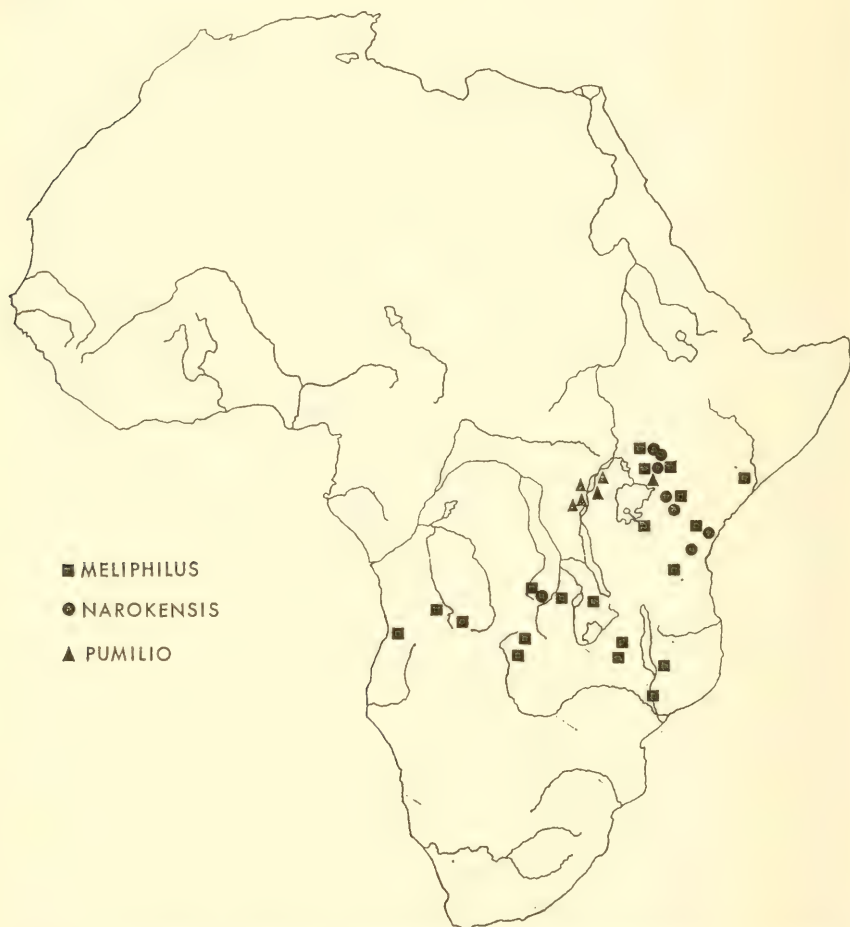


FIGURE 2.—Specimen records of the three small species of *Indicator* whose relationships are reinterpreted in this paper.

The subspecies *conirostris* is not wholly constant in its color characters; in fact, in parts of western Africa, especially in Upper Guinea, it and its geographic replacement *riggerbachi* frequently show some intergradation toward the adjacent, paler forms of *minor*—*alexanderi*,

ussheri, and *pallidus*, some of which are such intermediates as to be doubtfully recognizable as racial entities. Similarly, *pumilio* has been found to be geographically variable. Its data are much less extensive, being based merely on the fact that its easternmost example (Kakamega Forest, western Kenya) is different from Kivu topotypes, a difference that was sufficient to cause Williams and Friedmann (1965) to raise the possibility of the Kakamega bird being racially separable from the eastern Congo population. We found the single Kakamega specimen to be slightly larger (wing 70 mm), to have more uniformly grayish underparts without the streaks that are present in the birds from the Kivu and the Impenetrable Forest, southwestern Uganda, and to have the top and sides of the head less greenish, more grayish. If additional material from Kakamega should agree in these color characters, which are in the direction of a more grayish and paler shade—or, to an extremely slight, almost incipient degree, in the direction of the very much paler and grayer *narokensis*—there would be a situation faintly resembling that existing in *conirostris* and *ruggenbachi* in Upper Guinea and other races of *minor* in the open country north of the forest belt. Kakamega, where *pumilio* occurs, and Sigor, West Pokot, where *narokensis* has been taken, are barely 75 miles apart.

Enough has been said to warrant raising the question whether or not *pumilio* is a true species or an unusually distinct race of *narokensis*. To be wholly consistent, I would have to treat the two as conspecific forms by the same standards that I use when considering *conirostris* and *minor* in this matter. The real question is whether they are representative races or whether they have differentiated to the point where they are specifically distinct. Unfortunately, this question could be answered only by bringing them into contact under natural conditions, which cannot be done. I, therefore, favor considering the two as races of a single species merely to point out their mutually representative nature and to suggest their closer relationship in the not too distant past. That they are closely allied is intimated by analogy with *minor* and *conirostris*, and while this is certainly no proof, it may yet reveal a pattern or trend in these small species of *Indicator*.

Without pressing the point beyond its realistic implications, I add the suggestion that *maculatus* (with *stictithorax* as a race) is no more than a west African forest representative of *variegatus* of eastern and southern Africa. It is a comparable case.

Morphological Overlap and Sympatry in Sibling Species

While I conclude that *narokensis* is a species distinct from *meliphilus*, I realize that other observers may have the experience of finding specimens that are difficult to place in either species. It would be

comforting to find reliable and rigid key characters by which to separate *narokensis* from small *meliphilus*, but this is not always feasible.

A similar state of affairs occurs, however, with such generally accepted species as *exilis* (*pachyrhynchus*) and *minor*. Small individuals of the latter often are difficult to distinguish from examples of the former, but this does not cause serious doubts as to their specific distinctness. In these birds, not only is there a serial gradation in size among sympatric species, but also the very limits of the species are at times difficult to distinguish. The resulting situation makes one wish for more observational data regarding the critical isolating mechanisms involved. In the case of *pumilio* and *exilis* (*pachyrhynchus*), I was able to find skeletal characters that corroborated their external specific distinctness, but these differences are not necessarily isolating mechanisms (1963). Benson and Irwin (1964, p. 110) write that *meliphilus* has a thinner, softer skin than *exilis* and other local species of *Indicator*. They even suggest that, in this respect, *meliphilus* is more like *Prodotiscus* than like other species of *Indicator*. So far, however, no pertinent observations on the feeding habits of *meliphilus* have been brought forth that indicate whether or not it is more or less given to feeding on small insects generally than are other species of *Indicator*. It is known that it does feed on bee comb like its congeners and unlike *Prodotiscus*.

Sympatry and Parallelism in Sibling Species

Considering the fact that sibling species, or even species of only approximately similar external characters, usually are related fairly closely, and considering the further fact that the origin and establishment of the discontinuities between such species ordinarily involve allopatry of some duration, it is noteworthy how quickly and how extensively some of these small *Indicator* species once more have become sympatric. This fact argues for effective, but as yet unrecognized, isolating mechanisms. The number of instances of two or more of these morphologically similar honey-guides occurring together is very impressive—Kabompo District, Zambia: *exilis* (*pachyrhynchus*) and *meliphilus* (Benson and Irwin, 1965, p. 4); Tshibati, Kivu District, Congo: *pumilio* and *exilis* (*pachyrhynchus*) (Chapin, 1958, p. 48); Doiyo Narok, Kenya: *meliphilus* (specimen in American Museum of Natural History, collected by Jackson) and *narokensis* (Jackson, 1906, p. 20); Kibale Forest, west Uganda: *exilis*, *willcocksii*, *conirostris*; Impenetrable Forest, west Uganda: *willcocksii*, *exilis pumilio*; Sigor, West Pokot, western Kenya: *narokensis*, *meliphilus*; Mt. Moroto: *minor*, *narokensis*; Victoria, British Cameroons: *minor* (*conirostris*), *exilis*, *willcocksii* (Serle, 1965, p. 77).

Here, then, is a series of remarkably parallel situations of similarly colored, sympatric species, each with a paler, grayer form in the open grasslands of eastern Africa and each with a darker, greener representative in the forests of central and western Africa. In some, the representatives are clearly conspecific; in others, they have achieved specific distinction—*minor* and *conirostris*; *meliphilus*, *willcocksii*, and *exilis*; *narokensis* and *pumilio*; *variegatus* and *maculatus*.

It is, of course, impossible to state with any certainty either that these similar species all originated as greenish forest birds that gave rise to paler, grayer races in the open country, or that all began as grayish denizens of the savannas and each evolved a darker, greenish representative form in the wooded areas. It is equally possible that some may have gone one way, and others, the opposite direction; but the end result, which is all we have for study, shows a remarkable parallelism. As Mayr (1963, p. 609) noted, true parallelism is due to the necessarily similar response of a common genetic heritage to similar selection pressures. Inasmuch as all of these species of honey-guides seem in every way to be closely related, and, hence, to have a basically similar genetic composition, their parallel evolutionary picture seems to be true parallelism rather than mere convergence, a situation wherein similar phenotypic developments have resulted as a response to similar environmental selection factors. The small species of *Indicator* have, at best, a very restricted phenotypic potential, much like some of the tyrant flycatchers of the genera *Empidonax* and *Elaenia*.

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Copepod Crustaceans Parasitic
on Fishes of Eniwetok Atoll¹

By Alan G. Lewis²

Copepod parasites of fishes of Eniwetok Atoll, one of the Marshall Islands, have not been previously studied. The only reference dealing with parasitic copepods from this general region of the Pacific is that of Heegaard (1943) concerning some caligids from the Gilbert Islands. Both Heegaard (1940, 1962) and Kabata (1964, et al.), however, have described copepods from fishes from the neighboring Australian region, some of which are also found on fishes from Eniwetok Atoll, and Hewitt (1963, et al.) and Thomson (1889) have described copepods from fishes of New Zealand. These studies, as well as those of Lewis (1964a, et al.) concerning copepods from Hawaiian fishes, cover most of the named species although some of them have previously been described from other areas, primarily the western Pacific and the Indian Ocean.

The study herein reported is based on two collections made by the author during the summers of 1959 and 1961. He is indebted to the U.S. Atomic Energy Commission for the use of the facilities at the Eniwetok Marine Biological Laboratory. He is also grateful for the

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assistance given to him by James Coatsworth, John Shoup, and David Au, who were serving as research assistants at the Eniwetok Marine Biological Laboratory during the periods when the collections were made. Finally, the author appreciates the help given to him by members of the Division of Crustacea of the Smithsonian Institution during the time of final examination of the specimens in the collections.

METHODS.—The external surface, gill cavities, buccal cavity, and nasal cavities of the hosts were examined for parasitic copepods. Copepods collected were killed and preserved in 95 percent ethyl alcohol. Specimens to be drawn or dissected were placed in 85 percent lactic acid to clear and soften them, stained with Chlorazol Black E dissolved in 85 percent lactic acid, and then placed in benzyl alcohol for final clearing and for dissection and drawing.

Drawings of the entire animal were made from specimens placed in benzyl alcohol and covered with a cover slip, supported so that the shape of the organism was not distorted. A camera lucida was used in making the drawings. The appendages and processes were

TABLE 1.—*Armature of hypothetical thoracic leg shown in figure 1*

| Leg | Surface | Inter-podal Plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------------|---|-----------|-----|--------------------|------------|------|----------|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| | Outer | | m,h,rh,r | | r,D,d,dh | II | III,Z,mII, dmH. | C | c | mp',mp,Q |
| | Inner | | a,sss,s, dm,fm | | c,fm,II | c,P | Cl,cl,dH | P | p,p' | 2P',Q' |

drawn in situ or were removed and mounted in either Hoyer's mounting medium or a 1:1 mixture of Turttox's CMC-10 and CMC-S. Measurements were made with an ocular micrometer on specimens softened in lactic acid and held loosely in place by a cover slip supported by spacers.

In the figures, the ♀ and ♂ signs are used separately under each drawing to indicate a difference between the appendage or body part of the female and that of the male. The symbols are used together (♀ ♂) to indicate the similarity of the appendage or body part in both sexes. In the latter case the sex of the specimen from which the drawing was made is indicated by a line under the appropriate symbol.

TERMINOLOGY.—The term "cephalothorax" is used to indicate a condition in which one or more of the thoracic segments are fused with the cephalon. The maxilliped-bearing segment is considered as the first thoracic segment. The term "pedigerous segment" is used to indicate a leg-bearing thoracic segment, while the terms "free thoracic

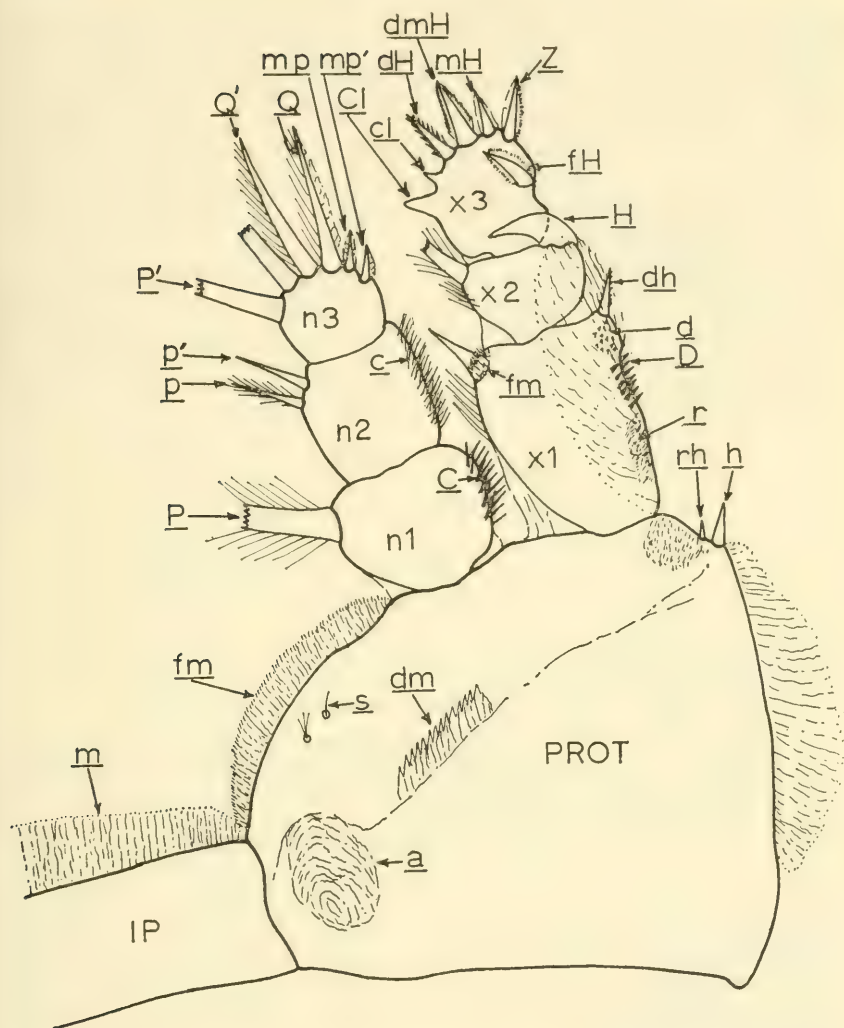


FIGURE 1.—Hypothetical thoracic leg showing the various armament components (a=adhesion pad; C=large plumosities; c=small plumosities; Cl=large spikelike extension of segment; cl=small spikelike extension of segment; D=large denticulations; d=small denticulations; dH=large spine with denticulations; dh=small spine with denticulations; dm=denticulated membrane; dmH=large spine with denticulated membrane or membranes; fH=large spine with frilled membrane or membranes; fm=frilled membrane; H=large spine; h=small spine; IP=interpodal plate; m=membrane; mH=large spine with simple membrane or membranes; mp=setule with membrane on both sides; mp'=setule with membrane on one side, naked on other; n 1,2,3=endopodite segments one, two, three; P=plumose seta; P'=naked seta; PROT=protopodite; p=plumose setule; p'=naked setule; Q=seta with plumosities on one side, membrane on other; Q'=seta with plumosities on one side, naked on other; r=numerous minute projections giving rugose appearance; rh=spinule; s=hairlike process; x 1,2,3=exopodite segments one, two, three; Z=spine with frilled membrane on one side, simple membrane on other).

segments" and "free pedigerous segments" are used to designate those thoracic segments that are not fused with the cephalon. The term "genital segment" is used, with some reservation, to designate the fused sixth and seventh thoracic segments (= fifth and sixth pedigerous segments) in the Caligidea (Caligoidea of Yamaguti, 1963). The term "ovigerous" is used to indicate a female with egg strings, the term "nonovigerous" to indicate a female without egg strings even though the genital segment may contain eggs.

The terminology applied to the appendages and processes is the same as that in Lewis (1967). To facilitate the use of the thoracic leg tables, a hypothetical thoracic leg is shown in figure 1, giving the various thoracic leg armature elements used in the tables; an analysis of the hypothetical thoracic leg is given in table 1.

Order CYCLOPOIDA

Family BOMOLOCHIDAE

Nothobomolochus gibber (Shiino)

FIGURES 2-4

Bomolochus gibber Shiino, 1957, p. 411, figs. 1-2.

Nothobomolochus gibber (Shiino).—Vervoort, 1962, p. 70.

Pseudartacolax gibber (Shiino).—Yamaguti, 1963, p. 14, pl. 8, fig. 1.

HOST AND DISTRIBUTION.—*Tylosurus giganteus*, Japan.

MATERIAL.—8 females and 2 males (USNM 120739) from the gill cavity of *Belones platyura* Bennett.

MEASUREMENTS (in mm).—7 females and 2 males:

| | female | | male |
|---|--------|-------------|--------------|
| | mean | (range) | |
| Greatest length, excluding caudal setae | 1. 82 | 1. 71-2. 02 | 1. 57, 1. 58 |
| Length of prosome | 1. 15 | 1. 03-1. 30 | 1. 01, 0. 95 |
| Width of prosome | 0. 98 | 0. 90-1. 08 | 0. 81, 0. 86 |
| Length of cephalothorax | 0. 67 | 0. 58-0. 74 | 0. 50, 0. 58 |
| Length of genital segment | 0. 21 | 0. 18-0. 25 | 0. 16, 0. 14 |
| Width of genital segment | 0. 29 | 0. 22-0. 36 | 0. 29, 0. 25 |
| Length of egg sac (6 sacs) | 1. 23 | 0. 99-1. 37 | |

DESCRIPTION.—Cephalothorax of ovigerous female (fig. 2a) wider than long, consisting of cephalon and first 2 thoracic segments. Anterior end of cephalothorax forming 2 bilobed projections separated by rounded dorsal and bilobed ventral median surfaces. Lateral margins irregular, lateral posterior margins lobate. Dorsal cephalothoracic surface arched, with anterior median fissure. Width of free second pedigerous segment slightly more than two and one-half times the length, slightly more than half the width of cephalothorax. Lateral surfaces winglike, extending slightly past base of second

thoracic leg. Third and fourth pedigerous segments separable ventrally, fused dorsally; dorsal surface topshaped although irregular, greatest width slightly more than that of second pedigerous segment; posterior surface overlapping fifth pedigerous (first urosomal) segment.

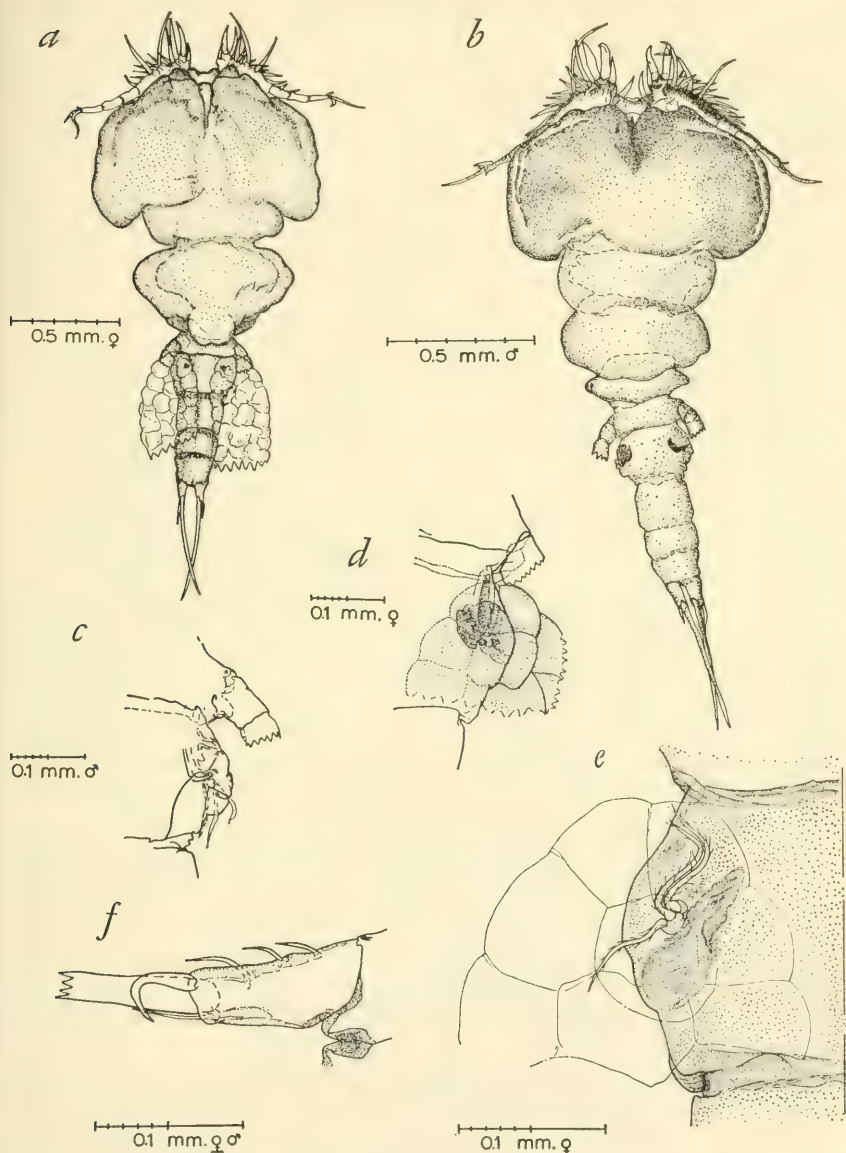


FIGURE 2.—*Nothobomolochus gibber* (Shiino, 1957): *a*, female dorsal view; *b*, male, dorsal view; *c*, male, genital segment, ventral view; *d*, female, genital segment and part of egg string, ventral view; *e*, same, dorsal view; *f*, caudal ramus, ventral view.

Female fifth pedigerous segment slightly less than half the width of third and fourth, widest medially, in region of leg attachment. Genital segment (figs. 2*d*, *e*) broadest medially, tapered to posterior and anterior ends. Oviducal openings situated on lateral dorsal surface, region around openings ornamented with heavily sclerotized platelets. Sixth legs situated on dorsal surface, adjacent to oviducal openings, consisting of 3 lightly plumose setae originating from nodule.

First segment of female abdomen subrectangular, length approximately three-fourths that of genital segment. Second segment subrectangular, four-fifths the length of first. Third segment slightly longer than second, tapered posteriorly, posterior surface with bilobed anal indentation. Caudal ramus (fig. 2*f*) subconical, bearing 3 naked or lightly plumose setules on outer surface and large, lightly plumose seta as well as 2 lightly plumose setules from distal surface.

Cephalothorax and free second pedigerous segment of male (fig. 2*b*) generally similar to those of female. Third and fourth pedigerous segments distinct, not fused as in female. Both segments of about equal length, third approximately one and one-third times the width of fourth. Fifth pedigerous, genital, and abdominal segments similar to those of female.

Female and male antennule (fig. 3*a*) 5-segmented, attached to ventral surface of inner lobe of bilobed projection at anterior end of cephalothorax. Segment lengths, in micra, 205:135:90:95:100. First segment with base at right angles to rest of segment and appendage, bearing 14 lightly plumose setae along anterior surface, 3 naked setules on posterior distal surface. Second through fifth segments rodlike; second with 6 lightly plumose and 3 naked setules, third with 3 naked setules, fourth with 2 naked setae on distal surface. Fifth segment with single, naked setule on distal posterior surface, also with 3 naked setules and one naked seta on distal surface.

Female and male antenna (fig. 3*b*) 3-segmented, attached slightly posterior and lateral to antennule base. First segment approximately equal to combined lengths of remaining two, tapered towards distal end, with single naked seta distally. Second segment short, unarmed. Third segment with ventrally facing rows of clawlike denticulations along entire surface and extending on toelike projection of distal surface. Distal surface also with 2 denticulated spines (one not shown in figure), one clawlike spine, and 5 clawlike setae.

Female and male mandible (figs. 3*c*, *d*) 1-segmented, basal region enlarged, with heavily sclerotized medial ridge; distal half rodlike. Distal end of segment bearing 1 large and 1 small, flattened spines serrated along anterior margins. Maxillule (fig. 3*c*) nodular, situated immediately posterior to mandible base, with 2 plumose setae and 2 plumose setules. Maxilla (figs. 3*c*, *e*) 2-segmented, proximal segment

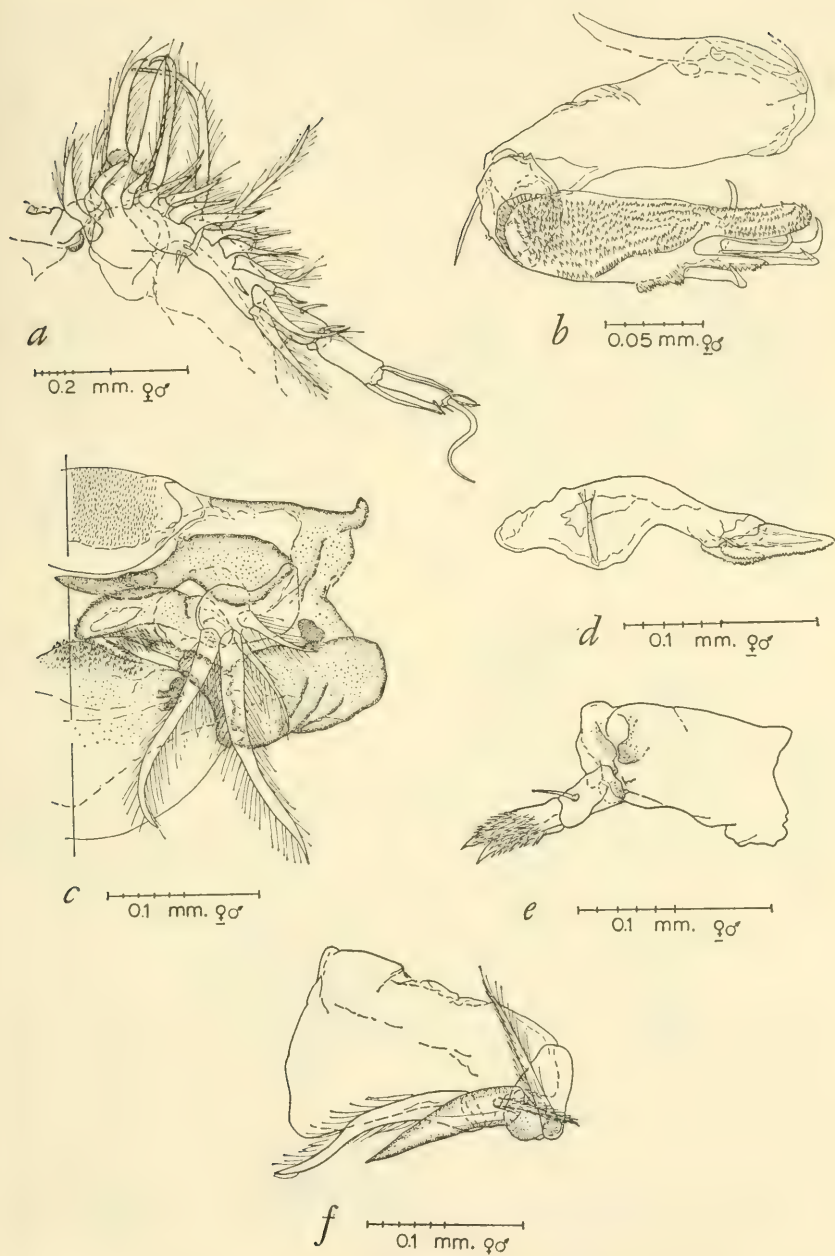


FIGURE 3.—*Nothobomolochus gibber* (Shiino, 1957), female, ventral views: *a*, left antennule; *b*, right antenna; *c*, left side of oral region, showing labrum, mandible, paragnath, maxillule and maxilla; *d*, right mandible; *e*, right maxilla; *f*, left maxilliped.

large, irregular; second segment short, rodlike, bearing 2 stiffly plumose terminal spines and 1 naked subterminal setule. Labrum (fig. 3c) apron-shaped, anterior surface with very fine projections giving fuzzy appearance to surface. Paragnath (fig. 3c) situated medial and posterior to maxillule base, bladeshaped, distal half of margins finely denticulated. Anteriorly V-shaped, posteriorly rounded padlike projec-

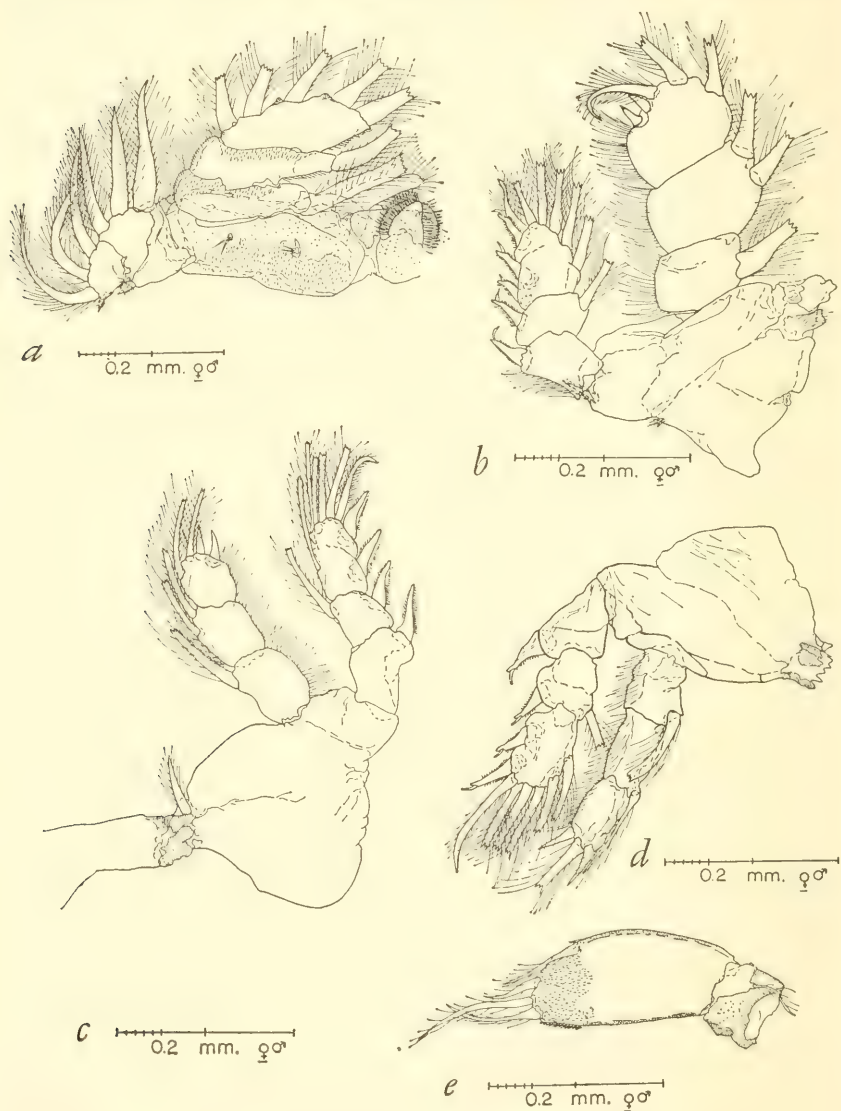


FIGURE 4.—*Nothobomolochus gibber* (Shiino, 1957), thoracic legs: *a*, left first, ventral view; *b*, left second, anterior view; *c*, right third, anterior view; *d*, right fourth, anterior view; *e*, right fifth, ventral view.

tion present immediately posterior to maxilla, extending between maxillae bases.

Female and male maxilliped (fig. 3f) 2-segmented, base situated lateral to maxilla base, body extending anteriorly to antenna base. First segment strongly developed, broad proximally, tapered distally, bearing single, long, finely plumose seta from knob on distal inner surface. Second segment short, inner surface cuplike, outer surface rounded; distal surface with large, sharply curved claw and finely plumose seta.

Thoracic legs 1-4 biramous, fifth leg uniramous. Ramal count 3-3 on first 4 legs. For nature of legs and armature, see figure 4 and table 2.

TABLE 2.—Armature of thoracic legs I-V of the female and male of *Nothobomolochus gibber* (Shiino, 1957)

| Leg | Surface | Inter-podal Plate | Protopodite | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------|-----------|----|--------|------------|------|-------|
| | | | | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | C | ss | dh | dh | dh | c | c | c,5P |
| | Inner | | P,sss | c | 3P | 3P | P | c,P | c |
| II | Outer | c | c,p | c,fH | fH | 3fH,2P | c | c | c,2h |
| | Inner | | ss | | P | 4P | P | c,2P | c,3P |
| III | Outer | | P | fH | fH | 2fH,2P | c | c | c,2h |
| | Inner | | | | P | 4P | P | c,2P | c,2P |
| IV | Outer | | | fH | fH | 2fH,2P | c | c | c,h,P |
| | Inner | | | | P | 4P | P | P | h |
| V | Outer* | | p | p,r,p | | | | | |
| | Inner | | | r,2p | | | | | |

*The designations "protopodite" and "exopodite" are used with some reservation.

DISCUSSION.—The Eniwetok specimens differ from Shiino's original description (1957) in several respects:

1. The total length is only 80 percent of that given for the holotype (2.28 mm for Shiino's holotype specimen, 1.82 mm average for the Eniwetok specimens) although Shiino (1957, p. 416) indicates that the holotype is the largest specimen in his collection. Other measurements also differ although it is suggested that these differences are due to both the size of the holotype and the effect of natural variation.

2. The caudal rami of the Eniwetok specimens have 3 setules on the outer surface while Shiino indicates only 2. The third setule, however, may have been overlooked as all 3 are small and almost transparent.

3. Part of the surface of the labrum has a "fuzzy" appearance due to numerous, minute projections. Shiino figures the labrum without the projections.

4. Shiino states (p. 415) that, in the first thoracic leg, "both the rami (are) fringed by stout long spines with multiserial barbs; . . ." This condition was not evident in the Eniwetok material.

5. The antennae of the Eniwetok specimens possess 2 denticulated subterminal setae on the third segment while Shiino indicates that there is only 1.

In spite of these differences, the Eniwetok specimens agree closely with Shiino's original description and, based on this similarity, are believed to be conspecific with *N. gibber*.

Pseudotaeniacanthus species

FIGURES 5, 6

MATERIAL.—1 adult male (USNM 120740) from the external surface of *Acanthurus gahhm* (Forskål).

MEASUREMENTS (in mm).—1 male:

| | |
|---|------|
| Greatest length, excluding caudal setae | 1.73 |
| Length of prosome | 0.81 |
| Width of prosome | 0.63 |
| Length of cephalothorax | 0.49 |
| Length of genital segment | 0.18 |
| Width of genital segment | 0.27 |

DESCRIPTION.—Body (fig. 5a) of general cyclopoid shape: cephalothorax of general bell shape, consisting of cephalon, maxilliped-bearing and first pedigerous segments. Anterior end of cephalothorax rounded although slightly concave medially, set off from rest of cephalothorax by lateral indentation and line of heavy sclerotization extending medially and curving posteriorly from lateral indentation. Lateral margins flatly convex, posterior margin irregularly concave. Second pedigerous segment distinct from cephalothorax, width approximately nine-tenths that of cephalothorax; lateral surfaces winglike, lateral margins flatly convex. Third pedigerous segment distinct from second, appearing slightly narrower than second although of similar shape. Fourth pedigerous segment distinct from third, approximately three-fourths its length, lateral surfaces winglike, as in preceding free pedigerous segments, although lateral margins more rounded.

Fifth pedigerous segment without winglike lateral projections, forming first segment of urosome; slightly narrower anteriorly than posteriorly. Genital segment (fig. 5b) barrel-shaped, slightly more than one and one-half times the length of fifth pedigerous segment;

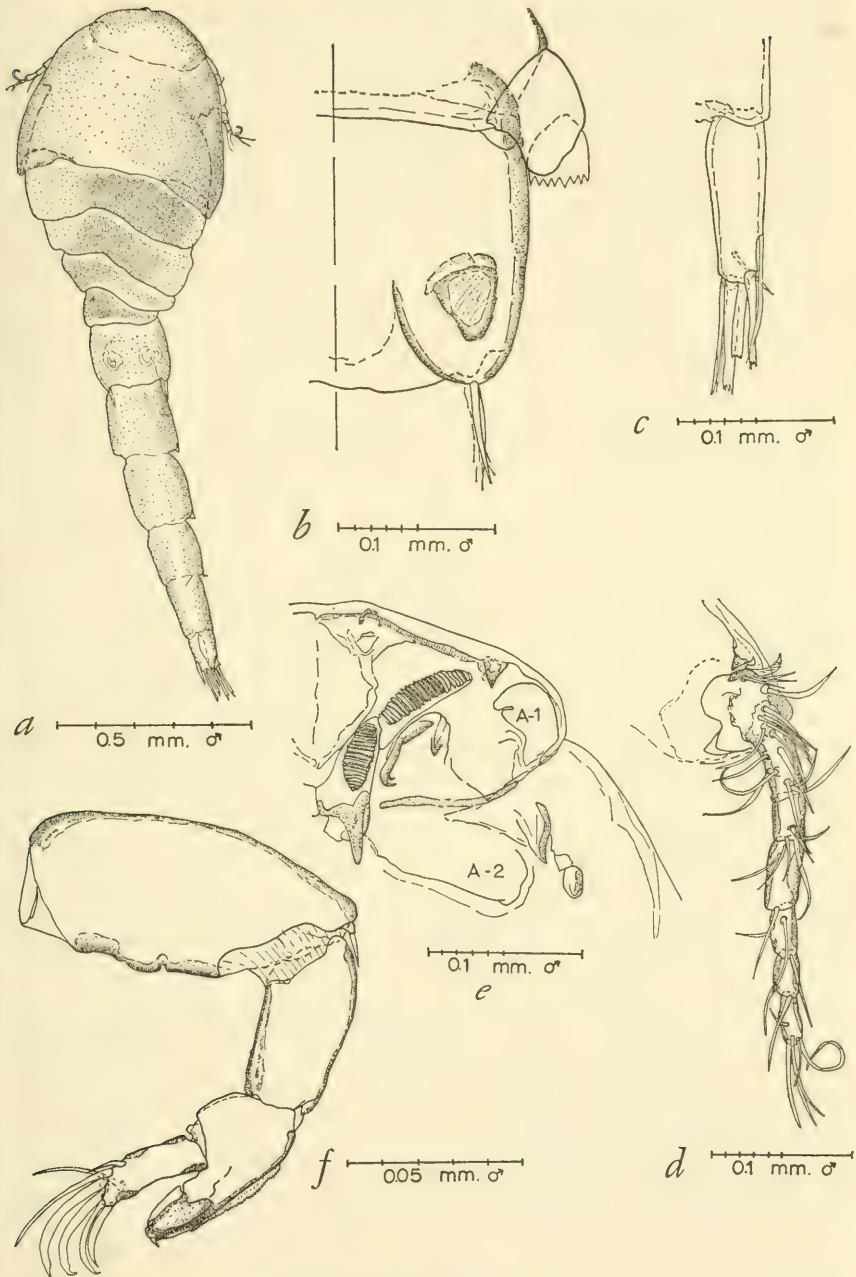


FIGURE 5.—*Pseudotaeniacanthus* species, male: *a*, dorsal view; *b*, left side of genital segment ventral view; *c*, left caudal ramus, ventral view; *d*, left antennule, ventral view; *e*, antenna, region showing antennule base (A-1), antennal base (A-2), and adjacent processes; *f*, right antenna, posterior view.

lateral posterior region lobate, lobes bearing genital openings and sixth legs. Sixth leg consisting of single finely plumose setule. Four segments present posterior to genital segment, first approximately equal to length of genital segment, second approximately nine-tenths its length, third and fourth approximately three-fourths its length. Posterior segments narrower than anterior, lateral margins of first 3 almost parallel, fourth tapered posteriorly, posterior margin with small anal indentation and distinct lateral concavities, at place of attachment and articulation of caudal rami. Caudal rami (fig. 5c) elongate, subrectangular, with setule-bearing indentation in distal half of outer surface; distal surface with 3 naked setae and 1 naked setule, additional naked setule present on dorsal surface just proximal to distal end.

Antennule (fig. 5d) 6-segmented, attached to anterior-lateral ventral surface of cephalothorax, adjacent to small, spikeshaped projection from lateral anterior surface of cephalothorax. First segment (may represent 2 fused segments) strongly flattened proximally, rodlike distally; bearing 19 naked or very lightly plumose setules. Second segment approximately one-third the length of first, with 4 naked or lightly plumose setules. Third segment approximately half the length of first, with 3 naked setules. Fourth segment slightly more than one-third the length of first, bearing 3 naked setules. Fifth segment slightly less than one-third the length of first, with 2 naked setules. Sixth segment slightly more than one-third the length of first, rounded distally, bearing single naked setule from medial posterior surface, 5 naked setules from distal surface. Antenna (fig. 5f) 4-segmented, situated posterior and medial to antennule base. First segment strongly developed, distal surface with naked setule. Second segment approximately half the length of first, subrectangular. Third segment, excluding terminal processes, slightly shorter than second with deep indentation in medial outer surface; distal surface with 2 spatulate and one clawlike projection, inner lateral surface of segment and spatulate process with denticulated membrane or individual denticulations. Fourth segment arising from indentation in third, rodlike, bearing 7 naked setae and setules distally.

Mandible (fig. 6a) 1-segmented, broad proximally, irregularly tapered distally, with spineshaped projection distally; second spine-shaped projection arising from distal half of posterior surface; both projections with denticulations, distalmost with single longitudinal row on posterior surface, proximal projection with 2 rows. Maxillule (fig. 6a) nodular, situated immediately posterior to mandible base, bearing 4 naked setae. Maxilla (fig. 6a) appearing 2-segmented, first segment swollen, nodular, second segment arising from inner lateral surface of first, rodlike, bearing 2 naked setules and single spatulate

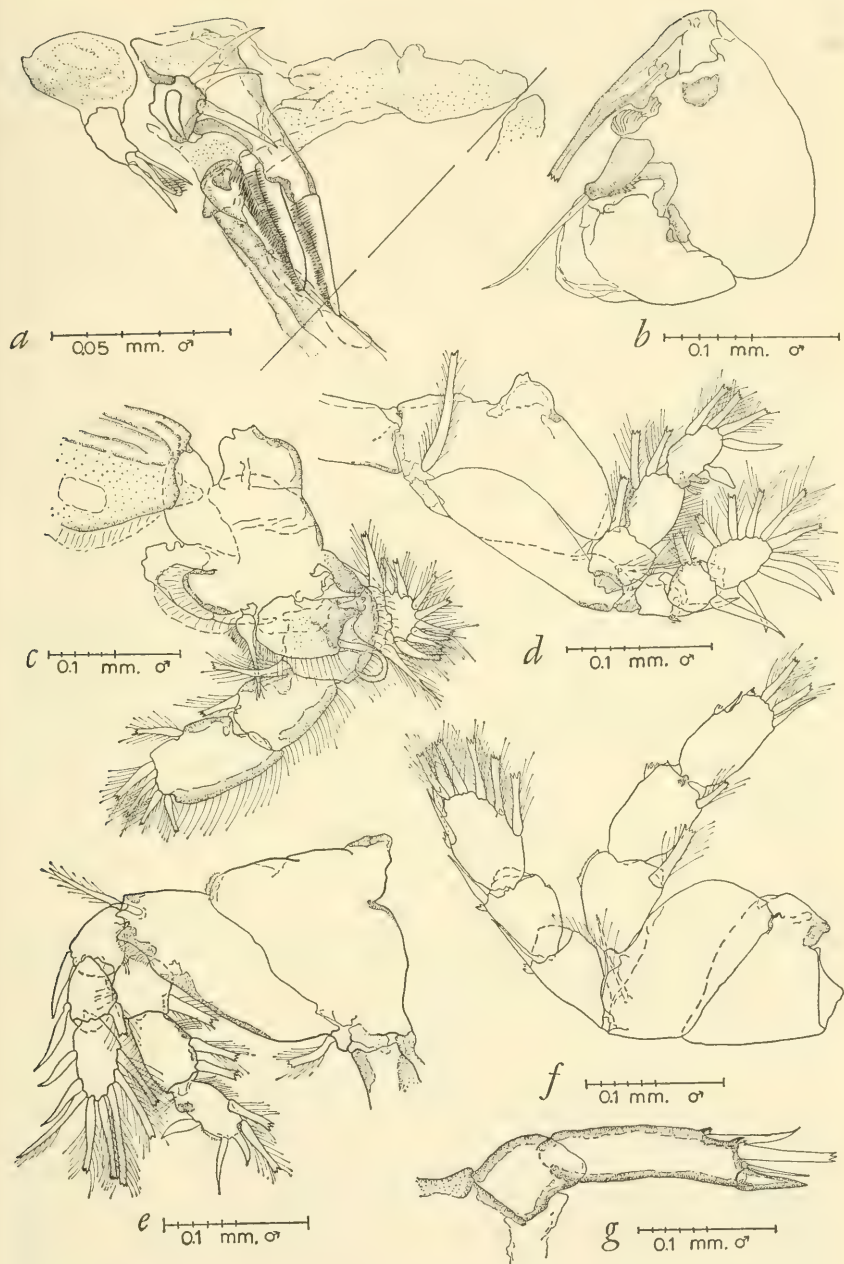


FIGURE 6.—*Pseudotaeniacanthus* species, male, ventral views: *a*, right side of oral region, showing mandible, paragnath, maxillule, and maxilla; *b*, left maxilliped. Thoracic legs: *c*, right first, posterior view (see table 3 for discussion of position of rami); *d*, right second, anterior view; *e*, right third, anterior view; *f*, left fourth, anterior view; *g*, left fifth, anterior view.

process distally, spatulate process denticulated distally. Paragnath (fig. 6a) small, nodular, without distinctive armature.

Ventral surface of cephalothorax with numerous heavily sclerotized knobs, adhesion processes and spikes. Postantennal process (fig. 5e) most prominent, extending as ridge from lateral anterior surface posteriorly to oral region, terminating as spinelike projection; ridge bearing 2 adhesion pads. Postantennal processes contiguous at base but not fused. Prominent pair of spinelike projections situated immediately lateral to antenna base, in position of postantennal process of many caligoids.

TABLE 3.—*Armature of thoracic legs I-V of the male of Pseudotaeniacanthus species*

| Leg | Surface | Inter-podal Plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------|-----|-----------------------------|------|-----------|------------|------|--------------------|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer* | m | | | | P | 3P | c | c | c,2P |
| | Inner | | m,p | c,P | P | 4P | P | c,P | c,3P | |
| II | Outer | | | p | dm,H | H | 2H,Q'#,P | c | c | c,h,2p' |
| | Inner | | P | fm | c | P | 4P | P | 2P | 3P |
| III | Outer | | | p | H | H | 2H,Q'#,P | c | c | c,h,p',fm, p',h |
| | Inner | | P | fm | c | P | 4P | P | c,2P | c,2P |
| IV | Outer | | | p | dm,H | dm,H | dm,H,H,2P | fm | fm | fm,h,fm,P |
| | Inner | | | | c | ? | 4P | P | P | p',P |
| V | Outer | | | | dm,p',dm, P',p',dm, H | | | | | |

*Position of rami in figure 6c reversed due to flattening and consequent movement during mounting; endopodite situated almost behind (posterior) exopodite in appendage in situ.

#Seta-like process with plumosities on one side, naked on other.

?Armature element may have been lost in handling.

Maxilliped (fig. 6b) 3-segmented, situated posterior and slightly medial to maxilla base. First segment irregular, base partially formed by heavily sclerotized ring; single naked seta present, on anterior inner surface. Second segment strongly developed, inner surface with large, heavily sclerotized, knob-tipped projection, projection with single row of denticles; inner distal surface with 2 contiguous oval adhesion pads. Third segment small, distinct from long, spinelike terminal process, bearing single, setalike accessory process.

Thoracic legs I-IV biramous, rami 3-segmented; fifth leg uniramous, 2-segmented. For nature of legs and armature see figures 6c-g and table 3.

DISCUSSION.—The single male specimen from Eniwetok differs from the diagnosis of the genus given in Yamaguti (1963) in the following characteristics:

1. The lateral extensions of the second to fifth pedigerous segments are not as large.

2. The antenna is 4-segmented, not 3-segmented. The condition exhibited in the third and fourth segments of the antenna of the Eniwetok specimen suggests that the terminal segment of the antenna of previously described species may be composed of 2 fused, or partially fused segments.

3. The postantennal processes are contiguous at their base but are not fused and do not form the characteristic Y-shaped structure present on other members of the genus. Additionally, although there are 2 adhesion pads on each postantennal process, the projections on these pads do not have the characteristic brushlike appearance of those on other members of the genus. These two differences, however, suggest that the structure, in the group to which the Eniwetok specimen belongs, is of a primitive nature.

In spite of these differences, the specimen is placed in the genus *Pseudotaeniacanthus* not only because the characteristics, other than the above, coincide most closely with those previously described for other members of the genus but also because there is an overall similarity of the postantennal process of the Eniwetok specimen with that of the other members.

Family PANDARIDAE

Pandarus cranchii Leach

Pandarus cranchii Leach, 1819, p. 535.—Lewis, 1966, p. 81, figs. 10–13.—Cressey, 1967, p. 9, figs. 27–33.

For remaining synonymy, see Lewis (1966) and Cressey (1967).

HOSTS AND DISTRIBUTION.—See Lewis (1966).

MATERIAL.—4 females (USNM 120746) from the external surface of *Galeocerdo cuvieri* (Lesueur).

MEASUREMENTS (in mm).—4 females:

| | mean | range |
|---|------|-----------|
| Length of body, excluding caudal setae | 6.87 | 6.51–7.14 |
| Length of cephalothorax, including frontal region | 4.06 | 3.85–4.33 |
| Width of cephalothorax | 4.26 | 3.96–4.48 |
| Length of genital segment | 2.61 | 2.37–2.74 |
| Width of genital segment | 2.94 | 2.74–3.03 |
| Length of caudal rami | 1.57 | 1.30–1.70 |
| Length of anal lamina | 1.63 | 1.52–1.74 |
| Length of egg strings (6 strings) | 4.07 | 3.55–5.00 |

DESCRIPTION.—See Lewis (1966).

Family DISSONIDAE

Dissonus heronensis Kabata

FIGURES 7-9

Dissonus heronensis Kabata, 1966a, p. 221, fig. 5.

HOST AND DISTRIBUTION.—“Unspecified fish of the family Balistidae” (Kabata, 1966a, p. 221), Heron Island, Queensland, Australia.

MATERIAL.—7 females and 1 male (USNM 120741) from the gill cavity of *Balistoides viridescens* (Bloch and Schneider).

MEASUREMENTS (in mm).—5 females and 1 male:

| | female | | male |
|--------------------------------------|--------|-----------|------|
| | mean | range | |
| Total length, excluding caudal setae | 1.96 | 1.82-2.03 | 1.51 |
| Length of prosome | 1.15 | 1.12-1.19 | 0.88 |
| Width of prosome | 0.85 | 0.79-0.88 | 0.67 |
| Length of cephalothorax | 0.87 | 0.83-0.94 | 0.61 |
| Length of genital segment | 0.56 | 0.49-0.63 | 0.52 |
| Width of genital segment | 0.47 | 0.43-0.50 | 0.31 |
| Length of abdomen | 0.20 | 0.11-0.25 | 0.11 |
| Length of egg strings (8 strings) | 1.43 | 1.37-1.48 | |

DESCRIPTION.—Female cephalothorax (fig. 7*b*) consisting of cephalon and first 2 thoracic segments, strongly arched in transverse section. Frontal region (fig. 7*g*) membranous, narrow, forming slightly less than 10 percent of length of cephalothorax; with small, median notch in anterior margin. Lateral margin irregularly convex, with fine membrane posteriorly. Posterior lateral cephalothoracic region lobate, projecting to posterior half of free second pedigerous segment. Major dorsal cephalothoracic grooves consisting of pair of convex grooves extending anteriorly from junction of inner margin of posterior lateral cephalothoracic region and outer margin of free second pedigerous segment, terminating lateral and slightly posterior to pair of small, slightly projecting heavily sclerotized ridges. Ocular region indistinct, situated on median longitudinal axis of body, anterior to ridges.

Female free second pedigerous segment slightly less than twice as wide as long, division between segment and cephalothorax distinct; lateral regions lobate, extending posteriorly to posterior region of third pedigerous segment; lobes with membrane along outer margin. Third pedigerous segment distinct from second, width slightly more than twice the length, segment without posterior extensions of lateral regions. Fourth pedigerous segment distinct from third, width slightly more than one and one-half times the length; broadest medially, tapered to anterior and posterior ends.

Female genital segment (fig. 7*d*) generally ovoid although shape variable; indistinctly separable from fourth pedigerous segment.

Platelike formation of cuticle covering most of dorsal surface, ventral surface with 2 series of nodules, each nodule bearing bifid hairlike projections, anterior series consisting of transverse row of 4 nodules, second series usually forming longitudinal row of 3 nodules on each

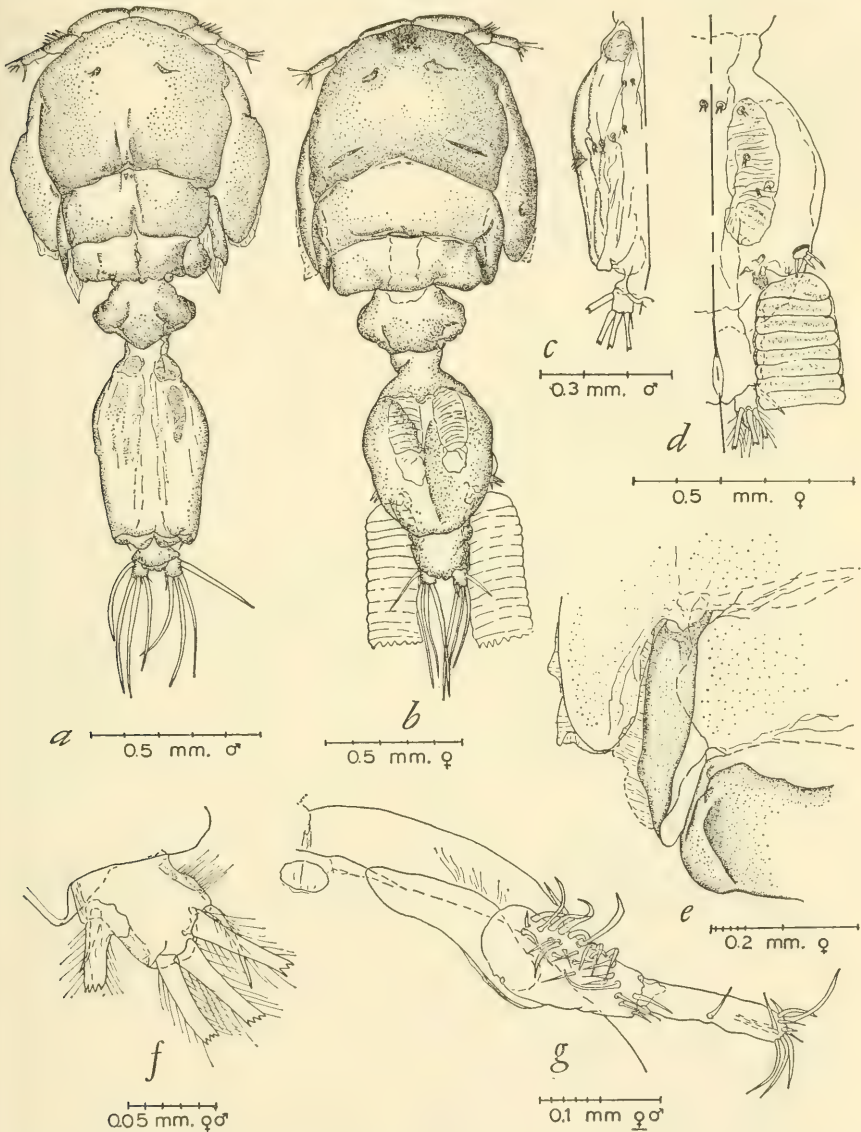


FIGURE 7.—*Dissonus heronensis* Kabata, 1966, dorsal views: *a*, male; *b*, female. Ventral views: *c*, male genital segment; *d*, female genital segment; *e*, female first, second, and third pedigerous segments (P-I, II, III); *f*, right caudal ramus; *g*, right antennule and adjacent frontal region.

side although nodules not always in row. Fifth leg (fig. 9e) situated on lateral ventral surface in posterior half of segment, consisting of palp bearing 4 plumose setules, Abdomen 1-segmented, distinctly separable from genital segment. Lateral margins, in adult, irregular, anterior surface broader than posterior. Posterior surface flat laterally, broadly bilobed medially, junction of lobes forming anal indentation. Caudal rami (fig. 7f) small, subrectangular, with 3 plumose terminal setae, 1 plumose setule on inner distal surface, and plumose seta and setule on proximal lateral surface.

Male cephalothorax and free pedigerous segments similar to those of female (fig. 7a). Genital segment (fig. 7c) elongate, rounded an-

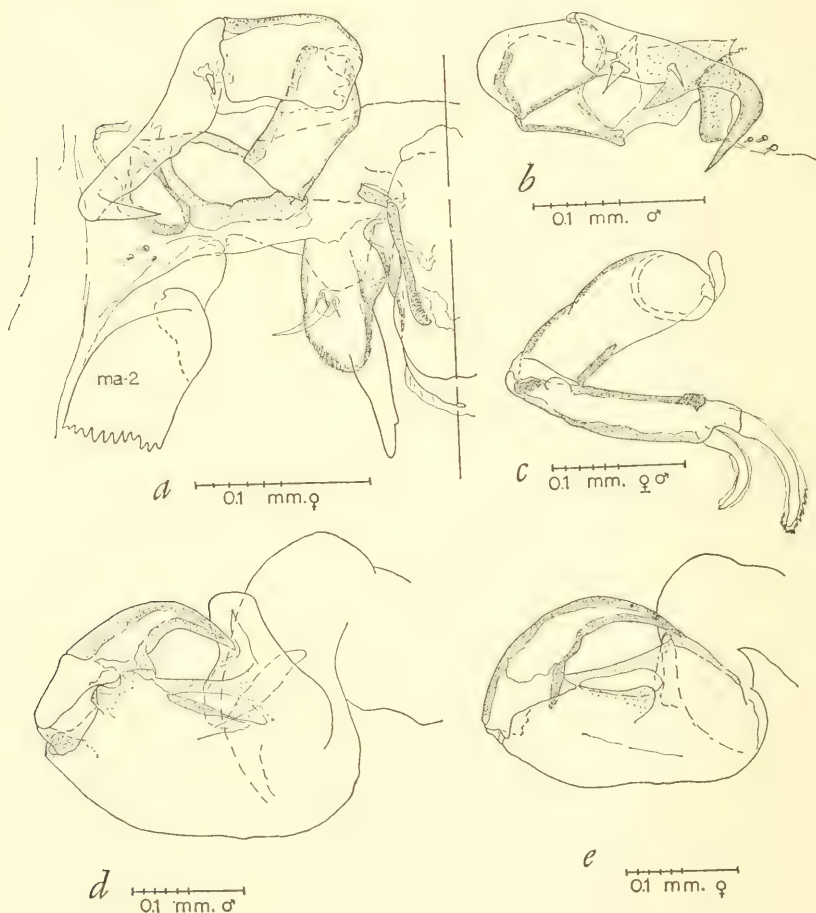


FIGURE 8.—*Dissonus heronensis* Kabata, 1966, ventral views: *a*, female oral region, showing antenna, mouth cone, mandible, maxillule, maxilla base (ma-2), postantennal process and postoral process; *b*, male left antenna and postantennal process; *c*, right maxilla; *d*, male left maxilliped; *e*, female left maxilliped.

teriorly, tapered slightly posteriorly; process-bearing nodules present although longitudinal row extending posterolaterally, consisting of 4 nodules, not 3 as in female. Fifth leg (fig. 9*f*) situated on lateral ventral surface, consisting of 5 lightly plumose setules originating from slight swelling. Sixth leg (fig. 9*g*) lappet-shaped, situated on lateral posterior surface of segment, bearing 2 lightly plumose setules. Abdomen 1-segmented, short; narrow anteriorly, flared sharply posteriorly, posterior surface as in female. Caudal rami as in female.

Female and male antennule (fig. 7*g*) 2-segmented, situated on lateral anterior ventral surface of cephalothorax and adjacent frontal region. Second segment approximately nine-tenths the length of first; first broader proximally than distally, lateral margins irregular; anterior ventral surface of first segment bearing approximately 28 lightly plumose setae and setules. Second segment rodlike, medial posterior surface with one naked setule, distal surface with 12 naked setules. Female antenna (fig. 8*a*) 3-segmented, situated posterior and medial to antennule base. First segment subrectangular, attached to heavily sclerotized padlike projection of cephalothorax. Second segment subrectangular, slightly longer than first segment. Third segment incompletely fused to clawlike terminal process, with setule-like accessory process proximally. Segments of male antenna (fig. 8*b*) similar to those of female although second with slight indication of adhesion surfaces (not shown in figure), terminal process of third segment with accessory claw proximally, segment with second accessory process at indistinct junction with terminal process.

Female and male mandible (fig. 8*a*) 4-parted, distalmost part flattened, inner margin with 10–12 denticulations. Female and male postantennal process (figs. 8*a*, *b*) situated posterior and slightly lateral to antenna base, consisting of 3 minute nodules, each with one or more hairlike processes. Female and male postoral process consisting of long, spatulate spine, male spine with light, spinelike accessory process distally. Female and male maxillule (fig. 8*a*) situated immediately lateral to mouth cone base, consisting of lobate projection, forming base of postoral process, bearing nodule, with seta and 2 setules, on proximal outer surface. Projection with slight adhesion surface on distal half of outer surface. Female and male maxilla (fig. 8*c*) 2-segmented, situated lateral and slightly posterior to maxillule. Segment lengths about equal, first more strongly developed, second rodlike, with small membrane on distal inner surface and 2 saber-shaped terminal processes. Innermost terminal process approximately one and one-half times the length of outermost, both with fine membranes, distal portion of membranes forming denticulations on innermost terminal process.

Female maxilliped (fig. 8e) 2-segmented, situated immediately posterior and medial to maxilla base. First segment irregular, strongly developed, proximal end fused with cephalothorax; large, shelflike projection present on proximal inner surface, receiving distal end of second segment terminal process when segment flexed. Second segment indistinctly separable from clawlike terminal process, with accessory

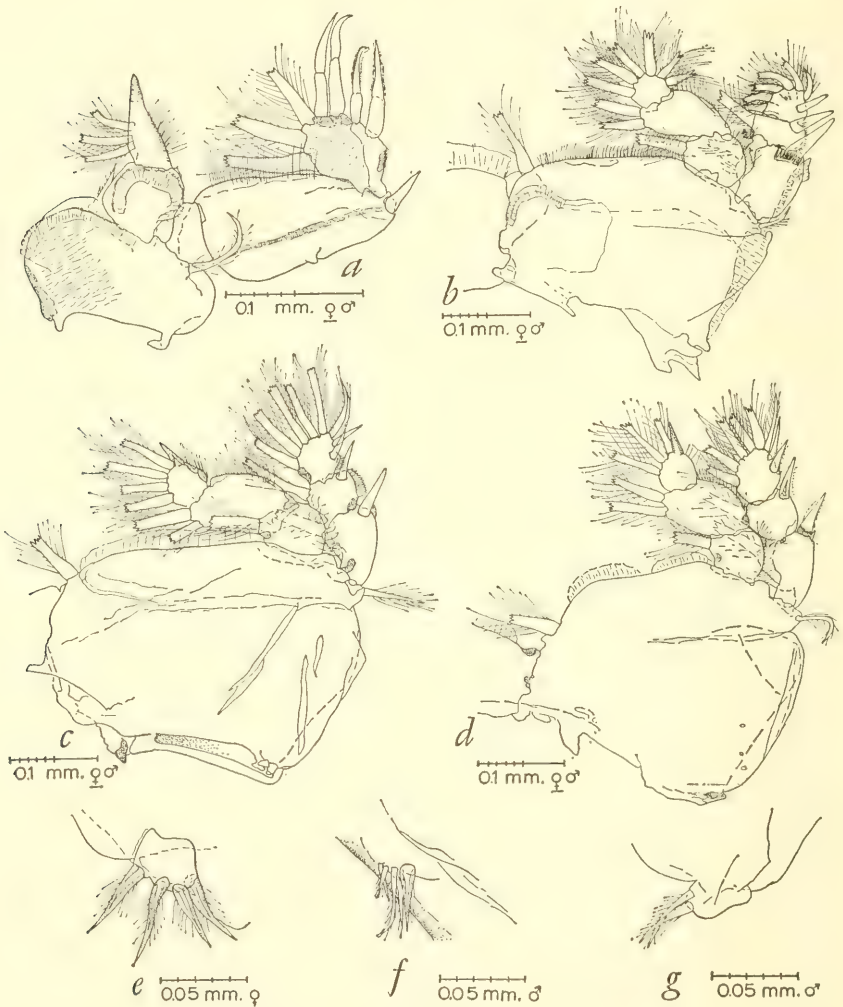


FIGURE 9.—*Dissonus heronensis* Kabata, 1966, right thoracic legs, anterior views: *a*, first; *b*, second; *c*, third; *d*, fourth. Legs, ventral views: *e*, female right fifth; *f*, male right fifth; *g*, male left sixth.

processes. Male maxilliped (fig. 8*d*) similar to that of female except shellike projection of first segment much smaller.

For nature of thoracic legs and armature, see figures 9*a-d* and table 4.

DISCUSSION.—The male specimen from Eniwetok differs slightly from the description given by Kabata (1966*a*) for the male specimen from Heron Island. The differences are in some of the armature elements on the thoracic legs and include the absence, on the Eniwetok specimen, of a small denticulation on the second segment of the endopodite of the first leg and the presence of a coarsely frilled membrane instead of 3 spinules on the second segment of the exopodite of the first thoracic leg.

TABLE 4.—Armature of thoracic legs I-IV of the female and male of *Dissonus heronensis* Kabata, 1966

| Leg | Surface | Inter-podal Plate | Proto-podite | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|--------------|-----------|--------|----------|------------|------|------|
| | | | | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | | p | h | 2fH,2H | | fm* | c,Cl | |
| | Inner | | fm*,a,p | c | 3P | | | 3p | |
| II | Outer | | m,p | m,dm,H | fm,H | fm,H,p | c | c | c,3P |
| | Inner | m | P,c | c,P | c,P | 5P | P | c,2P | 3P |
| III | Outer | | p | fm,H | fm,H | fm,2H,Q | c | c | c,Cl |
| | Inner | m | P,m,2s | c,P | c,P | 5P | P | c,2P | 4P |
| IV | Outer | | s#,p | dm,fmH | fH+ | fH+,p',Q | c | c | c,Cl |
| | Inner | m | P,2m | P | P | 5P | P | c,2P | 3P |

*Frilled membrane extending across part of segment, not only on indicated surface.

#Numerous processes scattered over surfaces of segment.

+Frilled membranes very small.

Dissonus similis Kabata

FIGURES 10-12

Dissonus similis Kabata, 1966*a*, p. 211, figs. 1, 2.

HOST AND DISTRIBUTION.—*Spheroides hamiltoni*, Queensland, Australia.

MATERIAL.—3 females and 5 males (USNM 120742) from the gill cavity of *Arothron meleagris* (Block and Schneider); 3 females, 2 males and 2 chalimus stages (USNM 120743) from the gill cavity of *A. meleagris*; 1 female and 1 male (USNM 120744) from the gill cavity of *A. meleagris*; 2 females and 1 male (USNM 120745) from the gill cavity of *A. meleagris*.

MEASUREMENTS (in mm).—7 females and 9 males:

| | females | | males | |
|--------------------------------------|---------|-------------|-------|-------------|
| | mean | range | mean | range |
| Total length, excluding caudal setae | 2. 18 | 1. 87-2. 43 | 1. 96 | 1. 73-2. 32 |
| Length of prosome | 1. 38 | 1. 22-1. 53 | 1. 24 | 1. 08-1. 44 |
| Width of prosome | 1. 20 | 1. 13-1. 26 | 1. 06 | 0. 95-1. 13 |
| Length of cephalothorax | 1. 06 | 0. 95-1. 13 | 0. 94 | 0. 83-1. 06 |
| Length of genital segment | 0. 56 | 0. 49-0. 67 | 0. 49 | 0. 45-0. 58 |
| Width of genital segment | 0. 59 | 0. 50-0. 61 | 0. 40 | 0. 22-0. 47 |
| Length of abdomen | 0. 21 | 0. 11-0. 32 | 0. 15 | 0. 13-0. 18 |
| Length of egg strings (5 strings) | 1. 63 | 1. 44-1. 80 | | |

DESCRIPTION.—Female cephalothorax (fig. 10*a*) consisting of cephalon and first 2 thoracic segments, strongly arched in transverse section. Frontal region narrow, projecting slightly past anterior end of cephalothorax, with wide membrane along anterior surface, membrane with median notch. Lateral margins convex, bearing fine membrane posteriorly; posterior lateral region lobate, extending posteriorly to posterior half of second pedigerous segment, with small cup-shaped indentation laterally, indentation associated with single hairlike process (not shown on figure). Single pair of major dorsal cephalothoracic grooves present, extending anteriorly from junction of posterior lateral and posterior median cephalothoracic regions, terminating in anterior half of cephalothorax. Ocular region (fig. 10*f*) distinct, situated at anterior end of cephalothorax, overlaid by small, anteriorly lobed plate. Pair of heavily sclerotized, knoblike projections present just anterior to plate, similar in shape, and position to conspicilla of *Nesippus*.

Female free second pedigerous segment approximately two and one-half times as wide as long, division between cephalothorax and third pedigerous segment distinct. Lateral regions lobate, extending posteriorly to posterior region of third pedigerous segment, without membrane along outer margin. Third pedigerous segment approximately three times as wide as long, with slight posterior extensions of lateral regions. Fourth pedigerous segment distinct from third, approximately three-fourths its width, length approximately one-half the width.

Female genital segment (fig. 10*d*) varying in shape from ovoid to circular, separated from fourth pedigerous segment by short, necklike formation with pair of small, saddle-shaped areas of heavy sclerotization laterally. Dorsal surface of genital segment platelike, anterior two-thirds of ventral surface bearing numerous (up to 60) bifid spines (fig. 10*e*). Fifth leg (fig. 12*f*) situated on ventral posterior lateral surface, consisting of palp bearing 3 plumose setules and 1 lightly

plumose, spinelike process. Abdomen 1-segmented, distinct from genital segment, lateral margins flatly convex, posterior surface biconcave. Caudal rami (fig. 10*h*) subrectangular, bearing 3 plumose setae and 1 plumose setule distally as well as plumose seta and setule from proximal half of outer surface; inner surface of rami ovoid.

Male cephalothorax and free pedigerous segments (fig. 10*b*) similar to those of female. Genital segment (fig. 10*c*) barrel-shaped, with

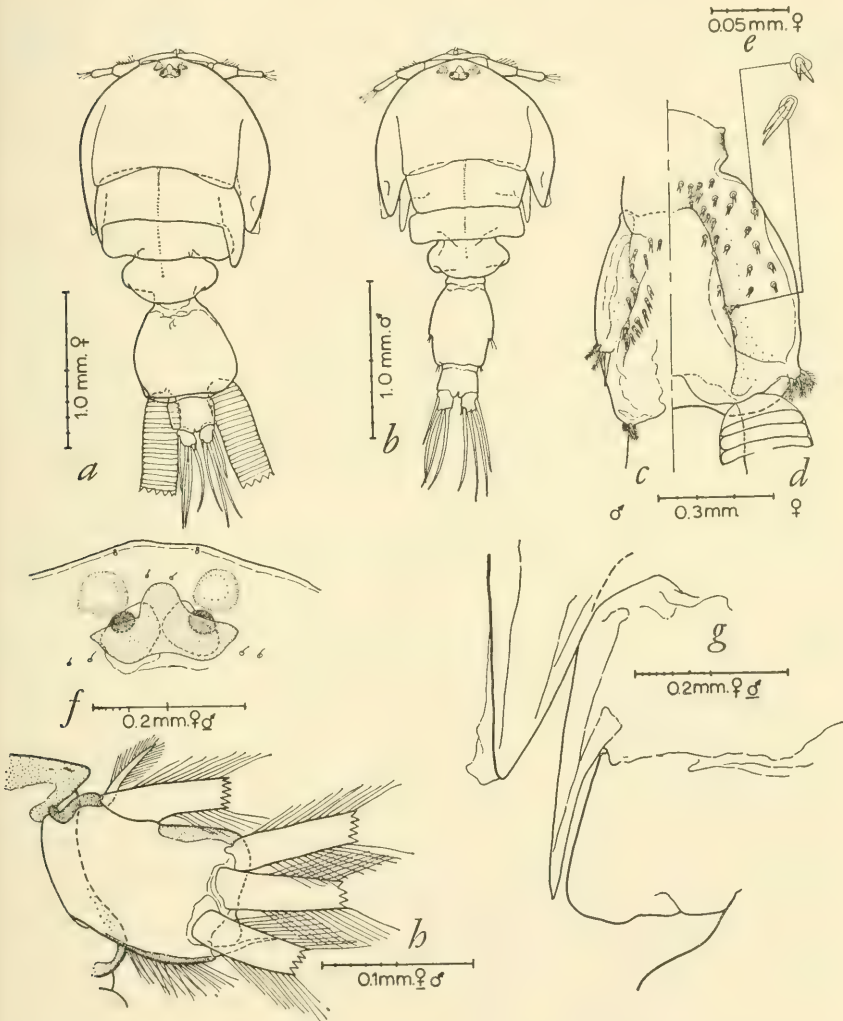


FIGURE 10.—*Dissonus similis* Kabata, 1966, dorsal views: *a*, female; *b*, male. Ventral views: *c*, male genital segment; *d*, female genital segment; *e*, processes on female genital segment; *f*, ocular region (dorsal view); *g*, first, second, and third pedigerous segments; *h*, caudal ramus.

approximately 30 bifid spines on ventral surface. Fifth leg (fig. 12*g*) situated on posterior medial lateral surface, consisting of slight indentation bearing 3 plumose setules and single naked, spinelike projection. Sixth leg (fig. 12*h*) situated on small projection of ventral lateral posterior surface, consisting of 3 plumose setules. Abdomen short, 1-segmented, slightly wider posteriorly than anteriorly. Caudal rami as in female.

Female and male antennule (fig. 11*a*) 2-segmented, situated on lateral anterior ventral surface of cephalothorax and adjacent portion of frontal region. Second segment approximately three-fourths the length of first, first clubshaped, bearing approximately 26 lightly plumose setules (plumosites not shown in figure) on anterior and anterior ventral surface. Second segment rodlike, with 1 naked setule on medial posterior surface and 12 on distal surface. Female antenna (fig. 11*b*) 3-segmented, situated posterior and slightly medial to antennule base. First segment dactyliform, attached to padlike projection of cephalothorax. Second segment subrectangular, approximately the same length as first segment. Third segment incompletely fused to clawlike terminal process, bearing single, setule-like accessory process. First and second segments of male antenna (fig. 11*c*) similar to those of female except second with small, earshaped area of heavy sclerotization on distal posterior surface. Third segment fused to clawlike terminal process, accessory processes consisting of spinelike secondary claw and 2 naked, setule-like structures.

Female and male mandible (fig. 11*b*) 4-parted, distalmost part flattened, inner margin with 12 denticulations. Female postantennal process (fig. 11*b*) situated posterior and slightly lateral to antenna base, consisting of 3 minute nodules, each appearing to have several hairlike processes. Male postantennal process (fig. 11*c*) consisting of 2 nodules (posteriormost of female not visible on male), each with several hairlike processes. Female and male maxillule (fig. 11*b*) situated immediately lateral to mouth cone base, consisting of 3 naked setules appearing to arise directly from lobate projection fitting over knoblike extension of cuticle. Lobate projection bearing elongate, slightly curved spine forming postoral process, spine with minute nodule on distal inner surface. Lobate projection and spine without distinct indication of adhesion surface on either male or female. Female and male maxilla (fig. 11*d*) 2-segmented, situated lateral and slightly posterior to maxillule. Second segment slightly less than three-fourths the length of first (including articulation and muscle attachment surface at proximal end of first). First segment subrectangular, more strongly developed than second, second rodlike, with pair of denticulated membranes in distal half and pair of saber-shaped terminal processes. Innermost terminal process approximately

twice the length of outermost, both with fine membranes, membranes extending to tip of innermost terminal process, forming complex series of denticulation (fig. 11*e*).

Female and male maxilliped (fig. 11*f*) 2-segmented, situated immediately posterior and medial to maxilla base. First segment strongly developed, with long, recurved articulation and muscle attachment surface embedded in cephalothorax; inner surface with large, shelflike projection, projection (fig. 11*g*) bearing 2-parted nodule, distal part spherical, with approximately 3 ridges forming roughened surface. Second segment distinct from clawlike terminal process, bearing single, minute, setule-like accessory process; terminal process with fine, longitudinal ridges distally.

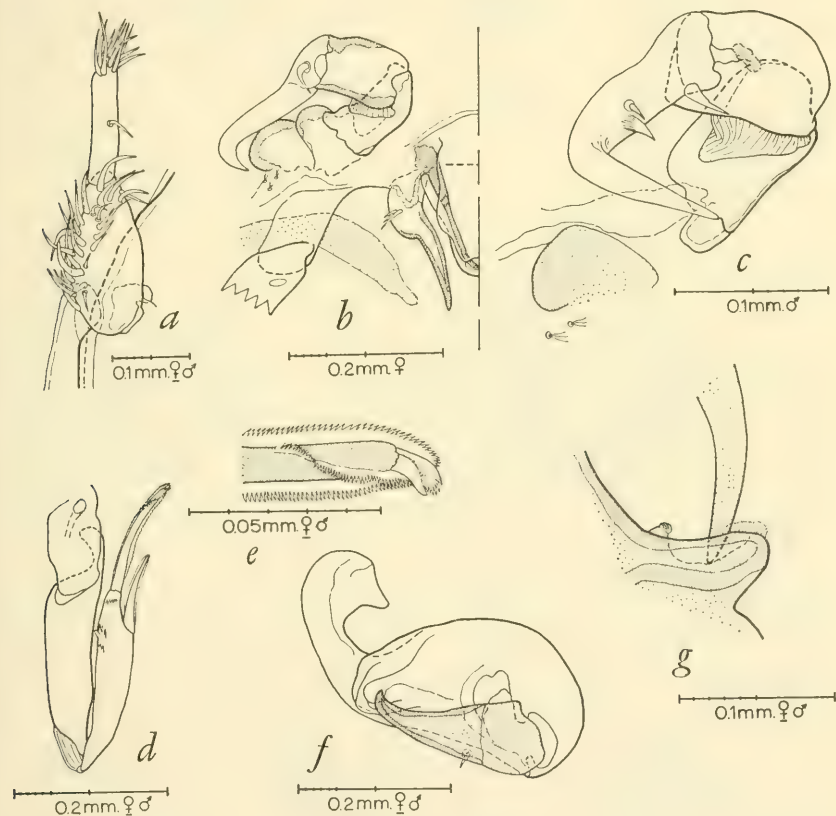


FIGURE 11.—*Dissonus similis* Kabata, 1966, ventral views: *a*, left antennule; *b*, female oral region showing antenna, postantennal process, mouth cone, mandible, maxillule, postoral process, and maxilla base; *c*, male right antenna and postantennal process; *d*, right maxilla; *e*, distal region of innermost terminal process of maxilla; *f*, left maxilliped; *g*, shelflike indentation on first segment of maxilliped.

For nature of thoracic legs and armature see figures 12*a-e* and table 5. Variation present in armature of second segment of endopodite of first thoracic leg; basic armature shown in table 5, consisting of 3 setae on inner surface, 1 terminal spinelike projection and 6 more or less lobulate projections of outer surface in addition to plumosities on outer surface. Variation exhibited in number of lobulate projections and expressed in decrease from basic number.

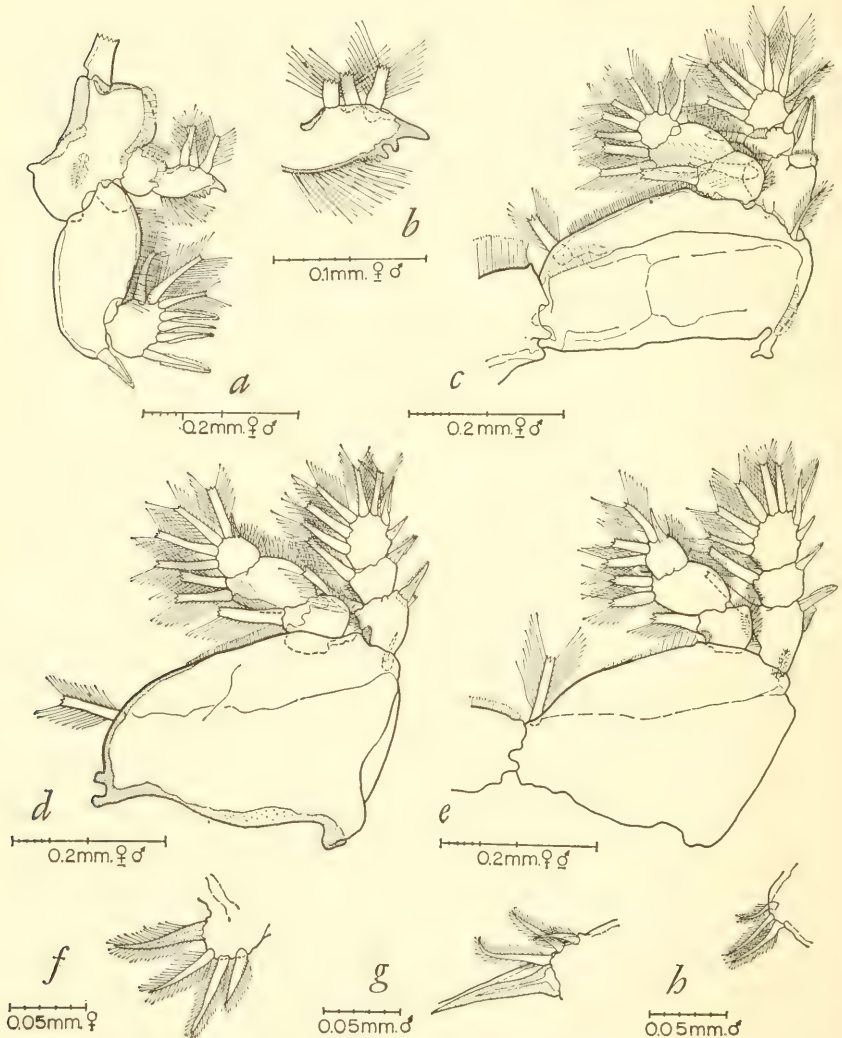


FIGURE 12.—*Dissonus similis* Kabata, 1966, right thoracic legs, anterior views: *a*, first; *b*, second segment of endopodite of first; *c*, second; *d*, third; *e*, fourth. Legs, ventral views: *f*, female left fifth; *g*, male right fifth; *h*, male right sixth.

DISCUSSION.—The female Eniwetok specimens differ from Kabata's original description (1966a, female only) in several respects:

1. The length is less than that given for *D. similis* by Kabata (average of 2.18 mm for the Eniwetok specimens, 2.84 mm for Kabata's two specimens).

2. The pad associated with the maxillule is indicated by Kabata (p. 213) to have numerous delicate ridges. These were not clearly seen on the Eniwetok material although they may be visible with phase contrast.

3. The minute process figured on the distal end of the spine associated with the above-mentioned pad is not visible in the Eniwetok material.

TABLE 5.—Armature of thoracic legs I–IV of the female and male of *Dissonus similis* Kabata, 1966

| Leg | Surface | Inter-podal Plate | Protopodite | Exopodite | | | Endopodite | | |
|-----|----------------|-------------------|-------------|-----------|---------------|------------|------------|------------------|-------|
| | | | | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer Inner | | p m, p | fH c | 2fH, 2H 3P | | m | c, 6cl, Cl 3P | |
| II | Outer | m | m, p | fm, fH | fH | H, mp*, 2P | c | c | 3P |
| | Inner | | m, P, C | c, P | P | 3P | P | c, 2P | 3P |
| III | Outer | m | p | fm, fH | fH | H, 2mp#, P | c | c | c, Cl |
| | Inner | | P, m | c, P | c, P | 4P | P | c, 2P | c, 4P |
| IV | Outer | m | p | fm, fH | fH | h, p', Q | c | c | c, Cl |
| | Inner | | P, m | c, P | c, P | c, 5P | P | c, 2P | c, 3P |

*Setule-like process with membrane along one side, naked on other side.

#Setule-like process with membrane along both sides.

4. Kabata indicates (table, p. 215) that there are 2 spines on the first segment of the exopodite of thoracic legs II–IV although he figures only a single spine (figs. 2D–F). The Eniwetok specimens possess only a single spine on this segment in these legs.

5. Kabata indicates (table, p. 215) the presence of plumosities on the inner surface of the third segment of the exopodite of the third thoracic leg. The Eniwetok specimens did not exhibit this.

6. The Eniwetok specimens possess plumosities on the inner surface of the third segment of the endopodite of the fourth thoracic leg. These are not listed in the original description of *D. similis*.

Kabata also indicates (p. 213 and fig. 1H) that the "eye spots" are what the present author is comparing with the conspiciilla of *Nesippus*. Kabata apparently failed to see the true ocular region lying below the

platelike area of heavy sclerotization situated between and immediately posterior to these processes.

Family EURYPHORIDAE

Alebia gracilis Wilson

FIGURE 13

Alebia gracilis Wilson, 1905b, p. 123.—Lewis, 1966, p. 136, figs. 36–38.
For synonymy, see Lewis (1966).

HOSTS AND DISTRIBUTION.—See Lewis (1966).

MATERIAL.—4 males (USNM 120747) from the external surface of *Carcharinus menisorrah* (Müller and Henle); 2 females (USNM 120748) from the external surface of *C. menisorrah*.

MEASUREMENTS (in mm).—2 females and 4 males:

| | female | male | |
|--------------------------------------|------------|------|-----------------|
| | | mean | range |
| Total length, excluding caudal setae | 6.66, 6.55 | 3.62 | 3.52–3.81 |
| Length of cephalothorax | 3.81, 3.59 | 2.09 | 2.04–2.15 |
| Width of cephalothorax | 2.89, 3.07 | 2.12 | 1.92–2.22 |
| Length of genital segment | 1.63, 1.66 | 0.76 | 0.70–0.81 |
| Width of genital segment | 1.96, 2.00 | 0.67 | (all specimens) |
| Length of genital segment processes | 1.11, 1.18 | | |
| Length of abdomen | 0.70, 0.74 | 0.56 | 0.44–0.67 |
| Length of egg strings (nonovigerous) | | | |

DESCRIPTION.—Male only (for description of female, see Lewis, 1966). Male cephalothorax (fig. 13a) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region slightly less than one-tenth the total length of cephalothorax, with narrow membrane along anterior margin; division between frontal region and rest of cephalothorax distinct. Lateral margins of cephalothorax smoothly convex, bearing narrow membrane. Posterior lateral region with small, semi-lunar concavity, concavity with fine, hairlike process. Posterior median cephalothoracic region terminating at level of posterior lateral regions, posterior margin flatly concave medially, posterior surface bearing approximately 5 spinules laterally. Posterior sinus U-shaped, with frilled membrane and shelflike projection extending medially from outer surface, second membrane extending posteriorly from posterior outer surface. Dorsal surface with major grooves forming irregular H, anterior longitudinal legs of H terminating lateral to distinct ocular region. Median dorsal surface with 3 pairs of spines situated between ocular region and cross bar of H formed by major dorsal grooves. Free fourth pedigerous segment short, length approximately one-third the width, dorsal surface with small, platelike lateral ex-

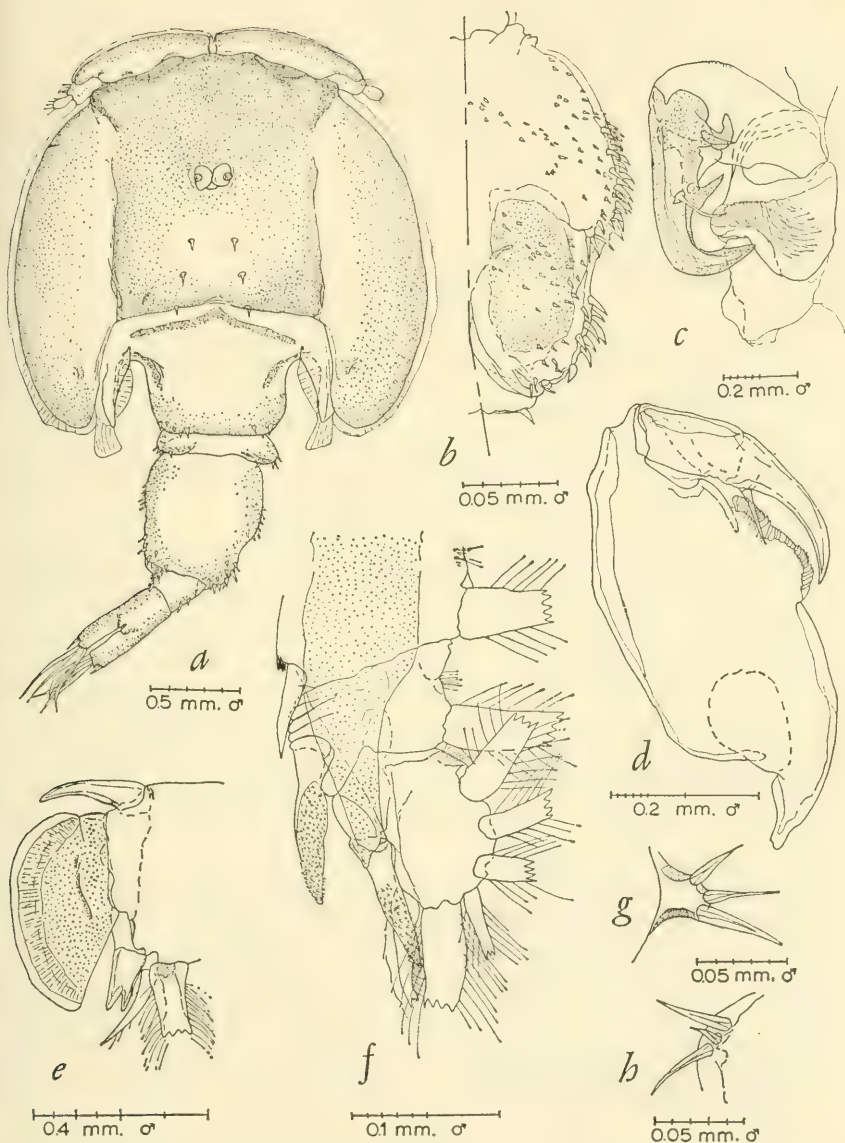


FIGURE 13.—*Alebion gracilis* Wilson, 1905, male: *a*, dorsal view; *b*, genital segment, ventral view; *c*, right antenna, ventral view; *d*, right maxilliped, ventral view; *e*, distal region of second segment of exopodite of right first thoracic leg, anterior view; *f*, exopodite of second thoracic leg, anterior view; *g*, right fifth leg, ventral view; *h*, right sixth leg, ventral view.

tensions, each with approximately 4 spinules posteriorly. Division between fourth pedigerous and genital segments distinct, complete.

Male genital segment (fig. 13*b*) with convex lateral margins anteriorly, tapered posteriorly. Anterior and posterior halves each with cluster of spinules and spines laterally. Posterior margin flat dorsally, bilobed ventrally. Fifth legs (fig. 13*g*) situated at break between anterior and posterior halves, consisting of node bearing 3 naked setules. Sixth legs (fig. 13*h*) situated on posterior end of lobe on ventral surface, consisting of 3 naked setules. Abdomen, 2-segmented, distinct from genital segment. First segment subrectangular, approximately five-eighths the length of second segment, medial lateral surfaces with cluster of spines and spinules. Second segment continuous with caudal rami, slightly wider posteriorly than anteriorly, anal indentation distinct. Caudal rami subrectangular plumose along distal inner surface. Rami bearing 3 plumose terminal setae, 1 plumose seta on lateral distal surface, and 2 plumose setules, first on distal inner surface, second just medial to outermost seta. Outer surface of rami with several minute spinules.

Male antennule similar to that of female although second segment approximately half the length of first, not one-third as in female. Antenna (fig. 13*e*) 3-segmented, situated posterior and medial to antennule base. First segment irregular, with ridgelike adhesion process proximally. Second segment clubshaped, with 2 knoblike adhesion processes on distal outer surface, anteriormost continuous with spikeshaped projection. Third segment continuous with clawlike terminal process, with node proximally bearing weakly sclerotized, spinelike projection; setulelike accessory process present at probable junction of segment and terminal process. Terminal process with secondary spine proximally.

Mandible, maxillule, maxilla, postantennal process and postoral process similar to those of female. Maxilliped (fig. 13*d*) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed, with narrow, somewhat recurved proximal articulation process. Distal inner surface of first segment with serrated ridge forming adhesion process. Second segment incompletely separable from clawlike terminal process, bearing setalike accessory process from distal inner surface.

Thoracic legs I-IV similar to those of female. Two major differences evident. Innermost terminal spine of second segment of exopodite of male first leg bifid (fig. 13*e*), female with simple spine. Spine on outer distal surface of second segment and spine on proximal outer surface of third segment of exopodite of male second thoracic leg (fig. 13*f*), with denticulations, not enlarged and hookshaped as in female.

Family CALIGIDAE

Pseudanuretes pomacanthi, new species

FIGURES 14, 15

MATERIAL.—1 female (holotype, USNM 120749) from the gill cavity of *Pomacanthus imperator* (Bloch).

MEASUREMENTS (in mm).—1 female:

| | |
|---|------|
| Total length, excluding caudal setae | 0.97 |
| Length of cephalothorax | 0.74 |
| Width of cephalothorax | 0.61 |
| Length of fused genital segment and abdomen | 0.23 |
| Width of genital segment | 0.31 |
| Length of egg strings (strings broken) | |

DESCRIPTION.—Cephalothorax (fig. 14*a*) consisting of cephalon and first 4 thoracic segments, anterior end bluntly pointed. Frontal region narrow, forming approximately one-sixteenth the length of cephalothorax, partially covered by adjacent portion of cephalothorax; with narrow membrane projecting from anterior ventral surface. Lateral surfaces of cephalothorax flatly convex, with fine, ventrally projecting membrane. Posterior lateral regions forming narrow, slightly projecting lobe, posterior sinus minute, without membrane. Posterior median cephalothoracic region broad, forming 90 percent of posterior surface, covering indistinct free fourth pedigerous segment and anterior end of genital segment. Major dorsal cephalothoracic grooves extending anteriorly from junction of posterior lateral and posterior median cephalothoracic regions, terminating on lateral surface in anterior third of cephalothorax; transverse groove absent. Ocular region distinct, situated well anterior to termination of dorsal grooves.

Free fourth pedigerous segment appearing as narrow annulus, indistinctly separable from cephalothorax but distinct from genital segment. Genital segment (fig. 14*b*) broad, lateral surfaces convex, posterior surface knobby, depressed medially. Fifth legs (fig. 15*f*) situated on posterior lateral surface, consisting of 4 plumose setules, 1 slightly anterior to other 3. Abdomen fused with genital segment, situated in posterior depression of segment. Anal opening distinct, between small caudal rami. Caudal rami (fig. 14*c*) short, bearing 4 plumose terminal setae.

Antennule (fig. 14*d*) 2-segmented, attached to cephalothorax immediately lateral to frontal region; segments flaccid, poorly sclerotized. First segment approximately one and one-half times the length of second, margins irregular, anterior ventral surface bearing approximately 13 naked or lightly plumose setae, distal ventral surface bearing

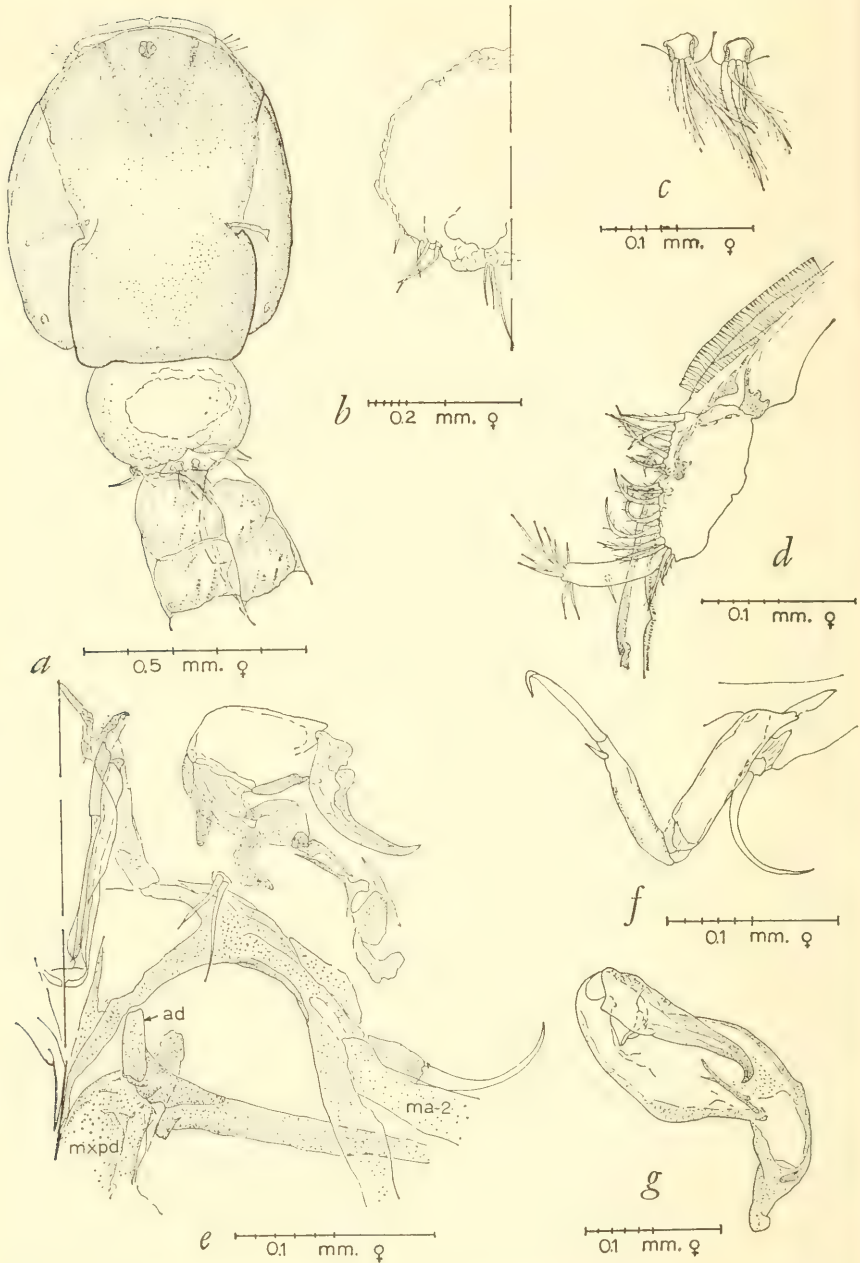


FIGURE 14.—*Pseudanuretes pomacanthi*, new species, female: *a*, dorsal view; *c*, caudal rami, same view. Ventral views: *b*, genital segment, right side; *d*, right antennule and adjacent section of frontal region; *e*, oral region, left side showing antenna, mouth cone, mandible, maxillule, maxilla base (ma-2), and associated processes, adhesion pad (ad), and maxilliped base (mxpd); *f*, left maxilla; *g*, left maxilliped.

3 setae. Second segment rodlike, with single naked setule from middle of segment, approximately 9 naked setules from distal surface. Antenna (fig. 14e) 3-segmented, situated posterior and slightly medial to antennule base. First segment generally ringshaped, heavily sclerotized, with spikelike projection from posterior surface. Second segment well developed, broader proximally than distally. Third segment and clawlike terminal process continuous, with knoblike articulation surface proximally and knoblike projection on medial inner surface; accessory processes not evident.

Mandible (fig. 14e) 4-parted, rodlike, distalmost part denticulated along inner margin. Postantennal process evident as small, lightly sclerotized area surrounded by ringlike area of heavy sclerotization situated lateral and posterior to antenna base, area with 3 nodule-like structures although "typical" hairlike processes not evident. Postoral process absent. Postoral adhesion pad present as barshaped projection of heavily sclerotized rod in sternal region, immediately anterior to maxilliped base. Maxillule (fig. 14e) minute, nodular, situated lateral and posterior to mouth cone, slightly posterior to antennal base. Nodule bearing 2 poorly sclerotized, naked setae. Maxilla (fig. 14f) 2-segmented, situated posterior and lateral to maxillule, adjacent to (though not associated with) large, naked seta (maxillary whip of Kabata, 1965b). First segment approximately one and one-fourth times the length of second, elongate, tapered to minutely bilobed proximal articulation process. Second segment elongate, with small, spikelike subterminal process and long, setalike terminal process.

Maxilliped (fig. 14g) 2-segmented, situated medial and slightly posterior to maxilla base. First segment well developed, proximal end narrow, recurved slightly. Second segment incompletely separable from clawlike terminal process, accessory process not evident. Sternal furca absent.

Thoracic legs I-III biramous although endopodite of first leg rudimentary, fourth thoracic leg uniramous, small, poorly sclerotized, 3-segmented. For nature and armature of thoracic legs, see figures 15a-e and table 6.

DISCUSSION.—The female of *Pseudanuretes pomacanthi*, new species, differs from the females of the two other recognized members of the genus, *P. chaetodontis* Yamaguti (1936) and *P. fortipedis* Kabata (1965b) (for a note on *P. schmitti* Rangnekar, 1957, see below), in two respects:

1. The antenna is simple and does not have an accessory spine.
2. The structure and armature of the fourth thoracic leg. The leg of *P. pomacanthi* is similar in structure to that of *P. fortipedis* but has 2 terminal setae instead of 1. The leg of both species is either 2- or 3-segmented while that of *P. chaetodontis* is only 1-segmented.

Kabata (1965b, p. 30) questions the inclusion of *P. schmitti* Rangnekar (1957) in the genus *Pseudanuretes* because of the presence of postantennal processes as well as the apparent absence of a maxillary whip. Whether the species belongs to the genus *Pseudanuretes* or

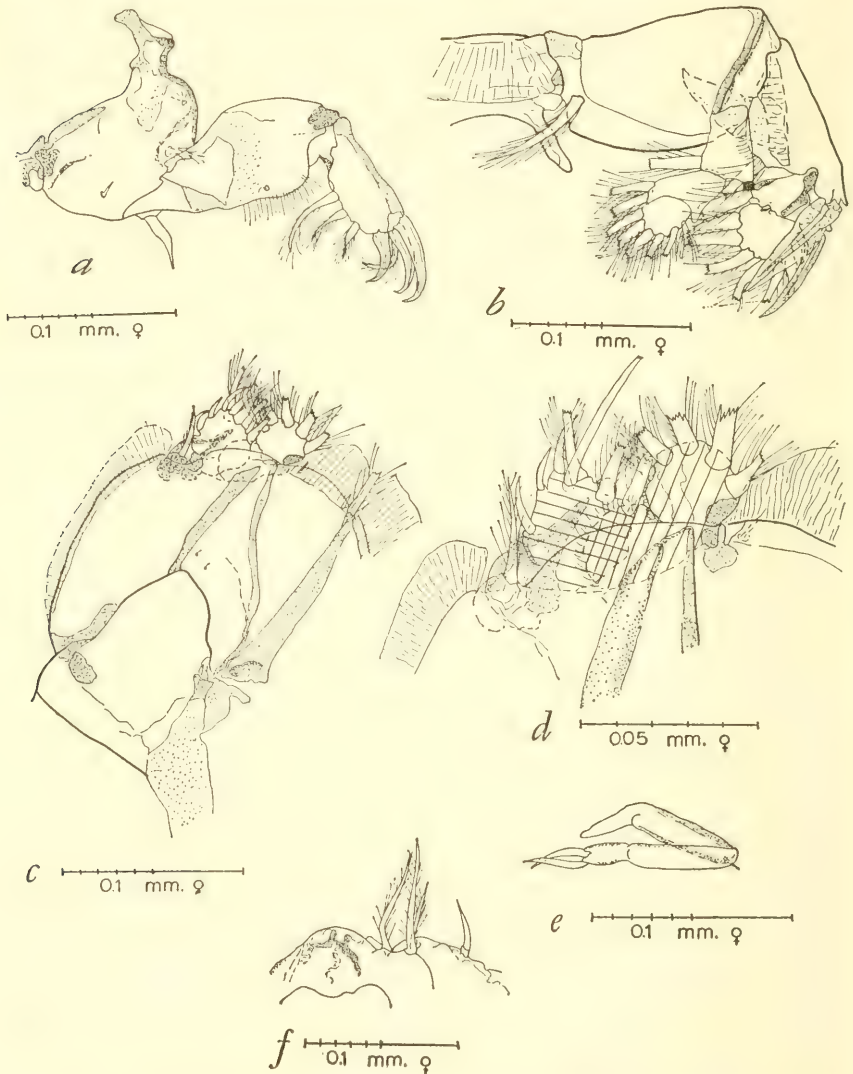


FIGURE 15.—*Pseudanuretes pomacanthi*, new species, female, thoracic legs: *a*, right first, posterior views; *b*, right second, anterior view; *c*, right third, posterior view; *d*, rami of right third, posterior view; *e*, left fourth, ventral view; *f*, right fifth, ventral view.

somewhere else can only be determined after the type material is reexamined.

There are several unique characteristics found in *P. pomacanthi* and, to some extent (reference to endopodite of second thoracic leg and to third thoracic leg), in *P. chaetodontis* (and presumably in *P. fortipedis*) which suggest a change from the general makeup of other caligids:

1. The second thoracic leg, which the present author believes is one of the more stable "elements" in caligids, lacks several armature elements in *P. pomacanthi* ("m," "p," and "s" on the protopodite; "c" on the inner surface of the second segment of the endopodite).

2. The third thoracic leg, which, in *P. pomacanthi* and *P. chaetodontis*

TABLE 6.—*Armature of thoracic legs I-IV of the female of Pseudanuretes pomacanthi, new species*

| Leg | Surface | Inter-podal Plate | Protopodite | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------|-----------|-----------|----------|------------|-------|----|
| | | | | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | | sss, p | | 3H, P | | | | |
| | Inner | | p' | c | P, 2p | | | | |
| II | Outer | m | fm | m, mH | H | H, Q, 3P | C | | 3P |
| | Inner | | P | c, P | P | 2P | P | 2P | 3P |
| III | Outer | m | m, p | H | c, 3h, P' | | c | c, 3P | |
| | Inner | | m, 2s | | 3P | | | 2P | |
| IV | Outer | | | | 2p' | | | | |

(and *P. fortipedis*?), lacks the typical plumose seta (P) on the inner surface of the first segment of the endopodite.

3. Several accessory processes are apparently absent on two appendages (antenna, segment 3; maxilliped, segment 2).

These differences, collectively, are unique. They are, however, listed after the observation of only a single specimen of *P. pomacanthi* and a review of the literature of *P. chaetodontis* and *P. fortipedis*. A reexamination of the material of the previously named species and other material of the presently described species is needed to clarify the situation. Further, the degree of sclerotization of the various body parts in *P. pomacanthi* is, in general, much less than in many other caligids, making the interpretation of many parts (e.g., maxillule) difficult.

The name "*pomacanthi*" is derived from the host name *Pomacanthus*.

Anuretes serratus Shiino

Anuretes serratus Shiino, 1954b, p. 260, figs. 1-2.—Lewis, 1964a, p. 188, figs. 13-14.

HOSTS AND DISTRIBUTION.—See Lewis (1964a).

MATERIAL.—7 females and 1 male (USNM 120750) from the external surface of several specimens of *Naso vlamingi* (Valenciennes); 3 females and 2 males (retained by the author) from the external surface of several specimens of *N. vlamingi*.

MEASUREMENTS (in mm).—9 females, 3 males:

| | female | | male |
|--|--------|-------------|---------------------|
| | mean | range | |
| Total length, excluding caudal setae | 2. 12 | 1. 98-2. 23 | 1. 67, 1. 67, 1. 69 |
| Length of cephalothorax | 1. 69 | 1. 64-1. 76 | 1. 30, 1. 30, 1. 26 |
| Width of cephalothorax | 1. 46 | 1. 39-1. 57 | 1. 19, 1. 19, 1. 15 |
| Length of genital segment | 0. 39 | 0. 31-0. 52 | 0. 36, 0. 34, 0. 31 |
| Width of genital segment | 0. 74 | 0. 63-0. 77 | 0. 38, 0. 43, 0. 40 |
| Length of egg strings (egg strings broken) | | | |

DESCRIPTION.—See Lewis (1964a).

Dentigryps litus Lewis

Dentigryps litus Lewis, 1964b, p. 362, figs. 9-11, 12*d,h,l*, 13*d*.—Kabata, 1965b, p. 19, fig. 1.

HOSTS AND DISTRIBUTION.—5 host records:

| locality | hosts | reference |
|------------|--|---------------------------------|
| Eniwetok | <i>Plectropomus leopardus</i> <i>Epinephelus fuscoguttatus</i> <i>Aulostomus chinensis</i> | |
| Queensland | <i>Balistoides viridescens</i> <i>Cromileptes altivelis</i> | Lewis (1964b) Kabata (1965b) |

MEASUREMENTS AND DESCRIPTION.—See Lewis (1964b).

Lepeophtheirus plectropomi? Nunes-Ruivo and Fourmanoir

FIGURES 16-18

Lepeophtheirus plectropomi Nunes-Ruivo and Fourmanoir, 1956, p. 74, figs. 5, 6.—Kabata, 1966b, p. 565, fig. 2.

HOSTS AND DISTRIBUTION.—2 host records:

| locality | hosts | reference |
|------------|-------------------------------|-----------------------------------|
| Madagascar | <i>Plectropomus maculatus</i> | Nunes-Ruivo and Fourmanoir (1956) |
| Australia | <i>Rachycentron canadus</i> | Kabata (1966b) |

MATERIAL.—5 females (USNM 120751) from the external surface of *Epinephelus fuscoguttatus* (Forskål); 12 females and 1 male (retained by the author) from the buccal cavity of *Epinephalus kohleri* Schultz.

MEASUREMENTS (in mm).—16 females and 1 male:

| | <i>female</i> | | <i>male</i> |
|--------------------------------------|---------------|--------------|-------------|
| | <i>mean</i> | <i>range</i> | |
| Total length, excluding caudal setae | 4.69 | 4.00-5.07 | 2.15 |
| Length of cephalothorax | 2.78 | 2.45-3.15 | 1.40 |
| Width of cephalothorax | 2.58 | 2.25-3.00 | 1.35 |
| Length of genital segment | 1.06 | 0.90-1.22 | 0.38 |
| Width of genital segment | 1.26 | 1.05-1.52 | 0.38 |
| Length of abdomen | 0.43 | 0.30-0.56 | 0.13 |
| Length of egg strings (12 strings) | 2.66 | 1.07-3.85 | |

DESCRIPTION.—Female cephalothorax (fig. 16a) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region narrow, anterior surface with slight medial indentation, with narrow membranous flange; division between frontal region and remaining cephalothorax distinct medially, indistinct laterally. Lateral margins slightly irregular, basically convex, with narrow membranous flange. Posterior sinuses distinct, V-shaped, with small membrane projecting medially from outer lateral surface. Posterior medial surface of cephalothorax with short, necklike projection forming attachment surface for free fourth pedigerous segment; posterior medial region extending posteriorly to posterior lateral cephalothoracic region. Major dorsal cephalothoracic grooves forming irregular H, anterior portion of longitudinal grooves of H terminating slightly posterior and lateral to ocular region. Ocular region distinct, in anterior third of cephalothorax.

Free fourth pedigerous segment approximately twice as wide as long; posterior lateral region of tergum heavily sclerotized, giving platelike appearance. Division between fourth pedigerous and genital segments indistinct, incomplete. Genital segment (fig. 16c) wider than long, lateral margins broadly convex, posterior surface bilobed from dorsal viewpoint. Fifth legs (fig. 16e) situated on posterior lateral ventral surface, consisting of short, spikeshaped projection bearing 3 plumose setules dorsally, additional setule present just anterior to base of leg.

Abdomen 1-segmented, short, length approximately two-thirds the width. Segment swollen medially, narrower at both ends. Lateral posterior surfaces angled posteromedially, medial region bilobed, forming anal opening. Caudal rami small, subrectangular, distal inner surface plumose. Distal surface with 3 plumose setae and 2 setules, one on either side of group of setae, additional plumose seta present on medial outer surface of rami.

Cephalothorax of male (fig. 16b) similar to that of female. Heavily sclerotized regions of tergum of free fourth pedigerous segment not extending as far posteriorly as those of female although segments similar. Genital segment subovoid, with slight indentation in middle

of lateral surface, at origin of fifth legs. Fifth legs (fig. 16f) lobate, short, bearing 3 plumose setules, additional setule present just anterior to base of lobe. Sixth legs (fig. 16g) lobate, approximately twice the size of fifth legs, situated on posterior ventral surface of genital segment, bearing 3 plumose setules. Abdomen 1-segmented,

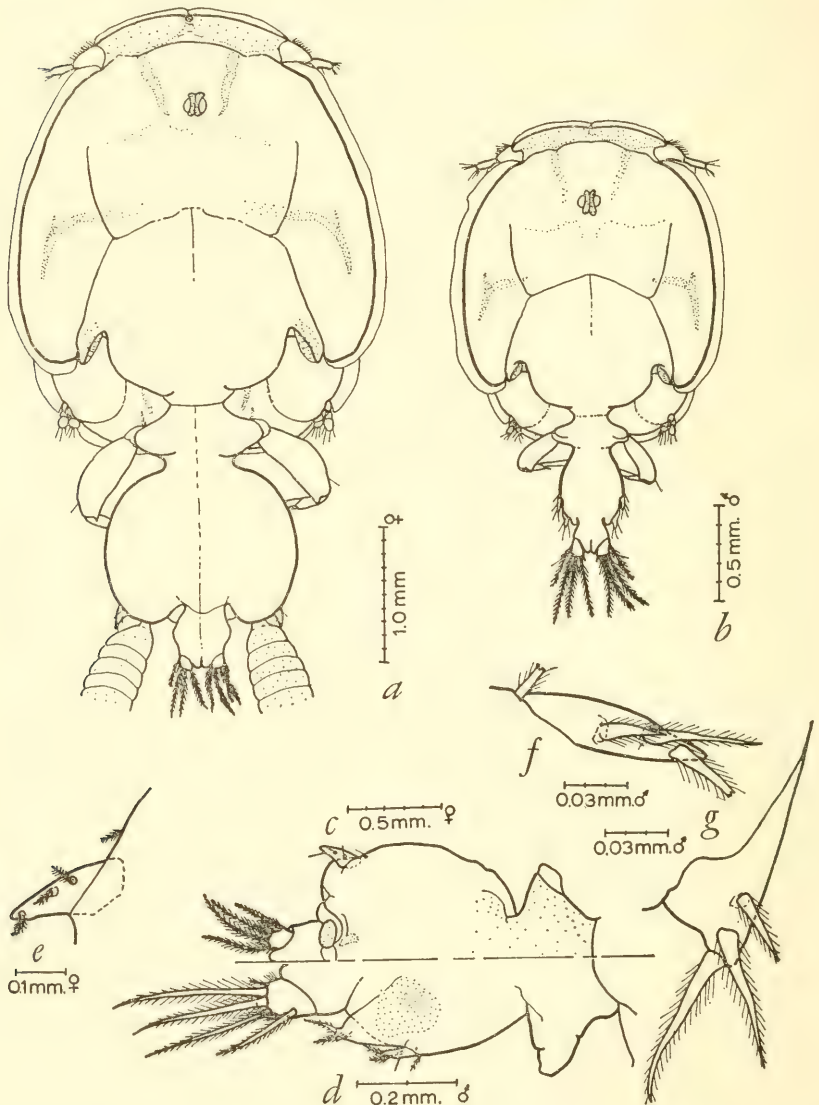


FIGURE 16.—*Lepeophtheirus plectropomi?* Nunes-Ruivo and P. Fourmanoir, 1956, dorsal views: a, female; b, male. Ventral views: c, female genital segment and fifth leg; d, male genital segment, fifth, and sixth legs. Legs, ventral views: e, female fifth; f, male fifth; g, male sixth.

short, length and width about equal, flared slightly towards posterior end. Caudal rami as in female.

Female and male antennule (fig. 17*a*) 2-segmented, first segment strongly developed, approximately one and one-half times the length of second. Irregular articulation surfaces on proximal end of first

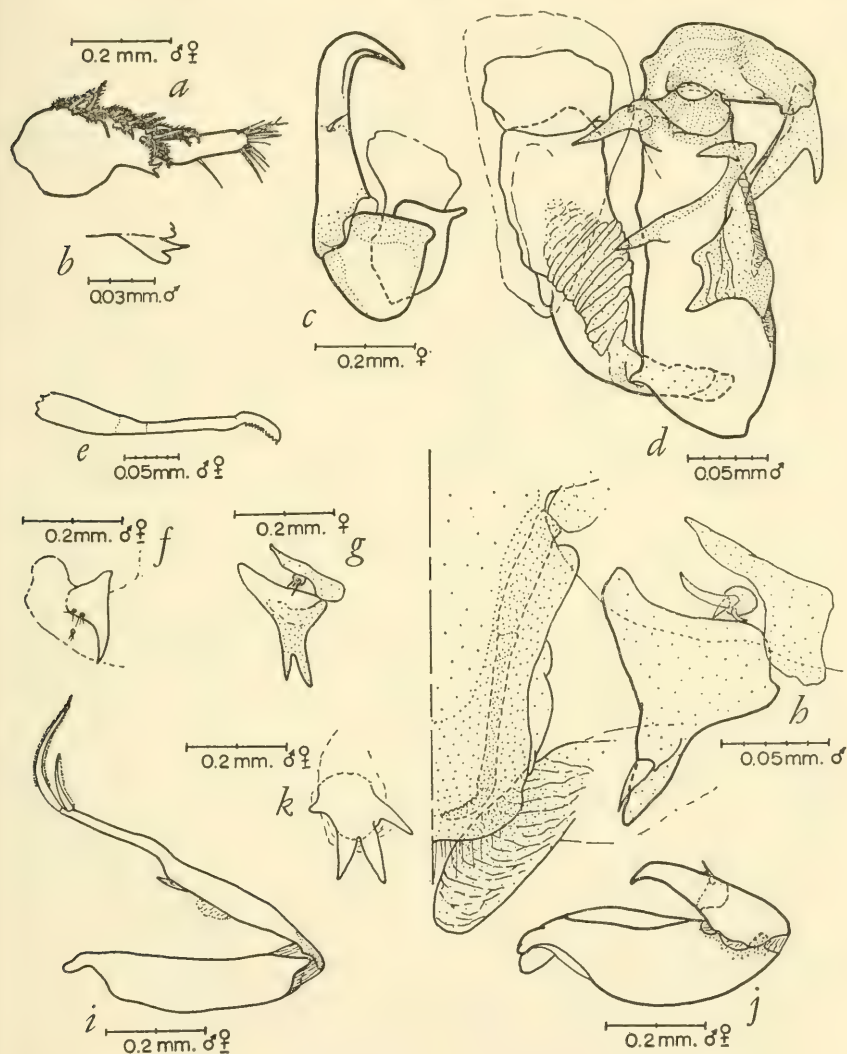


FIGURE 17.—*Lepeophtheirus plectropomi*? Nunes-Ruivo and P. Fourmanoir, 1956, ventral views (except *b*): *a*, left antennule; *b*, process on distal posterior surface of first segment of male antennule; *c*, female left antenna; *d*, male right antenna; *e*, left mandible; *f*, post-antennal process; *g*, female left maxillule and postoral process; *h*, male oral region, showing mouth cone, mandible, maxillule, postoral process, and postoral adhesion pad; *i*, left maxilla; *j*, left maxilliped.

segment articulating on platelike process extending posteriorly from frontal region, terminating in cephalothorax posterior to frontal region. Anterior ventral and anterior lateral surfaces of first segment bearing 24 plumose setae and setules, bifurcate process (fig. 17*b*) present on posterior edge of distal surface. Second segment elongate, bearing single naked seta from middle of posterior surface, 12 naked setae from distal surface. Female antenna (fig. 17*c*) 3-segmented, situated posterior and medial to antennule base. First segment broad, irregular, bearing spikelike projection on inner posterior surface. Second segment short, well developed. Third segment and terminal process indistinctly separable or continuous, clawlike, seta-like accessory process present at indistinct junction of segment and terminal process. Male antenna (fig. 17*d*) 3-segmented, positioned as in female. First segment elongate, with large adhesion surface ventrally; length of second segment approximately the same as first, segment well developed, with several irregular, spikelike projections and 2 adhesion surfaces, one on anterior medial region, second on broad, irregular projection of inner medial region. Third segment distinct from bifurcate terminal process, bearing single seta-like accessory process on inner surface, at junction of segment and terminal process.

Mandible of female and male (fig. 17*e*) 4-parted, rodlike, distalmost part curved inward, flattened, bearing 11-12 denticulations. Female and male postantennal process (fig. 17*f*) situated lateral and slightly posterior to antenna base, consisting of spikelike projection and 3 nodules, each bearing several hairlike processes. Two nodules present on base of spikelike projection, third situated immediately posterior to base. Female postoral process (fig. 17*g*) consisting of bifurcate projection immediately posterior to maxillule, male process (fig. 17*h*) spikeshaped, with poorly sclerotized accessory spine from distal half of inner ventral surface. Female and male maxillule (figs. 17*g,h*) consisting of nodule bearing 3 seta-like processes. Female and male maxilla (fig. 17*i*) 2-segmented, situated lateral and slightly posterior to postoral process. Both segments elongate, first approximately four-fifths the length of second. Rodlike second segment with 2 membranes on medial inner surface (one folded, appearing spinelike) and 2 saber-like terminal processes, innermost slightly more than twice the length of outer, with frilled membrane along both margins, outermost process with frilled membrane on outer margin only. Male with lobate postoral adhesion surface (fig. 17*h*), surface similar to adhesion surface on first segment of antenna although plates not as distinct.

Maxilliped of female and male (fig. 17*j*) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed, length slightly more than one and one-half times that of combined

second segment and terminal process. Second segment continuous with clawlike terminal process, bearing single, seta-like accessory process on inner surface, at junction of segment and terminal process. Female and male sternal furca situated between and slightly posterior

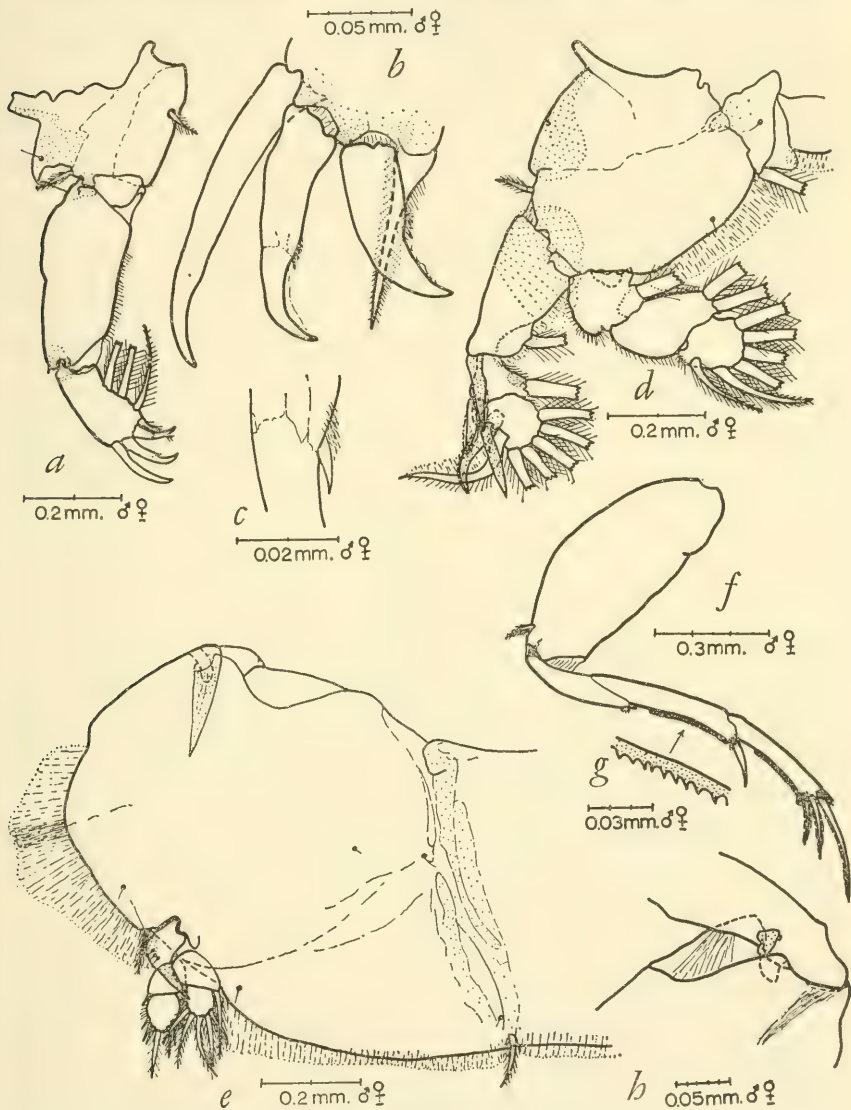


FIGURE 18.—*Lepeophtheirus plectropomi*? Nunes-Ruivo and P. Fourmanoir, 1956, thoracic legs, anterior views: *a*, right first; *b*, distal region of second segment of exopodite of first; *c*, portion of median terminal spine of second segment of exopodite of first; *d*, right second; *e*, right third; *f*, right fourth; *g*, enlarged portion of denticulated region of fourth; *h*, joint of protopodite and first segment of exopodite of fourth.

to maxilliped bases, tines angled outward slightly, bluntly pointed distally. Basal region of furca with lateral projection on each side, length of projections variable although projection on left usually longer than that on right.

Thoracic legs I-III biramous although endopodite of first leg rudimentary, fourth thoracic leg uniramous, 4-segmented. For nature of appendages and armature, see figures 18*a-j* and table 7.

DISCUSSION.—The identification of the Eniwetok specimens as *L. plectropomi* is questioned for three reasons:

1. The incomplete original description makes identification difficult.
2. The rami of the sternal furca of the Eniwetok specimens are thinner than those figured for *L. plectropomi*.
3. The membrane on the inner 2 terminal spines on the second segment of the exopodite of the first thoracic leg is figured as reaching

TABLE 7.—Armature of thoracic legs I-IV of the female and male of *Lepeophtheirus plectropomi*? Nunes-Ruivo and Fourmanoir, 1956

| Leg | Surface | Inter-podal plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------|-----|-----------|-------|----------|------------|------|------|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | | s,p | | rh | 3mH,P | | | | |
| | Inner | | p | | c | 3P | | | | |
| II | Outer | m | | m,p | m,mH | mH | 2mH,Q,2P | c | c | c,3P |
| | Inner | | s,P | m,s | c,P | c,P | c,3P | P | c,2P | c,3P |
| III | Outer* | m | m,s,P | | 3s,H | c,p' | c,3p',P | c | c,3P | |
| | Inner | | s,P,m,s | | P | c,P | c,3P | P | c,3P | |
| IV | Outer | | p | | fh | d,fH | d,3fH | | | |

*Several hairlike processes on protopodite not included.

the distal end of the spines (fig. 5*b* in Nunes-Ruivo and Fourmanoir, 1956). The condition in the Eniwetok specimens differs, as shown in figures 18*b, c*.

Both Nunes-Ruivo and Fourmanoir (1956) and Kabata (1966) compare *L. plectropomi* with *L. dissimulatus* Wilson (1905). The two species are similar in general body composition but exhibit appendage and other body characteristics that enable them to be readily separated. Two of these characteristics are:

1. The female of *L. plectropomi* possesses a short, spinelike projection as part of the fifth leg. The female of *L. dissimulatus* does not; the fifth leg of this species includes a setule-bearing lobe or node but not a spine.

2. The antenna of the adult male of *L. plectropomi* (providing the Eniwetok specimens are members of this species) has several spinelike projections on the second segment. The antenna of the adult male of *L. dissimulatus* does not have these. The only projecting process on the antenna of this species is a dactyliform adhesion process that usually is wrapped around the distal portion of the segment.

Lepeophtheirus dissimulatus Wilson

Lepeophtheirus dissimulatus Wilson, 1905, p. 631, pl. 22.—Lewis, 1964a, p. 178, figs. 11, 12.

HOSTS AND DISTRIBUTION.—See Lewis (1964a, 1967).

MATERIAL.—1 female (USNM 120752) from the gill cavity of *Parupeneus cyclostomus?* (Lacépède).

MEASUREMENTS (in mm).—1 female:

| | |
|--------------------------------------|------|
| Total length, excluding caudal setae | 2.38 |
| Length of cephalothorax | 1.75 |
| Width of cephalothorax | 1.62 |
| Length of genital segment | 0.58 |
| Width of genital segment | 0.83 |
| Length of abdomen | 0.14 |
| Length of egg string (1 string) | 1.75 |

DESCRIPTION.—See Lewis (1964).

Pseudocaligus similis, new species

FIGURES 19-21

MATERIAL.—1 female (holotype, USNM 120753) from the gill cavity of *Fistularia petimba* Lacépède; 1 male (allotype, USNM 120754) from the gill cavity of *F. petimba*; 1 male (paratype, USNM 120755) from the gill cavity of *F. petimba*; 7 females (2 damaged) (paratypes, USNM 120756) from the buccal cavity of *F. petimba*; 8 females and 5 males (retained by author) from the gill cavity of *F. petimba*.

MEASUREMENTS (in mm).—14 females, 5 males:

| | females | | males | |
|--------------------------------------|---------|-----------|-------|-----------|
| | mean | range | mean | range |
| Total length, excluding caudal setae | 6.13 | 5.44-6.81 | 4.36 | 3.92-4.77 |
| Length of cephalothorax | 2.18 | 1.92-2.41 | 2.22 | 2.11-2.41 |
| Width of cephalothorax | 1.79 | 1.48-2.00 | 1.92 | 1.70-2.11 |
| Length of genital segment | 1.81 | 1.44-2.07 | 0.87 | 0.74-1.00 |
| Width of genital segment | 1.36 | 0.96-1.78 | 0.69 | 0.59-0.78 |
| Length of abdomen | 1.78 | 1.44-2.00 | 0.87 | 0.78-0.96 |
| Length of egg string (16 strings) | 4.23 | 2.96-5.00 | | |

DESCRIPTION.—Female cephalothorax (fig. 19*b*) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately one-eleventh the total length of cephalothorax, anterior surface bilobed, with membranous margin; division between frontal region and remaining cephalothorax incomplete. Lunules (fig. 19*g*) distinct, extending posteriorly, on ventral surface, to posterior portion of frontal region. Lateral cephalothoracic margins irregular, with narrow membrane extending laterally, second membrane extending medially, on ventral surface. Posterior lateral regions lobate, with small, socket-like depression. Posterior sinus (fig. 19*e*) distinct, semi-V-shaped, with fine membrane on outer surface. Posterior median cephalothoracic region extending slightly past lateral regions, posterior margin irregular. Major dorsal cephalothoracic grooves forming irregular H, anterior legs of H terminating in narrow bands of heavy sclerotization. Ocular region distinct, just anterior to anterior end of H-shaped groove system.

Female free fourth pedigerous segment distinct from cephalothorax, indistinctly separable from genital segment. Approximate length slightly more than two-thirds the width, lateral margins irregularly convex. Genital segment (fig. 19*d*) elongate, irregularly tapered anteriorly, lateral posterior surface lobate. Fifth legs (fig. 21*g*) situated on posterior lateral surface, consisting of 4 plumose setules, 2 from nodule, remaining 2 arising from surface of genital segment adjacent to nodule.

Female abdomen elongate, 2-segmented, indistinctly separable from genital segment. First segment more than 4 times the length of second, lateral margins irregular; second segment with flatly convex lateral margins, posterior surface concave laterally, bilobed medially, at anal indentation. Caudal rami (fig. 19*f*) attached to concave lateral posterior surface of second segment of abdomen, shape subrectangular, with small convex projection on distal inner surface. Armature consisting of 2 plumose setules from distal outer surface, 3 plumose setae from outer distal surface, single plumose setule from inner distal surface, and plumes on convex projection of distal inner surface.

Male cephalothorax (fig. 19*a*) similar to that of female. Free fourth pedigerous segment slightly more than twice as wide as long, distinct from both cephalothorax and genital segment. Genital segment (fig. 19*c*) wider anteriorly than posteriorly, lateral margins flatly convex in anterior half, flatly concave in posterior half; dorsal posterior surface projecting posteriorly slightly past junction of genital segment and abdomen. Fifth legs (fig. 21*h*) situated on middle of lateral ventral surface, consisting of nodule bearing 3 plumose setules. Sixth legs (fig. 21*i*) situated on posterior ventral surface, slightly anterior

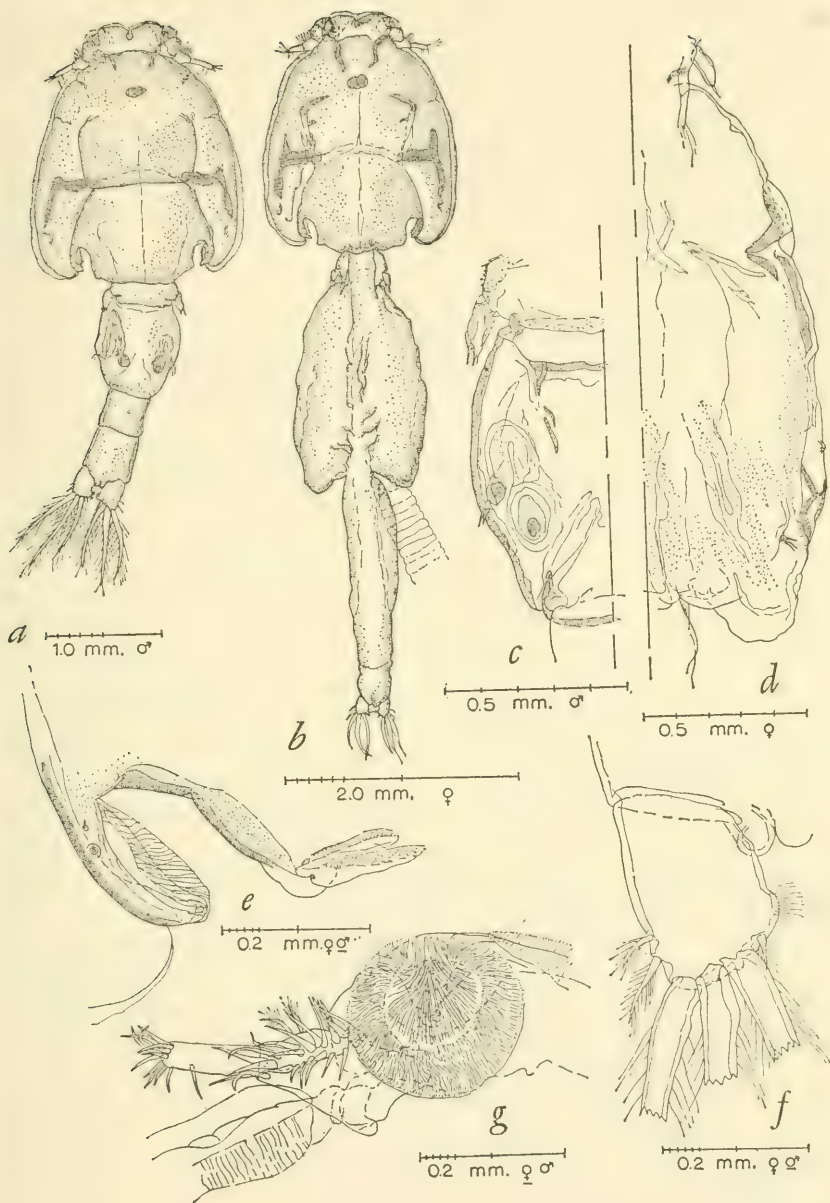


FIGURE 19.—*Pseudocaligus similis*, new species: *a*, male, dorsal view; *b*, female, dorsal view; *c*, male fourth pedigerous and genital segments, ventral view; *d*, female, same; *e*, posterior cephalothoracic sinus, dorsal view; *f*, right caudal ramus, ventral view; *g*, right lunule and antennule (see text for differences between female and male), ventral view.

to genital opening, consisting of 2 plumose setules. Abdomen distinct from genital segment, 2-segmented, first segment approximately three-fourths the length of second, both segments subrectangular. Caudal rami similar to those of female although small convex projection on distal inner surface more distinct in male.

Female antennule (fig. 19*g*) 2-segmented, attached to lateral posterior ventral surface of frontal region and adjacent ventral surface of cephalothorax. First segment slightly less than twice the length of second, broad proximally, tapered toward slightly constricted distal end, anterior ventral and anterior surface bearing 24 naked and lightly plumose setae and setules. Second segment rodlike, with single naked setule from middle of posterior surface, approximately 11 naked setules from distal surface. Male antennule similar to that of female except second segment longer, first segment only 1.4 times the length of second. Female antenna (fig. 20*b*) 3-segmented, situated posterior and medial to antennule base. First segment short, distal surface subtriangular, inner posterior surface with small, spikelike projection. Second segment short, slightly wider proximally than distally. Third segment continuous with clawlike terminal process, bearing 2 setulelike accessory processes, 1 proximally, 1 medially. Male antenna (figs. 20*a,c*) 3-segmented, first segment longer than that of female, spikelike projection minute. Second segment longer than that of female, with one adhesion pad on proximal inner surface, another forming ridgelike projection from distal posterior surface. Third segment short, suborbicular, distinct from short, beakshaped terminal process, bearing 2 setulelike accessory processes, 1 on either side of terminal process.

Female and male mandible (figs. 20*a,b*) rodlike, 4-parted, distalmost part flattened, curved inward, inner margin with 12 denticulations. Female and male maxillule (figs. 20*a,b*) palplike, situated posterior and slightly lateral to mandible base, with naked terminal setule and seta. Female and male maxilla (fig. 20*d*) 2-segmented, situated posterior and lateral to maxillule. First segment slightly less than half the length of second, with spikeshaped projection from inner proximal surface; segment curved inward slightly toward distal end. Second segment elongate, with small, membranous, subconical projection from distal half of inner surface, distal surface bearing 2 seta-like processes, innermost slightly less than twice the length of outermost, with fine membrane along inner surface, outer terminal process with fine membrane along outer margin.

Female postantennal process (fig. 20*b*) situated posterior and slightly lateral to antenna base, consisting of 3 nodules bearing several hairlike processes and short, spikeshaped projection originating from round, heavily sclerotized plate. Anterior 2 nodules situated on plate, third

located slightly posterior and medial to plate. Plate and projection of male postantennal process (fig. 20a) much larger, projection falciform, process bearing nodules present on plate of female not visible on male, nodule posterior to plate of female present on male. Female and male postoral process (figs. 20a,b) spikeshaped, situated slightly posterior to maxillule base. Postoral adhesion pads present in male (figs. 20a,f) although not rugose, consisting of pair of heavily sclerotized, U-shaped ridges on median longitudinal axis slightly posterior to maxilla bases.

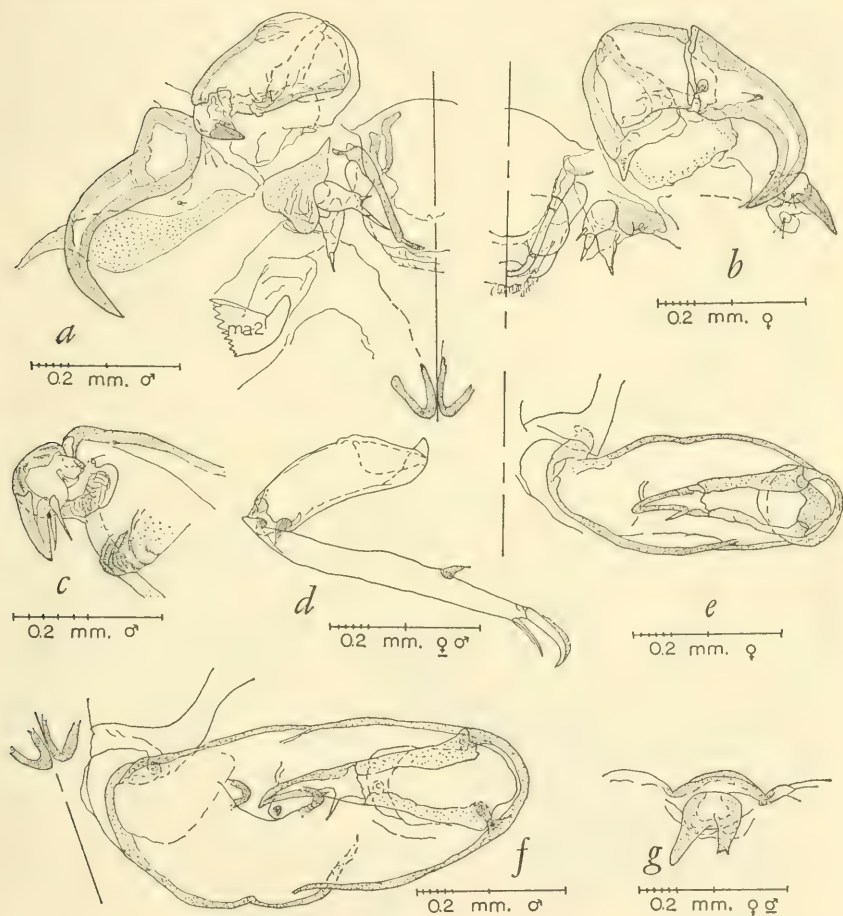


FIGURE 20.—*Pseudocaligus similis*, new species, ventral views: a, oral region of male, showing antenna, mouth cone, mandible, maxillule, maxilla base (ma-2), postantennal process, postoral process, and postoral adhesion pad; b, same of female (postoral adhesion pads missing in female); c, third segment and distal region of second segment of right antenna of male; d, right maxilla; e, female left maxilliped; f, male postoral adhesion pads and left maxilliped; g, sternal furca.

Female maxilliped (fig. 20e) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed, with small, ridgelike projection on medial inner surface. Second segment distinct from clawlike terminal process; inner surface longer than outer, with setulelike accessory process distally. Male maxilliped (fig. 20f) similar

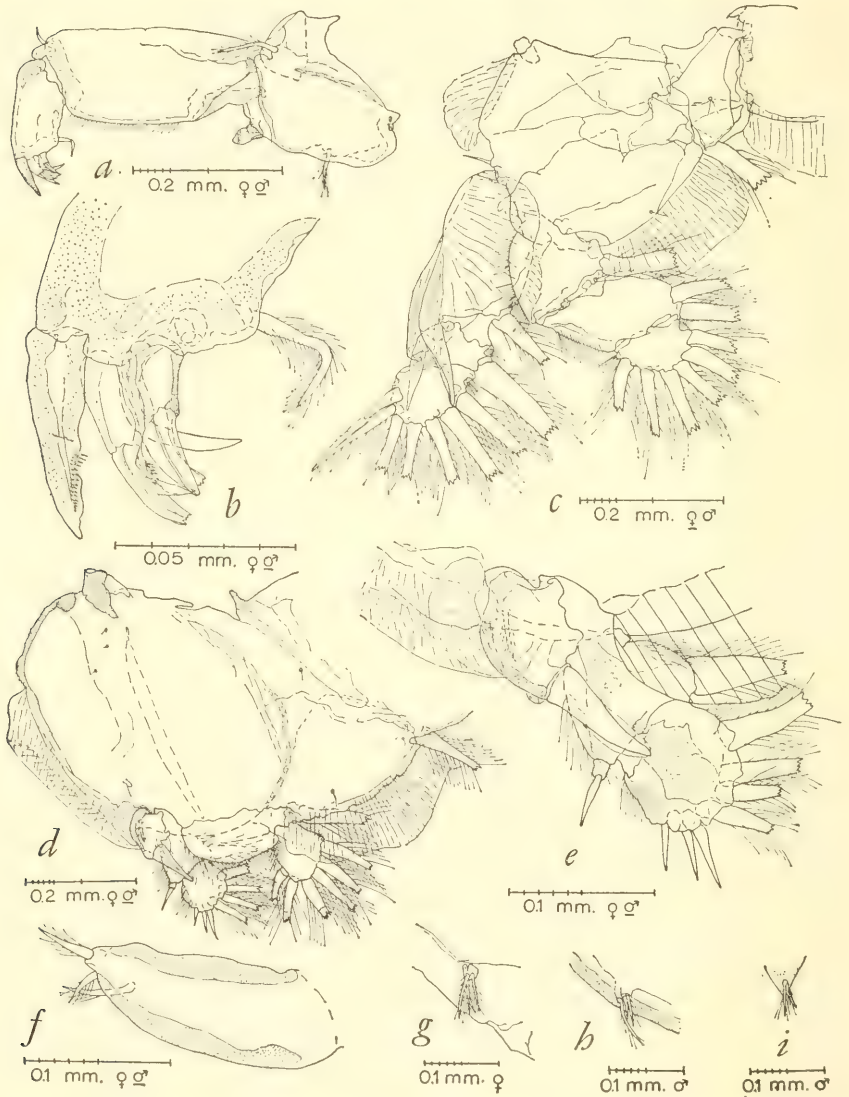


FIGURE 21.—*Pseudocaligus similis*, new species, right thoracic legs, anterior views (except *f*): *a*, first; *b*, distal region of second segment of exopodite of first; *c*, second, *d*, third, *e*, exopodite of third; *f*, left fourth (posterior view). Right legs, ventral views: *g*, female, fifth; *h*, male, fifth; *i*, male, sixth.

to that of female although larger and first segment bearing 3 knoblike projections adjacent to ridge described for female. Sternal furca (fig. 20g) U-shaped, associated with trilobate platelike structure posterior to maxilliped bases; tines of furca sharply rounded distally.

For nature and armature of thoracic legs I-IV, see figures 21a-f and table 8. Second segment of exopodite of first thoracic leg with only single plumose setule on inner surface. Pair of padlike structures present posterior to interpodal plate of first thoracic leg.

DISCUSSION.—*Pseudocaligus similis* most closely resembles *P. fistulariae* Pillai (1961) and *P. tenuicauda* Shiino (1964), both of which are also found on *Fistularia*. The similarities are not only in the overall body shape (especially the elongate, 2-segmented abdomen in the female and the shorter 2-segmented abdomen in the male) but also in

TABLE 8.—Armature of thoracic legs I-IV of the female and male of *Pseudocaligus similis*, new species

| Leg | Sur- face | Inter- podal plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|--------------|--------------------------|----------------|------|-----------|------------|----------|------------|-------|-------|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | | p | | p' | 2dH, H, P' | | | | |
| | Inner | | p | | c | p | | | | |
| II | Outer | | | m, p | m, mH | mH | rh, H, Q | c, c | c | c, 3P |
| | Inner | m | ss, P | m, s | c, P | c, P | c, 5P | P | c, 2P | c, 3P |
| III | Outer | | r, m, p | | m, mH | c, p' | c, 3p' | c | c, 2P | |
| | Inner* | m | ss, P, s, m, s | | c, P | c, P | c, 4P | P | c, 4P | |
| IV | Outer# | | 3p | | | | | | | |

*Elements in middle of protopodite not tabulated.

#Elements not to be definitively associated with protopodite, status of segments obscure.

the appendages, especially the male antenna. The fifth leg of both *P. tenuicauda* and *P. similis* is, however, 1-segmented while that of *P. fistulariae* is distinctly 2-segmented and has a plumose setule on the distal surface of the first segment. *Pseudocaligus similis* can be most readily distinguished from *P. tenuicauda* by 3 characteristics:

1. The maxillule is better developed in *P. similis* and, in this respect, resembles the condition figured for *P. fistulariae*.

2. The 3 terminal spines on the second segment of the exopodite of the first thoracic leg are described as being bifid in *P. tenuicauda* while only the inner 2 spines are bifid in *P. similis* although the armature of the spine can give a pseudobifid appearance in unstained specimens.

3. The size of the terminal seta on the second segment of the exopodite of the first thoracic leg differs between the 2 species, being large in *P. tenuicauda* and small in *P. similis*.

The species name is derived from the Latin word for "like" or "resembling" and alludes to the similarity of *P. similis* to *P. tenuicauda* and *P. fistulariae*.

Caligus coryphaenae Steenstrup and Lütken

Caligus coryphaenae Steenstrup and Lütken, 1861, p. 360, pl. 4, fig. 7.—Lewis, 1967, p. 101, figs. 37–39.

HOSTS AND DISTRIBUTION.—See Lewis (1967).

MATERIAL.—4 females and 2 males from the external surface of *Euthynnus yaito* (Jordan and Evermann); 4 females and 1 male from the external surface of *Sarda orientalis* (Schlegel); 1 male from the external surface of *Grammatoreynus bilineatus* (Rüppell); 2 females from the external surface of *Caranx melampygus?* Cuvier and Valenciennes; 7 females and 1 male from the external surface of *Katsuwonus pelamis* (Linnaeus). (All specimens retained by author.)

MEASUREMENT (in mm).—15 females, 5 males:

| | females | | males | |
|--------------------------------------|---------|-----------|-------|-----------|
| | mean | range | mean | range |
| Total length, excluding caudal setae | 4.76 | 4.51–6.36 | 3.99 | 3.55–4.77 |
| Length of cephalothorax | 2.71 | 2.48–3.33 | 2.60 | 2.37–3.00 |
| Width of cephalothorax | 2.28 | 2.04–2.96 | 1.97 | 1.81–2.37 |
| Length of genital segment | 1.13 | 0.96–1.33 | 0.64 | 0.59–0.85 |
| Width of genital segment | 1.25 | 1.11–1.52 | 0.86 | 0.78–1.07 |
| Length of abdomen | 0.90 | 0.70–1.33 | 0.61 | 0.52–0.74 |
| Length of egg strings (13 strings) | 4.67 | 4.22–5.70 | | |

DESCRIPTION.—See Lewis (1967).

REMARKS.—The size of the Eniwetok specimens is less than that of the specimens described from Hawaii. The reasons for this difference warrant further study. One possible source for the reasons may be that the specimens were all taken from fishes captured in the atoll lagoon; no host specimens were available from the open ocean outside the lagoon.

Caligus productus Dana

Caligus productus Dana, 1853, p. 1354, pl. 94 (fig. 4).—Lewis, 1967, p. 116, figs. 43–45.

HOSTS AND DISTRIBUTION.—See Lewis (1967).

MATERIAL.—2 females (USNM 120759) from the gill cavity of *Sarda orientalis* (Schlegel); 1 female and 2 males from the gill cavity and buccal cavity of *S. orientalis*; 5 females and 2 males from the gill cavity and buccal cavity of *S. orientalis*.

MEASUREMENTS (in mm).—6 females, 3 males:

| | females | | males |
|--------------------------------------|---------|------------|------------------|
| | mean | range | |
| Total length, excluding caudal setae | 4.54 | 4.29–4.92 | 4.00, 3.81, 3.74 |
| Length of cephalothorax | 1.86 | 1.78–1.96 | 1.96, 1.81, 1.81 |
| Width of cephalothorax | 1.64 | 1.48–1.85 | 1.74, 1.48, 1.48 |
| Length of genital segment | 1.49 | 1.37–1.70 | 1.00, 0.81, 0.81 |
| Width of genital segment | 1.10 | 1.00–1.18 | 0.70, 0.59, 0.67 |
| Length of abdomen | 1.12 | 0.96–1.26 | 0.85, 0.74, 0.78 |
| Length of egg strings (2 strings) | | 2.96, 3.03 | |

DESCRIPTION.—See Lewis (1967).

Caligus bonito Wilson

Caligus bonito Wilson, 1905a, p. 589, pl. 13, figs. 150–153, text figs. 5, 12–15, 29, 30, 35, 37, 38, 40–45.—Lewis, 1967, p. 124, figs. 46–48.

HOSTS AND DISTRIBUTION.—See Lewis (1967).

MATERIAL.—2 females from the gill cavity and buccal cavity of *Sarda orientalis* (Schlegel) (specimens retained by author).

MEASUREMENTS (in mm).—2 females:

| | |
|--------------------------------------|------------|
| Total length, excluding caudal setae | 4.66, 5.55 |
| Length of cephalothorax | 2.11, 2.48 |
| Width of cephalothorax | 2.04, 2.48 |
| Length of genital segment | 1.52, 1.48 |
| Width of genital segment | 1.33, 1.22 |
| Length of abdomen | 0.96, 1.11 |

DESCRIPTION.—See Lewis (1967).

Caligus asymmetricus Kabata

Caligus asymmetricus Kabata, 1965c, p. 110, figs. 1B,D,E.—Lewis, 1967, p. 131, figs. 49–51.

HOSTS AND DISTRIBUTION.—See Lewis (1967).

MATERIAL.—4 females (one damaged) and 4 males (USNM 120762) from the external surface, gill cavity and buccal cavity of *Grammatorecynus bilineatus* (Rüppell); 2 males (retained by author) from the external surface of *Sarda orientalis* (Schlegel); 2 females (retained by author) from the gill cavity of *Grammatorecynus bilineatus* (Rüppell); 1 male (retained by author) from the buccal cavity of *G. bilineatus*.

MEASUREMENTS (in mm).—5 females and 7 males:

| | females | | males | |
|--------------------------------------|---------|-----------|-------|-----------|
| | mean | range | mean | range |
| Total length, excluding caudal setae | 3.05 | 2.72–3.51 | 2.78 | 2.35–3.15 |
| Length of cephalothorax | 1.69 | 1.49–1.94 | 1.74 | 1.51–2.00 |
| Width of cephalothorax | 1.42 | 1.31–1.53 | 1.38 | 1.28–1.48 |
| Length of genital segment | 0.89 | 0.76–0.99 | 0.54 | 0.41–0.70 |
| Width of genital segment | 0.80 | 0.63–0.95 | 0.51 | 0.45–0.56 |
| Length of abdomen | 0.33 | 0.29–0.36 | 0.36 | 0.31–0.41 |

DESCRIPTION.—See Lewis (1967).

REMARKS.—Based on the examination of the Eniwetok material and a comparison of this material with the Hawaiian specimens (USNM 112912, 112913), two additions should be made to the description in Lewis (1967):

1. There are 2 adhesion processes on the male antenna, the first (op. cit., p. 136) is a ridged, lappet-like adhesion pad on the distal inner surface of the second segment while the second (not previously described) extends, as a narrow band, from the proximal anterior surface to the distal inner surface of the second segment. This adhesion band is more distinct in the Eniwetok specimens than in those from Hawaiian fishes.

2. The positioning of the denticulations shown on the second segment of the endopodite of the second thoracic leg in Lewis (1967, fig. 51c) is incorrect for the appendage in situ. For detailed examination and camera lucida drawings, the thoracic legs are normally removed and mounted under 9 mm cover slips. This technique frequently causes the arrangement of the denticulations on the second segment of the endopodite of the second thoracic leg to be distorted. In the appendage in situ, on both Hawaiian and Eniwetok specimens, the denticulations are typically arranged in pairs (except for the single proximalmost denticulation), straddling the outer surface of the segment (as shown in Kabata, 1965c, fig. 1E).

Caligus ligatus Lewis

Caligus ligatus Lewis, 1964a, p. 164, figs. 8-9; 1967, p. 163, figs. 62-64.

HOSTS AND DISTRIBUTION.—6 host records:

| locality | hosts | reference |
|------------------|----------------------------------|---------------|
| Hawaiian Islands | <i>Acanthurus dussumieri</i> | |
| | <i>Naso hexacanthus</i> | Lewis (1964a) |
| | <i>Dascyllus albisella</i> | |
| | <i>Aulostomus chinensis</i> | |
| | <i>Holocentrus xantherythrus</i> | |
| | <i>Pranesus insularum?</i> | Lewis (1967) |

MATERIAL.—7 females and 3 males (USNM 120764) from the buccal cavity of *Holocentrus spinifer* (Forskål); 14 females and 4 males from the buccal cavity of *H. spinifer* (retained by author).

MEASUREMENTS (in mm).—19 females, 6 males:

| | female | | male | |
|--------------------------------------|--------|-----------|------|-----------|
| | mean | range | mean | range |
| Total length, excluding caudal setae | 3.42 | 2.92-3.85 | 2.56 | 2.22-2.89 |
| Length of cephalothorax | 1.63 | 1.37-1.89 | 1.43 | 1.22-1.59 |
| Width of cephalothorax | 1.55 | 1.33-1.67 | 1.27 | 1.11-1.48 |
| Length of genital segment | 1.06 | 0.89-1.22 | 0.49 | 0.41-0.59 |
| Width of genital segment | 0.95 | 0.78-1.15 | 0.43 | 0.37-0.52 |
| Length of abdomen | 0.54 | 0.44-0.63 | 0.42 | 0.37-0.52 |
| Length of egg strings (8 strings) | 2.49 | 2.33-2.78 | | |

DESCRIPTION.—See Lewis (1964a, 1967).

Caligus kapuhili Lewis

Caligus kapuhili Lewis, 1967, p. 152, figs. 57-59.

HOSTS AND DISTRIBUTION.—2 host records:

| locality | host | reference |
|------------------|---------------------------|--------------|
| Hawaiian Islands | <i>Chaetodon miliaris</i> | |
| | <i>Chaetodon fremblii</i> | Lewis (1967) |

MATERIAL.—2 females (USNM 120768) from the gill cavity of *Chaetodon auriga* Forskål; 2 males (USNM 120768) from the gill cavity of *Chaetodon lunula* (Lacépède).

MEASUREMENTS (in mm).—2 females and 2 males:

| | female | male |
|---|------------|------------|
| Total length, excluding caudal setae | 1.94, 1.87 | 1.51, 1.42 |
| Length of cephalothorax | 1.06, 1.10 | 0.94, 0.92 |
| Width of cephalothorax | 1.04, 0.90 | 0.90, 0.90 |
| Length of genital segment | 0.56, 0.40 | 0.29, 0.31 |
| Width of genital segment | 0.52, 0.49 | 0.29, 0.27 |
| Length of abdomen | 0.20, 0.20 | 0.14, 0.18 |
| Length of egg strings (strings broken or missing) | | |

DESCRIPTION.—See Lewis (1967).

Caligus confusus? Pillai

FIGURES 22, 23

Caligus confusus Pillai, 1961, p. 104, fig. 10.—Kirtisinghe, 1964, p. 68, figs. 70, 71.

Caligus alalongae (not Krøyer).—Kirtisinghe, 1937, p. 435, figs. 1-4.—Yamaguti, 1954, p. 379, pl. 2 (fig. 19), pl. 3 (fig. 21).

?*Caligus constrictus* (not Heller).—Wilson, 1937a, p. 25, pl. 3, figs. 3a-i; 1937b p. 428, fig. 1.—Shiino, 1959a, p. 285, figs. 9, 10.

HOSTS AND DISTRIBUTION.—7 host records:

| locality | host | reference |
|-------------------------|------------------------------|-------------------|
| Trivandrum, South India | <i>Caranx sansun</i> | Pillai, 1961 |
| Panama, Ecuador | <i>Elagatis bipinnulatus</i> | |
| | <i>Caranx hippos</i> | Wilson, 1937a |
| Panama | <i>Coryphaena hippurus</i> | Wilson, 1937b |
| Costa Rica | <i>Seriola?</i> species | Shiino, 1959a |
| Celebes | <i>Elagatis</i> species | |
| | <i>Caranx</i> species | Yamaguti, 1954 |
| Ceylon | several species of carangids | Kirtisinghe, 1964 |

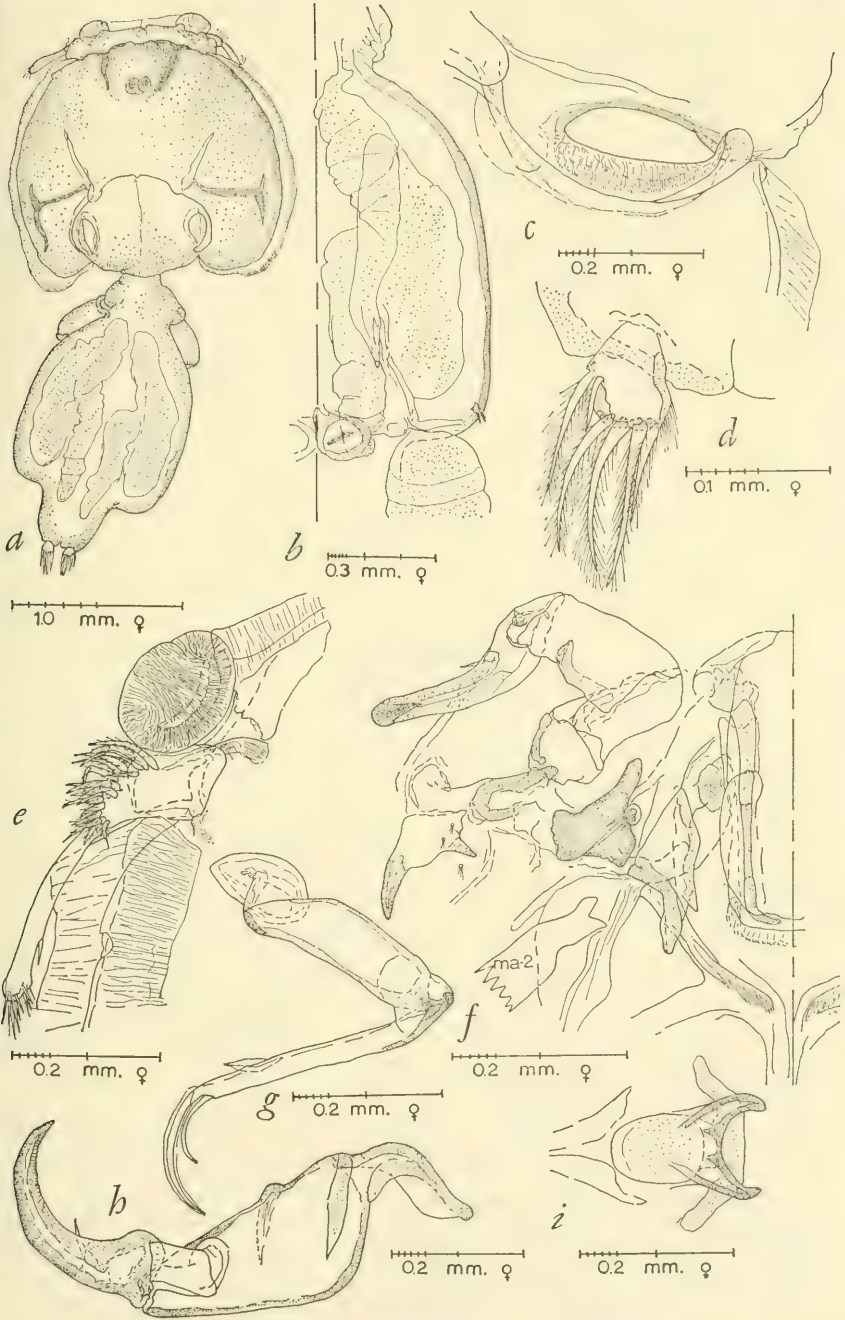
MATERIAL.—17 females and 1 immature male (probably late chalimus) (USNM 120763) from the buccal cavity of *Caranx melampygus* Cuvier and Valenciennes.

MEASUREMENTS (in mm).—16 females, 1 immature male:

| | female | | |
|--------------------------------------|--------|-------------|-------|
| | mean | range | male |
| Total length, excluding caudal setae | 3. 22 | 2. 70-3. 44 | 2. 14 |
| Length of cephalothorax | 1. 49 | 1. 24-1. 57 | 1. 33 |
| Width of cephalothorax | 1. 57 | 1. 33-1. 67 | 1. 13 |
| Length of genital segment | 1. 19 | 0. 92-1. 31 | 0. 41 |
| Width of genital segment | 0. 98 | 0. 83-1. 08 | 0. 29 |
| Length of abdomen | 0. 46 | 0. 31-0. 56 | 0. 27 |
| Length of egg string (11 strings) | 2. 19 | 1. 57-3. 33 | |

DESCRIPTION.—Female only. Cephalothorax (fig. 22a) ovoid, consisting of cephalon and first 4 thoracic segments. Frontal region approximately one-twelfth the length of rest of cephalothorax, with median indentation; membrane normally projecting from leading edge of frontal margin in caligids much heavier in *C. confusus*, appearing as extension of frontal region. Lunules (fig. 22e) well developed, projecting anteriorly slightly past anteriormost portion of frontal region, projecting posteriorly, on ventral surface, to junction of frontal region and cephalothorax. Division between frontal region and remaining areas of cephalothorax distinct, with saddle-like median section. Lateral surface of cephalothorax slightly irregular, ventral portion with fine, laterally projecting membrane and second, medially projecting membrane. Indentation present in posterior lateral cephalothoracic region of many caligids here present indistinctly, as slight concavity on lateral surface, without normally associated hairlike process or processes.

FIGURE 22.—*Caligus confusus?* Pillai, 1961, female: a, dorsal view; c, posterior cephalothoracic sinus, same view. Ventral views: b, genital segment and part of egg string; d, right caudal ramus; e, right lunule and antennule; f, oral region, showing antenna, mouth cone, mandible, maxillule, maxilla base (ma-2), postantennal process, and postoral process; g, left maxilla; h, left maxilliped; i, sternal furca.



Posterior sinus (fig. 22c) distinct, frequently closed posterly; exterior margin bearing fine membrane, dorsal cephalothoracic surface adjacent to anterior and inner surfaces of sinus with minute, ridgelike roughenings. Posterior surface of median cephalothoracic region projecting slightly past posterior surfaces of lateral cephalothoracic regions, division between free fourth pedigerous segment and cephalothorax distinct. Major dorsal cephalothoracic grooves forming irregular H, anterior legs terminating well posterior to distinct ocular region present on median longitudinal axis of body, in anterior third of cephalothorax.

Free fourth pedigerous segment subtriangular, anterior region narrowest; medial constriction evident in some specimens, not in others; fourth pedigerous and genital segments fused. Genital segment (fig. 22b) narrow anteriorly, broad posteriorly, lateral margins strongly convex anteriorly, almost parallel posteriorly. Fifth leg (fig. 23g) situated on ventral posterior surface, consisting of slight swelling bearing nodule with 3 plumose setules. Genital segment and abdomen fused.

Abdomen 1-segmented, broad anteriorly, narrower posteriorly, lateral margins flatly convex. Caudal rami (fig. 22d) attached to posterior ventral surface of abdomen, paddle-shaped, distal inner surface plumose. Distal surface of rami bearing 3 plumose setae and 1 plumose setule, additional plumose seta and setule present on slight indentation of middle of outer lateral surface.

Antennule (fig. 22e) 2-segmented, attached to knoblike cuticular projection of lateral anterior ventral surface of cephalothorax. First segment subrectangular, approximately two-thirds the length of second segment, anterior ventral and anterior surfaces with 21 naked or lightly plumose setules and setae; second segment rodlike, with naked setule from distal third of posterior surface, 11 naked setules from distal surface. Antenna (fig. 22f) 3-segmented, situated posterior and medial to antennule base. First segment flattened, irregular in outline; second segment subrectangular, with small, subtriangular projection from outer anterior surface. Third segment and terminal process indistinctly separable, clawlike, with setule-like accessory process medially, at junction of segment and terminal process; additional, lobate process present on proximal portion of segment.

Mandible (fig. 22f) rodlike, 4-parted, distalmost part flattened, curved inward, with 12 denticulations along inner surface. Postantennal process (fig. 22f) situated posterior and lateral to antenna base, consisting of plate bearing posteriorly directed spine and shorter, medially directed spine; 3 nodules present, 2 on plate, third slightly posterior to plate, all with several hairlike processes. Postoral process (fig. 22f) with broad base, irregularly tapered to bifid distal end, innermost tine approximately one-third the length of outer. Maxillule

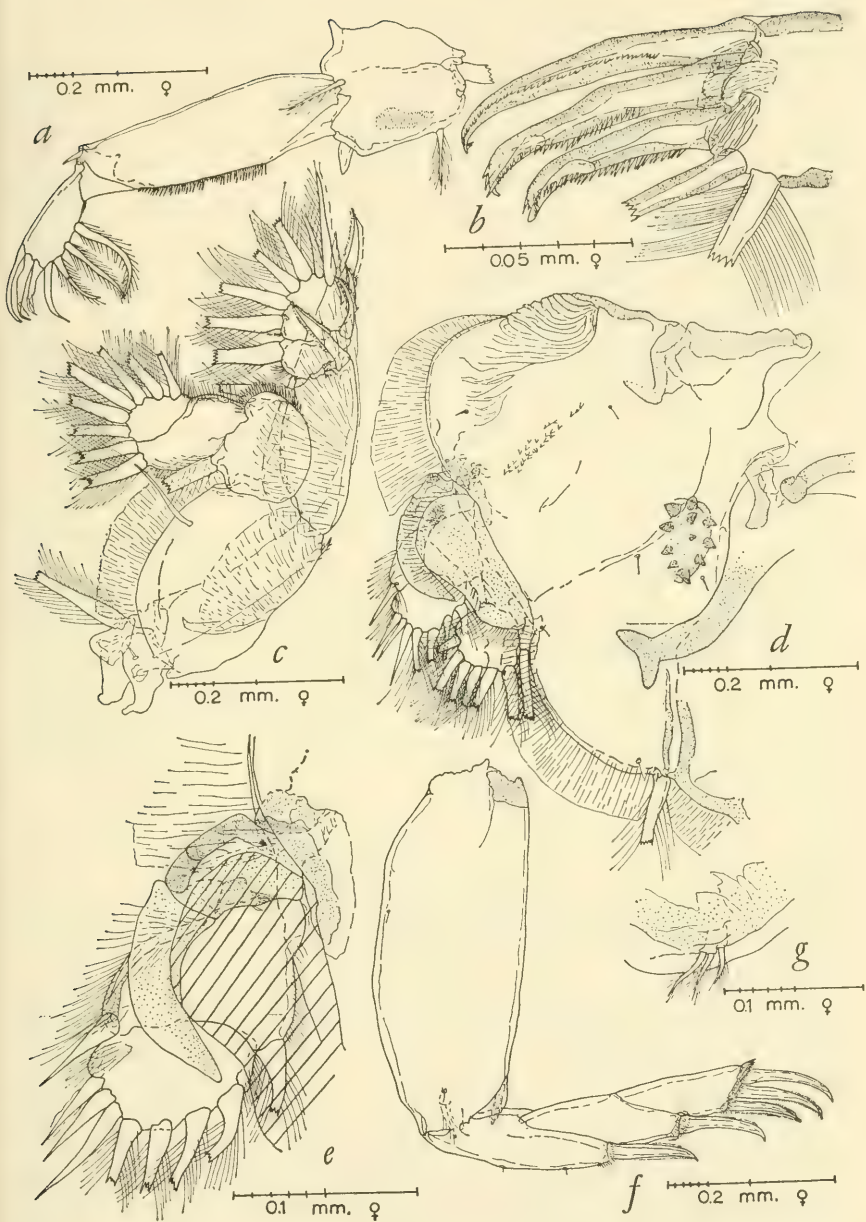


FIGURE 23.—*Caligus confusus?* Pillai, 1961, female, right thoracic legs, anterior views: *a*, first; *b*, distal region of second segment of exopodite of first; *c*, second; *d*, third, *e*, exopodite of third; *f*, fourth. Left fifth leg: *g*, ventral view.

(fig. 22*f*) nodular, situated lateral and slightly posterior to mandible base, bearing single naked seta and 2 naked setules. Maxilla (fig. 22*g*) 2-segmented, situated lateral and slightly posterior to maxillule. First segment approximately four-fifths the length of second, tapered proximally and distally to articulation surface. Second segment rodlike with U-shaped membrane on distal half of inner surface; distal surface with 2 saber-shaped processes, innermost approximately one and one-half times the length of outermost, both with fine membranes along outer and inner margins. Postoral adhesion pads (fig. 22*f*) evident as V-shaped ridges of heavy sclerotization adjacent to median longitudinal axis of body, slightly posterior to maxilla bases.

Maxilliped (fig. 22*h*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, inner

TABLE 9.—*Armature of thoracic legs I-IV of the female of Caligus confusus? Pillai, 1961*

| Leg | Surface | Inter-podal Plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------------|-------|-----------|----------|-------------|------------|-------|-------|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | | p | | m, rh | 3dH | | | | |
| | Inner | | p, r* | | C, C | 3P, P' | | | | |
| II | Outer | m | | m, p | m, dmH | dmH | dmH, Z#, Q | C | c | c, 3P |
| | Inner | | s, P | m, p' | c, P | c, P | c, 5P | P | c, 2P | 3P |
| III | Outer | m | a, m, p | | II | c, p', s | c, 3p', P | c | c, 2P | |
| | Inner | | D, 2s, P, s, m, s | | | c, P | c, 3P | P | 4P | |
| IV | Outer | | p | | fm, mH | fm, mH | 3fm, 2mH, H | | | |

*Roughened by minute projections giving brushlike appearance to element.

#Spine with simple membrane on one side, frilled membrane on other.

proximal half with heavily sclerotized transverse ridge; additional small, knoblike projection present on posterior surface (not shown on figure). Second segment and incompletely separable terminal process clawlike, segment with setule-like accessory process. Sternal furca (fig. 22*i*) situated between and slightly posterior to maxilliped bases, tines angled outward, sinus between tines broad.

Thoracic legs I-III biramous although endopodite of first leg reduced; fourth leg uniramous. For nature and armature of legs, see figures 22*a-f* and table 9.

DISCUSSION.—The Eniwetok specimens differ from Pillai's figures and description of *Caligus confusus* (1961) in two respects:

1. Pillai figures a membrane-like structure around the major spine on the postantennal process, another around the major spine on the

postoral process, and one on the outer margin of each ramus of the sternal furca. The Eniwetok specimens do not have any of these membranes although the edge of these structures is thin and semi-transparent and unless closely examined, gives a membrane-like appearance.

2. Pillai figures a blunt secondary projection on the proximal inner portion of the postoral process that is not present on the Eniwetok specimens.

The identification of the Eniwetok material as *C. confusus* Pillai is questioned because of the two differences mentioned above and the absence of an adequate first description of the species.

Both Pillai (1961) and Kirtisinghe (1964) list Wilson's (1937a,b) and Shiino's (1959a) "*Caligus constrictus*" as a synonym of *C. confusus* because of the very similar morphology of the figured specimens. There are some differences in the morphology that could be considered to be of a minor nature (e.g., shape of the postoral process), but there is a difference in the size of the specimens that should be evaluated with sufficient material. Pillai's female specimen(s) are 2.9 mm while Shiino's are 3.75 mm and Wilson's 5.0 mm in length. Even the female specimen(s) of Kirtisinghe (1964), from Ceylon, measure 4.5 mm in length, more than 1.5 times the length of Pillai's specimen(s) from southern India. Because of the difference in size, as well as the other characteristics, it is felt that there is some question (as noted in the synonymy) about the inclusion of Wilson's and Shiino's material and perhaps even that of Kirtisinghe.

Caligus pseudokalumai, new species

FIGURES 24, 25

MATERIAL.—1 female (holotype, USNM 120765) from the external surface of *Gymnosarea nuda* Günther.

MEASUREMENTS (in mm).—1 female:

| | |
|--|------|
| Total length, excluding caudal setae | 2.89 |
| Length of cephalothorax | 2.04 |
| Width of cephalothorax | 1.48 |
| Length of genital segment | 0.81 |
| Width of genital segment | 0.89 |
| Length of abdomen | 0.19 |
| Length of egg strings (strings broken) | |

DESCRIPTION.—Cephalothorax (fig. 24a) ovoid, consisting of cephalon, maxilliped-bearing and first 3 pedigerous segments. Frontal region approximately one-ninth the length of cephalothorax, anterior surface with narrow membrane. Lunules (fig. 24e) continuous with membrane along anterior margin, extending posteriorly, on ventral surface, to junction of frontal region and rest of cephalothorax. Lateral edge of

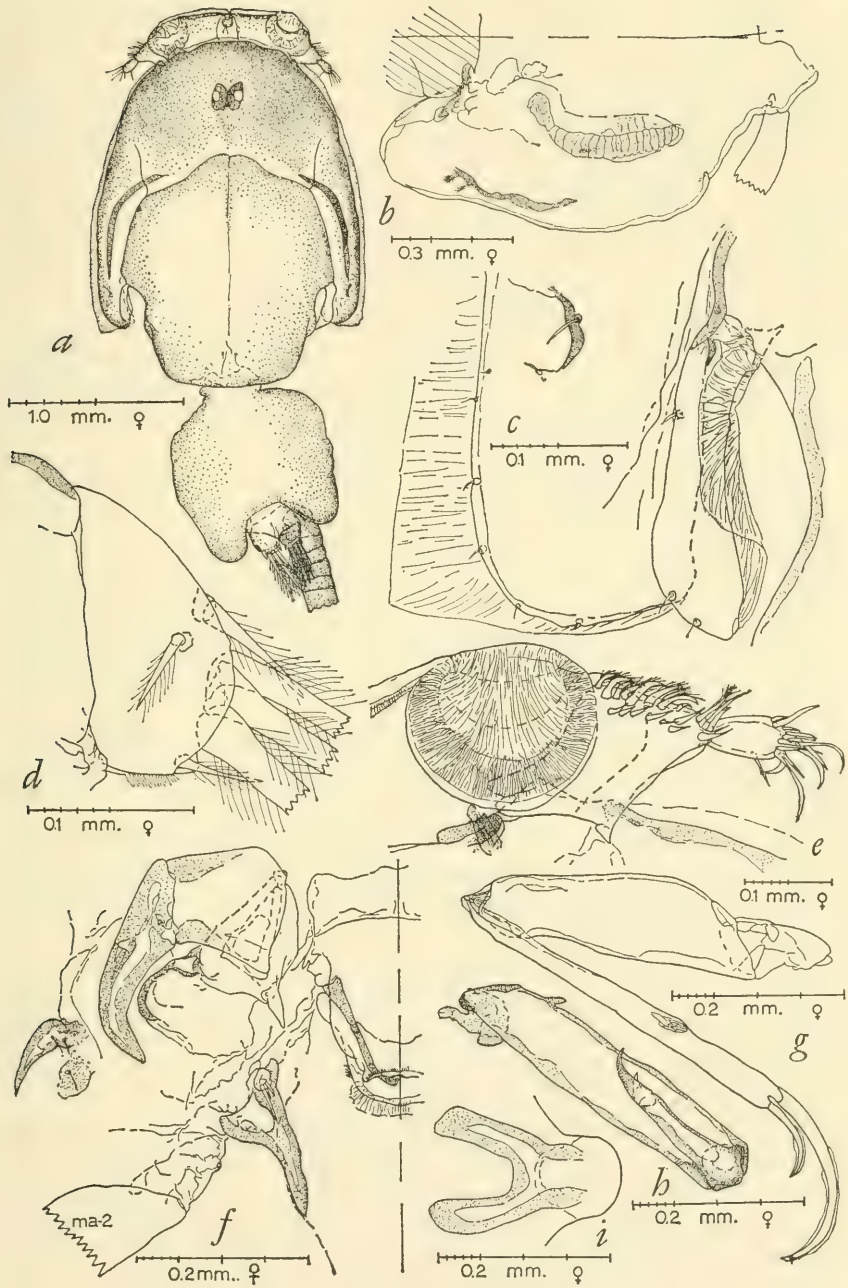
cephalothorax smooth, with slight indentation in anterior third, bearing narrow membrane and several hairlike processes. Posterior lateral region with small, cupshaped indentation. Posterior sinus (fig. 24*c*) distinct, anterior end sharply angled, lateral margins flatly concave, outer lateral surface bearing filmy membrane. Posterior median region of cephalothorax extending posteriorly well past lateral regions, posterior margin flatly convex in dorsal view; pair of minute, hairlike projections present, slightly anterior to posterior margin. Major dorsal cephalothoracic grooves forming irregular H, posterior legs flatly convex, anterior flatly concave, cross groove extending anteriorly from junction with legs of H. Ocular region distinct, in anterior fourth of cephalothorax.

Free fourth pedigerous segment distinct from cephalothorax although anterior half overlapped by posterior median cephalothoracic region. Fourth pedigerous and genital segments fused dorsally and ventrally. Surfaces of genital segment (fig. 24*b*) irregular; anterior region of segment broad, posterior bilobed, lobes extending posteriorly to caudal rami. Fifth legs (fig. 25*g*) situated on ventral surface, at beginning of posterior lobes, consisting of 2 nodules, anteriormost bearing single, lightly plumose setule, posterior bearing 2 plumose setules.

Abdomen 1-segmented, distinct from genital segment, lateral margins smooth, posterior margin V-shaped, almost covered by proximal surface of caudal rami. Caudal rami (fig. 24*d*) broad, lobate, width almost twice the greatest length. Inner surface plumose, distal surface bearing 3 plumose setae; inner distal surface with 1 plumose setule, distal outer surface with 2 plumose setules.

Antennule (fig. 24*e*) 2-segmented, attached to lateral posterior ventral surface of frontal region and adjacent surface of cephalothorax. First segment of general parallelogram shape, anterior and anterior ventral surface with 21 naked and lightly plumose setae and setules. Second segment clubshaped, length slightly less than two-thirds the length of anterior surface of first segment, with single naked seta from distal half of posterior surface, 13 naked setae from distal surface. Antenna (fig. 24*f*) 3-segmented, situated posterior and medial to antennule base. First segment squat, irregular, with narrow, dagger-like projection from posterior surface. Second segment slightly broader proximally than distally, distal surface irregular. Third segment and terminal process continuous, clawlike, with small, setule-like accessory process on proximal inner surface, second on medial surface.

FIGURE 24.—*Caligus pseudokalumai*, new species, female: *a*, dorsal view; *c*, posterior cephalothoracic sinus, same view. Ventral views: *b*, fourth pedigerous and genital segments; *d*, left caudal ramus; *e*, left lunule and antennule; *f*, oral region, showing antenna, mouth cone, mandible, maxillule, maxilla base (ma-2), postantennal, and postoral processes; *g*, right maxilla; *h*, right maxilliped; *i*, sternal furca.



Mandible (fig. 24f) rodlike, 4-parted, distalmost part curved inwards, inner surface with 12 denticulations. Postantennal process (fig. 24f) situated posterior and lateral to antenna base, consisting of heavily sclerotized clawlike projection with 2 nodules proximally, third present just posterior to base of projection; nodules each bearing single, large, hairlike process. Postoral process (fig. 24f) dagger-like, immediately adjacent to maxillule. Maxillule (fig. 24f) situated lateral and slightly posterior to mouth cone base, consisting of node bearing 2 short and one long seta-like projections. Maxilla (fig. 24g) 2-segmented, situated lateral and slightly posterior to maxillule. First segment slightly more than three-fourths the length of second, proximal articulation and muscle attachment surface directed at sharp angle to axis of segment. Second segment rodlike, bearing small, horseshoe-shaped membrane from medial inner surface and 2 saber-shaped terminal processes. Inner terminal process approximately twice the length of outer, both with fine membrane along inner and outer surfaces.

Maxilliped (fig. 24h) small, 2-segmented, situated posterior and slightly medial to maxilla base. First segment narrow, with small, spikelike projection from proximal posterior surface. Second segment rodlike, distinct from short, clawlike terminal process, with setule-like accessory process on distal inner surface. Sternal furca (fig. 24i) situated on median longitudinal axis of body posterior to maxilliped bases. Basal region of furca subconical, tines flattened, chisel-shaped distally.

Thoracic legs I-III biramous although endopodite of first leg rudimentary. Fourth thoracic leg uniramous, 3-segmented. For nature and armature of legs, see figures 25a-f and table 10.

DISCUSSION.—*Caligus pseudokalumai* most closely resembles *C. kalumai* Lewis (1964a) recorded from *Acanthurus guttatus* from the Hawaiian Islands. The relatively minor differences between the two species include the following:

1. The cephalothorax is more elongate in *C. pseudokalumai*, and the posterior median cephalothoracic region projects posteriorly past the posterior lateral cephalothoracic regions more than twice as far as it does in *C. kalumai* (0.36 mm to 0.16 mm). As a percent of the length of the cephalothorax, this equals 12 and 9 respectively.

2. The postantennal and postoral processes as well as the sternal furca are bulkier and more heavily sclerotized in *C. kalumai*. Even with this, however, the 3 nodules associated with the postantennal process each bears a single large (in comparison with other species of the genus), hairlike process (not 2 as stated in Lewis, 1964a, p. 175) as do those in *C. pseudokalumai*.

3. The first segment of the endopodite of the second thoracic leg bears a tuft of plumosities in *C. kalumai* but does not in *C. pseudo-*

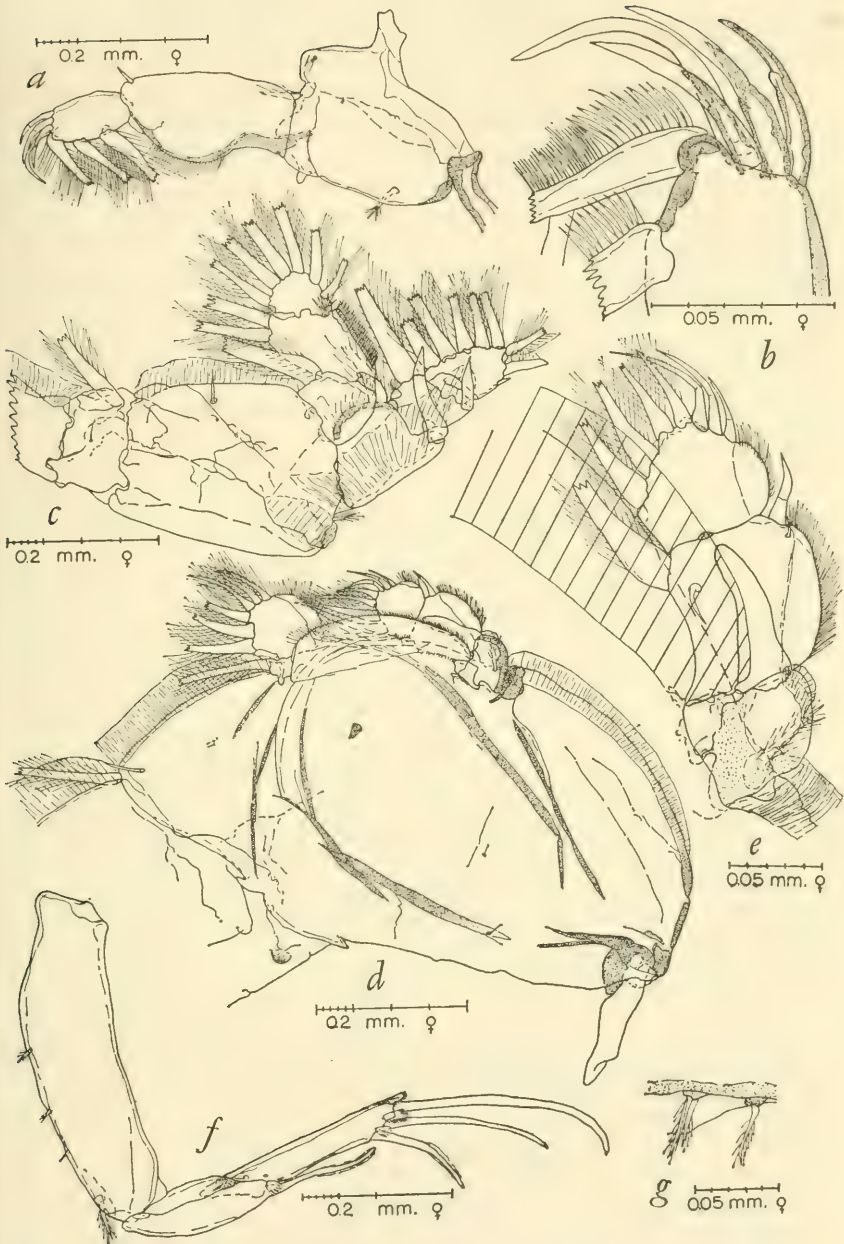


FIGURE 25.—*Caligus pseudokalumai*, new species, female, right thoracic legs, anterior views: *a*, first; *b*, distal region of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third; *f*, fourth. Left fifth leg; *g*, ventral view.

kalumai. The plumosities on the outer margin of the second and third segments of the endopodite are heavier in *C. pseudokalumai* than in *C. kalumai*.

4. The first segment of the exopodite of the fourth leg bears a filamentous (or slightly denticulated) membrane at the base of the spine in *C. pseudokalumai* which is missing in *C. kalumai*.

With one possible exception, these do not appear to be gross differences and the apparent close relationship between the two species should be more closely examined when larger collections are available. The single difference that may be of a relatively gross nature is the tuft of plumosities (or their absence) on the first segment of the endopodite of the second thoracic leg. This is the easiest characteristic to use in separating the two species and, because of the relatively stable nature of the second thoracic leg, may indicate more divergence than is presently believed.

TABLE 10.—*Armature of thoracic legs I-IV of the female of Caligus pseudokalumai, new species*

| Leg | Surface | Inter-podal Plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------|------|-----------|----------|-----------|------------|-------|-------|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | | sss, p | | rh | 3H, P' | | | | |
| | Inner | | p | | c | 3P | | | | |
| II | Outer | | | m, p | m, mH | mH | rh, mH, Q | | C | C, 2P |
| | Inner | m | s, P | m, s | c, P | c, P | 5P | P | c, 2P | c, 4P |
| III | Outer* | | m, p | | s, m | c, s, p' | c, 3p', p | c | c, 3P | |
| | Inner | m | 3s, P, m, s | | H | P | c, 3P | P | 3P | |
| IV | Outer | | 3s, p | | fm, mH | 2H | | | | |

*Armature tabulation does not include several hairlike processes in middle of protopodite.

The species name indicates the similarity between the new species from Eniwetok and *Caligus kalumai* from Hawaii.

Caligus alaihi, new species

FIGURES 26-28

MATERIAL.—1 female (holotype, USNM 120766) and 1 male (allotype, USNM 120767) from the buccal cavity of *Holocentrus sammara* (Forskål).

MEASUREMENTS (in mm).—1 female and 1 male:

| | <i>female</i> | <i>male</i> |
|-------------------------------------|---------------|-------------|
| Total length, excluding caudal seta | 2.77 | 2.07 |
| Length of cephalothorax | 1.55 | 1.21 |
| Width of cephalothorax | 1.53 | 1.12 |
| Length of genital segment | 0.65 | 0.40 |
| Width of genital segment | 0.68 | 0.36 |
| Length of abdomen | 0.34 | 0.32 |

DESCRIPTION.—Female cephalothorax (fig. 26*a*) ovoid, consisting of cephalon, maxilliped bearing and first 3 pedigerous segments. Frontal region approximately one-seventh the total length of cephalothorax, with fine membrane along anterior edge. Lunules (fig. 26*g*) distinct, extending posteriorly, on ventral surface, past junction of frontal region and remaining cephalothorax. Lateral margin of cephalothorax flatly convex although slightly irregular, with slight indentation anteriorly. Lateral ventral surface bearing 2 narrow membranes, first extending laterally, second medially, on ventral surface. Small, cup-shaped depression present in dorsal posterior lateral surface, with single, hairlike process arising from middle of cup. Posterior sinus irregularly U-shaped, with membrane along outer lateral surface. Median posterior surface extending posteriorly slightly past lateral posterior surfaces, overlapping anterior end of free fourth pedigerous segment. Major dorsal cephalothoracic grooves forming irregular H, anterior legs terminating well posterior to ocular region. Ocular region distinct, in anterior third of cephalothorax.

Female free fourth pedigerous segment short, length slightly more than half the width; segment widest medially, in region of fourth leg attachment. Segment distinct from genital segment ventrally, fused dorsally. Genital segment (fig. 26*c*) of general apple shape from dorsal viewpoint, anterior end narrowest. Fifth legs (fig. 28*h*) arising from posterior lateral surface, consisting of 2 setule-bearing nodules, anteriormost with single, lightly plumose setule, posterior with 3 lightly plumose setules.

Female abdomen 1-segmented, distinct from genital segment, lateral margins essentially parallel except at constricted anterior end; posterior surface angular, forming attachment surface for caudal rami, median posterior surface bilobed. Caudal rami (fig. 26*f*) constricted proximally, otherwise subrectangular, distal surface with 3 plumose setae and 1 plumose setule, on inner edge, distal outer surface with 2 plumose setules; distal half of inner surface plumose.

Male cephalothorax (fig. 26*b*) and free fourth pedigerous segment similar to that of female. Genital segment (fig. 26*d*) of general barrel

shape, fifth legs (fig. 28g) situated on posterior lateral surface, consisting of 2 setule-bearing nodules, anteriormost with single plumose setule, posterior with 2 plumose setules; sixth legs (fig. 28g) situated on posterior surface, adjacent to junction of genital segment and abdomen, consisting of nodule bearing 3 plumose setules. Abdomen

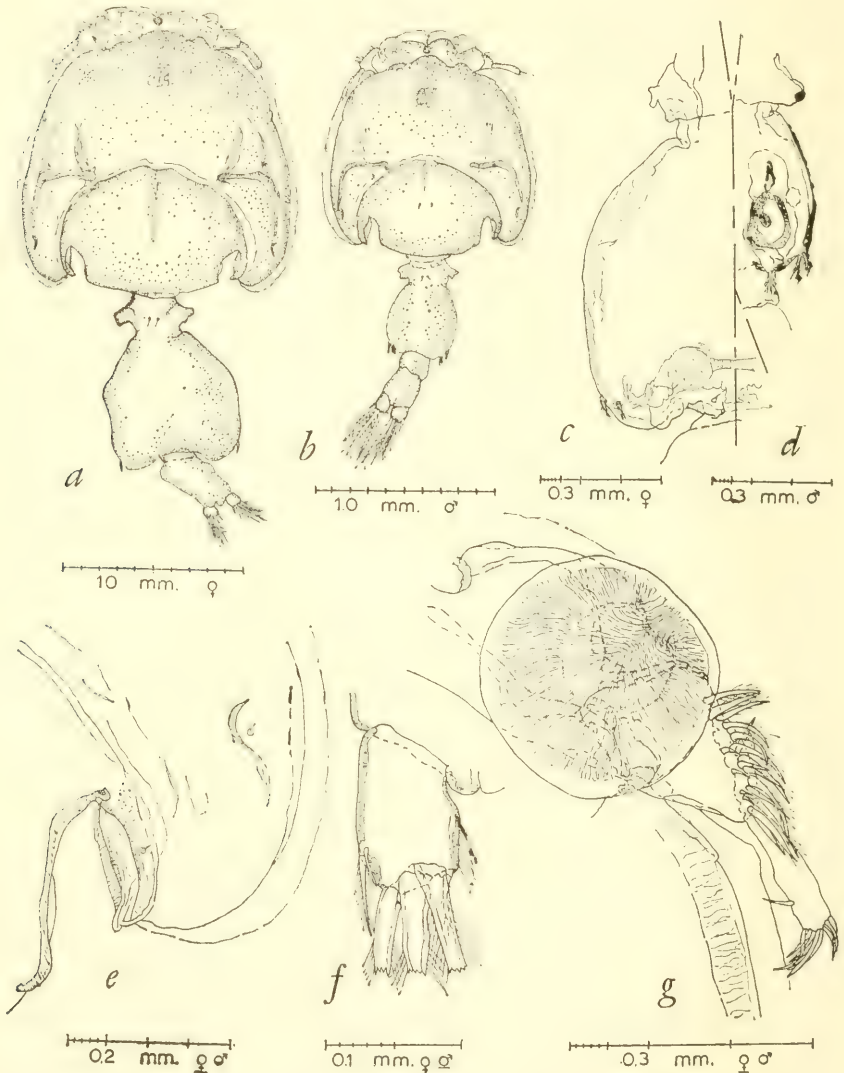


FIGURE 26.—*Caligus alaihi*, new species, dorsal views: *a*, female; *b*, male; *e*, posterior cephalothoracic sinus. Ventral views: *c*, female fourth pedigerous and genital segments; *d*, male fourth pedigerous, genital, and first abdominal segments; *f*, right caudal ramus; *g*, left lunule and antennule.

2-segmented, distinct from genital segment dorsally, indistinctly separable ventrally. First segment short, slightly more than half the length of second, lateral margins flatly convex; second segment constricted anteriorly, margins parallel posterior to constriction, posterior surface angular, as in female. Caudal rami as in female.

Female and male antennule (fig. 26*g*) 2-segmented, attached to both lateral ventral surface of frontal region and lateral anterior ventral surface of cephalothorax. First segment broad proximally, tapered to narrow distal end, anterior and ventral anterior surface with approximately 20 naked and lightly plumose setae and setules. Second

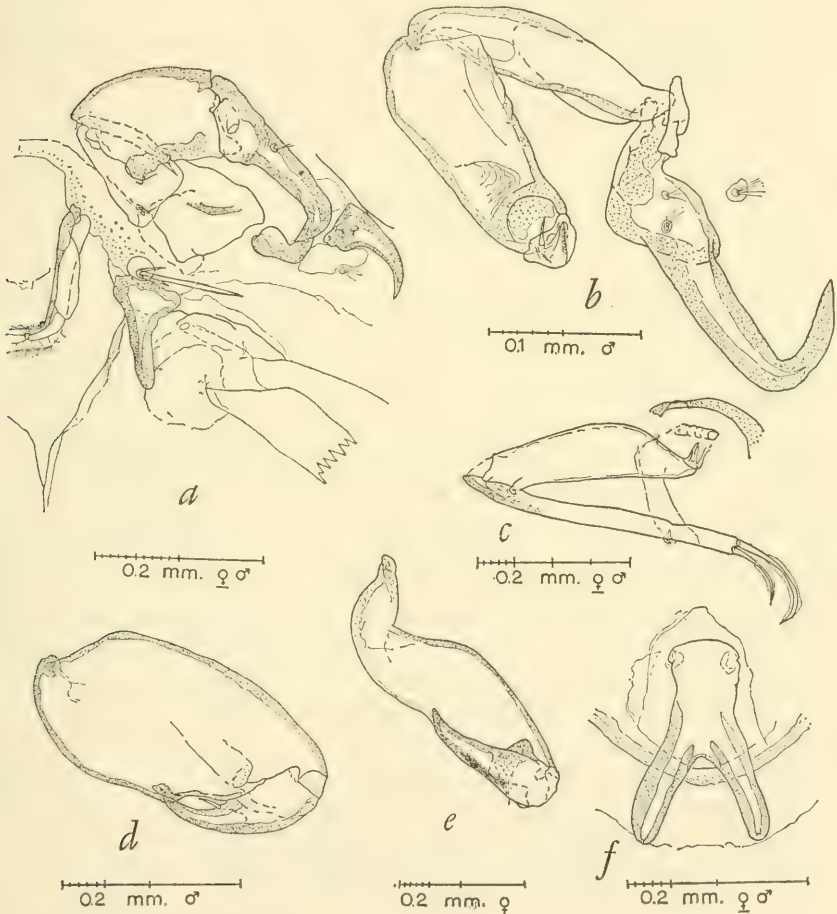


FIGURE 27.—*Caligus alaihi*, new species, ventral views: *a*, female oral region, showing antenna, mouth cone, mandible, maxillule, maxilla base (ma-2), postantennal, and postoral processes; *b*, male right antenna and postantennal process; *c*, right maxilla; *d*, male right maxilliped; *e*, female right maxilliped; *f*, sternal furca.

segment rodlike, approximately four-fifths the length of first segment, posterior surface with single naked setule distally, distal surface with 12 naked setae and setules. Female antenna (fig. 27*a*) 3-segmented, situated posterior and medial to antennule base. First segment short, squat, outline subtriangular. Second segment subrectangular; third segment and incompletely fused terminal process clawlike, with subconical accessory process proximally, setule-like, accessory process medially, at indistinct division between segment and terminal process. Male antenna (fig. 27*b*) 3-segmented, situated posterior to antennule base. First segment elongate, fused proximally with cephalothorax, angled ventrally toward distal end. Second segment well developed, broader proximally than distally, with adhesion pad on distal half of inner surface. Third segment fused with short, bifurcate terminal process, tines of terminal process pointed; setule-like accessory process present, arising just proximal to terminal process.

Female and male mandible (fig. 27*a*) rodlike, 4-parted, distalmost part curved inward, flattened, inner surface with 12 denticulations. Female postantennal process (fig. 27*a*) situated lateral and slightly posterior to antenna base, consisting of short, clawlike projection and 3 nodules, first 2 on base of projection, third slightly posterior to base, all 3 with several hairlike processes. Male postantennal process (fig. 27*b*) as in female except clawlike projection much longer. Female postoral process (fig. 27*a*) spinelike, situated immediately posterior to maxillule, spine projecting from middle of base, distal end rounded. Male postoral process as in female except spine projecting from outer portion of base. Female and male maxillule (fig. 27*a*) nodular, situated lateral and slightly posterior to mandible base, nodule bearing 2 short and 1 long, seta-like processes. Female and male maxilla (fig. 27*c*) 2-segmented, located posterior and lateral to postoral process; both segments slender although first approximately two and one-half times the diameter of second, length slightly more than four-fifths that of second. Second segment rodlike, with small flapshaped membrane on distal third of outer surface, bearing 2 saberlike terminal processes, innermost longer than outer, both with fine membrane along outer and inner margins.

Female maxilliped (fig. 27*e*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, with slightly recurved proximal region terminating in knoblike proximal end; inner medial surface with small, shelllike projection (not shown on figure) receiving distal end of terminal process of second segment when segment flexed. Second segment distinct from clawlike terminal process, bearing setule-like accessory process on distal inner surface. Male maxilliped (fig. 27*d*) similar to that of female except first segment more strongly developed and recurved proximal end

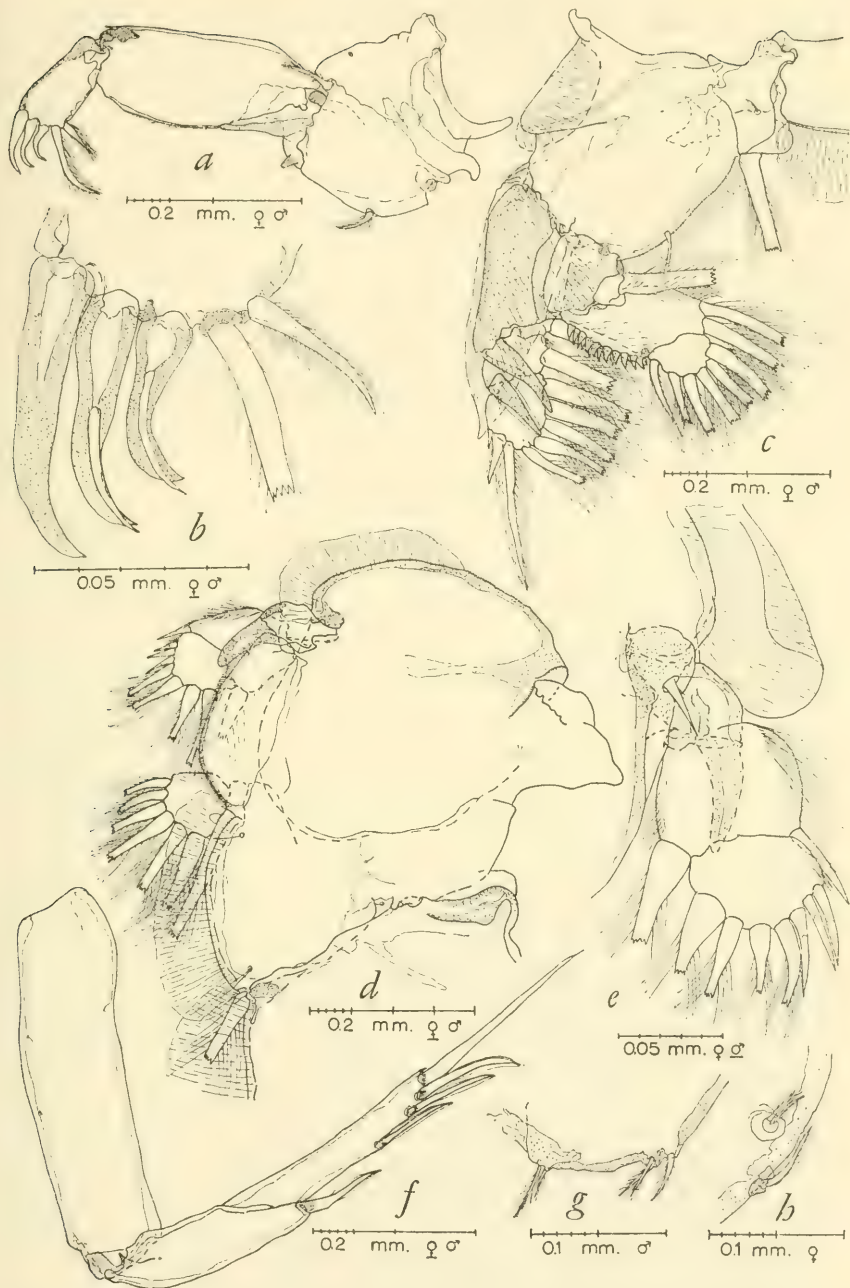


FIGURE 28.—*Caligus alaihi*, new species, right thoracic legs, anterior views: *a*, first; *b*, distal region of second segment of exopodite of first; *c*, second; *d*, third; *e*, exopodite of third (posterior view); *f*, fourth. Legs, ventral views: *g*, male left fifth and sixth; *h*, female right fifth.

reduced. Female and male sternal furca (fig. 27f) well developed, Y-shaped, distal ends of rami rounded.

Thoracic legs I-III biramous although endopodite of first leg rudimentary; fourth thoracic leg uniramous, 3-segmented. For nature and armature of thoracic legs, see figures 28a-f and table 11.

DISCUSSION.—The diagnostic characteristic of *Caligus alaihi* is the combination of a 2-segmented abdomen on the male, denticulations on the second segment of the endopodite of the second thoracic leg (but not on the first segment), and the presence of only 1 plumose seta on the inner surface of the second segment of the exopodite of the first thoracic leg. Of these three, the most uncommonly found feature in other members of the genus is the presence of a single seta on the inner surface of the second segment of the exopodite of

TABLE 11.—Armature of thoracic legs I-IV of the female and male of *Caligus alaihi*, new species

| Leg | Surface | Inter-podal Plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|---------|-------------------|-------------|------|-----------|-------------|-----------|------------|-------|----|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer | | ss, p | | rh | 3H, P | | | | |
| | Inner | | p | | c | p | | | | |
| II | Outer | m | | m, p | m, mH | mH | rh, mh, Q | c | D | 3P |
| | Inner | | s, P | m, s | c, P | c, P | 5P | P | c, 2P | 3P |
| III | Outer | m | r, m, p | | | c, p' | c, 3p', P | c | c, 3P | |
| | Inner | | 3s, P, m, s | | H | c, P | 3P | P | 3P | |
| IV | Outer | | 2s, p | | fm, mH | 4fm, 3mH, H | | | | |

the first thoracic leg. This feature, however, is found in at least one other species, *Caligus pagrosomi* Yamaguti, 1939. *Caligus alaihi* can be most readily distinguished from *C. pagrosomi* by the presence of denticulations on the second segment of the endopodite of the second thoracic leg, in contrast to the plumosities presumed to be found on the same segment of *C. pagrosomi*. (Yamaguti, 1939, does not provide a description of the second thoracic leg of *C. pagrosomi* but does indicate, p. 445, that the species is very similar to *C. epinepheli* Yamaguti, 1936, which does possess plumosities on the second segment of the endopodite of the second thoracic leg.) *Caligus alaihi* can also be distinguished from *C. pagrosomi* by the apparent length of the abdomen of the female, that of *C. pagrosomi* being approximately twice the length of that of *C. alaihi*. This characteristic, however, should be used with some reservation as the variability (or potential variation)

is not discernable from the single female in the collection of copepods from Eniwetok fishes.

The species name is derived from the Hawaiian name, "alaihi," for several of the holocentrid fishes, the family to which the host of this copepod belongs.

Caligus laticaudus Shiino

FIGURES 29, 30

Caligus laticaudus Shiino, 1960, p. 482, figs. 5, 6.—Pillai, 1961, p. 91, fig. 3.—Yamaguti, 1963, p. 55, pl. 68, fig. 4.

HOSTS AND DISTRIBUTION.—3 host records:

| locality | host | reference |
|-------------|--------------------------------|--------------|
| Japan | <i>Pagrosomus major</i> | Shiino, 1960 |
| South India | <i>Polynemus heptadactylus</i> | |
| | <i>Rhabdosargus sarba</i> | Pillai, 1961 |

MATERIAL.—1 female (USNM 120769) from the external surface of *Acanthurus olivaceus* Bloch and Schneider.

MEASUREMENTS (in mm).—1 female:

| | |
|--|------|
| Total length, excluding caudal setae | 2.46 |
| Length of cephalothorax | 1.24 |
| Width of cephalothorax | 1.21 |
| Length of genital segment | 0.56 |
| Width of genital segment | 0.72 |
| Length of abdomen | 0.41 |
| Length of egg strings (not present, condition suggests specimen an immature adult) | |

DESCRIPTION (female only).—Cephalothorax (fig. 29a) ovoid, consisting of cephalon, maxilliped-bearing and first 3 pedigerous segments. Frontal region approximately one-ninth the length of cephalothorax, with narrow membrane along anterior margin. Lunules (fig. 29e) distinct, extending posteriorly, on ventral surface, to posterior portion of frontal region, of relatively simple construction in comparison with those of *Caligus coryphaenae*. Division between frontal region and rest of cephalothorax distinct. Lateral margin of cephalothorax flatly convex, bearing single, narrow membrane extending laterally; posterior lateral surface lappet-shaped, with small, cupshaped indentation bearing 2 clusters of hairlike processes. Posterior sinus (fig. 29c) U-shaped, with membrane along outer margin. Median posterior surface of cephalothorax extending slightly past lateral posterior surfaces, posterior margin irregular on single specimen in collection. Major dorsal cephalothoracic grooves forming irregular H, anterior legs of H terminating well posterior to ocular region. Ocular region distinct, in anterior third of cephalothorax.

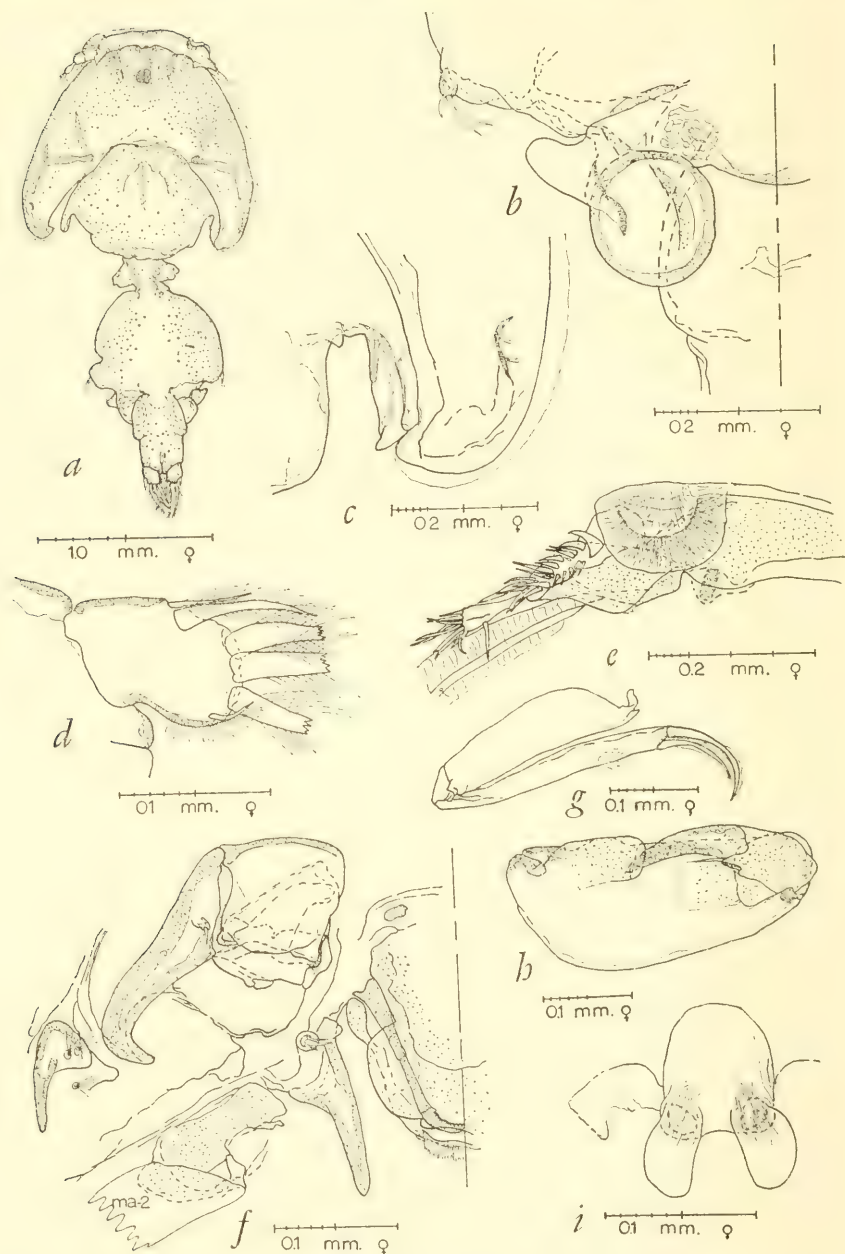


FIGURE 29.—*Caligus laticaudus* Shiino, 1960, female: *a*, dorsal view; *d*, right caudal ramus, same view. Ventral views: *b*, posterior region of genital segment and adjacent surface of abdomen, showing fifth leg and attached spermatophore; *c*, posterior cephalothoracic sinus; *e*, left lunule and antennule; *f*, oral region, showing antenna, mouth cone, mandible, maxillule, maxilla base (ma-2), postantennal, and postoral processes; *g*, right maxilla; *h*, left maxilliped; *i*, sternal furca.

Free fourth pedigerous segment distinct from cephalothorax, indistinctly separable from genital segment; segment widest medially, at junction with fourth thoracic legs, tapered anteriorly and posteriorly. Genital segment (fig. 29*b*) subovoid, posterior region irregular in single available specimen. Fifth legs (fig. 30*g*) situated on posterior lateral surface of segment, consisting of node bearing 2 or 3 plumose setules (2 present on specimen, indication of additional broken setule) and nodule bearing single plumose setule (= sixth leg of Shiino, 1960, p. 485).

Abdomen indistinctly 2-segmented, distinct from genital segment ventrally, indistinctly separable dorsally. First segment with flatly convex lateral surfaces, second tapered slightly to posterior surface. Division between segments consisting of break in cuticle of lateral regions only, muscle-segment associations not distinct enough to indicate segmentation. Caudal rami subpalmate, bearing 3 plumose setae and 1 plumose setule distally, plumose seta and setule present on distal half of outer lateral surface; distal half of inner surface plumose.

Antennule (fig. 29*e*) 2-segmented, attached to anterior lateral ventral surface of cephalothorax and adjacent surface of frontal region. First segment approximately twice the length of second, broad proximally, tapered distally; anterior surface sharply angled distally. First segment bearing approximately 22 lightly plumose and naked setae and setules. Second segment rodlike, bearing single naked setule from distal half of posterior surface, 11 naked setae and setules (including 1 bifurcate seta) distally. Antenna (fig. 29*f*) 3-segmented, situated posterior and slightly medial to antennule base. First segment squat, subtriangular from ventral viewpoint; second segment well developed, broad proximally, tapered slightly to distal end. Third segment and terminal process fused, with falciform outline; single, setule-like accessory process present on node at proximal end of fused segment and terminal process.

Mandible (fig. 29*f*) rodlike, 4-parted, distalmost part curved inward, flattened, inner surface with 12 denticulations. Postantennal process (fig. 29*f*) situated lateral and slightly posterior to antenna base, consisting of spikelike projection and 3 nodules bearing several hairlike processes. Projection arising from small, subtriangular, heavily sclerotized plate, plate also bearing 2 of 3 nodules, third nodule immediately posterior to plate. Postoral process (fig. 29*f*) spinelike, curving outward slightly. Maxillule (fig. 29*f*) nodular, situated immediately anterior to postoral process, nodule bearing 1 long, 2 short, naked seta-like processes. Maxilla (fig. 29*g*) 2-segmented, situated immediately posterior and slightly lateral to postoral process. First segment approximately nine-tenths the length of second, second elongate, with

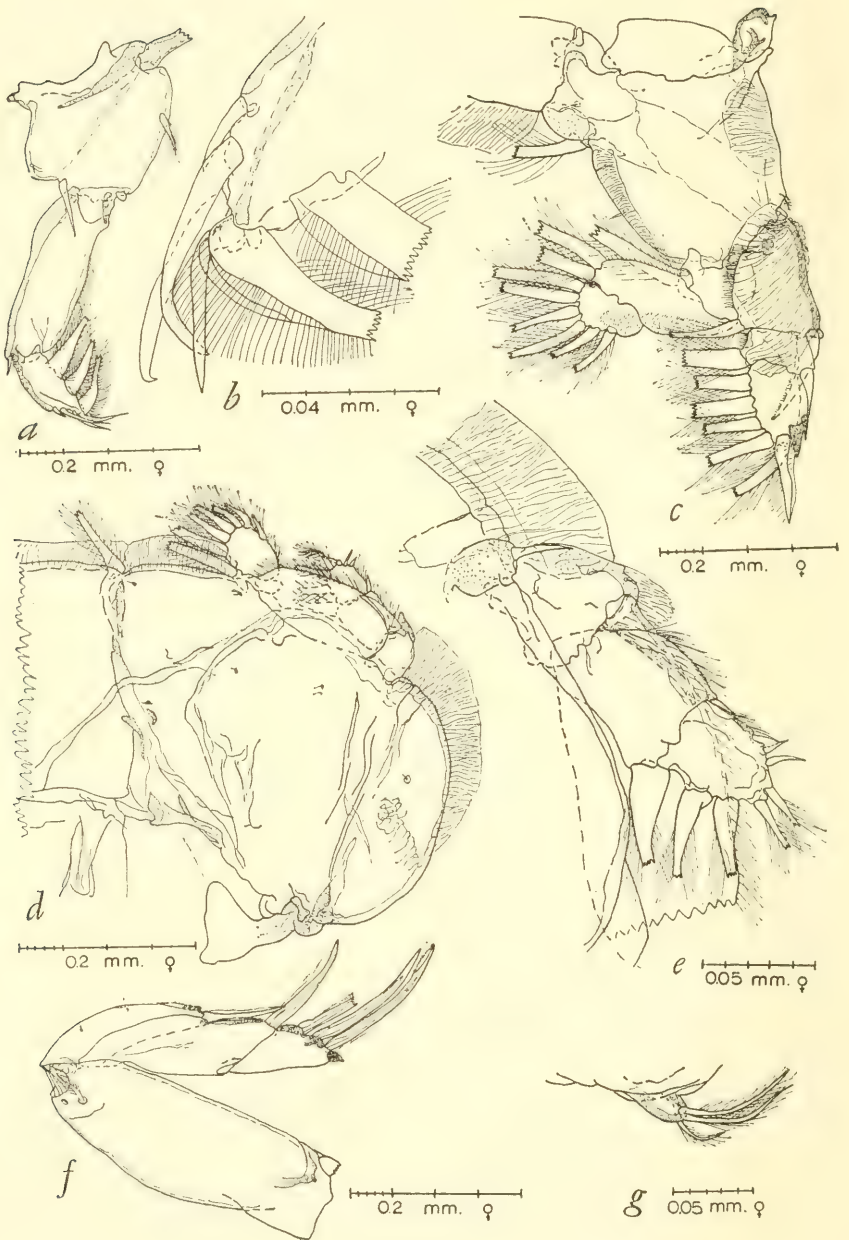


FIGURE 30.—*Caligus laticaudus* Shiino, 1960, female, right thoracic legs: *a*, first, anterior view; *b*, distal region of second segment of exopodite of first, anterior view; *c*, second, posterior view; *d*, third, anterior view; *e*, exopodite of third, posterior view; *f*, fourth, posterior view. Right fifth leg: *g*, ventral view.

fine membrane on distal half of outer surface, distal surface bearing 2 saber-shaped processes, innermost approximately one and one-fourth times the length of outermost, both fringed with fine membrane.

Maxilliped (fig. 20*h*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment strongly developed, irregular in outline; widest medially, proximal end narrow, distal approximately half the greatest width; segment with socket-like shelf on medial inner surface, receiving distal end of second segment terminal process when segment flexed. Second segment distinct from clawlike terminal process, bearing setule-like accessory process on distal inner surface. Sternal furca (fig. 29*i*) situated between and slightly posterior to maxilliped bases, bifurcations flattened anteroposteriorly, lobate in outline.

TABLE 12.—*Armature of thoracic legs I-IV of the female of Caligus laticaudus Shiino, 1960*

| Leg | Surface | Inter-podal Plate | Protopodite | | Exopodite | | | Endopodite | | |
|-----|----------------|-------------------|-------------|-------|-----------|-----------------|---------|------------|-------|-------|
| | | | 1 | 2 | 1 | 2 | 3 | 1 | 2 | 3 |
| I | Outer Inner | | ss, p p | | rh c | h, 2H, p' 3P | | | | |
| II | Outer | m | | m, p | m, dmH | H | h, H, Q | | c | c, P |
| | Inner | | s, P | m, s, | c, P | c, P | 5P | P | c, 2P | c, 3P |
| III | Outer | m | m, P | | m, s | c, p' | c, 3p' | c | c, 3P | |
| | Inner | | P, s, m, s | | H | P | 4P | P | 3P | |
| IV | Outer | | p | | fm, mH | fm, mH | fm, 3mH | | | |

Thoracic legs I-III biramous although endopodite strongly reduced in first leg; fourth thoracic leg uniramous, 4-segmented. For details of legs and armature, see figures 30*a-f* and table 12.

DISCUSSION.—The Eniwetok specimen differs from Shiino's original description in several points:

1. There is a setule on the inner surface of the protopodite of the first thoracic leg that is not listed or figured in Shiino's publication.

2. The sternal furca appears broader than that shown by Shiino for *C. laticaudus* although the angle from which the drawing was made may at least partially explain this.

3. The total length of the Eniwetok specimen is smaller than that listed by Shiino (3.51 mm) although Pillai (1961) lists 2.6 mm as the length of his female specimen(s?). The difference in length between the Eniwetok specimen and Shiino's is presumed to be, at least in part, due to the possible immature adult condition of the Eniwetok specimen.

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North and Central American
Species of *Aneurus* Curtis
(Hemiptera: Aradidae)

By Nicholas A. Kormilev¹

Fifteen species of the genus *Aneurus* Curtis, 1825, have been recorded for North and Central America. In the present paper five additional species are described and a key to the 20 species is presented.

This study is based on specimens from the U.S. National Museum, Washington, D.C., and the American Museum of Natural History, New York, N.Y., loaned by Drs. Richard C. Froeschner and Peter Wygodzinsky, respectively; and information from types in the British Museum (Natural History) furnished by Dr. William J. Knight. To all these men I offer my sincere thanks.

Measurements in this paper were taken with a micromillimeter eyepiece; 25 units equal 1 mm. For convenience, the length of the abdomen was taken from the tip of scutellum to the tip of hypopygium in the male and to segment IX in the female.

There has been some confusion concerning the identity of the Florida species, *Aneurus politus* Say (1832, p. 31). The original description made no reference to the important shape of the hypopygium. On the basis of five specimens from Guatemala, Champion (1898, p. 115) gave a short redescription with two drawings (table 7; figs. 29, 29a) and remarked about a "small and transverse" hypopygium. Comparison of three Florida specimens with three Central

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American (Mexico and Guatemala) specimens found them to be superficially similar but specifically distinct. In addition to smaller differences, the shapes of the scutellum and hypopygium are quite different (cf. figs. 14 with 17, and 15 with 18); the proportions of the antennal segments do not coincide; and the production of the paratergites of the females differ (cf. figs. 16 and 19). Thus, it is evident that Champion's specimens probably were not *politus* but an unnamed species that will be described below as *championi*.

To establish this usage and avoid further confusion, a neotype for *politus* will be proposed and described under the specific treatment of that taxon.

Key to North and Central American Species of *Aneurus*

- Clavus fully developed, reaching tip of scutellum; latter triangular with pointed apex Subgenus **Aneurosoma** Champion, 1898
(contains a single species, *dissimilis* (Bergroth), 1889)
- Clavus greatly reduced to small triangle near basolateral angle of scutellum; apex of scutellum arcuate Subgenus **Aneurus** Curtis, 1832

SUBGENUS *Aneurus*

1. Spiracles II to VII lateral, visible from above, VIII terminal.
 vauriei Kormilev, 1964, Jamaica, Guadeloupe
 At least spiracles III ventral or sublateral, not visible from above . . . 2
2. Spiracle III sublateral, placed close to border, though not visible from above.
 nasutus Kormilev, 1966, Guadeloupe
 Spiracle III ventral, placed far from border 3
3. Spiracles IV ventral, placed near border, not visible from above.
 1. **pusillus**, new species, Guatemala, Panama
 Spiracles IV ventral, placed far from or close to border; when near border,
 spiracle V sublateral but not visible from above 4
4. Spiracle V lateral, visible from above 5
 Spiracle V ventral or sublateral, not visible from above 7
5. Scutellum longer, ratio between length and width at least 2:3 6
 Scutellum very short, ratio between length and width 1:2.
 simplex Uhler, 1871, northeastern U.S.
6. Smaller species, length less than 4.0 mm; anterior process of the head not
 reaching tip of antennal segment I; antennal segment II obovate.
 2. **aibonitensis**, new species, Puerto Rico
 Larger species, length about 5.0 mm; anterior process of head produced
 beyond tip of antennal segment I; antennal segment II clavate.
 septentrionalis Walker, 1873, eastern Canada
7. Spiracle V sublateral, not visible from above.
 3. **pisoniae**, new species, Puerto Rico
 Spiracle V ventral, placed far from border 8
8. Spiracle VI lateral, visible from above 9
 Spiracle VI ventral, not visible from above 14
9. Head longer than width across eyes (35:33); anterior process of the head
 slightly produced beyond tip of antennal segment I.
 barberi Kormilev 1960, St. Lucia (Lesser Antilles)
 Head as long or shorter than width across eyes; anterior process at most
 reaching as far as tip of antennal segment I 10

10. Head shorter than width across eyes (11:12).
pygmeus Kormilev, 1966, southern U.S.
 Head as long as width across eyes 11
11. Antennal segment II clavate, as long as I; larger species, length over 4.0 mm 12
 Antennal segment II obovate, shorter than I; smaller species, length less than 4.0 mm 13
12. Anterior process of the head reaching tip of antennal segment I; postocular tubercle (composed of 3 minute teeth) very short, not reaching to outer border of eyes *haitiensis* Kormilev 1968, Haiti
 Anterior process not reaching to tip of antennal segment I; postocular tubercles strong, acute, reaching outer border of eyes.
 6. *championi*, new species, Guatemala, Mexico
13. Scutellum wider, ratio between length and width 11.5:19; lateral borders of abdomen finely serrate 4. *froeschneri*, new species, Panama
 Scutellum narrower, ratio between length and width 12:16; lateral borders of abdomen roughly serrate.
minutus Bergroth, 1886, southern U. S., Central America
14. Antennal segment II obovate, III and IV cylindrical 15
 Antennal segment II clavate, III tapering toward base, IV fusiform 17
15. Scutellum subtriangular, rounded apically; ratio between length and width 10.5:19; hypopygium small, transverse (3.5:4).
tenuis Champion, 1898, Panama, Cuba?
 Scutellum semicircular; ratio of length to width 2:3 or 3:4 16
16. Larger species, length over 5.0 mm; hypopygium long and wide (10.5:10).
montanus Champion, 1898, Guatemala
 Smaller species, length less than 4.5 mm; hypopygium smaller (8:7).
fiskei Heidemann, 1904, U.S., Cuba?
17. Scutellum short, ratio of length to width 10:16 18
 Scutellum longer, ratio of length to width 15:19 or 20:24.
 7. *inconstans* Uhler, 1871, U.S.
18. Smaller species, length less than 4.0 mm; antennae shorter, less than twice as long as head is wide (24:12.5).
 5. *politus* Say, 1832, southern U.S. (Florida)
 Larger species, length over 5.0 mm; antennae longer, more than twice as long as head is wide (38:16).
leptocerus Hussey, 1957, Guatemala, Panama

1. *Aneurus pusillus*, new species

FIGURES 4-6

MALE.—Elongate, sides subparallel; minutely granulate. Head slightly shorter than width across eyes (σ^7 10:11.5, ♀ 10.5:12). Anterior process conical, not reaching to tip of antennal segment I; jugae slightly visible from above. Antenniferous tubercles small, acute, convex exteriorly. Eyes large, semiglobose, protruding. Postocular tubercles conical with blunt tip, produced as far as, or a little less than, outer borders of eyes. Vertex very finely, transversely striate. Vertex mesad of eyes with two (1+1) large, ovate callosities. Antennae thin, one and one-half times as long as length of the head

(♂ 14:10, ♀ 15:10.5); segment I barrel shaped; II obovate, much smaller and narrower; III and IV cylindrical. Relative lengths of antennal segments I to IV: ♂ 3:3:2.5:5.5, ♀ 3.5:2.75:2.75:6. Labium very short, reaching middle of head.

Pronotum less than half as long as maximum width (♂ 9:19.5, ♀ 8.5:20). Collar tiny, sinuate in front. Anterolateral angles evenly rounded, produced neither forward, nor sideways. Lateral borders of forelobe parallel; humeri parallel, strongly converging anteriorly. Hind border sinuate in the middle. Foredisc with two (1+1) bean-shaped callosities, and a few small callosities laterad. Hind disc extremely finely punctured, with an arcuate, slightly raised, transverse, longitudinally striate strip.

Scutellum almost as long as basal width (♂ 10:11, ♀ 10:11), evenly arcuate apically; disc finely, concentrically striate.

Hemelytra reaching to the middle of tergum VII in both sexes; corium extended along basal third of scutellum.

Abdomen elongate ovate, longer than maximum width across segment IV (♂ 40.5:25, ♀ 40.5:25). Connexivum narrow; PE-angles not protruding; PE-VII rounded in the male, angularly rounded in the female. Paratergites (♂) moderately large, subtruncate apically, reaching apical fourth of hypopygium; latter moderately large, as long as maximum width (5:5). Paratergites (♀) triangular, very short, produced almost as far as segment IX; latter truncate posteriorly. Spiracles II lateral, III ventral, IV ventral placed nearer to border, V to VII lateral, VIII terminal.

COLOR.—Yellow brown or pale testaceous, partially testaceous.

MEASUREMENTS.—Total length: ♂ 2.85, ♀ 2.85 mm; width of pronotum: ♂ 0.78, ♀ 0.80 mm; width of abdomen: ♂ 1.00, ♀ 1.00 mm.

HOLOTYPE.—♂, Guatemala, Cacao, Trece Aguas, Alta v. Paz; Schwarz and Barber coll. (USNM type 69794).

ALLOTYPE.—♀, collected with holotype; in the same collection.

PARATYPES.—2 ♂♂ and 4 ♀♀, Panama, C.Z., Bohio; Schwarz coll., 6-9.II.; 1 ♀, Porto Bello; Schwarz coll., 26.II.; in the same and Kormilev collections.

REMARKS.—*Aneurus pusillus* is the smallest known American species of *Aneurus*. It belongs to the group with evenly rounded scutellum and relatively large hypopygium. Its relation to other species is seen from the key.

2. *Aneurus aibonitensis*, new species

FIGURES 7, 8

FEMALE.—Elongate ovate; head, pronotum, and lateral borders of abdomen, densely and relatively roughly punctured; lateral borders of pronotum finely serrate.

Head shorter than width across eyes (11.5:13). Anterior process conical; jugae slightly shorter than clypeus, their tips still visible from above; tip rounded, reaching to apical fourth of antennal segment I. Antenniferous tubercles short, acute, divergent. Eyes large, semiglobose, protruding. Postocular tubercles strong, dentiform, acute, with minuscule serrations on the foreborder. Vertex transversely rugose, with two (1+1) large, ovate callosities mesad of eyes. Antennae moderately robust, twice as long as head (21.5:11.5); antennal segment I obovate, thick; II obovate, but half as thick as I; III and IV subcylindrical, very slightly tapering toward the base. Relative lengths of antennal segments I to IV: 4:4:4.5:9. Labium short, reaching line connecting hind borders of eyes.

Pronotum less than half as long as maximum width (12.5:27.5). Collar very thin, feebly sinuate in front. Anterior borders truncate; anterolateral angles angularly rounded, produced neither forward, nor sideways; lateral borders of forelobe straight, convergent; lateral borders of hind lobe slightly convex; both finely, but distinctly serrate. Hind border sinuate in the middle, convex laterally. Foredisc with four (2+2) low callosities; hind disc densely punctured and transversely striate along posterior border laterally.

Scutellum semicircular, shorter than basal width (12.5:18); disc concentrically rugose.

Hemelytra reaching slightly over foreborder of tergum VII; corium very short, reaching basal one-fourth of scutellum; membrane densely and deeply punctured.

Abdomen elongate ovate, longer than maximum width across segment IV. Connexivum moderately wide; connexiva III to V twice as long as wide; exterior borders slightly raised, densely granulate; mesad of granulation obliquely rugose around callosities. Tergum VIII roughly, obliquely rugose. Paratergites very short, serrate, reaching middle of segment IX; latter subtruncate, slightly sinuate in the middle of posterior border. Spiracles II and V to VII lateral and visible from above, III and IV ventral and placed far from border, VIII terminal.

COLOR.—Reddish brown; membrane darker, with pale, opaque, basolateral border.

MEASUREMENTS.—Total length 3.70 mm, width of pronotum 1.10 mm, width of abdomen 1.40 mm.

HOLOTYPE.—♀, Puerto Rico, Aibonito BF, Medina coll., VI.1961 (USNM type 69795).

REMARKS.—*Aneurus aibonitensis*, new species, is related to *A. fiskei* Heidemann, 1904, but is smaller, narrower, and with different position of spiracles.

3. *Aneurus pisoniae*, new species

FIGURES 9-11

MALE.—Elongate ovate.

Head shorter than width across eyes (σ^7 12.5:14, ♀ 13:15). Anterior process conical with rounded tip; reaching apical fifth of antennal segment I; jugae not visible from above. Antenniferous tubercles short, subtruncate anteriorly, blunt. Eyes moderately large, protruding. Postocular tubercles blunt, with minute granulation, short, not approaching outer borders of eyes. Vertex roughly, transversely rugose, with two (1+1) large, ovate callosities placed mesad of eyes. Antennae moderately thin; antennal segment I obovate, robust; II also obovate, but much narrower; III and IV subcylindrical, slightly tapering toward base. Relative lengths of antennal segments I to IV: σ^7 4.5:4:5:10, ♀ 5:4.5:5.25:10.5. Labium reaching line connecting the middles of eyes.

Pronotum less than half as long as maximum width (σ^7 12.5:29, ♀ 14:31). Collar thin, sinuate in front. Anterior borders straight, slightly oblique; anterolateral angles rounded and slightly produced forward beyond collar; lateral borders of forelobe straight, converging; lateral borders of hindlobe subparallel, convergent, rounded anteriorly. Hindborder sinuate in the middle, convex laterally. Foredisc with two (1+1) bean-shaped callosities and a few callous rugae laterad of them. Hind disc finely, transversely striate anteriorly; very finely, longitudinally striate posteriorly.

Scutellum subtriangular; lateral borders moderately convex, apex angularly rounded. Scutellum shorter than basal width (σ^7 12.5:19, ♀ 12.5:20). Disc concentrically rugose along the borders; longitudinally rugose in the middle.

Hemelytra reaching to the middle of tergum VII in both sexes; corium reaching basal fourth of scutellum.

Abdomen ovate in both sexes, longer than wide (σ^7 53:38.5, ♀ 58:42.5). Connexivum moderately wide; segments IV to VI twice as long as wide. Exterior borders of connexiva slightly raised, granulate; disc around callosities sparsely rugose. Paratergites (σ^7) short, rounded, reaching apical fourth of hypopygium; latter small, shorter than its maximum width (5:6). Paratergites (♀) short, forming an obtuse angle, their interior border twice as long as exterior, produced as far as segment IX; latter truncate posteriorly. Spiracles II and VI to VII lateral and visible from above, III to IV ventral, V placed close to border but not visible from above, VIII terminal.

COLOR.—Head, pronotum, and scutellum yellow brown; connexivum brown; membrane black; ventral side ochraceous medially, yellow brown laterally.

MEASUREMENTS.—Total length: ♂ 3.70, ♀ 4.00 mm; width of pronotum: ♂ 1.16, ♀ 1.24 mm; width of abdomen: ♂ 1.54, ♀ 1.70 mm.

HOLOTYPE.—♂, Puerto Rico, Maricao; De Leon coll., 16.IV.1940, on *Pisonia subcordata* (USNM type 69796).

ALLOTYPE.—♀, collected with holotype; in the same collection.

PARATYPES.—4 ♂♂ and 2 ♀♀, collected with holotype; in the same and Kormilev collections.

REMARKS.—*Aneurus pisoniae*, new species, is related to *A. haitiensis* Kormilev (1968, p. 2), but is smaller, with lateral borders of forelobe of pronotum straight, hypopygium more narrowly rounded, paratergites shorter, and color more contrasting: yellow brown with black membrane.

4. *Aneurus froeschneri*, new species

FIGURES 12, 13

FEMALE.—Elongate ovate, finely granulate.

Head slightly shorter than width across the eyes (12.5:13). Anterior process conical, rounded apically, reaching to tip of antennal segment I; jugae reaching almost to tip of clypeus, clearly visible from above. Antenniferous tubercles small, acute, convex exteriorly, and slightly divergent. Eyes moderately large, protruding. Postocular tubercles strong, dentiform, acute, reaching as far as outer margins of eyes. Vertex finely, transversely rugose, with two (1+1) large, ovate callosities mesad of eyes. Antennae slender, less than twice as long as head (20.25:12.5); antennal segment I stout, obovate; II narrowly obovate; III and IV cylindrical; relative lengths of antennal segments I to IV: 4:3.75:3.75:8.75. Labium reaching line connecting middles of eyes.

Pronotum less than half as long as maximum width (11.5:27). Collar thin, sinuate in front. Anterolateral angles rounded, produced forward beyond collar; lateral borders of forelobe together with lateral notch slightly sinuate; lateral borders of hind lobe slightly convex, converging anteriorly; both finely serrate, particularly in the lateral notch. Hind border sinuate medially, angularly produced laterally. Foredisc with two (1+1) large ovate callosities, and granulate laterad of them. Hind disc very finely granulate anteriorly and medially; very finely, transversely striate along posterior border laterally.

Scutellum shorter than basal width (11.5:19); lateral borders weakly convex, apex evenly rounded.

Hemelytra reaching almost to hind border to tergum VII. Corium reaching basal third of scutellum; membrane densely and roughly punctured.

Abdomen elongate ovate, longer than maximum width across segment IV (53:38). Connexivum moderately wide. Paratergites small, rounded, reaching as far as segment IX; latter truncate posteriorly. Spiracles II and VI to VII lateral and visible from above, III to V ventral and placed far from border, VIII terminal.

COLOR.—Dark yellow brown; connexivum brown; membrane dark brown.

MEASUREMENTS.—Total length 3.64 mm, width of pronotum 1.08 mm, width of abdomen 1.52 mm.

HOLOTYPE.—♀, Panama, El Valle; N.L.H. Krauss coll., XI.1946 (USNM type 69797).

REMARKS.—It is a pleasure to name this species for Dr. Richard C. Froeschner, by whose kind offices I have had an opportunity to study this lot as well as many other Aradidae from the collections in his charge.

Aneuris froeschneri, new species, is related to *A. minutus* Bergroth, 1886, from which it differs as indicated in the key.

5. *Aneuris politus* Say

FIGURES 14-16

Aneuris politus Say, 1832, p. 31.

MALE.—Elongate ovate; shiny.

Head as long as width across eyes (♂ 12.5:12.5, ♀ 15:15). Anterior process conical, rounded anteriorly, reaching slightly beyond the tip of antennal segment I; jugae adherent to clypeus, not visible from above. Antenniferous tubercles short, truncate anteriorly, not acute. Eyes moderately large, protruding. Postocular tubercles stout, dentiform, blunt, produced as far as lateral margins of eyes. Vertex transversely rugose, with two (1+1) moderately large, ovate callosities mesad of eyes. Antennae almost twice as long as head (♂ 24:12.5, ♀ 29.5:15); antennal segment I barrel shaped; II and III clavate; IV elongate fusiform; relative lengths of antennal segments I to IV: ♂ 3.5:5:5.5:10, ♀ 4:6.5:7.5:11.5. Labium reaching line connecting hind borders of eyes.

Pronotum less than half as long as maximum width (♂ 10:25, ♀ 12.5:30). Anterior borders straight, slightly oblique; anterolateral angles rounded, slightly produced beyond collar; lateral borders of forelobe together with lateral notch moderately sinuate; lateral borders of hind lobe slightly convex, strongly converging anteriorly; hind border sinuate, medially. Foredisc with four (2+2) large, ovate, blurred callosities. Hind disc very finely, transversely striate anteriorly and along hind border laterally; shiny in the middle.

Scutellum transverse, much shorter than basal width (♂ 10:16.5, ♀ 11:20); tip widely arcuate. Disc with an elongate callous spot

in the middle anteriorly; concentrically striate around callosity.

Hemelytra reaching to the middle of tergum VII; corium reaching basal third of scutellum; membrane finely punctured, finely wrinkled around punctures; exterior border of membrane smooth, transparent.

Abdomen longer than maximum width across segment IV (σ^7 55:37.5, ♀ 60:56). Connexivum moderately wide. Paratergites (σ^7) long, subtriangular, rounded apically, reaching apical fourth of hypopygium; latter large, elongate, rounded at base and apically (10:8). Paratergites (♀) large, rounded apically, produced far beyond small and short segment IX, latter slightly sinuate posteriorly. Spiracles II and VII lateral, visible from above; III to VI ventral, placed far from border; VIII terminal.

COLOR.—Reddish brown; forelobe of pronotum, tergum, prosternum, meso- and metasternum around coxae, pale yellow brown; membrane brown.

MEASUREMENTS.—Total length: σ^7 3.60, ♀ 4.20 mm; width of pronotum: σ^7 1.00, ♀ 1.20 mm; width of abdomen: σ^7 1.50, ♀ 2.24 mm.

NEOTYPE.— σ^7 , U.S.A., Florida, Biscayne; 21.V.1887, ex Uhler collection (USNM type 69798).

EXAMINED SPECIMENS.—1 ♀ , Florida, Biscayne; 26.V.1887, ex Uhler collection (USNM). 1 ♀ , Florida, Belle Air; ex collections of Mrs. A. T. Slosson (AMNH).

6. *Aneurus championi*, new species

FIGURES 17-19

FEMALE.—Elongate ovate, shiny.

Head almost as long as width across eyes (♀ 15.5:16, σ^7 15:14.5). Anterior process conical, reaching three-fourths of antennal segment I; tips of jugae slightly visible from above. Antenniferous tubercles acute exteriorly, slightly divergent. Eyes semiglobose, protruding. Postocular tubercles dentiform, acute, slightly produced beyond outer border of eyes (♀), or reaching to latter (σ^7). Infraocular, ovate, callous spots large. Vertex transversely rugose. Antennae slender, less than twice as long as head (♀ 27.5:15.5, σ^7 24.5:15); antennal segment I obovate; II clavate; III subcylindrical, tapering toward base; IV cylindrical; relative lengths of antennal segments I to IV: ♀ 5.5:5.5:5.5:11, σ^7 5:5:5:10.5. Labium reaching line connecting hind borders of eyes.

Pronotum less than half as long as its maximum width (♀ 15:34, σ^7 12.5:30). Collar sinuate. Anterolateral angles rounded, very slightly produced forward beyond collar. Lateral borders parallel at humeri, strongly convergent and sinuate anteriorly. Hind border sinuate in the middle. Foredisc with two (1+1) bean-shaped calloused spots and with a few semifused callosities laterad of them; granulate

in front of callosities. Hind disc finely longitudinally striate, with exception of two (1+1) transverse, glabrous spots.

Scutellum subtriangular with subtruncate or widely arcuate apex. Disc concentrically rugose around mediobasal longitudinal rugae.

Hemelytra reaching middle of tergum VII (♀), or hind border of tergum VI (♂).

Abdomen longer than its maximum width across segment IV (♀ 69:50, ♂ 60:46). Connexivum relatively wide; PE-angles barely protruding. Tergum VIII (♀) small, narrower than head (12:16). Segment IX more than one-third width of head (6:16); paratergites rounded, reaching segment IX. In male, paratergites small, divergent, produced beyond small, transverse hypopygium; the latter much shorter than wide (3:5). Spiracles: II, VI, and VII lateral and visible from above; III and IV ventral and placed far from border; VIII terminal.

COLOR.—Yellow brown, venter paler; membrane infusate; labium and tarsi yellow.

MEASUREMENTS.—Total length: ♀ 4.68, ♂ 3.90 mm; width of pronotum: ♀ 1.36, ♂ 1.20 mm; width of abdomen: ♀ 2.00, ♂ 1.84 mm.

HOLOTYPE.—♀, Guatemala, Chicacao; E. J. Hambleton coll., 7.VII.1945 (USNM type 69799).

ALLOTYPE.—♂, Mexico, Vera Cruz, Peñuela; H. Dybas coll., 17.VII.1941; deposited in the Field Museum of Natural History, Chicago.

PARATYPES.—2 ♀♀ and 1 ♂, collected with allotype; in the Field Museum of Natural History, Chicago, and Kormilev collection.

REMARKS.—This species is named for the eminent British entomologist, G. C. Champion, who did the first comprehensive survey of Central American Aradidae.

7. *Aneurus inconstans* Uhler

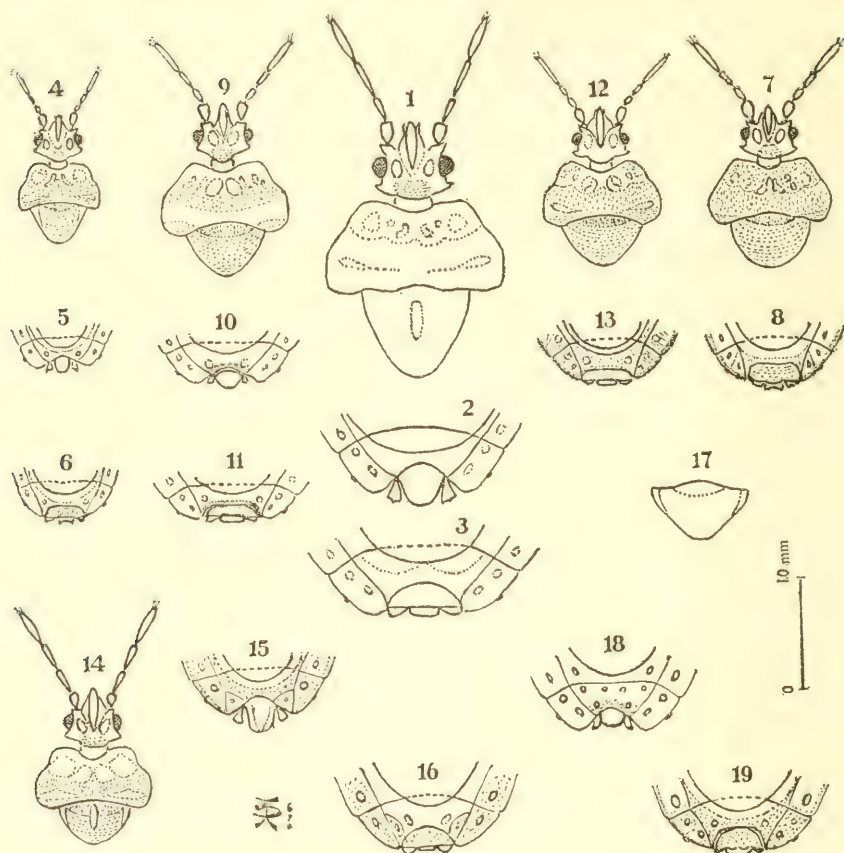
FIGURES 1-3

Aneurus inconstans Uhler, 1871, p. 105.

In the collections examined, this species was sometimes confused with *A. septentrionalis* Walker. The key given earlier plus the three drawings will permit ready separation of the two forms.

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FIGURES 1-19.—*Aneurus inconstans* Uhler 1871: 1, head, pronotum, and scutellum, ♂; 2, apex of abdomen from above, ♂; 3, same, ♀. *Aneurus pusillus*, new species: 4, head, pronotum, and scutellum, ♂; 5, apex of abdomen from above, ♂; 6, same, ♀. *Aneurus aibonitensis*, new species: 7, head, pronotum, and scutellum, ♀; 8, apex of abdomen from above, ♀. *Aneurus pisoniae*, new species: 9, head, pronotum, and scutellum, ♂; 10, apex of abdomen from above, ♂; 11, same, ♀. *Aneurus froeschneri*, new species: 12, head, pronotum, and scutellum, ♀; 13, apex of abdomen from above, ♀. *Aneurus politus* Say 1832: 14, head, pronotum, and scutellum, ♂; 15, apex of abdomen from above, ♂; 16, same, ♀. *Aneurus championi*, new species: 17, scutellum, ♂; 18, apex of abdomen from above, ♂; 19, same, ♀.

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Interspecific Competition
in the Tropical Rain Forest:
Ecological Distribution
Among Lizards at Belém, Pará

By A. Stanley Rand and Stephen S. Humphrey¹

The ecological differences between sympatric species have proved useful foci for ecological studies, particularly those with an evolutionary viewpoint. The information provided by such studies is relevant to considerations of interspecific competition and to the problem of the causes of tropical species diversity. In general, it is assumed that a species' closest competitors in an area are its nearest relatives. This is probably true within generic and specific groups, but, as this study suggests, it may not be true for higher categories.

Studies on the ecology of sympatric lizards (usually restricted to sympatric congeners) have been made at several localities by various workers, among them Milstead (1957), Inger (1959), Collette (1961), Rand (1964). Little has been published about the ecology of the lizards of lowland tropical forests and almost nothing about those in the rain forests of the Amazon. The study most comparable to the present one is that of Sexton, Heatwole, and Knight (1964) in Panama.

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As a result of the observations made in conjunction with other field studies, the authors have collected considerable information about the natural history of lizards in the vicinity of Belém, Pará, Brazil. Some of this has already been published (Rand, 1965; Rand and Rand, 1966), and additional papers are planned. In this paper we present our data on microdistribution patterns among the common diurnal lizard species and its relevance to possible interspecific competition among lizards. We also present our data on lizard body temperature and their relation to habitat distribution.

The senior author, who has made four trips to Belém, has spent a cumulative total of almost four months there between 1963 and 1966. These visits were all made during the period of May through August, a time of intermediate rainfall. The junior author visited Belém from July through August, 1964, and from June through August, 1965.

The observations reported herein were made in the vicinity of the city of Belém, Pará, at lat. $1^{\circ}27'S$, long. $48^{\circ}30'W$, altitude less than 100 feet. The climate is hot tropical with abundant rain and a marked but not severe or prolonged dry season in the southern winter. The climax vegetation is forest, of which three types are locally recognized: "mata de terra firme" or upland forest; "varzea" or forest that is flooded daily by the freshwater tides; and "igapo" or permanently flooded swamp forest (Ducke and Black, 1953). We were able to sample the first two forests much more adequately than the latter.

In addition to the above, we visited a variety of sites that had been disturbed by man and were in various stages of regeneration—from scattered bunches of grass and bare ground to old second growth.

The main localities where our observations were made are as follows:

Parque do Museu Goeldi - a small patch of forest in the city, the undergrowth much modified and denser than normal because of edge effect in some places, cleaned out in others, but the canopy only slightly disturbed.

Bosque Municipal - a somewhat larger but still small patch of forest in the city, modified in much the same way as the Parque do Museu, but less so.

Utinga and Agua Preta - localities in the preserve around the city water supply on the edge of the city, which include "mata de terra firme," selectively cut but quite good in places, and various ages of second growth from just abandoned "roças" through dense tangles to forest that betrays its second growth nature only in the species composition.

IPEAN and Guama Forest Reserve - localities of "mata de terra firme," "varzea" and some "igapo" forest. A variety of ages of

second growth and agricultural situations also were sampled in this area.

The following species were seen frequently enough to provide some idea of habitat distribution: *Gonatodes humeralis*, *Iguana iguana*, *Tropidurus torquatus*, *Plica umbra*, *Uranoscodon superciliosa*, *Polychrus marmoratus*, *Anolis punctatus*, *Anolis fuscoauratus*, *Cnemidophorus lemniscatus*, *Ameiva ameiva*, *Kentropyx calcaratus*, *Tupinambis nigropunctatus*, *Mabuya mabuya*. All are diurnal and together these species include over 99 percent of all the lizards we saw active during the day.

Two geckos, *Hemidactylus mabouia* and *Thecadactylus rapicaudus*, the first a common species, are omitted because they are nocturnal. Also seen only rarely were *Anolis ortonii*, *Amphisbaena alba*, *Crocodilurus lacertinus*, and several microteiidids.

We must thank Dr. Daley Albuquerque, Director of the Museu Paraense "Emilio Goeldi," and Dr. Robert Shope, then Director of the Belém Virus Laboratory, for their help during our visits to Belém.

We are much indebted to Dr. P. Humphrey of the University of Kansas and Dr. P. Vanzolini of the Departamento de Zoologia, São Paulo, for their field assistance and encouragement and for arranging support for the field work of the junior and senior authors, respectively. We also wish to thank the directors of the Instituto de Pesquisas Experimentação Agropecuarias do Norte (IPEAN) and the Belém Virus Laboratory for their many courtesies and assistance.

SPHAERODACTYLIDAE

Gonatodes humeralis

HABITAT.—Found only in the forest and in old second growth in the "mata de terra firme" and, less commonly, in the "varzea." They were not found in the young second growth or in open areas without a closed canopy.

These geckos perch above the ground on the trunks of small to very large trees, on large logs and stumps. They are almost always within one and one-half meters of the ground. Rarely were they seen on twigs or leaves or in small bushes, but most frequently on buttressed trees, trees with loose bark, or many small branches or suckers against the trunk that provide complex hiding places, but they are not restricted to such trees. They may leave a perch to hide in leaves on the ground and sometimes come to the ground to catch food.

ABUNDANCE.—This is the most frequently seen lizard in the forest and probably the most abundant. It was most common in the somewhat

disturbed areas (Bosque and Parque), where densities of several per 100 square meters were probably reached. In the less disturbed and more extensive forests they were much less common. Usually a single lizard was seen on a tree, occasionally two (a male and female), but seldom more.

FOOD.—Insects and other small invertebrates.

TEMPERATURE.—Probably a nonheliotherm, it was never seen basking, but no temperatures were taken.

IGUANIDAE

Iguana iguana

HABITAT.—Very few of these large lizards were seen but they are reported to be most common along the edges of the rivers. One was seen on the edge of a large clearing. It is quite possible that they live in the canopy of the forest away from clearings and rivers as well as on edges, but they are very difficult to see in such situations. They did well in the forested Parque do Museu Goeldi.

In most forested localities (Panama, Swanson, 1950; Costa Rica, Hirth, 1963; British Honduras, Neill and Allen, 1959), iguanas are highly arboreal lizards as adults, though one occasionally comes to the ground. The juveniles are reported as living closer to the ground. Apparently this is true around Belém for local men who hunt them say that they live on the branches of trees. Those running loose in the Museu Goeldi Parque were seen usually 10–20 meters up in the larger trees.

ABUNDANCE.—We saw them rarely, even when we were examining the river margin. Due to hunting they are probably very shy.

FOOD.—Primarily herbivorous and probably largely eat leaves.

TEMPERATURE.—A heliotherm (McGinnis and Brown, 1966). No temperatures were taken but iguanas in the Parque do Museu Goeldi were seen frequently basking.

Tropidurus torquatus

HABITAT.—Found only in open areas and along the edges of clearings, and not in dense second growth or forest.

These lizards perch above the ground, usually below two meters, on tree trunks, logs, rocks, walls, stumps, etc. They seldom climb above three meters except when frightened and are very rarely seen in bushes, on twigs, leaves, etc. They frequently come to the ground to feed.

ABUNDANCE.—This is the most frequently seen lizard in the open and probably the most common. Only one adult male is seen per perch but sometimes one or two females and several juveniles may be associated with him.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A heliotherm (fig. 2). It frequently basks and shows difference in posture related to substrate temperatures. (For more detailed data on this species, see Rand and Rand, 1966.)

Plica umbra

HABITAT.—Found only in the forest and older second growth. These lizards occur in the “mata de terra firme” and, at least occasionally, in the “varzea” and are not found in the open or on isolated trees.

Individuals of *Plica umbra* were seen on the trunks and branches of moderate to large trees from close to the ground up to at least several meters. None were seen in bushes or on twigs.

FOOD.—Insects and other invertebrates.

ABUNDANCE.—Moderately common. Seldom were two seen on the same perch, but several times a male and a female were found only a few meters apart, more frequently than we would have expected by chance alone. Perhaps some sort of pair bond is formed.

TEMPERATURE.—A nonheliotherm (fig. 2). No basking behavior was seen.

Uranoscodon superciliosa

HABITAT.—Found only along the shaded margins of streams and lakes where the forest interior comes to the edge of the water in both “mata de terra firme” and “varzea.”

Individuals were seen up to two meters high on moderate to large diameter tree trunks and on logs at the edge or in the water, some of which the lizards could have reached only by swimming. They frequently jumped into the water when approached and sometimes dove to the bottom and hid.

ABUNDANCE.—This species is moderately common in its habitat. No more than one individual was seen on a perch.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A nonheliotherm (fig. 2). No basking behavior was seen.

Polychrus marmoratus

HABITAT.—An animal collector for the Belém Virus Laboratory took large numbers in second growth along the edges of forest. Our few specimens were found in similar places. It is likely that this species also occurs in the crown of the forest, as Rand has seen it in such habitats in Trinidad.

Polychrus can and does climb easily on small twigs and branches.

ABUNDANCE.—Though we saw few individuals, many were taken in the area by the Virus Laboratory collector.

FOOD.—Insects and other invertebrates plus an appreciable amount of plant material.

TEMPERATURE.—Probably a heliotherm (fig. 2).

Anolis punctatus

HABITAT.—In the forest, found in “mata de terra firme” and older second growth; not in “varzea” though this lizard probably occurs there at least occasionally. It was not found in the open, on isolated trees, or in young second growth.

Individuals were seen most commonly on the trunks and branches of moderate to large trees up to four meters. They probably also climb up into the branches and lower crown. One individual was seen once coming to the ground to catch something.

ABUNDANCE.—This is a moderately abundant species; usually single individuals were found, occasionally a male and female were found on the same perch or adjacent perches.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A nonheliotherm (fig. 2). No basking behavior was seen.

Anolis fuscoauratus

HABITAT.—In the “mata de terra firme,” in old second growth and at least edge of “varzea,” and not in the open areas on isolated trees or bushes, nor in young second growth.

Individuals were seen sometimes on tree trunks but somewhat more frequently on bushes and slender twigs close to the ground; they were found usually below two meters but occasionally as high as three or four, and also they were seen on the leaf litter on the ground.

ABUNDANCE.—Moderately common. Usually isolated individuals were found, but once a male and tiny juvenile were found on the same tree. There is some suggestion that they group themselves in loose colonies with adjacent home ranges rather than distributing themselves evenly or randomly over the available habitat.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A nonheliotherm (fig. 2). No basking behavior was seen.

TEIIDAE

Cnemidophorus lemniscatus

HABITAT.—Found in open areas where the vegetation is so sparse that there is bare, unshaded ground exposed between tussocks of grass or bushes and not in the forest or even young second growth. The juveniles seem to occur in the most open parts of the habitat.

The species is terrestrial though individuals occasionally climb short distances up bushes or onto logs and hide in holes in the ground.

ABUNDANCE.—Occurring in only a few places but abundant there.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A heliotherm (fig. 2). Individuals were seen basking and were active only in the heat of the day on sunny days.

Ameiva ameiva

HABITAT.—Primarily along edges of clearings in forest and second growth. It ranges out into open areas but seldom far from bushes and other cover, and also into second growth and forest but seldom more than a few meters from an edge. Ameivas turn up in clearings completely surrounded by forest, indicating that they do disperse through the forest.

Ameivas are terrestrial, occasionally climbing on rocks and logs, hiding in holes in the ground and among rocks.

ABUNDANCE.—Widespread and common in edge and edificarian situations.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A heliotherm (fig. 2). Ameivas were seen basking; they are usually active only during the heat of the day and primarily on sunny days.

Kentropyx calcaratus

HABITAT.—Primarily in the forest, "mata de terra firme," old second growth, and high spots in the "varzea"; very occasionally individuals were seen in open areas.

Though terrestrial, they not uncommonly were seen climbing upon a log, the base of a tree, or branches of a fallen treetop. They hide in holes in the ground and under logs.

ABUNDANCE.—Widespread in the forest but only moderately common.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A heliotherm (fig. 2). Individuals were seen basking in sun patches on the forest floor; they were active only in the middle of the day and on sunny days.

Tupinambis nigropunctatus

HABITAT.—This seems to be a wide-ranging species, moving out into open areas, occurring in second growth and far inside the forest in "mata de terra firme" and "varzea."

Largely terrestrial, it hides in holes in the ground.

ABUNDANCE.—Not commonly seen but, because it is hunted, it is very shy.

FOOD.—A variety of animal prey including small vertebrates.

TEMPERATURE.—Probably a heliotherm, as several were seen basking (no temperature records).

SCINCIDAE

Mabuya mabouia

HABITAT.—Most common along the edges of forest and of second growth, it also occurs well inside the forest and out in open grassy situations where hiding places are available. With the possible exception of *Tupinambis*, this has the widest habitat range of all the species considered in this paper.

This species is partly terrestrial, but also it is seen frequently on logs, wood piles, and even short distances up tree trunks. It is one of the few species regularly seen in tall grass areas, where they are seen on tree trunks and on posts that extend above the grass.

ABUNDANCE.—Moderately common, least so inside the forest.

FOOD.—Insects and other invertebrates.

TEMPERATURE.—A heliotherm (fig. 2). Frequently seen basking.

Discussion

The ecological profile given in figure 1 summarizes the microdistributions of the lizards under consideration in the Belém area. No species ranges throughout the whole spectrum of the area though some species certainly are more widely distributed than are others.

Of the habitats studied, the forest is the richest in number of species, but most of the species there are not abundant—at least they are not commonly seen. Some of the species high in the forest canopy and others in the leaf litter are certainly more abundant than indicated by the number of times that we saw them. Restricting consideration to areas where our observations are best, among the species that live on tree trunks near the ground or are conspicuously active on the ground, most of the species in the relatively undisturbed forest seem rarer than those outside it. The localities where most of the forest species were most common—the Parque do Museu and the Bosque Municipal—were places where the canopy was only slightly disturbed but the understory more so and where many things, particularly certain snakes, birds, and mammals that might be predators or competitors, were probably absent.

In the forest habitats not only density of individuals per species, but also total density of individuals of all lizard species taken together seemed less than in some more disturbed areas.

Second growth has a lizard fauna much like that of the forest except that certain species are missing and a few like *Ameiva* are more com-

mon. Canopy species, particularly *Polychrus marmoratus*, are seen here, more frequently than in older forest apparently because the canopy is closer to the ground.

Clearings and edges have few species but they are sometimes extremely abundant, particularly *Tropidurus torquatus*. These species are undoubtedly native in areas such as Belém, where rain forest is the climax vegetation, but they also occur in other major habitat areas such as "cerrado," where rain forest is absent. Though the lizards typical of clearings disperse through and even live inside the rain forest (e.g., *Mabuya*), they are never abundant there.

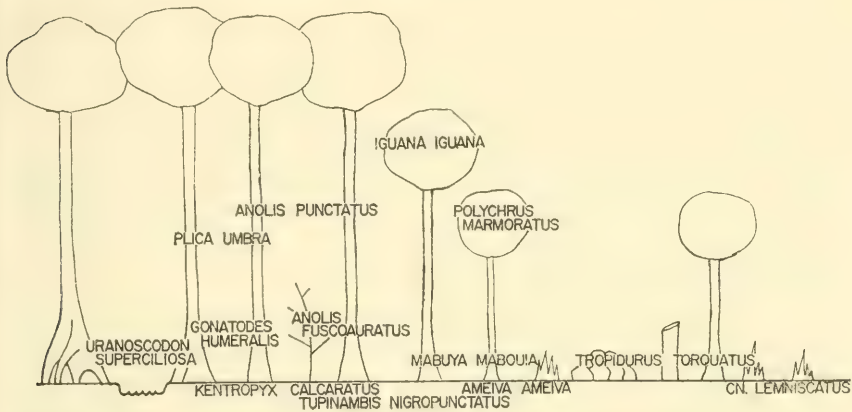


FIGURE 1.—Habitat distribution in Belém lizards: Schematic cross section of Belém habitats from upland forest, with a small forest stream at left, through second growth and grassland to bare ground at right (each species located in area of maximum observed abundance).

There are a number of factors that may be involved in making the forest the environment where the largest number of species occur. Of the environments in the Belém region, the forest comprises the greatest area, it is the most stable on any one site, and it contains the widest floristic diversity and probably the most numerous species of other animals. (These factors were all certainly true before the advent of modern man.) All of these may well be involved in promoting species diversity, and this paper provides no evidence for emphasizing or excluding any of them. Figure 1 suggests that the greater structural complexity of the forest may also be important. There are lizards in the forest occupying structural situations that do not exist or exist only rarely outside the forest. Their restriction to the forest may be, in part, the direct result of the fact that the forest's more complex structuring provides places for the lizards to live.

The physical structures in an environment that a lizard uses as look-outs, hiding places, basking spots, etc., form an important aspect of the

environment from the lizard's point of view. They have been called the lizard's "structural niche" (Rand, 1964). When the term was proposed for West Indian anoles, it was found that certain measurements of the perches on which the lizards were seen provided a useful description. Though the concept of structural niche seems useful for Belém lizards, measurements used for West Indian anoles are not sufficient and other environmental parameters must also be considered. In the case of *Uranoscodon superciliaris*, the proximity of water seems important. No system of quantifying the various aspects of structural niches was devised, and they have been described verbally in the foregoing species accounts.

Another set of parameters, in addition to structural niche, must be considered in describing the ecological distribution of lizards. These can be grouped as the lizard's "climatic niche." There are a variety of environmental factors that show parallel gradients here, among them insolation, light, temperature, and humidity. In general, one set of extremes for all these factors in the area is reached on or near the floor of the mature forest, and the other set is reached on the ground in clearings devoid of vegetation. Edges, second growth, and the top of the canopy show intermediate conditions.

The various lizards arrange themselves differently with respect to these gradients. To understand better the relationships of the lizards to the microclimates, we took a number of cloacal temperatures of the former while they were active in periods when the sun was shining; behavioral thermoregulation was possible at this time. In West Indian anoles similar data showed that the lizards in shaded habitats had lower body temperatures than those in open habitats (Ruibal, 1961; Rand, 1964).

The Belém data are a bit more complicated. Figure 2 shows the body temperature plotted against air temperatures taken in the immediate vicinity at the same time. These plots suggest that there are two very different kinds of thermal relationships represented among the Belém lizards: those whose temperature approximates that of the surrounding air and those whose temperature is much above it. A review of observations made of the various species shows that those in the first class were not seen basking while those in the second class were observed with definite basking behavior. Regarding this behavior, it seems safe to conclude that the high temperatures of the second group are due to behavioral thermoregulation and that they are heliotherms while the other group is not—at least at the ambient temperatures observed. (Since their temperature approximates the air and there is no evidence that they use substrates for thermoregulation, we prefer not to use "thigmotherm" but rather the more neutral "nonheliotherm.")

There is a definite relationship, but not unvarying, between thermal relationship and habitat used. The nonheliotherms are all inside the forest, and this is thermally the most constant habitat. The heliotherms occur in the more extreme environments in clearing, second growth, and canopy. One species of heliotherm, however, is almost entirely restricted to the area within the forest (*Kentropyx*), where it basks in the numerous patches of sun that reach the forest floor.

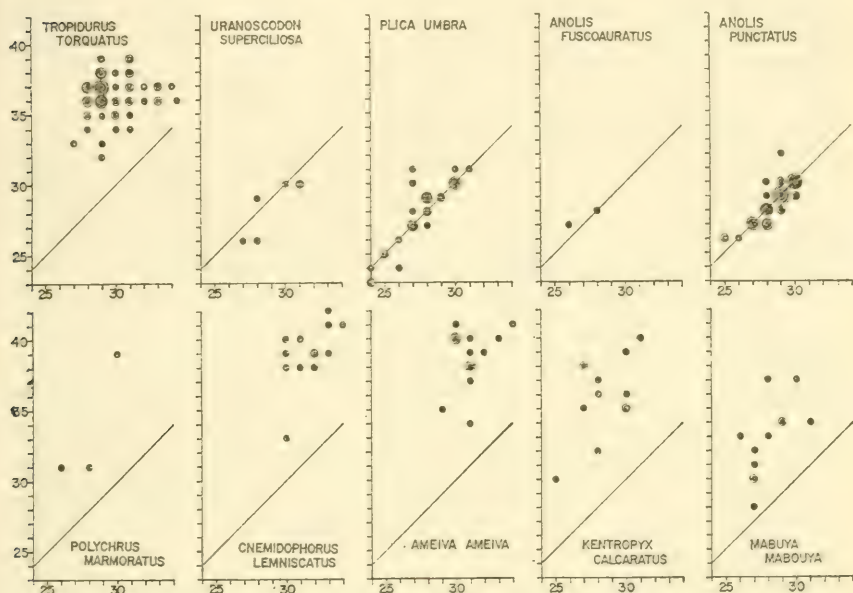


FIGURE 2.—Temperature relationships in Belém lizards: Cloacal temperature plotted against ambient air temperature at time of capture (temperatures in centigrade of just-captured lizards in natural habitat during day).

It should be noted from figure 2 that, under the conditions tested, the nonheliotherms in the forest are about as homeothermic as are the heliotherms that practice behavioral thermoregulation outside the forest (see Rand and Rand, 1966, for details of thermoregulatory behavior in *Tropidurus*). It certainly seems likely that the body temperatures of the open habitat animals would fluctuate much more than they are observed to do if the lizards did not practice some sort of thermoregulation. These data suggest that, if heliothermy has evolved to increase homeothermy rather than to produce high body temperature per se, then it has probably evolved in response to the fluctuating conditions in open environments. The data also suggest that the high body temperatures observed in heliotherms reflect the general principle

that, if an animal is to be diurnally active, heating is easier to accomplish than cooling in an area of high insulation.

The foregoing indicates that *Kentropyx* may be a recent invader of the forest from a macroteiid ancestor that was adapted basically to living in open habitats.

Though *Kentropyx* is the only primarily forest heliotherm, other heliotherms like *Tupinambis* and *Mabuya* also occur there. Low eccentric temperatures usually are associated with low temperature tolerances. Because of this and because the upper threshold of tolerance is usually sharper and more quickly lethal than the lower, it is probably easier and safer for open habitat animals to disperse through the forest than for forest animals to disperse through open habitats.

The role of interspecific competition is a basic problem in animal ecology. One of the reasons for our interest in the distribution of Belém lizards was that the evolution of differences in microdistribution has been suggested as an important strategy in reducing interspecific competition among sympatric lizard species (Rand, 1964; Milstead, 1957; and others). The basis for this suggestion in lizards has come usually from studies of sympatric congeners, but there seems no reason that it could not occur between sympatric relatives of different genera. Ecologists (e.g., MacArthur, Recher, and Cody, 1966) who attempt to discover environmental parameters that will predict bird species diversity seem to be assuming that a phylogenetic group as large as birds can be treated as an ecological unit for these purposes. We can make a similar assumption about the Belém lizards but, as we will show, it is probably wrong.

The clearest cases wherein differences in microdistribution can be associated with interspecific interactions are those wherein two or more species occur in the same area, utilize the same structural niche, and replace one another in different habitats or different climatic niches. The only case of such replacement suggested by the distributions plotted in figure 1 is the three smaller macroteiids. There is some overlap between these, but each species reaches its maximum abundance in a different environment: *Cnemidophorus* in the bare open patches, *Ameiva* in the edges and second growth, and *Kentropyx* in the forest. All three have similar foraging habits and could well compete if they occurred syntopically.

There are suggestions that size may be playing a role in reducing interaction between overlapping species. This is a strategy much seen in birds (Schoener, 1965, and others). In general, larger lizards take larger prey and this tends to reduce food competition among species of different sizes. In the Belém lizards, the very large macroteiid *Tupinambis nigropunctatus* widely overlaps *Ameiva ameiva* and *Ken-*

tropyx calcaratus. *Tupinambis* is several times the size of the others and as an adult takes much larger food. Another suggestive case is the two forest *Anolis* that occupy very similar structural and climatic niches but differ sharply in size. The third case is the difference between *Polychrus* and *Iguana*, the two lizards of the tree crowns. It seems unlikely that this size difference is related to food competition since *Iguana* is largely and *Polychrus* is partly herbivorous.

There is no evidence of the sort of temporal replacement during the day that Inger (1959) recorded in forest skinks in Borneo. Diurnal versus nocturnal replacement (perhaps involving the large nocturnal trunk gecko of the forest, *Thecadactylus rapicaudus*) is possible, but it is an unstudied problem.

The only major diet difference we now know (our examination of stomach contents has been limited and casual and there is much still to be learned) lies between the two species that regularly take a considerable amount of leaves and flowers, *Iguana iguana* and *Polychrus marmoratus*, and the remainder, which take largely or exclusively animal food. This diet difference plus the difference in structural niche separate the two herbivorous species very sharply from the rest.

To return to microdistribution as a mechanism for reducing species competition, there is considerable difference among species with respect to structural niches as there is with respect to climatic niches. Taken together, the microdistributions (fig. 1) do not show a regular pattern of replacement of one lizard by another because of the presence of overlaps between species (e.g., *Plica umbra* and *Anolis punctatus*) and of gaps between others (e.g., *Uranoscodon* and *Tropidurus torquatus*) in distribution. Since there is a lack of regular replacement, microdistribution does not suggest itself as an important factor in reducing interspecific competition among the lizards in general, though it may be so between certain species. As we have discussed, our observations on other strategies for reducing possible interspecific competition suggest that, even when all are considered together, no regular pattern of ecological separation among species appears. We are left with the impression, which we cannot prove rigorously, that the relationships of the lizard species to each other are not the over-riding factors in shaping their ecologies.

There are several possible explanations. It may be that our data are so incomplete that we have been given a completely erroneous impression. Further study may show that other species occur at Belém. This may fill the gaps in our picture and reveal differences among common species that would eliminate the apparent overlaps. Certainly, much more is to be learned and the latter possibility cannot be eliminated,

but, if for no other than heuristic reasons, it cannot be accepted as the only possibility.

There are two other possibilities not mutually exclusive that seem to us more likely. One is that lizards do not make an ecological unit. They, as a group, do not occupy a "lizard niche" that is subdivided among them; rather, the broad niche or niches that lizards occupy are occupied also by organisms of widely differing phylogenetic relationships with the result that several lizards in the same habitat may each have as its close competitors animals that are not lizards at all but other vertebrates or even invertebrates. It may not be coincidental that the most convincing studies of interspecific competition and mechanisms for reducing it in lizards come from the arid areas of North America and from those areas of the West Indies where lizards are very abundant both as individuals and species and play an important role in the trophic ecology. Certainly, one has the impression in the Belém area that inside the forest the disappearance of all lizards would not greatly upset the forest ecological economy if at all.

The relative rarity of lizards in the Belém forests suggests another possible explanation for the apparent lack of regularity in interspecific relationships. This is that populations of lizards are held at such low levels (perhaps by predation) that the populations never reach densities wherein interspecific competition for food or space occurs. It may be relevant that forest lizards are most common in the park areas, where many of the larger predatory birds, mammals, and perhaps snakes are rare or absent; these are also areas where the number of competitors may also be reduced.

Certainly, it is striking how little agonistic behavior one sees among iguanids in the Belém forests. This is in contrast to desert iguanids and those in the West Indies, where fighting or displaying between males is a common sight. One has the impression that the problem the forest lizards are usually faced with is not that of spacing out the population to avoid overcrowding but rather that of bringing together mates at the proper time. Among *Plica umbra*, *Anolis punctatus*, and *Gonatodes humilis*, we have the impression that we found individuals of the opposite sex near one another more often than we would have expected on chance alone. It may be that these lizards form pairs or at least that males and females permanently establish adjacent or overlapping home ranges in preference to living solitarily. The absence of territorial defense and the large amount of potential home range that seems unoccupied suggest that population densities are so low that direct intraspecific competition for exhaustible resources is nonexistent, and it also suggests that probably there is no inter-

specific competition between most lizard species and, consequently, no selection pressure for mechanisms that would reduce the competition.

If this is true, how can one account for the observed specialization in both climatic and structural niche? The answer is, of course, intraspecific competition in the Darwinian sense. When any species can exploit the available resources (in the broadest sense) more effectively by specializing in part of them, the specialization itself will be selected for unless this selection pressure is countered by selection in other directions. Specialization, by definition, involves loss of ecological amplitude, and selection against specialization is largely generated by temporal fluctuations in environmental conditions that generate a selection pressure for ecological amplitude (Pianka, 1967). In stable habitats—and the inside of the tropical rain forest is one of the most stable—the selection against specialization should be at its lowest.

It may be that low counterselection against specialization, rather than any unusually strong selection pressure for it, has produced some of the extreme specializations we see in tropical forest forms.

We have not the data to choose between these two hypotheses, which, in fact, are not mutually exclusive. It seems most likely that lizards as a block do not occupy a monolithic trophic niche but share a niche in a complex way with many other animals. It also seems likely that the low population levels in the forest lizards result in minimizing the importance of selective forces that arise from interspecific competition between many lizard species.

Conclusions

(1) The Belém area contains several different habitats and no species of lizard studied ranges uniformly through the area. (2) The forest is richest in number of species and the evidence suggests that this is at least in part because of its greater structural complexities. (3) Two types of thermal relationships with the environment are demonstrated by the lizard fauna: the heliothermic in both open and forest habitats and the nonheliothermic inside the forest. The latter show about as much homeothermism as the former because of the relatively low ambient temperature variation inside the forest. (4) The distribution of three species of macroteiid suggests that they replace one another ecologically. A fourth macroteiid that is syntopic with at least two of these is much larger. Two *Anolis* species that are syntopic and occupy very similar structural niches are different in size. (5) These replacements are probably important, but the impression of the distributions is one of irregular overlaps and gaps between niches of species. (6) The apparently unoccupied niches are

probably in part filled by animals that are phylogenetically distantly related to lizards, but ecologically the former should be considered with the latter. The lizards do not make an ecological unit. (7) The low population densities within the forest are such that interspecific competition may be relatively unimportant and ecological specialization may be the result of intraspecific competition for maximum efficiency of resource exploitation. Selection pressure for this must always exist, but the tropical rain forest, because of its great continuous extent and stability, probably generates unusually few counterselection pressures and, consequently, a high relative selection pressure toward specialization.

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Records and Descriptions of
Additional Scoliidae from New Guinea,
Bismarck Archipelago, and Solomon Islands
(Hymenoptera: Aculeata)

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Several hundred Scoliidae have been obtained in New Guinea, Bismarck Archipelago, and Solomon Islands by field parties of the Bernice P. Bishop Museum, Honolulu, since those reported upon in my revisionary study of these wasps (Krombein, 1963). I am grateful to J. L. Gressitt and C. M. Yoshimoto for supplying me the specimens for study. I have prepared the following brief paper inasmuch as included among the specimens are several distinctive new species and subspecies of *Campsomeris* subgenera *Laevicampsomeris* and *Phalerimeris*, and *Campsomeris*, sensu lato, the previously unrecognized males of two other species belonging to the subgenus *Laevicampsomeris*, and the previously unknown female of *Diliacos r. ribbei* (Betrem). Also, many specimens came from a number of new localities and provide additional data on seasonal occurrence of many species.

The species are arranged in systematic order as in my revisionary paper. The nomenclature employed is also the same except for the changes necessitated by two recent papers on classification of the Scoliidae (Betrem, 1962, 1967; Bradley and Betrem, 1967).

Campsomeris (Laevicampsomeris) bonguensis Betrem

Northern District, Papua: 3 ♂, Popondetta, 60 meters, 2 and 26 September 1963, P. Shanahan and J. Sedlacek, in Malaise trap.

Central District, Papua: 3 ♂, Cape Rodney, 10 meters, 2-4 November 1960, J. L. Gressitt, 1 in Malaise trap. 2 ♂, Otomata Plantation, east of Port Moresby, 1 meter, 2 November 1960, J. L. Gressitt, in Malaise trap. 1 ♂, Brown River, 23 October 1960, J. L. Gressitt.

West New Guinea: 1 ♀, Dawai River, south-southeast of Sumbababa, Japen Island, 3 November 1962, N. Wilson. 1 ♂, Nabire, 5-50 meters, 25 August-2 September 1962, J. Sedlacek, in Malaise trap. 1 ♂, Kebar valley, west of Manokwari, 550 meters, 4-31 January 1962, L. W. Quate.

Campsomeris (Laevicampsomeris) nigerrima (Smith)

Northern District, Papua: 1 ♀, Popondetta, 60 meters, 26 September 1963, P. Shanahan, in Malaise trap.

West New Guinea: 1 ♀, Dawai River, south-southeast of Sumbababa, Japen Island, 3 November 1962, N. Wilson.

Bismarck Archipelago: 2 ♀, 1 ♂, Illugi, Upper Warangoi, Gazelle Peninsula, New Britain, 230 meters, 8-15 December 1962, J. Sedlacek. 1 ♂, Upper Warangoi, Gazelle Penin., 250-600 meters, 28-30 November 1962, J. Sedlacek. 2 ♂, Gaulim, Gazelle Penin., 130-140 meters, 23-28 October and 19-20 November 1962, J. Sedlacek. 1 ♀, Mt. Sinewit, Gazelle Penin., 900 meters, 7-16 November 1962, J. Sedlacek.

Males of *nigerrima* have not been recognized previously. These key to *laglaizei* Betrem, couplet 9 (Krombein, 1963, p. 553), and agree with that species in details of punctuation and coloration. The genitalia of both *laglaizei* and *nigerrima* appear to be indistinguishable from those of *bonguensis* Betrem. The males of *nigerrima* recorded above are 18-23 mm long, and the forewing is 16-21 mm. It is presumed that the single *bonguensis* male recorded earlier from New Britain (Krombein, 1963, p. 568) is actually a specimen of *nigerrima*.

Campsomeris (Laevicampsomeris) laglaizei Betrem

West New Guinea: 1 ♀, Dawai River, south-southeast of Sumbababa, Japen Island, 3 November 1962, N. Wilson.

Campsomeris (Laevicampsomeris) brandti Krombein

Bismarck Archipelago: 1 ♀, 1 ♂, Lelet Plateau, Schleinitz Mts., New Ireland, October 1959, W. W. Brandt.

This pair bears exactly the same label data as the female holotype (Krombein, 1963, p. 570), the only specimen known previously. The

male is 18 mm long with the forewing 16 mm. The genitalia are identical with those of *bonguensis* Betrem and other known Melanesian males of the subgenus *Laevicampsomeris*. The male keys to *solomonis* Krombein, couplet 10 (Krombein, 1963, p. 553), and cannot be separated from males of that species except by reference to label data.

Campsomeris (Laevicampsomeris) solomonis solomonis, new status

I am reducing this taxon to subspecific rank because of the discovery of the distinctive new subspecies described below.

Solomon Islands: 1 ♂, Kukugai, Bougainville, 150 meters, November 1960, W. W. Brandt. 1 ♂, Ulo Crater, Vella Lavella Island, 10 meters, 16 December 1963, P. Shanahan. 1 ♂, Pepele, Kolombangara Island, 0–30 meters, 3 February 1964, P. Shanahan. 1 ♀, 1 ♂, Dala, Malaita Island, 50 meters, 9–14 and 21 June 1964, J. and M. Sedlacek. 2 ♂, Tambalia, 30 km west of Honiara, Guadalcanal, 22–25 May 1964, R. Straatman, J. and M. Sedlacek. 1 ♀, Betikama River, Guadalcanal, August 1960, W. W. Brandt. 1 ♀, Wugiroga, San Cristoval, 9 August 1960, C. W. O'Brien. 1 ♂, Kira Kira, San Cristoval, 0–50 meters, 10 November 1964, R. Straatman.

Campsomeris (Laevicampsomeris) solomonis sedlaceki, new subspecies

At first glance, this anomalous member of the subgenus *Laevicampsomeris* reminds one of a female of *Campsomeris (Radumeris) extranea leveri* Krombein without the narrow yellow bands on the first three abdominal terga; however, it has such *Laevicampsomeris* characters as the lack of a carina between the dorsal and lateral propodeal surfaces, the very short, impunctate, nontuberculate median area of the dorsal propodeal surface, the pronounced oblique furrow on the scapula, large impunctate areas on the front, vertex, and thoracic dorsum, and the lack of a second recurrent vein in the forewing. What makes it so distinctive among the taxa of *Laevicampsomeris* is the bright fulvous vestiture on the entire body and the yellowish wings, whereas the vestiture and wings are black in the more typical members of the subgenus.

In my key the female runs to *solomonis*, couplet 8, if one disregards the character of wing color in couplet 4. It is separated at once from typical *solomonis* by the color of the vestiture and wings.

I assume that the male from Gizo Island, which I included in the type-series of typical *solomonis*, is actually the opposite sex of *solomonis sedlaceki*. It has the black integument, vestiture, and wings of *solomonis* males from other of the Solomon Islands. If this assumption is correct, we have in *solomonis sedlaceki* a taxon of *Laevicampsomeris* exhibiting a most unusual form of sexual dimorphism.

HOLOTYPE.—♀, Gizo Island, New Georgia Group, Solomon Islands, 100 meters, 16 July 1964, J. and M. Sedlacek, Bishop Museum.

Length 23 mm, forewing 18 mm. Exactly like typical *solomonis* in punctuation and shape of longer hind tibial spur, but the vestiture fulvous, wings yellowish and lacking the green and blue reflections, and veins testaceous.

MALE.—Presumably identical to typical *solomonis* in color of vestiture and integument.

PARATYPE.—1 ♀, same data as holotype, but 19 July 1964, USNM. It is very similar to the holotype but is only 20 mm long.

Campsomeris (Laevicampsomeris) quatei, new species

This is known from a single female from West New Guinea. It is unique among females of this subgenus in having the entire posterior half of the vertex, scutellum, postscutellum, and median area of dorsal surface of propodeum with rather close punctures. It keys to couplet 8 and is distinguished from *nigerrima* (Smith) and *solomonis* Krombein as noted above.

HOLOTYPE.—♀, Bokondini, 40 km north of Baliem Valley, ca. 1300 meters, West New Guinea, 16–23 November 1961, L. W. Quate, Bishop Museum.

Length 25 mm, forewing 22 mm. Integument black; wings dark brown with purplish reflections, the margin of forewing darker. Vestiture black except that on clypeus and a few hairs on vertex light brown.

Clypeus with only a small median area and the apical rim impunctate; area frontalis and spatium frontale coarsely and closely punctate, upper part of front with scattered punctures; a narrow space anteriorly on vertex impunctate, elsewhere closely punctate.

Pronotum with moderately large, close punctures bearing stout erect setae, a narrow strip along posterior margin and anterior declivity impunctate; scutum with large contiguous punctures on anterior half and lateral third posteriorly, the median posterior space nearly smooth except for some punctures near midline; disks of scutum and scutellum with moderately sized, subcontiguous punctures except along midline; metapleuron and propodeum devoid of large punctures except median area of dorsal surface of propodeum with mostly subcontiguous, moderately large punctures.

Longer spur of hind tibia spatulate at tip, about two-thirds as long as hind basitarsus.

MALE.—Unknown.

Campsomeris (Laevicampsomeris) papuana, new species

The presence of abundant pale hair on the front, sides, and venter of head, the sides and venter of thorax (dorsum also in male), legs,

and on part (female) or all (male) of the abdomen distinguish this handsome species at a glance from other Melanesian members of the subgenus *Laevicampsomeris*.

The female runs to couplet 8 of my key (Krombein, 1963, p. 553). It has spatulate hind tibial spurs and moderately dense punctures on scutellum and postscutellum. This combination of characters coupled with the distinctive vestiture separate it from *nigerrima* (Smith) and *solomonis* Krombein, the two species keyed out in that couplet.

The male keys to couplet 9. It is separated from *laglaizei* Betrem and the species keying out in the subsequent couplet, *solomonis* and *bonguensis* Betrem, by a combination of characters such as the pale erect vestiture, lack of a propodeal tubercle, moderately dense punctation of the propodeal dorsum, and small yellow mark opposite the posteroventral margin of the eye. The genitalia, as is true in all Melanesian *Laevicampsomeris*, afford no differentiating characters.

HOLOTYPE.—♀, Karimui, south of Goroka, Eastern Highlands Dist., Terr. New Guinea, 1000 meters, 6 June 1961, J. L. and M. Gressitt, Bishop Museum.

Length 29 mm, forewing 24 mm. Integument black; wings fuscous, the forewing with purplish reflections. Erect vestiture brown to black on clypeus, vertex, dorsum of thorax including scapulae, terga three to six, and sterna five and six, whitish with an ochereous cast on front, sides, and venter of head, sides and venter of thorax, legs, and first and second abdominal segments; appressed preapical fringes of sterna two to four pale, apical fringes on sterna dark except for a few pale intermixed setae on second; sides and venter of thorax with abundant, silvery, sericeous pubescence.

Clypeus contiguously punctate except middle; area frontalis, spatium frontale, and a narrow strip on lower half of front between eyes densely and coarsely punctate; vertex and occiput densely and coarsely punctate except for a longitudinal median strip on vertex; setae arising from frontal, vertexal and occipital punctures coarse, erect and moderately long.

Scapulae, and anterior and lateral areas of scutum with dense, small punctures bearing conspicuous, erect setae, the impunctate median space on posterior half of scutum about a third as wide as scutal width and with a few scattered larger punctures; scutellum, postscutellum, and propodeal dorsum with subcontiguous punctures except for a narrow median strip; propodeum not tuberculate.

Posterior areas of terga and sterna shining; terga two to four mat on anterior two-thirds.

Legs with spurs of hind tibia spatulate at apex as in *bonguensis*, the longer one two-thirds as long as basitarsus.

ALLOTYPE.—♂, Karimui, 3 June 1961, J. L. and M. Gressitt, in Malaise trap, Bishop Museum.

Length 24 mm, forewing 20 mm. Integument mostly black, the dorsum of thorax and abdomen with weak blue reflections; the following creamy to yellowish: clypeus above and broadly on sides, narrow strip along inner eye margin to ocular sinus, short stripe adjacent to posteroventral eye margin, and apical half of foredistitarsus; wings fuscous, the forewing anteriorly with darker streak. Head, thorax, legs, and abdomen clothed with erect white setae except for a few intermixed dark setae on vertex and scutum, and the sixth and seventh terga with all dark setae; silvery sericeous pubescence on sides of thorax very conspicuous, longer and denser than in female.

Propodeum with denser, larger punctures than in *bonguensis*, those on dorsal surface separated from each other by about the diameter of a puncture, tubercle absent; genitalia as in *bonguensis* (Krombein, 1963, p. 597, fig. 18).

PARATYPE.—1 ♂, same data as holotype, but 5 June 1961, J. L. and M. Gressitt, in light trap, USNM. The paratype is 25 mm long and agrees with the allotype in vestiture, punctuation, and coloration.

Couplets 9 and 10 of my key may be expanded to include the males of these additional species of *Laevicampsomeris* as follows:

9. Median area of dorsal surface of propodeum with a distinct tubercle posteriorly, most of punctures on this area large and contiguous to subcontiguous 9a
 - Median area of dorsal surface of propodeum not tuberculate, most of punctures on this area finer and separated by more than the diameter of a puncture except in *papuana* and *solomonis* 10
- 9a. Side of clypeus with narrow yellow streak; propodeal punctation denser on dorsum in middle, many of punctures contiguous; New Guinea, Waigeu *Campsomeris laglaizei* Betrem
 - Clypeus entirely black; propodeal punctation slightly sparser on dorsum in middle, many of punctures separated from each other by about half the diameter of a puncture; New Guinea, Misool, New Britain.
 - Campsomeris nigerrima* (Smith)
10. Head, thorax, and most of abdomen with long, erect white hair; punctures on dorsum of median area of propodeum larger and denser, usually separated by no more than the diameter of a puncture; New Guinea.
 - Campsomeris papuana*, new species
 - Erect hair almost entirely dark; propodeal punctures finer and more separated except in *solomonis* 10
- 10a. Clypeus with a narrow yellow stripe along lateral margin; propodeal punctation fine and well separated; New Guinea.
 - Campsomeris bonguensis* Betrem
 - Clypeus entirely black 10b
- 10b. Foredistitarsus with a small yellowish spot; punctures on median area of propodeal dorsum finer and shallower, many of them separated by more than the diameter of a puncture; New Ireland.
 - Campsomeris brandti* Krombein
 - Foredistitarsus black; punctures on median area of propodeal dorsum coarser, many of them separated by less than the diameter of a puncture; Solomon Islands *Campsomeris solomonis* Krombein

Campsomeris (Laevicampsomeris) formosa (Guérin)

Northern District, Papua: 3 ♀, Popondetta, 25 meters, June 1966, P. Shanahan and Lippert, in light trap.

Central District, Papua: 1 ♀, Bisianumu Station, 40 km north-northwest of Port Moresby, 29 April 1960, C. W. O'Brien. 1 ♂, Brown River, 23 October 1960, J. L. Gressitt.

Morobe District, Terr. New Guinea: 15 ♀, 6 ♂, Wau, 900–1300 meters, 25 February 1962, 23 March 1963 and 1964, 27–31 March 1964, 12 April 1963, 13 April 1964, 27 June 1961, 27 July 1964, 14, 15, 16, and 19 August 1964, 11 September 1964, 17 September 1961, 11 October 1962, 19 October 1965, 15 December 1961, J. and M. Sedlacek, C. Montieth, P. Shanahan, 3 ♂ in Malaise trap. 1 ♀, 1 ♂, Mt. Kaindi, Wau, 900–1800 meters, 12–14 June 1963, P. Shanahan. 3 ♀, 2 ♂, Mt. Misim, Wau, 900–1100 meters, 16 February 1963, 14 August and 25 September 1964, J. and M. Sedlacek. 1 ♂, Bulldog Road, ca. 14 km south of Edie Creek, 2405 meters, 4–10 July 1966, G. A. Samuelson, in Malaise trap. 1 ♀, Pindiu, Huon Peninsula, 860 meters, 22 April 1963, J. Sedlacek. 1 ♀, Singaua River, Lae, 30 meters, 8 April 1966, O. R. Wilkes.

Eastern Highlands District, Terr. New Guinea: 9 ♂, Kassam, 48 km east of Kainantu, 1350 meters, 30 October 1959, T. C. Maa.

West New Guinea: 1 ♀, 1 ♂, Ifar, Cyclops Mts., 300–900 meters, 23–25 June 1962, J. L. Gressitt and J. Sedlacek. 1 ♂, Kampong Landbouw, 30 km northeast of airstrip, Biak Island, 16 July 1957, J. L. and M. Gressitt, in light trap. 1 ♂, Sucumi Camp, near head of Ransiki River, Vogelkop, 300 meters, 6 August 1957, D. E. Hardy.

Bismarck Archipelago: 1 ♀, Riat, Upper Warangoi, Gazelle Peninsula, New Britain, 250 meters, 1 November 1962, J. Sedlacek. 1 ♀, Illugi, Upper Warangoi, Gazelle Penin., 15 December 1962, J. Sedlacek. 1 ♂, Gaulim, Gazelle Penin., 130 meters, 23–28 October 1962, J. Sedlacek.

Solomon Islands: 1 ♂, Kokugai, Bougainville, 150 meters, October 1960, W. W. Brandt. 2 ♂, Gollifer's Camp, Kolombangara Island, 100–700 meters, 22–23 January 1964, P. Shanahan, one in Malaise trap. 1 ♀, Kolosulu, Guadalcanal, 20 May 1960, C. W. O'Brien. 1 ♂, Betikama River, Guadalcanal, August 1960, W. W. Brandt.

The male from Gaulim, New Britain, has more reduced yellow markings than in any specimens noted in my revision. The scutellar spots are reduced in size, the band on postscutellum is lacking, reduced posterolateral spots are present on the first two terga only, and the sternal spots are smaller on two and three. The Vogelkop male lacks yellow maculations on both the scutellum and postscutellum, but abdominal bands are present on the first three terga, only

those on the third being narrowly separated. The vestiture in the latter specimen is normal for *formosa*.

Campsomeris (Radumeris) tasmaniensis (Saussure)

Northern District, Papua: 1 ♀, 1 ♂, Popondetta, 20–60 meters, May 1966 and 2 September 1963, P. Shanahan and J. Sedlacek, ♂ in Malaise trap.

Central District, Papua: 1 ♂, Boroko, Port Moresby, 6–7 November 1960, J. L. Gressitt, in Malaise trap. 1 ♂, Otomata Plantation, east of Port Moresby, 1 meter, 2 November 1960, J. L. Gressitt, in Malaise trap. 1 ♂, Bisianumu Station, 40 km north-northwest of Port Moresby, 29 April 1960, C. W. O'Brien.

Western District, Papua: 1 ♀, 1 ♂, Daru Island, 2–3 meters, 19 July 1964 and 24–25 October 1960, J. L. Gressitt and H. Clissold, ♂ in Malaise trap. 1 ♀, Oriomo River, 6 meters, 14 February 1964, H. Clissold, in light trap.

Morobe District, Terr. New Guinea: 1 ♀, 1 ♂, Wau, 1200 meters, 12 April 1963 and 19 August 1964, J. Sedlacek.

West New Guinea: 7 ♂, Nabire, south of Geelvink Bay, 0–50 meters, 2–9 July and 25 August–20 September 1962, J. L. Gressitt, J. Sedlacek, H. Holtman, 1 in light trap and 6 in Malaise trap. 2 ♂, Enarotadi, Wisselmeeren, 1800–1900 meters, 27 July 1962, J. Sedlacek.

Campsomeris (Radumeris) extranea moluccensis Betrem

Bismarck Archipelago: 2 ♂, Kandan, New Britain, 24 December 1959, W. W. Brandt. 1 ♂, Talliligap, Gazelle Peninsula, New Britain, 300 meters, 17–18 December 1962, J. Sedlacek.

Solomon Islands: 1 ♀, Fauro, northeast Solomon Islands, 12 April 1964, P. Shanahan.

One of the males from New Britain has the yellow band on the fourth tergum narrowly interrupted in the middle; the other male bearing identical label data has the normal coloration for this subspecies.

In my revision (Krombein, 1963, p. 585) I recorded *extranea moluccensis* from localities in New Guinea, Bismarck Archipelago, and Solomon Islands. In the latter group it was present only on the northernmost island, Bougainville, and was replaced by *extranea leverii* Krombein on the more southern islands, Santa Ysabel, Russell, Ulawa, and Guadalcanal. The present shipment from the Bishop Museum includes a female and two males of *extranea moluccensis* labeled as having been taken at Kira Kira, San Cristoval, 27–28 July 1960, by C. W. O'Brien. I am of the opinion that these specimens are mislabeled because San Cristoval lies to the southeast of Guadalcanal,

and we would expect to find it occupied by *extranea leveri*. This record becomes even more suspect when we note that in this material there is a specimen of the eastern New Guinea race, *Campsomeriella manokwariensis lanhami* (Krombein), bearing a "Kira Kira, San Cristoval" label as well as several specimens of *Austroscolia nitida nitida* (Smith), another taxon occurring in New Guinea and the Bismarcks. Both *Campsomeriella manokwariensis* and *Austroscolia nitida* are represented by other races in the Solomons. It appears probable that some of these presumably mislabeled specimens may have been collected in eastern New Guinea because of the specimen of *manokwariensis lanhami*, a race that occurs on the Huon Peninsula, Markham River Valley, and at Port Moresby.

***Campsomeris (Radumeris) extranea leveri* Krombein**

Solomon Islands: 1 ♂, Tambalia, 35 km west of Honiara, Guadalcanal, 30 meters, 22-25 May 1964, J. and M. Sedlacek.

***Campsomeris (Radumeris) extranea shanahani*, new subspecies**

The single female of this previously unrecognized taxon from Gizo Island in the New Georgia group differs from females of the other races of *extranea* in lacking yellow integumental markings on the abdomen and in the very reduced yellow spot adjacent to the upper inner eye margin. Disregarding the lack of yellow abdominal markings it keys without difficulty to *extranea* (couplet 23).

The putative male, represented by a short series from Vella Lavella Island in the New Georgia group, runs to *extranea* (couplet 34) if one disregards the lack of a yellow band on the postscutellum. It differs from males of the other races of *extranea* in having a very tiny yellow spot adjacent to the upper inner eye margin and in lacking yellow markings on the pronotum and postscutellum.

HOLOTYPE.—♀, Gizo Island, New Georgia group, Solomon Islands, 100 meters, 20 July 1964, J. and M. Sedlacek, in Malaise trap, Bishop Museum.

Length 18 mm, forewing 14 mm. Black, yellow markings lacking except for a tiny spot adjacent to upper inner eye margin. Vestiture dark fulvous on head and thoracic dorsum, whitish on sides of thorax and first abdominal segment; apical fringes of all terga and of fourth and fifth sterna dark brown, of second and third sterna light brown; decumbent setae on pygidium dark brown. Wings and punctuation as in *extranea leveri*.

ALLOTYPE.—♂, Pusiasama, Vella Lavella Island, Solomons; November 1963, P. Shanahan, in Malaise trap, Bishop Museum.

Length 19.5 mm, forewing 14.5 mm. Black, abdomen with weaker blue reflections than in *extranea leveri*, pale yellow maculations as

follows: mandible at base, sides and apex of clypeus more narrowly than in *extranea leverii*, line along inner eye margin to top of antennal insertions, very tiny spot in ocellocular area, narrow streak along posterior eye margin on lower two-thirds, a pair of small transverse spots on scutellum, tiny posterolateral spot on first tergum, a somewhat larger, transverse posterolateral streak on outer fourth of second tergum, a similar but shorter posterolateral streak on second sternum, small spot at apex of anterior surface of mid and hind femora, exterior surface of foretibia, and outer surface of forebasitarsus and distitarsus. Erect vestiture dark brown, appressed pubescence on side of thorax silvery. Wings slightly more infumated than in *extranea leverii*.

PARATYPES.—2 ♂, same data as allotype. 1 ♂, same data as allotype but 25 November 1963, USNM and Bishop Museum. Paratypes are 17–19 mm long. The color pattern is the same as described for the allotype except that one specimen has larger spots on the scutellum that are separated only narrowly on the midline, and the third tergum has a short posterolateral streak on the outer fourth. The genitalia are identical with those of the other subspecies of *extranea*.

Campsomeris (subgenus?) *oresbios oresbios* Tuijn

Morobe District, Terr. New Guinea: 1 ♀, 2 ♂, Wau, 1200 meters, 10 November 1965, 9 December 1961, and 17 December 1965, J. and M. Sedlacek and P. Shanahan, in Malaise trap.

Bismarek Archipelago: 1 ♂, Gaulim, Gazelle Peninsula, New Britain, 130 meters, 23–28 October 1962, J. Sedlacek.

This race has not been recorded previously from New Britain, although it has a wide distribution in New Guinea. This specimen agrees well with darker maculated and haired specimens from New Guinea except that there is slightly less yellow on the clypeus and the wings are darker. Additional material, especially of females, may demonstrate that the population occurring in the Bismarek Archipelago should be recognized as a race discrete from the New Guinea taxon.

Campsomeris (subgenus?) *microspatulata* Tuijn

Morobe District, Terr. New Guinea: 1 ♀, Wau, 1200 meters, 3 March 1963, J. Sedlacek. 1 ♂, Finschhafen, 14 April, J. and M. Sedlacek. 1 ♀, ca. 8 km west-northwest of Lab Lab, Umboi Island, 300 meters, 8–19 February 1967, G. A. Samuelson, in Malaise trap.

West New Guinea: 1 ♂, Nabire, south of Geelvink Bay, 10–40 meters, 7 October 1962, N. Holtmann, in Malaise trap in jungle.

Campsomeris (*Phalerimeris*) *loriae loriae* (Mantero)

Central District, Papua: 1 ♂, Laloki, 10 February, F. Muir.

Eastern Highlands District, Terr. New Guinea: 1 ♂, Kassam, 48 km east of Kainantu, 1350 meters, 30 October 1959, T. C. Maa.

West New Guinea: 3 ♀, 3 ♂, Sibil Valley, Star Mts., 1250 meters, 18 October-8 November 1961, S. and L. Quate. 1 ♂, Ifar, Cyclops Mts., 300-500 meters, 28-30 June 1962, J. L. Gressitt and J. Sedlacek, in light trap. 5 ♀, 4 ♂, Bokondini, 40 km north of Baliem Valley, about 1300 meters, 16-23 November 1961, L. W. Quate. 1 ♀, 2 ♂, Moanemani, Kamo Valley, Wisselmeeren, 1500 meters, 15 August 1962, J. Sedlacek. 1 ♀, Itouda, Kamo Valley, Wisselmeeren, 1500-1700 meters, 18 August 1962, J. Sedlacek. 1 ♀, Dawai River, south-southeast of Sumberbaba, Japen Island, October 1962, N. Wilson.

Campsomeris (Phalerimeris) loriae millironi Krombein

Solomon Islands: 1 ♀, Buin, Bougainville, 2 June 1956, J. L. Gressitt. 1 ♀, Pusiasama, Vella Lavella, 17-18 November 1963, L. and M. Gressitt. 3 ♀, 1 ♂, Betikama River, Guadalcanal, August 1960, W. W. Brandt. 1 ♂, Tambalia, 35 km west of Honiara, Guadalcanal, 30 meters, 20 May 1964, J. and M. Sedlacek.

Campsomeris (Phalerimeris) loriae kolombangarensis, new subspecies

This distinctive melanic race of *loriae*, known only from males, is separated from the other races of *loriae* by the reduced yellow markings. Although it is now known to occur only on Kolombangara in the New Georgia group, it is quite likely that it will be found on the other islands in that group when more extensive collecting has been accomplished. The closest congener, *loriae millironi* Krombein, is known from Guadalcanal, Florida, Rendova, Vella Lavella, and Bougainville Islands in the Solomons, and from New Britain in the Bismarck Archipelago. It differs from *loriae millironi* in having the clypeus black except sides, yellow markings very reduced or lacking on the pronotum, and the postscutellum, abdomen (almost entirely), and legs black. The genitalia are identical with those of the other subspecies.

HOLOTYPE.—♂, Iriri, Kolombangara, New Georgia group, Solomon Islands, 2 meters, 3 July 1964, J. and M. Sedlacek, Bishop Museum.

Length 14 mm, forewing 12 mm. Black, abdomen with faint blue reflections, yellow as follows: mandible on basal two-thirds, spot at lower corner of clypeus, short stripe along inner eye margin to antennal insertion, a pair of tiny spots anteriorly on pronotal disk, and short posterolateral streak on second tergum; tip of mandible and lower edge of clypeus reddish.

PARATYPES.—3 ♂, same data as holotype, USNM and Bishop Museum. These are uniform in size. Two of them lack yellow spots on the pronotum.

Campsomeris (Phalerimeris) ferrugineipes ferrugineipes (Mantero)

West New Guinea: 3 ♀, Moanemani, Kamo Valley, Wisselmeeren, 1500 meters, 15 August 1962, J. Sedlacek.

Campsomeris (Phalerimeris) ferrugineipes pembertoni Krombein

Bismarck Archipelago: 7 ♂, Talliligap, Gazelle Peninsula, New Britain, 300 meters, 17–18 December 1962, J. Sedlacek.

Campsomeriella (Campsomeriella) manokwariensis manokwariensis
(Cameron)

West New Guinea: 6 ♂, Hollandia [Kota Baru], 25–28 June 1962, N. Wilson. 1 ♀, Bokondini, 40 km north of Baliem Valley, about 1300 meters, 16–23 November 1961, S. and L. Quate. 1 ♂, Itouda, Kamo Valley, Wisselmeeren, 1500–1700 meters, 18 August 1962, J. Sedlacek. 3 ♂, Enarotadi, Wissel Lakes, 1800–2000 meters, 2–11 and 27 July 1962, N. Wilson and J. Sedlacek, 2 by sweeping. 1 ♀, Dawai River, south-southeast of Sumberbaba, Japen Island, 3 November 1962, N. Wilson. 2 ♀, Biak Island, 22–30 June 1962, J. L. Gressitt and J. Sedlacek, in light trap. 1 ♂, southeast Biak Island, 1 July 1962, J. L. Gressitt. 9 ♀, 16 ♂, Nabire, south of Geelvink Bay, 0–50 meters, 2–9 July, 25 August–2 September, 1–4, 7, and 17 September, 4, 7, 10, and 13 October 1962, J. Sedlacek, J. L. Gressitt, H. Holtmann, N. Wilson, 1 each in Malaise and light traps.

Bismarck Archipelago: 1 ♀, Kerawat, New Britain, 6 May 1956, G. Dun.

Campsomeriella (Campsomeriella) manokwariensis lanhami (Krombein)

The Bishop Museum material included one female of this eastern New Guinea race undoubtedly mislabeled as being from Kira Kira, San Cristoval, Solomon Islands, 27 July 1960, C. W. O'Brien (see my earlier remarks on these presumably mislabeled specimens under *Campsomeris extranea moluccensis*). This particular female agrees with the eastern New Guinea race in having the more lightly infuscated basal two-thirds of the forewing and white tergal fringes on the first four terga in contrast to the Solomon Islands race *manokwariensis manni* (Krombein), which has similarly colored wings but only the first three tergal fringes white, that on the fourth being brown.

Campsomeriella (Campsomeriella) manokwariensis manni (Krombein)

Solomon Islands: 1 ♀, Pუსisama, Vella Lavella Island, 29 November 1963, P. J. Shanahan.

Trisciloa saussurei Gribodo

Morobe District, Terr. New Guinea: 1 ♂, Wau, 1250 meters, 3 January 1963, J. Sedlacek. 1 ♂, Lae, 26 November 1961, J. Sedlacek. 1 ♂, Zenag-Lae, 200 meters, 15 January 1965, J. Sedlacek.

West New Guinea: 1 ♂, Ifar, Cyclops Mts., 300–500 meters, 28–30 June 1962, J. L. Gressitt and J. Sedlacek, in light trap. 1 ♀,

5♂, Kebar Valley, west of Manokwari, 550 meters, 4–31 January 1962, L. W. Quate. 1♂, Oransbani, south of Manokwari, February 1962, L. Richards.

Liacos fulgidipennis (Smith)

Northern District, Papua: 1♀, Popondetta Mission, 60 meters, 18 October 1963, P. Shanahan.

Morobe District, Terr. New Guinea: 1♀, 2♂, Wau, 1050–1400 meters, 26 May 1965, 9 July 1963, and 11 September 1961, P. Shanahan, J. and M. Sedlacek, 1♂ in Malaise trap. 1♀, Finschhafen, Huon Peninsula, 20–150 meters, 15 April 1963, J. Sedlacek.

West New Guinea: 1♀, Kebar Valley, west of Manokwari, 550 meters, 4–31 January 1962, S. Quate.

Diliacos quadriceps (Smith)

In my revision (1963, pp. 613–616) I used the name *Scolia* (*Diliacos*) *larradiformis* Smith, 1863, for a polytypic species occurring in New Guinea and the Admiralty Islands, and I suggested the possibility that the taxon I regarded as typical *larradiformis* might be identical with *quadriceps* Smith, 1859, from Aru. Betrem has restudied these types subsequently and has found that they are indeed identical (Bradley and Betrem, 1967, p. 311). The correct names for the taxa, therefore, that I placed under *larradiformis* are as follows:

Diliacos quadriceps grandiceps (Micha), p. 613

Diliacos quadriceps quadriceps (Smith), p. 615

Diliacos quadriceps manus (Krombein), p. 615

Diliacos quadriceps grandiceps (Micha)

Morobe District, Terr. New Guinea: 4♀, 2♂, Wau, 1050–1200 meters, 27 January 1966, 24 May 1965, and 16 September, 22 October, 9 November 1965, and 19 November 1961, J. and M. Sedlacek, 1♀, 3♂ in Malaise trap. 3♂, Kunai Creek, Wau, 1250–1500 meters, 28–30 May and 26 August 1963, P. Shanahan and J. Sedlacek, 1 in Malaise trap.

Diliacos ribbei stueberi (Krombein)

Eastern Highlands District, Terr. New Guinea: 3♀, 13–20 km southeast of Okapa, 1650–2250 meters, 24 and 26 August 1964, J. and M. Sedlacek.

West New Guinea: 3♀, Hollandia, 0–300 meters, 22 December 1961–21 January 1962, S. and L. Quate. 1♂, Bokondini, 40 km north of Baliem Valley, ca. 1300 meters, 16–23 November 1961, L. W. Quate. 1♂, Oransbani, northwest of Geelvink Bay, 16 February 1963, R. Straatman.

Diliacos ribbei ribbei (Betrem)

Bismarck Archipelago: 2 ♀, 1 ♂, Illugi, Upper Warangoi, Gazelle Peninsula, New Britain, 230 meters, 8–11 and 12–15 December 1962, J. Sedlacek. 1 ♀, Gaulim, Gazelle Penin., 140 meters, 21–26 October 1962, J. Sedlacek.

Females of the typical subspecies of *ribbei* were unknown previously. These specimens from New Britain key to couplet 62 (Krombein, 1963, p. 563). Females of typical *ribbei* are intermediate in density of punctation between *ribbei stueberi* (Krombein) from northern New Guinea and *ribbei hurdi* (Krombein) from the Solomon Islands. As in *ribbei stueberi* the front between the spatium frontale and the anterior ocellus is impunctate except for a few scattered punctures in the ocular sinus and along the inner eye margin, but the ocellar triangle has one or two punctures instead of being impunctate and the posterior half of the scutum has 15–20 scattered punctures between the parapsidal furrows instead of being impunctate. In contrast, the more densely punctate *ribbei hurdi* has about 30 punctures on the front between the spatium frontale and anterior ocellus, the ocellar triangle has half a dozen punctures, and the posterior half of the scutum has 44–50 punctures between the parapsidal furrows. Each female of *ribbei ribbei* has only two discoidal cells in the forewing. They are 13–15 mm long, and the forewing is 10–12 mm long.

Diliacos ribbei hurdi (Krombein)

Solomon Islands: 1 ♀, Pepele, Kolombangara Island, 0–30 meters, 3 February 1964, P. Shanahan. 1 ♂, Iriri, Kolombangara, New Georgia Group, 2 meters, 3 July 1964, J. and M. Sedlacek. 1 ♂, Nalimbu River, 29 km southeast of Honiara, Guadalcanal, 5 June 1960, C. W. O'Brien.

Diliacos glabrata glabrata (Micha)

Northern District, Papua: 1 ♀, Popondetta Mission, 60 meters, 18 October 1963, P. Shanahan. 1 ♀, Gona Road, Popondetta District, 60 meters, 30 October 1963, H. W. Clissold.

Morobe District, Terr. New Guinea: 3 ♀, 1 ♂, Wau, 1200–1300 meters, 1 and 14–17 January 1963, 17 May 1965, and 14 November 1965, J. and M. Sedlacek and P. Shanahan, 2 ♀ in Malaise trap. 1 ♀, 24 km west of Bulolo, Upper Watut River, 760 meters, 5–6 March 1963, J. Sedlacek. 1 ♀, ca. 8 km west-northwest of Lab Lab, Umboi Island, 300 meters, 8–19 February 1967, G. A. and S. L. Samuelson, and P. H. Colman.

West New Guinea: 1 ♀, Genjam, 40 km west of Hollandia, 100–200 meters, 1–10 March 1960, T. C. Maa.

Diliacos glabrata praslini (Bradley)

Bismarck Archipelago: 1 ♀, Illugi, Upper Warangoi, Gazelle Peninsula, New Britain, 230 meters, 12–15 December 1962, J. Sedlacek.

Solomon Islands: 1 ♂, Kukugai, Bougainville, 150 meters, October 1960, W. W. Brandt. 1 ♀, 1 ♂, Gizo Island, New Georgia Group, 50–120 meters, 16–26 April 1964, J. Sedlacek, in Malaise trap. 6 ♂, Pepele, Kolombangara Island, New Georgia Group, 30 meters, 7–9 February 1964, P. Shanahan, in Malaise trap. 2 ♂, Kow, Vella Lavella, 30 meters 28 November 1963, P. Shanahan, in Malaise trap. 7 ♂, Ulo Crater, Vella Lavella, 10 meters, 16–21 December 1963, P. Shanahan, 4 in Malaise trap. 1 ♂, Kolotuve, Santa Ysabel, 21 June 1960, C. W. O'Brien. 1 ♂, Kolotuve-Sukapisu, Santa Ysabel, 20 June 1960, C. W. O'Brien. 1 ♀, Takopekope, Florida Group, 12 November 1960, C. W. O'Brien, in light trap. 1 ♀, Guadalcanal, 12–20, J. A. Kusche. 3 ♀, 4 ♂, Betikama River, Guadalcanal, August and September 1960, W. W. Brandt. 1 ♀, Kiwi Creek, Guadalcanal, 18 September 1944, H. E. Milliron. 2 ♂, Napagiwae, San Cristoval, 19 August 1960, C. W. O'Brien.

Microscolia maindroni (Betrem)

West New Guinea: 1 ♂, Oransbari, northwest of Geelvink Bay, 16 February 1963, R. Straatman.

Carinoscolia lorentzi (Cameron)

Morobe District, Terr. New Guinea: 1 ♂, Wau, 1050 meters, 18 December 1961, J. and J. H. Sedlacek. 1 ♂, Lae, 26 November 1961, J. Sedlacek. 1 ♂, Finschhafen, Huon Peninsula, 150 meters, 15 April 1963, J. Sedlacek.

Carinoscolia foveifrons (Cameron)

Bismarck Archipelago: 1 ♀, Illugi, Upper Warangoi, Gazelle Peninsula, New Britain, 230 meters, 8–11 December 1962, J. Sedlacek. 1 ♀, Lelet Plateau, Schleinitz Mts., New Ireland, October 1959, W. W. Brandt.

Solomon Islands: 1 ♂, Ulo Crater, Vella Lavella Island, 10 meters, December 1963, P. Shanahan. 1 ♂, Dala, Malaita Island, 50 meters, 22 June 1964, J. and M. Sedlacek, in Malaise trap. 1 ♂, Betikama River, Guadalcanal, August 1960, W. W. Brandt.

The present records extend the range of this species considerably to the south in the Solomons, the only previous record from that group being from Bougainville.

Austroscolia pulchripennis pulchripennis (Cameron)

Western Highlands District, Terr. New Guinea: 2 ♂, Tomba, 2450 meters, 24 May 1963, J. Sedlacek.

Bismarck Archipelago: 1 ♀, 5 ♂, Illugi, Upper Warangoi, Gazelle Peninsula, New Britain, 230 meters, 8–15 December 1962, J. Sedlacek. 2 ♂, Gaulim, Gazelle Penin., 140 meters, 21–27 October 1962, J. Sedlacek. 1 ♂, Talliligap, New Britain, 300 meters, 17–18 December 1962, J. Sedlacek. 1 ♂, Lelet Plateau, Schleinitz Mts., New Ireland, October 1959, W. W. Brandt.

Solomon Islands: 21 ♂, Dala, northwest Malaita, 6–22 June 1964, R. Straatman, J. and M. Sedlacek, 1 in MV light trap.

In my revision (Krombein, 1963, p. 638) I questioned the occurrence of this taxon in New Guinea on the basis of an old, possibly mislabeled specimen from West New Guinea. The two males recorded above from Tomba in the western part of the Territory of New Guinea definitely establish the presence of this subspecies in New Guinea as well as in the Bismarcks and on Malaita Island alone of the Solomons.

Austroscolia pulchripennis franclemonti (Krombein)

Morobe District, Terr. New Guinea: 1 ♀, 1 km north of Awelkom, Umboi Island, 600 meters, 21–28 February 1967, S. L. and G. A. Samuelson.

Solomon Islands: 2 ♂, Kugugai, Bougainville, 150 meters, October and December 1960, W. W. Brandt. 1 ♀, 4 ♂, Gizo Island, New Georgia Group, 30–120 meters, 16–26 April and 19 July 1964, J. and M. Sedlacek, ♀ in Malaise trap. 1 ♂, Irii, Kolombangara Island, 2 meters, 29 June 1964, J. and M. Sedlacek. 2 ♂, Kolotuve, Santa Ysabel, 21 June 1960, C. W. O'Brien. 1 ♂, Betikama River, Guadalcanal, August 1960, W. W. Brandt.

The female from Umboi Island is only 24 mm long. The smaller male is only 17 mm long. Both of these are smaller by a millimeter or two than the previously recorded minimal length.

Austroscolia betremianus (Krombein)

Bismarck Archipelago: 1 ♀, 3 ♂, Mt. Sinewit, Gazelle Peninsula, New Britain, 900–1200 meters, 5–16 November 1962, J. Sedlacek. 1 ♂, Upper Warangoi, Gazelle Penin., 250–600 meters, 28–30 November 1962, J. Sedlacek. 1 ♂, Illugi, Upper Warangoi, 230 meters, 12–15 December 1962, J. Sedlacek. 2 ♀, 2 ♂, Lelet Plateau, Schleinitz Mts., New Ireland, October 1959, W. W. Brandt.

The present series establishes the range of length in females as 20–25 mm.

Austroscolia nitida nitida (Smith)

Northern District, Papua: 1 ♀, 1 ♂, Popondetta, 5-60 meters, June 1966 and 26 September 1963, P. Shanahan, Gressitt and Tawi, ♂ in Malaise trap.

Central District, Papua: 1 ♂, Port Moresby, 6-7 November 1960, J. L. Gressitt, in Malaise trap.

Morobe District, Terr. New Guinea: 1 ♂, 35 km south of Lae, 120 meters, 6 August 1964, J. and M. Sedlacek. 1 ♂, Markham River, 60 meters, 8 August 1964, J. Sedlacek, in Malaise trap. 9 ♀, 36 ♂, Wau, 650-2400 meters, 9-12 January 1962, 15, 21-25, and 26 January 1963, 3 and 27-31 March 1964, 2 April 1966, 16-20 April 1962, 14 and 18 May 1965, 12-14 June 1963, 15 and 29 August 1961, 2, 10, 12, 17, 19, and 30 September 1961, 16-18 September 1964, 4 and 5 October 1962, 12 October 1965, 19 and 30 October 1961, 6-7 November 1961, 3 December 1962, and 18 December 1961, J., J. H., and M. Sedlacek, C. Monteith, P. Shanahan, and a native, several in Malaise trap, 3 on lucerne, 1 in light trap. 2 ♀, 10 ♂, Mt. Misim, Wau, 950-1600 meters, 13 and 16 February 1963, 14 August and 25 September 1964, J. and M. Sedlacek, 7 ♂ in Malaise trap. 1 ♀, Kunai Creek, Wau, 1500 meters, 28-30 May 1963, P. Shanahan. 1 ♀, 11.2 km north of Bulolo, 600 meters, 11 March 1962, J. H. Sedlacek. 1 ♂, Adelbert Mts., 800-1000 meters, 25 October 1958, J. L. Gressitt.

Eastern Highlands District, Terr. New Guinea: 1 ♂, Goroka, 1500 meters, 22 May 1961, J. L. Gressitt. 1 ♀, 1 ♂, Karimui, 1080 meters, 10 and 15 July 1963, J. and M. Sedlacek. 5 ♀, 12 ♂, Purosa, 20-26 km southeast of Okapa, 1700-2020 meters, 17-25 May 1966 and 28 August 1964, J. and M. Sedlacek, Gressitt and Tawi.

Western Highlands District, Terr. New Guinea: 9 ♀, 1 ♂, Tambul, 1200 and 2250 meters, 26 May and 2 June 1963, J. Sedlacek. 1 ♂, 6-12 km west of Wabag, 2020-2400 meters, 13 June 1963, J. Sedlacek.

West New Guinea: 3 ♀, Sibil Valley, Star Mts., 1245 meters, 18 October-8 November 1961, S. and L. W. Quate. 1 ♂, Hollandia, 13 March 1960, T. C. Maa. 7 ♂, Hollandia to Kotanica, 25-28 February 1960, T. C. Maa. 1 ♀, Ifar, Cyclops Mts., 300-500 meters, 26-28 June 1962, J. Sedlacek. 3 ♂, Bokondini, 40 km north of Baliem Valley, ca. 1300 meters, 16-23 November 1961, S. and L. Quate. 4 ♀, 20 ♂, Wamena, 1700 meters, 10-25 February 1960, T. C. Maa. 1 ♀, Moanemani, Kamo Valley, Wisselmeeren, 1500 meters, 15 August 1962, J. Sedlacek. 1 ♂, Nabire, south of Geelvink Bay, 10-40 meters, 12 October 1962, N. Wilson.

There is also before me a series of one female and six males of typical *nitida* labeled as having been taken at Kira Kira, San Cristoval, Solomon Islands, 27 and 28 July 1960, by C. W. O'Brien. The *nitida*

population occurring elsewhere in the Solomons is *nitida punctatissima* (Kirby). I regard these San Cristoval specimens as being mislabeled and suspect that they were actually collected in eastern New Guinea as discussed in my remarks earlier under *Campsomeris extranea moluccensis* Betrem.

Austroscolia nitida varifrons (Cameron)

Morobe District, Terr. New Guinea: 8 km west-northwest of Lab Lab, Umboi Island, 300 meters, 8-9 February 1967, S. L. and G. A. Samuelson, P. H. Colman.

Eastern Highlands District, Terr. New Guinea: 1 ♂, Simbai, Bismarck Range, 1850 meters, 27 May 1966, J. L. Gressitt.

Western Highlands District, Terr. New Guinea: 1 ♂, Tomba, 2450 meters, 24 May 1963, J. Sedlacek.

Bismarck Archipelago: 1 ♂, Illugi, Upper Warangoi, Gazelle Peninsula, New Britain, 230 meters, 8-11 December 1962, J. Sedlacek. 2 ♂, Talliligap, Gazelle Penin., 300 meters, 17-18 December 1962, J. Sedlacek. 1 ♂, Mt. Sinewit, Gazelle Penin., 1100-1200 meters, 15-16 November 1962, J. Sedlacek. 1 ♀, Lelet Plateau, Schleinitz Mts., New Ireland, October 1959, W. W. Brandt.

Austroscolia nitida punctatissima (Kirby)

Solomon Islands: 1 ♂, Kokugai, Bougainville, 150 meters, December 1960, W. W. Brandt. 1 ♀, 2 ♂, Pusiasama, Vella Lavella Island, 17-29 November 1963, L. and M. Gressitt, P. Shanahan. 1 ♀, 3 ♂, Munda, New Georgia, 1-30 meters, 21 July 1959, J. L. Gressitt. 1 ♂, Iriri, Kolombangara, New Georgia Group, 2 meters, 3 July 1964, J. and M. Sedlacek. 3 ♂, Sandfly Harbor, Kolombangara, 5-200 meters, 6-8 July 1964, J. and M. Sedlacek, 1 in light trap. 1 ♂, Gollifer's Camp, Kolombangara, 700 meters, 24 January 1964, P. Shanahan. 1 ♂, Pepele, Kolombangara, 30 meters, 15 February 1964, P. Shanahan. 1 ♂, Buala, Santa Ysabel, 27 June 1960, C. W. O'Brien. 1 ♂, Molao, Santa Ysabel, 29 June 1960, C. W. O'Brien. 1 ♂, Kolotuve, Santa Ysabel, 21 June 1960, C. W. O'Brien. 1 ♂, Dala, northwest Malaita Island, 30 June 1964, R. Straatman, in Malaise trap. 1 ♂, Denda, Small Nggela, Florida Group, 17 September 1960, C. W. O'Brien. 1 ♀, 5 ♂, Guadalcanal, 13 June and 16 July 1944. 6 ♂, Betikama River, Guadalcanal, August 1960, W. W. Brandt. 1 ♂, Honiara, Guadalcanal, 22 April 1964, R. Straatman. 2 ♂, Kira Kira, San Cristoval, 0-50 meters, 29 July 1960, C. W. O'Brien, and 13 November 1964, R. Straatman, in Malaise trap. 3 ♂, Wugiroga, San Cristoval, 8-9 August 1960, C. W. O'Brien. 1 ♂, Napagiwae, San Cristoval, 19 August 1960, C. W. O'Brien.

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1963. The Scoliidae of New Guinea, Bismarck Archipelago and Solomon Islands. Nova Guinea, Zool., vol. 22, pp. 543-651, 46 figs., 1 table.¹

¹ In this publication, the following errata appeared:

Page 552—second alternative of couplet 2 should lead to 43.

Page 617—figure reference to female head of *ribbei stueberi* should be 15 not 5.

Page 638—line 14 from bottom should read "NEW BRITAIN, BISMARCKS. 1 ♀, 1 ♂; Kinigunang (C. Ribbe) [CU]. 3 ♂;".

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Neotropical Microlepidoptera, XVII¹

Notes and New Species of Phaloniidae

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For several years I have been engaged, somewhat sporadically, on a revision of the American Phaloniidae. Because this revision will not be completed for several more years—indeed, there is yet much to be done—I wish to make known the new taxa described below and to clarify the status of several previously described forms.

None of the previously published species have been illustrated before (except *Phalonia embrihopa* Meyrick; Clarke, 1963, pl. 13: figs. 1–1a), but all the species included in this paper are being figured.

In recent years several investigators (Busck, 1939; Razowski, 1964) have attempted classifications of this family, but for the most part the treatments have been based on characters of the male genitalia. Not only have the females been neglected but also, when they have been used, the accessory bursa has generally been omitted from the figures and it has not been employed in classification. Actually, the value of this feature and its origin in relation to associated structures are not presently known. The reason for this state of affairs is that

¹ See list at end of paper.

apparently it is seldom seen by the investigators, is destroyed during the preparation of the genitalia mounts, and is now missing from most slides.

Busck (1939) illustrated the accessory bursa of several species but did not use it in his classification. His keys are based on male genitalia and wing venation. Razowski (1964) does not illustrate the accessory bursa at all, nor does he allude to it anywhere in his papers. At this time I am not using it in classification, although I am illustrating it wherever it could be found, but I believe that many more preparations of many species in numerous genera must be made before we can evaluate its true significance. In most species of most genera the accessory bursa has its inception posteriorly, either from the bursa copulatrix or the ductus bursae. In the species group consisting of *vesta*, *tornosema*, and *charma* this structure emerges anteriorly. Surely such differences are significant. The male *vesta*, the only male known for this group, suggests affinity with *Phalonidia* and *Amallectis*, but the females of these two genera do not exhibit the anterior origin of the accessory bursa. Since it is not clear at this time to what genus these three species are referable, I am placing them in the genus *Phalonia* until all the genera have been examined properly and revised.

Unfortunately, phaloniids seldom are collected in sufficient series to permit exhaustive study, and all too frequently one or the other sex is missing. The state of our knowledge, therefore, is imperfect but it is hoped that papers such as this will point out the need for more material so that more complete treatments can be presented. There is an appalling lack of biological information on the New World species, particularly the Neotropical representatives, but it will be a long time before microlepidopterists will be able to devote time to life history studies in the latter region. In the meantime we must content ourselves with making known the existing taxa.

The drawings of the genitalia were made by Mr. André del Campo Pizzini, staff artist. The photographs of the wings were made by Mr. Jack Scott and Mr. Victor Krantz.

Hysterosia Stephens

Hysterosia gigantea Busck

FIGURE 1; PLATE 1 (FIG. 5)

Hysterosia gigantea Busck, 1920, Ins. Insc. Mens., vol. 8, nos. 4-6, p. 87.

Female genitalia slide JFGC no. 11621. Ostium broad, slitlike, with posteroventral edge curved ventrally. Antrum membranous. Inception of ductus seminalis from deep concavity in side of bursa copulatrix. Ductus bursae very short; anterior portion ridged, the ridges continuing into bursa copulatrix. Bursa copulatrix studded with spicules

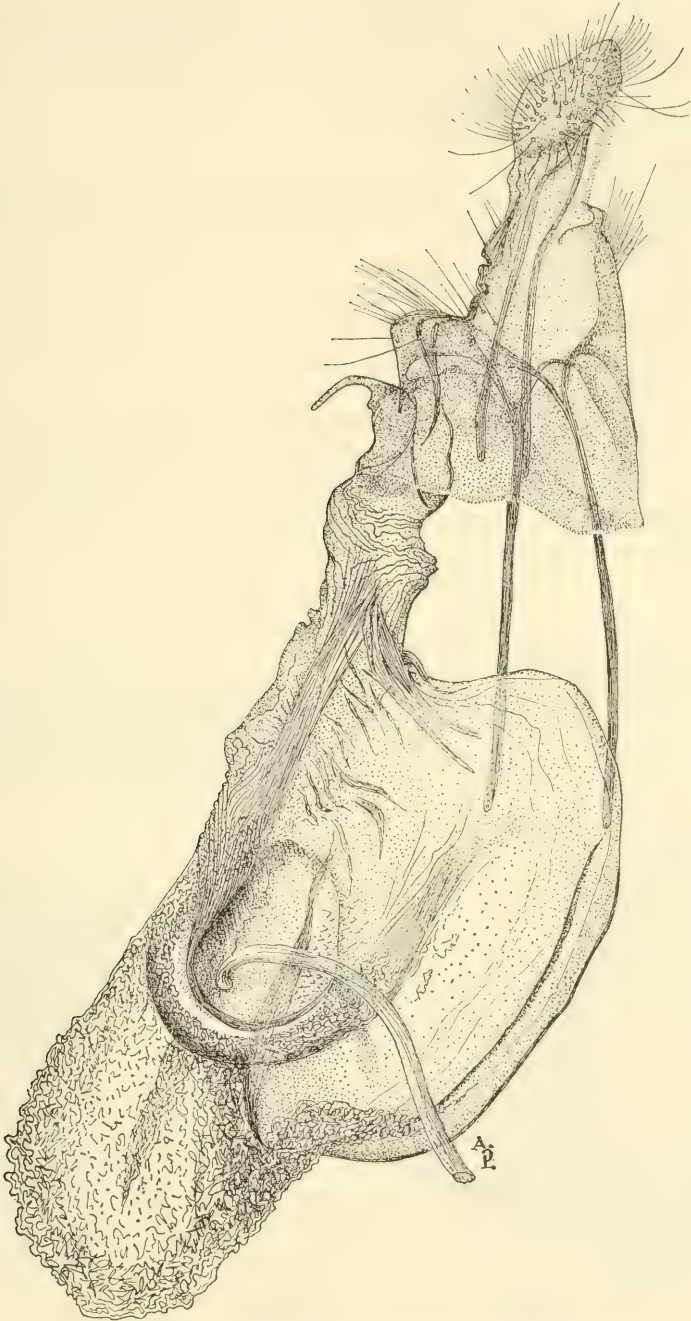


FIGURE 1.—*Hysterosia gigantea* Busck: lateral aspect of female genitalia.

in anterior third, strongly sclerotized in posterior two-thirds. Accessory bursa not evident in this example (may have been destroyed). Lamella antevaginalis and lamella postvaginalis rather strongly sclerotized.

Type: U.S. National Museum.

Type-locality: Mexico, Mexico City.

Distribution: Mexico.

In his description of this species, Busck did not mention the number of specimens he had before him. In the U.S. National Museum collection there are four specimens from Mexico: one ♀ marked "TYPE" in Busck's handwriting; one ♀ marked "Cotype" and a ♂ and ♀, the latter from Tehuacan, with red "cotype" labels. All bear USNM type number 22307 and all have a small white label with the number 3958.

The type and first cotype indicated above are conspecific, but the third and fourth specimens, the ♂ and the ♀ from Tehuacan, are what was described as *Hysterosia perspicuana* Barnes and Busck, from Arizona. The known range of *perspicuana* is thus extended into Latin America.

Hysterosia iodes, new species

FIGURE 2; PLATE 1 (FIG. 3)

Alar expanse 28 mm.

Labial palpus fuscous, the scales laterally sparsely white tipped, and strongly so dorsally on second segment. Antenna ochraceous buff with fuscous scaling dorsally at base; scape fuscous. Head and thorax

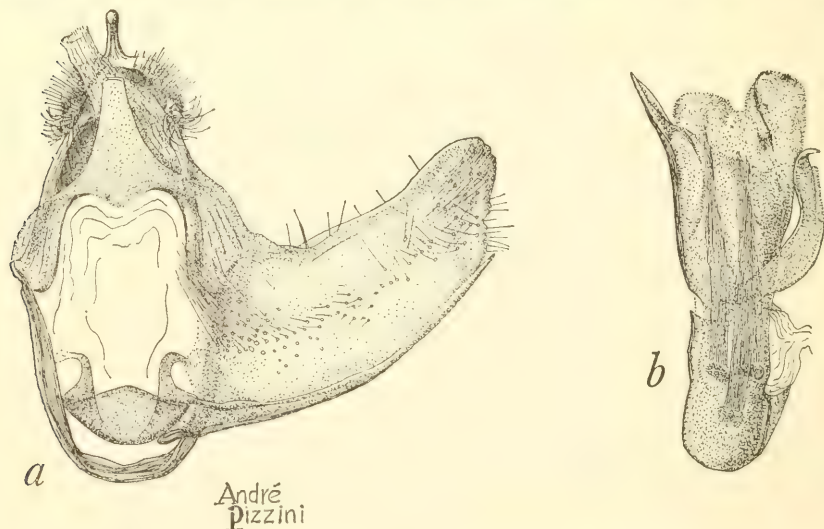


FIGURE 2.—*Hysterosia iodes*, new species: a, ventral view of male genitalia with left harpe and aedeagus removed; b, aedeagus.

fuscous with a sprinkling of white-tipped scales; posterior tuft of thorax with mixture of reddish-brown and white-tipped scales. Forewing ground color grayish fuscous, much of the area overlaid with violaceous-metallic scales; on inner angle a narrow, longitudinal, ferruginous dash; at basal fifth an inwardly oblique, blackish-fuscous patch to fold, then outwardly to dorsum; from middle of costa, to dorsum at basal third, a blackish-fuscous transverse band, strongest about midway across wing; at end of cell a small, blackish-fuscous spot; slightly beyond end of cell, obliquely, a blackish-fuscous transverse band extends nearly to tornus; from apical third of costa a blackish-fuscous transverse band, broadest at vein 7, extends to and narrows at tornus; along costa several small patches of white-tipped scales; cilia fuscous. Hindwing ochraceous white, heavily mottled with fuscous; cilia grayish fuscous with a very narrow, lighter, basal line. Foreleg pale ochraceous buff; femur and tibia strongly overlaid with fuscous exteriorly; tarsal segments almost wholly fuscous. Midleg similar to foreleg but not so strongly marked with fuscous; hindleg ochraceous buff with slight fuscous irroration and small fuscous patches at tibial spurs. Abdomen dull buff, suffused and irrorate with fuscous.

Male genitalia slide JFGC no. 11622. Harpe subrectangular; cucullus bluntly pointed; ventral edge of harpe produced into a slender pointed process before cucullus. Transtilla with long, smooth, median process. Uncus curved, slender. Vinculum evenly rounded, coalesced. Tegumen about two-thirds the length of harpe. Anellus a strongly sclerotized, curved, oval plate. Aedeagus stout, distally terminating in a sharp point ventrally; dorsally, from about middle, a long, curved process; cornuti, three long, closely compact, clusters of spines.

Holotype: U.S. National Museum No. 69729.

Type-locality: Guatemala, Volcan Santa Maria.

Distribution: Known only from the type-locality.

Described from the unique male holotype (Schaus and Barnes, "10.").

This species resembles the North American *Hysterosia birdana* Busck but lacks the unbroken, dark apical area of that species; moreover, the median portion of the transtilla of *birdana* is broad and armed with numerous, small, dentate processes, the cornuti are one or two, and the aedeagus lacks the long, curved, dorsal process of *iodes*.

Hysterosia turialba Busck

FIGURE 3; PLATE 1 (FIG. 1)

Hysterosia turialba Busck, 1920, Ins. Insc. Mens., vol. 8, nos. 4-6, p. 86.

Male genitalia slide AB Dec. 21, 1925. Harpe triangular; cucullus pointed; costa moderately sclerotized; from base of sacculus a long, irregular, sclerotized arm, free at distal extremity and ornamented with short ridges on each side. Uncus broad, divided, each lateral element terminating in a sharp point; socii recurved, slender. Vinculum

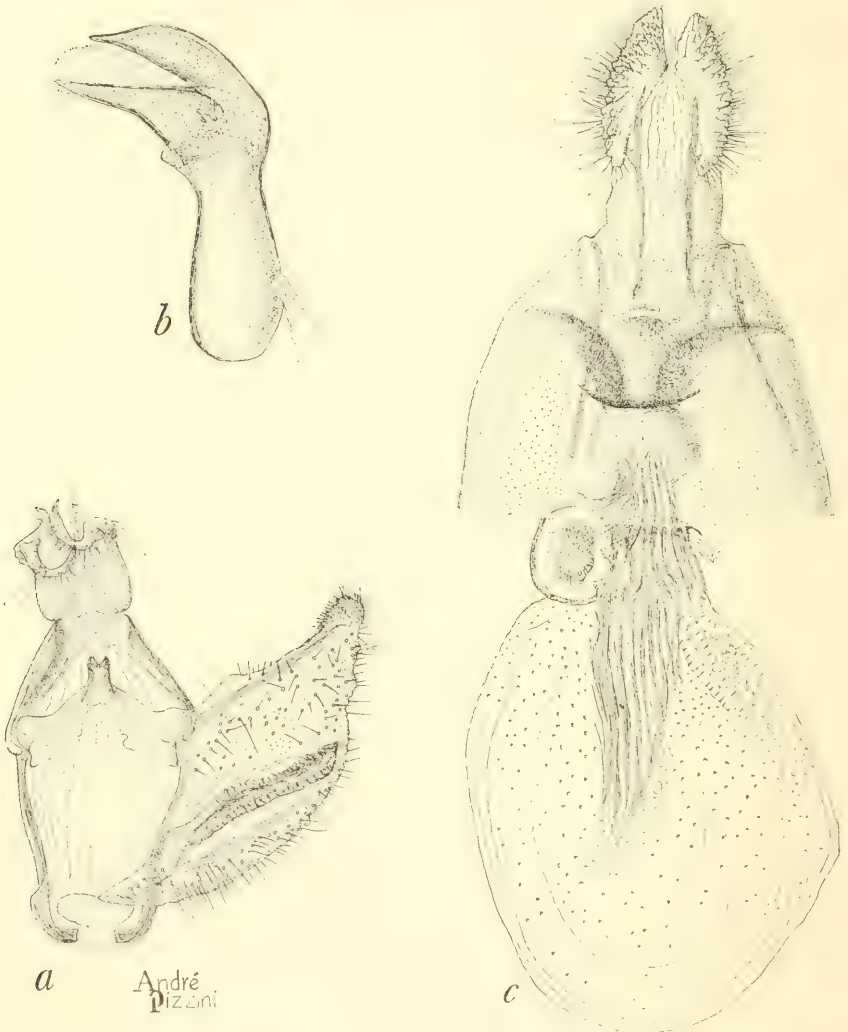


FIGURE 3.—*Hysterosia turialba* Busck: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

not coalesced. Tegumen short, about half the length of harpe. Anellus a broad, oval, sclerotized plate. Aedeagus stout, curved, with a dorsodistal, pointed, curved element and a pointed ventrodial part expanded basally as a flat plate.

Female genitalia slide AB Dec. 2, 1925. Ostium transverse, narrow, ventral lip slightly concave; lamella antevaginalis heavily sclerotized laterally. Antrum broad, flattened, sclerotized. Inception of ductus seminalis posterior, from a depressed area within a sclerotized ring in side of bursa copulatrix. Ductus bursae ribbed, short. Bursa copulatrix ribbed posteriorly, the ribs confluent with those of ductus bursae.

Type: U.S. National Museum.

Type-locality: Costa Rica, Juan Vinas.

Distribution: Costa Rica, Guatemala.

Busck's type is a ♀ from Juan Vinas as indicated in the original description. There are three other specimens (2 ♀♀, Turrialba, Costa Rica, Wm. Schaus; ♂, Volcan Santa Maria, Guatemala, Schaus and Barnes) not mentioned by Busck, which are marked "Cotype." Presumably these three were before Busck when he described the species and are, therefore, paratypes, not cotypes. In addition, there is another specimen, ♀, from Volcan Santa Maria, Guatemala.

The name of this species is a misspelling of Turrialba.

The illustrations of this species are presented for comparative purposes because the species has not been figured previously.

Hysterosia alplitopa, new species

FIGURE 4; PLATE 1 (FIG. 2)

Alar expanse 22–26 mm.

Labial palpus creamy white; second segment with ocherous-buff scaling basally on outer side. Antenna gray with white scaling dorsally at base of shaft; scape creamy white. Head creamy white with slight grayish-ocherous suffusion. Thorax creamy white; anteriorly burnt sienna; dorsally, two irregular but conspicuous black spots. Forewing ground color gray, basal third pale, ochraceous buff; at end of cell, and at extreme base of wing small, but conspicuous, yellow spots of raised scales; inner angle yellow; costa, to middle, broadly fuscous marked by dashes of leaden-metallic scales; beyond the fuscous basal portion a conspicuous, large, white blotch with a distinct black spot on costa at center of blotch; from the outer edge of the costal white blotch, at about vein 8, an oblique, outwardly curved, ocherous-white line extends to termen at vein 4, is preceded inwardly by an irregular patch of burnt sienna, the latter to tornus, with two small, black dashes costad, and followed by an irregular, outwardly oblique, blackish band, this bounded by narrow lines of metallic scales; at apex

and around termen, a series of burnt sienna spots; between dorsum and fold, at about basal third, a triangular burnt sienna spot with two small black spots costad; underside strongly overlaid with blackish fuscous, except whitish outer half of costa, the latter with several blackish spots; cilia burnt sienna mixed with gray and ochraceous buff. Hindwing gray strongly mottled with fuscous, in female almost wholly fuscous; cilia gray with darker subbasal line. Foreleg blackish fuscous outwardly with scattered white scales; inwardly creamy white; midleg femur white, irrorate with fuscous; tibia and tarsus fuscous, narrowly banded with whitish; hindleg creamy white, blotched and irrorate with fuscous. Abdomen fuscous dorsally, creamy white ventrally, speckled with fuscous.

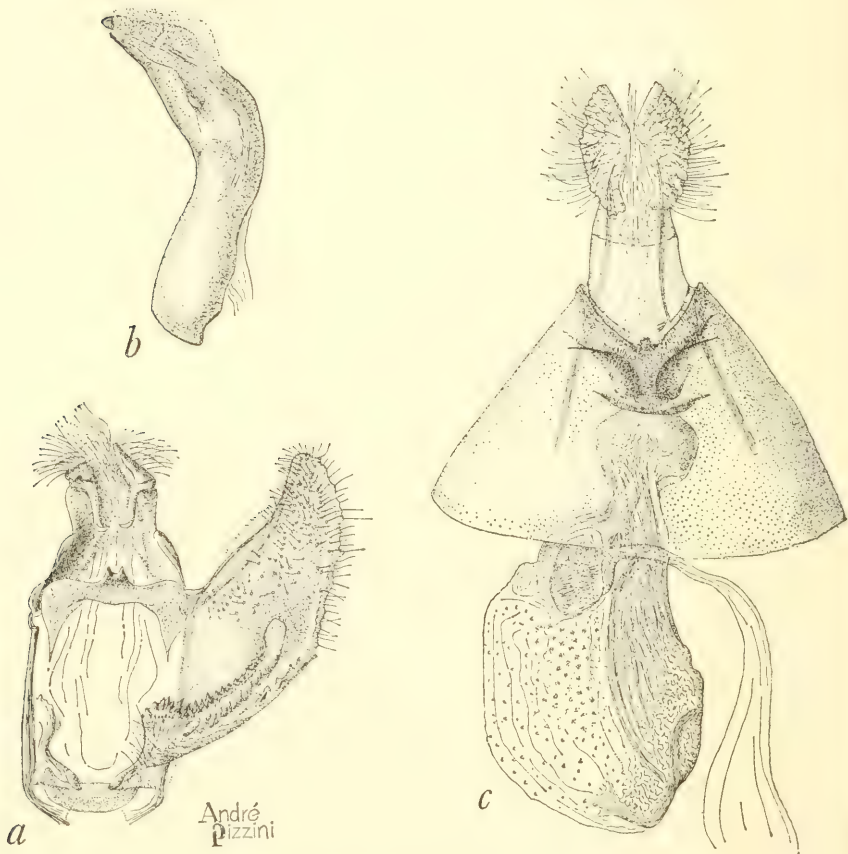


FIGURE 4.—*Hysterosia alplitopa*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

Male genitalia slide JFGC no. 11612. Harpe broad, saccular process extending to about half the length of harpe; posterior edge of process strongly setaceous. Uncus broad, divided into two flat elements, each terminating in a curved point. Vinculum narrow, lateral elements not coalesced in middle. Tegumen about half the length of harpe. Anellus cup shaped. Aedeagus stout, curved, with a long, narrow, dorsodistal projection.

Female genitalia slide JFGC no. 11613. Antrum strongly sclerotized. Inception of ductus seminalis from a fovea in posterior part of bursa copulatrix. Ductus bursae very short, broad. Bursa copulatrix strongly rugose on right side. Signum absent. Ostium broad, slitlike, transverse. Lamella antevaginalis moderately sclerotized; lamella postvaginalis with two strongly sclerotized lateral areas.

Holotype: U.S. National Museum No. 69730.

Type-locality: Venezuela, Aragua, Rancho Grande, 1100 m.

Distribution: Known only from the type-locality.

Described from the male holotype (16–23.X.66. S. S. and W. D. Duckworth), 5 ♂♂ and 1 ♀ paratypes with same locality and dates, from 16–31.X.66.

This taxon is strikingly similar to *turalba* but is a smaller insect with more strongly mottled hindwings. The saccular process of *alphitopa* is much shorter than that of *turalba* and the aedeagus is much more slender (see figs. 3, 4). The two lateral, sclerotized areas of the lamella postvaginalis of *turalba* are larger and the rugose portion of the bursa copulatrix is smaller than in *alphitopa*.

Hysterosia melasma, new species

FIGURE 5; PLATE 1 (FIG. 4)

Alar expanse 22–24 mm.

Labial palpus white; second segment fuscous ventrally and apically and irrorate with fuscous; third segment fuscous on outer side. Antenna gray, suffused with fuscous basally. Head mixed gray and sordid white. Thorax gray, irrorate with fuscous; tegula tipped with white; posterior tuft with white scales mixed. Forewing ground color gray, transversely marked with numerous fine, fuscous strigulae; from costal two-fifths, obliquely to inner angle, a straight, narrow, whitish line; from apical third of costa, a transverse, triangular whitish patch extends to center of wing; between this and the basal whitish line, a black, longitudinal dash; from apical third of costa, and confluent with the tip of the triangular patch, a double, narrow, whitish, transverse line extends outwardly to vein 3, then turns inwardly to tornus; outer edge of this pale line bordered with a very thin line of fuscous; subapically, a whitish line extends around termen; underside of costa spotted with white; cilia gray basally, white apically. Hind-

wing whitish, strongly mottled with grayish fuscous; cilia gray basally, white apically. Foreleg ochereous white, overlaid with fuscous; hindleg ochereous white, suffused and irrorate with grayish fuscous, particularly on outer side. Abdomen ochereous white with grayish-fuscous suffusion and irroration.

Male genitalia slide JFGC no. 11623. Harpe moderately broad, cucullus rounded; saccus very broad basally and heavily sclerotized, terminating in a sharp point. Uncus rather short, compressed, sharply pointed. Vinculum evenly rounded, narrow. Tegumen short, stout. Transtilla terminating in a median, stout, strongly spined process. Anellus subrectangular, broader than long. Aedeagus stout, distally terminating in a sharp, slightly curved, point; vesica armed with two long and two short cornuti.

Holotype: U.S. National Museum No. 69731.

Type-locality: Guatemala, Chejel.

Distribution: Guatemala.

Described from the male holotype (June, Schaus and Barnes) and 3 ♂♂ paratypes, all with the same data. Male genitalia figured from the holotype.

Apparently *melasma* is closely related to *H. perspicuana* Barnes and Busck but is immediately distinguished from it by the four cornuti, there being only three in *perspicuana*. The uncus of *melasma* is less than half the length of that of *perspicuana* and the saccus is much wider.

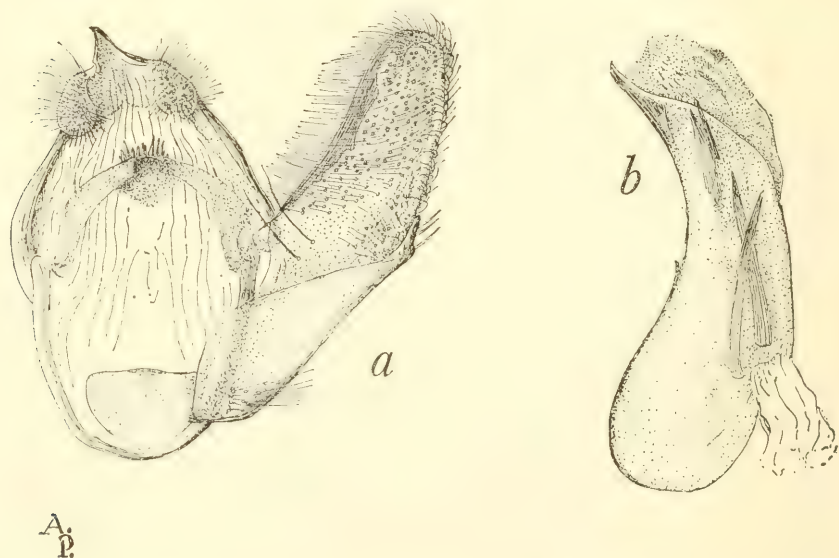


FIGURE 5.—*Hysterosia melasma*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus.

Phalonia Hübner*Phalonia embrithopa* Meyrick

PLATE 1 (FIGS. 6, 7)

Phalonia embrithopa Meyrick, 1927, *Exotic Microlepidoptera*, vol. 3, p. 366.—Clarke, 1963, *Catalogue of the type specimens of Microlepidoptera in the British Museum (Natural History)* described by Edward Meyrick, vol. 4, p. 27, pl. 13, figs. 1-1a.

Meyrick described *embrithopa* from three specimens stated by him to be females. One specimen has disappeared but the remaining two, the lectotype and a paralectotype, the latter before me, are males. In addition to these, I have three males from Colombia that are obviously this species but that are atypical. For two of these specimens I append the following description.

Alar expanse 26-28 mm.

Labial palpus clay color; first segment with conspicuous fuscous spot exteriorly; third segment mixed with fuscous. Antenna clay color; scape infuscated distally. Head light clay color. Thorax and tegula light clay color; posterior tuft fuscous mixed with sordid white. Forewing ground color sordid white, heavily overlaid and strigulated with tawny olive; from basal third of costa, obliquely to inner angle, a tawny-olive line delimiting a mixed tawny-olive and whitish basal patch; on middle of costa a tawny-olive spot continued indistinctly and transversely to cell, then obliquely and inwardly to dorsum; apical fourth tawny olive mixed with white and fuscous scales; at end of cell, between veins 2 and 4, an outwardly oblique, indistinct fuscous blotch extends to tornus; on dorsal edge a series of fuscous spots; underside strongly infuscated except apical two-fifths of costa; cilia sordid white mixed with gray, fuscous, and tawny olive. Hindwing sordid white, transversely striated and mottled with grayish fuscous, underside more strongly so; cilia whitish mixed with gray. Foreleg ochereous white strongly overlaid with fuscous outwardly; midleg similar to foreleg but banded with tawny olive; hindleg ochereous white suffused and irrorate with fuscous. Abdomen clay color infuscated ventrally.

These two, from Páramo de Puracé, are larger than the two remaining Meyrick types and the pattern of the forewing is less blotched and the reticulations are finer. The basal patch and median transverse fascia are more pronounced. The hindwing of the original *embrithopa* is darker and the mottling is heavier than in the two from Páramo de Puracé. The third additional specimen from Volcan Galeras is smaller than the types (22 mm) and the forewing is paler in color. The hindwing of this specimen is intermediate between the originals and the two from Páramo de Puracé.

All of the specimens are from high altitudes. Mt. Tolima (3846 m), Páramo de Puracé (3570 m) and Volcan Galeras (2900 m). The differences in altitude are not great but may well account for the variation that exists. All of the specimens are indistinguishable on genitalia.

Type: British Museum (Natural History).

Type-locality: Colombia, Mt. Tolima.

Distribution: Colombia: 2 ♂♂, Mt. Tolima; 2 ♂♂, Cauca, Páramo de Puracé, Lake San Rafael, 3570 m, 27.I.1959, J. F. G. Clarke; ♂ Nariño, Volcan Galeras, 2900 m, 13.I.1959, J. F. G. Clarke.

Phalonia tornosema, new species

FIGURE 6; PLATE 2 (FIG. 7)

Alar expanse 12–13 mm.

Labial palpus white; basal half of second segment fuscous on outer side; third segment with a few scattered fuscous scales. Antenna fuscous; scape white except fuscous apex. Head white with grayish scales laterally. Thorax gray, mixed with russet and fuscous; anterior margin narrowly white; posterior tuft ochraceous orange. Forewing ground color pale gray; on each side of fold a series of four (total 8) round spots of mixed russet and leaden gray scales; on tornus a conspicuous ochraceous-orange spot; basal patch indistinct, indicated mostly by ochraceous-tawny scales; inner angle fuscous; from middle of costa an ill-defined, brown, transverse fascia with a small fuscous spot on each edge in cell; beyond this fascia a costal whitish area followed by short, transverse whitish and russet fasciae; underside grayish fuscous except from fold to dorsal edge; cilia light tawny mixed with gray, lighter around tornal area. Hindwing grayish fuscous; cilia light grayish with darker sub-basal band. Foreleg sordid white strongly infuscated on outer side; tarsus banded with fuscous; midleg similar to foreleg; hindleg ochereous white; tibial spurs and tarsus minutely spotted with fuscous. Abdomen grayish fuscous dorsally; ochereous white ventrally, irrorate and suffused with fuscous.

Female genitalia slide JFGC nos. 11223, 11630. Ostium transverse, narrow. Antrum sclerotized in a narrow band. Inception of ductus seminalis from anterior end of bursa copulatrix; accessory bursa from near inception of ductus seminalis. Ductus bursae very short, about one-third the length of bursa copulatrix. Bursa copulatrix membranous. Signum absent. Lamella antevaginalis and lamella postvaginalis very lightly sclerotized.

Holotype: U.S. National Museum No. 69740.

Type-locality: Guatemala, Volcan Santa Maria.

Distribution: Guatemala.

Described from the female holotype and seven ♀♀ paratypes all

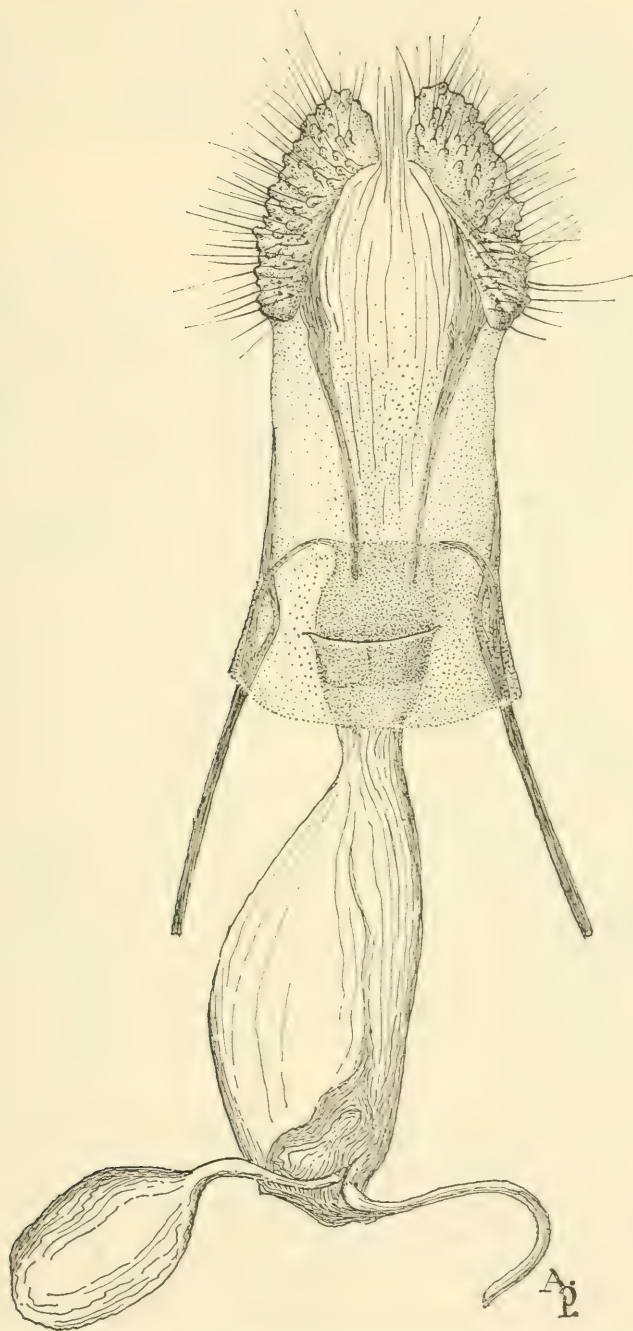


FIGURE 6.—*Phalonia tornosema*, new species: ventral view of female genitalia.

from the type-locality (June, July, November; Schaus and Barnes).

Under *vesta* I have indicated the close similarity, and the apparent close relationship of *vesta* and *tornosema*. The eight round spots of leaden gray scales on the forewing of *tornosema* are not apparent on the forewing of *vesta*.

Phalonia vesta, new species

FIGURE 7; PLATE 4 (FIG. 7)

Alar expanse 12-13 mm.

Labial palpus white; basal two-thirds of second segment strongly overlaid with grayish fuscous; third segment sparsely irrorate with grayish fuscous. Antenna grayish fuscous; scape white, irrorate with grayish fuscous. Head white, laterally suffused grayish. Thorax grayish, mottled with white, russet and ochraceous-tawny scales. Forewing ground color grayish, largely obscured by tawny, grayish-fuscous and leaden-metallic scales; on costa, three russet bars alternating with leaden-metallic, transverse fasciae; inner angle narrowly marked black; along fold a series of scattered black scales; at costal two-thirds an ill-defined whitish area; at end of cell a conspicuous elongate, oval, ochereous-white spot preceded and followed by black scales; tornus ochraceous orange; apex marked by several ill-defined transverse, russet fasciae; cilia clay color mixed with gray. Hindwing grayish fuscous; cilia pale gray with darker basal line. Foreleg sordid white overlaid with blackish fuscous on outer side; tarsal segments with only narrow bands of white showing on outer side; midleg similar but with less blackish fuscous on tibia; hindleg sordid white, faintly irrorate with gray. Abdomen grayish fuscous dorsally, sordid white, suffused with cinereous ventrally; anal tuft light ochereous gray.

Male genitalia slide JFGC no. 11638. Harpe about twice as long as tegumen, widest about middle, tapering to a blunt point; sacculus slightly thickened. Uncus a minute nodule. Vinculum not coalesced, narrow laterally. Tegumen broadly arched, dome shaped. Anellus subrectangular, lightly sclerotized. Aedeagus rather slender, curved; vesica without cornuti.

Female genitalia slide JFGC no. 11639. Ostium narrow, transverse. Antrum narrowly sclerotized. Inception of ductus seminalis from near anterior end of bursa copulatrix; accessory bursa adjacent to inception of ductus seminalis. Ductus bursae mainly membranous with narrow longitudinal ridges in anterior half. Bursa copulatrix membranous with weak sculpturing posteriorly. Signum absent. Lamella antevaginalis and lamella postvaginalis very lightly sclerotized.

Holotype: U.S. National Museum No. 69755.

Type-locality: Venezuela, Aragua, Rancho Grande, 1100 m.

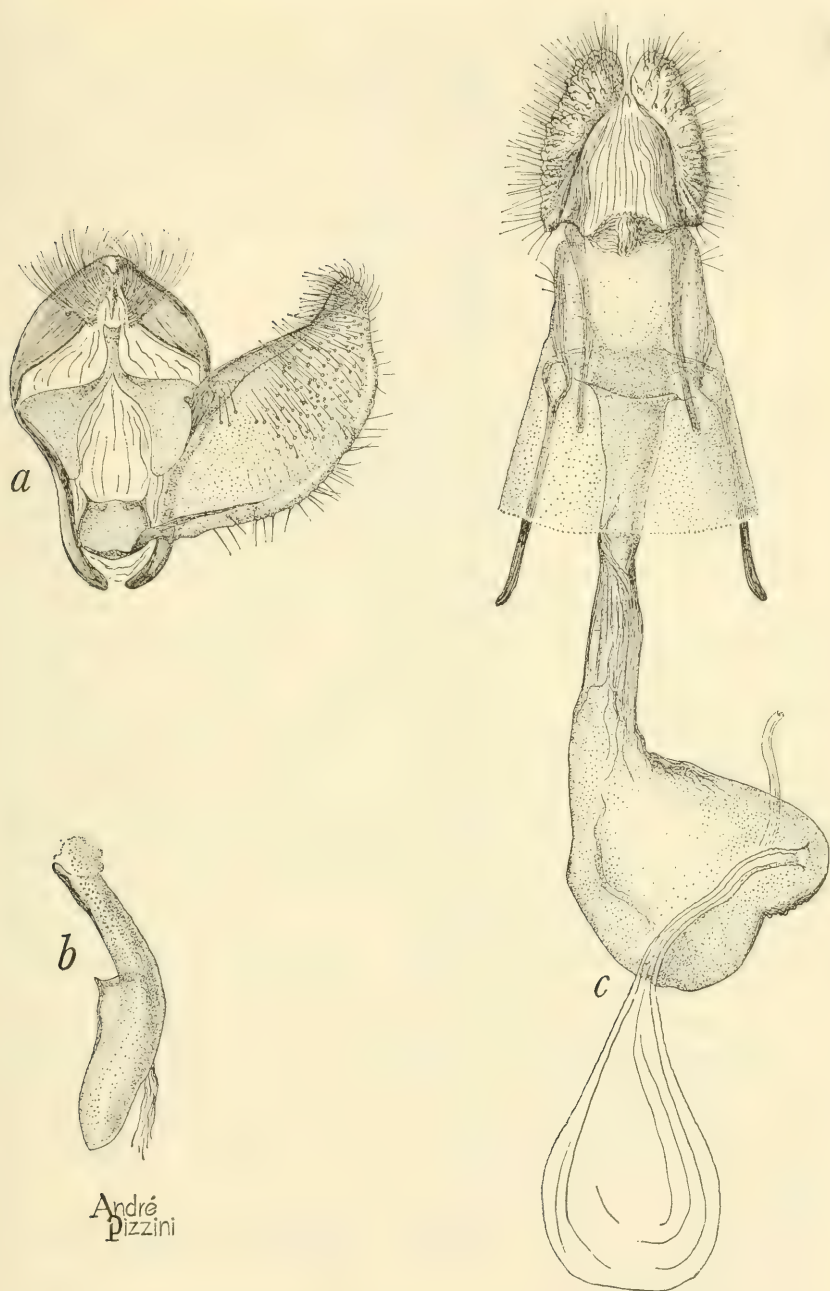


FIGURE 7.—*Phalonia vesta*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

Distribution: Venezuela.

Described from the male holotype, and one ♀ paratype, all from the same locality (16-23.X.1966, S. S. and W. D. Duckworth).

In general appearance *vesta* is very similar to *tornosema* but differs from that species by the presence of a large, oval, ochereous-white spot at end of cell in forewing. No males of *tornosema* are known but the ductus bursae of *tornosema* is very short; that of *vesta* is nearly four times as long (cf. figs. 6, 7).

Phalonia charma, new species

FIGURE 8; PLATE 3 (FIG. 7)

Alar expanse 14 mm.

Labial palpus white; second segment suffused grayish and sparsely irrorate with fuscous on outer side; third segment with fuscous dash dorsally and ventrally on outer side. Antenna grayish fuscous; scape sordid white with fuscous irroration. Head sordid white; face suffused grayish. Thorax sordid white with band of fuscous anteriorly and posteriorly; tegula fuscous anteriorly and irrorate with fuscous on remainder of surface. Forewing ground color sordid white; basal two-fifths of costa gray; on middle of costa a rectangular gray spot; at apical fourth of costa an olive-buff blotch; apical fifth of wing gray, strongly marked with blackish-fuscous spots and blotches; on mid-dorsum an olive-buff shade extending into cell, preceded basally by a blackish-fuscous blotch; on dorsum, before tornus a small, but conspicuous, blackish-fuscous spot; underside strongly infuscated except on apical half of costa; cilia sordid white with contrasting, dark gray basal line. Hindwing sordid white with pale grayish-fuscous mottling; cilia pale grayish with darker subbasal line. Foreleg white; femur and tibia fuscous on outer side; midleg similar to foreleg; hindleg sordid white. Abdomen ochereous white with grayish-fuscous suffusion and irroration dorsally; ventrally sparsely irrorate with fuscous.

Female genitalia slide JFGC no. 11634. Ostium crescentic, broad. Antrum strongly sclerotized. Inception of ductus seminalis at middle of bursa copulatrix. Ductus bursae short, broad. Bursa copulatrix membranous; accessory bursa extending well beyond anterior end of bursa copulatrix. Signa consisting of very fine spicules; lamella postvaginalis moderately sclerotized.

Holotype: U.S. National Museum No. 69744.

Type-locality: Argentina, Tucumán, Ciudad Universitaria, 800 m.

Distribution: Argentina.

Described from the unique female holotype (17.II.59. J. F. G. Clarke).

In general aspect *charma* is similar to the North American *Phalonia glaucofuscana* (Zeller), but the terminal dark area of *charma* is less

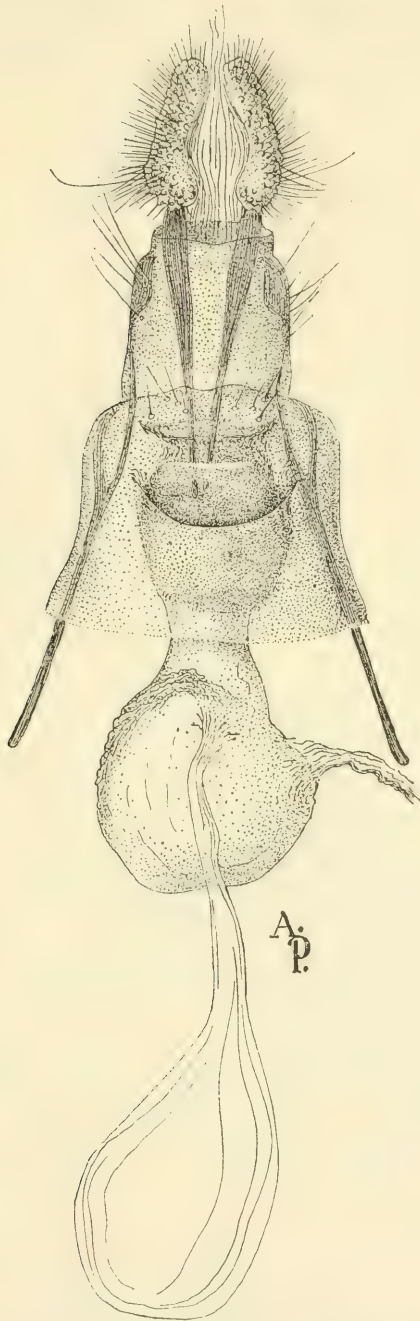


FIGURE 8.—*Phalonia charma*, new species: ventral view of female genitalia.

extensive than in *glaucofuscana* and the hindwing of the former is much lighter than that of the latter. The actual affinities of *charma* are not clear but the broad ostium and short ductus bursae characterize this species.

Cochylis Treitschke

Cochylis caesiata, new species

FIGURE 9; PLATE 3 (FIG. 4)

Alar expanse 10–12 mm.

Labial palpus ochraceous buff; second segment sparsely irrorate with fuscous; third segment with slight infuscation. Antenna grayish fuscous; scape buff. Head buff; laterally, scales slightly darker. Thorax buff, posteriorly a few tawny scales; tegula light clay color anteriorly. Forewing ground color buff; basal two-fifths clouded with clay color; across middle of wing a broad, leaden-gray, transverse band variously marked with brown and fuscous; within this broad band, from dorsum, along inner side of band, a large blackish-fuscous patch extending two-thirds distance to costa; outer margin of median band narrowly edged with brown; along extreme costal edge a series of small blackish dots, the last slightly before apex; subterminal pale area with a few scattered brown scales; underside with broad grayish-fuscous median band; terminal area tawny; cilia buff. Hindwing ochraceous white basally, followed by a grayish fuscous band; subterminal and apical areas light tawny. Foreleg buff, irrorate and shaded with fuscous; midleg buff, femur and tibia each with a proximal and distal blotch of fuscous; first tarsal segment with fuscous spot, remaining segments with scattered fuscous scales. Hindleg buff, tarsal segments slightly more ochraceous. Abdomen pale grayish dorsally; ventrally buff with a median longitudinal line of fuscous spots.

Female genitalia slide JFGC no. 11614. Ostium very broad, convex; anterior edge armed with sharp teeth. Inception of ductus seminalis at middle of bursa copulatrix, from an alveole at the anterior end of a sclerotized bar, the latter with one crenulate edge. Ductus bursae very short, hardly differentiated from bursa copulatrix; accessory bursa from posterior edge of bursa copulatrix. Bursa copulatrix membranous with spiculate inner surface. Signum absent. Lamella antevaginalis depressed, sclerotized; lamella postvaginalis lightly sclerotized.

Holotype: U.S. National Museum No. 69742.

Type-locality: Venezuela, Aragua, Rancho Grande, 1100 m.

Distribution: Known only from the type-locality.

Described from the female holotype (16–23.X.66. S. S. and W. D. Duckworth) and two ♀♀ paratypes, all from the type-locality. Paratypes dated 11–19.I.66.



FIGURE 9.—*Cochylis caesiata*, new species: ventral view of female genitalia.

In appearance quite similar to *Euxanthis amphimnesta* Meyrick, from Kumaon, but the median fascia of *caesiata* is broader and the tricolored hindwing immediately distinguishes the latter from the former. In female genitalia *caesiata* is nearest the North American *C. hospes* Walsingham.

Cochylis serena, new species

FIGURE 10; PLATE 4 (FIG. 6)

Alar expanse 15–17 mm.

Labial palpus white; second segment irrorate with fuscous on outer side; third segment suffused fuscous apically. Antenna grayish fuscous; basal fifth black dorsally; scape white. Head white with some gray scaling posterolaterally. Thorax gray, mixed with fuscous and leaden-metallic scales; tegula whitish to gray mixed with fuscous. Forewing ground color white; basal three-fifths fuscous mixed with leaden gray and tawny; in some specimens the basal dark area becomes attenuated so that dorsum is almost wholly white; on costal edge of cell, near middle of wing, two black spots and a third black spot beyond end of cell; from outer fifth of costa a crescentic, gray fascia to vein 4 at termen; on termen from vein 4 to vein 2 a narrow, tawny, transverse fascia; apical sixth of wing marked with several irregular strigulae and spots of mixed gray, fuscous and tawny; underside fuscous except a costal area at two-thirds; cilia ochraceous buff with a strong gray basal line around apex and termen. Hindwing sordid white mottled with grayish fuscous in male; in female grayish fuscous, the darker mottling ill-defined; cilia ochraceous white with gray sub-basal line. Foreleg ochraceous white; femur and tibia blackish fuscous on outer side; tarsal segments broadly banded blackish fuscous; midleg similar but not so strongly marked; hindleg ochraceous white lightly suffused and irrorate with fuscous. Abdomen grayish fuscous dorsally somewhat paler ventrally; anal tuft ochraceous white.

Male genitalia slide JFGC no. 11659. Harpe broad, tapering to a bluntly pointed cucullus. Transtilla with flattened dentate median process. Socii fleshy lobes. Vinculum narrow, lateral elements not coalesced. Tegumen a moderately narrow band. Anellus a broad sclerotized saucer-shaped plate. Aedeagus stout, acutely pointed; vesica armed with a single stout cornutus.

Female genitalia slide JFGC no. 11660. Ostium broad, anterior edge concave. Antrum moderately sclerotized. Inception of ductus seminalis ventrally from posterior third of bursa copulatrix; accessory bursa extending slightly beyond anterior end of bursa copulatrix. Ductus bursae short, broad with sclerotized ring near middle. Bursa copulatrix membranous except an irregular area posteriorly.

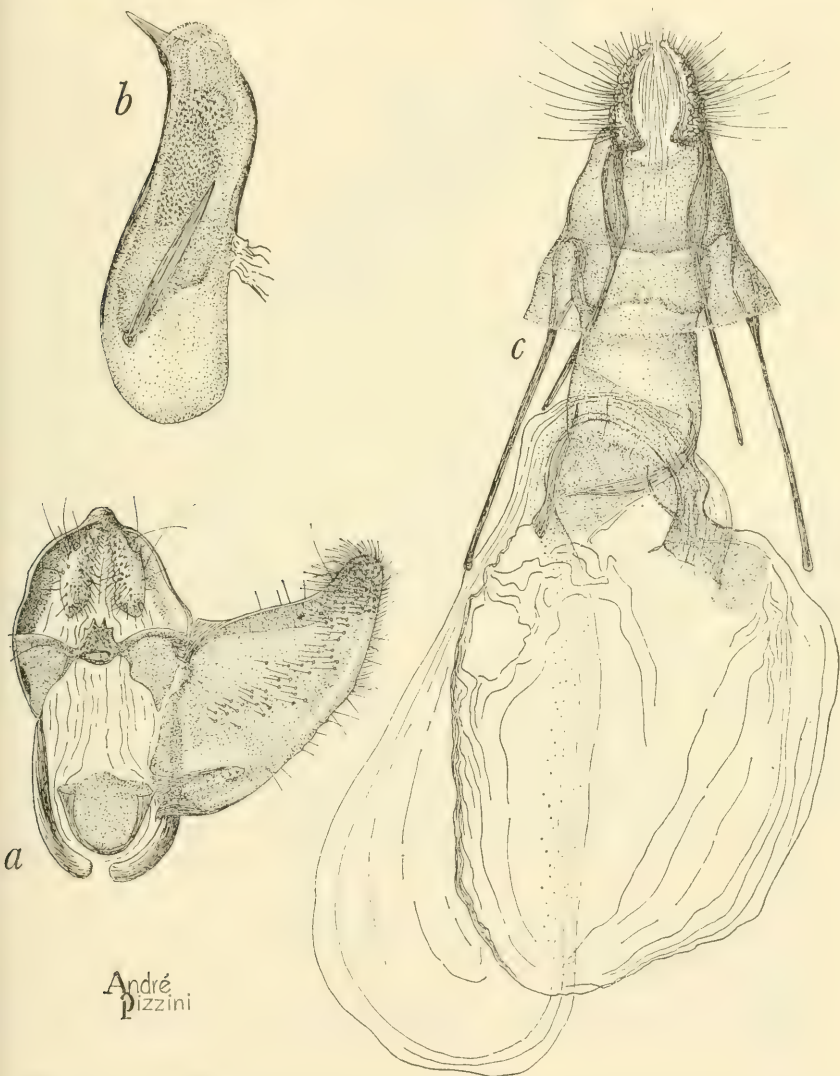
Holotype: U.S. National Museum No. 69754.

Type-locality: Brazil, Santa Catharina, Nova Teutonia.

Distribution: Known from the type-locality only.

Described from the male holotype (VII.1963, F. Plaumann), 4 ♂♂ and one ♀ paratypes all from the same locality (June to December dates).

This species is nearly allied to the following *constantia*, but the apical third of the forewing of *serena* is whitish except for a narrow,



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FIGURE 10.—*Cochylis serena*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

dark, subterminal line. In *constantia* only the extreme apex is white, the remaining part of the apical third is largely filled with fuscous and leaden-gray scales. The female genitalia of *constantia* show much more sculpturing and spining in the bursa copulatrix than is present in *serena*. No comparison of the male genitalia can be made because the male of *constantia* is unknown.

Cochylis constantia, new species

FIGURE 11; PLATE 4 (FIG. 8)

Alar expanse 17 mm.

Labial palpus fuscous, paler on inner surface of second segment. Antenna grayish fuscous; scape sordid white strongly suffused fuscous. Head fuscous. Thorax mottled fuscous and pale gray; posterior edge white; apex of tegula white. Forewing ground color sordid white; basal patch ill-defined, indicated mainly by fuscous and gray mottling; costa marked by gray spots and short bars; at middle of costa a subquadrate, gray blotch; on dorsal edge six small, fuscous spots; from mid-dorsum a large gray blotch extending into cell and superimposed over it an outwardly oblique fuscous band; from tornus to termen at vein 5, thence obliquely to costa before apex, a gray suffusion mixed with fuscous at its middle; apex white with three small, grayish-fuscous spots at edge; cilia grayish fuscous mixed with cinerous. Hindwing sordid white contrastingly mottled with grayish fuscous. Foreleg ochereous white overlaid with fuscous on outer side; midleg ochereous white suffused with grayish fuscous; tibia with fuscous spot distally on outer side; tarsal segments narrowly edged whitish distally; hindleg ochereous white with only slight suggestion of infuscation. Abdomen grayish fuscous.

Female genitalia slide JFGC no. 11593. Ostium slitlike; anterior edge slightly concave. Antrum broadly sclerotized. Inception of ductus seminalis from slight depression in side of bursa copulatrix. Ductus bursae short, membranous. Bursa copulatrix membranous except for longitudinal sculpturing posteriorly and spiculate inner surface. Accessory bursa from juncture of ductus bursae and bursa copulatrix. Lamella antevaginalis membranous; lamella postvaginalis scobinate.

Holotype: U.S. National Museum No. 69756.

Type-locality: Peru, Cusco, Machu Picchu, 2700 m.

Distribution: Peru.

Described from the unique female holotype (6.II.1959, J. F. G. Clarke).

Under the foregoing, *serena*, I have discussed the apparent relationship of the two species, but much additional material will be required before a proper alignment can be made.

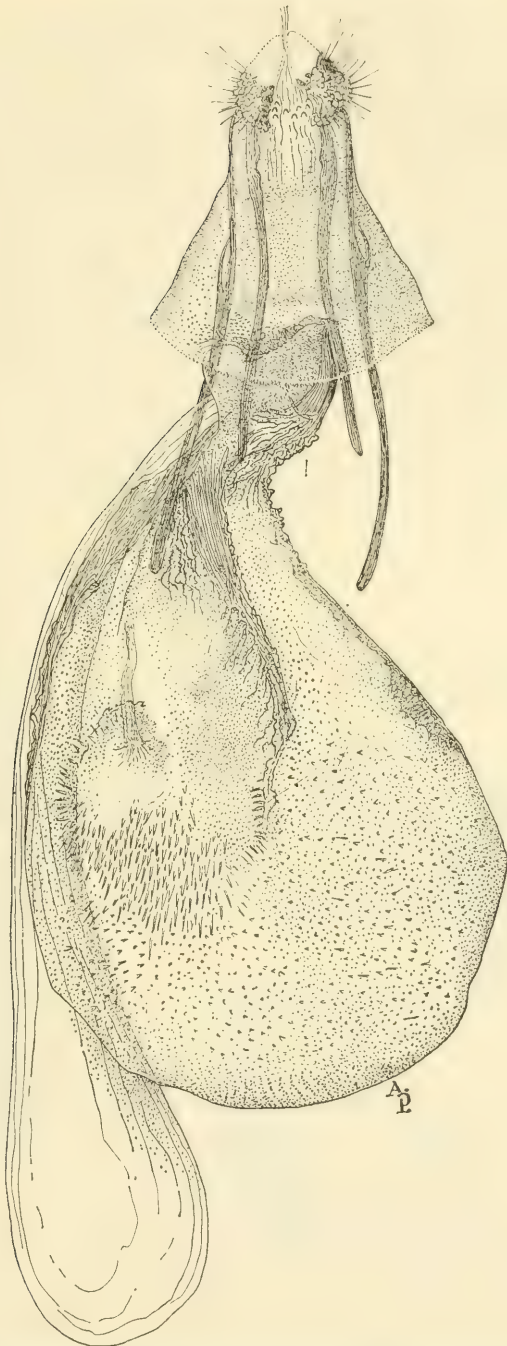


FIGURE 11.—*Cochylis constantia*, new species: ventral view of female genitalia.

Cochylis mendora, new species

FIGURE 12; PLATE 3 (FIG. 2)

Alar expanse 14–15 mm.

Labial palpus sordid white; second segment tinged ochereous on outer side; third segment tipped with fuscous. Antenna grayish fuscous; scape sordid white. Head sordid white tinged with ochereous posteriorly. Thorax sordid white, sparsely irrorate with brownish and ochereous; tegula fuscous anteriorly. Forewing ground color sordid white; base of costa narrowly fuscous, followed by several small dots and a bar of the same color at middle; basal fifth of wing light clay color forming an ill-defined basal patch; from middle of dorsum to middle of cell, a broad, outwardly oblique brown fascia followed at outer end by a clay-colored shade; on dorsum, four fuscous spots, the larger of the four astride the base of the transverse fascia; subterminally a clay-colored transverse shade; extreme terminal edge marked with clay

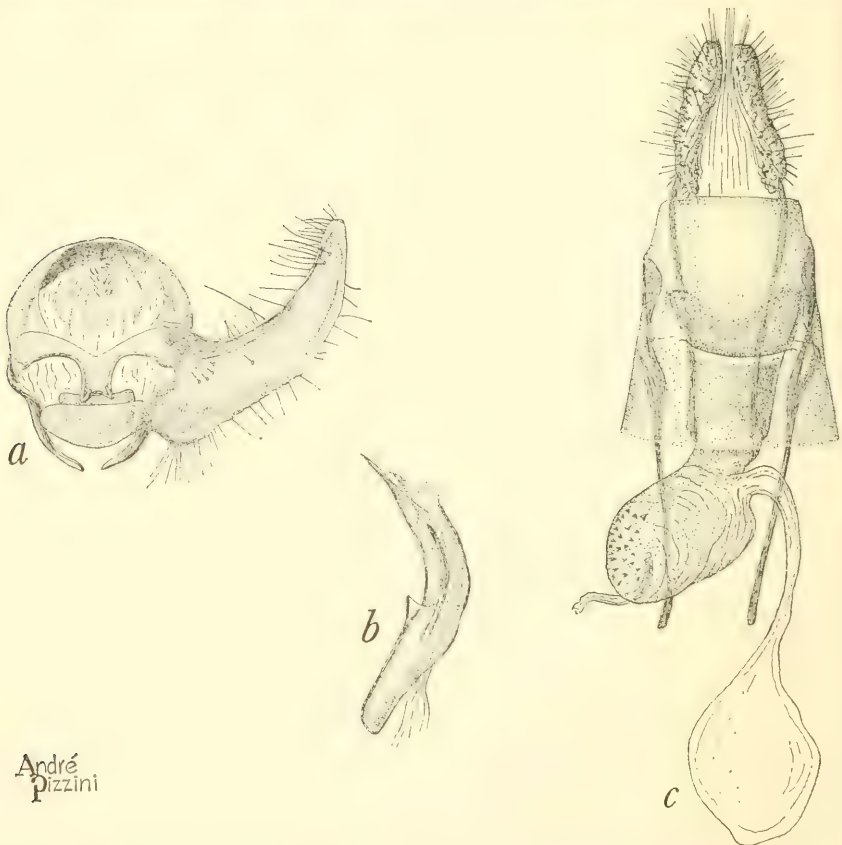


FIGURE 12.—*Cochylis mendora*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

color; underside, except costal two-fifths, fuscous; cilia white mixed with clay color and fuscous. Hindwing grayish fuscous, lighter basally; cilia pale gray with darker subbasal line. Foreleg ocherous white; femur and tibia shaded with fuscous on outer side; midleg similar to foreleg; hindleg ocherous white. Abdomen grayish fuscous dorsally, ocherous white ventrally.

Male genitalia slide JFGC no. 11632. Harpe slender; cucullus narrow, bluntly pointed; base of sacculus dilated. Vinculum very narrow, but coalesced medially. Tegumen broad, rounded, Anellus a broad, concave plate. Aedeagus moderately stout, curved, sharply pointed; vesica armed with a single, long, slender cornutus.

Female genitalia slide JFGC nos. 11633, 11217. Ostium wide; ventro-anterior lip concave. Antrum broadly sclerotized. Ductus seminalis from anterior half of bursa copulatrix. Ductus bursae short, broad. Bursa copulatrix membranous; accessory bursa extending well beyond anterior end of bursa copulatrix. Signa many small spinules.

Holotype: U.S. National Museum No. 69743.

Type-locality: Chile, Santiago Prov., Cajon de Maypo, Cordillera, El Centro.

Distribution: Known only from Chile.

Described from the male holotype (12-20 Jan. 1948, Tito Ramirez), and one ♀ paratype with same data, and one ♀ paratype, El Principal (11.1888, V. Izquierdo).

In general appearance *mendora* is similar to the North American *Cochylis felix* (Walsingham) but is smaller, lighter, and lacks the dark subterminal spot of that species. The harpe of *felix* is more evenly rounded and broader ventrally than that of *mendora* and the aedeagus is stouter. The ostium of *mendora* is twice as broad as that of *felix* and the spining of the bursa copulatrix is much less extensive than in the latter.

Cochylis laetitia, new species

FIGURE 13; PLATE 3 (FIG. 3)

Alar expanse 15 mm.

Labial palpus ocherous white, light ochraceous buff on outer side; second segment sparsely irrorate with grayish basally. Antenna pale grayish buff; scape with grayish-fuscous irrorations. Head ocherous white with slight, pale infuscation. Thorax ocherous white, suffused ochraceous buff; tegula ochraceous buff anteriorly. Forewing ground color buff; costa and dorsum marked with small grayish-fuscous spots; at basal two-fifths a triangular yellow-ocher spot astride fold; a similarly colored triangular spot, its base on dorsum slightly beyond middle, extending to fold; in apical third several ill-defined transverse fasciae composed of narrow yellow-ocher spots and the whole

area finely irrorate with grayish fuscous; underside lightly mottled with grayish fuscous; cilia mixed gray and yellow ocher with dark gray basal line. Hindwing sordid whitish mottled with grayish fuscous; cilia ocherous white with gray subbasal line. Foreleg ocherous white; femur and tibia overlaid with fuscous on outer side; tarsal segments broadly banded with grayish fuscous; midleg similar to foreleg; hindleg ocherous white; femur sparsely irrorate with grayish fuscous. Abdomen pale buff; dorsally suffused with grayish fuscous; ventrally with slight, fuscous, median irroration.

Male genitalia slide JFGC no. 11635. Harpe triangular, broad basally, tapering to a pointed cucullus. Vinculum coalesced, with median point. Tegumen rounded, broad. Anellus a broad, sclerotized plate. Aedeagus moderately stout, sharply curved at distal third, sharply pointed; vesica armed with a single, slightly curved, slender cornutus.

Holotype: U.S. National Museum No. 69745.

Type-locality: Argentina, Tucumán, Ciudad Universitaria, 800 m.

Distribution: Known only from the type-locality.

Described from the unique male holotype (20.II.59, J. F. G. Clarke).

Similar to *Phalonia sublimis* Meyrick from Peru, but lacking the contrasting transverse fascia of the forewing of that species.

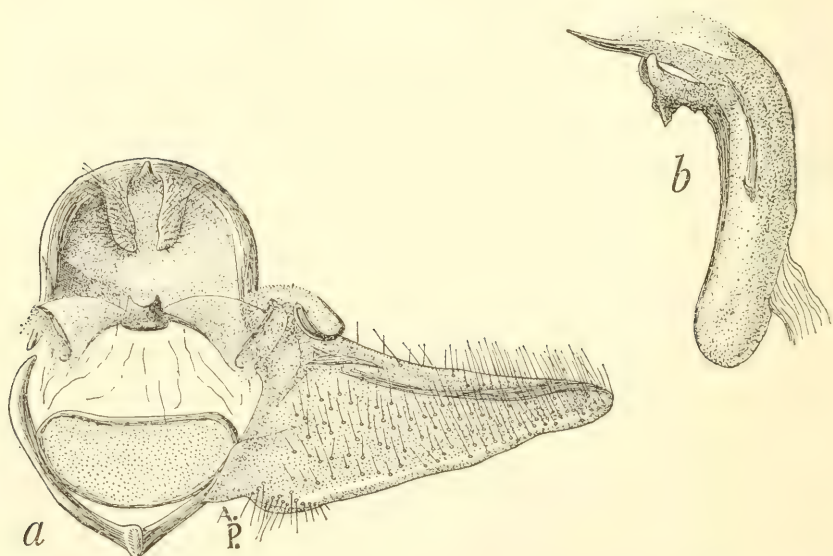


FIGURE 13.—*Cochylis laetitia*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus.

Amallectis Meyrick*Amallectis nephelodes*, new species

FIGURE 14; PLATE 2 (FIG. 3)

Alar expanse 16–21 mm.

Labial palpus creamy white overlaid with ochereous buff on outer side; second segment infuscated basally. Antenna grayish fuscous; scape fuscous. Head ochereous buff with grayish scales laterally; in female, head gray. Thorax brownish gray; apex of tegula grayish buff. Forewing ground color, light clay color in basal half, gray in apical half; basal third of wing overlaid with ochraceous buff; from basal

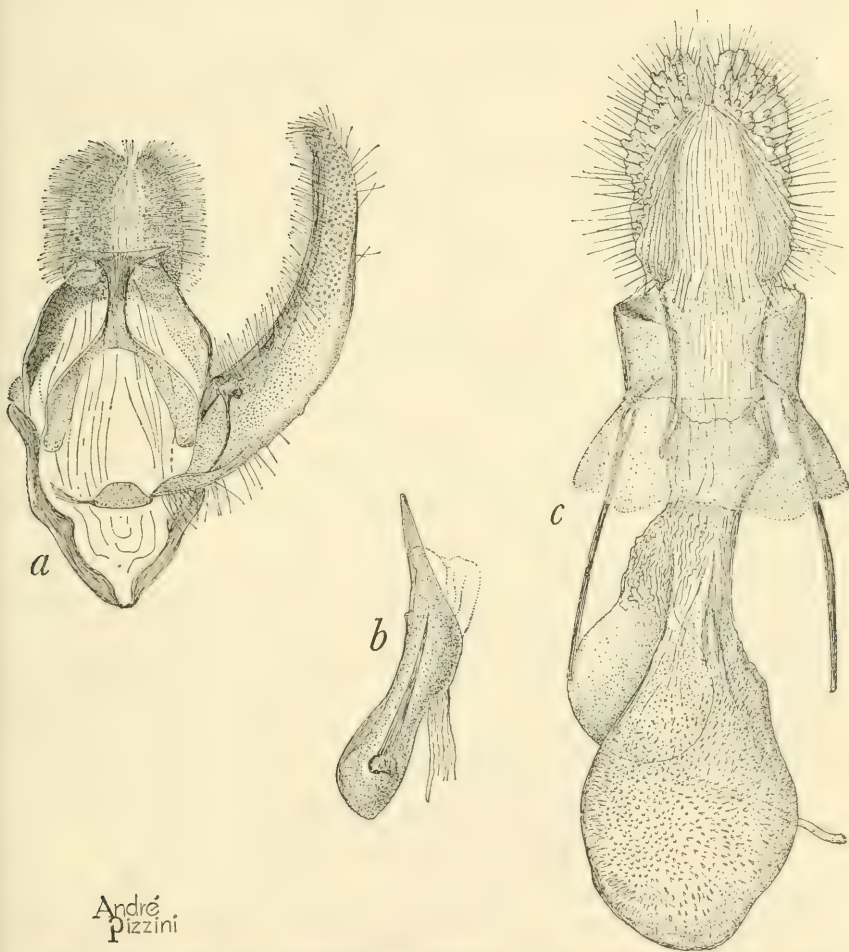
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FIGURE 14.—*Amallectis nephelodes*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

third of dorsum to well beyond middle of cell, an outwardly oblique ochraceous-tawny, transverse band with fuscous scales at base and apex; beyond this fascia, on middle of dorsum, an elongate, transverse, grayish-olive patch with its apex near end of cell; on tornus a small fuscous spot; beyond end of cell a large, irregular, transverse, fuscous blotch followed by a curved line of ground color, the latter followed by a broadly crescentic, subapical, fuscous, transverse bar; cilia mixed ochraceous, fuscous and gray. Hindwing grayish fuscous, somewhat paler basally. Foreleg ochraceous buff strongly infuscated on outer side; midleg similar to foreleg but with less fuscous; hindleg ochraceous buff lightly spotted with gray on femur and tibia; tarsal segments marked with blackish fuscous on outer side. Abdomen grayish fuscous dorsally, ochraceous white ventrally.

Male genitalia slide JFGC no. 11625. Harpe long, slender, without ornamentation; cucullus narrowly rounded. Transtilla long, terminating in two widely separated, acutely sharp, points. Uncus absent. Vinculum narrow, bluntly pointed. Tegumen broad, about half the length of harpe; socii long fleshy lobes. Anellus subtriangular. Aedeagus moderately slender, apically flattened and pointed; vesica armed with one cornutus, slightly more than half the length of aedeagus.

Female genitalia slide JFGC no. 11626. Ostium small with concave ventro-anterior lip. Antrum broad, wider than long. Inception of ductus seminalis at about middle of ductus bursae; accessory bursa a rounded, sclerotized sac dorsal to bursa copulatrix. Ductus bursae wide, mostly membranous. Bursa copulatrix with finely granular surface. Signum absent.

Holotype: U.S. National Museum No. 69737.

Type-locality: Bolivia, Cochabamba, Incachaca, Tropical cloud area, 2100 m.

Distribution: Bolivia.

Described from the male holotype (27.VIII-5.IX.56. L. Peña), and one ♀ paratype with identical data.

The female is the larger of the two specimens and has paler hindwings than the male.

This species is near *anaxia* and *peñai* but differs from both by the larger size and generally darker color.

Amallectis peñai, new species

FIGURE 15; PLATE 2 (FIG. 2)

Alar expanse 14 mm.

Labial palpus white; second segment, except apical portion, ochraceous buff on outer side. Antenna ochraceous tawny. Head sordid white with some ochraceous-buff scales around eye. Thorax grayish fuscous; apex of tegula sordid white. Forewing ground color white

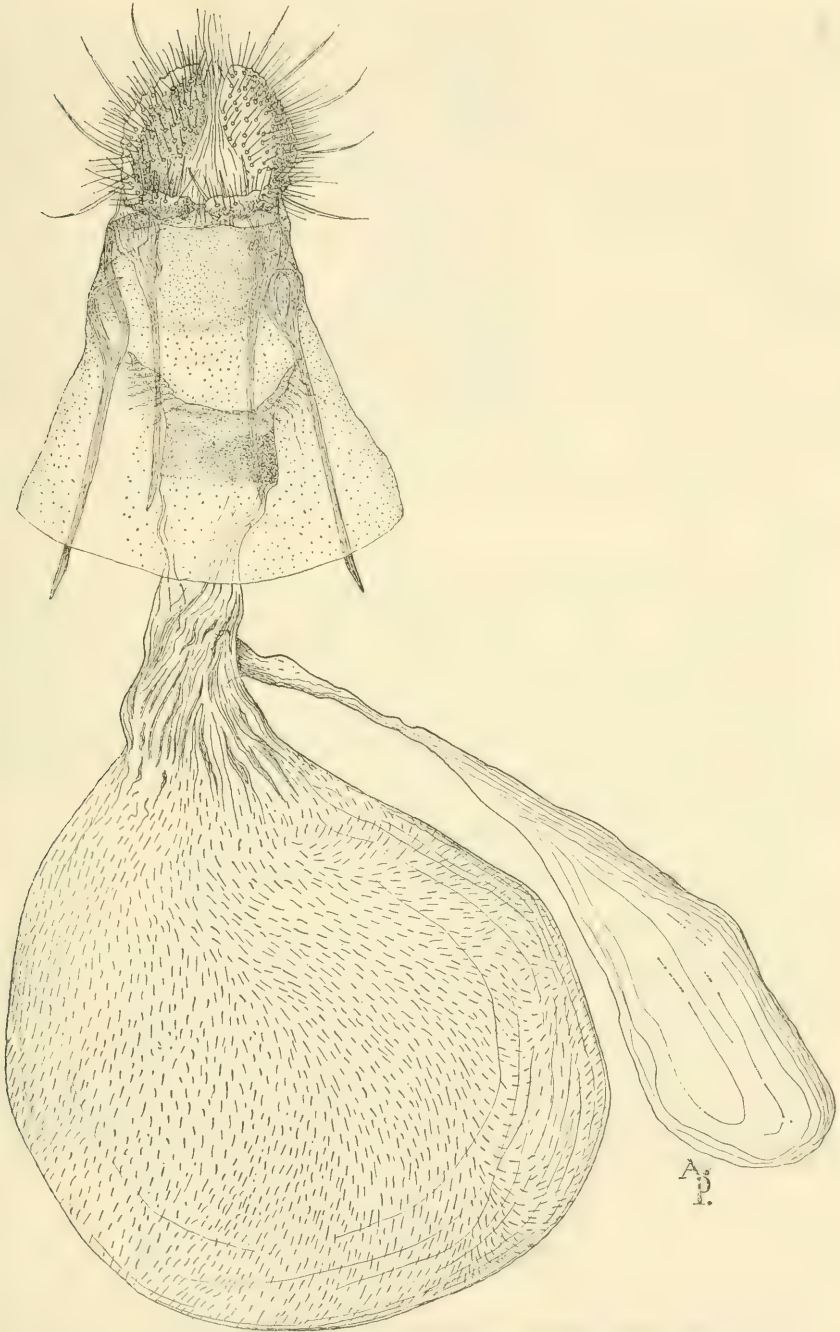


FIGURE 15.—*Amallectis peñai*, new species: ventral view of female genitalia.

(clearly visible only in apical area), heavily overlaid with ochraceous buff and olivaceous gray; basal half of costa ochraceous buff; from basal third of dorsum to cell, an oblique subrectangular blackish-fuscous and tawny patch bounded on each side with a narrow whitish line; basad of this shade an olivaceous shade parallels it and extends well into cell; beyond the dark dorsal mark a grayish shade, terminated by a few leaden scales, extends to tornus; on tornus a rounded, olivaceous spot extends to vein 6 and is bounded outwardly by ochraceous-tawny and blackish-fuscous scales; from apical third to termen at vein 4, an outwardly curved crescentic fascia, broadest in middle, shaded with ochraceous tawny on costa and edged with blackish fuscous in terminal half; on costa, on each side of the crescentic mark, a small patch of leaden scales; cilia buff with slightly darker basal band. Hindwing ochraceous white basally shading to light ochraceous buff apically; cilia ochraceous white becoming darker around apex. Foreleg ochraceous buff suffused with fuscous on outer side; midleg similar; hindleg buff. Abdomen ochraceous white to buff, suffused with grayish.

Female genitalia slide JFGC nos. 11219, 11629. Ostium moderately broad, slitlike, anterior edge concave. Antrum broadly sclerotized. Ductus bursae nearly as long as bursa copulatrix with weak sculpturing in the form of longitudinal ridges. Bursa copulatrix membranous with weak sculpturing in posterior portion, the ridges confluent with those from ductus bursae; inner surface of bursa copulatrix clothed with very fine, weak spicules. Lamella antevaginalis and lamella postvaginalis membranous.

Holotype: U.S. National Museum No. 69734.

Type-locality: Bolivia, Cochabamba, Incachaca. Tropical cloud area, 2100 m.

Distribution: Bolivia and Peru.

Described from the female holotype (27.VIII. to 5.IX.56, L. Peña), and one ♀ paratype, Peru, Cusco, Machu Picchu, 2700 m. (6.II.59, J. F. G. Clarke).

This taxon is nearest *anaxia* and is discussed under that species.

It is with great pleasure that I dedicate this species to its collector, Mr. Luis Peña, who has contributed much material toward a better knowledge of the Neotropical microlepidopterous fauna.

Amallectis frangula, new species

FIGURE 16; PLATE 2 (FIG. 8)

Alar expanse 16 mm.

Labial palpus ochraceous white; second segment shaded ochraceous buff basally on outer side; third segment brown dorsoposteriorly. Antenna grayish fuscous, basally suffused tawny; scape tawny. Head

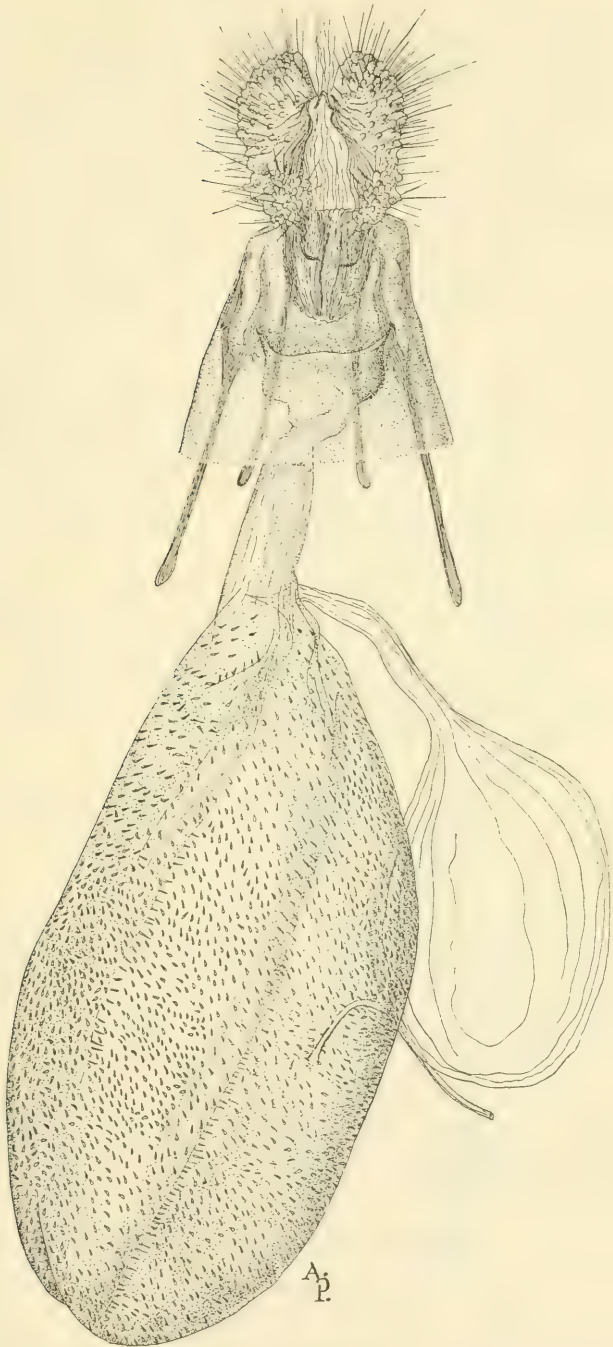


FIGURE 16.—*Amallectis frangula*, new species: ventral view of female genitalia.

ocherous white shaded ochraceous buff laterally and posteriorly. Thorax olivaceous with slight brassy hue. Forewing ground color ocherous white; extreme costal edge ochraceous tawny to two-thirds, shading to olivaceous brown for a short distance toward cell, parallel to costa; at two-thirds the olivaceous brown coloring forms a triangle, the apex of which extends nearly to end of cell; from near base to tornus a broad gray shade with tiny, short, transverse strigulae on dorsal edge and toward tornus two transverse brassy bars; apical third russet, interrupted by an oblique bar of ground color suffused pale russet, and an apical area of same color; from dorsal edge near base, an olivaceous shade extending well into cell; cilia ochraceous buff mixed with some paler scales.

Hindwing fuscous; cilia grayish fuscous. Foreleg ocherous white strongly overlaid fuscous outwardly; midleg ocherous white; tibia suffused tawny on outer side; tarsal segments fuscous on outer side; hindleg ocherous white with small, ill-defined fuscous spot on tibia, and tarsal segments with slight infuscation. Abdomen fuscous dorsally, ocherous white ventrally.

Female genitalia slide JFGC no. 11637. Ostium moderately broad, ventral edge concave. Antrum broadly sclerotized for short distance. Inception of ductus seminalis from side of bursa copulatrix. Ductus bursae membranous. Accessory bursa from near junction of bursa copulatrix and ductus bursae. Bursa copulatrix clothed with fine spines.

Holotype: U.S. National Museum No. 69733.

Type-locality: Venezuela, Aragua, Rancho Grande, 1100 m.

Distribution: Known only from the type-locality.

Described from the holotype female (16-23.X.1966, S. S. and W. D. Duckworth).

The three species *peñai*, *anaxia*, and *frangula* are closely similar and obviously closely related. Of these, *peñai* can at once be distinguished from the other two by its very pale hindwing; and *frangula* can be distinguished from *anaxia* by the extensive gray dorsal patch, absent in the latter species.

It is strange that not a single male of any of the three species has appeared although the dates of collection cover much of the year. This suggests some peculiar behavioral pattern for the males, an interesting subject for investigation.

Amallectis anaxia, new species

FIGURE 17; PLATE 2 (FIG. 1)

Alar expanse 17 mm.

Labial palpus ocherous white; second segment ochraceous buff on

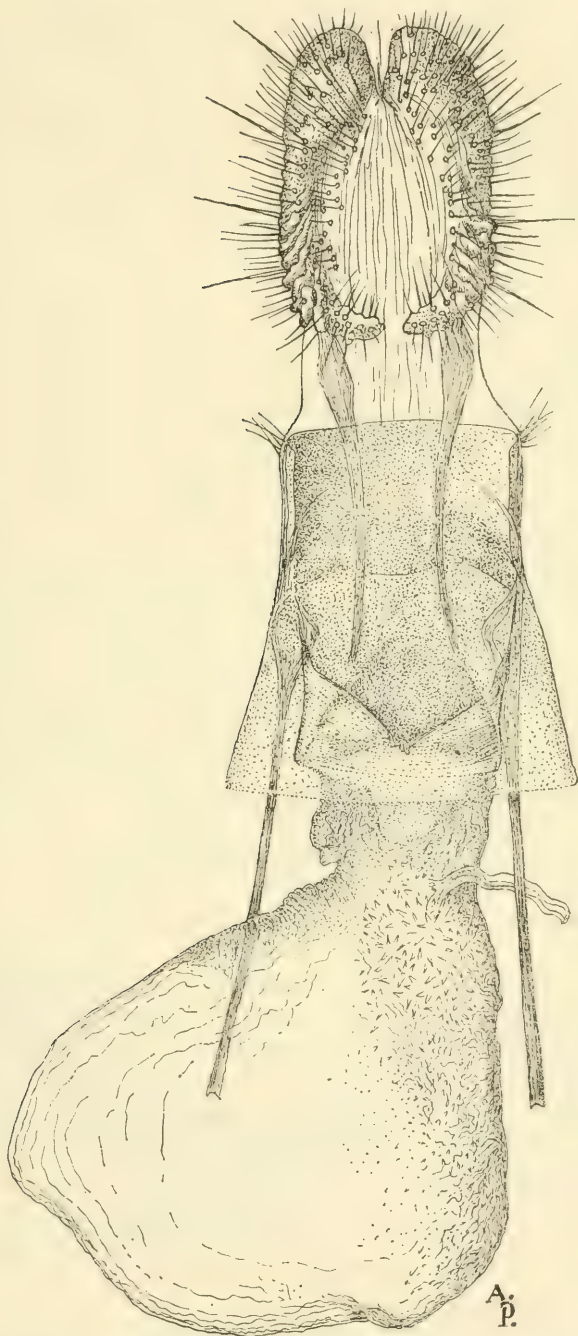


FIGURE 17.—*Amallectis anaxia*, new species: ventral view of female genitalia.

outer side; third segment with ochereous-fuscous spot on outside. Antenna pale brown; scape ochraceous buff. Head light buff; laterally ochraceous buff. Thorax pale grayish olive; tegula ochraceous buff anteriorly. Forewing ground color pale buff; costa ochraceous buff on basal fifth followed by gray then ochraceous buff, the three areas of equal length; from inner angle a slightly curved ochraceous-buff fascia extends to end of cell, where it terminates in a few leaden-gray scales; dorsally this fascia is separated from a fuscous and ochraceous-buff blotch by a narrow line of the ground color; before tornus an ochraceous-buff triangular spot followed by a few leaden-gray scales, then a larger blotch of ochraceous buff, the latter edged along vein 5 by fuscous; from apical fourth of costa to termen, between vein 5 and 6, an outwardly oblique ochraceous-buff fascia terminating in a fuscous spot; outer half of dorsal margin marked with several short fuscous dashes; cilia buff with slightly darker basal band. Hindwing grayish fuscous, paler basally; cilia pale grayish fuscous with a darker sub-basal line. Foreleg ochereous white suffused with fuscous on outer side; midleg similar; hindleg light buff; tibial spurs faintly tipped brown.

Female genitalia slide JFGC no. 11216. Ostium very broad; anterior edge deeply V-shaped. Ductus bursae very broad, short, slightly sclerotized, lightly sculptured, hardly differentiated from bursa copulatrix. Bursa copulatrix membranous, with slight sculpturing posteriorly and clothed with short, small spines; accessory bursa from juncture of ductus bursae and bursa copulatrix. Lamella antevaginalis and lamella postvaginalis lightly sclerotized.

Holotype: U.S. National Museum No. 69735.

Type-locality: Guatemala, Volcan Santa Maria.

Distribution: Recorded only from the type-locality.

Described from the unique female holotype (Schaus and Barnes. VII).

This and the foregoing *peñai* are very closely related but differ markedly in the color of the hindwing, which is ochereous white in *peñai* and grayish fuscous in *anaxia*; the gray dorsal patch of the forewing of *peñai* is absent in *anaxia* and the curved crescentic subapical fascia of the former is replaced in the latter by a straight band; the ground color of the apical part of the forewing is strongly contrasted against the darker markings in *peñai*, not so in *anaxia*.

Amallectis domna, new species

FIGURE 18; PLATE 2 (FIG. 4)

Alar expanse 15 mm.

Labial palpus olive buff; second segment deep olive buff on outer side, except apex; third segment almost wholly deep olive buff. Antenna fuscous basally shading to gray apically. Head pale olive buff, some-

what darker laterally, thorax deep olive buff suffused with fuscous; tegula pale olive buff apically. Forewing ground color very pale olive buff; basal fourth of costa, inwardly to cell, deep olive buff suffused with fuscous; from inner angle, well into cell, an oblique, narrowly triangular olive-gray shade; from basal third of dorsum to middle of cell a well-defined, outwardly oblique, blackish-fuscous fascia followed outwardly to tornus by an olive shade; from the apical corner of the dark fascia a slender blackish-fuscous line parallels dorsum to end of cell, where it broadens into an area irrorate with blackish-fuscous scales; from apical third of costa to tornus an irregular, indistinct, olive-buff fascia; apical area grayish with scattered olive-buff and fuscous scales; dorsal edge marked with a few small fuscous points; cilia composed of mixed olive-buff, gray, and fuscous scales. Hindwing ocherous white basally shading to fuscous apically; cilia very pale, whitish basally shading to grayish fuscous apically. Foreleg buff strongly overlaid with fuscous on outer side; midleg similar to foreleg; hindleg buff, tibial spurs and tarsal segments with faint infuscation.

Male genitalia slide JFGC no. 11617. Harpe moderately narrow, unornamented; cucullus rounded; sacculus dilated basally. Uncus absent. Socii large, fleshy. Vinculum not coalesced. Tegumen broad, about half the length of harpe. Anellus a broadly oval, sclerotized plate. Aedeagus stout, slightly curved, pointed; vesica armed with one large cornutus.

Holotype: U.S. National Museum No. 69736.

Type-locality: Colombia, Nariño, Volcan Galeras, 3100 m.

Distribution: Known only from the type-locality.

Described from the unique male holotype (14 Jan. 1959. J. F. G. Clarke).

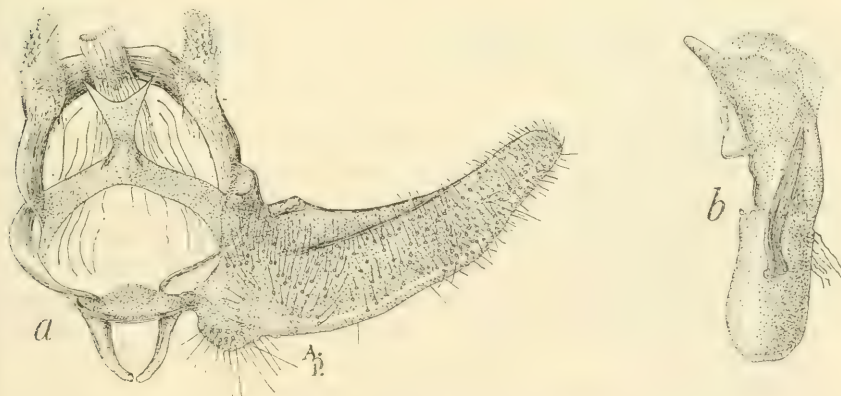


FIGURE 18.—*Amallectis domna*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus.

This species is very close to *A. devincta* Meyrick, from Peru, but is a slightly larger species. The prominent, fleshy socii at once set *domna* apart from *devincta*. It is further distinguished from *devincta* by the large cornutus, which is nearly half the length of the aedeagus; that of *devincta* is less than one-third the length of the aedeagus.

Phalonidia LeMarchand

Phalonidia heterophaea, new species

FIGURE 19; PLATE 4 (FIG. 1)

Alar expanse 11 mm.

Labial palpus pale buff; second segment suffused clay color with scattered brownish irrorations on outer side. Antenna grayish fuscous; scape buff, lightly suffused with fuscous. Head buff, tinged clay color laterally. Thorax buff; tegula grayish buff. Forewing ground color buff variously marked and suffused with dark olive buff; basal half of costa suffused grayish; on middle of costa a blackish-fuscous rectangular patch; two short transverse bars of the same color slightly before and at end of cell; before middle of termen two or three short, slender blackish-fuscous transverse dashes; from base of blackish-fuscous costal patch an irregular dark olive-buff transverse fascia reaching middle of dorsum; from apical fourth of costa an outwardly curved, crescentic, dark olive-buff bar ending at about vein 6; dorsum marked with scattered blackish-fuscous scales; underside strongly infuscated except outer half of costa; cilia olive buff. Hindwing shining grayish buff, darker toward margins; cell very thinly scaled; cilia grayish, darker around termen and apex. Foreleg buff, heavily overlaid with fuscous on outer side; midleg similar but less strongly marked fuscous; hindleg buff with slight grayish-fuscous suffusion on outer side. Abdomen grayish fuscous dorsally; ventrally buff except segments 5 and 6, which are grayish fuscous; anal tuft ochraceous buff. The sixth sternum is developed into a hollow evagination terminating in two divergent arms, turned upward on each side of the seventh segment.

Male genitalia slide JFGC no. 11645. Harpe broad basally narrowing abruptly slightly beyond middle, terminating in a very narrow, bluntly pointed cucullus. Transtilla with long median pointed process. Uncus tubular, enclosing anal tube. Vinculum narrow. Tegumen broad, rounded. Anellus an oval sclerotized plate. Aedeagus more than twice the length of harpe, curved and pointed distally; vesica armed with a long (almost as long as the entire aedeagus), undulating cornutus.

Holotype: U.S. National Museum No. 69749.

Type-locality: Colombia, Antioquia, La Estrella, 1730 m.

Distribution: Known only from the type-locality.

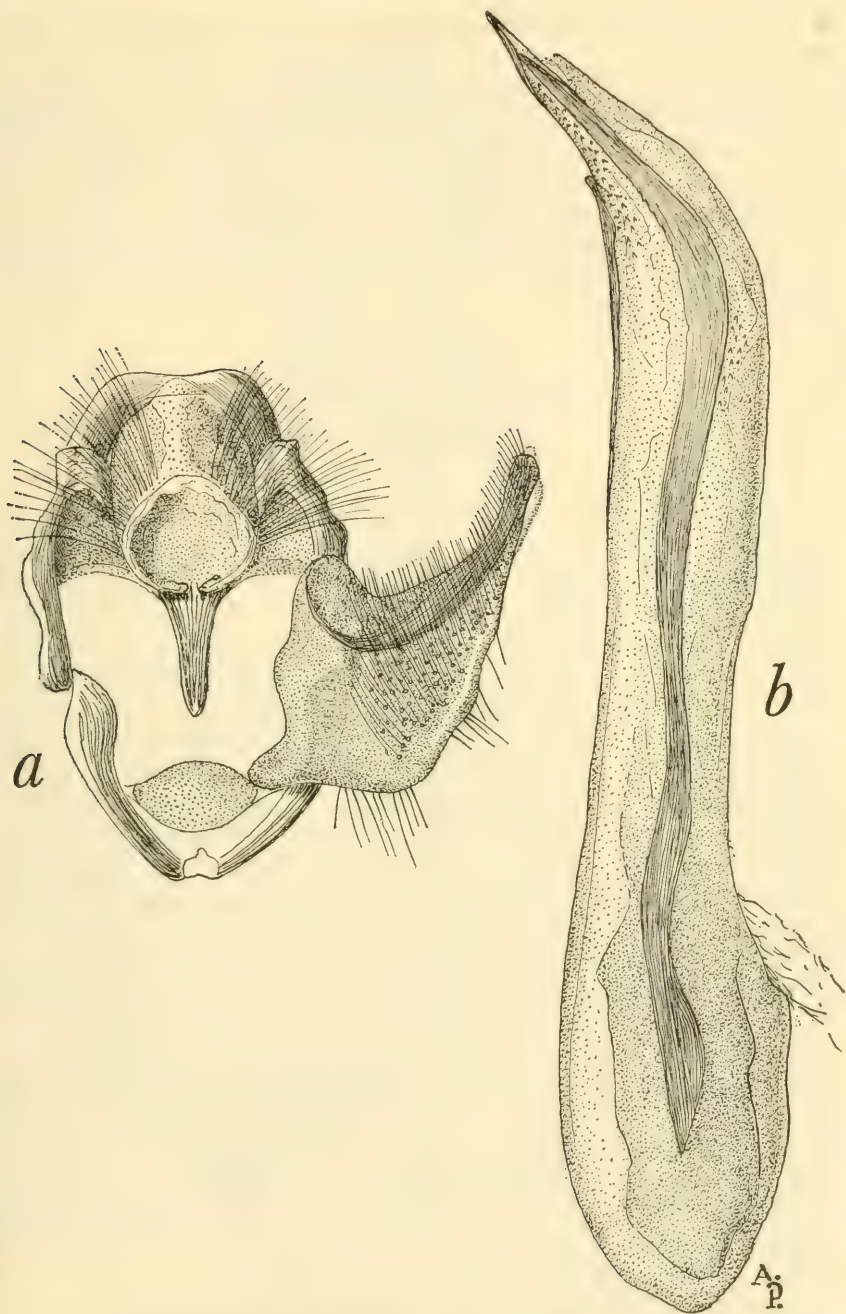


FIGURE 19.—*Phalonidia heterophaea*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus.

Described from the unique holotype male (13.XII.59, F. Luis Gallego M.).

This species is of particular interest because of the modified sixth sternum and the enormous cornutus, which has been demonstrated elsewhere only in the family by Razowski (1964: 367, figs. 28, 29), where he figures *P. ichthyochroa* (Walsingham) from St. Croix. Razowski's figure 28 does not correspond to other species in *Phalonidia*, nor does it match *heterophaea*. The enormous aedeagus and cornutus, however, relate *heterophaea* and *ichthyochroa*, which will probably require a new genus.

Irazona Razowski

Irazona icogramma, new species

FIGURE 20; PLATE 4 (FIG. 2)

Alar expanse 12–13 mm.

Labial palpus white; second segment tinged ochereous on outer side of basal half. Antenna grayish fuscous; scape white in distal half. Head white. Thorax fuscous. Forewing ground color white; dorsum broadly marked with leaden gray strigulae and blotches; basal patch, except dorsal half, tawny; at outer third of dorsum a conspicuous, large, fuscous spot reaching slightly beyond fold; from middle of costa to tornus an ill-defined, irregular, outwardly oblique, ochraceous-tawny fascia preceded and followed by scattered blackish-fuscous and leaden-gray scales; from apical third of costa, to termen at vein 5, a leaden-gray fascia with spots of ochraceous-tawny and fuscous scales along edges; apex and a spot between veins 2 and 4 similarly colored; costal scales elongate, clay color, at one-third; underside strongly infuscated; cilia light clay color. Hindwing grayish fuscous; cilia a pale grayish with darker subbasal line. Foreleg white, overlaid with grayish fuscous on outer side; midleg white with grayish suffusion on tarsal segments; hindleg white. Abdomen grayish dorsally, white ventrally.

Female genitalia slides JFGC nos. 11221, 11642. Ostium broad. Antrum strongly sclerotized. Inception of ductus seminalis at middle of bursa copulatrix. Ductus bursae short, strongly sclerotized except for small membranous band anterior to antrum. Bursa copulatrix with sclerotized, rounded evagination on right side posteriorly; inner wall clothed with sharp spines; accessory bursa extending beyond bursa copulatrix.

Holotype: U.S. National Museum No. 69750.

Type-locality: Guatemala, Volcan Santa Maria, October.

Distribution: Guatemala.

Described from the female holotype (October) and one ♀ paratype

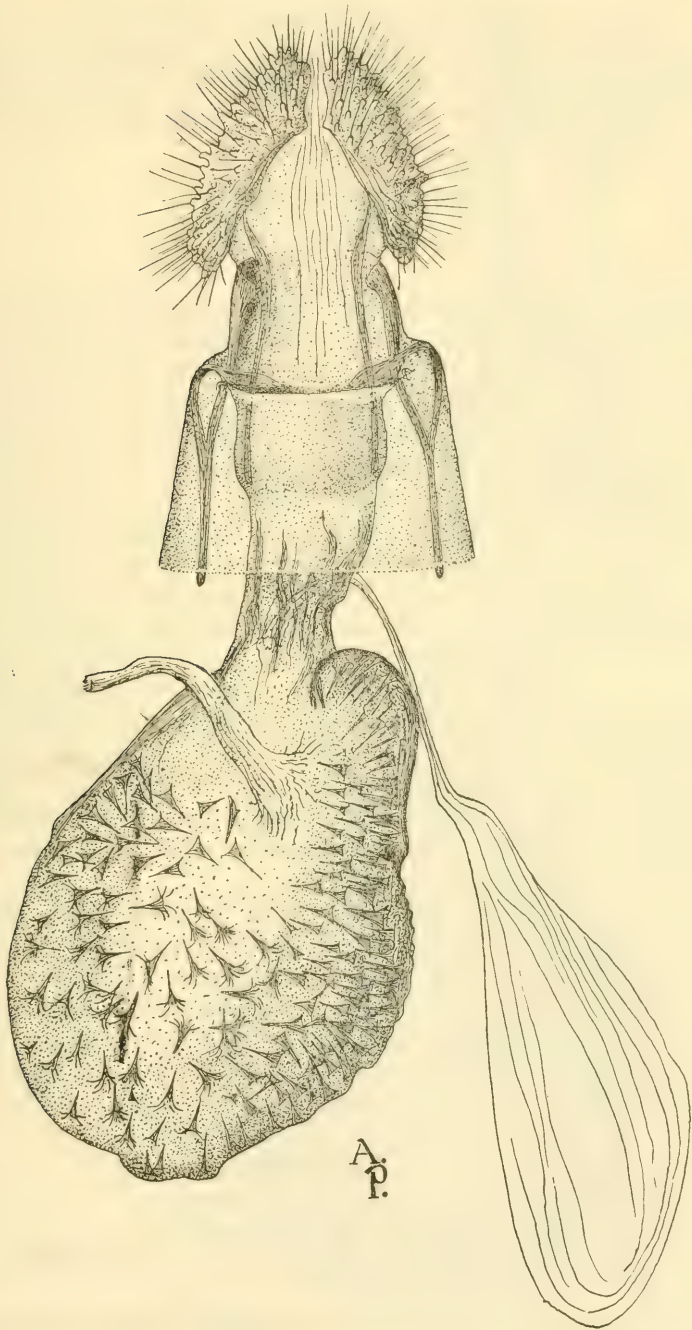


FIGURE 20.—*Irazona icogramma*, new species: ventral view of female genitalia.

(July), Schaus and Barnes, from the same locality.

Similar in appearance to *Irazona cognata* (Walsingham) but generally darker and with a much darker hindwing. No comparison of the genitalia can be made because *cognata* is represented by a male and *icogramma* is known only from females.

Irazona turbula, new species

FIGURE 21; PLATE 4 (FIG. 3)

Alar expanse 16 mm.

Labial palpus white; second segment with slight buff suffusion on outer side. Antenna grayish fuscous with some white scaling dorso-basally; scape white. Head white. Thorax white, suffused grayish. Forewing ground color white; dorsum broadly marked with wood-brown and gray bars, all confluent; basal patch, from one-fifth of costa to dorsum, grayish fuscous; on costa, slightly beyond middle, a pale grayish blotch with two small, darker gray spots on extreme costal edge; at end of cell a short, irregular, longitudinal grayish dash with a small spot of fuscous scales at outer end; from costa, slightly before apex, to vein 6 an outwardly oblique gray bar narrowly edged with grayish-fuscous and yellowish scales; extreme apex narrowly gray; between end of cell and subapical bar several irregular, faintly gray transverse strigulae; costal scales elongate beyond basal patch and also beyond middle; underside moderately infuscated; cilia pale gray at apex, white around termen and tornus. Hindwing grayish fuscous, paler basally; cilia sordid white to pale gray with darker subbasal line. Foreleg ocherous white suffused grayish fuscous on outer side; midleg similar to foreleg; hindleg ocherous white. Abdomen gray; first to third segments paler ventrally.

Female genitalia slide JFGC no. 11641. Ostium broad, slitlike. Antrum not developed. Ductus seminalis from center of right side of bursa copulatrix. Ductus bursae membranous in posterior half; anterior half ornamented with very fine sclerotized ridges. Bursa copulatrix irregularly ornamented with very fine sclerotized ridges and with a small sclerotized evagination posteriorly; accessory bursa not extending beyond end of bursa copulatrix; lamella antevaginalis crescentic.

Holotype: U.S. National Museum No. 69751.

Type-locality: Guatemala, Volcan Santa Maria.

Distribution: Known only from the type-locality.

Described from the unique female holotype (July, Schaus and Barnes).

Similar to *icogramma* but without the conspicuous subtornal spot and with a short subapical, transverse fascia. The female genitalia are similar, and the close relationship is indicated by the sclerotized



FIGURE 21.—*Irazona turbula*, new species: ventral view of female genitalia.

evagination from the posterior side of the bursa copulatrix. The ornamentation of the inner wall of the bursa copulatrix differs, being composed of fine spines in *icogramma* and fine ridges in *turbula*.

Irazona ademonia, new species

FIGURE 22; PLATE 4 (FIG. 4)

Alar expanse 16 mm.

Labial palpus white; second segment tinged ochraceous buff on outer side; third segment gray apically. Antenna grayish fuscous; scape grayish buff basally, white apically. Head white with some grayish scales posterolaterally. Thorax grayish fuscous, paler posteriorly; tegula pale grayish posteriorly. Forewing ground color white; dorsum broadly marked leaden gray and white mixed; basal patch, from basal fifth of costa to dorsum, grayish-fuscous; on dorsum, before tornus, a ring of fuscous scales surrounding a leaden-gray area; on costa, at middle, a pale leaden-gray spot edged posteriorly and anteriorly with buff; between dorsal and costal spots several pale gray spots and short dashes mixed with buff; subapically, from costa to vein 4, a curved, pale leaden-gray transverse fascia edged with buff; apex narrowly grayish fuscous; costal scales elongate beyond basal patch and beyond midcostal spot; underside moderately infuscated; cilia mixed gray and white. Hindwing grayish fuscous; cilia very pale gray with darker subbasal line. Foreleg ocherous white, suffused fuscous on outer side; midleg ocherous white with slight fuscous suffusion on outer side of tibia; hindleg ocherous white. Abdomen gray; ventrally first three segments paler.

Female genitalia slide JFGC no. 11640. Ostium very broad; anterior edge concave. Antrum broadly sclerotized. Inception of ductus seminalis from center of bursa copulatrix ventrally. Ductus bursae lightly sclerotized except for narrow membranous area anterior to antrum. Bursa copulatrix ornamented with fine spines and with a strongly sclerotized bulge dorsoanteriorly on right side. Accessory bursa not extending beyond anterior end of bursa copulatrix.

Holotype: U.S. National Museum No. 69752.

Type-locality: Costa Rica, La Florida, 500 feet.

Distribution: Known only from the type-locality.

Described from the female holotype (William Schaus).

This species is very near *turbula* but the latter lacks the subtornal dorsal ring, and the subapical fascia is much longer in *ademonia* than in *turbula*; the forewing of *ademonia* is broader than that of *turbula*.

Further differences may be seen in the genitalia, particularly in the position of the sclerotized swelling, or evagination, from the bursa copulatrix. The characters of the ductus bursae are widely different, also, as may be seen by a comparison of the figures.

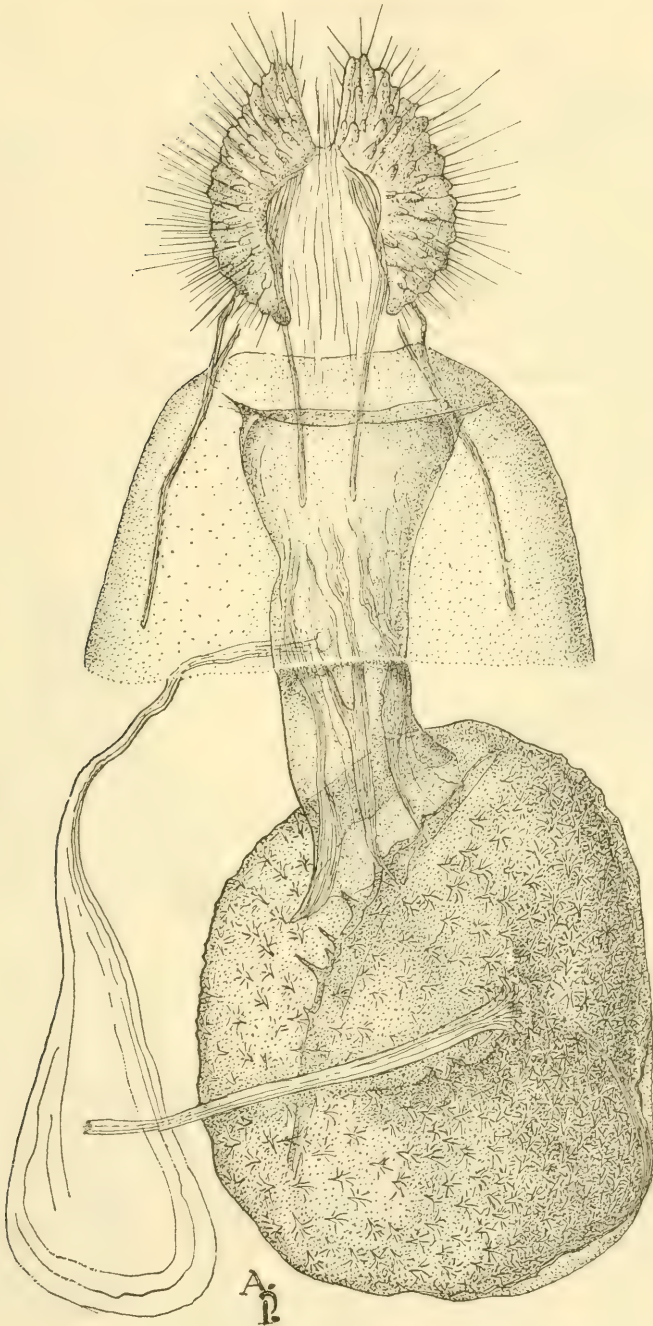


FIGURE 22.—*Irazona ademonia*, new species: ventral view of female genitalia.

Irazona melanoleuca, new species

FIGURE 23; PLATE 1 (FIG. 8)

Alar expanse 21–22 mm.

Labial palpus white; second segment fuscous on outer side of basal half. Antenna fuscous; basal half of scape white. Head white. Thorax fuscous; tip of tegula white. Forewing ground color white, variously suffused and marked with gray; basal sixth of costa blackish fuscous continuing across fold, forming a dark, triangular basal patch containing some leaden gray scaling; from middle of costa a broad gray blotch to cell where, in some specimens, it becomes confluent with a blackish-fuscous band, the latter extending to dorsum well before tornus; on costa, between basal patch and gray blotch, 3 or 4 short gray dashes; from outer fourth of costa to vein 5 a rectangular patch of mixed gray and blackish fuscous continued from its outer extremity as a narrow, curved, fuscous line, to tornus; apical area beyond the rectangular patch spotted with fuscous and

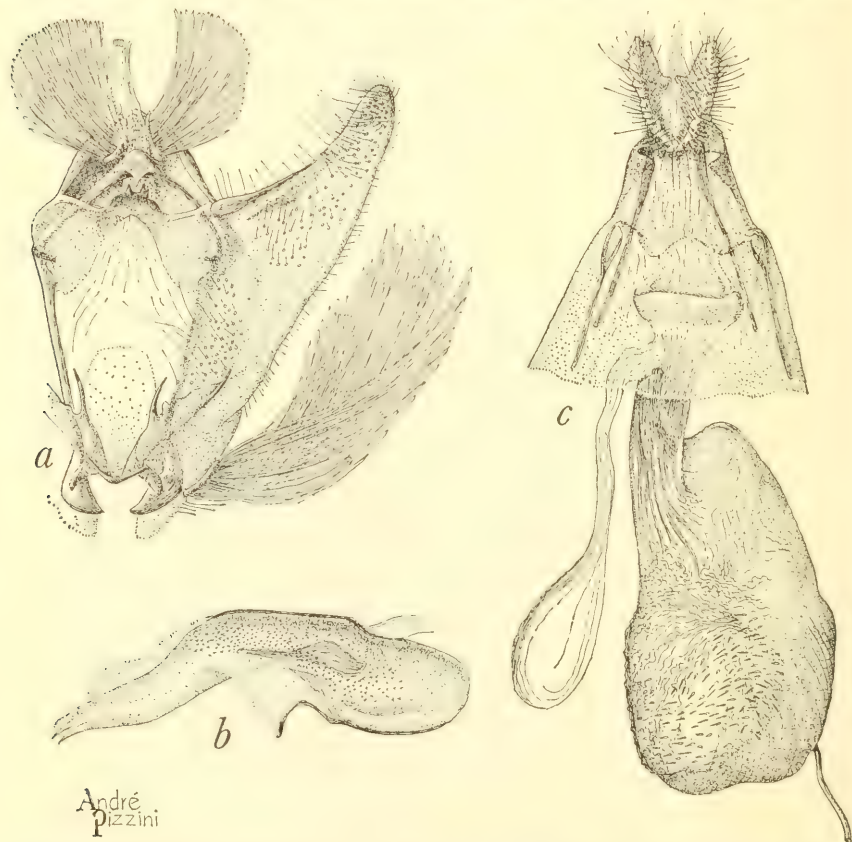

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FIGURE 23.—*Irazona melanoleuca*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

gray; cilia white with broad gray basal band. Hindwing grayish fuscous, paler basally; cilia gray with darker basal band. Foreleg white on inner side, fuscous outwardly; tarsal segments narrowly banded white; midleg white, suffused with fuscous on outer side of femur and tibia; tarsus with spots of fuscous; hindleg ochereous white, faintly marked with grayish. Abdomen white, suffused grayish dorsally and ventrally.

Male genitalia slide JFGC no. 11211. Harpe triangular, very broad basally; cucullus bluntly pointed; sacculus with a sharp, curved spine near base on inner side and a conspicuous hairpencil on outer side. Uncus a very short, digitate process. Transtilla widely expanded laterally; median area narrowed and armed with a few sharp teeth. Vinculum not coalesced at middle; lateral elements curved and thickened anteriorly. Tegumen short and broad. Anellus an elongate, sclerotized plate. Aedeagus stout basally, curved, terminating in a point; vesica armed with a single slender cornutus, dilated basally.

Female genitalia slides JFGC nos. 11624, 11212. Ostium broad, slitlike, posteroventral edge slightly convex. Inception of ductus seminalis dorsally from about middle of bursa copulatrix. Ductus bursae broad, short, ornamented with sclerotized ribs that extend into bursa copulatrix posteriorly; signum absent. Accessory bursa not reaching beyond anterior end of bursa copulatrix.

Holotype: U.S. National Museum No. 69732.

Type-locality: Mexico, Pue.

Distribution: Mexico.

Food plant: *Pinus* species.

Described from the male holotype and 2 ♀♀ paratypes all with identical data (January 1960. Guevara. Rf. *Pinus*).

There appears to be no known close relative of this species except the following, newly described *platina*.

Irazona platina, new species

FIGURE 24; PLATE 2 (FIG. 5)

Alar expanse 16 mm.

Labial palpus fuscous; third segment white on inner side. Antenna fuscous; scape white. Head white. Thorax fuscous with some white posteriorly. Forewing ground color silvery white with pale greenish-yellow reflections; basal fifth of costa, to fold, fuscous; on midcosta a broad, truncated triangular mark extends across end of cell; on costa, between midcostal mark and apex, two grayish-fuscous spots; on dorsum before tornus an elongate, transverse triangular spot preceded and followed by small fuscous dashes; from apex, along termen, a broad fuscous band interrupted by white spots; underside of forewing fuscous; cilia mixed ochraceous buff and fuscous. Hind-

wing sordid white with a fuscous shade around termen and mottled with fuscous inwardly. Foreleg fuscous; tarsal segments narrowly banded with white; midleg similar to foreleg; hindleg ochereous white faintly irrorate with fuscous. Abdomen removed before description.

Male genitalia slide 63-Obr., 1963. Harpe triangular, very broad basally; cucullus narrow, bluntly pointed. Socii two broad, fleshy lobes. Uncus a short, digitate process. Transtilla very broadly expanded laterally, constricted before middle, then expanded; median section armed with many sharp teeth. Vinculum not coalesced. Tegumen about as long as harpe. Anellus a deeply concave plate, fused with base of harpe by a long sclerotized rod, the latter dentate along most of its length. Aedeagus stout, curved, terminating in a pair of sharp points; vesica armed with one large and numerous spiculate cornuti.

Holotype: U.S. National Museum No. 69738.

Type-locality: Costa Rica, Mount Poas.

Distribution: Costa Rica.

Described from the unique male holotype (May).

In appearance similar to *melanoleuca*, but the dark basal patch does not extend across the wing as in that species, and there are pale yellow-green reflections, absent in *melanoleuca*. The genitalia of *platina* lack the strong hairpencil that is present in *melanoleuca*, and the median area of the transtilla is much broader and armed with many spines. The fused anellus and harpe are a distinguishing character of *platina*.

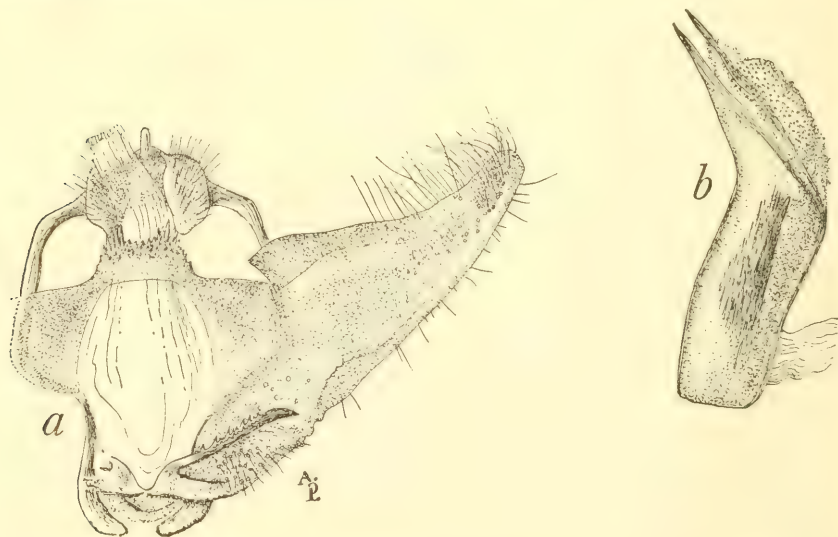


FIGURE 24.—*Irazona platina*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus.

*Lasiothyris Meyrick**Lasiothyris dysmorphia*, new species

FIGURE 25; PLATE 2 (FIG. 6)

Alar expanse 14 mm.

Labial palpus pale buff with fuscous irroration on outer side. Antenna grayish, finely spotted with fuscous basally; scape pale buff with fuscous irroration dorsally. Head pale brown, mixed with buff laterally; face buff. Thorax buff, mixed with pale brown and fuscous; tegula brown, narrowly edged with buff. Forewing ground color pale buff, irregularly irrorate with fuscous and spotted with pale brown; from basal fifth of costa almost to inner angle an ill-defined, brown, basal patch; from slightly beyond middle of costa to dorsum a poorly defined, irregular, brown, transverse fascia that extends narrowly along dorsum to basal third; at apical fifth of costa a quadrate brown blotch; apical area mottled brown; underside strongly infuscated; cilia mixed buff, brown, and fuscous. Hindwing pale buff, slightly shaded fuscous and with fuscous irroration around anal angle; costal hairpencil of male with black spot near outer end. Foreleg buff; femur and tibia fuscous on outer side; tarsal segments broadly banded with fuscous; midleg similar to foreleg; hindleg buff; femur with slight fuscous marking basally on outer side; tibia with sparse fuscous scaling at bases of spurs. Abdomen grayish with some heavy fuscous scaling dorsally; ventrally ochereous white, irrorate with grayish fuscous; anal tuft ochereous white.

Male genitalia slides JFGC nos. 11233, 11628. Harpe very broad basally, abruptly narrowed toward cucullus; cucullus expanded into two widely separated parts; sacculus produced into a long, curved point, the latter preceded by a dense patch of long, stiff setae and a sharp longitudinal ridge. Uncus absent or only faintly indicated. Socii fused along median line, flattened, and with a circular terminal excavation. Vinculum coalesced, broad. Transtilla arched and with double-keeled, median process fused distally. Tegumen very short, arched. Anellus a U-shaped, sclerotized plate. Aedeagus long, slender, curved, terminating in a blunt point; vesica armed with a single, short cornutus.

Holotype: U.S. National Museum No. 69739.

Type-locality: Bolivia, Cochabamba, Incachaca. Tropical cloud area, 2100 m.

Distribution: Known only from the type-locality.

Described from the male holotype (27.VIII-5.IX.56. L. Peña), and one ♂ paratype with the same data.

The extraordinary male genitalia immediately distinguish *dysmorphia* from any of the related species. It appears to be more closely

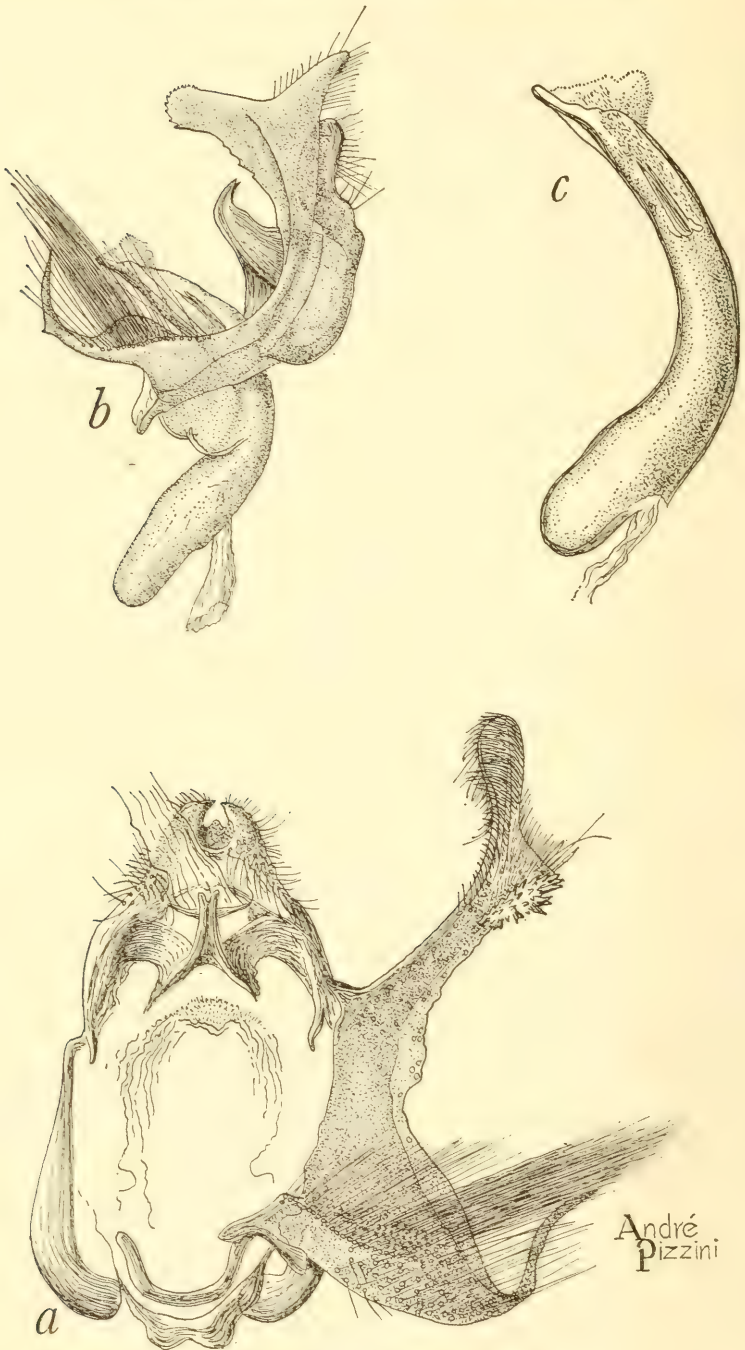
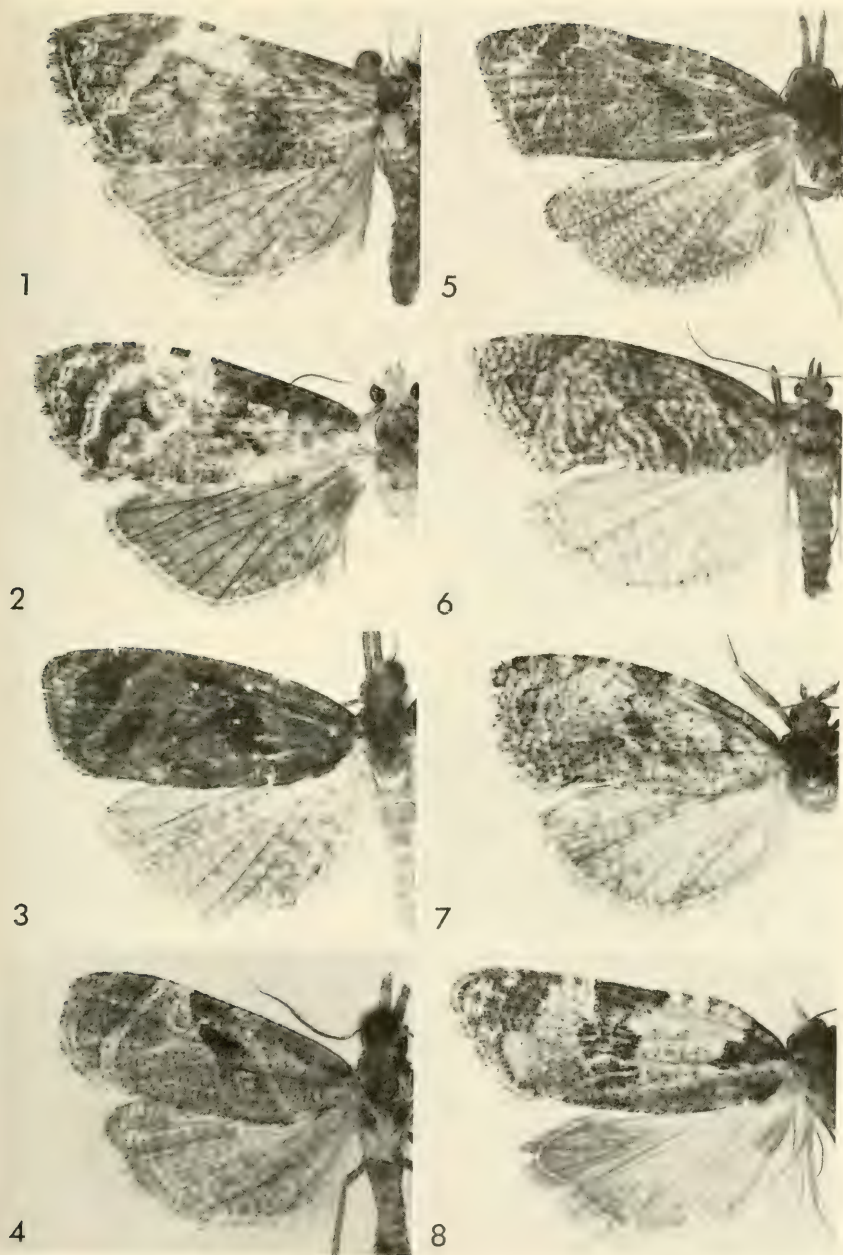
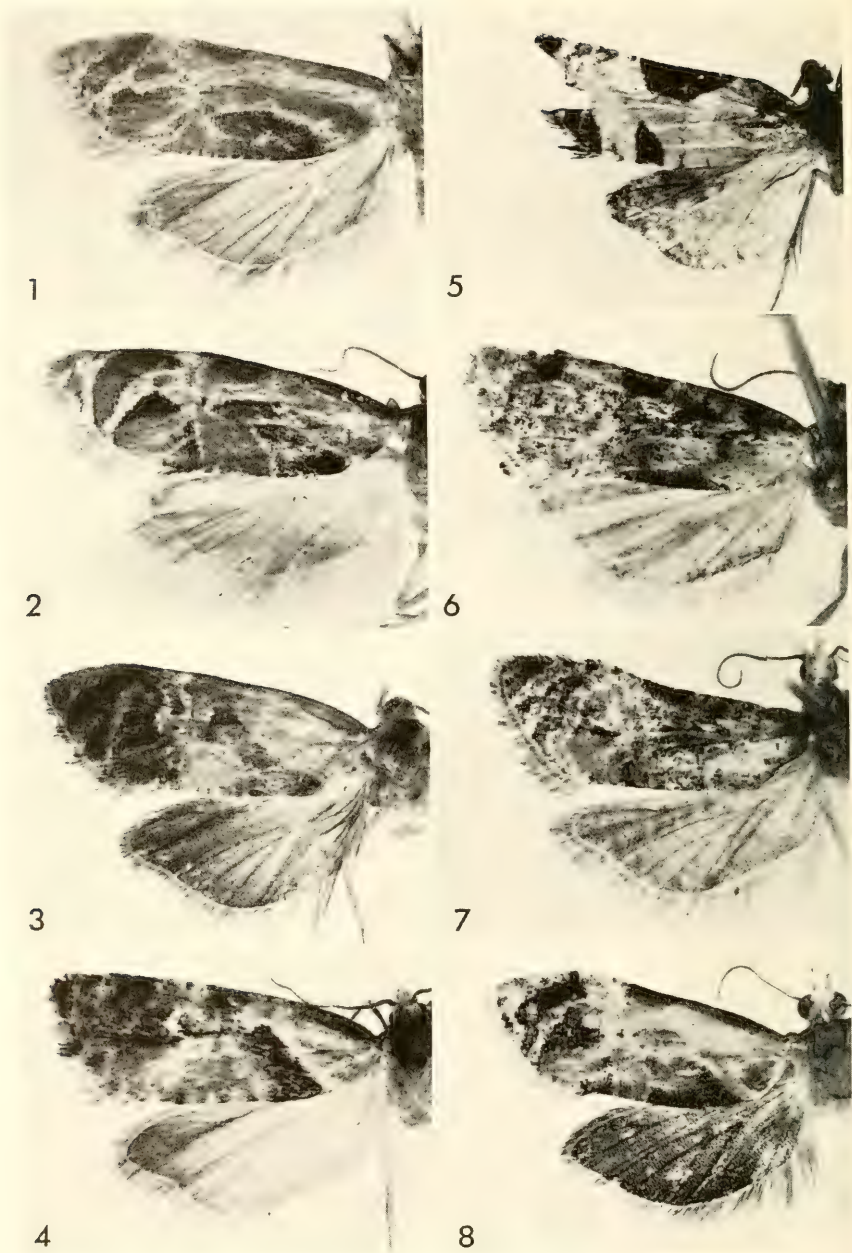


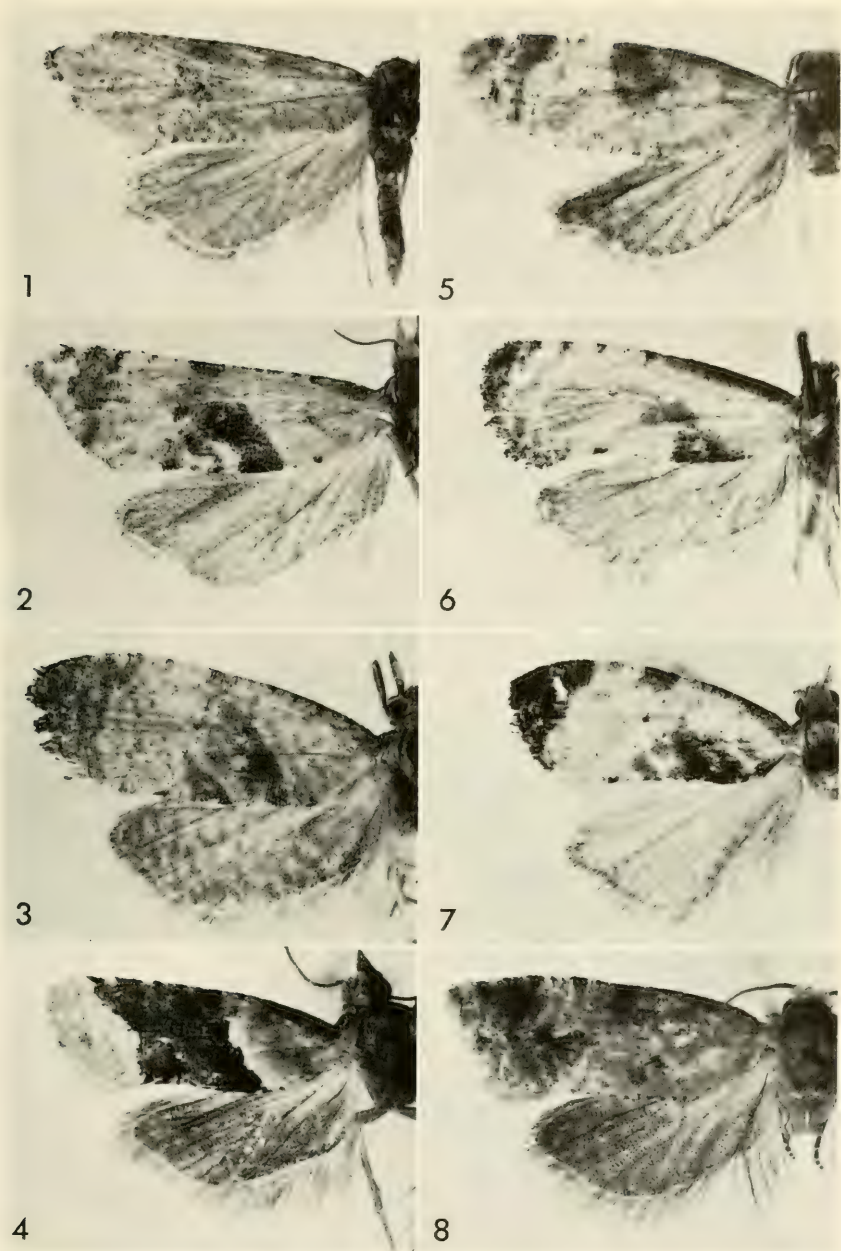
FIGURE 25.—*Lasiothyris dysmorphia*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, lateral aspect of male genitalia with aedeagus in situ; *c*, aedeagus.



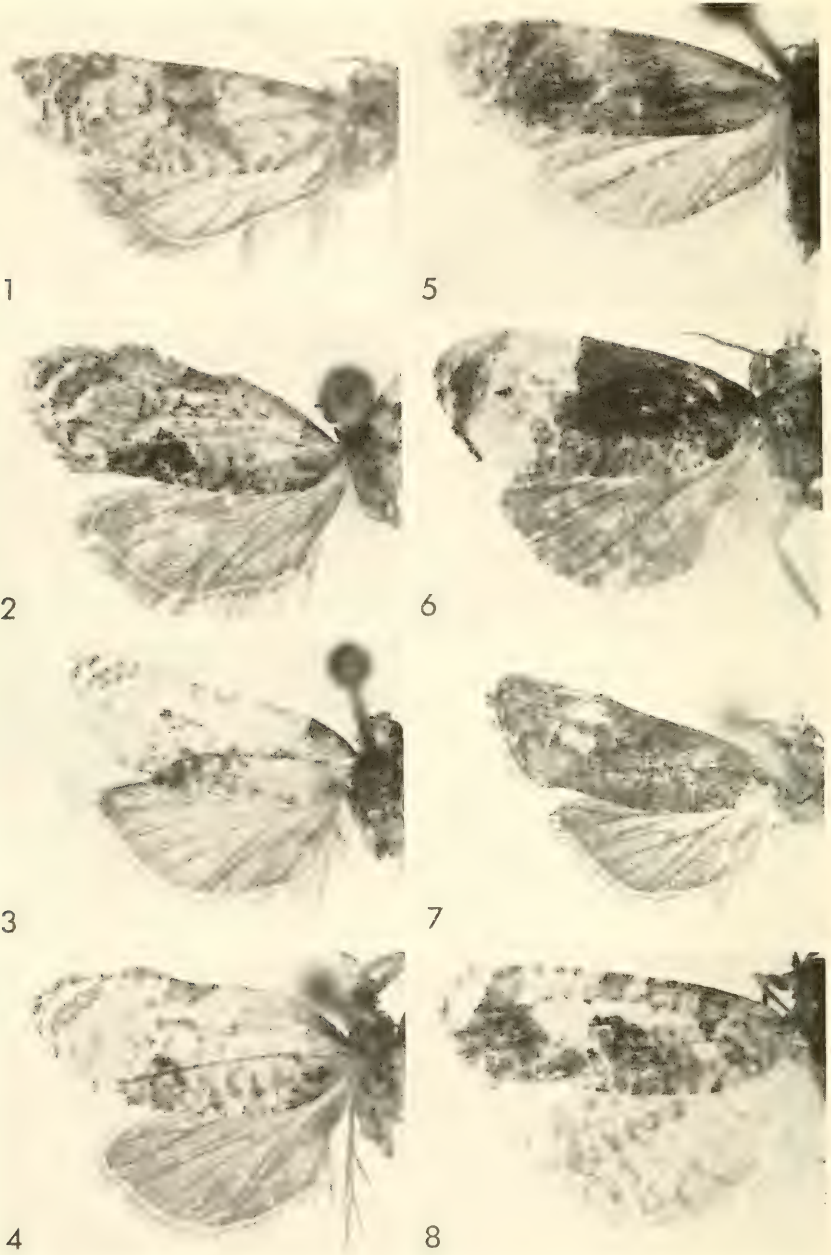
FIGURES 1-8.—1, *Hysterosia turialba* Busck, Guatemala, Volcan Santa Maria; 2, *Hysterosia alplitopa*, new species (paratype), Venezuela, Aragua, Rancho Grande; 3, *Hysterosia iodes*, new species (holotype), Guatemala, Volcan Santa Maria; 4, *Hysterosia melasma*, new species (paratype), Guatemala, Chejel; 5, *Hysterosia gigantea* Busck (type), Mexico, Mexico City; 6, *Phalonia embrihopa* Meyrick, Colombia, Cauca, Páramo de Puracé, Lake San Rafael; 7, *Phalonia embrihopa* Meyrick, Colombia, Nariño, Volcan Galeras; 8, *Irazona melanoleuca*, new species (paratype), Mexico, Pue.



FIGURES 1-8.—1, *Amallectis anaxia*, new species (holotype), Guatemala, Volcan Santa Maria; 2, *Amallectis peñai*, new species (holotype), Bolivia, Cochabamba, Incachaca; 3, *Amallectis nephelodes*, new species (holotype), Bolivia, Cochabamba, Incachaca; 4, *Amallectis domna*, new species (holotype), Colombia, Nariño, Volcan Galeras; 5, *Irazona platina*, new species (holotype), Costa Rica, Mount Poas; 6, *Lasiothyris dysmorphia*, new species (paratype), Bolivia, Cochabamba, Incachaca; 7, *Phalonia tornosema*, new species (paratype), Guatemala, Volcan Santa Maria; 8, *Amallectis frangula*, new species (holotype), Brazil, Nova Teutonia.



FIGURES 1-8.—1, *Lasiothyris hemitephras*, new species (holotype), Mexico, Tehuacan; 2, *Cochylis mendora*, new species (paratype), Chile, Santiago Prov., Cajon de Maypo, Cordillera, El Canelo; 3, *Cochylis laetitia*, new species (holotype), Argentina, Tucumán, Ciudad Universitaria; 4, *Cochylis caesiata*, new species (holotype), Venezuela, Aragua, Rancho Grande; 5, *Phtheochroa arrhostia*, new species (holotype), Peru, Cusco, Machu Picchu; 6, *Carolella asthenia*, new species (holotype), Guatemala, Palin; 7, *Phalonia charma*, new species (holotype), Argentina, Tucumán, Ciudad Universitaria; 8, *Carolella molybdina*, new species (paratype), Mexico, S.L.P., Tamazunchale.



FIGURES 1-8.—1, *Phalonidia heterophaea*, new species (holotype), Colombia, Antioquia, La Estrella; 2, *Irazona icogramma*, new species (holotype), Guatemala, Volcan Santa Maria; 3, *Irazona turbula*, new species (holotype), Guatemala, Volcan Santa Maria; 4, *Irazona ademonia*, new species (holotype), Costa Rica, La Florida; 5, *Lasiothyris diamphidia*, new species (paratype), Peru, Cusco, Machu Picchu; 6, *Cochylys serena*, new species (paratype), Brazil, Nova Teutonia; 7, *Phalonia vesta*, new species (holotype), Venezuela, Aragua, Rancho Grande; 8, *Cochylys constantia*, new species (holotype), Peru, Cusco, Machu Picchu.

related to *diamphidia* than any of the others but is easily separated by the genitalia.

Lasiothyris diamphidia, new species

FIGURE 26; PLATE 4 (FIG. 5)

Alar expanse 12–14 mm.

Labial palpus ochereous white; second segment shaded with buff and irrorate with brown on outer side; apex of third segment fuscous. Antenna grayish, speckled fuscous dorsobasally; scape ochereous white with fine fuscous irrorations. Head ochereous white, mixed with pale brown laterally and on crown. Thorax light brown, slightly suffused fuscous; tegula ochereous white posteriorly. Forewing ground color ochereous white suffused with buff; basal fifth light clay color, forming an ill-defined basal patch; costa finely strigulated with fuscous; from middle of costa to dorsum an inwardly oblique, clay color, transverse fascia, wider on dorsum than on costa and mixed with blackish-fuscous scales on dorsum and on dorsal half of inner margin; on tornus a large, tawny blotch, irrorate with blackish fuscous; from apical fourth of costa a tawny fascia outwardly oblique and attenuated to vein 4; subapically, on costa, a tawny spot; apical portion of wing with ill-defined, light clay color, transverse dashes and scattered blackish-fuscous scales; underside strongly infuscated except on apical half of costa; cilia buff mixed with gray-tipped scales. Hindwing ochereous white with grayish-fuscous shading at anal angle and on inner margin; apex with some short grayish-fuscous strigulae; cilia light buff with grayish subbasal line. Foreleg ochereous white; femur and tibia heavily irrorate with grayish fuscous on outer side; tarsal segments almost wholly overlaid fuscous; midleg similar to foreleg but tarsus less strongly marked; hindleg ochereous white; femur lightly irrorate with grayish fuscous on outer side. Abdomen grayish fuscous dorsally; buff, with fuscous irroration ventrally.

Male genitalia slide JFGC no. 11657. Harpe on right side broad, tapered to a rounded cucullus; sacculus strongly sclerotized, produced outwardly and clothed with stout, long setae; sclerotization of sacculus extended to middle of harpe into two thickened lumps. Left harpe moderately broad basally, abruptly narrowed into a slender terminal portion; from base of sacculus a long, hooked process. Uncus minutely developed and fused with bases of socii. Socii fused along median line, except at distal end. Vinculum coalesced and intimately associated with anellus. Tegumen nearly as long as harpe. Anellus a long U-shaped plate fused with aedeagus. Aedeagus long, rather slender open S-shaped, terminating in a sharp point; vesica unarmed.

Female genitalia slide JFGC no. 11658. Ostium asymmetrical;

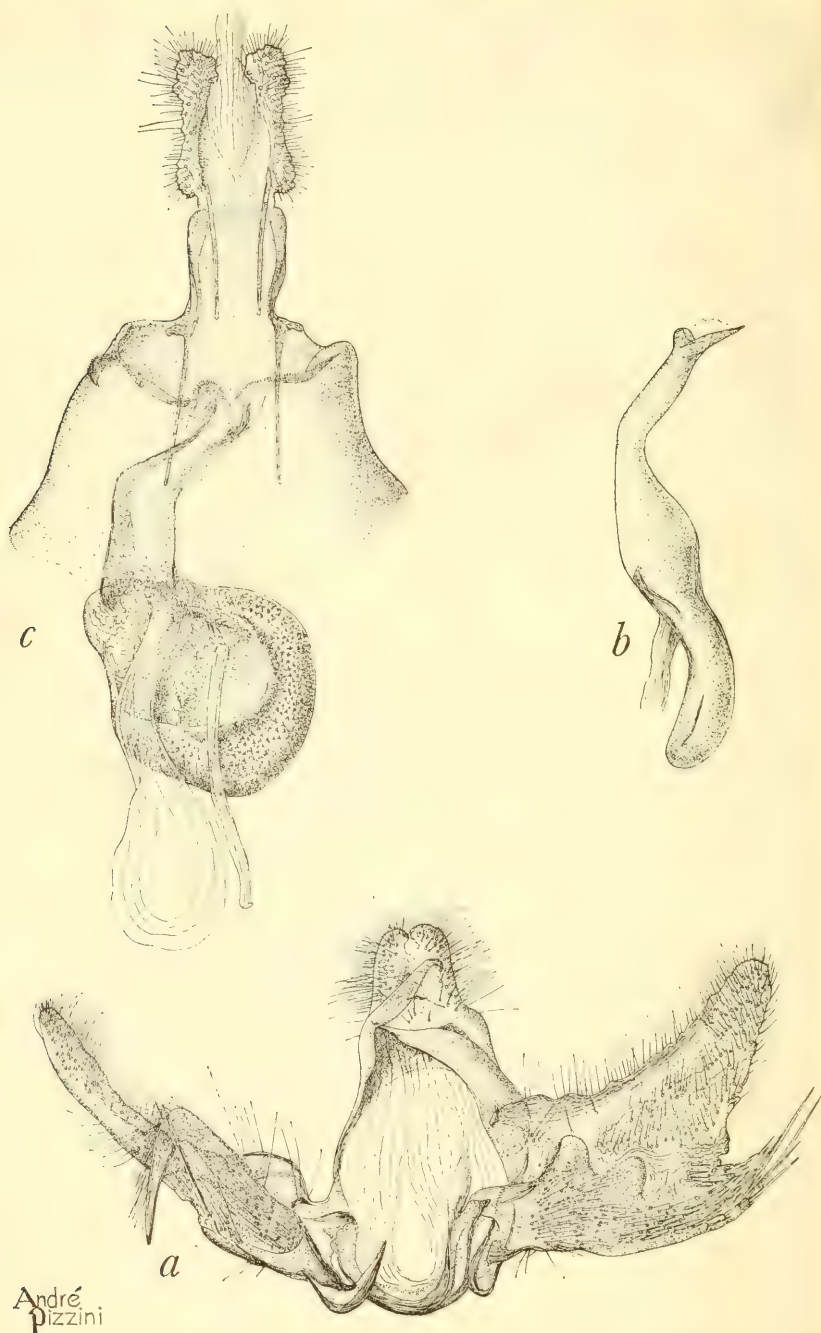


FIGURE 26.—*Lasiothyris diamphidia*, new species: *a*, ventral view of male genitalia with aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

anterior edge V-shaped, solidly fused with posterior margin of seventh sternum. Antrum not differentiated. Inception of ductus seminalis from middle of bursa copulatrix. Ductus bursae bent, sclerotized for its entire length. Accessory bursa arising at juncture of ductus bursae and bursa copulatrix. Bursa copulatrix heavily sculptured from juncture with ductus bursae to beyond middle; anteriorly and laterally clothed with a mass of short, stout spines.

Holotype: U.S. National Museum No. 69753.

Type-locality: Peru, Cusco, Machu Picchu.

Distribution: Known only from the type-locality.

Described from the male holotype (5.II.1959, J. F. G. Clarke), and 2 ♀ ♀ paratypes all from the same locality. The females are dated "6.II.1959."

This species is superficially very similar to *Phalonia sublimis* Meyrick but differs widely in the genitalia. The female genitalia of *diamphidia* are solidly fused with the posterior margin of the seventh sternum, those of *sublimis* are not; moreover, the ostium of *diamphidia* is markedly asymmetrical, that of *sublimis* is not. The male of *sublimis* is not known, but the male genitalia of *diamphidia* are unusually asymmetrical and the long aedeagus is fused to the anellus. I know of no other phaloniid with such marked asymmetry in the male genitalia.

Lasiothyris hemitephras, new species

FIGURE 27; PLATE 3 (FIG. 1)

Alar expanse 16–18 mm.

Labial palpus ochereous white; second segment sparsely and minutely irrorate with fuscous. Antenna pale grayish fuscous; scape ochereous white. Head ochereous white; laterally and on crown, light buff. Thorax ochereous white; tegula buff anteriorly. Forewing ground color cinereous; from mid-dorsum to costal edge of cell, a transverse ochraceous-buff shade; apical third ochraceous buff, irregularly and sparsely spotted with cinereous; underside rather strongly infuscated; cilia cinereous with a dark gray basal line. Hindwing light grayish fuscous; cilia ochereous white with a gray subbasal line. Foreleg ochereous white marked with cinereous; midleg similar to foreleg; hindleg ochereous white. Abdomen pale grayish fuscous dorsally, ochereous white ventrally.

Female genitalia slides JFGC no. 11222, 11717. Ostium wide, asymmetrical. Antrum not differentiated. Inception of ductus seminalis from left side of bursa copulatrix. Ductus bursae short, very broad, strongly sclerotized, with two longitudinal, folded ridges ventrally. Bursa copulatrix mostly membranous; accessory bursa

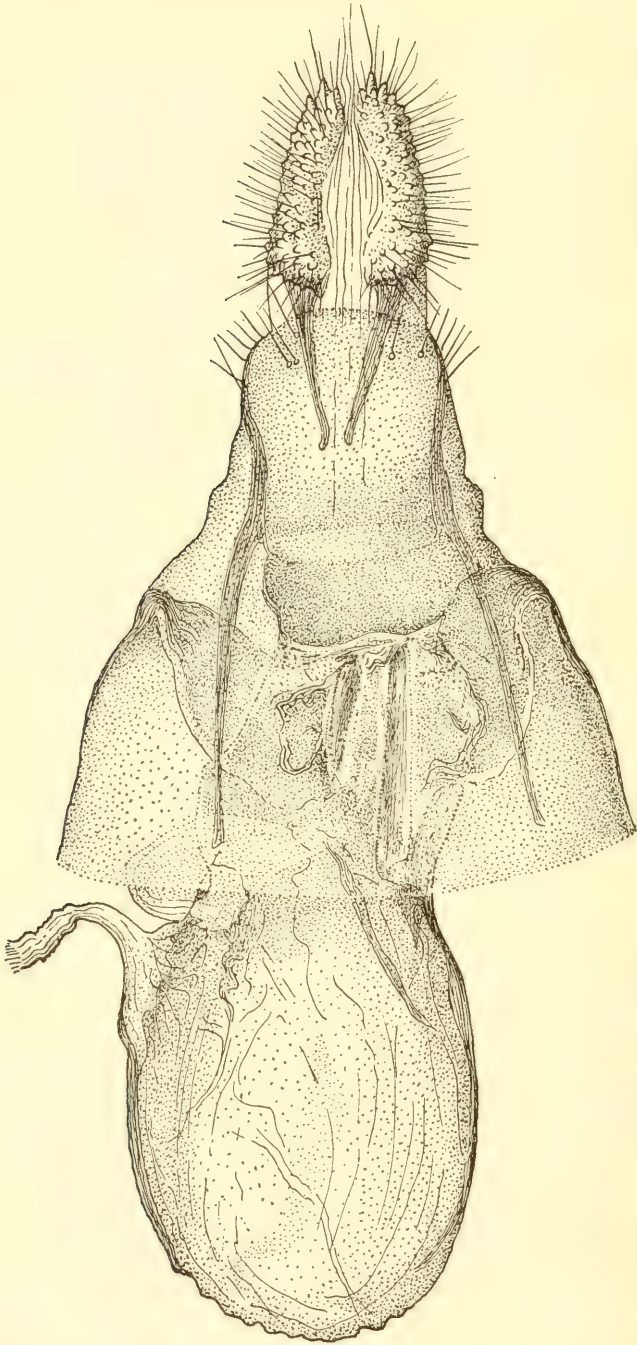


FIGURE 27.—*Lasiothyris hemitephras*, new species: ventral view of female genitalia.

very small, from dorsal, median surface of ductus bursae.

Holotype: U.S. National Museum No. 69741.

Type-locality: Mexico, Tehuacan.

Distribution: Mexico.

Described from the female holotype (October 10) and three ♀ paratypes all from the same locality (September 12).

I have placed *hemitephras* in *Lasiothyris* on the basis of the asymmetrical and much involved genitalia. Males are not known but probably, when discovered, will approach *diamphidia* in the form of the genitalia.

There are no species that are similar to *hemitephras* in coloring or maculation. Superficially, the forewing of *hemitephras* appears pale gray in the basal three-fifths and ochraceous buff in the apical two-fifths.

Carolella Busck

Carolella molybdina, new species

FIGURE 28; PLATE 3 (FIG. 8)

Alar expanse 11–14 mm.

Labial palpus creamy white; second segment with slight infuscation basally on outer side. Antenna gray; scape creamy white. Head creamy white with ochereous suffusion laterally. Thorax ochraceous buff with dull fuscous suffusion; tegula paler posteriorly. Forewing ground color yellow ocher; on vein 1b three small spots of leaden gray scales, and between the basal two, touching cell, a fuscous spot; costa mostly leaden gray with short, transverse fasciae of this color at one-sixth, one-third, midcosta, and at apical third, the last continued outwardly and obliquely as a line to vein 4, then inwardly, obliquely, to tornus; several groups of leaden-gray scales between this fascia and apex; outer third of wing, between the lead-colored lines and spots, fuscous, mixed with tawny; on middle of costa a fuscous patch edged inwardly with tawny; underside fuscous, with a few whitish spots on outer half of costa; cilia alternating groups of buff and leaden-gray scales. Hindwing fuscous; paler basally; cilia light gray with a broad grayish-fuscous subbasal line. Foreleg creamy white; femur and tibia heavily overlaid with fuscous on outer side; tarsal segments broadly banded with fuscous; midleg similar to foreleg; hindleg ochereous white; tibia suffused fuscous dorsally; tarsus broadly banded with fuscous. Abdomen grayish fuscous; ventrally segments edged with ochereous white posteriorly.

Male genitalia slide JFGC no. 9624. Harpe broad, rectangular, almost as wide as long; cucullus truncate; sacculus dilated basally.

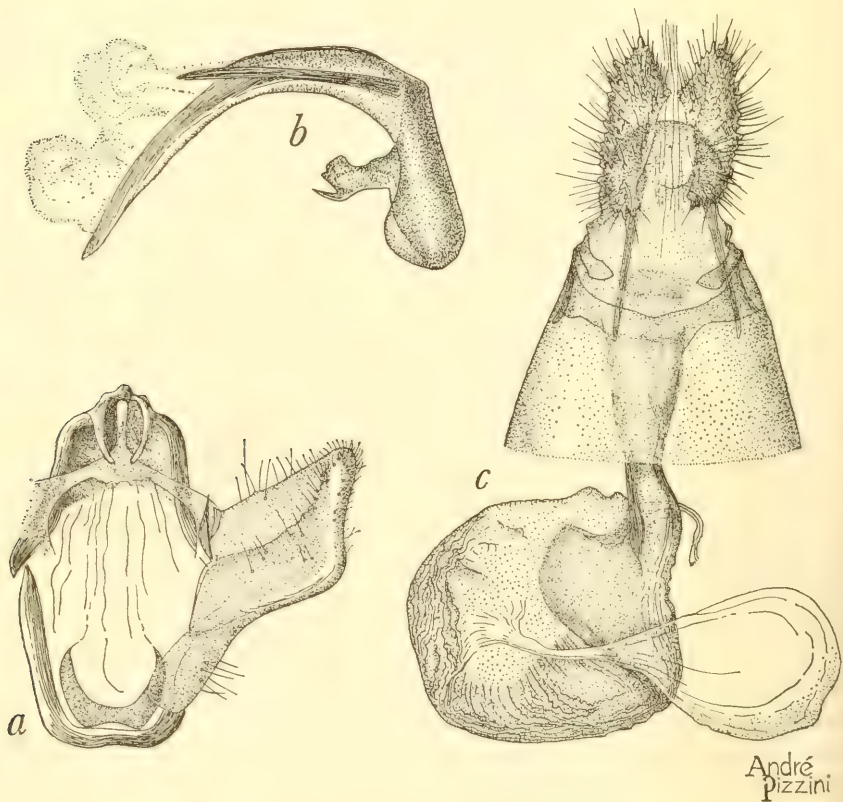
Transtilla narrow with long median projection. Uncus short, broad. Vinculum U-shaped, coalesced. Tegumen short, narrow. Anellus a U-shaped plate. Aedeagus long, slender, curved, pointed; vesica armed with a single long, slender cornutus.

Female genitalia slides JFGC nos. 11636, 11682. Ostium very wide; anterior margin concave. Antrum constricted but not differentiated from ductus bursae. Inception of ductus seminalis at juncture of ductus bursae and bursa copulatrix. Ductus bursae sclerotized; on each side a longitudinal fold. Bursa copulatrix mostly membranous with fine sculpturing and ventrally, a large, sclerotized fold. Accessory bursae arising in a depression on the left side of bursa copulatrix.

Holotype: U.S. National Museum No. 69746.

Type-locality: Mexico, S. L. P., Tamazunchale.

Distribution: Mexico.



André
Pizzini

FIGURE 28.—*Carolella molybdina*, new species: *a*, ventral view of male genitalia with left harpe and aedeagus removed; *b*, aedeagus; *c*, ventral view of female genitalia.

Described from the female holotype (6 Jan. 1948, Leary), 2♀♀ and one ♂ paratypes; ♂, same locality as holotype (1.IV.47, Chapman); ♀, "Mexico" (5.IV.54, Baker and Allen); ♀, San Luis Potosi (23.IV.47, Chapman).

Food plant: "Orchid plants."

Carolella asthenia, new species

FIGURE 29; PLATE 3 (FIG. 6)

Alar expanse 12 mm.

Labial palpus shining white on inner side, ocherous white on outer side. Antenna pale brown; scape white. Head white. Thorax white; tegula pale gray anteriorly. Forewing ground color creamy white; basal half of costa grayish fuscous edged with clay color on inner margin; in apical third of costa three small grayish-fuscous spots; on basal third of dorsum a fuscous blotch confluent with a clay-colored, outwardly oblique blotch that extends into middle of cell; at the end of a small fuscous dot; apical third lightly strigulated with pale ochraceous buff; extreme apex grayish fuscous; underside suffused fuscous; cilia gray, irrorate with fuscous. Hindwing very pale grayish fuscous; cilia light gray with slightly darker basal band. Foreleg ocherous with light fuscous suffusion on outer side of femur and tibia; midleg similar to foreleg; tarsus fuscous annulated; hindleg ocherous white.

Male genitalia slide JFGC no. 11616. Harpe broad basally, unornamented; cucullus rounded. Transtilla lightly sclerotized laterally with a long bluntly pointed median process. Socii long, slender, digitate,



FIGURE 29.—*Carolella asthenia*, new species: a, ventral view of male genitalia with aedeagus removed; b, aedeagus.

terminating in a point. Vinculum weak, not coalesced. Tegumen broad; truncate posteriorly. Anellus an elongate, lightly sclerotized, curved plate. Aedeagus stout, abruptly curved at distal third, sharply pointed; vesica armed with a single cornutus about half the length of aedeagus.

Holotype: U.S. National Museum No. 69747.

Type-locality: Guatemala, Palin.

Distribution: Known only from the type-locality.

Described from the unique male holotype. (July. Schaus and Barnes).

On the basis of the male genitalia I am placing this species in *Carotella*, but on habitus it is far removed from the North American members of the genus. In *asthenia* the apex of the median projection of the transtilla is spinous but in the type of the genus, *Pharmacis sartana* Hubner, it is smooth. The aedeagus of *asthenia* is less stocky than that of *sartana* and the cornutus is more slender.

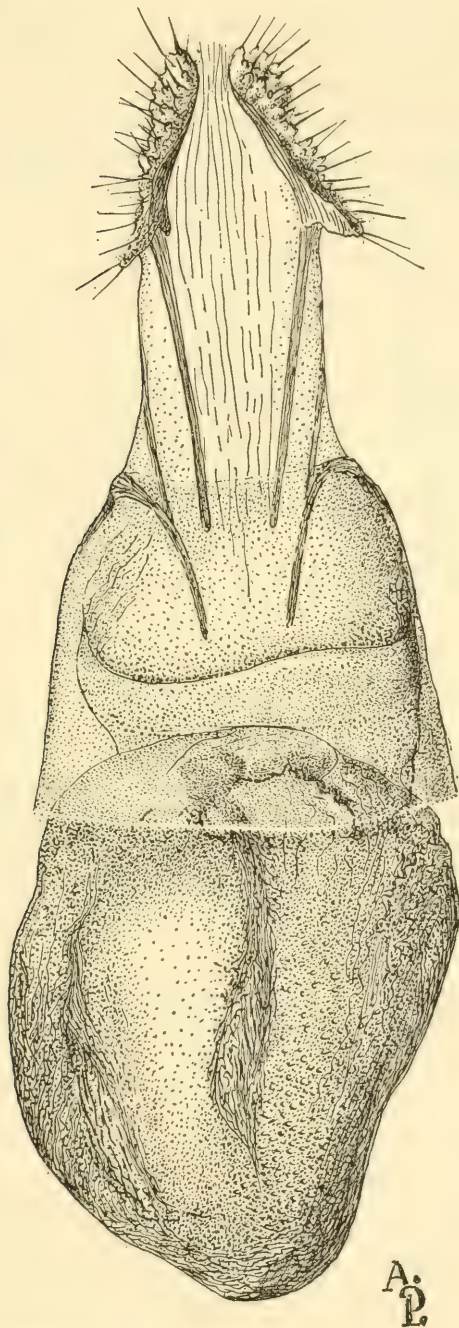
Phtheochroa Stephens

Phtheochroa arrhostia, new species

FIGURE 30; PLATE 3 (FIG. 5)

Alar expanse 10–11 mm.

Labial palpus white; second segment light ochraceous buff, irrorate with fuscous on outer side. Antenna light grayish fuscous, whitish dorsobasally; scape creamy white. Head creamy white; posteriorly and laterally ochereous white. Thorax ochereous white with light infuscation anteriorly. Forewing ground color creamy white; basal patch small, primarily indicated by a small grayish-fuscous spot on costa at basal fifth, continued transversely to fold, then inwardly to dorsum as a pale, ill-defined buff line; on middle of costa a large grayish-fuscous blotch continued to middle of cell; at apical third, on costa, a grayish-fuscous spot continued transversely and outwardly to vein 5 as a grayish-buff fascia; at end of cell a small fuscous spot followed outwardly by an ill-defined, irregular, transverse, pale buff fascia; from vein 5 around termen and tornus and along dorsum, a series of short, fine, fuscous strigulae; underside strongly infuscated except along costa; cilia mixed buff and white. Hindwing sordid white shading to and mottled with grayish fuscous at apex and outer margins; cilia sordid white with gray subbasal band. Foreleg creamy white; femur and tibia irrorate with fuscous on outer side; tarsus broadly banded with grayish fuscous; midleg similar to foreleg;

A.
P.FIGURE 30.—*Phtheochroa arrhostia*, new species: ventral view of female genitalia.

hindleg ochereous white with sparse, grayish-fuscous irroration. Abdomen grayish fuscous dorsally; ventrally ochereous white.

Female genitalia slide JFGC no. 11615. Ostium very wide, slitlike. Antrum narrowly sclerotized. Ductus bursae scarcely definable. Bursa copulatrix with serrate sclerotized area, where it joins ductus bursae, and an elongate, sclerotized portion dorsally; lamella postvaginalis broad, lightly sclerotized.

Holotype: U.S. National Museum No. 69748.

Type-locality: Peru, Cusco, Machu Picchu, 2385 m.

Distribution: Peru.

Described from the female holotype (5.III.1959, J. F. G. Clarke), and one ♀ paratype with the same data.

In placing *arrhostia* in *Phtheochroa* I do so with some hesitation, but there is no other available genus that has a female approaching this. Hubner's *rugosana*, the type of the genus, exhibits the broad ostial opening as in *arrhostia*, but the latter has much more sculpturing in the bursa copulatrix.

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Neotropical Microlepidoptera Series in the *Proceedings*

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Cyclopoid Copepods of the Genus *Lichomolgus*

Associated with Octocorals of the
Family Nephtheidae in Madagascar

By Arthur G. Humes and Ju-Shey Ho¹

Only one lichomolgid copepod, *Lichomolgus spinulifer* Humes and Frost, 1964, has been reported as an associate of nephtheid octocorals in Madagascar, where it lives on *Lemnalia* sp. This paper deals with six new species of *Lichomolgus* and with *L. spinulifer* washed from various species of Nephtheidae in the region of Nosy Bé in northwestern Madagascar.

All collections were made by A. G. Humes, those in 1960 during an expedition sponsored by the Academy of Natural Sciences of Philadelphia, and those in 1963-64 as part of the U.S. Program in Biology of the International Indian Ocean Expedition.

The study of the specimens has been aided by a grant (GB-5838) from the National Science Foundation of the United States.

All figures have been drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are: A_1 =first antenna, A_2 =second antenna, L =labrum, $MXPD$ =maxilliped, and P_1 =leg 1.

All descriptions are based on type material. The measurements of the length of the body have been made in all cases from specimens in

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lactic acid and do not include the setae on the caudal rami. The lengths of the segments of the first antenna have been measured along their posterior nonsetiferous margins.

We are indebted to Mme. A. Tixier-Durivault of the Muséum National d'Histoire Naturelle, Paris, for the identifications of the octocorals collected in 1960, and to Dr. J. Verseveldt, Zwolle, The Netherlands, for the determinations of those collected in 1963-64.

The new copepods described in this paper comprise the following:

1. *Lichomolgus varirostratus*, new species—from *Dendronephthya mucronata* (Pütter), *D. regia* Verseveldt, *D. stocki* Verseveldt, and *D. köllikeri* Kükenthal.
2. *Lichomolgus exilipes*, new species—from the same four species of *Dendronephthya*.
3. *Lichomolgus gentilis*, new species—from *Dendronephthya mucronata* (Pütter), *D. stocki* Verseveldt, *D. köllikeri* Kükenthal, *Stereonephthya acaulis* Verseveldt, and *S. papyracea* Kükenthal.
4. *Lichomolgus fissisetiger*, new species—from *Stereonephthya acaulis* Verseveldt, *S. papyracea* Kükenthal, and *Lemnalia elegans* (May).
5. *Lichomolgus cuneipes*, new species—from *Stereonephthya acaulis* Verseveldt.
6. *Lichomolgus aculeatus*, new species—from *Nephthea aberrans* Verseveldt, *N. sphaerophora* Kükenthal, *N. crassa* Kükenthal, *N. tixierae* Verseveldt, and *Litophyton arboreum* Forskål.

The following new hosts are recorded for *Lichomolgus spinulifer* Humes and Frost, 1964:

Lemnalia flava May, *L. elegans* (May), *L. amabilis* Tixier-Durivault, *L. africana* (May), and *Paralemnalia thyrsoides* (Ehrenberg).

Family LICHOMOLGIDAE KOSSMANN, 1877

Genus *Lichomolgus* Thorell, 1860

Lichomolgus varirostratus, new species

FIGURES 1-31

TYPE MATERIAL.—133 ♀♀, 95 ♂♂, and 7 copepodids from a colony of *Dendronephthya mucronata* (Pütter), in 4 m, on the northeastern coast of Antany Mora, Isles Radama, Madagascar, 14°06'10" S, 47°45'10" E, collected Sept. 30, 1964. Holotype ♀, allotype, and 85 paratypes (50 ♀♀ and 35 ♂♂) deposited in the United States National Museum, the same number of paratypes in the Zoölogisch Museum,

Amsterdam, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Dendronephthya mucronata*: 168 ♀♀ and 118 ♂♂ from 6 colonies, in 1 m, off Ampombilava, Nosy Bé, Madagascar, Sept. 26, 1964; 7 ♀♀ and 8 ♂♂ from 1 colony, in 1 m, Tany Kely, a small island south of Nosy Bé, June 23, 1963; 38 ♀♀, 36 ♂♂, and 4 copepodids from 1 colony, in 2 m, northern end of Nosy Sakatia, near Nosy Bé, Aug. 19, 1963; and 3 ♀♀ and 1 ♂ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963. From *Dendronephthya regia* Verseveldt: 5 ♀♀ and 1 ♂ from 1 colony, in 40 m, Banc de Cinq Mètres, west of Nosy Bé, at about 13°23'39" S, 48°04'00" E, Aug. 19, 1964. From *Dendronephthya stocki* Verseveldt: 3 ♀♀ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963, and 4 ♀♀ and 2 ♂♂ from 1 colony, in 40 m, Banc de Cinq Mètres, Aug. 19, 1964. From *Dendronephthya köllikeri* Kükenthal: 3 ♀♀ and 9 ♂♂ from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59' S, 47°46.5' E, Sept. 30, 1964.

FEMALE.—Body (fig. 1) with moderately broad prosome. Length 0.83 mm (0.77–0.90 mm) and greatest width (near middle of cephalosome) 0.47 mm (0.43–0.49 mm), based on 10 specimens. Ratio of length to width of prosome 1.24:1. Segment of first leg separated dorsally and laterally from head by a transverse furrow; lateral areas of this segment rounded posteriorly and not expanded. Lateral areas of segment bearing leg 2 expanded, those of segment of leg 3 expanded and slightly truncated, and those of segment of leg 4 small and rounded.

Segment of leg 5 (fig. 2) about twice as wide as long, $65\mu \times 120\mu$. Ventrally between this segment and genital segment a slight intersegmental sclerite. Genital segment (fig. 2) a little longer than wide, $138\mu \times 118\mu$, in dorsal view expanded in its midregion, anterior and posterior to which the segment is constricted (anterior constricted area set off ventrally from rest of segment by a weak transverse line). Areas of attachment of egg sacs situated dorsolaterally on posterior part of expanded area. Each area (fig. 3) with 2 naked spini-form setae, both about 11μ in length, and a prominent unguiform process. Three postgenital segments $36\mu \times 68\mu$, $26\mu \times 63\mu$, and $50\mu \times 62\mu$, from anterior to posterior.

Caudal ramus (fig. 4) about as long as wide, its greatest dimensions being $25\mu \times 28\mu$ when measured dorsally and $29\mu \times 28\mu$ when measured ventrally. Of the usual 6 setae, outer lateral seta 48μ long, pedicellate dorsal seta 26μ , outermost distal seta 73μ , innermost distal seta 122μ , and the 2 long median terminal setae 208μ (outer) and 290μ (inner) and both inserted between dorsal (unornamented) and ventral (with marginal rows of spinules) flaps. All these setae naked except

innermost distal one, which has a row of hairs along inner edge. A few surficial hairs on ramus.

Dorsal surface of prosome and urosome with minute hairs. Ratio of length of prosome to that of urosome 1.9:1.

Most ovigerous females observed carrying clusters of eggs, as in figure 1, rather than complete sacs; egg sacs delicate and easily broken in preserved specimens. One of the few intact egg sacs (fig. 5) $473\mu \times 180\mu$, elongated, reaching nearly to ends of ramal setae, with each egg about 50μ – 55μ in diameter.

Rostral area (fig. 6) broadly rounded posteroventrally.

First antenna (fig. 7) 7-segmented, 360μ in length, with third segment showing ventrally a proximal sclerotized area suggesting an intercalary segment. Lengths of segments: 39μ (66μ along anterior margin), 98μ , 26μ , 50μ , 54μ , 37μ , and 28μ respectively. Formula for armature: 4, 13, 6, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. All setae naked except for 2 delicately plumose on last segment.

Second antenna (fig. 8) 4-segmented, with last segment moderately elongated, 91μ along its outer edge, 52μ along its inner edge, and 26μ wide. Each of first 2 segments with a small inner seta and surficial spinules as indicated in the figure, third segment with 3 setae (2 subequal and much longer than third), and last segment with 7 elements: 5 short hyaline elements and 2 long slightly unequal recurved claws 101μ and 91μ (measured along greatest axis). All setae naked.

Labrum (fig. 9) with 2 relatively short broadly rounded posteroventral lobes.

Mandible (fig. 10) with basal region distal to constriction bearing on its convex margin a row of spinules followed by a serrated fringe and on its concave margin a row of slender spinules; flagellum elongated with lateral spinules. Paragnath (fig. 11) a small hairy lobe. First maxilla (fig. 12) an elongated segment bearing 3 terminal setae. Second maxilla (fig. 13) 2-segmented, large first segment unarmed, second segment with a small setule on proximal outer margin, a surficial posterior seta barbed along one edge, an inner distal spine with prominent lateral spinules, and the segment produced distally to form a lash with dentiform spines along one edge proximally and fine bilateral spinulation distally. Maxilliped (fig. 14) 3-segmented, first segment with surficial spinules, second with 2 unequal barbed setae and an inner marginal row of small spinules, and third with 2 terminal spiniform barbed setae (producing a bifurcated appearance) and a naked setule. (Articulations of these 2 setae obscure, with inner one perhaps a process rather than an actual seta.)

Area between maxillipeds and first pair of legs (fig. 15) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 16-19) with trimerous rami except for 2-segmented endopod of leg 4. Armature of legs as follows (Roman numerals = spines, Arabic numerals = setae):

| | | | | | | | |
|----------------|----------|-----|-----|-----|-----|-----|---------|
| P ₁ | protopod | 0-1 | 1-0 | exp | I-0 | I-1 | III,I,4 |
| | | | | end | 0-1 | 0-1 | I,5 |
| P ₂ | protopod | 0-1 | 1-0 | exp | I-0 | I-1 | III,I,5 |
| | | | | end | 0-1 | 0-2 | I,II,3 |
| P ₃ | protopod | 0-1 | 1-0 | exp | I-0 | I-1 | III,I,5 |
| | | | | end | 0-1 | 0-2 | I,II,2 |
| P ₄ | protopod | 0-1 | 1-0 | exp | I-0 | I-1 | II,I,5 |
| | | | | end | 0-I | II | |

Inner seta on coxa of legs 1-3 long and plumose, but in leg 4 very short (8μ) and naked. Row of hairs present on inner margin of basis in all 4 legs. In leg 1 spinules along proximal margins of outer spines of exopod more prominent than those on distal margins. Endopod of leg 4 shorter than exopod. First segment $49\mu \times 34\mu$ (including terminal spinous processes) bearing a distal inner barbed spine 32μ long instead of a seta. Second segment $75\mu \times 29\mu$ (including processes) bearing 2 terminal unequal barbed spines 29μ (outer) and 51μ (inner). Both segments with outer margins haired, and second segment with short hairs along proximal inner margin and a row of minute spinules near insertions of terminal spines.

Leg 5 (fig. 20) with free segment elongated and slightly arcuate, $120\mu \times 36\mu$ in greatest dimensions, but wider proximally than distally; outer convex surface covered with pointed scales (fig. 21); bearing 2 terminal naked setae 42μ and 65μ in length. Naked seta on body near free segment 52μ , with a group of spinules near its insertion.

Leg 6 probably represented by the 2 spiniform elements near areas of attachment of each egg sac (see fig. 3).

Color in life in transmitted light slightly opaque, eye red, ovary and egg sacs gray.

MALE.—Body (fig. 22) resembling in general form that of female. Length 0.73 mm (0.69-0.75 mm) and greatest width 0.32 mm (0.29-0.33 mm), based on 10 specimens. Ratio of length to width of prosome 1.37:1.

Segment of leg 5 (fig. 23) $41\mu \times 72\mu$. Genital segment about as long as wide, $169\mu \times 160\mu$, in dorsal view with its lateral borders rounded. No intersegmental sclerite ventrally between these 2 segments. Four postgenital segments $22\mu \times 52\mu$, $21\mu \times 48\mu$, $14\mu \times 45\mu$, and $33\mu \times 48\mu$ respectively.

Caudal ramus (fig. 23) relatively slightly longer than in female, $24\mu \times 22\mu$ when measured dorsally, $27\mu \times 22\mu$ when measured ventrally. Innermost terminal seta with row of hairlike spinules along both margins proximally.

Surface of prosome and urosome with minute hairs as in female. Ratio of length of prosome to that of urosome 1.48:1.

Rostral area (fig. 24) angular, with a minute median posteroventral knob.

First antenna resembling that of female but with 2 aesthetes about 100μ long added on segment 2 and another such aesthete on segment 4 (at points indicated by arrows in fig. 7), so that formula is 4, 13+2 aesthetes, 6, 3+1 aesthete, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. Second antenna (fig. 25) resembling that of female, but last segment relatively longer, 99μ along outer edge, 68μ along inner edge, and 21μ wide.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those in female. Maxilliped (fig. 26) slender and 4-segmented (assuming that proximal part of claw represents fourth segment). First segment unornamented. Second segment bearing on medial surface 2 naked setae and 3 rows of spinules, a single row extending the length of segment, other 2 rows close together and restricted to region distal to setae. Third segment very small and unarmed. Claw slender, 185μ long (measured along its axis), with narrow terminal lamella, slight fringe along its distal concave surface, and 2 very unequal setae near its base, one on postero-inner surface 86μ long and finely barbed at its tip, other on anterior surface only 5μ and naked. Claw showing a suggestion of division about midway.

Area between maxillipeds and first pair of legs resembling that of female.

Legs 1-4 segmented as in female and with same spine and setal formula, except for endopod of leg 1 (fig. 27), which has arrangement of 0-1; 0-1; I,I,4. This endopod geniculate, with second and third segments set at an angle to one another. First two segments without outer distal spinous processes. Third segment elongated, nearly as long as first two combined; with 2 terminal spines having strong lateral spinules; a prominent minutely spinose process near insertion of inner of these spines. Last segment of endopod of leg 2 (fig. 28) with 2 of terminal spinous processes larger than in female and bearing numerous minute spines. Legs 3 and 4 like those in female.

Leg 5 (fig. 29) with elongated slender straight free segment, $33\mu \times 9\mu$, with nearly parallel sides in dorsal view, bearing a few surficial scales and 2 terminal elements, an outer naked seta 30μ long and an inner spiniform seta 20μ long with coarse short lateral spines. No spinules on body near insertion of free segment.

Leg 6 (fig. 30) a posterolateral flap on ventral surface of genital segment bearing 2 naked setae 22μ and 27μ long.

Spermatophore (fig. 31), attached to female, elongated, $172\mu \times 78\mu$ without neck. Spermatophores readily extruded from male when placed in lactic acid, as shown in figure 30.

Color in life resembling that of female.

ETYMOLOGY.—The specific name *varirostratus*, from Latin *vari-*us=different and *rostratus*=furnished with a beak, alludes to the different shape of the rostrum in the two sexes of this species.

COMPARISON WITH RELATED SPECIES.—Two features of *L. varirostratus* serve to distinguish it from all other known species in the genus, namely, the presence of a spine instead of a seta on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna. In only one other species, *L. anomalus* A. Scott, 1909, does the endopod of leg 4 appear to have the formula 0-I, II (based on Scott's fig. 15, pl. LXVII); the usual formula in *Lichomolgus* is 0-1, II. Scott's species differs from the new species, however, in having only one claw on the second antenna. The general structure of the endopod in leg 1 of the male of *L. varirostratus* resembles rather closely that of *L. anomalus*. Scott noted that this geniculate form "is quite distinct from what is usually found in males of this genus."

Two unusually long terminal claws occur on the second antenna in four species—*L. canui* Sars, 1917; *L. ieverisi* Thompson and A. Scott, 1903; *L. marginatus* Thorell, 1860; and *L. tenuicornis* Brady, 1910—but in all of these species the formula for the endopod of leg 4 is 0-1, II, thus readily separating them from the new species from Madagascar.

Lichomolgus exilipes, new species

FIGURES 32-55

TYPE MATERIAL.—31 ♀♀ and 18 ♂♂ from a colony of *Dendronephthya mucronata* (Pütter), in 4 m, on the northeastern coast of Antany Mora, Isles Radama, Madagascar, $14^{\circ}06'10''S$, $47^{\circ}45'10''E$, collected Sept. 30, 1964. Holotype ♀, allotype, and 35 paratypes (25 ♀♀ and 10 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Dendronephthya mucronata*: 15 ♀♀ and 8 ♂♂ from 6 colonies, in 1 m, off Ampombilava, Nosy Bé, Madagascar, Sept. 26, 1964, and 6 ♂♂ from 1 colony, in 1 m, Tany Kely, a small island south of Nosy Bé, June 23, 1963. From *Dendronephthya regia* Verseveldt: 2 ♀♀ from 1 colony, in 40 m, Banc de Cinq Mètres, west of Nosy Bé, at about $13^{\circ}23'30''S$, $48^{\circ}04'00''E$, Aug. 19, 1964. From *Dendronephthya stocki* Verseveldt: 1 ♀ and 6 ♂♂ from 1 colony,

in 40 m, Banc de Cinq Mètres, Aug. 19, 1964. From *Dendronephthya köllikeri* Kükenthal: 7 ♀♀ and 12 ♂♂ from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59'S, 47°46.5'E, Sept. 30, 1964.

FEMALE.—Body (fig. 32) a little less broadened than in *L. varirostratus*. Length 0.99 mm (0.91–1.09 mm) and greatest width 0.50 mm (0.46–0.52 mm), based on 10 specimens. Ratio of length to width of prosome 1.3:1. Segment of first leg separated dorsally and laterally from head by a furrow. Lateral areas of segments of legs 1–4 shaped as in figure.

Segment of leg 5 measuring $73\mu \times 151\mu$. Between this segment and genital segment a slight ventral intersegmental sclerite. Genital segment (fig. 33) slightly longer than wide, $172\mu \times 156\mu$, in dorsal view constricted anteriorly and posteriorly but expanded in midregion. A pair of crescentic sclerotized ridges on anterior dorsal surface. Areas of attachment of egg sacs located dorsolaterally at level of expanded part of segment. Each area (fig. 34) bearing 2 naked setae 11μ and 20μ in length, with a small digitiform process between them. Three postgenital segments $34\mu \times 81\mu$, $23\mu \times 68\mu$, and $34\mu \times 70\mu$, from anterior to posterior.

Caudal ramus (fig. 35) only slightly longer than wide, its greatest dimensions being $30\mu \times 25\mu$ when measured dorsally and $33\mu \times 25\mu$ when measured ventrally. Outer lateral seta 109μ and naked, pedicellate dorsal seta 22μ and naked, outermost distal seta 180μ and naked, innermost distal seta 283μ with inner lateral spinules, and the 2 long median terminal setae 418μ (outer) and 550μ (inner), both inserted between dorsal (unornamented) and ventral (with marginal row of spinules) flaps, and bearing lateral spinules in their midregions. A delicate setule on proximal outer edge of ramus, and a few surficial hairs dorsally.

Dorsal surface of prosome and urosome with minute hairs. Ratio of length of prosome to that of urosome 2.24:1.

Egg sacs in most ovigerous females observed broken, as in figure 32. One intact egg sac measuring $430\mu \times 176\mu$, elongated, reaching well beyond ends of caudal rami, and containing many small eggs, each about 40μ in diameter.

Rostral area (fig. 36) linguiform, rounded posteroventrally.

First antenna (fig. 37) resembling in general form that of *L. varirostratus*, with same segmentation and formula for armature, but longer, 480μ . Lengths of segments: 36μ (77μ along anterior margin), 133μ , 32μ , 70μ , 75μ , 56μ , and 36μ respectively. All setae naked.

Second antenna (fig. 38) also resembling that of *L. varirostratus*, with similar segmentation and armature. Last segment 135μ along its outer edge, 86μ along its inner edge, and 31μ wide. Three setae on

third segment 42μ , 21μ , and 42μ from proximal to distal, with distal-most spiniform and minutely barbed along one edge. Both claws about 135μ in length.

Labrum (fig. 39) with 2 posteroventral lobes less broadly rounded than in *L. varirostratus*.

Mandible (fig. 40) resembling that of *L. varirostratus*, but with distinct constriction separating basal region into two parts, convex margin of distal part bearing spinules and projected distally as a short blunt process. Paragnath a small lobe bearing hairs. First maxilla (fig. 41) bearing a small subterminal element in addition to 3 terminal ones. Second maxilla (fig. 42) and maxilliped (fig. 43) segmented and armed as in *L. varirostratus*, but slight differences in ornamentation of elements as shown in figures.

Area between maxillipeds and first pair of legs (fig. 44) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 45-48) segmented as in *L. varirostratus*, with same spine and setal formula. Inner seta on coxa of leg 4 short (12μ) and naked. Inner margin of basis of leg 4 without hairs. In leg 1 spinules along proximal margins of outer spines of exopod longer and coarser than those on distal margins. Endopod of leg 4 only slightly shorter than exopod. First segment $56\mu \times 35\mu$ (including terminal spinous processes), bearing an inner distal minutely barbed spine 43μ long. Second segment $111\mu \times 30\mu$ (greatest dimensions including processes), bearing 2 terminal barbed spines 39μ (outer) and 77μ (inner); a few minute spinules along inner margin of segment.

Leg 5 (fig. 49) with free segment much elongated, slender, and slightly arcuate, $172\mu \times 23\mu$ (width 35μ at level of proximal inner expansion). Outer convex surface bearing pointed scales. Two terminal naked setae 122μ and 190μ in length. Naked seta on body near free segment 55μ , with a few minute spinules not far from its insertion.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 34).

Color in life in transmitted light as in *L. varirostratus*.

MALE.—Body (fig. 50) resembling that of female in general form. Length 0.78 mm (0.73-0.81 mm) and greatest width 0.34 mm (0.30-0.36 mm), based on 10 specimens. Ratio of length to width of prosome 1.4:1.

Segment of leg 5 measuring $36\mu \times 101\mu$. Genital segment (fig. 51) about as long as wide, $221\mu \times 216\mu$. No ventral intersegmental sclerite between these segments. Four postgenital segments $22\mu \times 56\mu$, $17\mu \times 55\mu$, $11\mu \times 51\mu$, and $24\mu \times 56\mu$ respectively.

Caudal ramus (fig. 51) somewhat shorter than in female, $22\mu \times 24\mu$ dorsally, $23\mu \times 24\mu$ ventrally. Innermost terminal seta with row of

spinules on both sides. Outermost terminal seta with inner spinules proximally.

Surfaces of prosome and urosome with minute hairs as in female. Ratio of length of prosome to that of urosome 1.43:1.

Rostral area as in female.

First antenna resembling that of female, but with 2 long aesthetes added on second segment and another aesthete on fourth segment, so that formula is same as for male of *L. varirostratus*.

Second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla similar to those in female. Maxilliped (fig. 52) less slender than in *L. varirostratus*, but segmented and armed similarly. Claw slender and 170μ along its axis; proximal region of claw slightly swollen and faintly striated.

Area between maxilliped and first pair of legs as in female.

Legs 1-4 segmented as in *L. varirostratus*, with spine and setal formula as in male of that species. Endopod of leg 1 (fig. 53) slightly geniculate. Third segment elongated, with outer terminal spine straight, having lateral spinules and hyaline tip, inner terminal spine bent, with strong spinules along its inner distal edge; spinous process between these 2 spines enlarged and finely spinose. No obvious sexual dimorphism in legs 2-4.

Leg 5 (fig. 54) with a very elongated slender straight free segment, $55\mu \times 11\mu$, bearing on its outer surface a few scales and terminally an outer naked seta 56μ long and an inner spine 29μ long with short lateral spinules. No spinules on body near insertion of free segment.

Leg 6 similar to that in *L. varirostratus*, with 2 naked setae 41μ and 78μ in length.

Spermatophore (fig. 55), attached to female, elongated, $174\mu \times 91\mu$, not including neck.

Color in life as in *L. varirostratus*.

ETYMOLOGY.—The specific name *exilipes*, from Latin *exilis*=slender and *pes*=foot, refers to the elongated slender form of leg 5 in both sexes of this species.

COMPARISON WITH RELATED SPECIES.—Like *L. varirostratus*, this species may be distinguished from all other known species in the genus on the basis of a combination of two characters: the spine (instead of a seta) on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna.

Lichomolgus exilipes may readily be separated from *L. varirostratus* by the form of the rostrum, the presence of lateral spinules on the two long setae on the caudal rami, the form of the fifth legs and the genital segment in the female, and the structure of the two spines on the last segment of the endopod of leg 1 in the male.

Lichomolgus gentilis, new species

FIGURES 56-69

TYPE MATERIAL.—20 ♀♀ and 28 ♂♂ from a colony of *Dendronephthya mucronata* (Pütter), in 4 m, on the northeastern coast of Antany Mora, Isles Radama, Madagascar, 14°06'10''S, 47°45'10''E, collected Sept. 30, 1964. Holotype ♀, allotype, and 36 paratypes (14 ♀♀ and 22 ♂♂) deposited in the United States National Museum and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Dendronephthya mucronata*: 4 ♀♀ from 6 colonies, in 1 m, off Ampombilava, Nosy Bé, Madagascar, Sept. 26, 1964; 10 ♀♀ and 19 ♂♂ from 1 colony, in 1 m, Tany Kely, a small island south of Nosy Bé, June 23, 1963; 2 ♀♀ from 1 colony, in 2 m, northern end of Nosy Sakatia, near Nosy Bé, Aug. 19, 1963; and 2 ♀♀ and 1 ♂ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963. From *Dendronephthya köllikeri* Kükenthal: 15 ♀♀ and 19 ♂♂ from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59'S, 47°46.5'E, Sept. 30, 1964. From *Dendronephthya stocki* Verseveldt: 1 ♂ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963. From *Stereonephthya acaulis* Verseveldt: 1 ♀, 2 ♂♂, and 45 copepodids from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963; 5 ♀♀, 22 ♂♂, and 1 copepodid from 1 colony, in 10 m, Tany Kely, Aug. 21, 1964; 11 ♀♀ and 8 ♂♂ from 1 colony, in 1 m, off Ampombilava, Nosy Bé, Sept. 26, 1964; and 15 ♀♀, 9 ♂♂, and 1 copepodid from 1 colony, in 2 m, Andraikarekabe, Nosy Komba, near Nosy Bé, Oct. 9, 1964. From *Stereonephthya papyracea* Kükenthal: 39 ♀♀ and 52 ♂♂ from 1 colony, in 6 m, Tany Kely, Aug. 26, 1963.

FEMALE.—Body (fig. 56) with moderately broad prosome. Length 0.91 mm (0.82–1.03 mm) and greatest width 0.47 mm (0.45–0.49 mm), based on 10 specimens. Ratio of length to width of prosome 1.28:1.

Segment of leg 5 measuring $52\mu \times 159\mu$. Between this segment and genital segment no ventral intersegmental sclerite visible. Genital segment (fig. 57) nearly as long as wide, $148\mu \times 159\mu$, in dorsal view expanded in its anterior three-fourths but constricted posteriorly. Areas of attachment of egg sacs located dorsolaterally on posterior part of expanded region. Each area (fig. 58) with a slender naked seta 13μ long, a spiniform unilaterally barbed seta 18μ long, and an adjacent slender setiform process. Three postgenital segments $26\mu \times 86\mu$, $20\mu \times 82\mu$, and $25\mu \times 77\mu$ from anterior to posterior.

Caudal ramus (fig. 57) a little shorter than wide, its greatest dimensions being $25\mu \times 32\mu$ when measured dorsally and $27\mu \times 32\mu$ when measured ventrally. Outer lateral seta 143μ long and naked, pedicellate dorsal seta 39μ and naked, outermost distal seta 235μ and naked, innermost distal seta 352μ with row of spinules along inner edge, and the 2 long median terminal setae 517μ (outer) and 583μ (inner), both inserted between dorsal (unornamented) and

ventral (with marginal row of spinules) flaps, and both with strong coarse lateral spinules in midregion (these spinules much stronger than in *L. exilipes*).

Ratio of length of prosome to that of urosome 2.5:1.

Most ovigerous females observed carrying only clusters of eggs as in figure 56. One of few intact egg sacs measuring $462\mu \times 198\mu$, elongated oval, reaching far beyond caudal rami, with each egg about 44μ in diameter.

Rostral area and first antenna (453μ long) resembling those of *L. exilipes*. Second antenna (fig. 59) formed in general like that of *L. exilipes*, but 3 elements on third segment 35μ , 24μ , and 25μ from proximal to distal. Last segment 130μ along its outer edge, 83μ along its inner edge, and 31μ wide. Two terminal claws different in form and length, one being slender and 143μ along its axis, other stout and 127μ . (Apparently some variation in lengths of claws, with one female 153μ and 117μ on one side and 146μ and 130μ on other. In one female from *Stereonephthya acaulis* 120μ and 99μ , and in another 125μ and 107μ . In all cases, however, longer claw slender, shorter one stout.)

Labrum as in *L. exilipes*. Mandible (fig. 60) without blunt process on convex margin of basal region as in *L. exilipes*. Paragnath, first maxilla, and second maxilla similar to those in *L. exilipes*. Maxilliped (fig. 61) differing only slightly from that species.

Area between maxillipeds and first pair of legs not protuberant, with a sclerotized line connecting bases of maxillipeds.

Legs 1-4 segmented as in 2 previous species, with same spine and setal formula. Inner seta on coxa of leg 4 short (10μ) and naked. Inner margin of basis of leg 4 without hairs. In leg 1 (fig. 62) and leg 2 spinules along proximal margins of outer spines of exopod longer and stouter than those on distal margins. Endopod of leg 4 (fig. 63) shorter than exopod. First segment $55\mu \times 34\mu$ (including terminal spinous processes), bearing an inner distal finely barbed spine 35μ long. Second segment $99\mu \times 34\mu$ (greatest dimensions including processes), bearing 2 terminal spines, outer 44μ and finely barbed, inner 79μ with lateral spinules; a row of long hairs along proximal two-thirds of inner margin of segment.

Leg 5 (fig. 64) with elongated free segment, $143\mu \times 20\mu$ (width taken at level of proximal inner expansion). Outer convex surface with pointed scales. Two terminal naked setae 99μ and 148μ in length. Seta on body near insertion of free segment 40μ long and slightly plumose; a few small spinules near this seta.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 58).

Color in life in transmitted light as in 2 previous species.

MALE.—Body (fig. 65) resembling that of female in general aspect. Length 0.72 mm (0.69–0.77 mm) and greatest width 0.34 mm (0.32–0.36 mm), based on 10 specimens. Ratio of length to width of prosome 1.36:1.

Segment of leg 5 measuring $39\mu \times 104\mu$. Genital segment (fig. 66) as long as wide, $200\mu \times 203\mu$. No ventral intersegmental sclerite between these segments. Four postgenital segments $15\mu \times 61\mu$, $17\mu \times 57\mu$, $12\mu \times 56\mu$, and $22\mu \times 58\mu$ respectively.

Caudal ramus as in female, but proportions slightly different, $20\mu \times 24\mu$ dorsally, $27\mu \times 24\mu$ ventrally. As in *L. exilipes*, outermost terminal seta with inner spinules proximally and innermost terminal seta with row of spinules on both sides.

Ratio of length of prosome to that of urosome 1.7:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added (length of proximalmost = 130μ) so that formula is same as for males of 2 previous species. Second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla like those of female. Maxilliped (fig. 67) with general form similar to *L. exilipes*, but ornamentation of major setae slightly different. Claw slender and 172μ along its axis.

Area between maxillipeds and first pair of legs as in female.

Legs 1–4 segmented as in 2 previous species, with spine and setal formula as in males of those species. Endopod of leg 1 (fig. 68) only slightly geniculate. Third segment moderately elongated, with outer terminal spine straight, having lateral spinules and small hyaline tip, inner terminal spine slightly bent (not as strongly so as in *L. exilipes*) with moderately strong spinules along its inner distal edge; spinous process between these 2 spines as in *L. exilipes*. No obvious sexual dimorphism in legs 2–4, except that endopod of leg 4 (fig. 69) has slightly different proportions: first segment $33\mu \times 25\mu$, with spine 25μ , second segment $70\mu \times 22\mu$ (more elongated than in female, ratio 3.2:1 instead of 2.9:1 as in that sex), with 2 terminal spines 31μ and 61μ .

Leg 5 (fig. 66) with elongated free segment, $57\mu \times 11\mu$, without pronounced proximal inner expansion, bearing on its outer surface a few scales and terminally an outer naked seta 71μ and an inner barbed spine 19μ . No spinules on body near insertion of free segment.

Leg 6 similar to those in 2 previous species, with 2 naked setae 50μ and 82μ in length.

Spermatophore, attached to female, as in *L. exilipes*.

Color in life as in 2 previous species.

ETYMOLOGY.—The specific name *gentilis*, from Latin = belonging to the same gens or clan, alludes to the close relationship of this species with *L. exilipes*.

COMPARISON WITH RELATED SPECIES.—Like *L. varirostratus* and *L. exilipes* this species may be distinguished from all other members of the genus by the combination of two characters: the spine (instead of a seta) on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna.

Lichomolgus gentilis may be readily separated from *L. varirostratus* by the form of the rostrum, the presence of lateral spinules on the two long setae on the caudal rami, the form of the genital segment in the female, and the structure of the two spines on the last segment of the endopod of leg 1 in the male.

From *L. exilipes* the new species may be separated by the coarser lateral spinules on the two long setae on the caudal rami, the more unequal nature of the two claws on the second antenna, the lack of a blunt process on the inner margin of the mandible, and the form of the fifth legs and the genital segment in the female.

Lichomolgus fisisetiger, new species

FIGURES 70-83

TYPE MATERIAL.—24 ♀♀ and 20 ♂♂ from a colony of *Stereonephthya acaulis* Verseveldt, in 2 m, Ambafaho, Nosy Bé, Madagascar, collected Sept. 25, 1964. Holotype ♀, allotype, and 34 paratypes (18 ♀♀ and 16 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Stereonephthya acaulis*: 45 ♀♀ and 89 ♂♂ from 1 colony, in 10 m, Tany Kely, a small island south of Nosy Bé, Aug. 21, 1964; 22 ♀♀, 9 ♂♂, and 2 copepodids from 1 colony, in 1 m, off Ampombilava, Nosy Bé, Sept. 26, 1964; and 9 ♀♀ and 16 ♂♂ from 1 colony, in 2 m, Andraikarekabe, Nosy Komba, near Nosy Bé, Oct. 9, 1964. From *Stereonephthya papyracea* Kükenthal: 53 ♀♀, 80 ♂♂, and 92 copepodids from 1 colony, in 6 m, Tany Kely, Aug. 26, 1963. From *Lemnalia elegans* (May): 3 ♀♀ from 1 colony, in 1 m, Pte. Lokobe, Nosy Bé, Oct. 16, 1960.

FEMALE.—Body (fig. 70) similar to that of *L. exilipes* and *L. gentilis*. Length 0.99 mm (0.92-1.03 mm) and greatest width 0.49 mm (0.46-0.51 mm), based on 10 specimens. Ratio of length to width of prosome 1.5:1.

Segment of leg 5 measuring $65\mu \times 143\mu$. Between this segment and genital segment a small ventral intersegmental sclerite. Genital segment (fig. 71) slightly shorter than wide, $127\mu \times 143\mu$, in dorsal view with its lateral borders rounded. Areas of attachment of egg sacs located almost laterally (only slightly dorsally) in posterior half of segment. Each area (fig. 72) with 2 small naked setae about 11μ long and an adjacent small unguiform process. Three postgenital segments $26\mu \times 82\mu$, $21\mu \times 73\mu$, and $26\mu \times 70\mu$ from anterior to posterior.

Caudal ramus (fig. 73) shorter than wide, its greatest dimensions being $20\mu \times 28\mu$ when measured dorsally, $21\mu \times 28\mu$ when measured ventrally. Outer lateral seta 83μ long and naked, pedicellate dorsal seta 25μ and naked, outermost distal seta 117μ with proximal inner spinules, innermost distal seta 208μ with spinules along both sides, and the 2 long median terminal setae 440μ (outer) and 590μ (inner), both inserted between dorsal (unornamented) and ventral (with marginal row of spinules) flaps, and both with lateral spinules in midregion (these spinules not as strong as in *L. gentilis*, and more like those of *L. exilipes*).

Ratio of length of prosome to that of urosome 2.9:1.

Egg sac (fig. 70) $550\mu \times 209\mu$, elongated, reaching far beyond ends of caudal rami, containing many eggs, each about 45μ in diameter.

Rostral area and first antenna (428μ long) similar to those of *L. exilipes* and *L. gentilis*. Second antenna (fig. 74) resembling that of *L. gentilis*, but differing in details. Three naked elements on third segment 35μ , 21μ , and 20μ in length from proximal to distal. Last segment 94μ along outer margin, 60μ along inner margin, and 25μ wide. Two terminal claws unequal, not as long as in *L. gentilis*, one 92μ along its axis and slender, the other 77μ and stouter.

Labrum as in *L. exilipes* and *L. gentilis*. Mandible (fig. 75) similar to that in *L. gentilis*, but showing an even more pronounced constriction of basal region. Paragnath and first maxilla as in *L. exilipes* and *L. gentilis*. Second maxilla (fig. 76) resembling *L. exilipes* and *L. gentilis*, but spinulation of lash and distal seta slightly different. Maxilliped as in *L. exilipes* and *L. gentilis*.

Area between maxillipeds and first pair of legs not protuberant, with a sclerotized line between bases of maxillipeds.

Legs 1-4 segmented as in 3 previous species, with same spine and setal formula. Leg 1 similar to that of *L. exilipes* and *L. gentilis*. Legs 2 and 3 like those of *L. exilipes*. Leg 4 (fig. 77) resembling that of *L. gentilis*. Endopod shorter than exopod. First segment $42\mu \times 32\mu$ (including terminal spinous processes), with inner distal minutely barbed spine 31μ long. Second segment $90\mu \times 29\mu$ (greatest dimensions including processes), outer terminal spine 34μ with finely barbed fringe, inner 72μ with more coarsely spinulose fringe. Proximal inner margin of this segment with row of very short spinules.

Leg 5 (fig. 78) with elongated free segment having prominent inner basal expansion. Greatest length 148μ , width 42μ at expansion, 23μ immediately distal to expansion, and 16μ near tip. Outer surface with narrow scalelike spines. Two terminal naked setae 72μ and 110μ (the latter with a narrow membrane in its midregion). Seta on body near insertion of free segment about 50μ long and slightly plumose; a few small spinules near this seta.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 72).

Color in life in transmitted light somewhat opaque, eye red, ovary dark gray, egg sacs gray.

MALE.—Body (fig. 79) resembling that of female in general form. Length 0.78 mm (0.74–0.81 mm) and greatest width 0.29 mm (0.27–0.30 mm), based on 10 specimens. Ratio of length to width of prosome 1.48:1.

Segment of leg 5 measuring $36\mu \times 91\mu$. Genital segment (fig. 80) as long as wide, $185\mu \times 185\mu$. No ventral intersegmental sclerite between these segments. Four postgenital segments $17\mu \times 50\mu$, $14\mu \times 52\mu$, $12\mu \times 50\mu$, and $19\mu \times 52\mu$ respectively.

Caudal ramus resembling that of female but smaller, $14\mu \times 22\mu$ dorsally, $18\mu \times 22\mu$ ventrally.

Ratio of length of prosome to that of urosome 1.62:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added as in 3 previous species, so that formula is same as for those males. Aesthetes much longer than in preceding species, proximalmost one 240μ in length. Second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla like those in female. Maxilliped resembling in general form that of *L. gentilis*, but one of setae on inner surface of second segment terminating in several pointed spiniform elements (fig. 81). Claw 133μ in length (measured along its axis).

Area between maxillipeds and first pair of legs as in female.

Legs 1–4 segmented as in 3 previous species, with spine and setal formula as in those males. Endopod of leg 1 (fig. 82) only slightly geniculate. Third segment resembling that of *L. gentilis*. Legs 2–4 as in female.

Leg 5 (see fig. 80) resembling that of *L. exilipes*, with free segment $52\mu \times 9\mu$, terminally with inner spine 18μ and barbed, outer seta 68μ and naked.

Leg 6 (fig. 83) similar to that in 3 preceding species, with 2 naked setae 44μ and 66μ in length.

Spermatophore not observed.

Color in life in transmitted light more translucent than in female, eye red, genital segment hyaline.

ETYMOLOGY.—The specific name *fissisetiger*, from Latin *fissus*=split and *setiger*=bearing a seta, refers to the nature of the seta on the second segment of the maxilliped in the male of this species.

COMPARISON WITH RELATED SPECIES.—Like the three preceding species *L. fissisetiger* may be distinguished from all other members of the genus by the combination of two characters: the spine (instead

of a seta) on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna.

Lichomolgus fissisetiger may be separated from *L. varirostratus* by the form of the rostrum, the presence of lateral spinules on the two long setae of the caudal rami, the form of the genital segment and leg 5 in the female, the long aesthetes on the first antenna of the male, and the structure of the two spines on the last segment of the endopod of leg 1 in the male.

It may be distinguished from *L. exilipes* by the form of the genital segment and leg 5 in the female, the more unequal nature of the two claws on the second antenna, the lack of a blunt process on the inner margin of the mandible, the peculiar split seta on the second segment of the maxilliped in the male, and the long aesthetes on the first antenna of the male.

From *L. gentilis* the new species may be distinguished by the form of the genital segment and leg 5 in the female, the pronounced constriction of the basal region of the mandible, the split seta on the second segment of the maxilliped in the male, and the long aesthetes on the first antenna of the male.

Lichomolgus cuneipes, new species

FIGURES 84-96

TYPE MATERIAL.—39 ♀♀ and 18 ♂♂ from a colony of *Stereonephthya acaulis* Verseveldt, in 1 m, off Ampombilava, Nosy Bé, Madagascar, collected Sept. 26, 1964. Holotype ♀, allotype, and 46 paratypes (32 ♀♀ and 14 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS (all from *Stereonephthya acaulis*).—6 ♀♀ and 3 ♂♂ from 1 colony, in 2 m, Ambafaho, Nosy Bé, Sept. 25, 1964; 9 ♀♀ and 10 ♂♂ from 1 colony, in 10 m, Tany Kely, a small island south of Nosy Bé, Aug. 21, 1964; and 11 ♀♀ and 9 ♂♂ from 1 colony, in 2 m, Andraikarekabe, Nosy Komba, near Nosy Bé, Oct. 9, 1964.

FEMALE.—Body (fig. 84) resembling that of *L. fissisetiger*. Length 0.94 mm (0.89–0.98 mm) and greatest width 0.48 mm (0.45–0.49 mm), based on 10 specimens. Ratio of length to width of prosome 1.56:1.

Segment of leg 5 measuring $65\mu \times 138\mu$. Between this segment and genital segment a small ventral intersegmental sclerite. Genital segment (fig. 85) about as long as wide, $125\mu \times 120\mu$, in dorsal view with its lateral borders somewhat irregular. Areas of attachment of egg sacs located dorsolaterally in middle of segment. Each area (fig. 86) with 2 small naked setae about 8μ long with a pointed sclerotized process between them. Three postgenital segments $26\mu \times 75\mu$, $21\mu \times 71\mu$, and $26\mu \times 71\mu$ from anterior to posterior.

Caudal ramus (fig. 87) shorter than wide, its greatest dimensions being $22\mu \times 30\mu$ when measured dorsally, $24\mu \times 30\mu$ when measured ventrally. Outer lateral seta 75μ long, pedicellate dorsal seta 28μ , outermost distal seta 112μ , innermost distal seta 203μ , and the 2 long median terminal setae 380μ (outer) and 495μ (inner), both inserted between dorsal and ventral flaps as in previous species. All setae naked.

Ratio of length of prosome to that of urosome 2.78:1.

Egg sac (fig. 84) $462\mu \times 187\mu$, elongated, reaching far beyond ends of caudal rami, containing many eggs, each about 45μ in diameter.

Rostral area (fig. 88) broadly rounded posteroventrally.

First antenna (410μ long) similar to that of *L. exilipes*, the segments 31μ (61μ along anterior edge), 133μ , 28μ , 57μ , 56μ , 42μ , and 32μ in length respectively. Second antenna (fig. 89) with 4 segments having same formula for armature as in previous species. Three elements on third segment consisting of 2 naked setae 22μ and 23μ and a spiniform seta 11μ long and very finely spinulose. Last segment 74μ along outer margin, 40μ along inner margin, and 22μ wide. Two terminal claws not as long as in 4 previous species and unequal, one being 46μ and slender, other 43μ and much stouter.

Labrum as in *L. exilipes*. Mandible as in *L. fissisetiger*. Paragnath and first maxilla as in *L. exilipes*. Second maxilla (fig. 90) resembling in general form that of *L. fissisetiger*, but 4-5 central teeth on lash much stouter than others. Maxilliped much like that of *L. gentilis*.

Area between maxillipeds and first pair of legs not protuberant, with a sclerotized line between bases of maxillipeds.

Legs 1-4 segmented as in 4 previous species, with same spine and setal formula. Legs 1-3 closely resembling those of *L. exilipes*. Leg 4 (fig. 91) with endopod shorter than exopod, its first segment $41\mu \times 28\mu$ (including terminal spinous processes) with inner distal finely barbed spine 30μ , second segment $90\mu \times 24\mu$ (greatest dimensions including processes), outer terminal spine 29μ with finely barbed margins, inner 63μ with coarsely barbed fringe on outer margin and very slightly barbed fringe on inner margin. Inner margin of this segment with very short spinules.

Leg 5 (fig. 92) with elongated free segment having a prominent inner basal expansion directed distally. (Shape of this expansion varying somewhat in different individuals, as in figures 93 and 94.) Length of segment 134μ , width at expansion 40μ , width just distal to expansion 26μ . Outer surface with narrow scalelike spines. Two terminal setae 70μ and 88μ (the latter with a narrow membrane as in *L. fissisetiger*). Seta on body near insertion of segment about 40μ long and slightly plumose; a few small spinules near this seta.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 86).

Color in life in transmitted light as in *L. fissisetiger*.

MALE.—Body (fig. 95) resembling that of *L. fissisetiger*. Length 0.73 mm (0.69–0.77 mm) and greatest width 0.26 mm (0.22–0.28 mm), based on 10 specimens. Ratio of length to width of prosome 1.73:1.

Segment of leg 5 measuring $34\mu \times 81\mu$. Genital segment (fig. 96) about as long as wide, $169\mu \times 164\mu$. No ventral intersegmental sclerite between these segments. Four postgenital segments $16\mu \times 46\mu$, $16\mu \times 45\mu$, $13\mu \times 44\mu$, and $18\mu \times 47\mu$ respectively.

Caudal ramus similar to that of female but smaller, $17\mu \times 22\mu$ dorsally, $19\mu \times 22\mu$ ventrally.

Ratio of length of prosome to that of urosome 1.7:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added as in 4 previous species, so that formula is same as for those males. Aesthetes long as in *L. fissisetiger*, proximalmost 200μ in length. Second antenna like that of female, but with a few small spinules along inner margins of first, second, and fourth segments.

Labrum, mandible, paragnath, first maxilla, and second maxilla as in female. Maxilliped as in *L. gentilis*, with claw 146μ in length (measured along its axis).

Area between maxillipeds and first pair of legs as in female.

Legs 1–4 segmented as in 4 previous species, with spine and setal formula as in those males. Endopod of leg 1 as in *L. fissisetiger*. Legs 2–4 as in female.

Leg 5 as in *L. exilipes*, with free segment $51\mu \times 8\mu$, its seta 53μ and its spine 19μ in length.

Leg 6 similar to that of *L. fissisetiger*, with 2 naked setae 26μ and 53μ long.

Spermatophore not observed.

Color in life as in female.

ETYMOLOGY.—The specific name *cuneipes*, from Latin *cuneus*=a wedge and *pes*=a foot, alludes to the wedgelike form of the inner basal expansion of leg 5 in the female of this species.

COMPARISON WITH RELATED SPECIES.—*Lichomolgus cuneipes* may be differentiated from all other previously known species in the genus by the combination of two characters: the spine (instead of a seta) on the first segment of the endopod of leg 4 and the second antenna bearing terminally two claws and five small hyaline elements.

Lichomolgus cuneipes may be separated from all four species described above by the shorter and more unequal two claws on the

second antenna, by the nature of the teeth on the lash of the second maxilla, and by the form of the fifth legs in the female.

Lichomolgus aculeatus, new species

FIGURES 97-113

TYPE MATERIAL.—69 ♀♀, 116 ♂♂, and 39 copepodids from a colony of *Nephthea aberrans* Verseveldt, in 10 m, Tany Kely, a small island south of Nosy Bé, Madagascar, collected Aug. 21, 1964. Holotype ♀, allotype, and 154 paratypes (54 ♀♀ and 100 ♂♂) deposited in the United States National Museum, 20 paratypes (10 ♀♀ and 10 ♂♂) in the Zoölogisch Museum, Amsterdam, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Nephthea sphaerophora* Kükenthal: 33 ♀♀, 17 ♂♂, and 11 copepodids from 1 colony, in 3 m, Pte. Lokobe, Nosy Bé, Oct. 16, 1960. From *Nephthea crassa* Kükenthal: 27 ♀♀, 46 ♂♂, and 33 copepodids from 1 colony, in 2 m, Pte. Mahatsinjo, Nosy Bé, Aug. 8, 1960; 51 ♀♀ and 97 ♂♂ from 1 colony, in 2 m, Tany Kely, Aug. 26, 1960. From *Nephthea tizierae* Verseveldt: 70 ♀♀, 92 ♂♂, and 100 copepodids from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59'S, 47°46.5'E, Sept. 30, 1964. From *Litophyton arboreum* Forskål: 189 ♀♀ and 47 ♂♂ from 1 colony, in 3 m, Andraikarekabe, western shore of Nosy Komba, near Nosy Bé, Oct. 9, 1964.

FEMALE.—Body (fig. 97) with moderately broad prosome. Length 1.26 mm (1.21-1.32 mm) and greatest width 0.57 mm (0.55-0.59 mm), based on 10 specimens. Segment of leg 1 separated from head by a distinct furrow. Epimeral areas of segments of legs 2 and 3 angular. Ratio of length to width of prosome 1.49:1.

Segment of leg 5 measuring $83\mu \times 190\mu$. Between this segment and genital segment no ventral intersegmental sclerite. Genital segment (fig. 98) longer than wide, $221\mu \times 195\mu$, its lateral areas not expanded. Areas of attachment of egg sacs situated dorsally near middle of segment. Each area with 2 minute naked setae. Three postgenital segments $75\mu \times 127\mu$, $44\mu \times 107\mu$, and $39\mu \times 110\mu$ from anterior to posterior.

Caudal ramus (fig. 99) about 2.2 times longer than wide, $100\mu \times 48\mu$ when measured dorsally, $110\mu \times 48\mu$ when measured ventrally. Outer lateral seta 122μ long and naked; all other setae with prominent lateral spinules. Pedicellate dorsal seta 55μ , outermost distal seta 148μ , innermost distal seta 161μ , and the 2 long median terminal setae 213μ (outer) and 230μ (inner), both inserted between dorsal and ventral flanges bearing marginal spinules. Dorsal surface of ramus with fine ornamentation as in figure.

Ratio of length of prosome to that of urosome 1.7:1.

Egg sac (fig. 97) approximately $380\mu \times 200\mu$, reaching to insertion of caudal ramus, containing 8–11 eggs, each about 100μ in diameter.

Rostral area broadly rounded posteroventrally.

First antenna (433μ long) similar to that of *L. spinulifer* Humes and Frost, 1964, except that all setae are naked; segments 29μ (68μ along anterior edge), 125μ , 31μ , 64μ , 68μ , 46μ , and 31μ respectively. Second antenna (fig. 100) with 4 segments having same formula for armature as in previous species. Three elements on third segment consisting of 2 naked setae 49μ and 40μ and a spiniform seta 35μ barbed along one edge. Last segment 109μ along outer margin, 73μ along inner margin, and 30μ wide. Two terminal claws elongated, slender, and nearly equal, 140μ and 133μ .

Labrum (fig. 101) with 2 posteroventral lobes. Mandible (fig. 102) similar to that of *L. spinulifer*, but with a pointed prominence on its convex margin distal to proximal spinules. Paragnath and first maxilla as in *L. spinulifer*. Second maxilla (fig. 103) similar to *L. spinulifer*, but with first segment broadened so that convex margin of appendage is angular; long spinules on proximal edge of distalmost seta on second segment; small setule on proximal outer area of second segment (as in *L. spinulifer*). Maxilliped (fig. 104) resembling that of *L. spinulifer*, but differing in fine ornamentation; small seta on third segment (as in *L. spinulifer*).

Area between maxillipeds and first pair of legs as in *L. spinulifer*, with a sclerotized line between bases of maxillipeds as in that species.

Legs 1–4 segmented as in 5 previous species, with same spine and setal formula, and closely resembling those of *L. spinulifer*. Endopod of leg 4 (fig. 105) only slightly shorter than exopod, its first segment $55\mu \times 42\mu$ (including terminal spinous processes) with an inner distal plumose seta 104μ long, second segment $125\mu \times 35\mu$ (greatest dimensions including processes), outer terminal spine 25μ and finely barbed, inner 78μ with a finely serrated fringe. Outer margin of second segment with row of spinules (lacking distinct articulations) and inner margin smooth, as in *L. spinulifer*.

Leg 5 (fig. 106) similar to that of *L. spinulifer*, elongated free segment having a small proximal inner expansion. Length of segment 151μ , width at expansion 49μ , width near tip 16μ . Outer surface with scalelike spines. Two terminal naked setae 39μ and 88μ . Seta on body near insertion of segment 45μ and naked.

Leg 6 probably represented by the 2 setae near areas of attachment of egg sac.

Color in life in transmitted light opaque, eye red, ovary gray, egg sacs reddish gray.

MALE.—Body (fig. 107) resembling in general form that of female. Length 1.01 mm (0.96–1.07 mm) and greatest width 0.36 mm (0.35–

0.36 mm), based on 10 specimens. Ratio of length to width of prosome 1.56:1.

Segment of leg 5 measuring $44\mu \times 107\mu$. Genital segment (fig. 108) somewhat longer than wide, $239\mu \times 213\mu$. No ventral intersegmental sclerite between these segments. Four postgenital segments $26\mu \times 65\mu$, $23\mu \times 65\mu$, $18\mu \times 63\mu$, and $23\mu \times 70\mu$ respectively.

Caudal ramus similar to that of female, $83\mu \times 39\mu$ dorsally, $85\mu \times 39\mu$ ventrally.

Ratio of length of prosome to that of urosome 1.45:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added as in 5 previous species, so that formula is same as for those males; aesthetes resembling those of *L. spinulifer*. Second antenna (fig. 109) resembling that of female, but with prominent spinules on inner margins of first 2 segments and small spinules added on segments 3 and 4 as in figure.

Labrum, mandible, paragnath, first maxilla, and second maxilla as in female. Maxilliped (fig. 110) resembling that of *L. spinulifer*, with claw 224μ along its axis.

Area between maxillipeds and first pair of legs as in female.

Legs 1-4 segmented as in 5 previous species, with spine and setal formula as in those males. Endopod of leg 1 (fig. 111) with long terminal spine recurved and concave inwardly, bearing 2 rows of strong spinules: outer spine short and differentially barbed on its 2 margins. Legs 2-4 as in female.

Leg 5 (fig. 112) with free segment $55\mu \times 10\mu$ (extremes in 4 males 53μ - $59\mu \times 9\mu$ - 11μ), its seta 44μ and naked, its spine 20μ with an outer fringe; seta on body near insertion of free segment 35μ and naked.

Leg 6 similar to that of *L. spinulifer*, the 2 small naked setae about 8μ long.

Spermatophore (fig. 113), attached to female, elongated, $195\mu \times 83\mu$, not including neck.

Color in life as in female.

ETYMOLOGY.—The specific name *aculeatus*, from Latin=provided with prickles, refers to the nature of the terminal spine on the endopod of leg 1 in the male of this species.

COMPARISON WITH RELATED SPECIES.—*Lichomolgus aculeatus* differs from all five species described above in having a seta (instead of a spine) on the first segment of the endopod of leg 4. The new species appears to be closely related to *L. spinulifer* Humes and Frost, 1964, from *Lemnalía* sp. at Nosy Bé, yet differs from it in several significant features: the relatively shorter caudal ramus (2.2:1, instead of 3.3:1 as in *L. spinulifer*), the long terminal claws on the second antenna, the small pointed process on the convex side of the mandible,

and the concave spinulose spine on the last segment of the endopod in the male.

Lichomolgus spinulifer Humes and Frost, 1964

This species has been previously recorded from *Lemnalía* sp. at Nosy Bé, Madagascar (Humes and Frost, 1964).

NEW HOST RECORDS.—From *Lemnalía flava* May: 211 ♀♀, 133 ♂♂, and 26 copepodids from 1 colony, in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Dec. 14, 1963. From *Lemnalía elegans* (May): 815 ♀♀, 1018 ♂♂, and 230 copepodids from several colonies, in 15 cm, Boloboxo, Nosy Faly, east of Nosy Bé, May 13, 1964. From *Lemnalía amabilis* Tixier-Durivault: 22 ♀♀, 26 ♂♂, and 15 copepodids from 1 colony, in 3 m, Pte. Ambarionaomby, Nosy Komba, Oct. 3, 1960. From *Lemnalía africana* (May): 59 ♀♀, 55 ♂♂, and 3 copepodids from 1 colony, in 2 m, Pte. Ambarionaomby, Nosy Komba, Sept. 27, 1964. From *Paralemnalia thyrsoides* (Ehrenberg): 60 ♀♀, 62 ♂♂, and 12 copepodids from 1 colony, in 3 m, Antsamantsara, northwest of Madirokely, Nosy Bé, Sept. 20, 1964.

These specimens conform completely with paratypes of *L. spinulifer*. The figures of Humes and Frost (1964) should be modified in certain details as follows: in their figures 142 and 160 of the second antenna, another minute element is present near the bases of the two terminal claws, making five such elements in all; in their figure 147 of the female second maxilla, there is a small seta on the proximal outer area of the second segment, and the distalmost seta on this segment has a few minute inner spinules near its tip; in their figure 148 of the female maxilliped, a small seta is present near the two terminal elements; and in their figures 151–154 (female) and 162 (male) of legs 1–4, the outer distal corner of the coxa bears a few small spinules.

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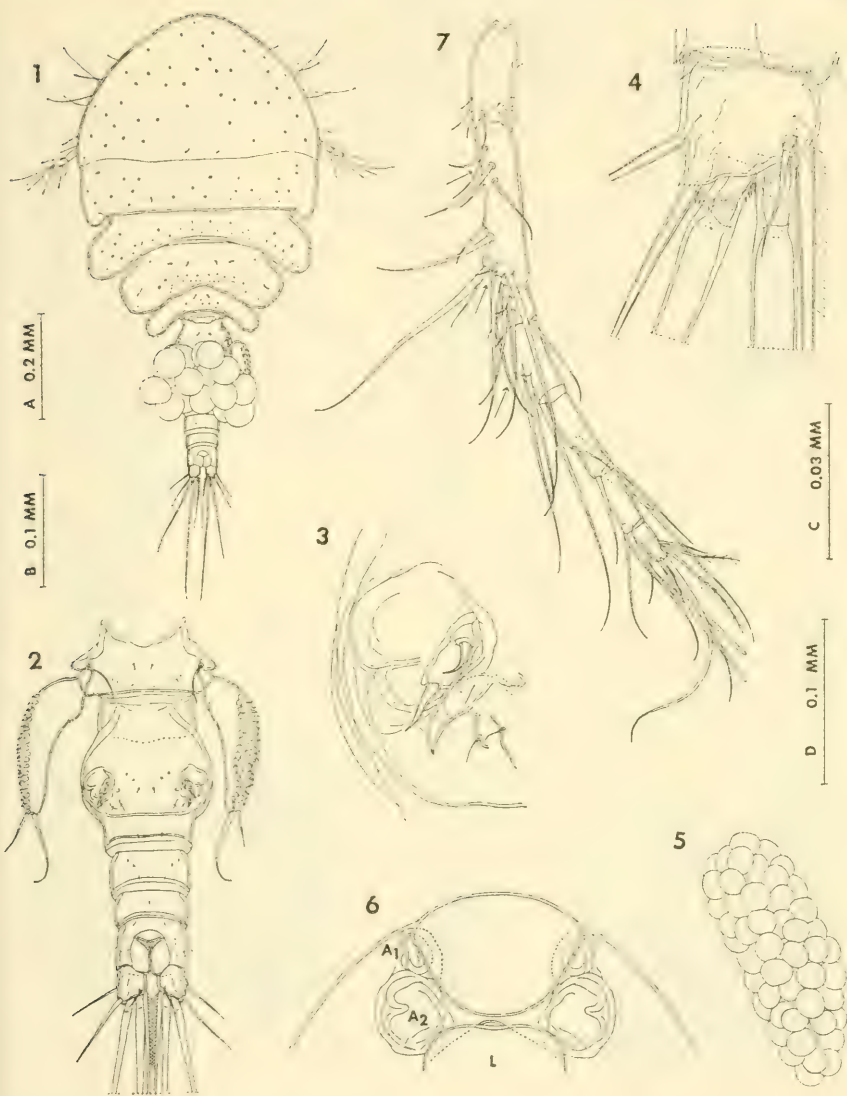
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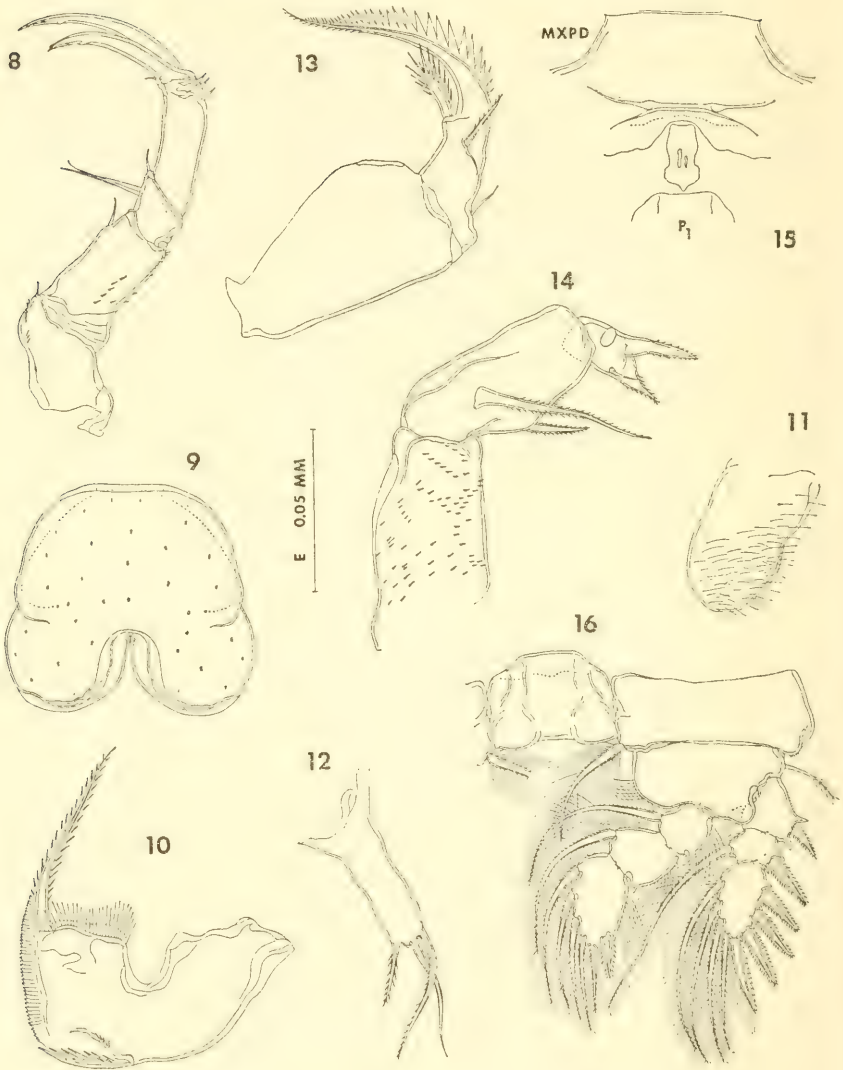
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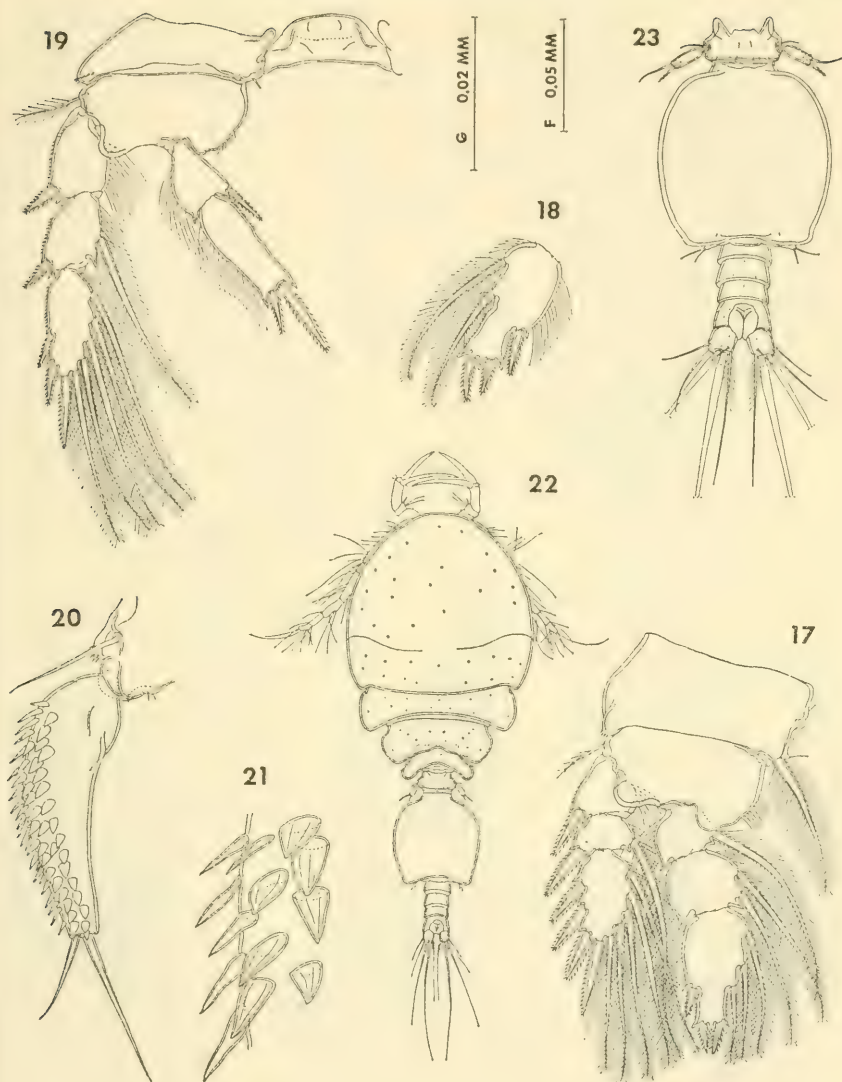
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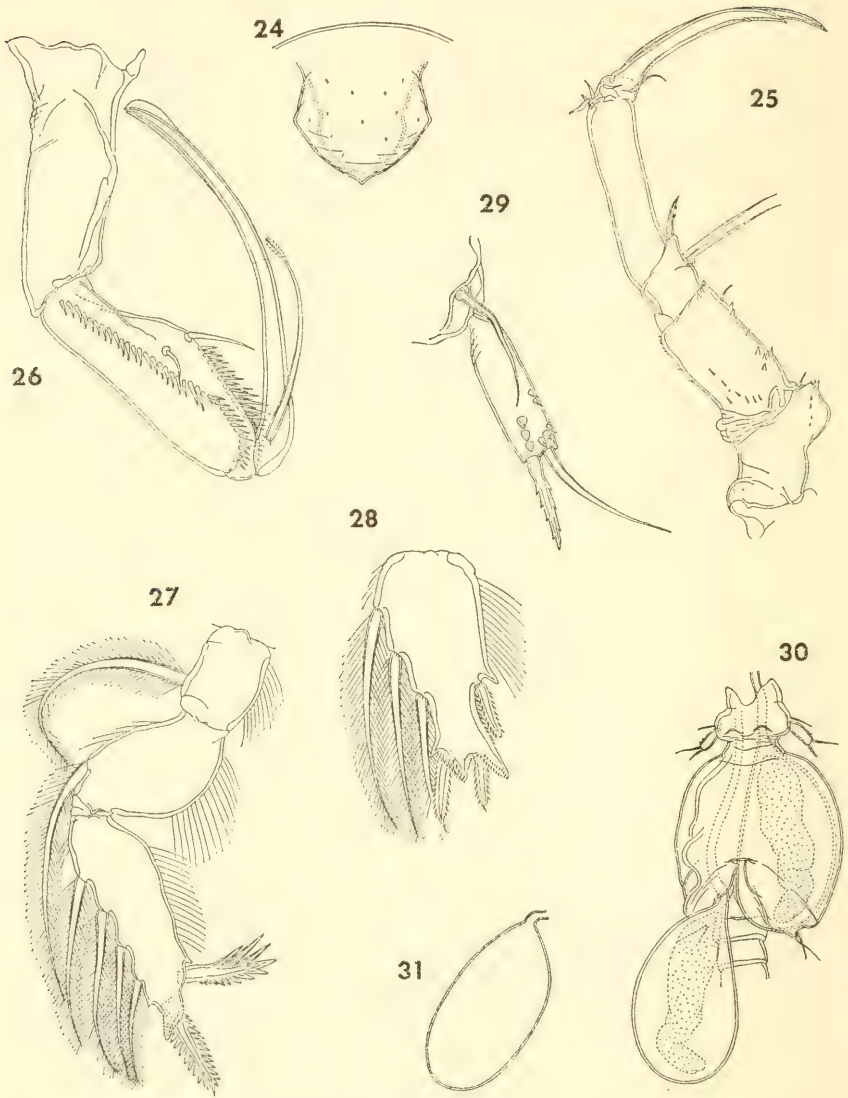
FIGURES 1-7.—*Lichomolgus varirostratus*, new species, female: 1, body, dorsal (A); 2, urosome, dorsal (B); 3, area of attachment of egg sac, dorsal (C); 4, caudal ramus, dorsal (C); 5, egg sac, dorsal (A); 6, rostral area, anteroventral (B); 7, first antenna, dorsal (D).



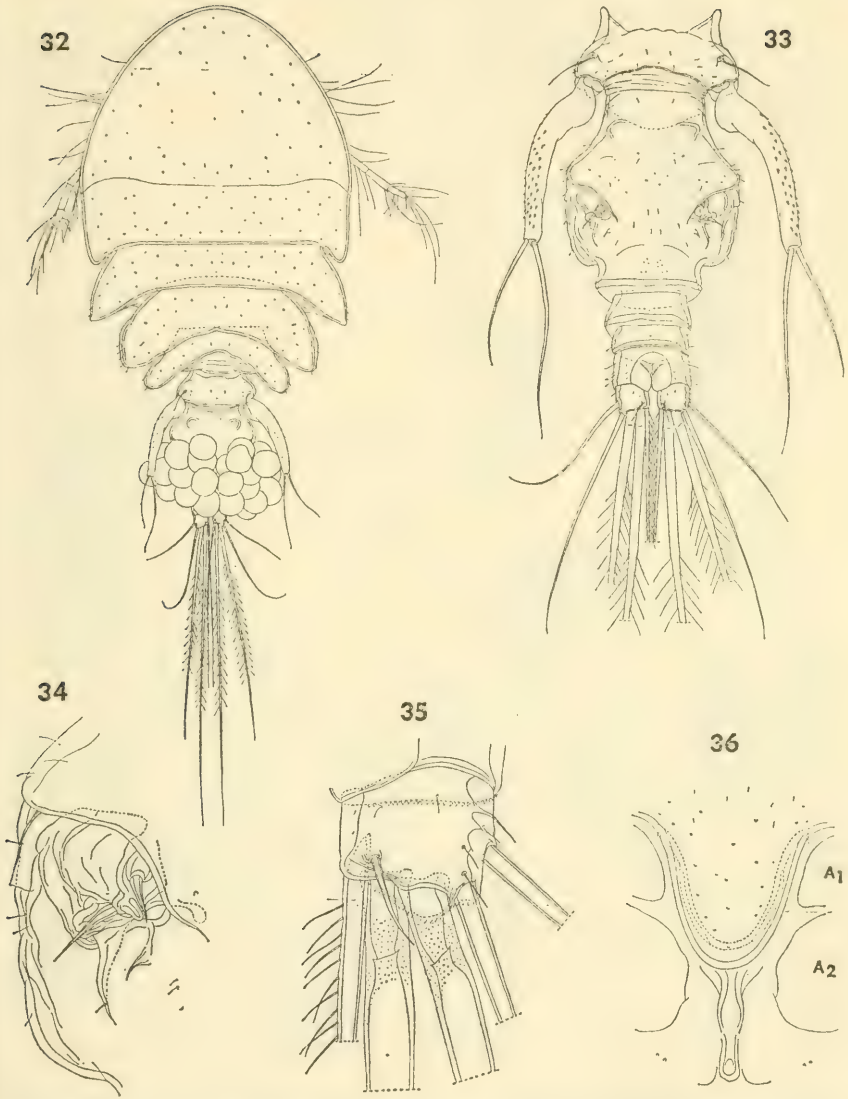
FIGURES 8-16.—*Lichomolgus variostratus*, new species, female: 8, second antenna, anterior (inner) (D); 9, labrum, ventral (D); 10, mandible, posterior (E); 11, paragnath, ventro-inner (C); 12, first maxilla, anterior (E); 13, second maxilla, posterior (E); 14, maxilliped, postero-inner (E); 15, area between maxillipeds and first pair of legs, ventral (D); 16, leg 1 and intercoxal plate, anterior (D).



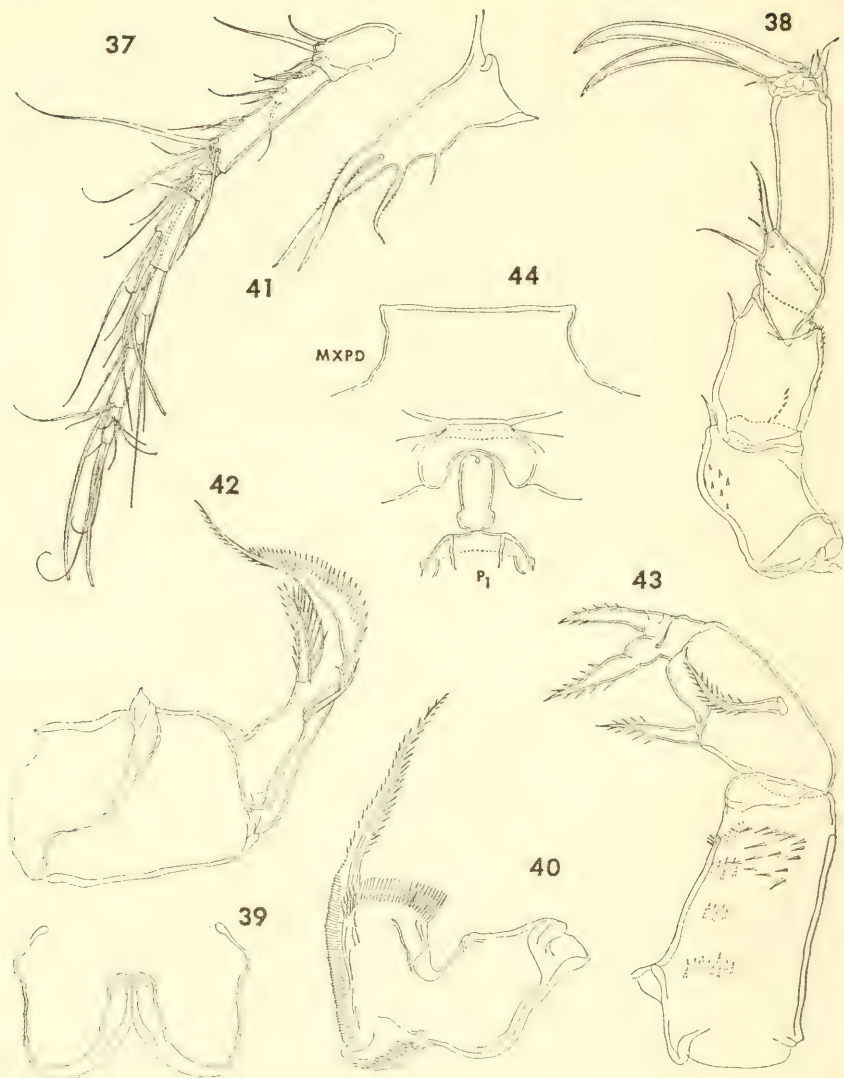
FIGURES 17-23.—*Lichomolgus varirostratus*, new species, female: 17, leg 2, anterior (D); 18, last segment of endopod of leg 3, anterior (D); 19, leg 4 and intercoxal plate, anterior (D); 20, leg 5, dorsal (F); 21, scalelike spines on leg 5, dorso-outer (G). Male: 22, body, dorsal (A); 23, urosome, dorsal (B).



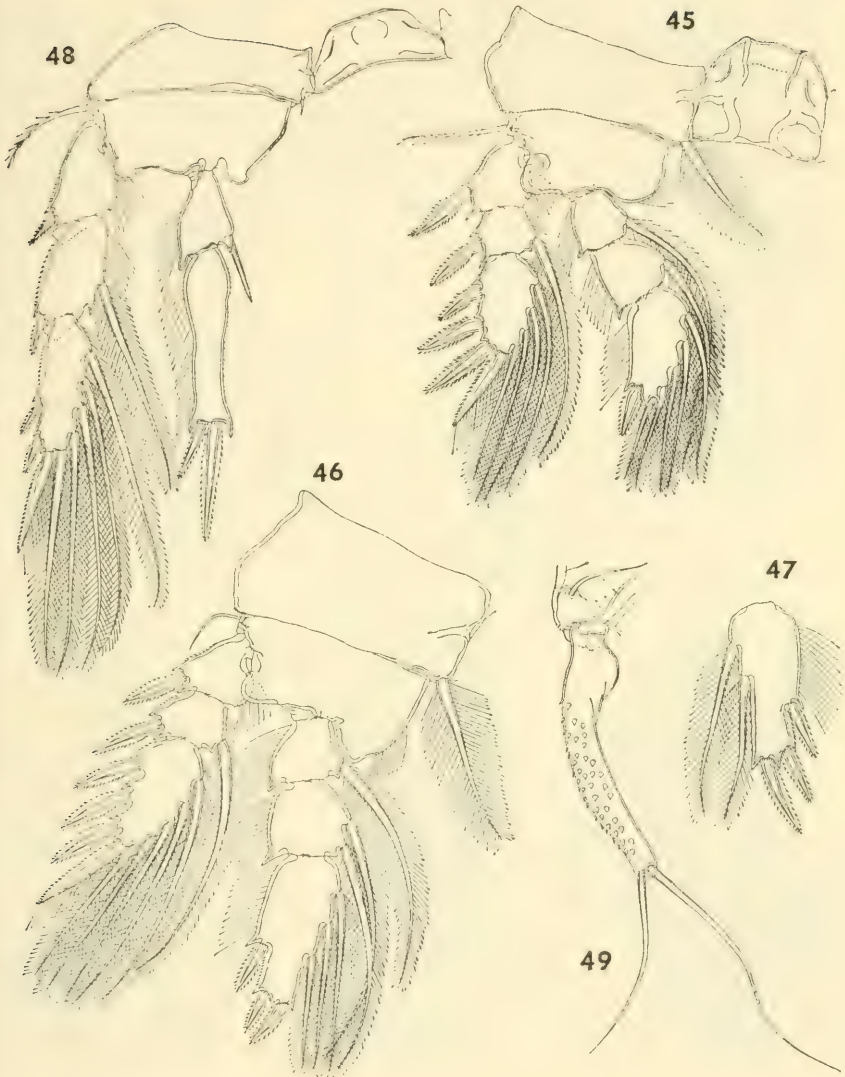
FIGURES 24-31.—*Lichomolgus variostratus*, new species, male: 24, rostral area, ventral (D); 25, second antenna, anterior (inner) (F); 26, maxilliped, postero-inner (F); 27, endopod of leg 1, anterior (E); 28, last segment of endopod of leg 2, anterior (E); 29, leg 5, dorsal (C); 30, anterior part of urosome, showing extrusion of spermatophore in lactic acid, ventral (B); 31, spermatophore, attached to female, lateral (B).



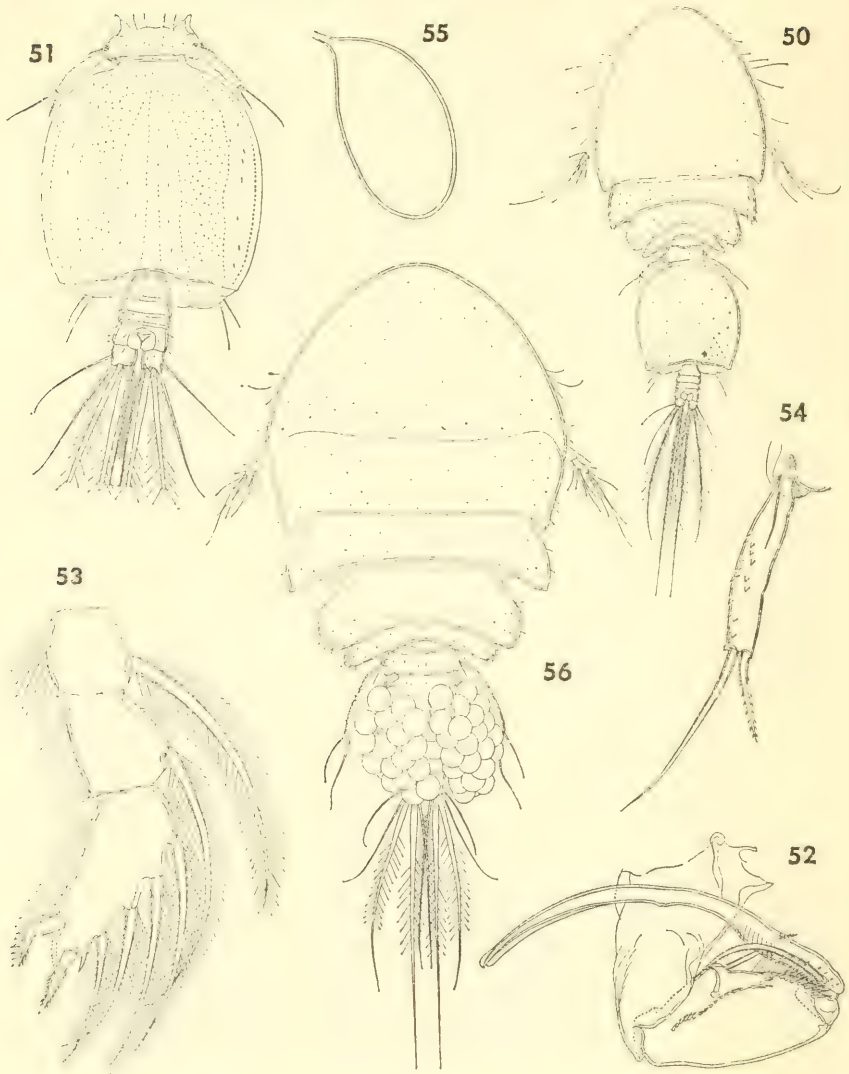
FIGURES 32-36.—*Lichomolgus exilipes*, new species, female: 32, body, dorsal (A); 33, urosome, dorsal (B); 34, area of attachment of egg sac, dorsal (E); 35, caudal ramus, dorsal (C); 36, rostral area, ventral (D).



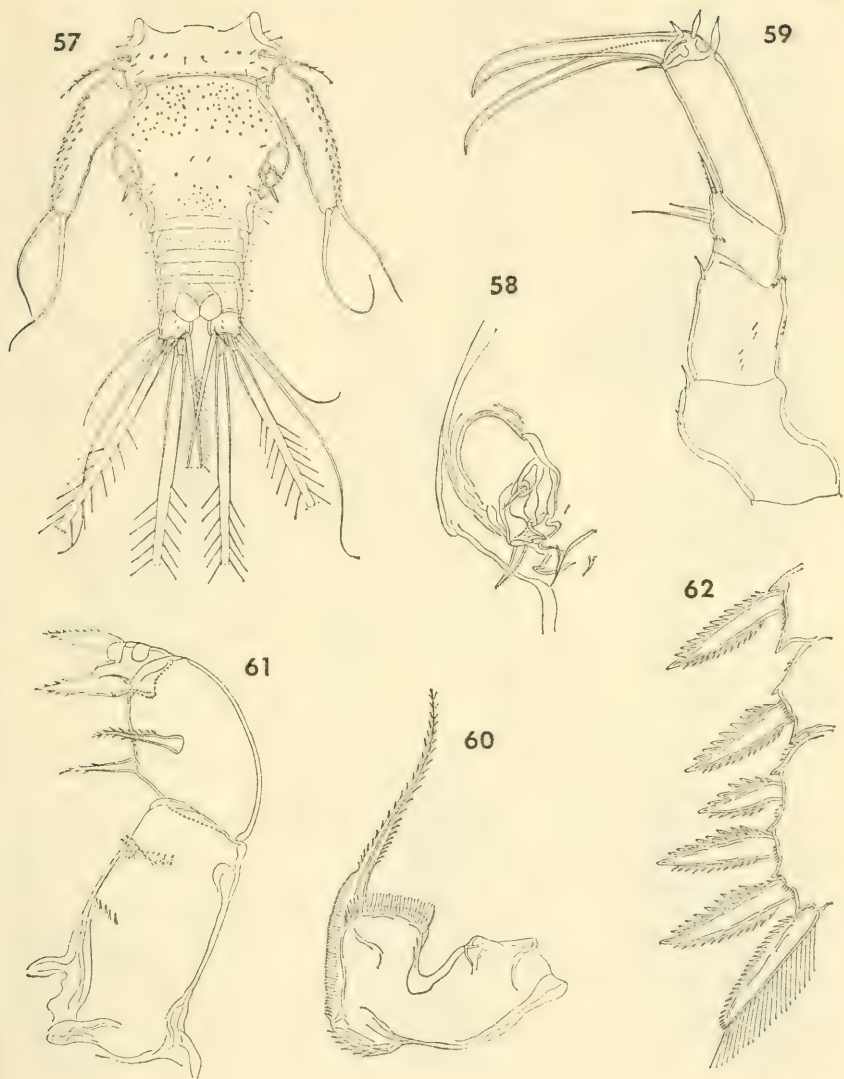
FIGURES 37-44.—*Lichomolgus exilipes*, new species, female: 37, first antenna, ventral (B); 38, second antenna, anterior (inner) (D); 39, labrum, ventral (F); 40, mandible, posterior (E); 41, first maxilla, posterior (E); 42, second maxilla, postero-inner (E); 43, maxilliped, postero-inner (E); 44, area between maxillipeds and first pair of legs, ventral (D).



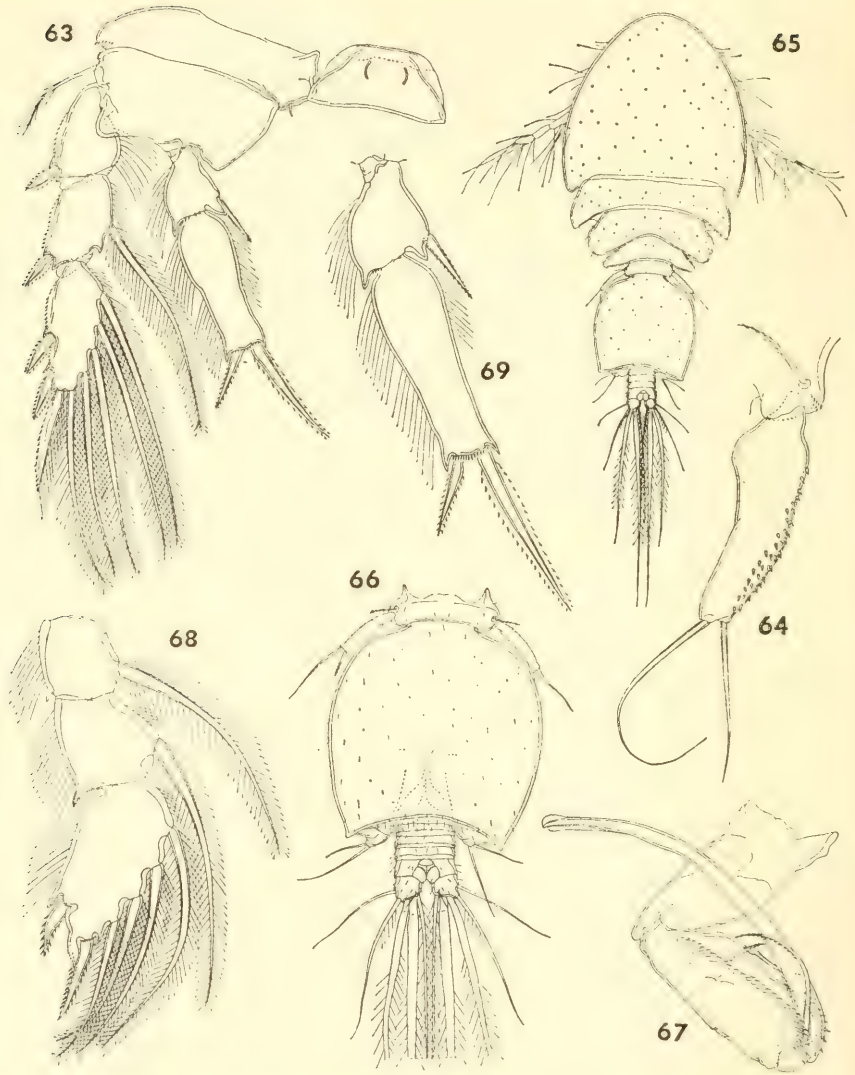
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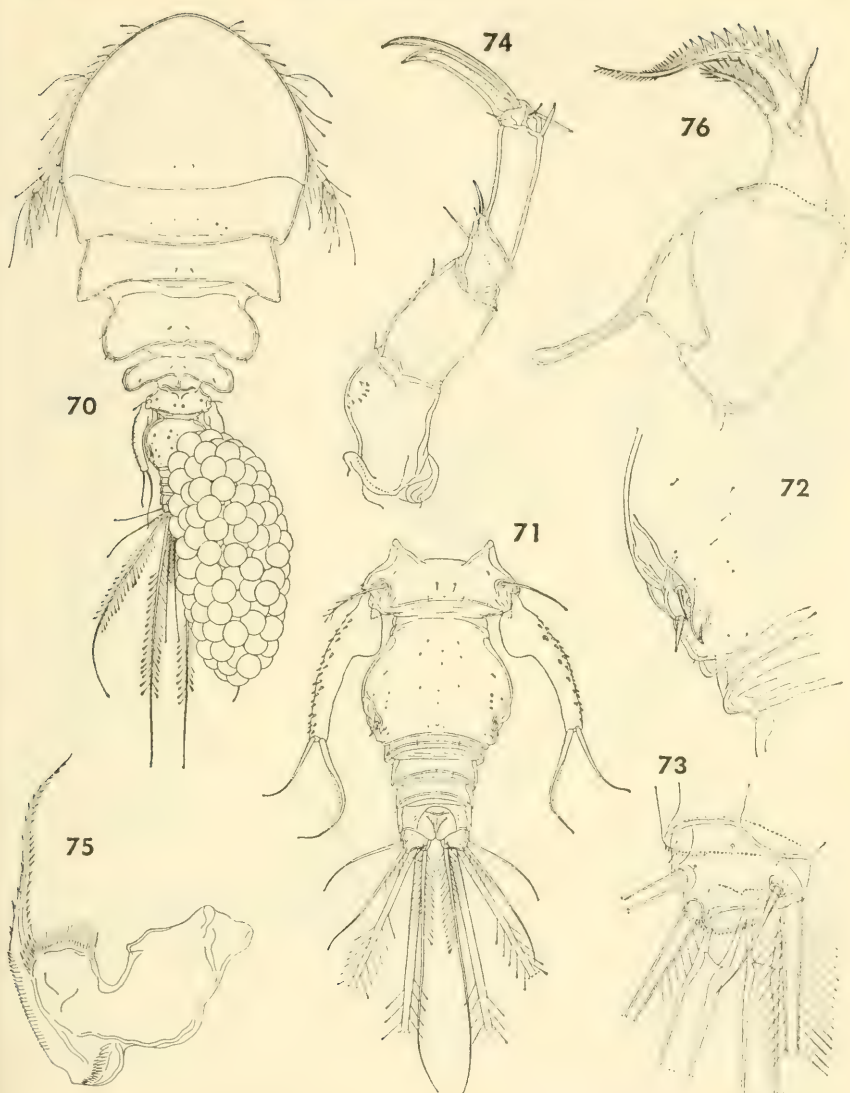
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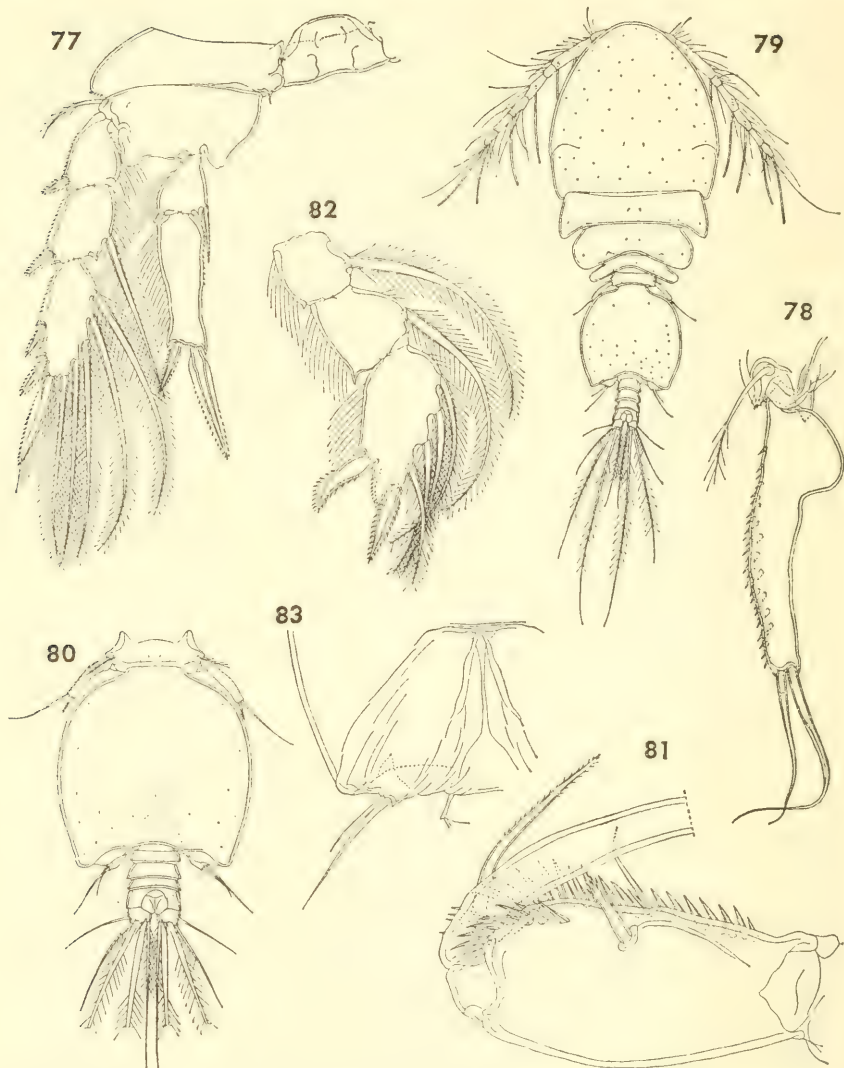
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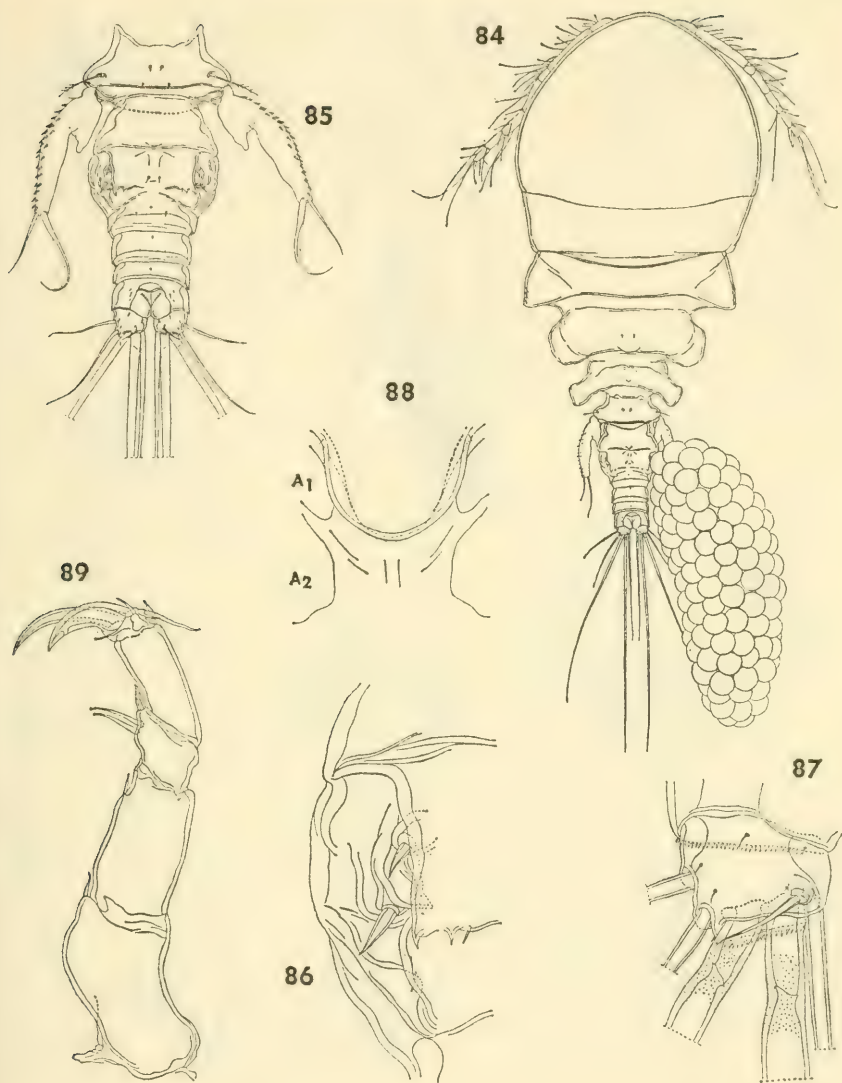
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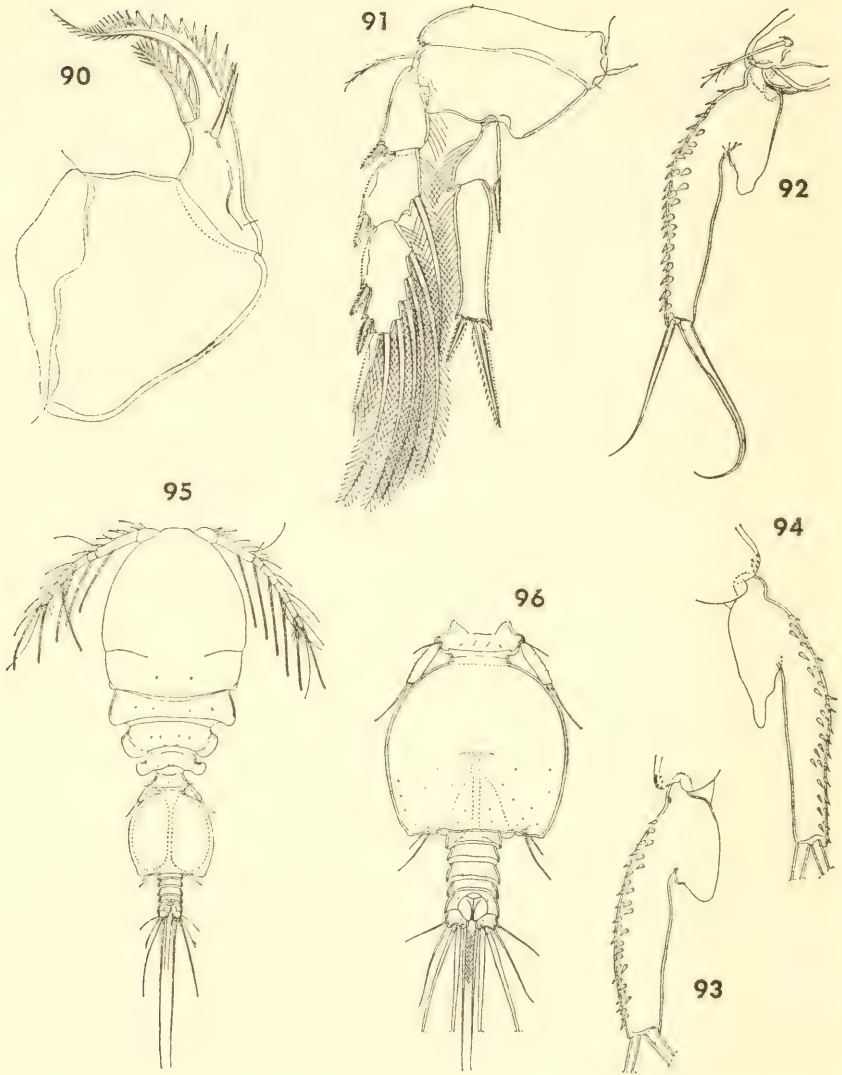
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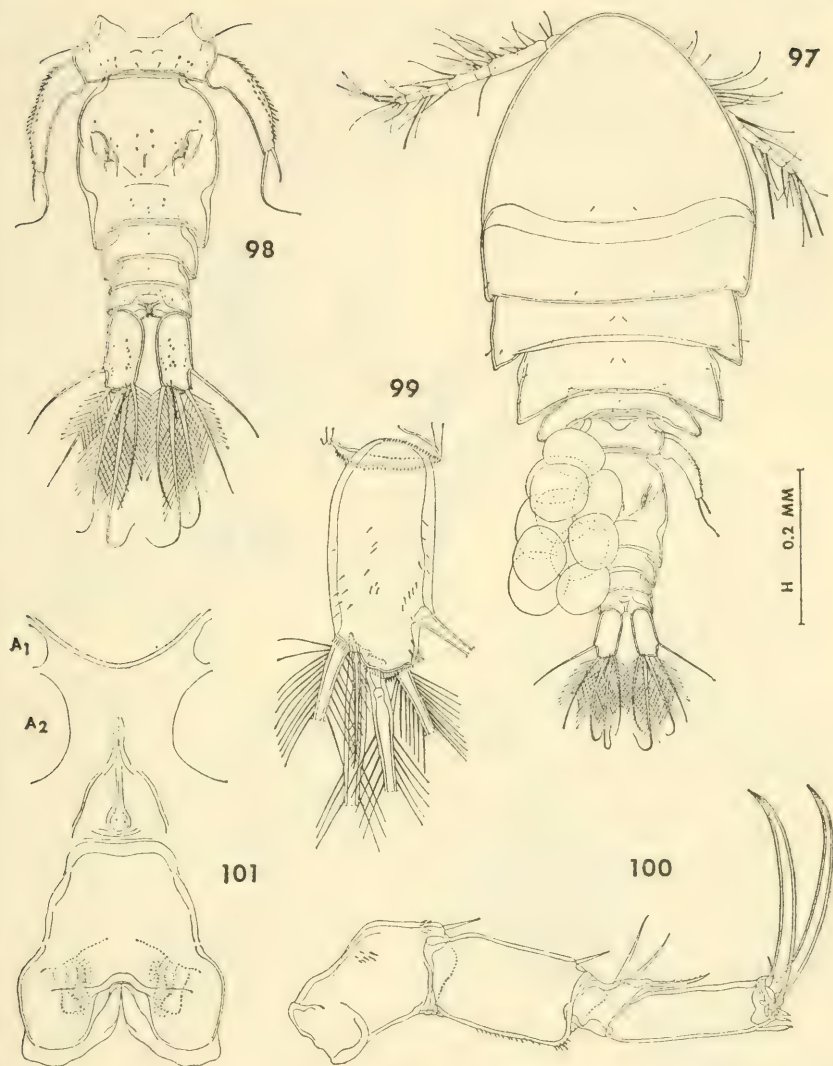
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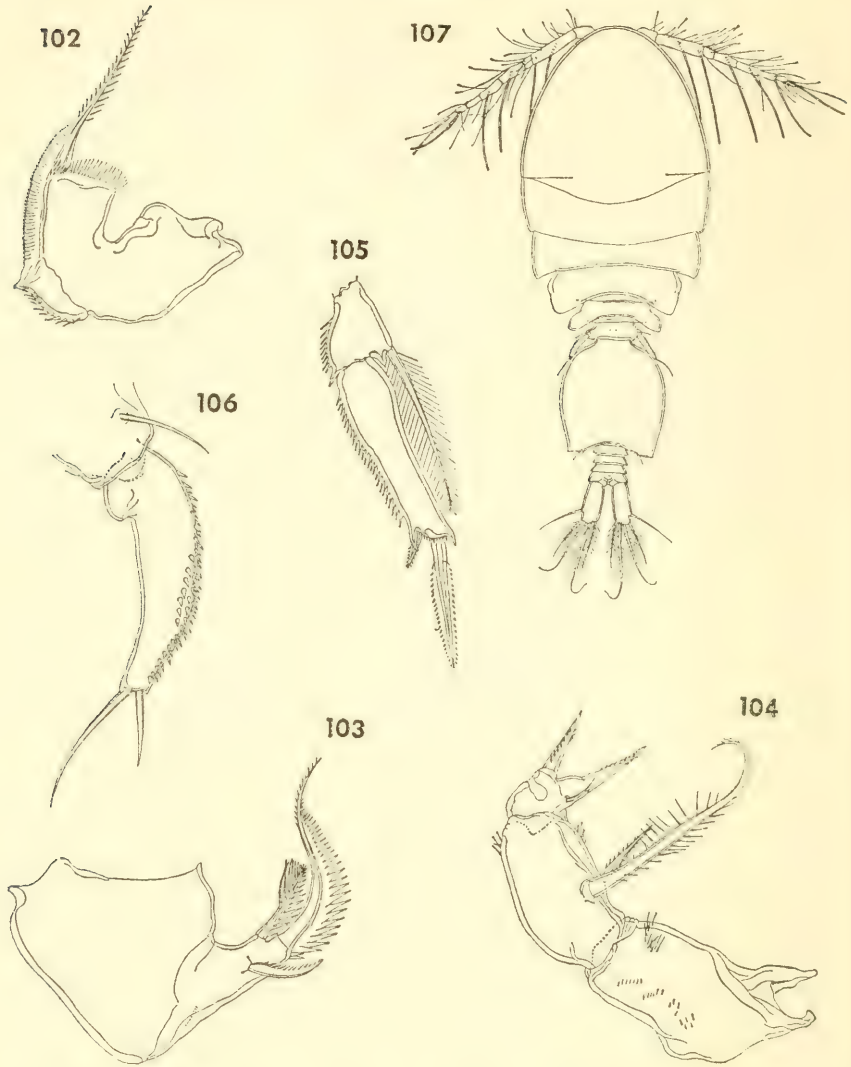
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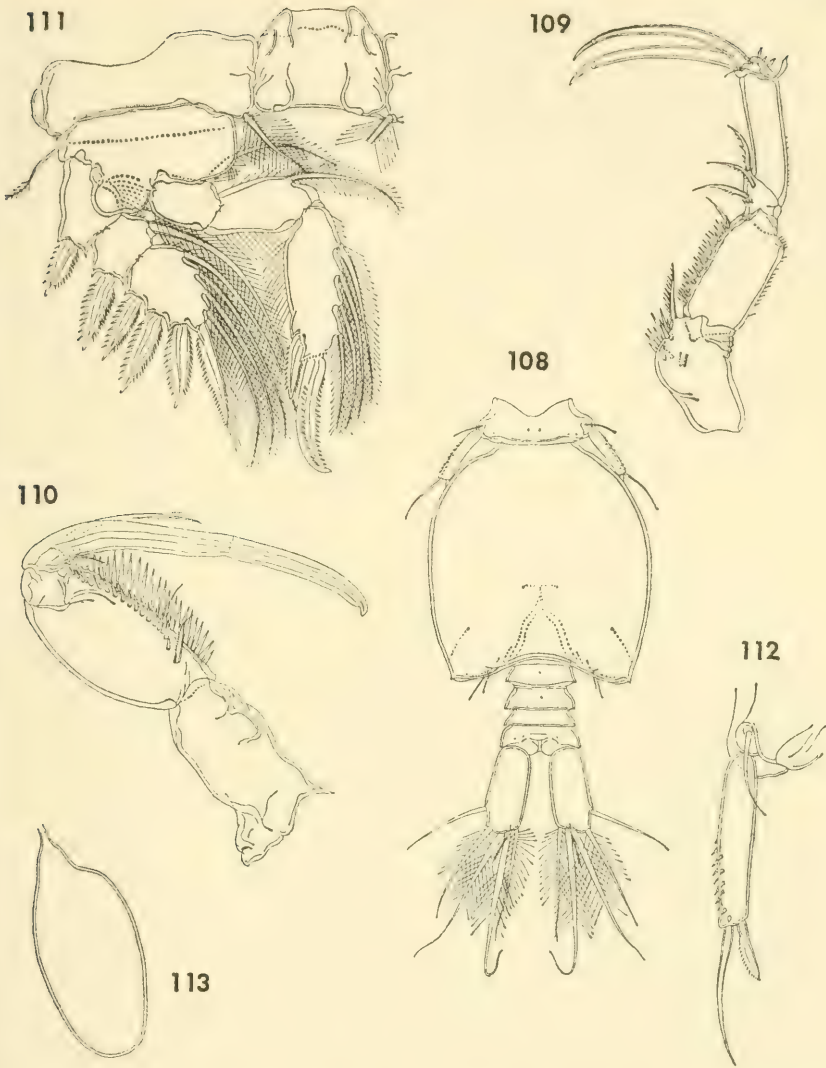
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Prospects in Primate Biology

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Preface

In recent years the great increase in studies in physical anthropology as well as the paleontology of the more recent periods of geologic time has focused scholarly attention on man's relative and potential ancestors to a new level of intensity. Partially, this has been the result of the effect of the evolutionary theories postulated since 1930 by Huxley, Dobzhansky, and others. As Mayr (1963, *Animal species and evolution*, p. 637) has stated:

It was hopeless to try making sense of hominid phylogeny as long as the fossil remains of man's ancestors were considered anatomical "types." . . . The study of the geographic variation of animals and a new insight into the process of speciation have introduced into the study of fossil man new concepts [and]—a great simplification of the general picture.

An understanding of man's rapid mental evolution in the past million years, based presumably on the refinements of speech and tool making, has led biologists and anthropologists into a major field of study—the social organization and behavior of primates. Primate biology gives every indication of being one of the most vigorous and rewarding areas of research although still in its formative stages. One of the charming idiosyncracies of this field of study is that it is

interdisciplinary, that is, it is the proper concern of "so-called" biologists, "so-called" anthropologists, and "so-called" paleontologists. Such an unorthodox area for research can obviously best be performed in unorthodox places, perhaps one reason why Hooton's hope (cited by Napier) that primate biology would become established as a separate teaching division in universities has not been realized. Universities as a whole are largely losing their ability to be innovative, thus putting more pressure on smaller institutions like private laboratories or museums to maintain their fundamental reasons for being. I once characterized the Smithsonian Institution as populated by specialists who were inheritors of a tradition of the "unfashionable in pursuit of the unconventional." The urgent need for studies such as those outlined in this paper is underscored by Dr. Napier's concise account of the rapidly diminishing status of many of the primate species. Conservation is by no means a subject to be ignored by scientists. Environmental studies make conservationists out of the most realistic among us. Primate biology thus becomes one of the most urgent of all interdisciplinary concerns of science today.

S. DILLON RIPLEY
Secretary
Smithsonian Institution

Primate biology as a scientific endeavor is unique inasmuch as it provides a mirror into which man may look to discern the nature of his own species.

Nonhuman primates, occupying an intermediate position between other mammals and man, serve as a constant reminder of the continuity of mammalian life. Thomas Henry Huxley in 1876 expressed the essence of this special primate role:

Perhaps no order of mammals presents us with so extraordinary a series of gradations as this—leading us insensibly from the crown and summit of the animal creation down to creatures from which there is but a step, as it seems, to the lowest, smallest and least intelligent of placental mammals.

The significance of this relationship between man and the non-human primates is—to translate and paraphrase the late Earnest Hooton's happy plagiarism of the poet Terence—that "anything to do with primates is something to do with man." It is inherently probable, therefore, that any basic concept developed in the fields of primate physiology, psychology, or therapeutics, for example, can be applied also to man. This tenet now widely appreciated provides the rationale for the extensive use of primates as experimental subjects in medical and sociological research.

Not so widely appreciated, however, is the urgency of providing rear-guard support for the flying columns of applied primate research.

Perhaps at this point it should be emphasized that there are two main types of primate research that, broadly speaking, can be classified as applied/project-oriented or academic/subject-oriented. Project-oriented research is research *with* primates using them as other laboratory animals are used in order to test the efficacy of a technique that cannot be so tested in man. Subject-oriented research is research *on* primates that leads to a further understanding of their biology and, by the nature of their relationship to man, to the development of hypotheses that can be tested subsequently in a human context. Subject-oriented research, thus, tends to produce results that are seldom of immediate applicability to areas of human health and welfare; they are usually at least one stage removed from medical or sociological usefulness.

The work of Landsteiner and Wiener on the *Rhesus-antigen*, which was later shown by Levine et al. (1941) to be identical with the blood-factor involved in cases of human erythroblastosis foetalis, provides a good example of the value of a "once-removed" type of applicability.

As an example of subject-oriented research, Haddow's (1952) field study on *Cercopithecus ascanius schmidti* may be recalled. This basic research project not only contributed to our knowledge of the ecology and behavior of the redtail guenon, but also it provided the essential background to Haddow's later work on the epidemiology of sylvan yellow fever. The work of Harlow and his associates (1958-1965), of Mason (1965), and of Hinde (1966, 1967) on the affectional systems of monkeys and apes already has had profound repercussions in the areas of child health and development and social psychology. In the field of sociology and social anthropology the zoological perspective (particularly in primate field studies) is leading already to a better understanding of human behavior and human social systems (Tiger and Fox, 1966; Morris, 1967). Subject-oriented research also is often anticipatory as discussed by Riopelle (in press), who recalls, *inter alia*, that W. S. Hunter developed the delayed-response test in 1913 long before it became useful as a means of measuring function in the frontal lobes in man.

Subject-oriented research requires not only a specific training in primatology (at least at graduate level) but a continuing exposure to an academic environment where peer-contact has the salutary effect of promoting self-criticism and of stimulating intradisciplinary, subject-oriented thinking. Project-oriented research, on the other hand, given good primatological advice at its inception, need not be done in a primate-oriented environment; it can be carried out wherever ap-

propriate laboratory facilities and experienced animal handlers are available.

It is easy to understand why, in a period of political or economic crisis with a premium on pragmatism, the "once-removed" aspect of subject-oriented research does not usually attract much in the way of sympathy or support. This attitude, however, is invoking expediency at the risk of self-immolation. It is precisely in such times that a long-term view is necessary. In a recent article, Leaf (1968) stated: "Emphasis only on applied research in medicine would quickly exhaust the present level of understanding and yield only inadequate solutions to major health problems." In particular reference to primate biology, the need for subject-oriented research is pressing, for seldom in the history of scientific endeavor has any new edifice been erected with so little regard for the nature of the bedrock. In a letter to "Science," Moor-Jankowski (1965) pointed out that the paucity of subject-oriented research in primatology has been due not so much to the lack of support (by funding agencies) as to the lack of competent scientists. This deficiency can be traced to the fact that university training for this fruitful field of research is virtually nonexistent.

The hope expressed by Hooton (1954) that primate biology would become established as a separate teaching division in the universities has not been realized. This is not to say that the subject is not being taught at all—far from it. Primatology always has constituted an important aspect of degree courses in anthropology and is taught in most university departments. Principally, however, the emphasis is placed on primate evolution—and a somewhat anthropocentric approach to evolution, at that. Only rarely, for example, are primate anatomy, genetics, behavior, and serology covered in any detail. Primate systematics and classification seldom, if ever, form a part of the curriculum. Perhaps the complete absence from scientific literature of a student textbook on primatology is the best pointer to the present deplorable state of affairs.

It would seem to be a matter of fundamental importance that in countries where primate research is active and ongoing that there should be centers where teaching and training programs in primatology can be carried out and where future staffing needs of research institutes and primate breeding centers can be catered to.

Considering the enormous national investment in primate research, it seems quixotic, to say the least, not to insure that centers of research are also centers of education. Basic research and education programs are inseparable. The establishment of graduate and undergraduate education programs will bring about a rapid accumulation of the baseline data so urgently needed by research scientists today.

It is not possible to anticipate in detail the direction that future research will take, but, without a shadow of doubt, it will become heavily committed in the areas of child development, and mental, social, and environmental health and behavior. In these fields the experimental animal must be a primate. Information, firmly rooted in biology, will be needed about the behavioral parameters of primates under varying conditions: firstly, in the field in the framework of ecology; and secondly, in artificial environments ranging from the near-normal conditions of the field-cage to the wholly artificial conditions of the laboratory. These studies of naturalistic and "semi-naturalistic" behavior are subject-oriented just as certainly as are the more traditional academic disciplines of anatomy, taxonomy, and phylogeny.

Primate Biology Today

The last ten years have seen the coming of age of two subjects concerned with the science of man—human biology and primate biology. Although they can scarcely be considered new disciplines, they reflect a new attitude of mind and provide fresh ways of looking at old problems.

The approach to both is naturalistic. The animal, whether man or nonhuman primate, is studied primarily as a living creature in the context of its normal environment; it is regarded as a member of a natural population, not as an individual; and it is regarded as an expression of the phenotypic variation of the species rather than as the archetype of the race. These principles require new and liberal perspectives in study methods. Human walking, for instance, one of the more simple components of human behavior, cannot be investigated merely by studying the osteology of the limbs, nor can it be explained solely in terms of the biomechanical functions of the relevant muscle groups. Walking also is concerned with the environment of men who walk and with their physiological needs in a variety of different habitats; it is concerned with the effects of culture on the periodicity of this human activity and the historical conditions that led to its evolution.

To study primate behavior entails a consideration of anatomy, physiology, biochemistry, ecology, ergonomics, paleontology, anthropology, and genetics. With a multidisciplinary approach of this sort, primate biologists cannot afford to be specialists. While inevitably possessing special knowledge in particular fields, they require a general awareness of all relevant fields. In this context "awareness" can be interpreted as an attitude of mind that, in turn, can only evolve from a training that is designed to develop it. There is much to

be said for the training of the specialist with his rigorously channelled expertise, providing that his future employment asks no more of him than this; but there is a real place in twentieth-century science for the multidisciplinary scientist.

The interrelationship of primate and human biology is intricate and important both pragmatically and philosophically. They stand in much the same relationship, for example, as political economy and political history, as mining engineering and petrology, as sociology and social anthropology. The first of each pair is concerned primarily with the present, and the second is involved principally with the past. Primate biology, though not a historical subject per se, stands in historical relationship to human biology. Man is a recent innovation of primate phylogeny with a relatively brief history as *man* but an extremely ancient one as a *primate*. Chimpanzees and gorillas are the living descendants of the same group from which man's remote ancestors were drawn millions of years ago. In this regard they serve as genetic models for man. Their value for biomedical research depends on this close blood relationship. Other primates—the baboons, for instance, which, like man, are recent innovations—are too phylogenetically remote to serve as genetic models. Baboons and macaques occupy a broadly similar ecological niche today as the primate precursors of man occupied some fifteen million years ago. The study of these animals, which can be regarded as ecological models, might, therefore, be expected to provide valuable clues for the development of hypotheses concerning the roots of the human social organization. It is no coincidence that baboons, macaques, and chimpanzees are the most widely used of all nonhuman primates in biomedical and sociological research.

The past of organisms is one of the determinants of their future, and the most fruitful place to look for man's past is not only in ancient and inaccessible rocks but also in the structure and behavior of living primates.

At Oxford, England, in 1864 Disraeli said: "The question is this: is man an ape or an angel? My Lord, I am on the side of the angels." A hundred years later we are no longer interested in the answer to Disraeli's rhetorical question. We do not regard it as being particularly important. Man and apes are part of one zoological order, the Primates, an order that also includes the monkeys and the lemurs, and the close relationship of these forms to man is no longer a matter of dispute or concern. The essential conformity of man and the primates in morphology, physiology, serology, and behavior is beyond question, and the problem now facing primate biologists is the clarification of the relationships within the order, with extension of knowledge in depth and breadth to include as much information on struc-

ture, genetics, behavior, and ecology for as many different species of primates as possible.

Professor Sir Wilfrid Le Gros Clark in an address to anthropologists in 1959 discussed the evolution of a new discipline. He observed that all branches of science in their neonatal stages passed through a collecting and cataloging phase. As far as primate biology is concerned, these preliminaries must be regarded as an essential stock-taking exercise during which the language and methodology of the subject must develop and the basic facts of primate biology are collected, synthesized, and disseminated. Primate biology is still, strictly speaking, in this phase. We still need to find out what it is all about, what we know, what we don't know, what is relevant, and what is totally irrelevant. Primate biology needs a plan, a blueprint from which to build a significant and durable structure.

Diminishing Primate Stocks

High on the priorities list of a primate research program should be studies directed toward the understanding of the *captive* primate. Before the end of this century there will be only a few natural populations of primates, living undisturbed lives, left in Africa, Asia, or Latin America. The majority of nonhuman primates will be captive in one sense or another. They may be under close restraint in medical laboratories, in zoos, in breeding ranches in the tropics, in free-ranging colonies in temperate zones, on isolated islands, or in reservations and game parks, but captive, nevertheless. This gloomy prognosis is the inevitable result of extrapolation from three unrelated trends: firstly, the ever increasing deforestation that results from agricultural development in tropical countries; secondly, the widespread native habit of killing monkeys for food, particularly in West Africa, where they constitute a vital source of animal protein; and thirdly, the exorbitant rate of consumption of primates by research scientists. Importation of monkeys into the United States during F.Y. 1966 has been estimated to have exceeded 100,000 individuals; the vast majority, it can be assumed, ended up in biomedical research laboratories. This rate of consumption could lead rapidly to extinction of certain populations in the wild: monkeys simply do not breed at this rate. Rhesus monkeys and the common langur (*Presbytis entellus*) already are showing signs of depletion in certain regions of Asia. Southwick, Beg, and Siddiqi (1961), who carried out a population study of rhesus monkeys in 1959-1960 in the Uttar Pradesh province of India, observed a marked shortage of juveniles in many troops.

The golden tamarin (*Leontideus rosalia*) is said to be near extinction in Brazil although the blame in this instance cannot be laid at the

door of the scientist. In Sierra Leone it has been estimated that, for every young chimpanzee exported for research or for zoos, between four and six mothers have to be killed. Since each of these mothers might be expected to produce up to ten offspring in a lifetime, the potential loss to the wild population for *every* young chimpanzee captured is between forty and sixty individuals. Estimations of this sort can never be particularly reliable, but even the loss of a single breeding female for every infant captured could eventually have a severe effect on population numbers.

There are clearly several ways of approaching the problem of diminishing primate stocks. Firstly, there is the matter of conservation. This is an admirable concept, and, indeed, conservationists can chalk up a number of important successes for which the whole world should be grateful, but unless the aims of conservation are anticipatory rather than retrospective, the problem of the primates will not be solved by such measures. The only possible procedure for the orangutans of Borneo (it seems inevitable that the Sumatran race is past saving) is to establish protected colonies on suitable islands. The real problem for the future are monkeys such as the patas, the vervet, the baboon, and the macaque, all of which, though plentiful now, may not always remain so. On the basis of present trends, it is difficult to see how natural populations of these animals can survive beyond the end of the century. It is the *potentially* vanishing species that should be the principal targets of conservationists, not populations that are already doomed.

Information is urgently needed on the population numbers of free-ranging primates, particularly the most popular laboratory animals, in order to guide future policies on importation of primates and the establishment of breeding colonies at home. We have little or no precise knowledge of current wild population numbers or of population dynamics in the countries of origin of these animals. Rumors abound, but factual information is lacking.

Choice of Primates in Medical Research

Although the literature in recent years on the care of primates in medical research laboratories has grown astronomically, relatively little consideration has been given to the selection of primates specifically appropriate to particular types of research investigations.

The choice of a nonhuman primate is largely a hit-or-miss affair and will continue to be so until the biological properties of all species have been fully investigated. Reference to recent publications (e.g., Montagna, 1967), to the symposium volumes edited by Vagtborg (1965) and Fiennes (1966), respectively, and to the textbooks of

Ruch (1959) and Fiennes (1967) would reveal a great deal of information on the proved and potential usefulness of particular species for particular problems. A comprehensive account of the research potential of the 197 species of primates is beyond the scope of the present article.

Choice of a suitable primate for a specific project, therefore, must depend on hearsay, on the published reports of other workers, or, in the last instance, on trial and error. Finally, selection will be influenced by pragmatic considerations that relate to available space, available resources, and available primate species. There are no hard and fast principles by which suitable animals may be selected except that of phylogeny, which, at best, can act only as a general guide.

The phylogenetic article of faith is simply stated: The experimental results that are most likely to be meaningful in a human context are those carried out on animals that have the closest genetic relationship (and, therefore, phylogenetic proximity) to man.

The phylogeny of the primates is shown diagrammatically in figure 1, wherein primate families and their component genera have been arranged in terms of their relative closeness to man.

PROSIMIANS.—The Prosimians comprise six families, which are arranged as follows: Tupaiidae, Lorisidae, Daubentoniidae, Indriidae, Lemuridae, and Tarsiidae (Napier and Napier, 1967). The use of prosimians as laboratory animals has been discussed recently by Manley (1967), Montagna (1967), and Hill (in press).

Treeshrews (Tupaiidae) are not unequivocally primates. Opinions differ strongly at the present time as to whether they should be so regarded. The attitude taken by the author is that, whether technically they are primates or not, they are thought to be so close to the phyletic root of the order (at a time when all primates were insectivores, so to speak) that they should be retained in the Primates, if only as a permanent reminder of the generalized mammalian origins of the stock. Treeshrews have not been used widely as laboratory animals except in strictly physiological experiments, but with the new information emerging on breeding behavior (Martin, 1966), they may well attract more attention.

Among the Lorisidae, galagos are potentially the most useful. Their relatively short gestation period (*Galago crassicaudatus*: 130–135 days; *G. senegalensis*: 144–146 days) and the not uncommon occurrence of twin births mark them as possibles. A number of primate centers and research laboratories are breeding these animals successfully. The melanistic race, *G. c. argentatus*, is tougher and heavier than the brownish *G. c. crassicaudatus* and may prove to be more hardy in captivity; it is possible that it may be a good subject for an open-air colony situation.

The Lemuridae are the only other family of the Prosimian radiation that are likely to be available for laboratory work; the remaining families are too rare and too delicate to be considered. Lemurs, specially the robust ring-tail (*L. catta*), have been bred successfully

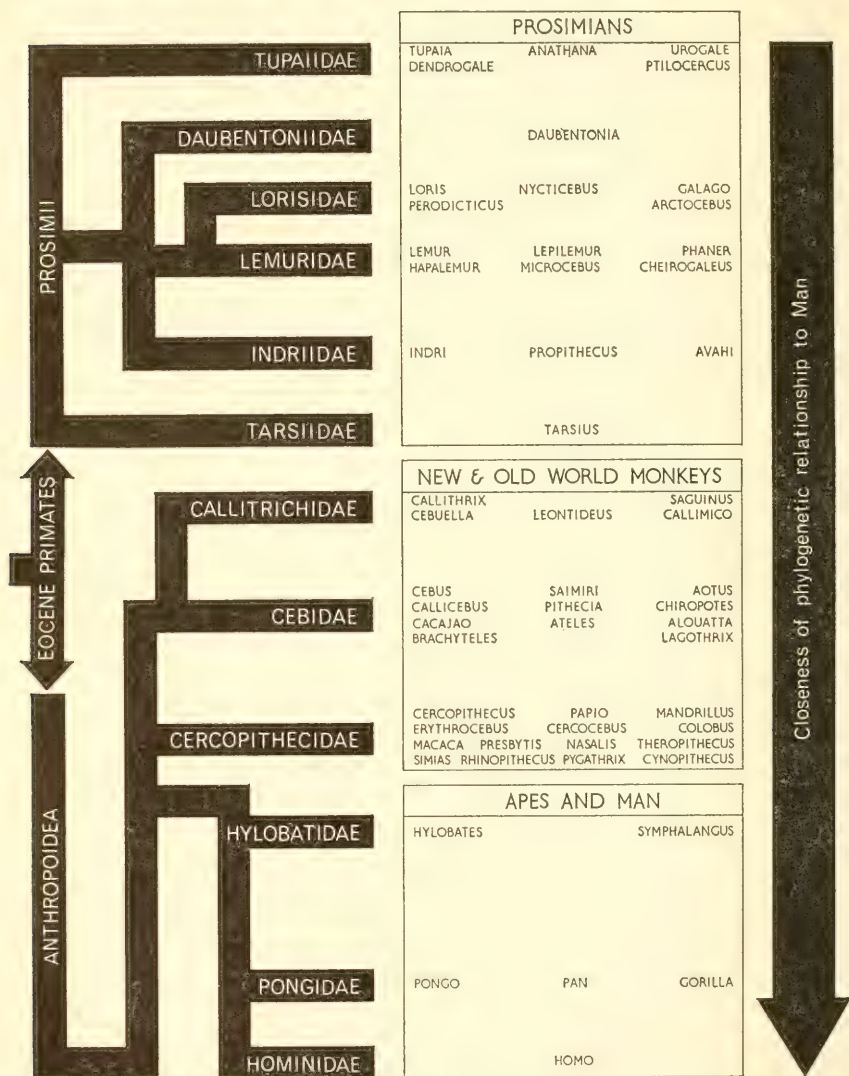


FIGURE 1

in quite large numbers in laboratories and zoos in recent years also, to a lesser extent, have the black lemur (*L. macaco*) and the brown lemur (*L. fulvus*); however, it is certain that scientists who have a special reason for employing these animals in research will have to

depend wholly on their own breeding stocks in the future as all Madagascan prosimians are rigorously protected. The value of prosimians as laboratory animals is largely unknown, but, generally speaking, their usefulness lies in the field of basic research. This is exemplified by the ongoing studies of Montagna and his colleagues on cutaneous anatomy and physiology. As substitutes for higher primates in the fields of cancer research, immunology, and pharmaceuticals, they leave much to be desired.

NEW WORLD MONKEYS.—The New World monkeys comprise two families, the Callitrichidae¹ and the Cebidae. Marmosets (*Callithrix*) and tamarins (*Saguinus*) have enjoyed—if that is the right word—a high popularity during the last five years. Their principal advantage is their small size and the free availability, in particular, of *Saguinus*. The common marmoset (*C. jacchus*) is becoming increasingly rare according to certain authorities (Hill, in press).

A discussion of the suitability, disease hazards, and basic biological data of marmosets and tamarins has been summarized by Deinhardt and Deinhardt (1966); breeding of marmosets in captivity has been discussed by Hampton et al. (1966).

Although phylogenetically the most remote from man of all higher primates—and, therefore, of limited value in procedures that hinge on close genetic proximity to man—marmosets are most useful animals in certain specific research projects. In the study of viral hepatitis, for example, they appear superior to other nonhuman primates, always excepting the expensive chimpanzee (Deinhardt and Deinhardt, 1966).

Among the Cebidae, the only species that merit consideration at the moment are the squirrel monkeys, the douroucoulis or night monkeys, and the capuchins. The shortness of this list reflects as much as anything the neglect of the New World genera by primate biologists. No doubt this neglect can be traced to the remoteness of this group from the story of human evolution, which in the past constituted the principal *raison d'être* for studying primatology.

Cebus, the capuchin, which is said to be resistant to tuberculosis, has been discussed by Stare et al. (1963), principally in relation to dietary factors in the etiology of atherosclerosis. Squirrel monkeys, which fulfill nearly all the criteria for the ideal laboratory animal except that of phyletic proximity, are widely used in neuroanatomical studies in arteriosclerosis research and in space physiology. One of the most surprising animals to emerge as a promising laboratory species

¹ The spelling of Callitrichidae is that originally used by Thomas (1903). The termination appears to be formed in accordance with Appendix D, Table 2, of the "International Code of Zoological Nomenclature" (1964), and, therefore, there is no case for amending Thomas' spelling.

is *Aotus* (the douroucouli), the only nocturnal higher primate and one of the most primitive monkeys in existence.

OLD WORLD MONKEYS.—The Old World monkeys comprise the single family Cercopithecidae; of the two subfamilies, the Colobinae and the Cercopithecinae, only the last named are presently of interest to the research scientist. The contribution of the Cercopithecinae to human research has been discussed by Jolly (1966).

Macaca mulatta, the rhesus monkey, the "monkey" of medical literature, is too well known to merit discussion here; its use in the identification of the Rh blood factor and in the development of poliomyelitis vaccine is common knowledge. The breeding record of the rhesus macaque, its toughness, availability, and cheapness make it the best all-round research animal. Certain other macaque species as the crab-eater, the pig-tail, the stump-tail, the bonnet, and the Japanese macaque all breed well in captivity. The last mentioned promises to be especially valuable as a species that can be bred freely in open-air compounds, even in high latitudes.

The closely related Celebes black "ape" (*Cynopithecus niger*) is another primate that seems to breed well in captivity. As a bonus, Celebes apes are, for Old World primates, quite friendly animals. One might guess that imported stocks of *Cynopithecus* are never likely to be adequate for extensive research usage due to the restricted range of the species. Their future usefulness will have to depend largely on domestic breeding programs.

Baboons have grown in popularity in recent years and are becoming biologically very well documented (Vagtborg, 1965). They are of particular value in surgical procedures (Moor-Jankowski, 1967). Baboons have been used extensively in studying the etiology of atherosclerosis and other cardiovascular diseases of man at Sukhumi in the U.S.S.R., for instance, and at the Southwest Foundation, San Antonio, Texas.

The leaf-eating section of the Cercopithecidae, the Colobinae of southeast Asia (*Presbytis*, *Nasalis*, etc.) and Africa (*Colobus*) are so specialized in their diet and, relatively speaking, so little known biologically that they have no place in medical laboratories at the present time. A possible exception to this generalization is the Hanuman or entellus langur (*P. entellus*), which is hardier than most other species and more ground adapted (Jay, 1965).

The remaining Old World monkeys to which reference should be made have been grouped by some taxonomists (Jolly, 1965) into a tribe, the Cercopithecini, that includes the following genera and subgenera: *Cercopithecus*, *Cercopithecus* (*Miopithecus*), *Cercopithecus* (*Allenopithecus*), and *Erythrocebus*. This tribe is not generally regarded as important in biomedical research, but there are at least three

species that are worthy of note—the talapoin, the savannah monkey,² and the patas. The talapoin is untried as a laboratory animal but is theoretically desirable in view of its small size and the possession of a sexual swelling in females. Savannah monkeys have been used fairly extensively, notably in the culture of poliomyelitis vaccine. Patas monkeys are used quite widely in Britain today; the fully adult male patas monkey, however, equals a male baboon in size.

Some slight success in breeding talapoins in the laboratory has been reported (Hill, 1967). There is little information on breeding of patas monkeys beyond the fact that between 1959 and 1963 twenty-four births were recorded in world zoos (Napier and Napier, 1967). Goswell and Gartlan (1965) have recorded a single instance of a laboratory birth. Savannah monkeys and their allies, on the other hand, breed moderately freely. It seems logical to anticipate that other members of the genus *Cercopithecus*, such as *C. ascanius schmidti* (the red tail), would be of value in research once they are better known biologically.

APES.—It is hardly necessary to discuss the apes in the context of human research. While it is obviously highly desirable on phylogenetic grounds that chimpanzees should be used for many aspects of biomedical research, their expensiveness and relative rarity should preclude their use other than in very exceptional circumstances wherein no alternatives exist. This does not prevent chimpanzees from being employed in experimental work that does not result in the sacrifice of the animal. It is perhaps in the fields of functional morphology and growth and aging studies that these animals can contribute most to human understanding.

Gorillas and orangutans have no place in the medical laboratory owing to their extreme rarity although, as in the case of chimpanzees, they can contribute to many aspects of human biology. The only remaining ape species to be considered is the gibbon. Being the most active of all primates, they require considerable space in order to remain healthy through the performance of a normal locomotor repertoire. Their unique—in an Old World primate sense—social behavior patterns make them unsuitable as breeding animals.

The scientist faced with a research problem must choose the animal most suited to his requirements. Perhaps the most serious question that he must ask himself is: Need primates be used at all for this particular experiment? Would not a white rat, a guinea pig, or a rabbit do just as well? The conservation of wildlife is a serious scientific, economic, and social problem and not simply a hobby for elderly ladies. Primates are rare animals, and it should be a matter for pro-

² Common names of the three geographical species of the savannah monkey (*C. aethiops* group) are the grivet, the vervet, and the green monkey.

found thought before the decision is made to remove an animal from the wild. Medically useful primates must be bred in captivity in sufficient numbers so that the cause of scientific conservation is not imperilled by the extravagant demands of a sister science.

Primate Biology at the Smithsonian

This recently inaugurated primatology program has a single, clear purpose: To foster the development of primate biology as a scientific endeavor on an international scale. It is to be hoped that this new program will play a central and a catalytic role in the rapidly expanding field of primatology by encouraging basic research, particularly in systematics, and promoting educational programs in the universities, particularly those closely associated with centers of primate research.

The Primate Biology Program is planned as an international facility having, in the first instance, two offices, one in Washington, D.C., at the Smithsonian Institution, and one, in London, England, with close affiliations to the University of London. For geographical and other practical reasons it is likely that the program emphasis will differ somewhat between the two centers; for instance, the magnificent collections, the preparation and storage facilities of the U.S. National Museum, and the proximity of other major museum collections would favor Washington as the locus of systematics research. On the other hand, the close association of the London office with the University of London will facilitate the development of this center as a locus of undergraduate teaching. Graduate training programs would be located in both centers; however, it is not envisaged that the various projects will be divided between the two centers so much as shared between them. Each will contribute to the total program as its native talents and material resources dictate. A regular exchange of students and professional staff between London and Washington will do much to foster the principle of unity.

The following section constitutes a working plan that embodies a research and education program of considerable magnitude and breadth. It is not anticipated that all the projects will develop simultaneously; indeed, it may be several years before some of them can be initiated.

Research Program

Certain aspects of primate biology such as systematics and nomenclature, anatomy and physiology, evolution, zoogeography and population dynamics, free-ranging behavior and ecology, and base-line data on the ecology of captivity are in urgent need of development. These problems are the basic requirements of research workers who, in the design stage of their experiments, must ask themselves a series

of questions (the particular fields of study that might be expected to supply the answer are shown in parenthesis):

Q. 1. Which is the most suitable primate for my purpose? (Anatomy, physiology, psychology. Evolution. Systematics and nomenclature.)

Q. 2. Where can I obtain a regular supply of this species? (Zoogeography. Population dynamics.)

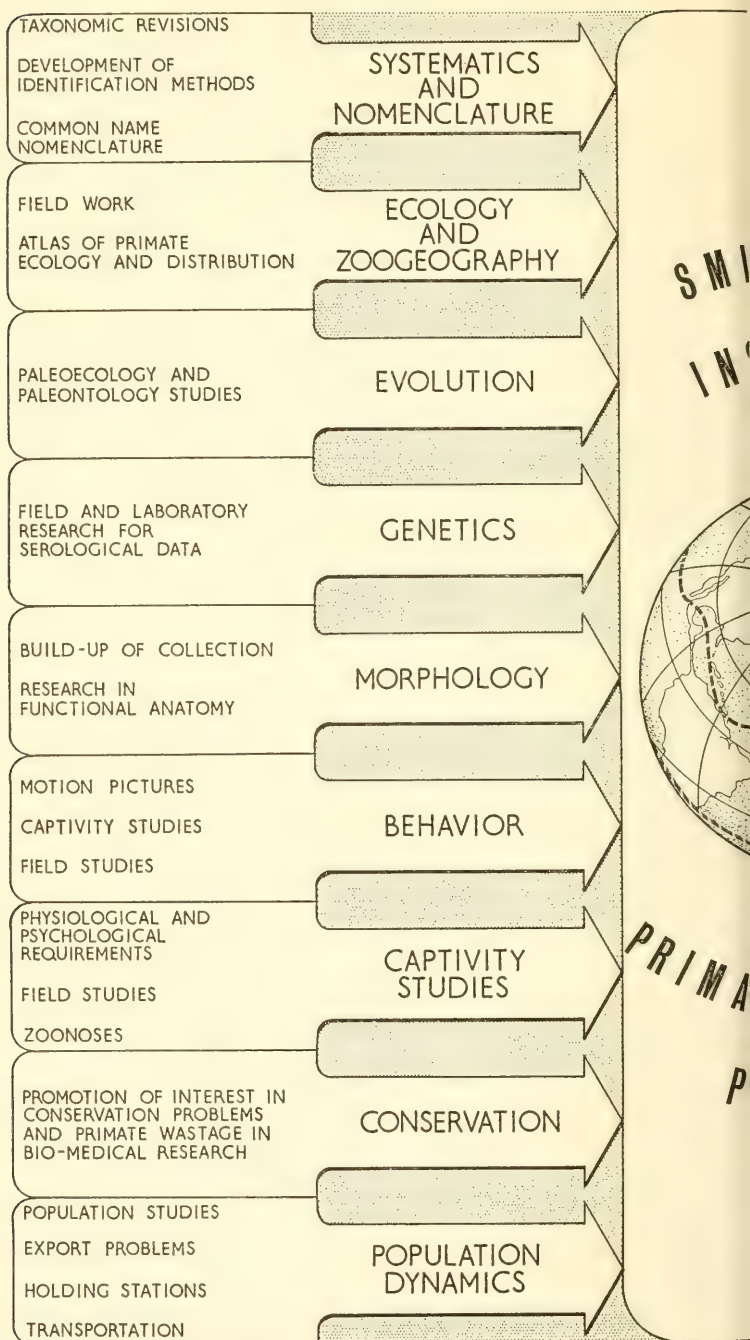
Q. 3. How can I best maintain these animals in captivity? (Free-ranging behavior and ecology. Base-line data on captivity ecology.)

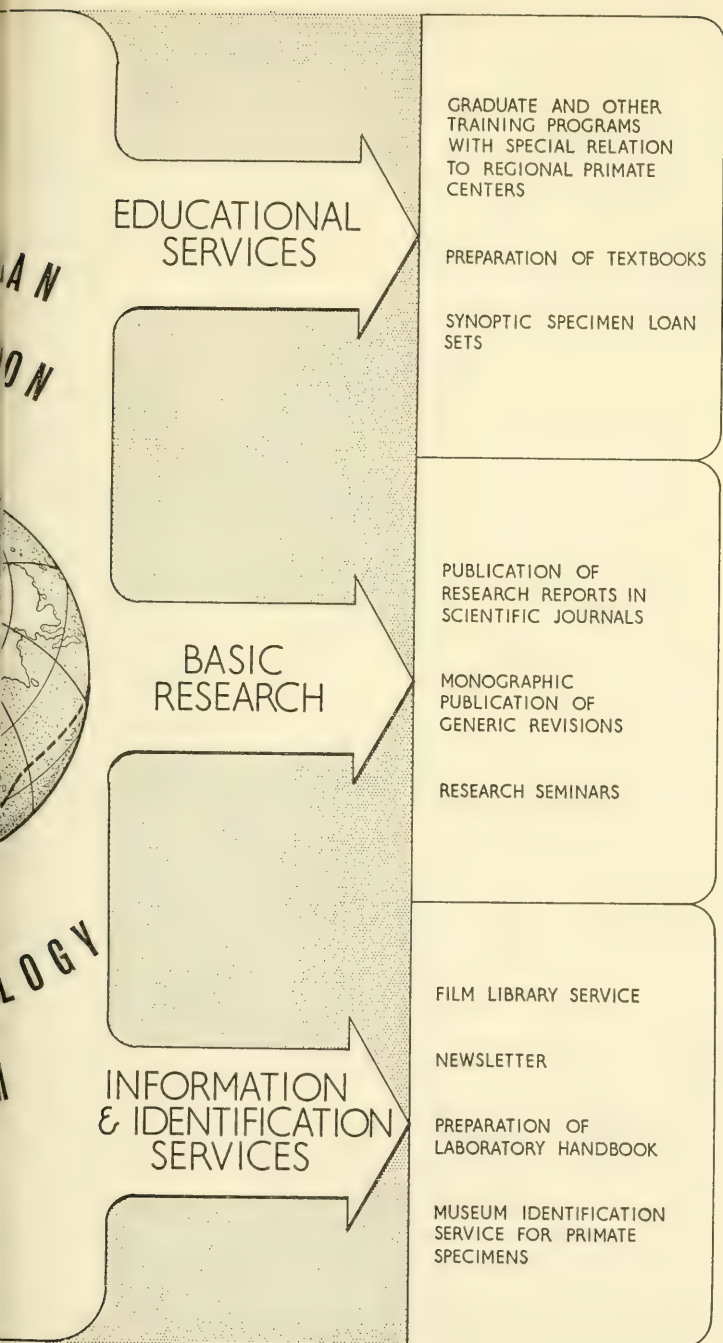
It is in such fields of inquiry as these that the Smithsonian Primate Biology Program will concentrate its efforts.

PRIMATE SYSTEMATICS.—Problems in primate systematics are many and great and constitute a major handicap in the rapid development of research programs employing nonhuman primates as experimental animals. The interpretation of results in fields of physiology, pharmacology, psychopathology and neuropsychiatry, comparative psychology and ethology often depends on a precise knowledge of the systematic status of the subject animal. With imperfect identification, the contributions of previous research workers cannot be utilized, experiments cannot be repeated, and hypotheses—dependent on the precise knowledge of relationships—cannot be developed or tested.

A revision of primate systematics is long overdue for many groups and should rank high in the priorities of any program. Research in primate taxonomy should start with revision of genera. It is difficult to talk about species within a genus without knowing the exact limits of variations among genera themselves. Genera in most urgent need of revision, other than those already being examined, are found in most of the prosimians, many of the Cebidae, certain Cercopithecidae (particularly *Cercopithecus* and *Cercocebus*), and all the Colobinae. Only after restudying such genera can classifications be revised in a meaningful way. Many of these lists are half a century or more old and include species and subspecies that, in the light of modern theories, are quite invalid. The use of computers and advanced statistical techniques are providing new and more accurate means of zoological classification. A recently (Groves, 1967) completed study of gorilla populations using these techniques is an example of the sort of results that can be obtained. Evolutionary studies are a necessary component of systematic revisions; for example, the arrangement of higher categories of Old World monkeys depends on understanding of the phylogenetic relationships among the *Macaca-Papio* ground-living group of Old World monkeys, the arboreal colobine monkeys, and the curiously intermediate *Cercopithecus* and *Cercocebus* groups.

Inasmuch as modern systematics is based on the total biology of populations, a program of revision must be broadly based and must





involve research into many diverse fields of primate biology such as anatomy, paleontology, behavior, serology, and genetics. Thus, the systematics program undoubtedly will provide a considerable mass of fall-out information in these special fields of study in addition to providing taxonomic revisions of the genera.

Priority from the point of view of early revision will be given to those genera most commonly used in scientific research. The marmosets are undergoing revision at present (Hershkovitz, 1966, and in litt.) as are some of the macaque species (Fooden, 1964, 1967). *Papio* recently has been restudied, principally from the viewpoint of osteology and paleontology (Jolly, 1965).

The genus *Cercopithecus*, on the other hand, has not been fully revised since Schwarz' (1928) study, although Hill (1964, 1966a, 1966b) has contributed much toward our knowledge of the taxonomy of these animals, particularly from the point of view of gross anatomy. Certain species and species-groups such as the Mona monkeys have been reviewed recently by Booth (1955); and the *aethiops* group, by Dandelot (1959). Verheyen (1962) has studied the skull osteometrically and osteologically; Chiarelli (1966) has supplied a great deal of information on chromosome numbers. Jacob and Tappen (1957, 1958) have studied haemoglobins. Booth (1956, etc.) has studied the ecology of certain West African representatives, and Haddow (1952) has supplied detailed information for a single subspecies, the redtail (*C. ascanius schmidti*). Few behavior studies have been published; Hall and Gartlan (1965) have observed the social behavior of *C. aethiops* on Lolui Island, Lake Victoria, and Cynthia Booth (1962) and Brain (1965) have studied the behavior of certain species of *Cercopithecus* in captivity. These studies must be extended to include all twenty-one species and sixty-seven subspecies now recognized. It must also be extended to the closely related forms *Miopithecus* (the talapoin, a species potentially of great value to research on account of its small size), *Allenopithecus* (the swamp monkey), and *Erythrocebus* (the patas monkey) with a view to determining whether these forms are congeneric with *Cercopithecus*. The *aethiops* species-group of *Cercopithecus* are another potentially important source of laboratory primates. The aspects of the biology of this group needing particular study are serology, ecology, and behavior. Evolutionary studies, which should provide the basis of any classification, are also most important (see Jolly, 1966); fortunately, the fossil material of the Cercopithecidae is moderately common, particularly in the Pleistocene (Jolly, 1965). A zoogeographical study of the group after the manner of Hershkovitz on *Callicebus* (1963) is also imperative for the full understanding of their origin and dispersal (see also Tappen, 1960). It is proposed, therefore, to initiate a revision of the genus *Cercopithecus*. Other

genera to be studied early in the program will include *Saimiri* (the squirrel monkeys) and *Presbytis* (the langurs).

Taxonomic Teams: Revisions of the systematics of any group cannot, and should not, be carried out by any one individual. Essentially, these are team projects that should reflect the multidisciplinary approach of primate biology. For the proposed fundamental revision of the genus *Cercopithecus*, a team consisting of specialists in the following fields will be co-opted and will operate under the general direction of the author:

1. Osteometric and osteological studies.
2. Serology.
3. Locomotor adaptations.
4. External characters.
5. Ecology.
6. Behavior.
7. Evolution and zoogeography.

Other scientists will be co-opted on an ad hoc basis to study various special aspects of the program, i.e., parasitology.

Duration of Project: In view of the proposed depth and breadth of the revision of *Cercopithecus*, it seems likely that the project will last at least three years, possibly four or even five. Since the systematics team will be drawn from suitably experienced scientists working in different parts of the world, it is considered essential that they should be in constant communication in order that the products of their different viewpoints can be closely coordinated. As far as is possible, a new systematics project involving a separate team will be initiated every second year. Thus, at the end of a five-year period the revision of three important primate genera will be underway.

Study Conferences: The majority of the scientists comprising a "taxonomy team" will be employed on a consultant basis. In order to facilitate close coordination on the project, annual study conferences will be held to bring together the scientists concerned either in Washington or in London.

Publication: During the course of the project, publication of the results of individual studies will be encouraged. At the conclusion of the project, the revision will be published as part of a monograph on the biology of the *Cercopithecus* group.

NOMENCLATURE.—Revision is needed also in primate nomenclature. As more and more medical research laboratories utilize primates, the more urgent becomes the problem. The present nomenclature of primates is neither adequate nor sufficiently stabilized for scientists to communicate with one another without considerable danger of misunderstanding. The common laboratory primate, the crab-eating macaque, is a classic inmate of the nomenclatorial madhouse. It is widely and incorrectly known as *Cynomolgus* and less widely, and cor-

rectly, known as *Macaca fascicularis*, although most current systematic lists refer to it as *Macaca irus*. It is understandable that harassed research workers should throw up their hands at such an impossible situation and end by using its unequivocal common name, the crab-eating monkey. The stability-loving primate biologist asks nothing more than that he should be able to retire at night with a name on his lips that is still valid when he wakes up in the morning.

A Study Group for Primate Nomenclature and Systematics Research will be established at the Smithsonian under the aegis of the Primate Biology Program. Its purposes will be twofold: immediate and long-term. The immediate aim will be to prepare, in the light of present knowledge, the best possible working list of primate species for use in the Primate Centers and other research laboratories; its long-term function will be to determine the areas of primate biology where systematics research is most urgently needed, to foster such research, and to revise critically the nomenclatorial list from time to time as new, irrefutable evidence becomes available. In this way it is to be hoped that primate nomenclature will achieve a *uniformity* in primate research that it has never before enjoyed. Total *stability* of nomenclature is something that cannot be guaranteed; to advocate such a procedure would be to deny the ebb and flow of scientific opinion. Stability, nevertheless, will be the watchword of the Study Group and purely technical name changes will be examined very critically before the status quo of the working list is disturbed.

LABORATORY IDENTIFICATION.—The identification of animals at specific and subspecific level is a fundamental need in both the research laboratory and in the museum. The simplest method is by means of external characters. In the event, considerable reliance is placed on coat coloration. The only means by which this can be achieved other than by direct comparison with known specimens is by reference to published descriptions. Many of the current descriptions antedate the introduction of the Ridgway color system and are, therefore, unstandardized. The earlier Munsel system has been little used in mammalian identification. Even post-Ridgway descriptions with their innumerable subtypes (1115 in all) of the named colors of the spectrum are so complex as to be almost useless in practice for the taxonomist and nontaxonomist alike. At best, all qualitative systems are subjective.

It is proposed to investigate the feasibility of developing a quantitative method of determination of coat colors using the technique of "reflectance spectrophotometry" (Dice, 1947; Hill, 1960). There are a number of techniques available for color specification: the spectrophotometric curve, the tricolor reflectance value, and the C.I.E.

(Commission Internationale de L'Eclairage) system, which provides evidence of the dominant wave length of samples.

A pilot study of *Saimiri* is already underway. Hopefully, this technique will provide a method that can be used by nonprimatologists and primatologists alike to aid in the identification of the species under investigation.

POPULATION DYNAMICS.—Information is urgently needed on the population numbers of free-ranging primates, particularly the most popular laboratory species, in order to guide future policies on importation of primates and the establishment of breeding colonies in temperate climates. We have little or no precise knowledge of current wild population numbers or of population dynamics in the countries of origin of these animals.

Primate population studies should provide information on population levels, population trends, export problems, holding stations, transport mortality, as well as local attitudes and customs involving primates that might affect exportation.

This is a major project and will need to be developed in two phases: (1) The basic background knowledge of the distribution, abundance, and population dynamics will be gleaned from what is already published in the literature on primates. Much of it is archaic and imprecise, but, nevertheless, there is much that is of value that should be collated as a first step. It will be possible to extract much information on distribution, less on abundance, and very little on population dynamics. (2) Following library research, there should be corollary field studies of several of the important species. Primary emphasis would be on the definition of ecological factors most critical in limiting population growth and those factors favoring population expansion and maintenance. Means of carrying out censuses of populations in various situations would be sought. Finally, model studies of the population dynamics of one or two important species should be undertaken.

Much of the field work in the preliminary stages could be carried out in certain of the soft-currency countries under the Smithsonian's Foreign Currency Grant Program.

STUDIES OF THE HUSBANDRY AND WELFARE OF CAPTIVE PRIMATES.—One approach to the problem of diminishing stocks discussed above is obviously the increase of breeding and holding programs in artificial environments. Much more basic research is required before such programs can supply all the animals of different species that scientists require. One must know, for example, the normal diet of the primates concerned, as well as its seasonal variations, and the typical locomotor habits and resting postures of the primates in order that appropriate

cages, enclosures, holding chairs, etc., can be designed. One must understand the social composition of the species concerned; each species has its own pattern of social behavior that must be understood if the animals are to be kept in captivity as healthy breeding units. One must know the technical details of the microclimate, the temperature-ranges, and the humidity. One must know the physical nature of the environment: Do these monkeys live among the small flexible branches of the canopy, on the stout branches near the trunk, or on the trunk itself? Only by finding the answers to these questions can one hope to provide, artificially, something approaching a realistic (though obviously not a normal) environment for the animal concerned. To provide a captive animal with an adequate, suitable environment is not only humane but sound common sense. Many of these problems are now being tackled in the Regional Primate Centers in the United States, but the basic research necessary for a full awareness of the welfare and husbandry of a wide range of primates will take many years of detailed and imaginative research.

Boredom in captive primates is another very serious, but generally unappreciated, problem. In the wild, most of the primate's working hours are spent in search of food. If, in captivity, it is deprived of this occupation, it has no normal substitutes. It develops behavioral aberrations such as coprophagy, masturbation, and stereotyped behavior patterns like staring into space for long periods, clasping the head or body and rocking to and fro, and hopping from one foot to another. These are typical withdrawal patterns seen in deprived primates, human or nonhuman. It has been said that "a solitary chimpanzee is no chimpanzee at all." Much of the boredom can be alleviated by caging monkeys in social groups so that normal social interactions, such as grooming activities among adults and play among infants and juveniles, can help to compensate for the lack of active food-getting. Ideally, some type of food-getting activity should be devised; for example, it should be possible to mix food pellets or natural food objects into the deep gravel or sandy floor surface of the day cage in order that the animals can spend many hours of the day digging and hunting for food. In this way an element of uncertainty and variety can be introduced into the daily life of the animal. Higher primates need, above all, intellectual employment and the stimulation of unusual objects or events.

The principal aim of the research will be to obtain measurements of tolerance of monkeys to captive conditions in laboratories, zoos, and in "free-ranging" captivity. The following aspects of tolerance should be considered:

1. Climatic: Response to high and low temperatures and humidity levels; habitus changes associated with different climatic conditions.

2. Physical Environment: Responses to altered environmental situations demanding changes in locomotor habits, resting habits, spacing behavior, sexual behavior, aggressive behavior, etc.

3. Dietetic: Responses to wide range of food and feeding patterns, with particular reference to changes in the skeleton.

4. Social Organization: Study of ideal group size in differing captivity situations and its relation to cage size.

5. Diversionary: Investigation of the value of "spare time" activities in the general welfare of the captive.

An essential correlate of this program will be a field investigation of certain basic behaviors of primates in the wild, e.g., diet, locomotion, climatic tolerance, resting posture, etc. (see "Field Studies" below). Captivity studies are clearly a long-term project that will be based both in the United States and the United Kingdom. Informal talks already have been held with a pharmaceutical research center in England that is interested in the possibility of setting up primate research of this general nature on its estates in the South Midlands.

FIELD STUDIES.—Field studies of free-ranging primates are pivotal to the systematics, captivity, and population studies discussed above, and they will constitute an important part of the program.

It is hoped that it will be possible to establish junior and senior field-study studentships for graduate as well as post-doctoral scientists. Senior studentships normally would be held for five years and the junior appointment for three years. This period will ensure that the post-doctoral worker will, on the completion of his field work, be available to contribute to the systematics and captivity research projects and to the teaching and other activities of the Primate Biology Program. A policy might be adopted whereby the holders of these two studentships would act as senior and junior members of a field-research team.

The possibility of establishing a field primate research training program at the Smithsonian Tropical Research Institute, Barro Colorado Island, Panama, in connection with the award of the junior field-study studentship will be investigated.

FUNCTIONAL ANATOMY.—Collection of data on sound biometric principles is still an important part of primate biology. There is no better example of this type of work than that provided by Adolph Schultz, whose lifetime study of growth and variability in the skeletons of higher primates has contributed so much to our knowledge. Statistical techniques such as that of multivariate analysis will in the future provide an even better method of assessment of such data; furthermore, it is expected, as a fall-out from such projects as systematics research, that new information on the anatomy and physiology of primates will become available. The field of primate anatomy has

been developed industriously for the past hundred years by authorities too numerous to mention. A synthesis of a century's work is admirably recorded in the monumental treatises of Dr. W. C. Osman Hill of the Yerkes Regional Primate Center. The physiological, or functional, anatomy of primates has attracted less attention. Because of its relevance for primate behavior, the anatomical and physiological whys and wherefores will rate special attention. The "new" science of Lorenzian ethology, in particular, seems to the writer to require an injection of what Elliot-Smith called the "illumination of comparative anatomy"; it is somewhat paradoxical to study the evolutionary significance of facial expression in primates, for instance, without a detailed understanding of the function of their facial musculature.

Over the years a number of projects in functional anatomy have occurred to the writer and are listed below. These are random ideas and are in no sense a definitive list of research proposals.

1. Significance of cheek pouches in primates.
2. Phylogeny and physiology of sexual swelling.
3. Anatomy, social significance, distribution, and phylogeny of sexual dimorphism.
4. Adaptive significance of the bulla tympanica.
5. The relationship of the fat pad under the heel of primates to ecological adaptation.
6. The anatomy and behavioral significance of swimming in primates.
7. The functions of the primate tail.
8. Adaptations of the vertebral column in relation to primate locomotor patterns.
9. Adaptations of the nails and their phylogenetic significance.
10. The carriage of infants in relation to the locomotion of primates.
11. The functional morphology of ischial callosities.
12. The neonatal coat color; its significance in natural selection.

Education Program

In the earlier part of this paper considerable emphasis has been laid on the multidisciplinary approach of primate biology and on the need of its students to acquire a versatile attitude of mind. Primate biologists, for instance, who possess a working knowledge of systematics are to be preferred to systematicists who have a working knowledge of primates, for the systematics of primates should be based on the sum total of their biology, past and present.

The greatest deterrent to subject-oriented research in primate biology is, undoubtedly, the lack of primate biologists. The Smithsonian will not only supply grist for its own mill, but also it will provide a service for other museums and research institutions by developing an education program in this field.

Cooperative Graduate Programs: It is anticipated that the Smithsonian will be seeking education agreements for cooperative graduate

programs with certain universities in special relation to centers of primate research. Schemes of this nature would involve participation by staff specialists in lectures and seminars held at the graduate school in question and the admission of graduate students to internships at the Smithsonian for a period of a year or less under the supervision of staff members.

Crash Courses: Short and intensive courses on the principles of primate biology will be arranged for institutions and research centers for the benefit of professional employees and technicians.

Undergraduate Courses: Lectures and seminars will be arranged under educational agreements with universities in association with anthropology and zoology degree courses. In order to implement such educational agreements, the permanent professional staff, term appointees, graduate students, and consultants in specialist fields would be expected to play a professorial as well as a research role. Although the academic level of the different courses will vary with the status of students concerned and with the nature of their scholastic background, the subject content will be fairly constant and will embrace the following fields of study:

Principles of evolution, systematics, classification and evolution of primates. Zoogeography and ecology. Anatomy, physiology and behavior with particular reference to habitat (anatomical and ecological basis of behavior). Molecular biology and genetics. Zoonoses, welfare and husbandry of the captive primate. Conservation.

Courses will comprise some lectures but principally seminars and practical classes. Motion picture film will be used extensively (see "Film Library" p. 26). An essential corollary of a teaching program is the production of a comprehensive textbook. This obviously cannot be conjured up overnight and it may be several years before a satisfactory student manual can be produced. As an interim measure, the author is preparing a short student text that should be available, modestly priced, in 1969.

Collection Programs

The nature of the program outlined above will necessitate, above all, large and adequately cataloged study collections of primate skins, skulls, skeletons, and wet specimens.

Data Processing: Participation in the Automatic Data-Processing System for cataloging and retrieving information relating to specimens, a system already in use in the Museum of Natural History, is a possibility to be investigated. It is questionable whether the size of the present collection of Primates in the Division of Mammals would justify the high cost involved. Considered in terms of the international orientation of this program, however, such a partici-

pation would seem highly desirable; accordingly, the Primate Biology Program will consider the feasibility of processing data relating to primate collections in the major museums of the world. A project of this sort would be inconceivable for such organizational units as the Department of Invertebrate Zoology or the Division of Ornithology, but for the Primate Biology Program, which is concerned with relatively fewer species, a world-wide catalog is not out of the question. Such a catalog housed in one institution would be of immense value to primatologists.

Augmentation of Collection: Few museums possess sufficient duplicate material to allow synoptic loan-kits of skulls and postcranial bones to be made available to accredited institutions or to permit wet specimens to be dissected by graduate students; yet, such facilities would form an important part of an education program. Efforts will be made to augment the Smithsonian's already extensive collections by various means so that the following services can be implemented:

1. **Specimens for Dissection:** At present there is no adequate collection of embalmed specimens suitable for detailed anatomical dissection. Many requests for such material reach the Smithsonian annually. In the course of building up systematic reference collections, stocks of properly preserved anatomical material should be developed. These stocks would serve as a "bank" from which specimens could be drawn for study.

2. **Whole Specimens for Loan:** It is proposed to build up a "library" of the common varieties of primates. The animals preserved in their entirety would be stored in polythene envelopes without fluid and would be available for loan to scientific institutions.

3. **Synoptic Osteological Collections:** For temporary loan to primate centers and other scientific institutions.

4. **Film Library:** For certain fields of study, motion pictures are the essential correlate of more formal methods of instruction; for example, in primate biology, with its emphasis on behavior, films should comprise a major part of the course. It is not easy with large classes to demonstrate behavioral experiments on primates in the laboratory, but the identical experiments can be presented to any number of students simultaneously through motion pictures. Ecological and behavioral studies in the wild are assuming great importance in primate biology and naturally constitute a major part of student instruction; it is clearly impossible to transpose a group of students to the rain forest but perfectly feasible to bring the rain forest to them—on film. Locomotion studies are pivotal to the understanding of primate biology for the primate is structurally a locomotor machine. Locomotion can be illustrated theoretically in a biomechanical diagram of forces, but its behavioral significance, in relation to feeding, etc., can be understood only in dynamic terms where posture, movement, and environment are brought together in one demonstration. It is proposed to develop a library service lending films to laboratories and university departments for educational use. This is substantially the procedure that is followed at the present in the Smithsonian Unit of Primate Biology in London.

5. **Identification Service:** The existing collections of the Division of Mammals would make it possible to provide an identification service for outside organizations.

6. Identification Manual: There would appear to be an urgent need in many laboratories that use for a short and concise identification manual; preparations for such a publication are already underway. The manual would incorporate a number of color plates of the skins of certain common laboratory primates.

Postscript

A long time has elapsed since 130 A.D., when the anatomist Galen of Pergamum, discovering that, of all living things, the ape is "likeliest to man," proceeded to practice what he preached by using monkeys as substitutes for human cadavers. Eighteen centuries later—although the correctness of Galen's pronouncement has long since been proven up to the hilt—we are still somewhat chary of admitting the full potential of this relationship.

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BREDIN-ARCHBOLD-SMITHSONIAN
BIOLOGICAL SURVEY OF DOMINICA¹

8. The Intertidal Balanomorph Cirripedia

By ARNOLD ROSS²

The present study on the intertidal balanomorph barnacles of Dominica is based on incidental collections made during April and May of 1966 by Dr. Ernst Kirsteuer of the American Museum of Natural History and by Dr. Klaus Rützler of the Smithsonian Institution. These collections are of considerable value largely because there have been no previous studies or mention of the Cirripedia of Dominica. Represented in the collections are: *Chthamalus angustitergum* Pilsbry, 1916; *Tetraclita* (*Tetraclita*) *stalactifera* (Lamarek), 1818; *Tetraclita* (*Tetraclitella*) *divisa* Nilsson-Cantell, 1921; and *Balanus* (*Megabalanus*) *stultus* Darwin, 1854. That this list does not embrace all the barnacles inhabiting this region is recognized, but it probably includes the more common species.

All the Dominica species have been reported previously from other regions in the Caribbean and western Atlantic with the exception

¹See list at end of paper.

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of *T. divisa*; however, these barnacles remain poorly known because earlier workers failed to provide detailed descriptions and illustrations of their distinctive features, especially of the mouth field and cirral appendages. The addition of such information, provided herein for the Dominica fauna, should aid materially in an understanding of the morphological and biological characters of other populations of the same species as well as closely related species in the Caribbean and elsewhere.

The dissected specimens, which have been figured, are deposited in the collections of the American Museum of Natural History (AMNH). Representative samples of all the species have been placed in the collections of the American Museum and the U.S. National Museum (USNM).

The author is indebted to Drs. Ernst Kirsteuer and Klaus Rützler, who made these collections available for study. Dr. William K. Emerson of the American Museum kindly read a manuscript draft of this paper and offered several suggestions for improvement. Dr. William A. Newman, Scripps Institution of Oceanography, first brought to the writer's attention the fact that *Balanus stultus* was a megabalanid. The writer should also like to thank Dr. Newman for many informative discussions on the systematics, evolution, and phylogeny of the Cirripedia.

Family CHTHAMALIDAE Darwin, 1854

Genus *Chthamalus* Ranzani, 1817

Chthamalus angustitergum Pilsbry

FIGURE 1

- Chthamalus stellatus angustitergum* Pilsbry, 1916, p. 305, text-figs. 85, 86, pl. 71, figs. 5, 5a, 5b; 1927, p. 37, fig. 1.—Nilsson-Cantell, 1933, p. 506.—Kolosváry, 1939, p. 161, figs. 6-1, 6-2; 1941, p. 68, fig. 1sa.—Stephensen and Stephensen, 1950, p. 389; 1954, p. 80.—Henry, 1954, p. 444.—Wells, 1966, p. 92.
- Chthamalus stellatus*.—Smith, Williams, and Davis, 1950, p. 134.—Marshall, 1953, p. 435.—Voss and Voss, 1960, p. 102.—Werner, 1967, p. 70.
- Chthamalus angustitergum*.—Newell, Imbrie, Purdy, and Thurber, 1959, p. 209.

MATERIAL.—Western side of Panto Hole Bay, east of town of Marigot, approximately 15°32'21"N, 61°17'31"W; intertidal, on *Tetraclita* (*Tetraclita*) *stalactifera*; May 1-10, 1966; about 100 specimens.

DIAGNOSIS.—Articular ridge of scutum straight to slightly convex, basal end of which evenly rounded and not projecting beyond the basitergal angle. Tergum narrow, about twice as high as broad, and nearly twice as thick as scutum. Mandible quadridentoid, with basal

comb containing 22–28 teeth. Maxilla I with subapical notch, below which spines divided into two distinct clusters.

SUPPLEMENTARY DESCRIPTION.—In the majority of the specimens examined, prominent radial ribs or their remnants ornament the parietes. The shell is pale grey as is the outer surface of the operculum. Internally, near the apices, the opercular plates are tinted pale pink.

Measurements (in mm) of the five specimens dissected are as follows:

| specimen | shell | | | opercular plates | |
|----------|-------------------------|------------------|--------|------------------|---------------|
| | carino-rostral diameter | lateral diameter | height | scutum height | tergum height |
| 1 | 5.8 | 5.6 | 2.7 | 1.5 | 1.6 |
| 2 | 6.1 | 6.0 | 2.7 | 1.8 | 1.9 |
| 3 | 8.0 | 8.0 | 3.1 | 1.5 | 1.6 |
| 4 | 5.3 | 4.9 | 2.0 | 1.2 | 1.3 |
| 5 | 5.1 | 5.4 | 3.1 | 1.1 | 1.2 |

The height of the scutum is about one-half its width. The articular ridge extends about three-fifths the length of the tergal margin. It is straight, and the basal margin is evenly rounded and does not project. There is no adductor ridge; the adductor muscle depression is very small and deep. Situated on the basitergal angle, which projects beyond the tergal margin, is the pit for the depressor muscle.

The tergum is about one-half as wide as it is high, and the plate is exceedingly thick. There is a small, narrow, and clearly delimited spur. Crests for the tergal depressor muscle number five to seven.

The multidenticulate labrum has a shallow, medial, saddle-like depression, on each side of which are 11–14 teeth. Short setae are dispersed between the teeth along the crest of the labrum (fig. 1*f*). A large elongate-oval patch of downward-directed spines extends obliquely from each side of the superolateral margins toward the basimedial portion of the labrum.

The superior margin of the palp is straight and free of setae (fig. 1*c*). The basal margin is covered with short setae, but those on the superodistal margin are extremely long; all of the setae are clothed with spinules.

The cutting edge of the mandible is armed with five teeth including the inferior angle (fig. 1*a*). The distance between the second and third teeth is one-half that between the first and second teeth. The fourth tooth is bifid. The inferior angle bears three to four spines, above which is the typically developed comb, containing about 22–28 spinules.

Maxilla I has a somewhat trilobed cutting edge. There is a prominent subapical, V-shaped notch, and on some specimens there is a suprabaasal notch. The spination along the edge is readily separable into three zones, the apical consisting of both long and short, stout

spines; the medial, below the subapical notch, containing long, slender spines; and the basal, which may or may not be set off from the medial by a slight notch, containing only short, slender spines (fig. 1*b*).



FIGURE 1.—*Chthamalus angustitergum* Pilsbry, 1916, AMNH 12458, Panto Hole Bay, Dominica: *a*, mandible; *b*, maxilla I; *c*, palp; *d*, maxilla II; *e*, cirrus I; *f*, labrum; *g*, distal end of penis; *h*, cirrus II; *i*, comb seta from cirrus II; *j*, cirrus III; *k*, cirrus VI. (Setae omitted on cirri I and II; on numbered segments of cirri III and VI, only one set of setae shown; a=anterior ramus; p=posterior ramus; scale in millimeters.)

Maxilla II has a distinctly bilobed anterior margin. The appendage is broad, but the height is somewhat greater.

The anterior ramus of cirrus I is slightly longer than the posterior ramus, and all of the articles of both rami are broader than they are high. The terminal article of the posterior ramus bears a few comb setae. The same relationships as found in cirrus I hold for cirrus II except that comb setae are found on the terminal articles of both rami. The comb setae on both cirri lack basal guards. Cirrus III is not modified. Cirri III-VI are essentially equal in length with equal rami. At each articulation along the posterior curvature of the intermediate articles of cirri III-VI there are 1-3 long, slender setae and 1-3 short, slender setae. There are no bristles or teeth arrayed along the lateral faces of the posterior cirri. Pigment spots occur at each articulation along the posterior border of the cirri and along the whole length of the anterior border of the cirri. Chaetotaxis of the anterior border of the intermediate articles of cirri IV-VI is typically ctenopod, there being 5 pairs.

A count of the segments of specimen number 1, illustrated in figure 1, is as follows:

| | | I | II | III | IV | V | VI |
|-------|-----------|---|----|-----|----|----|----|
| right | anterior | 8 | 6 | 14 | 17 | 19 | 19 |
| | posterior | 6 | 6 | 15 | 17 | 19 | 19 |
| left | anterior | 7 | 7 | 13 | 18 | 19 | 19 |
| | posterior | 6 | 7 | 15 | xx | 19 | 19 |

Data on the cirral counts of the five specimens dissected are presented below. The range (R) and mean (\bar{x}) values for the number of segments in the anterior (a) and posterior (p) rami of the right side are as follows:

| | I | | II | | III | | IV | | V | | VI | |
|-----------|-----|-----|-----|-----|-------|-------|-------|-------|-------|-------|-------|-------|
| | a | p | a | p | a | p | a | p | a | p | a | p |
| n | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| R | 6-8 | 5-6 | 6-9 | 5-7 | 14-15 | 14-16 | 13-17 | 15-17 | 16-19 | 16-19 | 17-19 | 17-19 |
| \bar{x} | 7.0 | 6.0 | 7.4 | 6.0 | 14.5 | 15.0 | 15.4 | 16.0 | 17.4 | 16.8 | 18.0 | 17.6 |

The penis is annulated throughout its length, and it is covered with long bristles. The distal extremity is densely clothed with bristles. There is no basidorsal point.

REMARKS.—The nominal subspecies *Chthamalus stellatus angustitergum* is readily separable from *C. stellatus stellatus* (Poli, 1791) on taxonomic as well as geographic and reproductive grounds. Although apparently alike superficially, differences exist that clearly warrant the recognition of this Caribbean barnacle at the specific level.

Although there are notable differences in the coloration of these two species, by far the greatest number of distinguishing characters are found in the opercular plates. The scutum of the Caribbean species is about one-half as tall as it is wide, whereas in *C. stellatus* it is about two-thirds. In the latter species the adductor muscle pit is exceedingly large and the basal end of the articular ridge is acute, extending out to the basitergal angle; the opposite conditions exist in *C. angustitergum*. In *C. angustitergum*, furthermore, the tergum is narrow—hence, the name—the width being about one-half the height and the spur being well set off from the basiscutal angle, but in *C. stellatus* the spur is virtually confluent with the basiscutal angle and the height of the plate exceeds the width by one-fourth or less. Crests for the tergal depressor muscles, of which there are four in *C. stellatus*, are low and feebly developed. In *C. angustitergum* there are five crests, which are both high and strongly developed.

Insular populations of *C. angustitergum* in the Caribbean are obviously isolated geographically from the Asia Minor, Mediterranean, and eastern Atlantic populations of *C. stellatus*—indeed, there is no indication of recruitment of *C. stellatus* in the Caribbean; consequently, the populations of these two species are reproductively isolated and more than likely have been for a significantly long period. Such isolation, both reproductive and spatial, speaks in favor of eliminating the antiquated subspecific label attached to *C. angustitergum*.

There are at least three other species of *Chthamalus* in the Caribbean and western Atlantic: *C. fragilis* Darwin, 1854; *C. stellatus thompsoni* Henry, 1958; and *C. rhizophorae* de Oliveira, 1940. There should be little confusion regarding the identity and distinction among these species. *Chthamalus fragilis* is confined for the most part to the Atlantic coast of the United States, although it has been reported in the Caribbean and on the west African coast (Stubbings, 1967, p. 262). Bermuda is apparently the only locality where *C. stellatus thompsoni* occurs (Henry, 1958, p. 220). The euraphian, *C. rhizophorae*, has been collected by the present writer at several localities in the Bahamas, although previously it was known only from Brazil (Oliveira, 1940b, p. 379; Stubbings, 1967, p. 257).

Family TETRACLITIDAE Nilsson-Cantell, new status

TETRACLITINAE Nilsson-Cantell, 1921, p. 357.

At the present time, students of balanomorph systematics favor inclusion of the tetracelitids in the family Balanidae. Although Nilsson-Cantell (1921) took the first and only bold step when he segregated the two dozen or so species of this complex into a distinct subfamily,

there apparently has been no further attempt to reevaluate the systematic position of these barnacles. Assignment of the tetracelitids as a subfamily of the Balanidae seems untenable at this time because they obviously represent a different and distinct lineage that in many respects parallels closely that of the Chthamalidae.

The tetracelitids are compounded of forms with a shell consisting of only four tubiferous plates, the number of tubes ranging from one row in *Tesseropora* to several rows in *Tetracelita* and *Tetracelitella*. In the latter group the radii are also tubiferous, and only in this group are the radii as well developed as they are in the Balanidae. The basis with few exceptions is membranous, and where calcareous, it is neither tubiferous nor does it possess complex ridges marginally that interdigitate with the basal margin of the wall.

One of the salient structures of primary importance in the classification of the Balanomorpha is the state of development of the labrum. In the Chthamalidae there is no notch in the labrum, and it is effectively bullate, whereas in the Balanidae the labrum is distinctly notched and not bullate. In the tetracelitids this structure is clearly not bullate, nor is it notched, but rather it holds an intermediate position since it is thin, as in the balanids, and the crest has a saddle-like groove, as in *Chthamalus*. The presence of a bullate or simple un-notched labrum indicates a primitive evolutionary state, which is readily recognizable in the chthamalids and, of the other Thoracica, in the verrucomorphs and lepadomorphs. On the basis of the foregoing evidence alone it is not likely that an un-notched labrum could have evolved from a notched labrum; hence, the tetracelitids could not have evolved from the balanids.

Modifications in tetracelitid mandibular structure closely parallel that found in the chthamalids, wherein there are groups with either a comblike or serrate inferior margin. The inferior margin is never molariform as is frequently the case in the Balanidae.

The first three pairs of cirri in the Balanidae are highly modified and effectively serve as mouth appendages. In *Chthamalus* and related genera only the first two pairs of cirri are so modified. In the tetracelitids, cirrus III is modified as a mouth appendage but significantly less so than in the Balanidae. In the Balanidae the third cirrus is never antenniform, but it commonly is in the Chthamalidae and rarely in tetracelitids of the *Tetracelita squamosa* complex.

Other features that argue for exclusion of the tetracelitids from the Balanidae are the absence of a basidorsal point on the intromittant organ and the presence of comb setae on the anterior cirri. Caudal appendages, present in many of the chthamalids, are lacking in the tetracelitids as well as the balanids.

In all likelihood the tetracelitids and chthamalids shared a common ancestry, but unlike the chthamalids the tetracelitids probably evolved and deployed far more rapidly. The balanids, on the other hand, probably evolved from the chthamalid lineage, but at a much later time. Unfortunately, the fossil evidence documenting these evolutionary steps remains to be discovered.

Inclusion of the tetracelitids in the Balanidae would clearly appear to be precluded on the basis of the foregoing. By the same token their inclusion in the Chthamalidae would serve only to weaken the definition of this group also. Because no intergrades or transitional forms are known to occur between the Balanidae and tetracelitids, separation of these two groups at the familial level is clearly warranted.

Genus *Tetracelita* Schumacher, 1817

Tetracelita (Tetracelita) stalactifera (Lamarek)

FIGURE 2

Balanus ponderosus [Lightfoot, 1786,] p. 89.—Dillwyn, 1823, p. 23.

Balanus stalactiferus Lamarek, 1818, p. 394.—Lamy and André, 1932, p. 222.

Balanus latus Lamarek, 1818, p. 397.—Lamy and André, 1932, p. 222.

C[onia] stalactifera.—Chenu, 1843, pl. 4, figs. 6–8.

Tetracelita porosa var. *communis* Darwin, 1854, in part, p. 329, pl. 10, fig. 1a, 1i (?), 1k (?).

Tetracelita porosa.—Verrill, 1901, p. 22.—Bigelow, 1901, p. 180.

Tetracelita squamosa stalactifera.—Pilsbry, 1916, p. 254, pl. 59, figs. 1, 1a, 1b.—Oliveira, 1940a, p. 138; 1941, p. 7, pl. 1, figs. 1, 2, pl. 2 (fig. 4), pl. 10 (figs. 1, 3, 6); 1947, p. 715.—Stephensen and Stephensen, 1950, p. 388; 1952, p. 8.—Henry, 1954, p. 444; 1958, p. 224, pl. 1, fig. b, pl. 5, figs. a, b.—Newell, Imbrie, Purdy, and Thurber, 1959, p. 209.—Voss and Voss, 1960, p. 102, 106.—Ross, 1962, p. 31.—Rehder, 1967, p. 16.

Tetracelita stalactifera.—Pilsbry, 1927, p. 38.

Tetracelita porosa stalactifera.—Nilsson-Cantell, 1933, p. 508; 1939, p. 5.

Tetracelita squamosa.—Smith, Williams, and Davis, 1950, p. 134.—Marshall, 1953, p. 435.—Werner, 1967, p. 70.—Multer and Milliman, 1967, p. 260, fig. 2.

MATERIAL.—Scotts Head Bay, at southern end of Soufriere Bay, approximately 15°12'40" N, 61°22'40" W; 0.5 meters; May 17–28, 1966; about 150 specimens. Middle Bay, adjacent to town of Marigot, approximately 15°32'21" N, 61°17'28" W; intertidal, on basaltic rocks; April 15–30, 1966; 4 specimens; same locality as that cited by Kirsteuer (1967). Western end of Panto Hole Bay, approximately 15°32'21" N, 61°17'31" W; intertidal, on basaltic rocks; May 1–10, 1966; about 125 specimens.

DIAGNOSIS.—Sheath of shell tinted plumbeous black and opercular plates violet black or raisin black with whitish or paler borders and ridges. Parietes relatively thin; tubes large, commonly in 3–5 rows. Radii very poorly developed or obsolete. Labrum with slight notch

and 4 teeth on each side of notch. Mandible with 6 teeth including inferior angle; second and third teeth bifid; fifth tooth rudimentary; inferior angle strongly pectinate. Maxilla I with 2 spines above

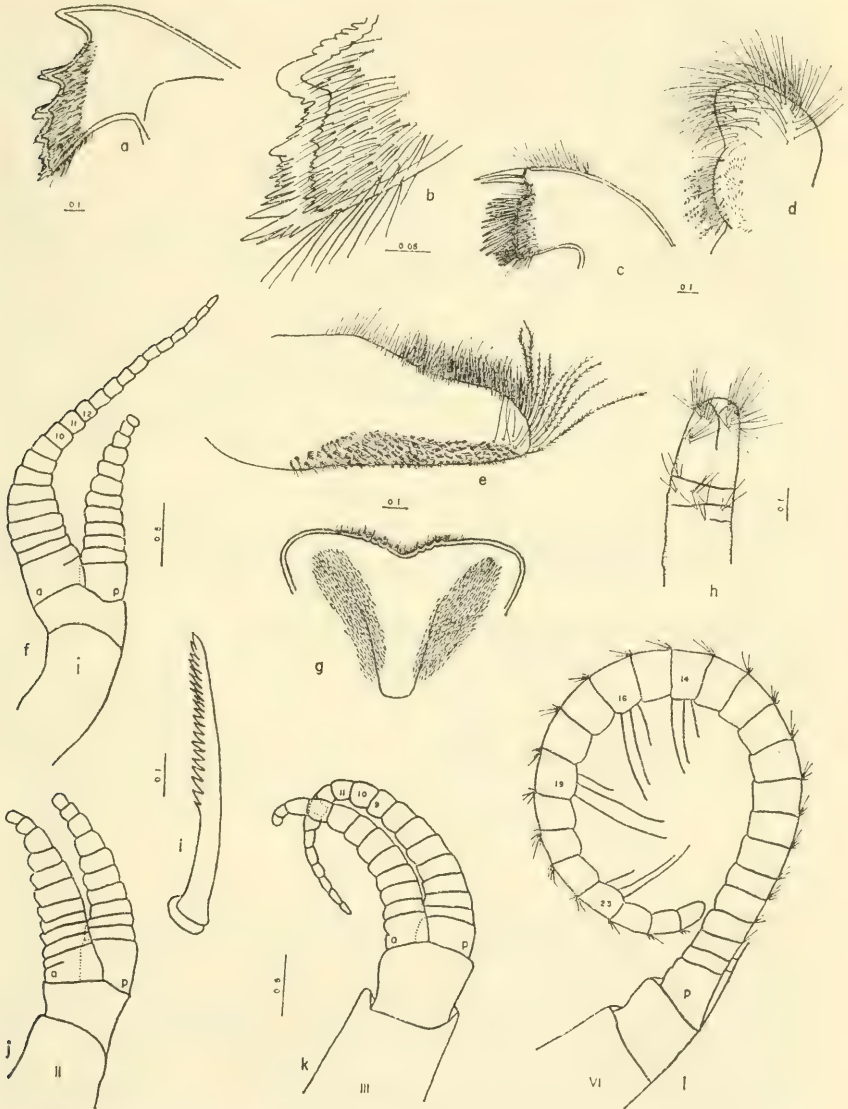


FIGURE 2.—*Tetracilita stalactifera* (Lamarck), 1818, AMNH 12459, Scotts Head Bay, Dominica: *a*, mandible; *b*, enlarged view of fourth tooth and inferior angle of mandible shown in *a*; *c*, maxilla I; *d*, maxilla II; *e*, palp; *f*, cirrus I; *g*, labrum; *h*, distal end of penis; *i*, comb seta from cirrus II; *j*, cirrus II; *k*, cirrus III; *l*, cirrus VI. (Setae omitted on cirri I–III; on numbered segments of cirrus VI, only one set of setae shown; *a* = anterior ramus; *p* = posterior ramus; scale in millimeters.)

subapical notch, and 18-24 spines beneath, unequally divided into 2 clusters. Anterior ramus of cirrus I longer than rami of cirri II and III. Comb setae of cirri II and III lacking basal guards.

SUPPLEMENTARY DESCRIPTION.—The shell is typically conic, spreading, commonly eroded externally, and tinted various shades of white with deep purple. The radii are extremely narrow or obsolete, and often external demarcation of the four parietal plates is virtually impossible to recognize. The surface of the body cavity wall is smooth or slightly irregular but never ribbed or ridged.

Externally, the surface of the scutum is eroded, as is the tergum. The adductor ridge of the scutum extends nearly the whole length of the valve. It is long, low, deeply undercut, and the ridge moderately thin. The articular ridge occupies about two-thirds the length of the tergal margin, and it is evenly and broadly rounded distally. Prominent ridges exist for the insertion of the lateral and rostral depressor muscles. Dentition of the ocludent margin is limited to 4-6 strong, oblique teeth. The number and development of these teeth, however, is no doubt contingent upon the age and degree of corrosion of the specimen.

The apex of the tergum is produced into a slight but noticeable beak. The articular ridge is high, and its thickness varies. There are 6-8 strong, well-spaced, inclined crests for the insertion of the depressor muscles.

Parameters of the shell and opercular plates of the five dissected specimens (in mm) are as follows:

| specimen | shell | | | opercular plates | |
|----------|-------------------------|------------------|--------|------------------|---------------|
| | carino-rostral diameter | lateral diameter | height | scutum height | tergum height |
| 1 | 19.5 | 17.2 | 13.4 | 5.1 | 6.0 |
| 2 | 18.7 | 17.6 | 12.1 | 5.4 | 6.5 |
| 3 | 20.6 | 18.6 | 12.9 | 6.1 | 7.0 |
| 4 | 30.8 | 27.2 | 16.2 | 7.8 | 8.6 |
| 5 | 11.9 | 17.6 | 4.7 | 2.9 | 2.8 |

On both sides of the shallow, saddle-like groove in the crest of the labrum there are four short teeth, although in one specimen dissected there were four teeth on one side and only three on the other. Interspersed among the teeth in the notch and extending laterally along the rim of the labrum are short, slender bristles (fig. 2*g*). Two elongate-oval patches of spines extend obliquely from the superolateral margin on each side of the crest toward the basicentral portion of the labrum.

The palps are long, high, and free of setae along their basal margins; however, the basal portion of the appendage is uniformly covered with ctenoid scales (fig. 2*e*). The setae on the distal extremity are long and setulose whereas those on the superior margin are shorter and not covered with setules.

Along the cutting edge of the mandible there are six teeth including the inferior angle (fig. 2*a*). The distance between teeth decreases by about one-half, proceeding from the first tooth to the fifth. Both the second and third teeth have subsidiary cusps. Along the superior slope of the third and fourth teeth there are serrations. Similarly, the inferior angle is serrate, but very coarsely.

Maxilla I has a deep subapical notch (fig. 2*c*). Above the notch there are two long, stout spines and one or two shorter, slender spines. Below the notch 11–16 long, slender spines and 8–14 shorter, slender spines are present. On larger and older specimens there may be little distinction between these two spine clusters.

Maxilla II is taller than broad and distinctly bilobed. The setae on the basal lobe are setulated.

The rami of cirrus I are grossly unequal in length, the posterior ramus being about one-half the length of the anterior ramus (fig. 2*f*). The rami of cirrus II are essentially equal in length while the posterior ramus of cirrus III is slightly longer than the anterior ramus. The intermediate and basal articles of the anterior three pairs of cirri are squat, not appreciably protuberant. Both rami of cirrus II and III are clothed with long comb setae, which lack basal guards. Cirri IV–VI are essentially equal in length with equal rami. At each articulation along the posterior curvature of the intermediate articles of cirri IV–VI there is one short, stout seta, 2–4 long, slender setae, and 1–2 short, slender setae. On the lateral face of both rami of cirri IV–VI immediately below each articulation of the intermediate articles, there is a single row of short spines. Chaetotaxis of the intermediate articles of the posterior three pairs of cirri, along the anterior curvature, is ctenopod, there being three pairs of setae. Between or at the bases of the distal one or two pairs of setae there are one or two short slender setae.

A count of the segments of the cirri of specimen 1 above, illustrated in figure 2, is as follows:

| | I | II | III | IV | V | VI |
|-----------------------|-----------|-----------|-----------|-----------|-----------|-----------|
| right anterior ramus | <u>22</u> | <u>11</u> | <u>13</u> | <u>19</u> | <u>21</u> | <u>23</u> |
| right posterior ramus | 12 | 11 | 20 | 22 | 25 | 26 |
| left anterior ramus | <u>23</u> | <u>11</u> | <u>12</u> | <u>18</u> | <u>22</u> | <u>21</u> |
| left posterior ramus | 12 | 10 | 18 | 21 | 24 | 21 |

Counts of the cirral segments are summarized below for the five specimens dissected. The range (R) and mean (\bar{x}) values for the number of segments in the anterior (a) and posterior (p) rami of the cirri of the right side are as follows:

| | I | | II | | III | | IV | | V | | VI | |
|-----------|-------|------|------|------|------|-------|-------|-------|-------|-------|-------|-------|
| | a | p | a | p | a | p | a | p | a | p | a | p |
| n | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| R | 15-26 | 8-17 | 9-14 | 8-13 | 8-14 | 11-20 | 16-21 | 16-22 | 18-24 | 18-26 | 19-26 | 19-26 |
| \bar{x} | 20.4 | 11.8 | 10.8 | 10.8 | 11.4 | 17.2 | 18.8 | 20.6 | 21.0 | 23.0 | 22.4 | 23.4 |

The intromittant organ is distinctly annulated throughout its length. It is sparsely hirsute except for the tip where there are two or three distinct clusters of setae. There is no basidorsal point.

REMARKS.—In a recent study Rehder (1967) listed the valid zoological names from an anonymously authored auction catalogue of the Portland Museum collections. Of the names cited in this catalogue, which is purported to have been authored by the Reverend John Lightfoot, only one, *Balanus ponderosus*, is of concern here. In listing this name, Lightfoot referred to a published figure of Lister's (1770, pl. 442, fig. 284). The species represented by that figure most closely resembles *Tetraclita stalactifera* of all the presently known Caribbean barnacles. Although this illustration of a specimen from Barbados is poorly executed, Rehder (1967, p. 17) stated that, "The form, sculpture, and locality cited under Lister's figure seem to point to this tropical Western Atlantic barnacle but because Lightfoot's name has never been used for this subspecies, it should be considered a nomen oblitum." In concurring with Rehder, it need only be added that Lamarck's species should be conserved because of its widespread and common usage for 150 years, whereas Lightfoot's name, as noted by Rehder, has never appeared in the primary literature.

Passing mention should be made of the species *Balanus latus* Lamarck (1818, p. 397). This name was also based on the same figure as that of *B. ponderosus*. Under these circumstances it is obviously not amiss to include this name in the synonymy of *T. stalactifera*.

Tetraclita stalactifera ranges from South Carolina, through the Caribbean to southern Brazil (Stephensen and Stephensen, 1952; Pilsbry, 1916). It also has been reported from Bermuda (Verrill, 1901; Henry, 1958). Its range in the eastern Pacific is from the Gulf of California to Acapulco, Mexico.

The presence of this species in the eastern Pacific, although over a considerably restricted range, indicates it is a relatively old species, probably ranging as far back as the Miocene. It is readily separable from all other forms of *Tetraclita* on the basis of its geologic history, distribution, color, shell and trophic morphology, and cirral counts;

consequently, it is regarded herein as a full species and cited accordingly.

Subgenus *Tetraclitella* Hiro, 1939

Tetraclita (*Tetraclitella*) *divisa* Nilsson-Cantell

Tetraclita divisa Nilsson-Cantell, 1921, pp. 93, 362, text-figs. 8, 83, pl. 3 (fig. 11).—Visscher, 1927, p. 201, fig. 6B.—Hiro, 1939, p. 275, fig. 15.—Zevina and Tarasov, 1963, p. 96, fig. 13.—Stubbings, 1967, p. 291, fig. 21.

Tetraclita (*Tetraclitella*) *divisa subquadrata* Ross, 1961, p. 210, pl. 4, fig. 1-5.

Tetraclita costata.—Pilsbry, 1928, p. 316.

MATERIAL.—Western side of Panto Hole Bay, east of town of Marigot, approximately 15°32'21" N, 61°17'31" W; intertidal, on *Tetraclita stalactifera*; May 1-10, 1966; 2 specimens.

DIAGNOSIS.—Shell covered by persistent, hirsute, chitinous membrane; parietes furnished with prominent, radial ribs. Radii with horizontal summits parallel to base; external surface covered with horizontal ridges scored at regular, close-spaced intervals. Scutum broader than high; adductor ridge of variable degrees of prominence, and apically fused with articular ridge to effectively form roof. Tergum only slightly higher than wide; both terga form about one-third of bulk of operculum; spur extremely broad and separated from basiscutal angle by less than one-half its own width. Few low denticles on both sides of shallow, saddle-shaped groove in labrum. Cutting edge of mandible armed with 5 teeth including strongly serrate inferior angle, not furnished with comb.

SUPPLEMENTARY DESCRIPTION.—The small size, peltate form; regularity of shell ornamentation and outline, and the pale purple or whitish-purple shell of this species should serve as readily recognizable features for field identification.

Measurements (in mm) of the two specimens in the present collections are as follows:

| specimen | shell | | | opercular plates | |
|----------|-------------------------|------------------|--------|------------------|---------------|
| | carino-rostral diameter | lateral diameter | height | scutum height | tergum height |
| 1 | 11.1 | 11.1 | 3.9 | 4.2 | 4.0 |
| 2 | 8.2 | 7.6 | 2.6 | 3.7 | 3.0 |

In view of the excellent available descriptions of this species by Nilsson-Cantell (1921), Hiro (1939), Zevina and Tarasov (1963), and Stubbings (1967), nothing more need be added at this time; however, the specimens were dissected, and cirral counts are given below for each of them:

| | | I | II | III | IV | V | VI |
|------------|-----------------|---|----|-----|----|----|----|
| specimen 1 | right anterior | 9 | 6 | 6 | 11 | 15 | 15 |
| | right posterior | 5 | 5 | 5 | 12 | 15 | 15 |
| | left anterior | 7 | 6 | 5 | 11 | 14 | 15 |
| | left posterior | 5 | 5 | 4 | 13 | 14 | 15 |
| specimen 2 | right anterior | x | 6 | 6 | 12 | 14 | 15 |
| | right posterior | 5 | 5 | 5 | 12 | 14 | 15 |
| | left anterior | 9 | 7 | 5 | 11 | 13 | 15 |
| | left posterior | 5 | 6 | 4 | 13 | 14 | 15 |

In the larger of the two dissected specimens there were about 45 embryos. In the smaller specimen there were 32 cyprids. The latter have been figured by Nilsson-Cantell (1921, text-fig. 8).

REMARKS.—Based on specimens collected by A. E. Verrill in the Hawaiian Islands the present writer described *T. divisa subquadrata* (Ross, 1961, p. 210). After critical reexamination of the type specimens the author has concluded that this subspecies does not warrant recognition, and should be considered a synonym of the nominate species.

Nilsson-Cantell (1921, p. 364) described *T. divisa* from specimens collected in Sumatra. Subsequent workers have reported it from Formosa (Hiro, 1939, p. 275), the South China Sea (Zevina and Tarasov, 1963, p. 97), and Ghana on the west coast of Africa (Stubbing, 1967, p. 293). The presence of this species in the Caribbean and the Hawaiian Islands extends greatly its known distribution. The fact that it has virtually a circumtropical distribution tends to confirm the long history of members of the Tetracelitidae.

Family BALANIDAE Leach, 1817

Genus *Balanus* DaCosta, 1778

Subgenus *Megabalanus* Hoek, 1913

Balanus (Megabalanus) stultus Darwin

FIGURE 3

Balanus stultus Darwin, 1854, p. 216, pl. 3, figs. 2a-2d.—Weltner, 1897, p. 262.—Gravel, 1905, p. 221, fig. 243.—Pilsbry, 1916, p. 235.—Nilsson-Cantell, 1929, p. 1, figs. 1c, 1d, 2; 1939, p. 5.—Pilsbry, 1953, p. 25, pl. 2 (figs. 1-3).—Henry, 1954, p. 443.

Tetracelita radiata.—Pilsbry, 1927, p. 38.

Balanus stultus morycowae Kolosváry, 1966, p. 69, pls. 1, 2.

MATERIAL.—Scotts Head Bay, at southern end of Soufriere Bay; approximately 15°12'40" N, 61°22'40" W; 0.5 meters; May 17–28, 1966; 5 living and 2 dead specimens on *Millepora complanata* Lamarek; locality no. 2 of Kier (1966).

DIAGNOSIS.—Basis, radii, and parietes tubiferous. Basal margin of scutum sinuous and strongly protuberant medially; growth ridges of plate straight and narrow at lateral extremities, but flexed basally in medial third. Labrum with 3 teeth on each side of medial notch. Mandible with 5 teeth including inferior angle; second tooth bifid. Cutting edge of maxilla I straight. Living strictly on milleporine corals.

SUPPLEMENTARY DESCRIPTION.—This barnacle is readily recognized by its habitat, although the shell is commonly overgrown by the milleporine. In all of the present specimens the shell is high, conical, the parietes slightly to strongly ribbed, and the basis flat. The radii are moderately broad with summits parallel to the basis. The sutural surface of the radii and opposed sutural surfaces possess septa on which both the superior and inferior margins are denticulate.

Shell and opercular dimensions (in mm) of four dissected specimens are as follows:

| specimen | shell | | | opercular plates | |
|----------|-------------------------|------------------|--------|------------------|---------------|
| | carino-rostral diameter | lateral diameter | height | height scutum | height tergum |
| 1 | 23.8 | 18.9 | 14.0 | 5.9 | 6.9 |
| 2 | 19.1 | 15.0 | 13.2 | 5.2 | 6.1 |
| 3 | 20.7 | 18.7 | 16.1 | 6.2 | 7.3 |
| 4 | 23.4 | 15.9 | 16.7 | 6.8 | 7.1 |

Both the scutum and tergum are tinted apically, either pink or pale purplish blue. The articular ridge of the scutum is about two-thirds the length of the articular margin, and it terminates in an acute point. In young stages the adductor ridge is prominent, acute, and it extends nearly to the midpoint of the basal margin, but in older specimens it is less prominent and less broadly rounded. The adductor muscle depression is deep, and its outline varies from elongate-oval to oval, to nearly circular.

The tergum is broad, triangular, and thinner than the scutum. The spur is separated by about its own width from the basiscutal angle. Externally, the longitudinal furrow is commonly closed but sometimes open. Crests for the attachment of the tergal depressor muscles are weakly developed, and few in number.

On each side of the deeply notched crest of the labrum there are three teeth (fig. 3*d*). Interspersed among the teeth and extending laterally the complete length of the crest, there are short, soft setae. Extending obliquely from the superolateral margin on each side of the crest toward the basicentral portion of the labrum, there are

large, elongate-oval patches of spines directed downward toward the esophagus.

The palps are long, high, and spatulate. Along the superior margin the setae are moderately long and densely concentrated, whereas

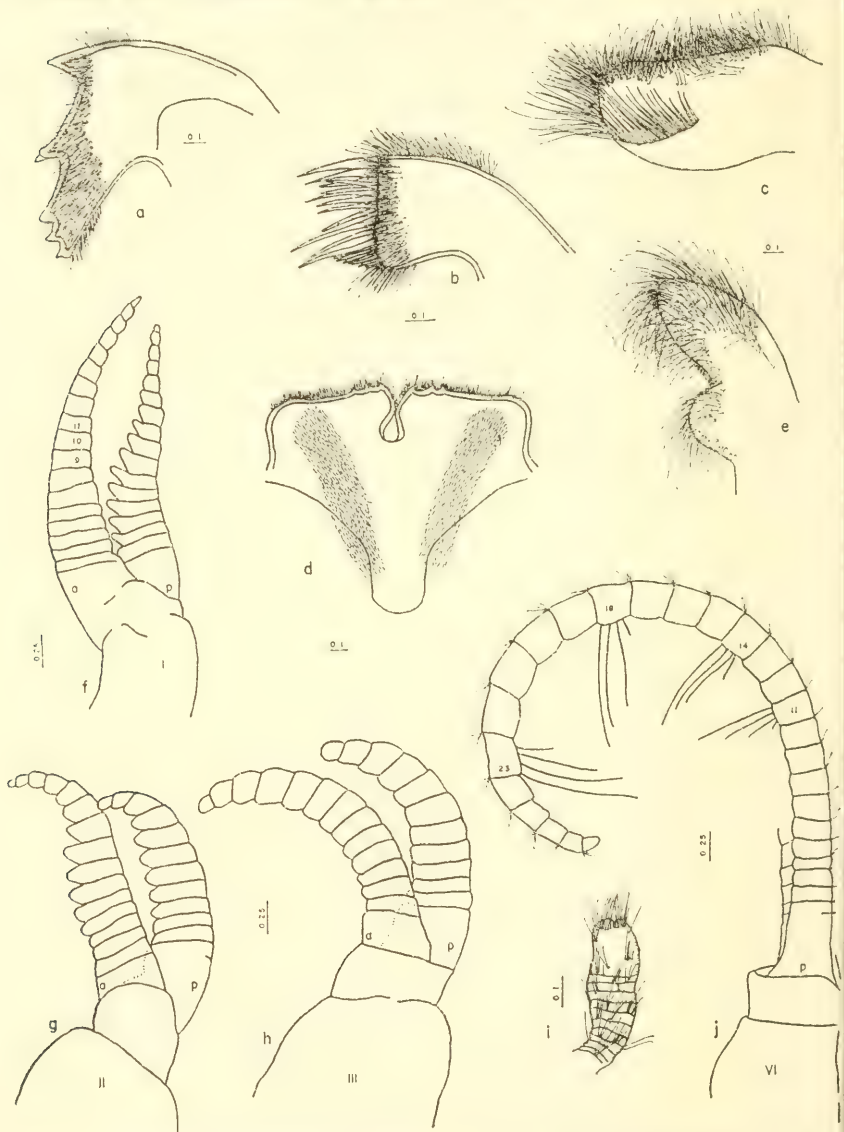


FIGURE 3.—*Balanus (Megabalanus) stultus* Darwin, 1854, AMNH 12460, Scotts Head Bay, Dominica: *a*, mandible; *b*, maxilla I; *c*, palp; *d*, labrum; *e*, maxilla II; *f*, cirrus I; *g*, cirrus II; *h*, cirrus III; *i*, distal end of penis; *j*, cirrus VI. (Setae omitted on cirri I-III on numbered segments of cirrus VI, only one set of setae shown; a=anterior ramus; p=posterior ramus; scale in millimeters.)

at the distal extremity they are significantly longer and more sparsely concentrated. A single row of long setae occurs on the outer lateral face, above and oblique to the basal margin of the appendage.

Five teeth, including the inferior angle, occur along the cutting edge of the mandible (fig. 3a). The distance between the teeth decreases by about one-half proceeding from the first tooth to the inferior angle. The inferior angle is simple, not molariform, and does not project forward beyond the fourth tooth. The second and occasionally the third tooth is bifid, or it bears subsidiary cusps.

Maxilla I has a straight cutting edge, although on one specimen dissected there appears to be a minute notch above the center. The spines are separable into three poorly defined groups, the apical consisting of two long, stout spines, a central group of 10-14 spines of varying lengths and diameters, and a basal cluster of about 7-12 short, very slender spines.

Maxilla II is tall, slender, and the anterior edge distinctly bilobed (fig. 3e). At the juncture of the two lobes there is a large patch of short, stiff bristles.

The anterior ramus of cirrus I is slightly longer than the posterior ramus, the intermediate articles of which are strongly protuberant, whereas those of the anterior ramus are less so (fig. 3f). The anterior ramus of cirri II and III are longer than the posterior. The intermediate articles of both rami of cirrus II are strongly protuberant, but less so in cirrus III (figs. 3g, h). Cirri IV-VI are essentially equal in length, with rami of more or less similar lengths. At each articulation along the greater curvature of the intermediate articles of cirri IV-VI there are two to three short, slender bristles, one short, stout bristle, and one to two very short, fine bristles. Immediately below each articulation of the inner lateral faces of both rami of the posterior three pair of cirri there is a row of short, triangular spines. Chaetotaxis along the anterior curvature of intermediate articles of cirri IV-VI is ctenopod, there being four pairs of setae on each article.

A count of the segments for specimen 1 above (fig. 3) is as follows:

| | | I | II | III | IV | V | VI |
|-------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| right | anterior | <u>19</u> | <u>16</u> | <u>14</u> | <u>25</u> | <u>26</u> | <u>29</u> |
| | posterior | <u>17</u> | <u>12</u> | <u>12</u> | <u>31</u> | <u>31</u> | <u>28</u> |
| left | anterior | <u>19</u> | <u>15</u> | <u>15</u> | <u>23</u> | <u>27</u> | <u>31</u> |
| | posterior | <u>15</u> | <u>14</u> | <u>13</u> | <u>31</u> | <u>32</u> | <u>32</u> |

A summary of the data on the cirri of the four specimens dissected are summarized below. Range (R) and mean (\bar{x}) values for the number of segments in the anterior (a) and posterior (p) rami of the cirri of the right side are as follows:

| | I | | II | | III | | IV | | V | | VI | |
|-----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| | <i>a</i> | <i>p</i> | <i>a</i> | <i>p</i> | <i>a</i> | <i>p</i> | <i>a</i> | <i>p</i> | <i>a</i> | <i>p</i> | <i>a</i> | <i>p</i> |
| n | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 3 | 2 | 4 |
| R | 17-21 | 13-18 | 13-16 | 10-13 | 12-15 | 11-14 | 25-29 | 29-31 | 26-32 | 31-35 | 29-32 | 28-34 |
| \bar{x} | 19.5 | 13.2 | 14.7 | 11.5 | 13.2 | 12.2 | 28.2 | 30.0 | 29.2 | 32.6 | 30.5 | 31.2 |

The penis is annulated throughout its length, but it is sparsely hirsute except for the distal extremity (fig. 3*i*). The basidorsal point is small, bluntly rounded, and sparsely covered with short, stiff bristles.

REMARKS.—*Balanus stultus* is herein assigned to the subgenus *Megabalanus*. Darwin (1854, p. 216), however, obviously could not reconcile the morphological evidence with the sectional (=subgenus) diagnosis he proposed for other megabalanids, and, consequently, he was forced to assign *B. stultus* to a different section of *Balanus*, subsequently regarded as the subgenus *Conopea*. Pilsbry (1953, p. 27) also could not accept the fact that *B. stultus* is a megabalanid; he stated:

In Florida when I first saw these barnacles I thought they were a species of *Megabalanus* (the *B. tintinnabulum* group), but the absence of pores in the radii was against this view. Later, upon identifying them as *B. stultus*, I was amused to find that Darwin had been similarly embarrassed by the structure of this barnacle.

The failure of earlier workers to note the obvious affinities of *B. stultus* stems from the fact that the tubes of the radii are not readily observed unless the radius is broken away from the parietes. Particularly significant, in regard to facies similarity, are the form and topography of the opercular valves and the structure of the trophic as well as the cirral appendages. It should be pointed out at this time, however, that there are at least two recognizable species groups in the megabalanids that are based in part on certain elements of the mouth field and on certain shell and opercular characters. Some semblance of these two groups may be seen in the key to the species of *Megabalanus* presented by Pilsbry (1916, p. 53). Of these groups, *B. stultus* perhaps is allied most closely to the *B. tintinnabulum* group.

The specimens that Pilsbry (1927, p. 38) reported as *Tetraclista radiata* were subsequently reexamined by Nilsson-Cantell (1939, p. 5), who found them to be specimens of *B. stultus*. It would also appear that the specimen Pilsbry cites and illustrates in the same paper as *B. tintinnabulum antillensis*, growing on *Millepora alcicornis*, may also prove, on closer scrutiny, to be a specimen of the present species.

In a recent paper, Kolosváry (1966) reported the occurrence of what he believed to be a new subspecies of *B. stultus* from Cuba, which he called *morycowae*. The cardinal differences between *morycowae* and the nominate subspecies is that, in the former the adductor

muscle pit of the scutum is circular in outline and the spur faciole of the tergum is extremely narrow and apparently closed. To judge from the studies of earlier workers and from specimens on hand, it appears that the degree and length of closure of the longitudinal furrow of the tergum is highly variable and of little diagnostic value in this species. In regard to the outline of the adductor muscle depression, this too appears to be quite variable and no doubt dependent on the age of the specimen, among other things. Consequently, the author unhesitatingly considers Kolosváry's taxon a junior synonym of *B. stultus* and not worthy of recognition.

Although Darwin (1854, p. 216) reported *B. stultus* from Singapore as well as from the West Indies, the western Pacific record obviously is an error.

DISTRIBUTION.—*Balanus stultus* ranges from the Dry Tortugas (Nilsson-Cantell, 1929) and Florida (Pilsbry, 1953) to Cuba (Kolosváry, 1966) and Curaçao (Pilsbry, 1927; Nilsson-Cantell, 1939). Pilsbry (1927) reported it growing on *Millepora alcicornis* Linnaeus, and Weltner (1897) found it to be living on *M. complanata*.

Summary

Four species of intertidal cirripeds, reported for the first time from the island of Dominica, West Indies, are described and illustrated. *Chthamalus angustitergum* and *Tetraclita stalactifera* are elevated to the rank of species. *Tetraclita divisa* is shown to be of circumtropical distribution, and *T. divisa subquadrata* is accordingly placed in synonymy with the nominate subspecies. *Balanus stultus* is removed from the subgenus *Conopea* and assigned to *Megabalanus* on the basis of facies similarity and the presence of tubes in the radii. The subfamily Tetraclitinae is elevated to the rank of family.

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Moore on the Hirudinea
with Emphasis on His Type-Specimens

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The late John Percy Moore, during his 70 years of scientific activity (1893–1963), published more than 100 papers, almost exclusively on the Annelida. In the 62 publications dealing with the Hirudinea, 3 of which were coauthored (Moore and Meyer, 1951; Meyer and Moore, 1954, 1955), 11 new genera, 78 new species, 9 new subspecies, 1 new variety, and 3 new generic names were proposed. Of the aforementioned, 1 new species and 2 new generic names were coauthored.

Moore's publications on the Hirudinea began in 1898, with a paper on the leeches of the U.S. National Museum. In that paper and those which followed in close succession, he showed those qualities of accurate observation, penetrating analysis, careful description, scholarly thoroughness, and readable style that characterized his research and publications on leeches for considerably more than half a century.

The wide geographical range of the source of his research leeches is impressive. A somewhat abridged listing includes every section of the continental United States and its coasts, Canada, Alaska and the Bering Sea area, Siberia, Greenland, Mexico, Central America, Chile, Patagonia, [British] Guiana, Puerto Rico, Hawaiian Islands, Fiji Islands, Assumption Islands, New Hebrides, Dalmatia, New Guinea, Arctic and Antarctic Seas, Palestine, Morocco, Central and East

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Africa, Natal, islands of the Malay Archipelago, Thailand, China, Burma, India, Kashmir, Australia, and New Zealand. That his leeches originated from such widely scattered points of the world attests to Moore's standing as a hirudinologist.

Moore's technical papers are devoted largely, although not exclusively, to leeches—their anatomy, both external and internal, and their ecology. His chapters on the Hirudinea in Ward and Whipple's "Freshwater Biology" (1918, 1959a), attest to his skill in analyzing, synthesizing, and evaluating the work of himself and others. In contrast to the work of his American predecessors, whose taxonomy was based only upon external characters, which themselves are ephemeral in animals known for their changeableness, Moore's descriptions were based upon dissections or serial sections, or both, and were characterized by equally detailed accounts of both the external and internal anatomy. In preparing the chapter on Hirudinea for the second edition of Ward and Whipple, he encountered so many contradictions in the diagnoses of named species that he found it necessary to reexamine Verrill's available "types" and study living specimens from the type-localities (Moore, 1952b). When he found it necessary to disagree with or to criticize work that did not seem well grounded, he always managed to do it courteously.

While Moore's contribution to the systematics of leeches deserves special mention, he will be most remembered for his earlier work on the leech neuro-segment theory and his method of expressing segment-annular relationships, a method still in current use. This theory, in character with his other writings, reflects his sound judgments. In the light of present day specialization, his versatility is amazing. It enabled him to produce important contributions on polychaetes and oligochaetes and to achieve a position of world leadership on leeches.

Moore spent a sabbatical year (1930–1931) trekking through India studying firsthand the land leeches, after which he published a paper (1932b), correcting or modifying certain statements made in his account of the Haemadipsidae in the Hirudinea volume of "The Fauna of British India" series (1927). In a 1 March 1931 letter from Calcutta, according to Wenrich (1965, p. 195), Moore stated, among other things:

Over here I have acquired a most evil reputation, for wherever I go I am known as the Professor who studies land leeches, which is generally regarded as the acme of American eccentricity; and in a country where Al Capone, Jack Dempsey and Charlie Chaplin are regarded as the greatest and most representative Americans, that is saying a good deal.

Moore was a modest person, a gracious host with a keen sense of humor. His conversation was spiced with witticisms. I cannot speak too highly of his orderly, constructive mind and his analytical powers. He was a person who did not think in absolutes, and was able to be ob-

jective even when deeply stirred emotionally. I enjoyed his friendship for nearly three decades, during which time we collaborated closely, and I shall cherish always my visits with him.

Moore bequeathed his leech collection and scientific library to the United States National Museum, with which he was associated for 30 years as a Collaborator in the Division of Marine Invertebrates. After his death on 1 March 1965, shortly before his 96th birthday, I went to Chapel Hill, N.C., where he spent his last years, and to the family homestead near Media, Penn., to assist his daughter Elinor Moore Irvin in preparing the collection for transfer to the National Museum. At the Museum, the large collection, consisting of 2721 lots and more than 9000 specimens, was given a preliminary sorting by Marian Pettibone and George Ford of the Division of Worms. As a result of my interest in the Hirudinea and my close association with Dr. Moore, I undertook the task of getting the collection into shape for cataloging, in which priority was given to the type-specimens.

The Moore collection, the most important assemblage of specimens of its kind in the world, will serve hirudinologists both here and abroad as a reference for systematic studies on leeches. In addition to its value for the type-specimens, the collection is important because it contains many species from the main faunal regions of the world. While most of the identifications of this material were made by Moore there are numerous specimens identified and contributed by his contemporary workers abroad, viz., C. Badham, Australia; R. Blanchard and E. Brumpt, France; E. Caballero y C., Mexico; W. A. Harding and K. H. Mann, Great Britain; L. Johansson, Sweden; T. Kaburaki and A. Oka, Japan; R. Ringuelet, Argentina.

Some of the type-specimens of the Moore species-group had already been returned to the institutions supplying the material, and some had been set apart from the general collection but retained by Moore. Some of the type material, however, including paratypes and syntypes (often referred to as cotypes), had not been returned to the suppliers, nor had it been set apart from the general collection by Dr. Moore. In extracting the type-specimens from the general collection, I have been guided by the data given in the original references.

The purpose of this paper is to indicate the change in the location of the Moore material, not already deposited in museums, from his private collection to the U.S. National Museum; to verify the presence of type-specimens previously deposited in museums in America and abroad; and to provide relevant information on the type-specimens for the benefit of interested future workers.

A search was made to locate as many of Moore's type-specimens as possible. For the most part this was done by corresponding with the institutions where types had been deposited, as stated in relevant

publications, and with the institutions supplying the material. I also visited the Academy of Natural Sciences of Philadelphia, with which Moore had been actively associated for more than half a century. I have succeeded in verifying the existence of type-specimens of 70 taxa of the species-group, at the following seven institutions:

United States National Museum, Washington, D.C. (USNM): 59 species and subspecies (21 holotypes, 13 syntypes, and 111 paratypes).

British Museum (Natural History), London, England (BMNH): 16 species and subspecies (15 holotypes and 11 paratypes). Data kindly furnished by R. W. Sims and J. G. George.

Academy of Natural Sciences of Philadelphia, Philadelphia, Penn. (ANSP): 5 species (4 holotypes, 2 syntypes, and 2 paratypes). Personal visit kindly arranged for by C. W. Hart, Jr.

Zoological Survey of India, Calcutta, India (ZSI): 8 species and subspecies (8 holotypes). Data kindly furnished by A. P. Kapur.

Australian Museum, Sydney, Australia (AM): 2 species (2 holotypes and 2 paratypes). Data kindly supplied by C. N. Smithers and F. H. Talbot.

American Museum of Natural History, New York, N.Y. (AMNH): 2 species (2 holotypes and 1 paratype). Data kindly supplied by Arnold Ross.

Bernice P. Bishop Museum, Honolulu, Hawaii (BPBM): 2 species (2 holotypes and 1 paratype). Data kindly supplied by Dennis M. Devaney.

The following institutions were contacted in the search for type-specimens, but with negative results:

Beltsville Parasitological Laboratory, Animal Disease and Parasite Research Division, Agricultural Research Center, USDA, Beltsville, Md., through Willard W. Becklund; Illinois Natural History Survey, Urbana, Ill., through John D. Unzicker; Department of Zoology, University of Minnesota, Minneapolis, Minn., through Franklin G. Wallace; and Sarawak Museum, Kuching, Sarawak, Malaysia, through Benedict Sandin.

No type material was uncovered for 16 taxa of the species-group and 1 variety. It is hoped that these will be found. The missing types include the following:

GLOSSIPHONIIDAE: from Illinois, *Actionobdella incquianulata* Moore, 1901a, *Placobdella montifera* Moore, 1906; from Connecticut, *Helobdella papillata* Moore, 1952b; from Mexico, *Placobdella mexicana* Moore, 1898; from Siberia, *Protoclepsine sexoculata* Moore, 1898. PISCICOLIDAE: from Chile, *Platybdella chilensis* Moore, 1910; from Japan, *Trachelobdella okae* Moore, 1924c. HIRUDINIDAE: from Puerto Rico, *Diplobdella antellarum* Moore, 1901b, *Hirudinaria blanchardi* Moore, 1901b; from Minnesota, *Haemopsis plumbeus* Moore, 1912; from India, *Hirudo nipponia* var. *fuscolineata* Moore, 1924c; from Louisiana, *Philobdella gracile* Moore, 1901a. ERPOBDELLIDAE: from Northwest Territories, Canada, *Dina dubia* Moore and Meyer, 1951; from Illinois, *Dina microstoma* Moore, 1901a; from Minnesota, *Dina parva* Moore, 1912; from British Columbia, Canada, *Erpobdella punctata annulata* Moore, 1922. DIESTECOSTOMIDAE: from Guatemala, *Diestecostoma octannulata* Moore, 1946a.

For each of the new taxa described by Moore, which are listed alphabetically by family, I have given the original reference as well

as subsequent references to that taxon by Moore. I have also included selected references to publications by other authors in which additional figures or other supplementary data are given, or in which the species are transferred to other genera or have been synonymized. A complete list of the publications dealing with leeches by Moore is included, together with a list of the new taxa described and the new names proposed in each paper. The type material is documented by names of the museum(s) where it is deposited, its catalog number, locality, collector (when available), and the number of specimens. In attempting to track down the types, I found that the data accompanying the material occasionally did not agree with the text. In such cases the data accompanying the specimens are given. Only those types have been included that have had their presence verified.

To the aforementioned individuals, who kindly cooperated in the search for type material, and the institutions they represent, I wish to express my appreciation. I am also grateful to Meredith L. Jones, Supervisor and Associate Curator of the Division of Worms, and Marian H. Pettibone, Curator of the Division of Worms, both of the Museum of Natural History, for helpful comments and good working conditions, to Fenner A. Chace, Jr., Senior Zoologist, Department of Invertebrate Zoology, Museum of Natural History, for help in deciding some problems of nomenclature, and to the administration of the University of Maine for granting me a leave of absence, enabling me to take advantage of a Visiting Research Associateship, tenable at the U.S. National Museum, awarded me by the National Research Council.

Order RHYNCHOBDELLAE

Family GLOSSIPHONIIDAE

Actinobdella Moore

Actinobdella annectens Moore

Actinobdella annectens Moore, 1906, p. 160, figs. 1, 2; 1918, p. 655; 1924a, pp. 26, 551.

Type material: Holotype, USNM 5228, Rondeau Harbor, Lake Erie, Long Point, Ontario, Canada, August 1899, from snapping turtle, J. Reighard collector.

Actinobdella inequiannulata Moore

Actinobdella inequiannulata Moore, 1901a, p. 504, pl. 43 (figs. 8-11); 1912a, p. 99, pl. 3 (figs. 19-20); 1918, p. 655, fig. 1001; 1924a, p. 26; 1959, p. 551, fig. 23.6.

Type material: No type material was found.

Type-locality: Illinois River at Havana, Ill. (Moore, 1924a, p. 26).

Actinobdella triannulata Moore

Actinobdella triannulata Moore, 1924a, p. 23, fig. 1; 1959, p. 551.—Meyer and Moore, 1954, p. 66.

Type material: Holotype, ANSP 4054, Lake Nipigon, Ontario, Canada, August 1921, F. B. Adamstone collector. Paratype, ANSP 4055, Lake Nipigon, Ontario, Canada, August 1921, F. B. Adamstone collector. Paratype; USNM 36302, station 7, McL. Bay, Lake Nipigon, Ontario, Canada, July 1922, F. B. Adamstone collector.

Batrachobdella amnicola Moore

Batrachobdella amnicola Moore, 1958, p. 313, pl. 7 (figs. 5-7).

Type material: Syntype, USNM 36387, no. 32, Engamani River, Hluhluwe, Zululand, under stones, 1949. Syntypes, USNM 36416, no. 32, Engamani River, Hluhluwe, Zululand, under stones, 1949, 2 specimens, sectioned (1 transverse, 1 sagittal). Syntypes, USNM 36417, no. 27, Hluhluwe Game Preserve, under stones in river, 1949 2 specimens, sectioned (transverse). Syntypes, USNM 36431, 1949, 3 specimens mounted (2 slides). Since uncertainty exists as to which lot of material the whole mounts belong, the exact locality in Zululand is unknown.

Remarks: The generic name *Batrachobdella* should read *Batracobdella*, the original spelling (M. C. Viguier, July 1879, "Comptes Rendus des Seances de L'Academie des Sciences," Paris, vol. 89, pp. 110-112), which Moore had used earlier infra. Later in the same year in an English translation of Viguier's article (September 1879, "Annals and Magazine of Natural History," ser. 5, vol. 4, pp. 250-251), the spelling of *Batracobdella* was changed to *Batrachobdella*.

Batracobdella quadrata Moore

Batracobdella quadrata Moore, 1939c, p. 304, pl. 26 (fig. 20).

Type material: Holotype, BMNH 1933.1.19.12, Omer-Cooper collection from Abyssinia, Addis Ababa, pond no. 1, British Legation, September 1926. Paratypes, BMNH 1933.1.10.13/14, Omer-Cooper collection from Abyssinia, Addis Ababa, pond no. 1, British Legation, September 1926, 2 specimens. Paratype, USNM 36425, Lang-Chapin Congo Expedition, no. 4542, pool in steppe, Kabare, Belgian Congo, August 1914, specimen mounted.

Glossiphonia conifera Moore

Glossiphonia conifera Moore, 1933, p. 297.

Helobdella conifera.—Autrum, 1936, p. 30.—Moore, 1939b, p. 428; 1939c, p. 300, pl. 25 (fig. 2), pl. 26 (fig. 18); 1958, p. 310, pl. 7 (fig. 4), text-fig. 3.

Type material: Holotype, BMNH 1933.1.21.18, Lake Bunyoni, among weeds along the shore, station 707 A, Uganda, E. B. Worthing-

ton collector. Paratypes, BMNH 1933.1.19.1/2, Lake Bunyoni, among weeds along the shore, station 707 A, E. B. Worthington collector, 2 specimens. Paratype, USNM 36340, Lake Bunyoni, among weeds along the shore, station 707 A, Uganda, E. B. Worthington collector. Paratype, USNM 36424, Lake Bunyoni, among weeds along the shore, station 707 A, Uganda, E. B. Worthington collector, specimen mounted.

Glossiphonia disjuncta Moore

Glossiphonia disjuncta Moore, 1939c, p. 299, pl. 25 (fig. 1).

Type material: Holotype, BMNH 1933.1.21.17, in shore weeds at Bufundi on Lake Bunyoni, Uganda, station no. 716, August 1931, E. B. Worthington collector. Paratypes, BMNH 1933.1.19.16/18, water hole, north of Make River, Abyssinia, November 1926, J. Omer-Cooper collector, 2 specimens; Wourambouchi [Wouramboulchi River], Abyssinia, October 1926, J. Omer-Cooper collector, 1 specimen. Paratype, USNM 36361, in shore weeds at Bufundi on Lake Bunyoni, Uganda, station no. 716, August 1931, E. B. Worthington collector. Paratype, USNM 36434, in shore weeds at Bufundi on Lake Bunyoni, Uganda, station no. 716, August 1931, E. B. Worthington collector, specimen sectioned (frontal).

Glossiphonia duplicata Moore

Glossiphonia duplicata Moore, 1911, p. 675, pl. 49 (fig. 10), pl. 50 (figs. 16-22).

Helobdella duplicata.—Autrum, 1936, p. 27, fig. 17.—Ringuélet, 1944, p. 22, fig. 11.

Type material: Syntypes, ANSP 570, small stream on Rio Chico, 15 miles above Sierra Oveja, Patagonia, February 1908, J. B. Hatcher collector, 2 specimens. Syntype, USNM 36301, on Rio Chico, Patagonia, J. B. Hatcher collector, specimen sectioned (sagittal, anterior end; transverse, posterior end).

Glossiphonia lata multipapillata Moore

Glossiphonia lata multipapillata Moore, 1930b, p. 175, pl. 7 (figs. 6-8).

Type material: Paratypes, USNM 36337, Honda at Rokotan, Manchuria, October 1925, 3 specimens.

Glossiphonia magnidiscus Moore

Glossiphonia magnidiscus Moore, 1938b, p. 68, figs. 1-2.

Type material: Holotype, USNM 36352, San Bulha Cave, Motul, Yucatan, from gills of the fish *Rhamdia guatemalensis decolor* Hubbs, July 1932, A. S. Pearse and E. P. Creaser collectors. Paratypes, USNM 36353, El Paso de Caballo on Rio San Pedro de Martin, Guatemala, from mouth of the fish *Petenia splendida*, April 1932, C. L. Lundell collector, 2 specimens.

Glossiphonia simplex Moore

Glossiphonia simplex Moore, 1911, p. 681, pl. 49 (fig. 11), pl. 50 (figs. 15, 23, 24).
Helobdella simplex.—Autrum, 1936, p. 22.—Moore, 1939b, p. 428.—Ringuelet,
 1944, p. 26, figs. 12–15.

Type material: Holotype, ANSP 572, on Rio Chico, 5 miles above Sierra Ventana, Patagonia, February 1899, J. B. Hatcher collector.

Glossiphonia (Helobdella) nuda Moore

Glossiphonia (Helobdella) nuda Moore, 1924c, p. 354, pl. 19 (figs. 3–4), pl. 21 (figs. 20–23); 1930b, p. 175.

Helobdella nuda.—Moore, 1930a, p. 39; 1930b, p. 191.

Batracobdella nuda.—Autrum, 1936, p. 42.

Type material: Holotype, USNM 36303, Soochow, China, N. Gist Gee collector. Paratypes, USNM 36304, Soochow, China, N. Gist Gee collector, 3 specimens. Paratypes, USNM 36423, Soochow, China, N. Gist Gee collector, 4 specimens: 3 mounted (2 slides), 1 sectioned (sagittal).

Helobdella papillata Moore*Clepsine papillifera* var. b. Verrill, 1872

Helobdella papillata Moore, 1952b, p. 3; 1959a, p. 549.

Type material: No type material was found.

Type-locality: Whitneyville Lake, near New Haven, Conn.

Helobdella punctato-lineata Moore

Helobdella punctato-lineata Moore, 1939b, p. 422, figs. 1–2.—McAnnally and D. V. Moore, p. 196, figs. 1–2.

Helobdella punctato-lineata.—Moore, 1959, p. 548.—Mann, 1962, p. 156.

Type material: Holotype, USNM 36359, ponds in Guajataca and Isabela, NW Puerto Rico, March 1938, W. A. Hoffman collector. Paratypes, USNM 36360, ponds in Guajataca and Isabela, NW Puerto Rico, March 1938, W. A. Hoffman collector, 11 specimens. Paratypes, USNM 36402, ponds in Guajataca and Isabela, NW Puerto Rico, March 1938, W. A. Hoffman collector, 6 specimens: 4 stained and mounted (2 slides) and 2 sectioned (1 transverse, 1 sagittal).

Remarks: According to Art. 32c(i) of the "International Code of Zoological Nomenclature" (Intern. Trust Zool. Nomen. London, 1961), *punctato-lineata* should read *punctatolineata*.

Hemiclepsis marginata asiatica Moore

Hemiclepsis marginata asiatica Moore, 1924c, p. 359, pl. 21 (fig. 24); 1930b, p. 179.—Harding, 1927, p. 87, fig. 35.—Bennike, 1943, p. 80.

Type material: Holotype, ZSI W 1445/1, Kashmir Survey, station

2, Srinagar, Chenar Bagh nullah [?stream], June 1921. Paratype, USNM 36305, Kashmir Survey, station 20, Nale Mar, a slow-running nullah from the Dal Lake into Jhelum River. Paratypes, USNM 36306, Achibal Spring, Jhelum Valley, Kashmir, 7 specimens (2 with young). Paratype, USNM 36534, Kashmir Survey, station 17, stream from the waterworks reservoir leading to trout farm at Harwan, Kashmir, July 1921, specimen mounted.

Microbdella Moore, 1900

Microbdella biannulata Moore

Microbdella biannulata Moore, 1900a, p. 51, pl. 6 (figs. 1-6).

Oligobdella biannulata.—Moore, 1918, p. 654, fig. 1000; 1959, p. 550, fig. 23.5.

Type material: Syntypes, USNM 36394, Yonahlossee Road, Blowing Rock, N. C., elevation exceeding 3500 ft., 1898, from the salamander *Desmognathus nigra*, 5 specimens sectioned (2 sagittal, 2 transverse, 1 frontal).

Remarks: *Desmognathus nigra* is now regarded as including 2 species, both occurring in North Carolina. *Desmognathus quadramaculata* is more common, but *D. fuscus fuscus* is larger and probably more aquatic. This information was kindly supplied by the late Doris M. Cochran, U.S. National Museum, to whom I am grateful.

Oculobdella lucida Moore

Oculobdella lucida Moore, 1954, p. 68, pl. 1 (figs. 1-2), pl. 2 [in Meyer and Moore, 1954]; 1959, p. 551.

Oculobdella lucida Meyer and Moore [sic].—Moore, 1959, p. 551.—Mann, 1962, p. 159.—J. E. Moore, 1964, pp. 1, 4.

Type material: Holotype, USNM 36390, Whitewater Lake, Manitoba, among *Typha* debris in shallow water, June 1950, N. Neufeld collector. Paratype, USNM 36391, Whitewater Lake, Manitoba, among *Typha* debris in shallow water, June 1950, N. Neufeld collector, specimen dissected. Paratypes, USNM 36392, Whitewater Lake, Manitoba, among submarginal and emergent plants and their debris, in shallow water, June 1950, N. Neufeld collector, 6 specimens (1 bisected midsagittally). Paratypes, USNM 36393, Whitewater Lake, Manitoba, among *Typha* and *Eleocharis* shoots, in shallow water, September 1950, N. Neufeld collector, 5 specimens (1 dissected). Paratypes, USNM 36421, Whitewater Lake, Manitoba, among submarginal and emergent plants and their debris, in shallow water, June 1950, N. Neufeld collector, 5 specimens, mounted (1 slide). Paratypes, USNM 36422, Whitewater Lake, Manitoba, among *Typha* and *Eleocharis* shoots, in shallow water, September 1950, N. Neufeld collector, 10 specimens: 9 mounted (2 slides), 1 sectioned (sagittal).

Placobdella (Parabdella) aspera Moore

Placobdella (Parabdella) aspera Moore, 1939c, p. 309, pl. 25 (figs. 5-7).

Type material: Holotype, AMNH 2585, American Museum Lang-Chapin Congo Expedition, no. 100, Medje, Belgian Congo, May 1910, from crocodile no. 475. Paratypes, AMNH 2581, American Museum Lang-Chapin Congo Expedition, no. 100, Medje, Belgian Congo, May 1910, from crocodile no. 475, 14 specimens. Paratypes, USNM 36362, American Museum Lang-Chapin Congo Expedition, no. 100, Medje, Belgian Congo, May 1910, from crocodile no. 475, 15 specimens (2 dissected). Paratypes, USNM 36430, American Museum Lang-Chapin Congo Expedition, no. 100, Medje, Belgian Congo, May 1910, from crocodile no. 475, 2 specimens (mounted, 1 slide).

Remarks: Moore stated (p. 311) that there are 30 type-specimens. But 32 type-specimens are present or accounted for: Arnold Ross confirmed the presence of 15 in the AMNH, and there are 17 in the USNM collection.

Protolepsine Moore, 1898*Protolepsine sexoculata* Moore

Protolepsine sexoculata Moore, 1898, p. 546, pl. 40 (fig. 1).

Protolepsis meyeri Livanow, 1902, p. 346, pl. 13 (fig. 4).

Theromyzon sexoculata.—Moore, 1924c, p. 346; 1936b, p. 191.—Harding, 1927, p. 82.

Protolepsis sexoculata.—Autrum, 1934, p. 274. [In Scriban and Autrum, 1932-1934.]

Theromyzon sexoculatum.—Autrum, 1936, p. 47.

Type material: No type material was found.

Type-locality: Bering Island, Commander Islands, Siberia.

Oligobdella Moore, 1918

New name for *Microbdella* Moore, 1900, preoccupied.

Placobdella auroguttata

Placobdella auroguttata Moore, 1939c, p. 317, pl. 26 (fig. 21).

Type material: Holotype, BMNH 1933.1.21.34, Station 123A no. 1, Kibero, SE shore, Lake Albert, Uganda, April 1928, E. B. Worthington collector.

Placobdella mexicana Moore

Placobdella mexicana Moore, 1898, p. 550, pl. 40 (fig. 3).

Haementeria (Placobdella) moorei.—Autrum, 1936, p. 70, fig. 40. [New name for *Haementeria mexicana* (Moore, 1898), preoccupied.]

Type material: No type material was found.

Type-locality: Mexico.

Placobdella montifera Moore

Hemiclepsis carinata.—Moore, 1901a, p. 498, pl. 42 (fig. 5). [Not *Clepsine papillifera* var. *carinata* Verrill, 1874.]

Placobdella montifera Moore, 1906, p. 160; 1912, p. 88, pl. 1 (fig. 5), pl. 2 (fig. 10); 1918, p. 652; 1920, p. 94; 1924a, p. 23; 1936c, p. 113; 1959, p. 549.

Haementeria (Placobdella) montifera.—Autrum, 1936, p. 64, fig. 40.

Type material: No type material was found.

Type-locality: Illinois.

Placobdella multilineata Moore

Placobdella multilineata Moore, 1953, p. 1, pl. 1 (fig. 1); 1959, p. 550.

Type material: Holotype, USNM 36435, New Orleans, La., March 1917, H. E. Hubert collector. Paratypes, USNM 36383, New Orleans, La., March 1917, H. E. Hubert collector, 4 specimens. Paratypes, USNM 36384, Norman, Okla., April 1926, C. Ellsworth collector, 2 specimens (1 dissected). Paratypes, USNM 36413, New Orleans, La., from snapping turtle, July 1922, P. Viosca collector, 2 specimens sectioned (1 transverse, 1 frontal [anterior half]). Paratype, USNM 36428, New Orleans, La., from snapping turtle, July 1922, P. Viosca collector, specimen mounted (posterior sucker detached but included).

Placobdella pulchra Moore

Placobdella pulchra Moore, 1939c, p. 314, pl. 25 (figs. 8–9).

Type material: Holotype, BMNH 1930.9.15.64/65, Christy Tanganyika Collection, no. 441, attached to weeds in a water-blocked river mouth, confluent of Lake Tanganyika, October 1926. Paratypes BMNH 1930.9.15.64/65, Christy Tanganyika Collection, no. 441, attached to weeds in a water-blocked river mouth, confluent of Lake Tanganyika, October 1926, 2 specimens. Paratypes, USNM 36363, Mansya River, outlet of Lake Young, Northern Rhodesia, no. 49, from neck of tortoise, August 1936, C. K. Ricardo collector, 8 specimens (1 dissected). Paratypes, USNM 36429, Mansya River, outlet of Lake Young, Northern Rhodesia, no. 49, from neck of tortoise, August 1936, C. K. Ricardo collector, 2 specimens mounted (1 slide).

Placobdella quadrioculata Moore

Placobdella quadrioculata Moore, 1930b, p. 178, pl. 8 (figs. 10–12).

Haementeria (Parabdella) quadrioculata.—Autrum, 1936, p. 80.

Type material: Holotype, USNM 36338, Nanking, China, no. 6, 1927, C. Ping collector. Paratype, USNM 36339, Nanking, China, F. C. Zia collector.

Placobdella unita Moore

Placobdella unita Moore, 1958, p. 320, pl. 8 (figs. 12-13), text-fig. 6.

Type material: Syntypes, USNM 36388, no. 3, Camaeis, Southwest Africa, from the reptile *Pelomedusa subrufa* (= *P. galeata*), 1925, R. F. Lawrence collector, 2 specimens, incomplete (cut parasagittally, only larger pieces present). Syntypes, USNM 36389, no. 26, Albert Falls, Natal, University of Natal, Zoological Survey, from the reptile *Pelusios sinuatus*, 15 specimens. Syntypes, USNM 36418, no. 3, Camaeis, Southwest Africa, from *Pelomedusa subrufa* (= *P. galeata*), 1925, R. F. Lawrence collector, 2 specimens+ocular region of a third, mounted (1 slide). Syntypes, USNM 36419, no. 26, Albert Falls, Natal, University of Natal, Zoological Survey, from *Pelusios sinuatus*, 4 specimens, mounted (1 slide). Syntypes, USNM 36420, no. 3, Camaeis, Southwest Africa, from *Pelomedusa subrufa* (= *P. galeata*), 1925, R. F. Lawrence collector, 2 specimens, sectioned (both sagittal).

Family PISCICOLIDAE

Austrobdella anoculata Moore

Austrobdella anoculata Moore, 1940, p. 520, figs. 1-4.—Ingram, 1957, p. 204.

Type material: Holotype, USNM 20573, between Capes Alexander and Chalon, NW Greenland, 25-40 fms, August 1937, R. A. Bartlett collector. Paratype, USNM 36406, between Capes Alexander and Chalon, NW Greenland, 25-40 fms, August 1937, R. A. Bartlett collector, specimen sectioned (transverse).

Branchellion lobata Moore

Branchellion lobata Moore, 1952a, p. 36, figs. 1, 7b, 8, 9.—Ingram, 1957, p. 213.

Type material: Holotype, USNM 36379, Pacific Grove, Calif., 40-60 fms, from the fish *Triakis henlei*, March 1929, E. F. Ricketts collector. Paratypes, USNM 36380, Pacific Grove, Calif., 40-60 fms, from *Triakis henlei*, March 1929, E. F. Ricketts collector, 4 specimens (1 dissected). Paratypes, USNM 36381, Pacific Grove, Calif., 40-60 fms, from the fish *Squalus acanthias* (= *S. sucklii*), April 1929, E. F. Ricketts collector, 2 specimens. Paratype, USNM 36382, off San Francisco, Calif., from *Squalus acanthias* (= *S. sucklii*), February 1941. Paratypes, USNM 36410, Pacific Grove, Calif., 40-60 fms, from *Triakis henlei*, March 1928, E. F. Ricketts collector, 4 specimens (2 slides). Paratypes, USNM 36411, Dillon Beach, Calif., from the fish *Squatina californica*, E. C. Dougherty collector, specimen mounted. Paratype, USNM 36412, Pacific Grove, Calif., February 1928, E. F. Ricketts collector, specimen sectioned (anterior half, sagittal; remainder, transverse).

Johanssonia abditovesiculata Moore

Johanssonia abditovesiculata Moore, 1952a, p. 29, figs. 2c, 6a-c, 7a.—Ingram, 1957, p. 212.

Type material: Holotype, BPBM R139, Honolulu Aquarium, from the fish *Arothron hispidus* (= *Tetraodon hispidus*), February 1949, S. Tinker collector. Paratypes, BPBM R155, Honolulu Aquarium, from *Arothron hispidus* (= *Tetraodon hispidus*), February 1949, S. Tinker collector, 5 specimens. Paratypes, USNM 36378, Honolulu Aquarium, from *Arothron hispidus* (= *Tetraodon hispidus*), February 1949, S. Tinker collector, 2 specimens. Paratypes, USNM 36409, Honolulu Aquarium, from *Arothron hispidus* (= *Tetraodon hispidus*), February 1949, S. Tinker collector, 5 specimens: 3 mounted (1 slide) and 2 sectioned (1 transverse [slide 6 in the series missing], 1 sagittal).

Remarks: Moore stated (pp. 32, 36) that there are 8 type-specimens. But 13 type-specimens are present or accounted for: D. M. Devaney confirmed the presence of 6 in the BPBM, and there are 7 in the USNM collection.

Marsipobdella Moore*Marsipobdella sacculata* Moore

Marsipobdella sacculata Moore, 1952a, p. 22, figs. 2b, 3-5.

Type material: Holotype, USNM 36376, Pacific Grove, Calif., from skates, E. F. Ricketts collector. Paratypes, USNM 36377, Pacific Grove, Calif., from skates, E. F. Ricketts collector, 15 specimens (2 missing anterior end). Paratypes, USNM 36408, Pacific Grove, Calif., from skates, E. F. Ricketts collector, 5 specimens plus anterior ends of 2 (missing pieces from 2 incomplete specimens, supra): 4 mounted (1 slide); 1 and portions sectioned (1 [parts of 2 specimens] transverse; 2 anterior ends, sagittal).

Notostomobdella Moore and Meyer, 1951

New name for *Notostomum* Levinsen, 1882, preoccupied.

Otoniobdella Moore and Meyer, 1951

New name for *Ottonia* Malm, 1874, preoccupied.

Otoniobdella stellata Moore

Otoniobdella stellata Moore, 1958, p. 307, pl. 7 (fig. 3), text-fig. 2.

Malmiana stellata.—Soós, 1965, p. 440.

Type material: Paratype, USNM 36426, Richards Bay, Natal, South Africa, from toby fish (species unknown), no. 38, July 1958, specimen mounted.

Oxytonostoma varituberculata Moore

Oxytonostoma varituberculata Moore, 1938a, p. 10, pl. 1 (figs. 4-5).

Type material: Holotype, AM W.4162, ANARE station 2, lat. 66°55'S, long. 145°21'E, 288-300 fms, December 1913 (specimen cut open midventrally in middle region). Paratype, AM W.4163, ANARE station 2, lat. 66°55'S, long. 145°21'E, 288-300 fms, December 1913. Paratype, USNM 36351, Mawson Antarctic Expedition, station 9, lat. 66°8'S, long. 94°17'E, 120 fms, January 1914.

Phyllobdella Moore*Phyllobdella maculata* Moore

Phyllobdella maculata Moore, 1939c, p. 321, pl. 25 (figs. 13-15), text-fig. 1.

Type material: Holotype, BMNH 1933.1.20.11, Pask-Christy Tanganyika Expedition, station 432S, Kirando, east shore of Lake Tanganyika, from tail of the fish *Barbus tropidolepis*, October 1926. Paratype, USNM 36364, Pask-Christy Tanganyika Expedition, station 432S., Kirando, east shore of Lake Tanganyika, from tail of the fish *Barbus tropidolepis*, October 1926.

Piscicola zebra Moore

Piscicola zebra Moore, 1898, p. 555.—Meyer, 1940, p. 364.

Type material: Syntypes, USNM 4818, Arichat, Cape Breton, Nova Scotia, from lips of lamper eel (*Petromyzon marinus*), 1890, W. A. Stearns collector, 4 specimens (1 in pieces).

Platybdella chilensis Moore

Platybdella chilensis Moore, 1910, p. 29.

Type material: No type material was found.

Type-locality: Valparaiso, Chile, from the fish *Aphos porosus* (= *Porichthys porosus*).

Pontobdella biannulata Moore

Pontobdella biannulata Moore, 1957, p. 102, fig. 1.

Stibarobdella biannulata.—Llewellyn, 1966, p. 405.

Type material: Holotype, USNM 36385, BANZ Antarctic Research Expedition, station 39, coll. no. 1809. Paratype, USNM 36414, BANZ Antarctic Research Expedition, station 107, coll. no. 1804, specimen sectioned (sagittal).

Pontobdella rugosa Moore

Pontobdella rugosa Moore, 1938a, p. 5, pl. 1 (figs. 1-3), text-fig. 1; 1957, p. 102.

Type material: Holotype, AM W.4164, ANARE station 7, lat. 65°42'S, long. 92°10'E, 60 fms, January 1914. Paratypes, AM W.4165, ANARE station 7, lat. 65°42'S, long. 92°10'E, 60 fms, January 1914, 2 specimens. Paratypes, USNM 36348, Mawson Antarctic Expedition station 7, lat. 65°42'S, long. 92°10'E, 60 fms, January 1914, 16 specimens (body wall of 1 cut longitudinally). Paratypes, USNM 36349, Mawson Antarctic Expedition, Commonwealth Bay, King George V Land, 25 fms (the label in the vial reads "Adelieland and 85 fms, for King George V Land and 25 fms, respectively, in text"), September 1912, from fish, 2 specimens. Paratype, USNM 36350, Mawson Antarctic Expedition, station 3, lat. 66°32'S, long. 141°39'E, 157 fms, December 1913. Paratypes, USNM 36401, Mawson Expedition, station 7, lat. 65°42'S, long. 92°10'E, 60 fms, January 1914, 3 specimens sectioned (2 transverse, 1 sagittal).

Remarks: Moore stated (p. 9) that 16 specimens were from station 7. But 22 specimens are present or accounted for: there are 19 in the USNM collection (16 in alcohol and 3 series of sections), and 3 in the Australian Museum.

Trachelobdella maculata Moore

Trachelobdella maculata Moore, 1898, p. 552, pl. 40 (fig. 6).

Type material: Holotype, USNM 1314 (in two pieces), Steamer *Albatross*.

Type-locality: Unknown.

Trachelobdella okae Moore

Trachelobdella okae Moore, 1924c, p. 345.—Oka, 1927, p. 239, figs. A-B.—Epshtein, 1964, p. 907, figs. 1-2.

Type material: No type material was found.

Type-locality: Bay of Tokyo, Japan (Blanchard, 1896, p. 317).

Trachelobdella rugosa Moore

Trachelobdella rugosa Moore, 1898, p. 553, pl. 40 (fig. 5).

Type material: Holotype, USNM 5035, from red snapper. Paratypes, USNM 36300, from red snapper, 5 specimens (2 in pieces).

Type-locality: Unknown.

Trachelobdellina Moore*Trachelobdellina glabra* Moore

Trachelobdellina glabra Moore, 1957, p. 104, fig. 2.

Type material: Holotype, USNM 36386, BANZ Antarctic Research Expedition, station 103, coll. no. 1807. Paratypes, USNM 36415, BANZ Antarctic Research Expedition, station 103, coll. no. 1807, 2 specimens: 1 mounted, 1 sectioned (transverse).

Order ARHYNCHOBDELLAE

Family HIRUDINIDAE

Aetheobdella Moore*Aetheobdella hirudoides* Moore

Aetheobdella hirudoides Moore, 1935b, p. 297, pl. 10, text-figs. 1-3.

Type material: Holotype BMNH, 1934.11.21.1, pond at Cambevarra, near Nowa, New South Wales, Australia, December 1930, F. A. Rodway collector.

Remarks: Whitman, 1886 (Quart. Journ. Micr. Sci., new ser., vol. 26, pp. 317-416) is followed here in the spelling of Hirudinidae, rather than the often used spelling of Hirudidae. According to Art. 29 and 29a of the "International Code of Zoological Nomenclature" (Intern. Trust Zool. Nomen., London, 1961), Hirudinidae is classically correct. The genitive singular of the type-genus *Hirudo* is "hirudin-is"—hence Hirudinidae. The correct spelling was kindly called to my attention by Roman Kenk, U.S. National Museum, to whom I am grateful.

Dinobdella Moore*Dinobdella notata* Moore

Whitmania sp.?—Moore, 1924c, p. 382, pl. 20 (figs. 15-18).

Dinobdella notata Moore, 1927, p. 185, 296, pl. 8 (figs. 34-35).

Type material: Holotype, ZSI W 1424/1, Kodaikanal, Palni Hills, South India, 6850 ft, August 1922, S. Kemp collector.

Diplobdella Moore*Diplobdella antellarum* Moore

Diplobdella antellarum Moore, 1901b, p. 219, pl. 13 (figs. 10-17).

Type material: No type material was found.

Type-locality: Puerto Rico.

Haemopsis gracilis Moore

Haemopsis gracilis Moore, 1930a, p. 40; 1930b, p. 186, pl. 8 (figs. 16–19).

Type material: Paratype, USNM 36332, Nanking, China, no. 12, C. Ping, collector, specimen (dissected). Paratypes, USNM 36333, Nanking, China, no. 9, C. Ping collector, 2 specimens (1 dissected). Paratypes, USNM 36334, Nanking, China, F. C. Zia collector, 2 specimens. Paratype, USNM 36335, Nanking, China, no. 4, F. C. Zia collector. Paratype, USNM 36336, Soochow, China, N. Gist Gee collector, specimen dissected.

Haemopsis plumbeus Moore

Haemopsis plumbeus Moore, 1921, p. 115, pl. 4 (figs. 29–31); 1918, p. 658.

Haemopsis plumbea Moore, 1959, p. 555.

Type material: No type material was found.

Type-locality: Minnesota.

Hirudinaria blanchardi Moore

Hirudinaria blanchardi Moore, 1901b, p. 214, pl. 12 (figs. 1–9).

Poecilobdella blanchardi.—Caballero, 1956, p. 283. [By implication.]

Type material: No type material was found.

Type-locality: Puerto Rico.

Hirudinaria javanica similis Moore

Hirudinaria javanica similis Moore, 1945b, p. 265, fig. 4.

Poecilobdella javanica similis.—Caballero, 1956, p. 283. [By implication.]

Type material: Holotype, USNM 20644, Yun Hsien, Yunnan Province, China, March 1943, W. J. Jellison collector. Paratypes, USNM 20645, Yun Hsien, Yunnan Province, China, March 1943, W. J. Jellison collector, 3 specimens (2 dissected).

Hirudinaria (Poecilobdella) viridis Moore

Hirudinaria (Poecilobdella) viridis Moore, 1927, p. 239, pl. 8 (figs. 31–33), text-figs. 57–58.

Poecilobdella viridis.—Caballero, 1956, p. 283. [By implication.]

Type material: Holotype, ZSI ZEV 3655/7, Shasthancottah, Travancore, Madras State, India, 300 ft, N. Annandale collector. Paratypes, USNM 36307, Shasthancottah, 12 miles NNE of Quilon, Travancore, Madras State, N. Annandale collector, 5 specimens (2 dissected).

Hirudo nipponia var. *fuscolineata* Moore

Hirudo nipponia var. *fuscolineata* Moore, 1924c, p. 373, pl. 21 (figs. 27-28).

Hirudo birmanica (Blanchard).—Moore, 1927, p. 192, pl. 8 (fig. 26), text-fig. 49.

Type material: No type material was found.

Type-locality: Madras Province, India.

Limnatis dissimulata Moore

Limnatis dissimulata Moore, 1938c, p. 65, pl. 6 (figs. 1-4).

Type material: Paratype, USNM 36354, Bukit Sagu, near Sungai Lembing, Pahang, Malay Peninsula, September 1935, M. W. F. Tweedie collector, specimen dissected. Paratype, USNM 36355, Bentong, Pahang, Malay Peninsula, July 1935, M. W. F. Tweedie collector.

Limnatis fenestrata Moore

Limnatis fenestrata Moore, 1939c, p. 343, pl. 27 (figs. 35-36, 43, 48), pl. 28 (fig. 56); 1958, p. 333.

Type material: Holotype, ANSP 4172, Botletle River near Lake Ngami, Bechuanaland, 1931, R. M. de Schauensee collector (specimen dissected). Paratypes, BMNH 1938.2.3.4/6, Northern Rhodesia, no. 15(1), Lake Young, Shiwa Ngandu, mouth of Mansya River, C. K. Ricardo collector, 1 specimen. Northern Rhodesia, no. (42/5), Mansya River, SE side of Lake Mansya, August 1936, C. K. Ricardo collector, 2 specimens.

Limnatis obscura Moore

Limnatis obscura Moore, 1939c, p. 341, pl. 27 (fig. 34), pl. 28 (figs. 54-55).

Type material: Holotype, BMNH 1938.2.3.3, Naukluft Mts. above Bullsport, South Africa, 1500 meters, December 1933, K. Jordan collector. Paratypes, BMNH 1938.2.3.1/2, Naukluft Mts. above Bullsport, South Africa, 1500 meters, December 1933, K. Jordan collector, 2 specimens.

Macrobdella ditetra Moore

Macrobdella ditetra Moore, 1936d, p. 502; 1953, p. 5, pl. 1 (figs. 2-3), text-fig. 1; 1959a, p. 553, text-fig. 23.8-b.—Meyer, 1959, p. 39.

Type material: Holotype, USNM 36345, marshes near New Orleans La., June 1916, H. E. Hubert collector. Paratypes, USNM 36346, marshes near New Orleans, La., June 1916, H. E. Hubert collector, 3 specimens (dissected). Paratypes, USNM 36347, under logs, border of pond, New Orleans, La., May and June, 1916, H. E. Hubert collector, 14 specimens (1 dissected). Paratype, USNM 36400, Washington, N.C., on the frog *Rana catesbiana*, 1934, B. B. Brandt collector, specimen sectioned (transverse).

Myxobdella africana Moore

Myxobdella africana Moore, 1939c, p. 326, pl. 26 (fig. 24), pl. 28 (fig. 51); 1958, p. 327, pl. 9 (figs. 17, 21).

Type material: Holotype, BMNH 1916.4.6.1, Nairobi, Kenya colony, January 1916.

Myxobdella maculata Moore

Myxobdella maculata Moore, 1938c, p. 328, pl. 27 (fig. 27), pl. 28 (fig. 50).

Type material: Holotype, AMNH 2579, Lang-Chapin Congo Expedition, Mopu, Belgian Congo, no. 705, January 1914.

Philobdella gracile Moore

Philobdella floridana.—Moore, 1898, p. 561. [Not Verrill, 1874.]

Philobdella gracile Moore, 1901a, p. 511, pl. 44 (figs. 12-21); 1918, p. 657, fig. 1005; 1959, p. 554, fig. 23.9.—Viosca, 1962, p. 243.

Type material: No type material was found.

Type-locality: New Orelans, La.

Praobdella radiata Moore

Praobdella radiata Moore, 1958, p. 328, pl. 9 (figs. 18-21).

Type material: Paratypes, USNM 36463, no. 9, Currey's Post, near Pietermaritzburg, Natal, March 1946, R. S. Crass collector, 4 young specimens (1 bisected midsagittally). Paratype, USNM 36427, Mount Gorgongozo, 1200 meters, on bush at waterfall, Portuguese East Africa, November 1957, Stuckenberger collector, young specimen (mounted).

Family HAEMADIPSIDAE

Chtonobdella parva Moore

Chtonobdella parva Moore, 1944b, p. 398, pl. 4 (fig. 6).

Type material: Holotype, BMNH 1934.3.6.30, Tatarii, W. Santo, New Hebrides, 4000 ft, November 1933, J. R. Baker collector.

Haemadipsa bilobata Moore

Haemadipsa bilobata Moore, 1946a, p. 181, figs. 1c-e, 3.

Type material: Holotype, BPBM R154, Ovalau, near Vuma, Fiji Islands, between 800 and 1000 ft, July 1938, E. C. Zimmerman collector.

Haemadipsa montana Moore

Haemadipsa montana Moore, 1927, p. 269, pl. 9 (figs. 38-40); 1932b, p. 1; 1935a, p. 121.

Type material: Holotype, ZSI W 1390/1, near Kukkal, Palni Hills, Madras, India, 5500-6500 ft, August 1922, S. Kemp collector. Para-

types, USNM 36318, near Kukkal, Palni Hills, Madras, India, 5500–6500 ft, August 1922, S. Kemp collector, 5 specimens (1 dissected). Paratype, UNSM 36395, Kukkal, Palni Hills, Madras, India, specimen sectioned (sagittal).

Haemadipsa ornata Moore

Haemadipsa ornata Moore, 1927, p. 284, pl. 5 (fig. 11), pl. 9 (fig. 42), text-fig. 63; 1932b, p. 2.

Type material: Holotype, ZSI ZEV 4875/7, Ghumti, Darjeeling District, India, 3000 ft, G. W. O'Brian collector. Paratypes, USNM 36319, Sonapur, Kamrup, Assam, India, L. W. Middleton collector, 5 specimens. Paratypes, USNM 36320, Assam, India, 2 specimens (have been dry).

Haemadipsa picta Moore

Haemadipsa picta Moore, 1929, p. 286, pl. 7 (figs. 10–12); 1935b, p. 303; 1938c, p. 71; 1944b, p. 386.

Type material: Holotype, USNM 36324, Mt. Matang [Mattang], West of Kuching, Sarawak, British Borneo, July, E. Mjöberg collector. Paratypes, USNM 36325, Mt. Matang [Mattang], west of Kuching, Sarawak, British Borneo, July, E. Mjöberg collector, 6 specimens (1 dissected). Paratype, USNM 36326, Mt. Dulit, Sarawak, British Borneo, 300 ft, E. Mjöberg collector. Paratypes, USNM 36327, Pamabo Range, Sarawak, British Borneo, October, E. Mjöberg collector, 2 specimens. Paratype, USNM 36328, Mt. Penrissen, Sarawak, British Borneo, 3000 ft, E. Mjöberg collector. Paratype, USNM 36329, Mt. Poi, Sarawak, British Borneo, 2000 ft, E. Mjöberg collector. Paratype, USNM 36330, Kalabit country, Sarawak, British Borneo, 3000 ft, E. Mjöberg collector.

Haemadipsa sylvestris interrupta Moore

Haemadipsa sylvestris interrupta Moore, 1935c, p. 70, pl. 6 (figs. 1–4); 1938c, p. 71; 1944, p. 387.

Type material: Paratypes, USNM 36341, Koh Chang, Thailand, in forest, June 1930, A. S. Pearse collector, 40 specimens. Paratypes, USNM 36342, Trengganu, North Malay Peninsula, 6 specimens. Paratypes, USNM 36343, Sungai Piah, Perak, March 1932, A. G. Billings collector, 18 specimens. Paratypes, USNM 36344, Kuala Legap, Plus Valley, Perak, March 1933, M. W. F. Tweedie collector, 21 specimens.

Haemadipsa zeylanica agilis Moore

Haemadipsa zeylanica agilis Moore, 1927, pp. 266, 298, pl. 4 (fig. 6).

Type material: Holotype, ZSI ZEV 4034/7, Shigadh, Naini Tal, India, 5500 ft, Paratypes, USNM 36311, Shigadh, Naina Tal, West

Himalayas, 5500 ft, 32 specimens (1 dissected). Paratype, USNM 36312, Almora, West Himalayas, August 1910. Paratypes, USNM 36313, Sariya Tal about 3 miles from Naina Tal, Kumaon Lakes, station 2, August 1920, B. Prashad collector, 3 specimens. Paratype, USNM 36314, Dhoni Forest, South Malabar, 1500-4000 ft, May 1923, E. Barnes collector. Paratypes, USNM 36315, Woodstock Gully, Landour, United Provinces, 7500 ft, H. G. Kribs collector, 6 specimens.

Haemadipsa zeylanica cochiniensis Moore

Haemadipsa zeylanica cochiniensis Moore, 1927, p. 265, pl. 9 (fig. 36); 1932b, p. 1.

Type material: Holotype, ZSI W 1453/1, Kavalai, Cochin State, India, September 1914, F. N. Gravely collector. Paratype, USNM 36308, Forest Tramway, mile 10-14, Cochin State, September 1914, F. N. Gravely collector. Paratypes, USNM 36309, Wilgiris, West slopes, 3500 ft. 1911, H. W. Andrews collector, 10 specimens. Paratypes, USNM 36310, Castle Rock, North Kanara district, Bombay, October 1916, S. Kemp collector, 4 specimens.

Haemadipsa zeylanica montivindicis Moore

Haemadipsa zeylanica montivindicis Moore, 1927, pp. 267, 298, pl. 5 (fig. 8), pl. 9 (fig. 37); 1932a, p. 701; 1932b, p. 1; 1935a, p. 119.

Type material: Holotype, ZSI ZEV 2268/7, Sureil, Darjeeling, India, 5000 ft, A. Alcock collector. Paratypes, USNM 36316, Sureil, Darjeeling, India, 5000 ft, 1905, A. Alcock collector, 16 specimens. Paratypes, USNM 36317, Sukli, E. side, Dawna Hills, 2100 ft, November 1911, F. H. Gravely collector, 3 specimens.

Remarks: *montivindicis* should read *montivindica*.

Haemadipsa zeylanica subagilis Moore

Haemadipsa zeylanica subagilis Moore, 1929, p. 279, pl. 7 (figs. 6-7); 1935c, p. 70.

Type material: Paratypes, USNM 36323, Mt. Penrissen [Penerissen], Sarawak, British Borneo, 3000 ft, E. Mjöberg collector, 2 specimens.

Phytobdella catenifera Moore

Phytobdella catenifera Moore, 1938c, p. 74, pl. 4 (fig. 6), pl. 5 (figs. 9-11); 1944b, p. 397.

Type material: Holotype, NSNM 36357, Gunong Pulai, Johore, Malay Peninsula, from the turtle *Testudo emys*, April 1934, M. W. F. Tweedie collector. Paratypes, USNM 36358, Gunong Pulai, Johore, Malay Peninsula, from *Testudo emys*, April 1934, M. W. F. Tweedie collector, 9 specimens (2 dissected). Paratype, USNM 36403, Gunong Pulai, Johore, Malay Peninsula, from *Testudo emys*, April 1934, M. W. F. Tweedie collector, specimen sectioned (transverse).

Phytobdella lineata Moore

Phytobdella lineata Moore, 1944b, p. 387, pl. 4 (figs. 2-3).

Type material: Holotype, BMNH 1940.12.7.2/5, Kakoda, Papua, New Guinea, 1200 ft, May 1933, L. E. Cheeseman collector. Paratypes, BMNH 1940.12.7.2/5, Kakoda, Papua, New Guinea, 1200 ft, May 1933, L. E. Cheeseman collector, 4 specimens. Paratypes, USNM 36368, Kakoda, Papua, New Guinea, 1200 ft, May 1933, L. E. Cheeseman collector, 2 specimens (1 dissected). Paratypes, USNM 36407, Kakoda, Papua, New Guinea, 1200 ft, May 1933, L. E. Cheeseman collector, 2 specimens sectioned (1 transverse, 1 sagittal).

Phytobdella maculosa Moore

Phytobdella maculosa Moore, 1944b, p. 392, pl. 4 (figs. 4-5).

Type material: Holotype, BMNH 1940.12.7.6/11, Mafulu, Papua, New Guinea, 4000 ft, no. 520, December 1931, L. E. Cheeseman collector. Paratypes, BMNH 1940.12.7.6/11, Mafulu, Papua, New Guinea, 4000 ft, no. 520, December 1931, L. E. Cheeseman collector. Paratypes, BMNH 1940.12.7.12/13, Mafulu, Papua, New Guinea, 4000 ft, no. 520, December 1931, L. E. Cheeseman collector [total of 8 paratypes in BMNH]. Paratypes, USNM 36367, Mafulu, Papua, New Guinea, 4000 ft, December 1933, L. E. Cheeseman collector, 2 specimens (1 dissected).

Tritetrabdella Moore*Tritetrabdella scandens* Moore

Tritetrabdella scandens Moore, 1938c, p. 72, pl. 5 (figs. 7-8).

Type material: Paratype, USNM 36356, Penang Hill [?Penang Island], April 1935, M. W. F. Tweedie collector, specimen sectioned (transverse).

Family ERPOBDELLIDAE

Barbronia delicata Moore

Barbronia delicata Moore, 1939c, p. 355, pl. 28 (fig. 62).

Type material: Holotype, BMNH 1930.9.15.7/9, Christy Tanganyika Expedition, Kapili, Lake Tanganyika, no. 450, October 1926. Paratypes, BMNH 1930.9.15.7/9, Christy Tanganyika Expedition, Kapili, Lake Tanganyika, no. 450, October 1926, 19 specimens. Paratypes, USNM 36366, Christy Tanganyika Expedition, Kapili, Lake Tanganyika, no. 450F, October 1926, 4 specimens: 3 mounted (2 slides), 1 sectioned (sagittal).

Remarks: Moore stated (p. 356) that there are 21 type-specimens.

But 24 type-specimens are present or accounted for: R. W. Sims confirmed the presence of 20 in the BMNH, and there are 4 in the USNM collection.

Dina anoculata Moore

Dina anoculata Moore, 1898, p. 558; 1918, p. 659; 1959, p. 556.

Dina (Dina) anoculata.—Soós, 1966b, p. 387.

Type material: Syntype, USNM 4844, San Diego County, California, O. R. Orcutt collector, specimen sectioned (sagittal).

Dina bucera Moore

Dina bucera Moore, 1949, p. 38; 1953, p. 9, pl. 1 (fig. 4), text-fig. 2.

Mooreobdella bucera.—Moore, 1959, p. 555.—Mann, 1962, p. 167.

Dina (Mooreobdella) bucera.—Soós, 1966b, p. 373.

Type material: Holotype, USNM 36370, permanent pond on Platt Road, 7.5 miles from Ann Arbor, Mich., April 1941, R. Kenk collector. Paratypes, USNM 36371, permanent pond on Platt Road, 7.5 miles from Ann Arbor, Mich., April 1941, R. Kenk collector, 2 specimens (1 dissected). Paratypes, USNM 36372, temporary pond on W side of U. S. Highway 23, about 5.5 miles SE of Ann Arbor, Mich., April 1941, R. Kenk collector, 11 specimens. Paratypes, USNM 36373, temporary pond on W side of U.S. Highway 23 about 5.5 miles SE of Ann Arbor, Mich., December 1941, R. Kenk collector, 4 specimens. Paratypes, USNM 36374, temporary pond on W side of U.S. Highway 23, about 5.5 miles SE of Ann Arbor, Mich., May 1941, R. Kenk collector, 14 specimens. Paratype, USNM 36375, permanent pond on E side of Platt Road about 7.5 miles SSE of Ann Arbor, Mich., May 1941, R. Kenk collector.

Dina dubia Moore and Meyer

Dina dubia Moore and Meyer, 1951, p. 70, pl. 9 (figs. 6-7).—Moore, 1959, p. 556.

Dina dubia Moore [sic].—Oliver, 1958, p. 163.

Dina (Dina) dubia.—Soós, 1966b, p. 387.

Type material: No type material was found.

Type-locality: Outpost Island, Great Slave Lake, Northwest Territories, Canada, in shallow water.

Dina microstoma Moore

Dina microstoma Moore, 1901a, p. 537, pl. 47 (fig. 37); 1906, p. 163; 1908, p. 200; 1918, p. 659; 1936c, p. 114.—Soós, 1963, p. 259.

Erpobdella (Mooreobdella) microstoma.—Pawlowski, 1955, p. 5.

Mooreobdella microstoma.—Moore, 1959, p. 555.—Mann, 1962, p. 167.

Dina (Mooreobdella) microstoma.—Soós, 1966b, p. 389.

Type material: No type material was found.

Type-locality: Illinois.

Dina parva Moore

Dina parva Moore, 1912, p. 125, pl. 5 (figs. 33-34), pl. 6 (figs. 41-43); 1918, p. 659; 1920, p. 95; 1922, p. 39; 1924, p. 30; 1936c, p. 114; 1959, p. 556.
Dina (Dina) parva.—Soós, 1966b, p. 388.

Type material: No type material was found.

Type-locality: Minnesota.

Erpobdella punctata annulata Moore

Erpobdella punctata annulata Moore, 1922, p. 38; 1959, p. 556.

Type material: No type material was found.

Type-locality: Ucluelet, Vancouver Island, British Columbia, June 1909.

Dina quaternaria Moore

Dina quaternaria Moore, 1930a, p. 40; 1930b, p. 181, pl. 8 (figs. 13-15).

Erpobdella quaternaria.—Soós, 1966b, p. 393.

Type material: Paratypes, USNM 36331, Soochow, China, 1925, N. Gist Gee collector, 7 specimens.

Erpobdella triannulata Moore

Erpobdella triannulata Moore, 1908, p. 199; 1936a, p. 43.

Type material: Holotype, ANSP 2389, Lake Amatitlan, NW end, near Hotel Laguna, Guatemala, under rocks, January 1906, S. E. Meek collector. Paratypes, ANSP 2390, Lake Amatitlan, NW end, near Hotel Laguna, Guatemala, under rocks, January 1906, S. E. Meek collector, 112 specimens (some dissected).

Gastrostomobdella Moore*Gastrostomobdella monticola* Moore

Gastrostomobdella monticola Moore, 1929, p. 270, pl. 7 (figs. 1-5); 1935c, p. 77; 1946, p. 180.

Type material: Paratypes, USNM 36321, Mt. Poi [Poe or Poeh], W of Kuching, 5000 ft, Sarawak, British Borneo, June 1927, E. Mjöberg collector, 2 specimens. Paratypes, USNM 36322, Head Camp, Sarawak, British Borneo, E. Mjöberg collector, 2 specimens. Paratype, USNM 36397, Mt. Poi, W of Kuching, 5000 ft, Sarawak, British Borneo, specimen mounted. Paratype, USNM 36396, Head Camp, Sarawak, British Borneo, specimen sectioned (transverse).

Gastrostomobdella quinqueannulata Moore

Gastrostomobdella quinqueannulata Moore, 1946a, p. 177, figs. 1a, b; 2a, d.

Type material: Holotype, USNM 21127, Punaluu, Hawaii, March

1930, O. Degener and Y. Iwasski collectors. Paratype, USNM 36369, Punaluu, Hawaii, March 1930, O. Degener and Y. Iwasski collectors.

Remarks: Moore (p. 180) gives 110/400 as the USNM number. This is the accession, not the catalog number.

Gastrostomobdella vagabunda Moore

Gastrostomobdella vagabunda Moore, 1935c, p. 72, pl. 7 (figs. 6-7); 1946, p. 180.

Type material: Paratypes, USNM 36398, Plus Valley, Perak, Malay Peninsula, March 1933, 2 specimens mounted (1 slide). Paratypes, USNM 36399, Plus Valley, Perak, Malay Peninsula, March 1933, 2 specimens sectioned (transverse).

Mimobdella africana Moore

Mimobdella africana Moore, 1939c, p. 356, pl. 27 (figs. 39-40).

Type material: Holotype, BMNH 1938.3.3.2, Mbula Island, Lake Tanganyika, Northern Rhodesia, no. 415, February 1937, C. K. Ricardo collector.

Salifa elongata Moore

Salifa elongata Moore, 1939c, p. 351, pl. 27 (fig. 37).

Type material: Holotype, BMNH 1930.9.15.63, Christy Tanganyika Expedition, Kirando, Kapili Bay, Lake Tanganyika, March 1926. Paratypes, BMNH 1930.9.15.17/18, Christy Tanganyika Expedition, Kirando, Kapili Bay, Lake Tanganyika, 2 specimens. Paratype, USNM 36365, Christy Tanganyika Expedition, Kirando, Lake Tanganyika, no. 454, March 1926, 1 specimen (in 2 pieces). Paratypes, USNM 36404, Christy Tanganyika Expedition, Kirando, Kapili Bay, Lake Tanganyika, no. 453 4F, November 1926, 2 specimens (1 mounted, in 2 pieces; 1 sectioned, sagittal). Paratype, USNM 36405, Christy Tanganyika Expedition, Kirando, Lake Tanganyika, no. 452 F, February 1926, 1 specimen sectioned (anterior end sagittal, middle region transverse).

Family DIESTECOSTOMIDAE

Diestecostoma magna Moore

Diestecostoma magna Moore, 1945b, p. 261, figs. 1-3.

Diestecostoma magnum.—Soós, 1966a, p. 157.

Type material: Holotype, USNM 20642, Rio de los Playas, headwaters of Tonalá River, between Veracruz and Chiapas, Mexico, March 1944, M. W. Stirling collector. Paratype, USNM 20643, Tehuantepec, Mexico, F. E. Sumichrast collector.

Diestecostoma octannulata Moore

Diestecostoma octannulata Moore, 1946a, p. 184, figs. 1f-h, 2e-g, 4.

Diestecostoma octoannulatum.—Soós, 1966a, p. 157.

Type material: No type material was found.

Type-locality: Volcana Tajumulco, Guatemala, under stone at 12,500–13,000 ft.

Remarks: *octoannulatum* should read *octannulatum*.

Name Changes

| <i>original name</i> | <i>current name</i> |
|---|--|
| <i>Dina bucera</i> Moore, 1949 | <i>Mooreobdella bucera</i> (Moore) Moore, 1959 |
| <i>Dina microstoma</i> Moore, 1901 | <i>Mooreobdella microstoma</i> (Moore) Moore, 1959 |
| <i>Glossiphonia conifera</i> Moore, 1933 | <i>Helobdella conifera</i> (Moore) Autrum, 1936 |
| <i>Glossiphonia duplicata</i> Moore, 1911 | <i>Helobdella duplicata</i> (Moore) Autrum, 1936 |
| <i>Glossiphonia simplex</i> Moore, 1911 | <i>Helobdella simplex</i> (Moore) Autrum, 1936 |
| <i>Glossiphonia (Helobdella) nuda</i> Moore, 1924 | <i>Helobdella nuda</i> (Moore) Moore, 1930 |
| <i>Hirudinaria blanchardi</i> Moore, 1901 | <i>Poecilobdella blanchardi</i> (Moore) Caballero, 1956 [by implication] |
| <i>Hirudinaria javanica similis</i> Moore, 1945 | <i>Poecilobdella javanica similis</i> (Moore) Caballero, 1956 [by implication] |
| <i>Hirudinaria (Poecilobdella) viridis</i> Moore, 1927 | <i>Poecilobdella viridis</i> (Moore) Caballero, 1956 [by implication] |
| <i>Hirudo nipponia</i> var. <i>fuscolineata</i> Moore, 1924 | <i>Hirudo birmanica</i> (Blanchard) Moore, 1927 |
| <i>Microbdella biannulata</i> Moore, 1900 | <i>Oligobdella biannulata</i> (Moore) Moore, 1918 |
| <i>Placobdella mexicana</i> Moore, 1898 | <i>Haementeria (Placobdella) moorei</i> Autrum, 1936 |
| <i>Placobdella montifera</i> Moore, 1906 | <i>Haementeria (Placobdella) montifera</i> (Moore) Autrum, 1936 |
| <i>Placobdella quadrioculata</i> Moore, 1930 | <i>Haementeria (Placobdella) quadrioculata</i> (Moore) Autrum, 1936 |
| <i>Pontobdella biannulata</i> Moore, 1957 | <i>Stibarobdella biannulata</i> (Moore) Llewellyn, 1966 |
| <i>Protoclepsine sexoculata</i> Moore, 1898 | <i>Theromyzon sexoculatum</i> (Moore) Autrum, 1936 |

Remarks: I here follow Moore (1959) and Mann (1962) in raising *Mooreobdella* Pawlowski to generic rank and assigning to it those Erpobdellidae species (p. 23), which Moore originally placed in *Dina* R. Blanchard, characterized by having annulus b6 of complete segments distinctly enlarged and subdivided, and ejaculatory ducts without preatrial loops.

Publications by Moore on HIRUDINEA with Taxa Described

1898. Leeches of the U.S. National Museum. Proc. U.S. Nat. Mus., vol. 21, no. 1160, pp. 543-563, pl. 40. [*Protolepsine*, *Protolepsine secoculata*, *Placobdella mexicana*, *Trachelobdella maculata*, *Trachelobdella rugosa*, *Pisciola zebra*, *Dina anoculata*.]
- 1900a. A description of *Microbdella biannulata* with especial regard to the constitution of the leech somite. Proc. Acad. Nat. Sci. Philadelphia, vol. 52, pp. 50-73, pl. 6. [*Microbdella*, *Microbdella biannulata*.]
- 1900b. Note on Oka's biannulate leech. Zool. Anz., vol. 23, pp. 474-477, 1 fig.
- 1901a. The Hirudinea of Illinois. Bull. Illinois State Lab. Nat. Hist., vol. 5, pp. 479-547, pls. 42-47. [*Actinobdella*, *Actinobdella inequiannulata*, *Philobdella gracile*, *Dina microstoma*.]
- 1901b. Descriptions of two new leeches from Porto Rico. Bull. U. S. Fish Comm., vol. 2, pp. 211-222, pls. 12-13. [*Hirudinaria blanchardi*, *Diplobdella*, *Diplobdella antellarum*.]
1906. Hirudinea and Oligochaeta collected in the Great Lakes region. Bull. Bur. Fish., vol. 25, pp. 153-171, pl. 32; 2 figs. [*Actinobdella annectens*; *Placobdella montifera*.]
1908. The leeches of Lake Amatitlan. In Meek, The zoology of Lakes Amatitlan and Atitlan, Guatemala, with special reference to ichthyology. Field Columbian Mus., Zool. Ser., vol. 7, pp. 199-201. [*Erpobdella triannulata*.]
1910. *Platybdella chilensis*, sp. nov. Rev. Chilean Hist. Nat., vol. 14, pp. 29-30. [*Platybdella chilensis*.]
1911. Hirudinea of southern Patagonia. Repts. Princeton Univ. Exped. to Patagonia, 1896-1899, vol. 3, pp. 669-689, pls. 49-50. [*Glossiphonia duplicata*, *Glossiphonia simplex*.]
1912. Classification of the leeches of Minnesota. In The leeches of Minnesota. Geol. Nat. Hist. Surv. Minnesota, Zool. Ser. no. 5, pt. 3, pp. 63-150, pls. 1-6. [*Haemopsis plumbeus*, *Dina parva*.]
1918. The leeches (Hirudinea). In Ward and Shiple, Fresh-water biology, pp. 646-660, 14 figs. New York, N.Y.: John Wiley and Sons. [*Oligobdella* nom. nov. for *Microbdella* Moore 1900.]
1920. The leeches of Lake Maxinkuckee. In Evermann and Clark, Lake Maxinkuckee: A physical and biological survey, vol. 2, pp. 87-95. Dept. Conserv., State of Indiana.
1921. Hirudinea: Annelids, parasitic worms, protozoans, etc. Rept. Canadian Arctic Exped. 1913-18 Ottawa, vol. 9, pt. C, 4 pp.
1922. The fresh-water leeches (Hirudinea) of southern Canada. Canadian Field Natur., vol. 36, pp. 6-11, 37-39. [*Erpobdella punctata annulata*.]
1923. The control of blood-sucking leeches, with an account of the leeches of Palisades Interstate Park. Roosevelt Wild Life Bull., vol. 2, no. 1, pp. 7-53, pl. 1, 17 figs.
- 1924a. The leeches (Hirudinea) of Lake Nipigon. Univ. Toronto Stud., Publ. Ontario Fish. Res. Lab., no. 23, pp. 17-31, 1 fig. [*Actinobdella triannulata*.]
- 1924b. The anatomy and systematic position of the Chilean terrestrial leech, *Cardea valdiviana* (Philippi). Proc. Acad. Nat. Sci. Philadelphia, vol. 76, pp. 29-48, pl. 3.

- 1924c. Notes on some Asiatic leeches (Hirudinea) principally from China, Kashmir, and British India. Proc. Acad. Nat. Sci. Philadelphia, vol. 76, pp. 343-388, pls. 19-21. [*Trachelobdella okae*, *Glossiphonia* (*Helobdella*) *nuda*, *Hemiclepsis marginata asiatica*, *Hirudo nipponia* var. *fuscolineata*.]
1927. The segmentation (metamerism and annulation) of the Hirudinea: Arhynchobdellae. In Harding and Moore, The fauna of British India: Hirudinea, pp. 1-12, 97-302, pls. 1, 3-9, 25 figs. London. [*Dinobdella*, *Dinobdella notata*, *Hirudinaria* (*Poecilobdella*) *viridis*, *Haemadipsa zeylanica cochiniensis*, *Haemadipsa zeylanica agilis*, *Haemadipsa zeylanica montivindicis*, *Haemadipsa montana*, *Haemadipsa ornata*.]
1929. Leeches from Borneo with descriptions of new species. Proc. Acad. Nat. Sci. Philadelphia, vol. 81, pp. 267-295, pl. 7, 3 figs. [*Gastrostomobdella*, *Gastrostomobdella monticola*, *Haemadipsa zeylanica subagilis*, *Haemadipsa picta*.]
- 1930a. The leeches (Hirudinea) of China. Peking Soc. Nat. Hist. Bull. 1929-1930, vol. 4, pt. 3, pp. 39-43. [*Dina quaternaria*, *Haemopsis gracilis*.]
- 1930b. Leeches (Hirudinea) from China with descriptions of new species. Proc. Acad. Nat. Sci. Philadelphia, vol. 82, pp. 169-192, pls. 7-8, 1 fig. [*Glossiphonia lata multipapillata*, *Placobdella quadrioculata*.]
- 1931a. The life of the Darjeeling land leech. Journ. Darjeeling Nat. Hist. Soc., vol. 5, pp. 106-117.
- 1931b. A remarkable South American leech. Actas Congr. Arch. Soc. Biol. Montevideo, suppl., vol. 5, pp. 1220-1225.
- 1932a. How abundant are land leeches? Journ. Bombay Nat. Hist. Soc., vol. 35, pp. 701-702.
- 1932b. Land leeches in the "Fauna of British India"—Some corrections. Rec. Indian Mus., vol. 34, pt. 1, pp. 1-6.
- 1932c. Leeches and planarians compared. Journ. Darjeeling Nat. Hist. Soc., vol. 7, pp. 61-67.
1933. Leeches. In Scientific results of the Cambridge Expedition to the East African Lakes, 1930-1. Journ. Linnean Soc., vol. 38, pp. 297-299. [*Glossiphonia conifera*.]
- 1935a. More about land leeches: How abundant are they? Journ. Darjeeling Nat. Hist. Soc., vol. 9, pp. 116-124.
- 1935b. A description of *Aetheobdella hirudooides* gen. et sp. n., from New South Wales, with notes on leeches collected by the Oxford University Sarawak Expedition. Ann. Mag. Nat. Hist., ser. 10, vol. 16, pp. 296-304, pl. 10, 3 figs. [*Aetheobdella*, *Aetheobdella hirudooides*.]
- 1935c. Leeches from Borneo and the Malay peninsula. Bull. Raffles Mus., no. 10, pp. 67-79, pls. 6-7. [*Haemadipsa sylvestris interrupta*, *Gastrostomobdella vagabunda*.]
- 1936a. Hirudinea from Yucatan. Carnegie Inst. Washington, no. 457, pp. 41-43.
- 1936b. Report on Hirudinea. In Yale North Indian Expedition. Mem. Connecticut Acad. Arts. Sci., vol. 10, art. 11, pp. 191-192.
- 1936c. The leeches of Lake Nipissing. Canadian Field-Natur., vol. 50, pp. 112-114.
- 1936d. *Macrobdella ditetra*. In Brandt, Parasites of certain North Carolina Salientia. Ecol. Monogr., vol. 6, pp. 491-532. [*Macrobdella ditetra*.]

1937. Laboratory care of leeches. *In* Galtsoff, Lutz, Welch, and Needham, Culture methods for invertebrate animals, pp. 201-204. Ithaca, N.Y.
- 1938a. Leeches. *In* Australasian Antarctic Expedition, 1911-1914. Sci. Rept., ser. C, vol. 10, pt. 3, pp. 1-15, pl. 1, 1 fig. [*Pontobdella rugosa*, *Oxytostoma varituberculata*.]
- 1938b. Leeches (Hirudinea) from Yucatan caves. Carnegie Inst. Washington, no. 491, pp. 67-70, 2 figs. [*Glossiphonia magnidiscus*.]
- 1938c. Leeches (Hirudinea) principally from the Malay Peninsula, with descriptions of new species. Bull. Raffles Mus., no. 14, pp. 64-80, pls. 4-5. [*Limnatis dissimulata*, *Tritetrabdella*, *Tritetrabdella scandens*, *Phytobdella catenifera*.]
- 1939a. Leeches (Hirudinea) from the Atlas Mountains of Morocco. Ann. Mag. Nat. Hist., ser. 11, vol. 3, pp. 80-87.
- 1939b. *Helobdella punctato-lineata*, a new leech from Puerto Rico. Puerto Rico Journ. Hyg. Trop. Med., vol. 14, pp. 422-429, 2 figs. [*Helobdella punctato-lineata*.]
- 1939c. Additions to our knowledge of African leeches (Hirudinea). Proc. Acad. Nat. Sci. Philadelphia, vol. 90, pp. 297-360, pls. 25-28, 1 fig. [*Glossiphonia disjuncta*, *Batracobdella quadrata*, *Placobdella* (*Parabdella*) *aspera*, *Placobdella pulchra*, *Placobdella auroguttata*, *Phyllobdella*, *Phyllobdella maculata*, *Myxobdella africana*, *Myxobdella maculata*, *Limnatis obscura*, *Limnatis fenestrata*, *Salifa elongata*, *Barbronia delicata*, *Mimobdella africana*.]
1940. *Austrobdella anoculata*, a new species of fish leech from Greenland. Journ. Washington Acad. Sci., vol. 30, pp. 520-524, 4 figs. [*Austrobdella anoculata*.]
- 1944a. The leeches (Hirudinea) of Lake Huleh, Palestine. Ann. Mag. Nat. Hist., ser. 11, vol. 11, pp. 182-190.
- 1944b. Leeches in the British Museum, mostly Haemadipsinae from the South Pacific with descriptions of new species. Ann. Mag. Nat. Hist., ser. 11, vol. 11, pp. 383-409, pl. 4. [*Phytobdella lineata*, *Phytobdella maculosa*, *Chtonobdella parva*.]
- 1945a. A water-squirting Indian leech. Journ. Bengal Nat. Hist. Soc., vol. 20, pp. 16-19.
- 1945b. Two new leeches (Hirudinea) in the collection of the United States National Museum. Journ. Washington Acad. Sci., vol. 35, pp. 261-265, 4 figs. [*Diestecostoma magna*, *Hirudinaria javanica similis*.]
- 1946a. Leeches (Hirudinea) from the Hawaiian Islands, and two new species from the Pacific region in the Bishop Museum collection. Occ. Pap. Bernice P. Bishop Mus., vol. 18, no. 11, pp. 171-191, 4 figs. [*Gastrostomobdella quinqueannulata*, *Haemadipsa bilobata*, *Diestecostoma octannulata*.]
- 1946b. The anatomy and systematic position of *Myzobdella lugubris* Leidy (Hirudinea). Notulae Naturae Acad. Nat. Sci. Philadelphia, no. 184, pp. 1-12, 3 figs.
1949. Hirudinea. Pp. 38-39 *in* R. Kenk, The animal life of temporary and permanent ponds in southern Michigan. Misc. Publ. Mus. Zool., Univ. Michigan, no. 71, pp. 1-66. [*Dina buccera*.]
1951. [and Meyer, M. C.] Leeches (Hirudinea) from Alaskan and adjacent waters. Wasmann Journ. Biol., vol. 9, pp. 11-77, pls. 1-11. [*Dina dubia*, *Notostomobdella* nom. nov. for *Notostomum* Levinsen 1882, *Ottoniobdella* nom. nov. for *Ottonia* Malm 1874.]

- 1952a. New Piscicolidae (leeches) from the Pacific and their anatomy. Occ. Pap. Bernice P. Bishop Mus., vol. 21, no. 2, pp. 17-44, 9 figs. [*Marsipobdella*, *Marsipobdella sacculata*, *Johanssonia abditovesiculata*, *Branchelion lobata*.]
- 1952b. Professor A. E. Verrill's fresh-water leeches - A tribute and a critique. Notulae Naturae Acad. Nat. Sci. Philadelphia, no. 245, pp. 1-15, 7 figs. [*Helobdella papillata*.]
1953. Three undescribed North American leeches (Hirudinea). Notulae Naturae Acad. Nat. Sci. Philadelphia, no. 250, pp. 1-13, pl. 1, 2 figs. [*Placobdella multilineata*.]
1954. [With Meyer, M. C.] Notes on Canadian leeches (Hirudinea), with the description of a new species. Wasmann Journ. Biol., vol. 12, pp. 63-96, pls. 1-2. [*Oculobdella lucida* Moore.]
1955. [With Meyer, M. C., eds.] Études morphologiques et systématiques sur les Hirudinées, I: L'Organisation des Ichthyobdellides, by W. D. Selensky, 1915, viii + 256 pp. [English translation from Russian; published by editors.]
1957. Hirudinea. BANZ Antarctic Research Expedition, 1929-1931, ser. B, vol. 6, pt. 6, pp. 99-105, 2 figs. [*Pontobdella biannulata*, *Trachelobdellina*, *Trachelobdellina glabra*.]
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BREDIN-ARCHBOLD-SMITHSONIAN
BIOLOGICAL SURVEY OF DOMINICA ¹

9. The Trichoptera (Caddisflies) of the Lesser Antilles

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The Trichoptera or caddisflies are one of the panorpoid orders of insects closely related to the Mecoptera and Lepidoptera. The adults are quite mothlike in appearance, but their wings are generally covered with hairs rather than scales as in the Lepidoptera. They are holometabolous with their larval and pupal stages aquatic or, in a few cases, subaquatic or terrestrial. The larvae are most frequently noticed because of their habit of constructing some sort of shelter, which in certain families is a basically tubular case that encloses most of the body and that is carried around by the larvae as they wander over the substrate. The larvae of other families construct silken retreats that are fixed to the substrate and that serve to trap food particles from the flowing water.

The trichopterous fauna of the Lesser Antilles has been almost completely ignored in the past by systematists. *Polycentropus insularis* Banks, 1938, from Grenada, is the only species described from these

¹ See list at end of paper. Other faunal studies in this series will appear in "Smithsonian Contributions to Zoology." A companion series on the flora appears in "Contributions from the United States National Herbarium" and "Smithsonian Contributions to Botany."

islands, and the only other record that has been found is for *Leptonema albovirens* (Walker) from St. Vincent (Mosely, 1933). Including these two old records with the results of the present study, we now know 3 species from Guadeloupe, 36 from Dominica, 11 from St. Lucia, 1 from St. Vincent, and 12 from Grenada. These numbers may be compared with those reported for the Greater Antilles (Flint, 1968a): 24 on Cuba, 18 on Hispaniola, 39 on Jamaica, and 35 on Puerto Rico.

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My trip to Dominica, St. Lucia, and Grenada in 1963, which resulted in the only material available from the latter two islands, was made possible by grant J-481 from the American Philosophical Society. I wish to acknowledge the help received on St. Lucia from Jason Cadet in the field and from Harold F. C. Simmons in making the necessary arrangements.

I am indebted to André D. Pizzini for the figures of the cases and habitus drawings of the larvae.

DISTRIBUTION.—One of the problems frequently faced by insect zoogeographers is the one caused by lack of adequate collecting. This results in species with enigmatic relationships because the related species have not been collected or in misleading distribution because the range is only partially known. Enough has become known, however, about the Caribbean Trichoptera in recent years so that certain general patterns can be discerned. In the following paragraphs I will attempt to point out what these patterns seem to be for the Trichoptera, with the clear understanding that additional collecting will undoubtedly require changes in certain particulars.

The majority of the Trichoptera found on the Antilles appear to be limited to these islands and, in fact, endemic to a specific island. Of the total of 45 species that are found on the Lesser Antilles, only 6 are known from the mainland as well; an additional 13 species are also found on two or more Antillean islands, leaving 26 which are known from only one Lesser Antillean island.

There seem to be three basic patterns of distribution evident in the Lesser Antillean Trichoptera. The first (map 1) is shown by *Oxyethira janella* Denning, *O. tega* Flint, *O. cirrifera* Flint, *Neotrichia*



MAP 1.—Probable distribution of *Oxyethira janella* Denning (x=records).



MAP 2.—Probable distribution of *Leptonema albovirens* (Walker) (x=records).

iridescens Flint, *Ochrotrichia spinosissima* Flint, and *Oecetis pratti* Denning. These are distributed over the Greater and Lesser Antillean islands and may also be found on some of the adjacent mainland areas. The second pattern (map 2) is shown by *Wormaldia planae* Ross, *Chimarra caribea*, new species, *Leptonema albovirens* (Walker), *Leucotrichia sarita* Ross, and *Oxyethira azteca* (Mosely). This pattern shows a rather wide mainland distribution, generally from Mexico to Trinidad, and includes Grenada and, in the case of *L. albovirens*, St. Vincent also. The third pattern is shown by the remainder of the species that are endemic to one or more of the Lesser Antillean islands.

Although the origin of the Lesser Antillean fauna is not absolutely clear, there does seem to be overwhelming evidence that there is a major difference in the composition of the Trichoptera fauna of the Greater and Lesser Antilles in spite of a few elements in common (those representatives of "pattern 1"). The following genera or groups of species are all found on the Greater Antilles but are lacking on the Lesser: *Atopsyche*, *Cariboptila*, *Campsiophora*, *Chimarra* (*Curgia*), the *Polycentropus nigriceps* group, *Antillopsyche*, the *Smicridea comma* group, *Hydropsyche*, *Macronema*, *Leptocella*, *Marilia*, and the *Phylloicus cubana* group. The alternative of genera or species groups present on the Lesser Antilles but not on the Greater is also true: *Protoptila*, *Polyplectropus*, the *Chimarra caribea* group, *Zumatrichia*, *Bredinia*, the *Smicridea nigripennis* group, *Atanatolica*, *Brachysetodes*, and the *Phylloicus lituratus* group.

There is only a little evidence concerning the actual source for the colonization of the Lesser Antilles. In the majority of cases the genera or species groups are found throughout South and Central America, but for unknown reasons they have managed to colonize only one group of islands or the other. In a few cases, however (the *Chimarra caribea* group, *Atanatolica*, *Brachysetodes*, and the *Phylloicus lituratus* group), all the related species are found in South America and southern Central America. In these cases at least, their ancestors probably came from northern South America. In fact, the second distribution pattern (Grenada and adjacent mainland) may well represent an incipient stage in the introduction of species into the Lesser Antilles from adjacent South America.

TAXONOMY.—The following keys to families were published in Flint (1964b) and were modified from Ross (1944). Designed for use with the Antillean fauna only, they use obvious external characters whenever possible. No specific determination should ever be considered definite until the genitalia have been compared with, and found identical to, the figures for the species under consideration. The families Rhyacophilidae and Odontoceridae have not been taken on the Lesser Antilles, but they are included in the keys because of their presence on the Greater Antilles.

Key to Families

LARVAE

1. Pro-, meso-, and metanotum covered by sclerotized plates 2
- Meso- and metanotum either membranous or only partially covered . . . 3
2. Abdomen with many branched gills HYDROPSYCHIDAE
- Abdomen without gills HYDROPTILIDAE
3. Anal proleg projecting ventrad at right angles to the body axis; inhabiting a case made of sand grains in the shape of a turtle's shell . GLOSSOSOMATIDAE
- Anal proleg extending in axis of body, or fused to last segment; either free-living, or in a differently shaped case 4
4. Anal proleg extending freely from the abdomen; either free-living, or in a fixed silken retreat 5
- Anal proleg fused to apex of abdomen, claw only free; in a freely movable house 7
5. Ninth abdominal tergum with a sclerite; free-living . . . RHYACOPHILIDAE
- Ninth segment membranous dorsally; in a fixed retreat 6
6. Labrum membranous, with anterior margin expanded laterally (T-shaped).
PHILOPOTAMIDAE
- Labrum sclerotized, roughly semicircular PSYCHOMYIIDAE
7. Labrum with a transverse row of about 20 setae dorsally; in a flat case of leaf fragments CALAMOCERATIDAE
- Labrum with about 6 erect setae dorsally 8
8. Anal claw with a series of teeth, comblike; case coiled like a snail shell . . .
HELICOPSYCHIDAE
- Anal claw with a single tooth; case tubular 9
9. Antenna about 8 times as long as broad, arising near base of mandibles . .
LEPTOCERIDAE
- Antenna practically invisible, barely longer than broad . . ODONTOCERIDAE

PUPAE

1. Apex of abdomen with projecting, finger-like processes 5
- Apex of abdomen without long processes, with only the lobes containing developing genitalia 2
2. Mandibles with inner margin smooth HYDROPTILIDAE
- Mandibles with teeth or large serrations on inner margin 3
3. Mandibles with serrations along inner margin RHYACOPHILIDAE
- Mandible with 1 or 2 large teeth in addition to serrations 4
4. Mandible with a single large tooth on inner margin . . GLOSSOSOMATIDAE
- Mandible with 2 teeth on inner margin PHILOPOTAMIDAE
5. Third and/or fourth abdominal segments bearing hook-plates posteriorly . .
HYDROPSYCHIDAE
- Only the fifth segment bearing a hook-plate posteriorly 6
6. Seventh segment without hook-plates anteriorly 7
- Seventh segment with hook-plates anteriorly 8
7. Apical processes tipped with hairs as long as processes . HELICOPSYCHIDAE
- Apical processes either without hairs or they are much shorter than processes LEPTOCERIDAE
8. Lateral line of setae lacking on abdomen PSYCHOMYIIDAE
- Lateral line of setae well developed 9
9. Dorsum of abdomen with transverse brushes of setae . . CALAMOCERATIDAE
- Dorsum of abdomen without heavy brushes of setae . . . ODONTOCERIDAE

ADULTS

- | | | |
|----|---|------------------|
| 1. | Mesoscutellum with posterior portion forming a triangular, flat area with a vertical posterior margin; forewing length 4 mm or less | HYDROPTILIDAE |
| | Mesoscutellum rounded, without vertical margins; forewing length 3 mm or more | 2 |
| 2. | Ocelli present | 3 |
| | Ocelli absent | 5 |
| 3. | Maxillary palpi with fifth segment 2 or 3 times as long as fourth | |
| | Maxillary palpi with fifth segment barely longer than fourth | PHILOPOTAMIDAE 4 |
| 4. | Foretibia with apical spur prominent | RHYACOPHILIDAE |
| | Foretibia with apical spur absent or hairlike | GLOSSOSOMATIDAE |
| 5. | Mittitibia with preapical spur | 6 |
| | Mittitibia without preapical spur | 9 |
| 6. | Terminal segment of maxillary palpi elongate, and generally with suture-like cross striae | 7 |
| | Terminal segment of palpi about same length as preceding segment, without cross striae | 8 |
| 7. | Mesoscutum with a pair of small setal warts; foretibia often with a preapical spur | PSYCHOMYIIDAE |
| | Mesoscutum without setal warts; foretibia never with a preapical spur | HYDROPSYCHIDAE |
| 8. | Antennae much longer than wings | LEPTOCERIDAE |
| | Antennae about length of forewings | HELICOPSYCHIDAE |
| 9. | Mesoscutellum small and rectangular | CALAMOCERATIDAE |
| | Mesoscutellum large and domelike | ODONTOCERIDAE |

Family GLOSSOSOMATIDAE

Although the family is found over most of the world, the Protoptilinae, to which all the antillean species belong, is exclusively of New World distribution. The two genera known from the Greater Antilles seem to belong to a different section of the subfamily from where *Protoptila* belongs.

The larvae of the family all construct cases of small sand grains shaped like a turtle's shell. At pupation the ventral strap is cut away and the domelike dorsal covering is firmly anchored to the substrate, usually a rock, and a separate silken inner cocoon is spun to enclose the pupa.

Genus *Protoptila* Banks

Protoptila Banks, 1904, p. 215. [Type-species: *Beraca? maculata* Hagen, 1861, by original designation.]

The genus *Protoptila*, which contains many species and is found throughout the New World, is here recorded from the Antilles for the first time.

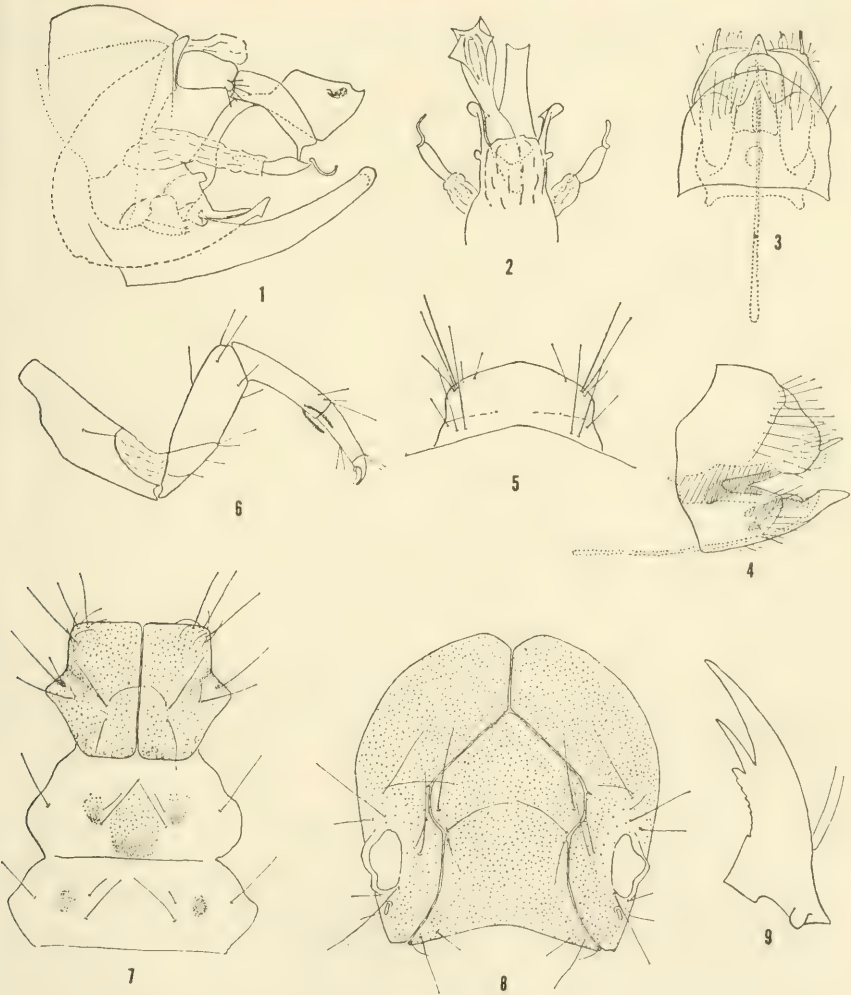
Preliminary descriptions of the larvae have been given by Ross (1944) and Flint (1963). The immature stages of the species described herein agree structurally with the other known species of the genus.

Prooptila dominicensis, new species

FIGURES 1-9

This species is a member of the *maculata* group, closest to *P. resolda* Mosely. From this species it differs in the nondivergent apices of the ninth sternum, the shape of the apical portion of the tenth tergite, and the very different aedeagus.

ADULT.—Length of forewing 3 mm. Color brown; legs paler, forewing with intermingled brown and gold hairs, a pale line at anasta-



FIGURES 1-9.—*Prooptila dominicensis*, new species: 1, male genitalia, lateral; 2, male genitalia, dorsal; 3, female genitalia, ventral; 4, female genitalia, lateral; 5, pupal labrum, dorsal; 6, larval foreleg, posterior; 7, larval thorax, dorsal; 8, larval head, anterior; 9, pupal mandible, anterior.

mosis. Male genitalia: eighth sternum elongate, tapering, tip slightly bifid; ninth sternum flattened, scooplike, tip bifid; lateral arms of tenth tergum rectangular, with a sharp apicomeral tooth; lateral process of aedeagus with a curled apical spine; aedeagus with dorso-mesal lobe, basal complex, narrow neck, and greatly enlarged apex. Female genitalia: eighth sternum with rounded ventrolateral lobes; internal plate rectangular in ventral view with a circular mesal opening, apically with a smaller ventral plate, a long internal whip attached to apex.

LARVA.—Length to 4 mm. Sclerites brown, head yellowish around eyes. Prosternum with a pair of broad plates filling the venter. Meso- and metasterna with narrow sclerites along posterior margins. All legs very similar; mid- and hindlegs with ventroapical seta of tibia nonfimbriate. Abdominal segments 1–6 with 1 pair, segments 7–8 with 2 pairs of dorsal setae; segments 1–8 with a lateral seta; segment 1 with 2 pairs, segments 2–9 with 1 pair of ventral setae. Ninth tergite with 2 pairs of long setae. Anal claw with 3 pairs of accessory teeth.

PUPA.—Length 3 mm. Mandibles and labrum as in figures 5, 9. Face with 3 pairs of setae. Abdomen with hook-plates anteriorly on segments 2–8 (2 and 8 lightly sclerotized and may be lacking), posteriorly on 4.

CASE.—Length 4 mm, width 2 mm. Made of small sand grains in typical shape. Irregular respiratory openings dorsally at anterior and posterior ends.

MATERIAL.—Holotype, pharate male: Dominica, Morne Nicholls, 9 Nov. 1964, P. J. Spangler, USNM Type 69879. Allotype, female: Fond Figues, 6 Apr. 1964, O. S. Flint, Jr. Paratypes: same data as holotype, 1 ♀; same data as allotype, 1 ♀; Clarke Hall, 11–20 Feb. 1965, W. W. Wirth, 1 ♀. Other: same data as holotype, 7 larvae, 1 prepupa, 6 pupae; Laudat, 20 Nov. 1964, P. J. Spangler, 1 larva.

BIOLOGY.—This species has been encountered only a few times on the island of Dominica. The larvae were found in clear, forested streams about 5 yards wide, where they were attached to gravel and rocks on the bottom.

Family PHILOPOTAMIDAE

The philopotamids are nearly ubiquitous wherever there is flowing water in most of the regions of the world. Many of the genera, including *Wormaldia*, are more or less limited to the cooler, spring-fed streams in mountainous regions, whereas others, especially *Chimarra*, are more diverse in the regions of larger, warmer, but still rapidly flowing, lowland rivers.

The larvae construct long, tubular, silken shelters attached to the underside of a rock or stick, where the flow of water will keep the

shelter distended. The pupae are enclosed in a rather loose, domed shelter of sand and silk.

Key to Genera

LARVAE

- Frontoclypeus with anterior margin evenly convex *Wormaldia*
 Frontoclypeus with anterior margin asymmetrically emarginate . . . *Chimarra*

PUPAE

- Mandible broad, subapical teeth close together, often arising from a single projection *Chimarra*
 Mandible narrower, teeth well separated, never arising from a single projection
Wormaldia

ADULTS

- Front tibia with 1 apical spur *Chimarra*
 Front tibia with 2 apical spurs *Wormaldia*

Genus *Wormaldia* McLachlan

Wormaldia McLachlan, 1865, p. 140. [Type-species: *Hydropsyche occipitalis* Pictet, 1834, designated by Ross, 1949.]

There are species placed in the genus *Wormaldia* from all regions of the world save the Australian; however, the genus seems to be most diverse in the Northern Hemisphere. This is the first record of the genus from the West Indies.

Larvae and pupae of the genus were described by Ross (1944), Lepneva (1964), and others.

Wormaldia planae Ross and King

FIGURES 10, 11

Wormaldia planae Ross and King, 1956, p. 64.

This species was described from Mexico, but I have seen examples from Panama, Colombia, and Trinidad, as well as these recorded here. It is thus a circum-caribbean species, and it may also be expected in the Andean region further south.

ADULT.—Length of forewing 4 mm. Color brown, legs slightly paler. Male genitalia: no sternal processes; eighth tergum with a U-shaped dorsomesal excision, flanked by a pair of knoblike protuberances; tenth tergum narrow, with apex enlarged in lateral aspect, dorsally with an expansion and a blunt tooth laterally, then narrowing to a subapical constriction, and a sharp apicolateral tooth; cercus reaching posteriad to subapical constriction of tenth tergum; clasper with basal segment short and broad, apical segment about as long as basal segment, somewhat narrowed, with a dense apicomeral patch of black spines; aedeagus with internal sclerotizations in the form of long

lateral rods, a domelike basal hood, and an internal complex at midlength.

LARVA AND PUPA.—Unknown.

MATERIAL.—Grenada, 2 miles west of Lake Grand Etang, 4–8 Aug. 1963, O.S. Flint, Jr., 4♂.

BIOLOGY.—The specimens were taken at an ultraviolet light placed beside a small tumbling, mountain brook.

Genus *Chimarra* Stephens

Chimarra Stephens, 1829, p. 318. [Type-species: *Phryganea marginata* Linnaeus, 1767, by monotypy.]

This is a very large genus with species found on every region of the earth. One or more species have been found on all the Antillean islands.

The larvae have been described many times. They live in silken tubes on the undersurface of rocks in fast water.

Key to Species

LARVAE

Anterior margin of frontoclypeus with a central tooth *C. dominicana*
 Frontoclypeus without a small central tooth *C. antilliana*

PUPAE

Mandibles with 2 separate subapical teeth *C. dominicana*
 Mandibles with 2 teeth arising from a common projection *C. antilliana*

ADULTS

1. Clasper of male with a long apicomesal projection; M in hindwing with only 2 branches *C. dominicana*
 Claspers without a long apicomesal projection; M with 3 branches 2
2. Clasper considerably enlarged basally; female with an elongate internal, ventral sclerite *C. caribea*
 Clasper barely broader basally; female without an elongate ventral sclerite. *C. antilliana*

Chimarra dominicana, new species

FIGURES 12–17

This species is apparently related to *C. puertoricensis* Flint. It differs in the ornamentation of the eighth tergum, the presence of

FIGURES 10–26.—*Wormaldia planae* Ross and King, male genitalia: 10, lateral; 11, dorsal. *Chimarra dominicana*, new species: 12, male genitalia, dorsal; 13, male genitalia, lateral; 14, aedeagus, lateral; 15, pupal mandible, anterior; 16, apex of larval frontoclypeus and mandibles, dorsal; 17, female genitalia, lateral. *C. caribea*, new species: 18, clasper, posteroventral; 19, male genitalia, lateral; 20, aedeagus, lateral; 21, female genitalia lateral. *C. antilliana*, new species: 22, apex of larval frontoclypeus and mandibles, dorsal; 23, pupal mandible anterior; 24, male genitalia, lateral; 25, clasper, posteroventral; 26, female genitalia, lateral.



two apical teeth on the ventral half of the tenth tergum, and the long apicomeral process of the clasper.

The larvae and pupae are attributed to this species on circumstantial evidence. Adults of two species of *Chimarra* have been taken on Dominica and the adults and larvae of *C. antilliana* have been definitely associated by means of metamorphotypes. By elimination, therefore, the larvae herein described must be those of *C. dominicana*.

ADULT.—Length of forewing 4 mm. Color fuscus, coxae and femora slightly paler. Vein M in hindwing with 2 branches. Male genitalia: eighth tergum with a broad mesal excision, lateral angles of which are developed into elongate points; ninth sternum with a short, terete apicomeral process; tenth tergum divided mesally, each side divided again into dorsal and ventral lobes; dorsal lobe rodlike, ventral lobe widened apically with two apicolateral teeth; cercus elongate; clasper slender and elongate, with a long apicomeral process; aedeagus (partially everted) with a pair of small dark apicoventral spines, and a longer pair of spines, a basal ring and rod with a pair of lateral wings. Female genitalia: eighth segment without anterolateral processes; posterior margin with a rounded lateral lobe bearing three large setae, ventral surface truncate; ninth tergum with a short anteroventral process, and a pair of dorsoapical lobes; bursa copulatrix consisting of several elongate sclerotized straps.

LARVA.—Length to 8 mm. Sclerites pale yellowish brown, posterior margin of pronotum black. Anterior margin of frontoclypeus with a slightly asymmetrical emargination that bears a short, pointed process centrally. Left mandible with a short pointed molar tooth, right mandible with a small molar area.

PUPA.—Length 5 mm. Mandibles with inner margin serrulate, with 2 large teeth. Apex of abdomen with a few bristly hairs.

MATERIAL.—Holotype, male: Dominica, .4 miles east Pont Casse, 6 May 1964, O. S. Flint, Jr., USNM type 69880. Allotype, female: 2.2 miles east of Pont Casse, 11 May 1964, O. S. Flint, Jr. Paratypes: Pont Casse, .5 miles south, 22-24 July 1963, O. S. Flint, Jr., 1 ♂4 ♀; same, but 8 Apr. 1964, 3 ♀; same, but 23 Apr. 1964, 1 ♂1 ♀; same, but 17 June 1964, 1 ♀; Pont Casse, .4 miles east, 21 Apr. 1964, O. S. Flint, Jr., 2 ♀; same, but 27 Apr. 1964, 5 ♂1 ♀; same, but 6 May 1964, 1 ♂5 ♀; same, but 23 June 1964, 2 ♀; Pont Casse, 1.3 miles east, 29 Apr. 1964, O. S. Flint, Jr., 1 ♀; same, but 12 May 1964, 1 ♀; same, but 18 May 1964, 1 ♀; same, but 11 June 1964, 1 ♀; Pont Casse, 2.2 miles east, 1 May 1964, O. S. Flint, Jr., 1 ♂; same, but 14 Apr. 1964, 1 ♀; Pont Casse, 27-30 Nov. 1964, P. J. Spangler, 1 ♀. Other: D'leau Gommier, 27 Apr. 1964, O. S. Flint, Jr., 4 larvae, 2 prepupae, 1 pupa.

BIOLOGY.—This species has been taken at elevations of around 2000 feet near Pont Casse and on the central divide. Larvae believed to be of this species were taken in a small, rapid stream on the underside of rocks in the bottom gravel.

Chimarra antilliana, new species

FIGURES 22-26

This species is clearly related to the following new species as is shown by the structure of the tenth tergum and aedeagus. It may be recognized by the more elongate, narrower clasper, which bears subapically a thin mesal shelf.

ADULT.—Length of forewing 4–5.5 mm. Color fuscus; coxae and femora pale brown. Vein M in hindwing with 3 branches. Male genitalia: eighth tergum unmodified; ninth sternum with a short terete apicomeral process; tenth tergum with a dorsomesal flaplike process, lateral lobe with a long straplike apicoventral process and a short apicodorsal one; cercus short, rounded; clasper elongate, straight, and barely widened basally in lateral aspect; in ventral aspect, bowed outwardly, with a narrow shelflike mesal projection subapically; aedeagus with 2 internal spines, a scabrous pouch with a darkened rounded lobe, and basal rod and ring. Female genitalia: eighth segment completely divided dorsomesally, with anterolateral processes, posterior margin with a few large setae; ninth tergum with long anterolateral processes; bursa copulatrix consisting of a heavily sclerotized ring basally, and apically of a nearly vertical plate capped dorsally by a hoodlike structure.

LARVAE.—Length to 9 mm. Sclerites yellowish brown, posterior margin of pronotum black. Anterior margin of frontoclypeus asymmetrically emarginate. Left mandible with enlarged molar area and blunt tooth, right mandible with arcuate molar area and basal tooth.

PUPA.—Length 4–5-mm. Mandibles with inner margin serrulate, with a large subapical, bifid tooth.

MATERIAL.—Holotype, male: Dominica, Mannett Gutter, near Clarke Hall, 4 April 1964, O. S. Flint, Jr. USNM Type 69881. Allotype, female: same data. Paratypes: same data, 4 ♂; same, but 10 Mar. 1965, W. W. Wirth, 1 ♂; Clarke Hall, 11–20 Jan. 1965, W. W. Wirth, 1 ♂; same, but 18–19 Jan. 1965, J. F. G. Clarke, 2 ♀; same, but 27 Jan. 1965, 1 ♀; same, but 1–10 Feb. 1965, W. W. Wirth, 1 ♂; same, but 10 Feb. 1965, J. F. G. Clarke, 1 ♂; same, but 11–20 Feb. 1965, W. W. Wirth, 1 ♀; same, but 21–28 Feb. 1965, 1 ♂; same, but 21–31 Mar. 1965, 3 ♂ 4 ♀; same, but 31 Mar. 1965, D. R. Davis, 1 ♂; same, but 1 June 1964, O. S. Flint, Jr., 1 ♂; same, but 9 June 1964, 1 ♀; same, but 3–8 Oct. 1964, P. J. Spangler, 1 ♀; same, but 1–7 Dec. 1964, 1 ♂ 5 ♀; Fond Figue, 23 Jan. 1965, W. W. Wirth, 1 ♀; same, but 9–13 Mar. 1965, 17 ♂ 16 ♀; same, but 16–17 Mar. 1964, D. F. Bray, 2 ♂ 5 ♀; same, but 6 Apr. 1964, O. S. Flint, Jr., 60 ♂ 63 ♀; same, but 7 May 1964, 7 ♂, 44 ♀; same, but 1 May 1965, D. R. Davis, 1 ♂ 2 ♀; same, but 10 June 1964, O. S. Flint, Jr., 42 ♂ 221 ♀; same, but 1 Dec. 1964, P. J. Spangler, 1 ♀; Pagua Bay, 19 Nov. 1964, P. J. Spangler, 1 ♂; Cabrit Swamp, 3 Nov. 1964, P. J. Spangler, 1 ♀; Clarke Hall, 1 mile east, 4 Apr. 1965, D. R. Davis, 13 ♂ 2 ♀; same, but 19 Apr. 1965, 5 ♂ 2 ♀; same, but 22 May 1965, 4 ♂; Layou Valley (upper bridge), 22–25 July 1963, O. S. Flint, Jr., 8 ♂; Springfield Estate, 20–26 July 1963, O. S. Flint, Jr., 1 ♂; Mahaut, Oct. 1966, E. L. Todd,

1 ♂; Syndicate Estate, 5 Mar. 1964, D. F. Bray, 1 ♀; Pont Casse, 12 Jan. 1965, J. F. G. Clarke, 1 ♀; Pont Casse, 2.5 miles north, 8 Apr. 1965, D. R. Davis, 8 ♀; Pont Casse, 3.5 miles north, 5 Dec. 1964, P. J. Spangler, 2 ♂ 104 ♀; Pont Casse, 2.2 miles east, 1 May 1964, O. S. Flint, Jr., 5 ♂ 1 ♀; same, but 2 May 1964, 7 ♂ 2 ♀; same, but 7 May 1964, 4 ♂ 3 ♀; same, but 11 May 1964, 1 ♂ 4 ♀; same, but 6 June 1964, 8 ♂ 1 ♀; same, but 19 June 1964, 2 ♀; Pont Casse, 1.3 miles east, 29 Apr. 1964, O. S. Flint, Jr., 1 ♀; same, but 10 May 1964, 4 ♂ 5 ♀; same, but 12 May 1964, 3 ♂ 13 ♀; same, but 18 May 1964, 2 ♀; same, but 11 June 1964, 1 ♂ 1 ♀; Pont Casse, .4 mile east, 27 Apr. 1964, O. S. Flint, Jr., 1 ♀; Pont Casse, .5 mile south, 8 Apr. 1964, O. S. Flint, Jr., 3 ♂ 3 ♀; same, but 11 Apr. 1964, 2 ♂ 3 ♀; same, but 17 June 1964, 2 ♀; same, but 22–24 July 1963, 16 ♂ 3 ♀; Pont Casse, 1.6 miles west, 28 Apr. 1964, O. S. Flint, Jr., 3 ♂; same, but 16 June 1964, 1 ♂ 4 ♀; Pont Casse, 3 miles east, 13–16 Oct. 1966, A. B. Gurney, 1 ♀; same, but 23 Oct. 1966, E. L. Todd, 1 ♂ 9 ♀; same, but 26 Oct. 1966, 1 ♀; La Ronde River, 15 Feb. 1964, H. Robinson, 1 ♀; Trafalgar, 21 May 1965, D. R. Davis, 2 ♂ 1 ♀; La Plaine, 23 Nov. 1964, P. J. Spangler, 1 ♀. ST. LUCIA: Vergallier River near Marquis, 31 July 1963, Flint and Cadet, 2 ♀; same, but 2 Aug. 1963, 1 ♀; R. Galet, south of Dennery, 1 Aug. 1963, Flint and Cadet, 21 ♂ 15 ♀. Other: DOMINICA: Roseau River, swift water, 16 June 1911, 12 larvae; Springfield River, Springfield Estate, 20–26 July 1963, O. S. Flint, Jr., 8 larvae, 3 prepupae, 2 pupae, 1 ♂ 1 ♀ metamorphotypes; Pont Casse, 2.2 miles east, 3 May 1964, O. S. Flint, Jr., 5 larvae; same, but 15 June 1964, 1 pupa, 1 ♂ metamorphotype; Pont Casse, .5 mile south, 22–24 July 1963, O. S. Flint, Jr., 1 larva, 1 prepupa, 3 pupae; Rosalie, 30 Nov. 1964, P. J. Spangler, 1 larva, 2 prepupae; Belfast River, .75 mile above mouth, 31 Jan. 1964, H. H. Hobbs, Jr., 11 larvae; Batali River, north of Salisbury, 21 Feb. 1964, R. Zusi and H. H. Hobbs, Jr., 1 larva; Espagnole River, cascades on Mt. Diablotin, east of Syndicate Estate, 26 Jan. 1964, H. H. Hobbs, Jr., 1 larva; Fond Figes, 1 Dec. 1964, P. J. Spangler, 2 larvae, 3 pupae, 3 ♂ metamorphotypes; Deux Branches, 30 Nov. 1964, P. J. Spangler, 2 larvae, 1 ♀ metamorphotype; Pagua Bay, 19 Nov. 1964, P. J. Spangler, 2 larvae. ST. LUCIA: Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, 8 larvae, 1 prepupa, 1 pupa, 3 ♂ metamorphotypes; R. Galet, south of Dennery, 1 Aug. 1963, Flint and Cadet, 12 larvae, 2 pupae, 1 ♀ metamorphotype.

BIOLOGY.—This species is one of the most frequently encountered Trichoptera on Dominica and St. Lucia. It has been taken in the larger lowland rivers and the small tumbling mountain brooks. The immature stages were taken under stones in the fast water of riffles and cascades.

Chimarra caribea, new species

FIGURES 18–21

This species appears to be the same as the one I have from the island of Trinidad and to be extremely close to *C. duckworthi* Flint from Costa Rica. The differences from the latter species lie in the narrower lateral lobes of the tenth tergites and the slightly more elongate clasper with a prominent thumblike apicomeral lobe in *C. caribea*. Additional material from Venezuela and Colombia may show these differences to be clinal, but for the present I consider them specifically distinct. *Chimarra antilliana* is also related, but very distinct in the shape of both the clasper and the tenth tergum.

ADULT.—Length of forewing 4.5–5 mm. Color fuscus; coxae and femora yellowish brown. Vein M of hindwings 3 branched. Male genitalia: ninth sternum with an elongate, terete, apicomeral process; tenth tergum with a dorsomesal flaplike lobe, lateral lobe with a darkened slightly protruding area at midlength bearing sensillae, ventrally with a pair of straplike sclerites articulating beneath aedeagus; clasper elongate, enlarged basoventrally, apex enlarged, curved mesally, with a thumblike, subapical projection; aedeagus with a spine-like apicoventral lip, a scabrous sac with darkened pouch, two spines, and ring and rod. Female genitalia: eighth segment divided dorsomesally, with anterolateral processes, posterior margin with a few enlarged setae; ninth tergum with very long anterolateral processes; bursa copulatrix with a basal ring, elongate ventral plates, and a dorsal hoodlike structure.

LARVA AND PUPA.—Unknown.

MATERIAL.—Holotype, male: Grenada, 2 miles west of Lake Grand Etang, 4–8 Aug. 1963, O. S. Flint, Jr., USNM Type 69882. Allotype, female: same data. Paratypes: same data, 14 ♂ 3 ♀. Other: Trinidad, Simla, Arima Valley, 9–12 Feb. 1966, S. S. and W. D. Duckworth, 6 ♂; same, but 13–19 Feb. 1966, 11 ♂; same, but 20–26 Feb. 1966, 6 ♂.

BIOLOGY.—The adults were collected on Grenada beside a small (3 feet wide by 3–6 inches deep) tumbling, mountain brook. It is assumed that the larvae were living in the same stream although none were found.

Family PSYCHOMYIIDAE

The psychomyiids are found throughout the world. Although most species breed in flowing water, there are a number that breed in lentic situations. The genera *Xiphocentron*, *Cernotina*, and *Polycentropus* are found throughout the Antilles although the species of the latter genus on the Greater Antilles are not closely related to the Lesser Antillean species. The West Indian endemic genus *Antillopsyche* is limited to the Greater Antilles, but the widespread genus *Polyplectropus* has not been found on these islands.

The immature stages of most genera make flimsy silken nets to trap their prey although certain others make long silken tubes affixed to the substrate. The pupae are generally sheltered in a domelike case of silk and sand.

Key to Genera

LARVAE

1. Tibia and tarsus fused; a broad flat process extending anteriorly from the mesopleuron **Xiphocentron**
- Tibia and tarsus not fused; no process from mesopleuron 2
2. Mandibles with dorsal row of teeth overhanging ventral row 3
- Mandibles with dorsal row not overhanging ventral row . . . **Polycentropus**

3. Head with dark muscle scars; anal claw with large ventral teeth.

Head uniformly pale; anal claw without ventral teeth **Polyplectropus**
 **Cernotina**

PUPAE

1. Tip of mandible hooked; apical process with 4 setae **Xiphocentron**
 Tip of mandible not hooked; apical process with many setae 2
 2. Apical process with about 10 setae; gills absent **Cernotina**
 Apical process with many more than 10 setae; gills present . . . **Polycentropus**

ADULTS

1. Foreleg with preapical spur 2
 Foreleg without preapical spur 3
 2. Hindwing with R_2 and R_3 fused to wing margin **Polyplectropus**
 Hindwing with R_2 separating from R_3 before wing margin . . . **Polycentropus**
 3. Anterior scutal warts of mesonotum delimited by a distinct lateral suture;
 general color black **Xiphocentron**
 Anterior scutal warts without lateral sutures; general color yellowish.

Cernotina

Genus *Xiphocentron* Brauer

Xiphocentron Brauer, 1870, p. 66. [Type-species: *Xiphocentron bilimcki* Brauer, 1870, by monotypy.]

Species of the genus are found from southwestern United States south through South America. All the Antillean islands intensively collected for Trichoptera have proven to support one or two species.

The immature stages were described by Edwards (1961) and Flint (1964b). The adults of the genus are generally diurnal and rarely attracted to lights, which accounts in part for their scarcity in collections.

Key to Species

ADULTS

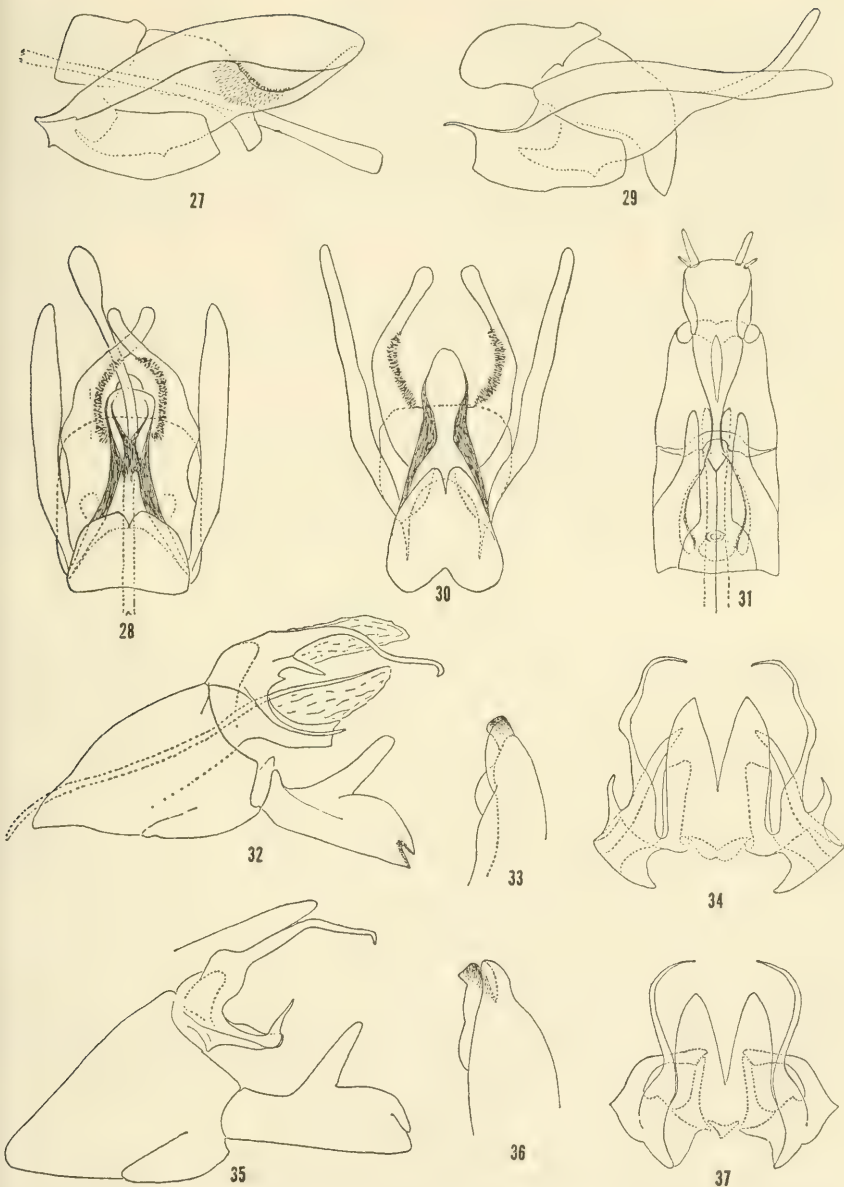
- Color totally black **X. fuscum**
 Color black, with a line of white hairs along the posterior margin of the forewings.
 **X. albolineatum**

***Xiphocentron fuscum*, new species**

FIGURES 27, 28

The species seems to be closest to *X. borinquensis* Flint from Puerto Rico. From this it differs in the apically widened cerci, much shortened anterior process of the ninth sternum, and differently shaped mesal lobes of the ninth tergum.

ADULT.—Length of forewing 3.4–4 mm. Color fuscus, coxae and femora pale brown, hairs on face ventrad of antennae pale brown. Apical spur of hindleg in male about $\frac{1}{2}$ length of basal tarsal segment. Male genitalia: ninth sternum with anterolateral process short and blunt, posterior margin truncate; ninth tergum rectangular in lateral aspect, posterior margin with a V-shaped mesal incision; tenth



FIGURES 27-37.—*Xiphocentron fuscum*, new species, male genitalia: 27, lateral; 28, dorsal. *X. albolineatum*, new species, male genitalia: 29, lateral; 30, dorsal. *Cernotina lutea*, new species: 31, female genitalia, ventral; 32, male genitalia, lateral; 33, apex of clasper, ventral; 34, male tenth terga and cerci, dorsal. *C. cadeti*, new species, male: 35, genitalia, lateral; 36, tip of clasper, ventral; 37, tenth terga and cerci, dorsal.

tergum sclerotized laterally, tip decurved; cercus about 10 times as long as broad, widened subapically; clasper with apical portion narrow and sharply curved dorsomesally, mesally with many dark spicules; aedeagus very long, slightly enlarged apically. Female genitalia: eighth segment divided dorsally with long anterolateral processes; ninth segment long and slender with long anterolateral processes; apex of tenth segment with a pair of slender papillae.

LARVA AND PUPA.—See *Xiphocentron* species.

MATERIAL.—Holotype, male: Dominica, Brantridge, 9 May 1964, O. S. Flint, Jr., USNM type 69883. Allotype, female: same data. Paratypes: same data, 5 ♂; same, but 30 April 1964, 12 ♂; Pont Casse, .4 miles east, 7–8 May 1964, O. S. Flint, Jr., 19 ♂; Pont Casse, 2.5 miles east, 16 Jan. 1965, W. W. Wirth, 1 ♂; Pont Casse, 1.5 miles north, 12 Feb. 1965, W. W. Wirth, 1 ♂.

BIOLOGY.—Apparently this species is limited to the higher elevations on the island of Dominica. I have swept them in numbers from rocks in nearly dry streambeds around Pont Casse.

Xiphocentron albolineatum, new species

FIGURES 29, 30

This is a species closely related to the preceding, from which it differs in possessing a line of white hairs along the posterior margin of the forewings and mesally on the head. The male genitalia differ most noticeably in the narrower clasper and the more elongate dorsomesal lobes of the ninth tergum.

ADULT.—Length of forewing 3–4 mm. Color fuscus, coxae and femora slightly paler, posterior margin of forewing, pro- and mesonota, and head mesally with a band of whitish hairs. Apical spur of hind tibia of male about $\frac{1}{2}$ as long as basal tarsal segment. Male genitalia: ninth sternum with anterolateral process long and attenuate; ninth tergum rounded basally, with dorsomesal lobes slightly elongate; tenth tergum with tip sharply decurved; cercus slender, narrowing apically, about 12 times as long as broad; apex of clasper slender, sharply curved dorsomesad, mesal surface with elongate spiculate patch. Female genitalia: identical to that of preceding species.

LARVA AND PUPA.—See *Xiphocentron* species.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 1.7 miles east, 12 March 1965, W. W. Wirth, USNM type 69884. Allotype, female: near Clarke Hall, 13 Feb. 1964, D. F. Bray. Paratypes: Pont Casse, 12 Oct. 1964, P. J. Spangler, 1 ♀; Mannett Gutter, 7 March 1965, W. W. Wirth, 1 ♀.

BIOLOGY.—This species is known only from Dominica but appears to be more widespread on the island than the preceding. It undoubtedly has a slightly different habitat preference, which unfortunately is unknown.

Xiphocentron species

I list here the immature stages of this genus that I have collected on the Lesser Antillean islands. Characters have not been found that will serve to separate the larvae of the various species; therefore, they are all listed together and described as a unit.

LARVA.—Length to 8 mm. Sclerites pale yellow, oral margin of head capsule darker. Structure apparently identical to other described species.

PUPA.—Unknown.

CASE.—A long silken tube attached to the substrate, generally a rock, often in great numbers crisscrossing the rocks both above and below the water line.

MATERIAL.—Dominica, Pont Casse, .5 miles south, 22-24 July 1963, O. S. Flint, Jr., 4 larvae; same, but 15 June 1964, 1 larva. Springfield Estate, .5 miles east, 21 July 1963, O. S. Flint, Jr., 1 larva. Pont Casse, 2.2 miles east, 15 June 1964, O. S. Flint, Jr., 2 larvae. Fond Figue, 6 April 1964, O. S. Flint, Jr., 2 larvae. Mannett Gutter, 23 April 1964, O. S. Flint, Jr., 2 larvae. St. Lucia, Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, 2 larvae.

Genus *Cernotina* Ross

Cernotina Ross, 1938, p. 136. [Type-species: *Cernotina calcea* Ross, 1938, by original designation.]

The genus is widely distributed in North and Central America and in the Greater Antilles.

The immature stages of the genus still have not definitely been correlated with the adult. It seems probable, however, that the larvae and pupae described by Flint (1964b) from Puerto Rico as an unknown Polycentropodinae belong to a species of this genus.

Key to Species

ADULTS

Ventrolateral lobe of cercus of male with tip bent sharply dorsomesad *C. cadeti*
Ventrolateral lobe of cercus spinelike *C. lutea*

Cernotina lutea new species

FIGURES 31-34

Cernotina lutea is a member of the calcea section of the genus closest to *C. ohio* Ross. From this species it differs in the elongate mesal lobe and in the long ventrolateral spines of the cerci.

ADULT.—Length of forewing 3.5-4 mm. Color yellowish brown, a slightly paler band of hairs mesally on head and thorax. Male genitalia: ninth segment expanded basoventrally; tenth tergites elongate, conical,

and semimembranous; cercus developed dorsally into a long slender, mesally curving process that bears on outer surface near base a short tooth and ventrolaterally a long curving spine; mesoventrally developed into an elongate quadrate plate; clasper with prominent dorsal arm, tip bifid; aedeagus semimembranous, with a heavily sclerotized dorsomesal rod. Female genitalia: lateral lobes of eighth sternum elongate and slender; dorsally with a transverse sclerite between ninth and tenth segments; bursa copulatrix with an elongate ventral plate and a ringlike sclerite between dorsolateral rods.

LARVA AND PUPA.—Unknown.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 1.3 miles east, 18 May 1964, O. S. Flint, Jr., USNM Type 69885. Allotype, female: same data. Paratypes: same, but 10 May 1964, 1 ♀; Pont Casse, .4 miles east, 15 June 1964, O. S. Flint, Jr., 1 ♀; same, but 23 June 1964, 2 ♂ 1 ♀; Brantridge, 30 April 1964, O. S. Flint, Jr., 1 ♀; Cabrit Swamp, 23 Feb. 1965, W. W. Wirth, 1 ♂.

BIOLOGY.—The adults have generally been taken near small streams at higher elevations on the island of Dominica. Presumably the larvae will be found in these streams. The one specimen from Cabrit Swamp probably represents an individual that wandered considerably from its breeding site.

Cernotina cadeti, new species

FIGURES 35-37

As to be expected, this species is clearly related to the preceding. It may be recognized by the lack of external teeth, by the more sharply angulate ventral spine of the cerci, and by the more mesally displaced dorsal plate at the tip of the clasper.

ADULT.—Length of forewing 3 mm. Color in alcohol, uniformly pale brown. Male genitalia: ninth segment considerably expanded basoventrally; tenth tergites conical, semimembranous; cercus developed into a long curving dorsal process and a ventrolateral spine whose tip is sharply angulate dorsomesad; mesoventral process elongate, rod-like; clasper with a dorsal arm; tip bifid, with dorsal plate displaced mesally; aedeagus semimembranous, with a long dorsomesal sclerite.

LARVA AND PUPA.—Unknown.

MATERIAL.—Holotype, male: St. Lucia, Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, USNM Type 69886.

BIOLOGY.—The specimen was taken at a light near a slowly flowing stream about a yard wide, in which the larva probably developed.

Genus *Polyplectropus* Ulmer

Polyplectropus Ulmer, 1905, p. 103. [Type-species: *Polyplectropus flavicornis* Ulmer, 1905, by monotypy.]

Ecnomodes Ulmer, 1911, p. 17. [New synonymy. Type-species: *Ecnomodes buchwaldi* Ulmer, 1911, by monotypy.]

Cordillopsyche Banks, 1913, p. 238. [Type-species: *Cordillopsyche costalis* Banks, 1913, by monotypy.]

Ecnomodellina Ulmer, 1962, p. 5. [Replacement name for *Ecnomodes* Ulmer 1911. New synonymy.]

Genus C Flint, 1964a, p. 476.

Species from tropical America, Africa, and the Orient have been placed in this genus; however, I expect that many of those from the Old World are not truly congeneric. On the basis of adult morphology, the genus is close to *Polycentropus*; indeed, most North American workers have not recognized the two as distinct.

The adults of this genus may be recognized by the fusion of R_2 and R_3 in the hindwing and generally by the division of the clasper in the male into distinct dorsolateral and ventromesal lobes. The larvae have the mandibles with the dorsal row of teeth overhanging the ventral row, the tibia and tarsus of the fore- and midlegs have a row of enlarged and generally black setae on the posterior face, and the anal claw bears several long teeth ventrally.

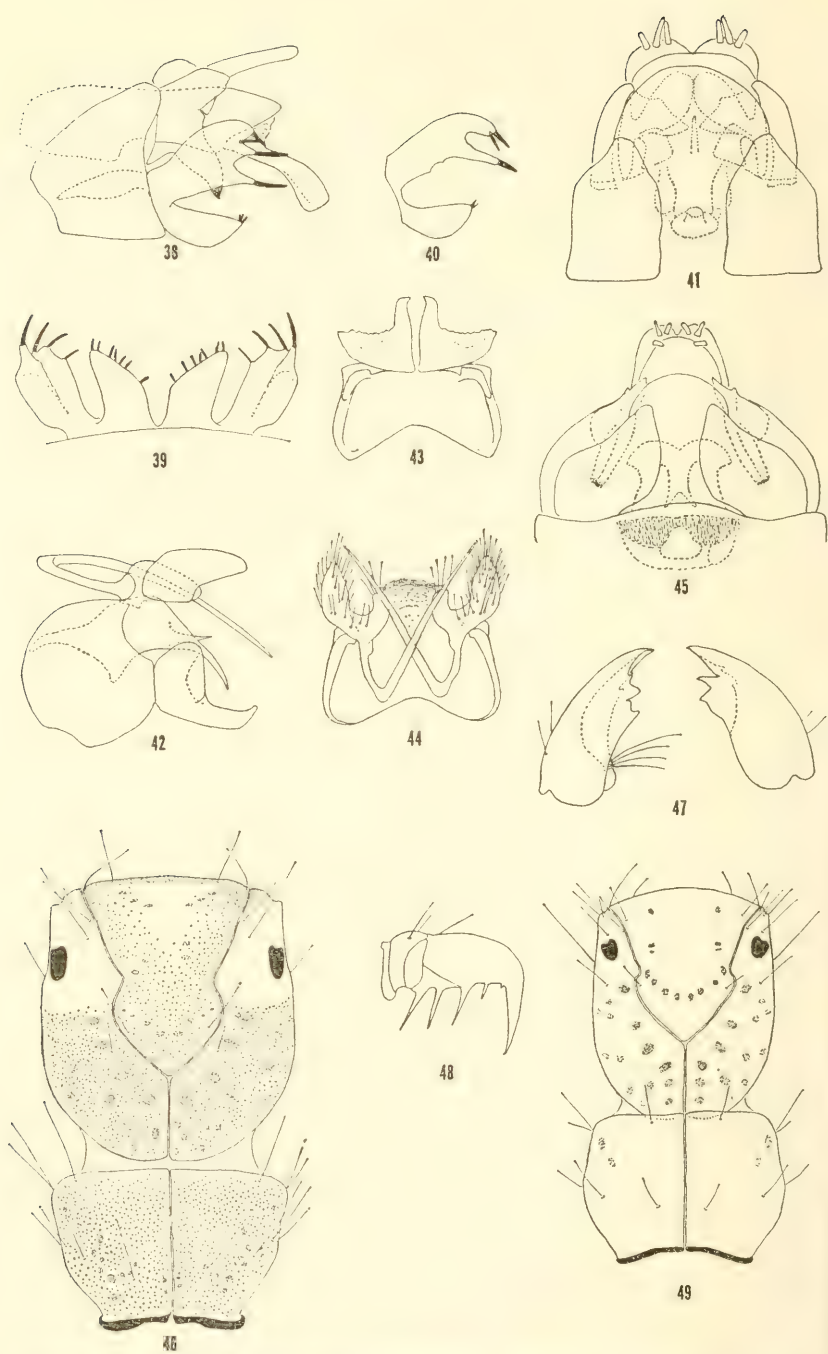
I have already synonymized the genus *Cordillopsyche* (Flint, 1967), and am here synonymizing *Ecnomodellina* (= *Ecnomodes*) Ulmer with *Polyplectropus* Ulmer. The original description of *E. buchwaldi* leaves little doubt that it is a typical species of *Polyplectropus*. The following New World species, mostly described in *Polycentropus*, must be transferred to *Polyplectropus* (all new combinations): *Ecnomodes buchwaldi* Ulmer, *Polycentropus charlesi* Ross, *P. santiago* Ross, *P. thilus* Denning, *P. alleni* Yamamoto, *P. altmani* Yam., *P. deltoides* Yam., *P. elongatus* Yam., *P. laminatus* Yam., *P. robacki* Yam., *P. recurvatus* Yam.

Polyplectropus bredini, new species

FIGURES 38-41, 47-49

This species seems quite unrelated to any other known species although there may be a slight relationship to *P. charlesi* (Ross). From this species it is easily distinguished by the more distinctly bipartite clasper that bears large black spines. The species is named for Mr. J. Bruce Bredin, a cosponsor of the Dominica Survey.

The relationship of the island populations is very close, but slight differences do exist. The males from St. Lucia have only three dark setae on the dorsal lobe of the clasper; the other dark seta on the Dominican specimens is pale. The Grenadan male (fig. 40) also has only three dark setae, but the ventralmost one is on an elongate process. Considering, the overall similarity however, I am considering these all one species.



FIGURES 38-49.—*Polyplectropus bredini*, new species: 38, male genitalia, lateral; 39, claspers, ventral; 40, clasper of Grenadan specimen, lateral; 41, female genitalia, ventral. *Polycentropus insularis* Banks: 42, male genitalia, lateral; 43, male genitalia, ventral; 44, tentin terga and cerci, dorsal; 45, female genitalia, ventral; 46, larval head and pronotum, dorsal. *Polyplectropus bredini*, new species, larva: 47, mandibles, dorsal; 48, anal claw, lateral; 49, head and pronotum, dorsal.

ADULT.—Length of forewing 5–5.5 mm. Color light brown, with whiter hairs middorsally, anterior margin of forewing dark brown. Male genitalia: ninth sternum moderately rounded basally; tenth tergites developed as long terete processes; cercus with a rounded dorsolateral lobe, posteroventrally developed into a sharp point; clasper divided into a thin, concave upper lobe bearing 4 short, broad, black setae, generally on elongate bases; basal lobe scooplike with a distal row of short dark setae; aedeagus with apicoventral portion developed into an elongate, narrow, hoodlike process. Female genitalia: lateral lobes of eighth sternum broad; subgenital plate produced and rounded apically; bursa copulatrix with a complex of sclerites apically, and a donut-shaped mesal structure.

LARVA.—Length to 8 mm. Head and pronotum pale brown with conspicuous dark muscle scars. Labrum, maxillolabium, and legs as illustrated by Flint (1964a, fig. 4). Mandibles with dorsal row of teeth overhanging ventral row. Basal segment of anal proleg with a few short setae mesally; claw with 3 long and 1 short ventral teeth, apex curved at right angles.

PUPA.—Unknown.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 1.3 miles east, 29 Apr. 1964, O. S. Flint, Jr. USNM Type 69887. Allotype, female: Syndicate Estate, 5 March 1964, D. F. Bray. Paratypes: same as holotype, but 11 June 1964, 1 ♂; same, but 12 May 1964, 1 ♂; Fond Figue, 13 March 1965, W. W. Wirth, 1 ♂; D'leau Gommier, 24 Feb. 1965, J. F. G. Clarke, 5 ♀. Other: Grenada, 2 miles west Grand Etang, 4–8 Aug. 1963, O. S. Flint, Jr., 1 ♂. St. Lucia, Cul de Sac River, at mile post 9, 29 July 1963, Flint and Cadet, 1 ♂; R. Galet, south of Dennery, 1 Aug. 1963, Flint and Cadet, 1 ♂, 8 larvae.

BIOLOGY.—The adults generally have been collected near small clear streams. The larvae were taken on St. Lucia in a stream only a few feet wide by several inches deep. They were found under rocks near the head or tail ends of pools in the stream.

Genus *Polycentropus* Curtis

Polycentropus Curtis, 1835, pl. 544. [Type-species: *Polycentropus irroratus* Curtis, 1835, by original designation.]

Polycentropus, as it is presently recognized by most North American workers, is found over most of the world; however, it seems to be best developed in the Northern Hemisphere. There is at least one species on all the Antillean islands.

The larvae of the genus are well known and described. They build various types of silken trap nets.

Polycentropus insularis Banks

FIGURES 42-46

Polycentropus insularis Banks, 1938, p. 302.—Fischer, 1962, p. 83.—Flint, 1967, p. 6.

Polycentropus insularis was described from Grenada, but the specimens collected on Dominica do not seem to differ significantly from the type. The species is rather distantly related to the other species of Antillean *Polycentropus*. From these it may be recognized by the lack of dorsomesal process on the clasper and the elongate ventromesal lip of the aedeagus.

ADULT.—Length of forewing 7-8 mm. Brown, body and wings flecked with spots of golden hair. Male genitalia: ninth segment rounded in lateral aspect; cercus divided into a dorsolateral ovate lobe bearing a smaller mesal lobe, and a long, angled, pointed process; clasper with a rounded dorsolateral lobe, and an elongate ventromesal section; aedeagus with a long pointed ventromesal lip. Female genitalia: lateral lobes slightly elongate, directed apicomesally; subgenital plate rounded apically; bursa copulatrix complex, with a heavily sclerotized basal plate and lateral supports.

LARVA.—Length to 12 mm. Sclerites pale brownish, muscle scars conspicuously darker, head irregularly clouded with darker brown. Structure typical of other West Indian species.

PUPA.—Unknown.

MATERIAL.—Holotype, male: Grenada, Grand Etang, Sept. 1910, Allen and Brues, collection MCZ. Other: Dominica, Pont Casse, .5 miles south, 22-24 July 1963, O. S. Flint, Jr., 1 ♂, 1 larva; Pont Casse, .4 miles east, 21 April 1964, O. S. Flint, Jr., 1 ♀; same, but 27 April 1964, 1 ♂; same, but 6 May 1964, 3 ♀; same, but 16 May 1964, 1 ♀; same, but 12 June 1964, 1 larva; same, but 23 June 1964, 1 ♂; Pont Casse, 1 mile east, T. M. and J. F. G. Clarke, 2 ♂; Pont Casse, 1.3 miles east, 29 April 1964, O. S. Flint, Jr., 1 ♀; same, but 10 May 1964, 1 ♀; same, but 18 May 1964, 1 ♀; same, but 26 May 1964, 1 ♂; same, but 11 June 1964, 1 ♂ 1 ♀; Pont Casse, 2.2 miles east, 1 May 1964, O. S. Flint, Jr., 1 ♂; Pont Casse, 3 miles east, 15 Oct. 1966, E. L. Todd, 1 ♀; Sylvania Estate, 28 Jan. 1965, T. M. and J. F. G. Clarke, 1 ♀; Boeri Lake, 22 Feb. 1964, D. F. Bray, 2 ♂; Freshwater Lake, 13 Oct. 1964, P. J. Spangler, 1 larva.

BIOLOGY.—The species has been taken only at higher elevations on the islands. Larvae were found sparingly in small streams. The two adults taken at Boeri Lake and the larva from Freshwater Lake indicate that the species may breed in high elevation lakes as well.

Family HYDROPSYCHIDAE

The Hydropsychidae are a very common and widely distributed family, breeding in flowing waters throughout the world. Representatives of two subfamilies, the Macronematinae and Hydropsychinae,

have been found on the Antilles. *Leptonema* and *Smicridea*, respectively, are the representatives throughout the Antilles, but *Macronema* and *Hydropsyche* are found only on the Greater Antilles.

The larvae construct a complex silken trap-net to strain their food from the water. The trap-net is attached to a tubular retreat in some crevice of the substrate. At pupation time a domelike shelter is constructed of silk with included sand or organic matter.

Key to Genera

LARVAE

Gills consisting of a long central stalk giving rise to many lateral filaments. **Leptonema**
 Gills branching into filaments near base. **Smicridea**

PUPAE

Hook-plate present posteriorly on segment 3 only. **Leptonema**
 Hook-plates present posteriorly on segments 3 and 4. **Smicridea**

ADULTS

Antennae at least twice as long as wing; large and pale green. . . . **Leptonema**
 Antennae subequal to forewings; small and dark. **Smicridea**

Genus *Smicridea* McLachlan

Smicridea McLachlan, 1871, p. 134. [Type-species: *Smicridea fasciatella* McLachlan, 1871, by designation of Milne, 1936.]

Smicridea is a genus of many species found from the southwestern United States to the southern tip of South America and Australia. All of the Antillean islands support at least one species. The larvae and pupae have been described on several occasions (Ross 1944, Flint 1964b).

Key to Species

PUPAE

Hook-plate 3P equidimensional with 3 long hooks. **S. cariba**
 Hook-plate 3P nearly twice as wide as long, with 5 hooks. **S. simmonsii**

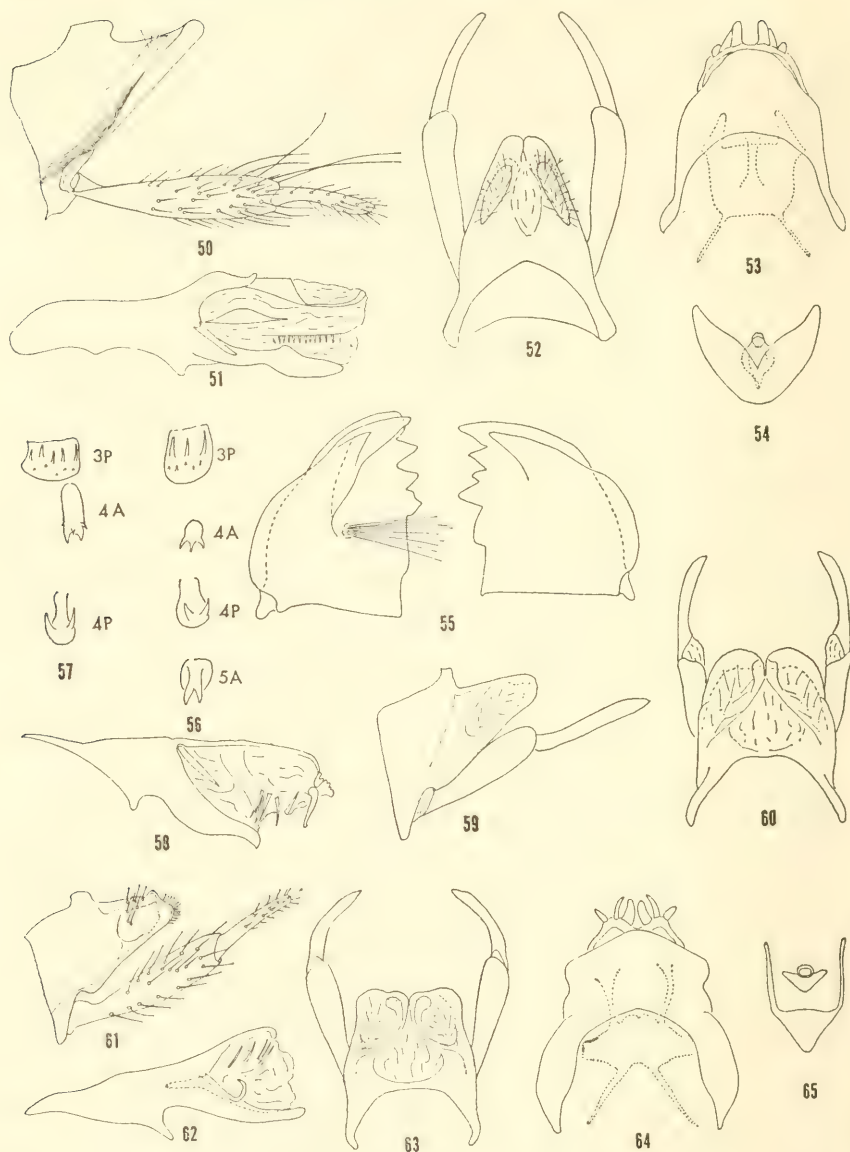
ADULTS

1. Forewing black with 2 transverse bands of white setae. 2
 Forewing uniformly grayish. **S. grenadensis**
2. Tenth tergite short and broad, aedeagus without lateral plate. . . **S. simmonsii**
 Tenth tergite long and narrow, aedeagus with lateral plate. . . **S. cariba**

Smicridea cariba, new species

FIGURES 50-56

This species, found on Dominica, is most closely related to the following species from St. Lucia. It differs strikingly in the structure of the tenth tergite and aedeagus.



FIGURES 50-65.—*Smicridea caribea*, new species: 50, male genitalia, lateral; 51, aedeagus, lateral; 52, male genitalia, dorsal; 53, female genitalia, dorsal; 54, bursa copulatrix, dorsal; 55, larval mandibles, dorsal; 56, pupal hook-plates, dorsal. *S. simmonsii*, new species: 57, pupal hook-plates, dorsal; 58, aedeagus, lateral; 59, male genitalia, lateral; 60, male genitalia, dorsal. *S. grenadensis*, new species: 61, male genitalia, lateral; 62, aedeagus, lateral; 63, male genitalia, dorsal; 64, female genitalia, dorsal; 65, bursa copulatrix, dorsal.

ADULT.—Length of forewing 4–5 mm. Color fuscus, leg bases slightly paler, forewing with a transverse band of iridescent white hair at level of anastomosis and another halfway to wing base, apical fringe white. Sixth and seventh segments of male with internal reticulate sacs. Male genitalia: ninth segment with anterior margin angulate at middle; tenth tergite elongate, rounded apically, with lateral margin heavily sclerotized; clasper widening uniformly to apex of basal segment, apical segment terete; aedeagus large and complex, apicoventrally heavily sclerotized and scooplike, a ventrally directed spine laterally at midlength, a short dorsal hood, a flat lateral plate in apical membrane that bears 2 rows of short spines and an apicodorsal angulate rod. Female genitalia: lobes of eighth sternum slightly longer than broad, evenly rounded apically; ninth segment without clasper groove or receptacle, with anterolateral angle greatly enlarged; internal plate with a quadrate central section bearing short apical arms and a pair of long basal arms; bursa copulatrix with a central ring and broad basolateral wing-like supports.

LARVA.—Length to 7 mm. Sclerites brownish. Each gill on basal abdominal segments with 3–4 filaments. Abdomen with many short, broad, black setae.

PUPA.—Length 4–5 mm. Right mandible with 3 inner teeth, left with 4. Hook-plates anteriorly on segments 2–8, posteriorly on 3 and 4; posterior plates about equidimensional, anterior plates with 2–3 teeth, apex of posterior plates considerably elevated above body. Apical processes widely separated, with a brush of setae on apical third.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 2.2 miles east, 2 May 1964, O. S. Flint, Jr., USNM Type 69388. Allotype, female: same data. Paratypes: same data, 8♂ 4♀; same, but 14 April 1964, 1♂; same, but 1 May 1964, 7♂ 3♀; same, but 7 May 1964, 1♂ 5♀; same, but 11 May 1964, 1♂; same, but 21 May 1964, 1♀; Pont Casse, 1.3 miles east, 10 May 1964, O. S. Flint, Jr., 2♂ 1♀; same, but 12 May 1964, 6♂ 1♀; same, but 18 May 1964, 1♀; same, but 11 June 1964, 1♀; Pont Casse, .4 miles east, 21 April 1964, O. S. Flint, Jr., 1♂; same, but 27 April 1964, 2♂; same, but 6 May 1964, 4♂ 1♀; same, but 7 May 1964, 1♂; same, but 15 June 1964, 1♂; Pont Casse, .5 miles south, 22–24 July 1963, O. S. Flint, Jr., 2♂ 1♀; Sylvania, 9 Feb. 1964, D. F. Bray, 1♂; Trafalgar Falls, 15 March 1964, O. S. Flint, Jr., 1♂ 1♀; Fond Figue, 23 Jan. 1965, W. W. Wirth, 1♀; D'leau Gommier, 15 Feb. 1965, W. W. Wirth, 1♂. Other: Pont Casse, 2.2 miles east, 3 May 1964, O. S. Flint, Jr., 8 larvae; Pont Casse, .4 miles east, 20 May 1964, O. S. Flint, Jr., 2 larvae; same, but 12 June 1964, 8 larvae; same, but 25 June 1964, 3 larvae, 1 prepupa, 1 pupa; Pont Casse, .5 miles south, 22–24 July 1963, O. S. Flint, Jr., 36 larvae, 2 prepupae, 16 pupae, 2♀ metamorphotypes; same, but 15 June 1964, 6 larvae, 4 pupae, 1♀ metamorphotype; D'leau Gommier, 27 April 1964, O. S. Flint, Jr., 5 larvae, 1 pupa; Springfield Estate, 20–26 July 1963, O. S. Flint, Jr., 1 larva, 1 pupa; Roseau River, swift water, 16 June 1911, 5 larvae; Espagnole River, cascades on Mt. Diablotin, east of Syndicate Estate, 26 Jan. 1964, H. H. Hobbs, Jr., 1 larva; Boeri Lake, outlet, 10 Nov. 1964, P. J. Spangler, 4 larvae.

BIOLOGY.—The species is most abundant around the small, tumbling mountain brooks; however, the collection of larvae in the Roseau River suggests that they breed sparingly in the large lowland rivers as well.

Smicridea simmonsii, new species

FIGURES 57-60

This species appears to be most closely related on the basis of male genitalia to *S. grenadensis*, although in coloration it is apparently the same as *S. cariba*. From *S. grenadensis* it may be separated by the more evenly rounded apices of the tenth tergites, by the straight lateral process of the aedeagus, and by the very long apical segment of the clasper,

ADULT.—Length of body 4.5 mm, forewing probably about 5 mm. Wing dark with a transverse white band at region of anastomosis, apparently some white obliquely along the base of Cu. Sixth and seventh abdominal segments of male with internal reticulate sacs. Male genitalia: ninth segment with a pronounced dorsolateral angle; tenth tergite short, broad, apex rounded; basal segment of clasper short, apical segment subequal in length; aedeagus with well-developed ventral scoop, lateral spine straight, no lateral plate, dorsal hood semimembranous, membranous portion with about 6 pairs of long spines, apex with a crenulate crescentic hood above an elongate U-shaped sclerite.

LARVA.—Length to 7 mm. No differences found from the larva of *cariba*.

PUPA.—Length 4.5 mm. As in *S. cariba*, except hook-plate 3P almost twice as wide as long and with 5 hooks.

MATERIAL.—Holotype, pharate male: St. Lucia, Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, USNM Type 69889. Other: same data, 22 larvae, 1 pupa; Grand Riviere du Mabouya, 29 July 1963, Flint and Cadet, 1 larva; Cul de Sac River at mile post 9, 29 July 1963, Flint and Cadet, 2 larvae, 1 prepupa, 1 pupa; R. Galet, south of Dennery, 1 Aug. 1963, Flint and Cadet, 32 larvae, 1 prepupa, 3 pupae.

BIOLOGY.—The larvae of this species are most abundant in the small clear streams on the island of St. Lucia, but they are also found in the larger rivers in smaller numbers.

Smicridea grenadensis, new species

FIGURES 61-65

This species, known only from Grenada, is most closely related to *S. simmonsii* of St. Lucia; however, it is nearly unicolorous, and and in the male the tenth tergite bears a distinct anteapical bulge,

the basal segment of the clasper is longer, and the lateral spine of the aedeagus is hooked.

ADULT.—Length of forewing 4–4.5 mm. Color uniform grayish brown. Males with two pairs of ovoid internal saes in abdominal segments 6 and 7. Male genitalia: ninth segment with pronounced dorsolateral angle; tenth tergite short, blunt, with anteapical dorsal bump; clasper with apical segment about half as long as basal segment; aedeagus with a strong ventral scoop, lateral spine hook-shaped, membranous portion with about 6 pairs of long spines. Female genitalia: lobes of eighth sternum slightly longer than broad, produced apicomesally; ninth segment without clasper groove or receptacle, greatly produced anterolaterally; internal plate with central part narrowly quadrangular, with long posterior and anterior arms, anterior pair arising mesally; bursa copulatrix with a central heart-shaped plate with a central hole, lateral supports U-shaped.

LARVA AND PUPA.—Unknown.

MATERIAL.—Holotype, male: Grenada, 2 miles west Lake Grand Etang, 4–8 Aug. 1963, O. S. Flint, Jr., USNM Type 69890. Allotype, female: same data.

BIOLOGY.—The adults were taken beside a small tumbling mountain brook in which the larvae are probably to be found.

Genus *Leptonema* Guerin

Leptonema Guerin, 1843, p. 396. [Type-species: *Leptonema pallidum* Guerin, 1843, by monotypy.]

This is a genus of many species throughout the American tropics and Africa. Species are known from Cuba and Puerto Rico on the Greater Antilles.

The larvae have been described previously (Flint, 1964b).

Key to Species

LARVAE

- Coxa of foreleg with anteroapical process short and with setae on anterior margin **L. archboldi**
 Coxa of foreleg with process longer but without setae **L. albovirens**

ADULTS

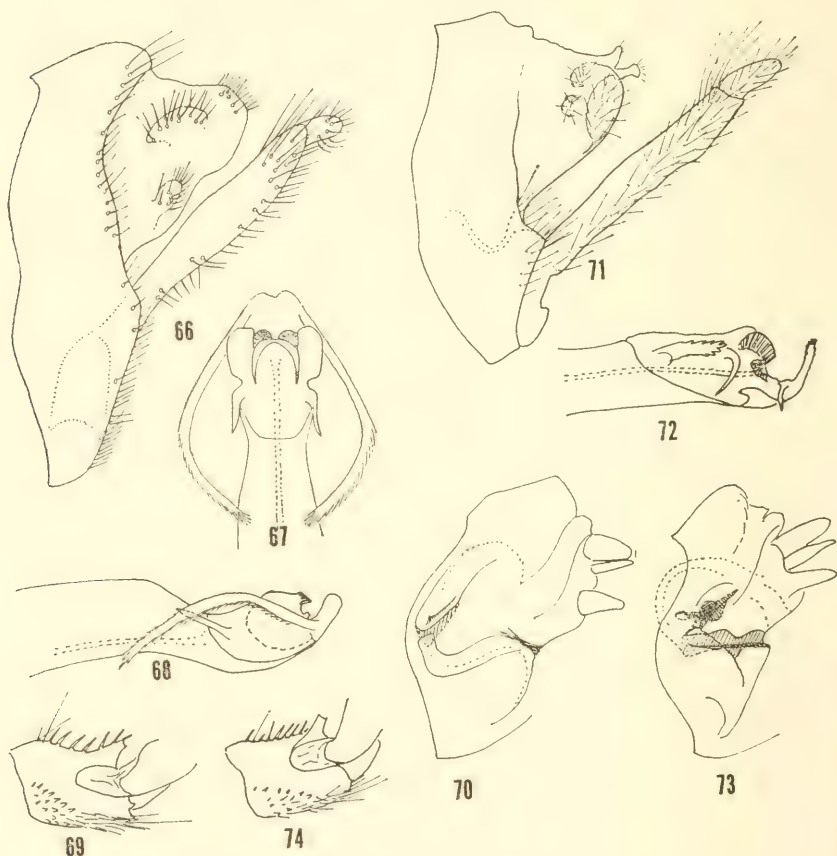
- Males with a very long, basally directed process from apex of aedeagus; females with a shallow groove laterally on 9th segment **L. archboldi**
 Males with a short lateroventrally directed process from apex of aedeagus; females with a deep, complex lateral groove on 9th segment . . . **L. albovirens**

Leptonema archboldi, new species

FIGURES 66–70

This species is very distinct, not being closely related to any described species. It probably belongs to the stigmatosum section of the

genus, from which it may be separated by the lack of the spot of dark hair on the forewing and the longer apical and shorter lateral processes of the aedeagus. I take pleasure in naming this species for Mr. John D. Archbold, one of the sponsors of this survey.



FIGURES 66-74.—*Leptonema archboldi*, new species: 66, male genitalia, lateral; 67, tip of aedeagus, dorsal; 68, tip of aedeagus, lateral; 69, larval coxa, dorsal; 70, female genitalia, lateral. *L. albovirens* (Walker): 71, male genitalia, lateral; 72, tip of aedeagus, lateral; 73, female genitalia, lateral; 74, larval coxa, dorsal.

ADULT.—Length of forewing: male 12-13 mm, female 14-15 mm. Color pale green when alive, becoming brownish after death. Female with a yellow cellule on 1A of hindwing. Male genitalia: ninth segment narrow, slightly produced dorsomesally; tenth tergite broadly triangular, with a produced hirsute knob near ventral angle, and a setose patch dorsally; clasper long and slender, without basomesal process, basal segment with rows of spinelike setae apicomesally,

apical segment short with many spinelike setae mesally; aedeagus angled near base, with a long, basally directed, fimbriate process arising apically, a short fimbriate process subapically, and a dorso-mesal stub arising from a semicircular basal structure. Female genitalia: lobes of eighth sternum about $\frac{2}{3}$ as broad as long; ninth segment with clasper receptacle shallow, entered from above, a narrow groove on surface ventrad to receptacle; with an indistinct angulate plate internally whose attachment to posterior margin of ninth segment is heavily sclerotized.

LARVA.—Length to 20 mm. Head and pronotum dark reddish brown, meso- and metanota paler, pale around eyes and on posterior of head. Anteroapical process of forecoxa short, with setae on anterior margin. Body covered densely with broad, erect, or decumbent, black setae.

PUPA.—Unknown.

MATERIAL.—Holotype, male: Dominica, Pont Casse, .5 miles south, 22-24 July 1963, O. S. Flint, Jr., USNM Type 69891. Allotype, female: Pont Casse, 2.2 miles east, 2 May 1964, O. S. Flint, Jr. Paratypes: same data as holotype, but 8 April 1964, 1♂1♀; same, but 23 April 1964, 1♀; same data as allotype, but 14 April 1964, 1♂3♀; same, but 1 May 1964, 1♀; same, but 7 May 1964, 1♀; same, but 11 May 1964, 2♀; same, but 21 May 1964, 2♀; Pont Casse, 3 miles east, 26 Oct. 1966, E. L. Todd, 2♀; Pont Casse, 1.3 miles east, 18 May 1964, O. S. Flint, Jr. 1♀; Pont Casse, .4 miles east, 27 April 1964, O. S. Flint, Jr., 1♀; Boeri Lake, 10 May 1964, P. J. Spangler, 1♀; Pont Casse, 2.5 miles north, 8 April 1965, D. R. Davis, 3♀. Other: Pont Casse, .5 miles south, 22-24 July 1963, O. S. Flint, Jr., 1 larva; same, but 16 Feb. 1964, H. H. Hobbs, Jr., 1 larva; Pont Casse, 2.2 miles east, 3 May 1964, O. S. Flint, Jr., many larvae, 2 prepupae; same, but 15 June 1964, 1 larva, 1 prepupa; Espagnole River, Cascade on Mt. Diablotin, east of Syndicate Estate, 26 Jan. 1964, H. H. Hobbs, Jr., 3 larvae; Morne Nicholls, 9 Nov. 1964, P. J. Spangler, 2 larvae.

BIOLOGY.—This species seems to be restricted to the fast waters of small highland streams, and it may also breed around the rocky margins of Boeri Lake. The larvae make typical trap-nets and sand-enclosed retreats. Pupation takes place in a silk and sand cocoon attached tightly to a rock in the substrate.

Leptonema albovirens (Walker)

FIGURES 71-74

Macronema albovirens Walker, 1852, p. 76.

Leptonema albovirens (Walker).—Mosely, 1933, p. 45.—Fischer, 1963, p. 166.

The species is known from the extreme northeast of Mexico throughout Central America, across northern South America to Trinidad, and north in the Lesser Antilles to Grenada and St. Vincent. I give only a few more pertinent references to this species; a complete bibliography is to be found in Fischer (1963).

The species is related to *L. dissimile* Mosely, from which it differs in the much shorter apical process of the aedeagus. The following descriptions are based on Grenadan specimens.

ADULT.—Length of forewing: male 11 mm, female 12–14 mm. Color pale green. Female with a yellowish cellule on vein 1A in hindwing. Male genitalia: ninth segment narrow, posterior margin angulate above base of clasper; tenth tergite trianguloid in lateral view, with an apical setate patch, dorsoapically with 2 short processes; clasper long and slender, no mesobasal lobe; basal and apical segments with patches of short spinelike setae mesoapically; aedeagus with apex bearing 2 pairs of fimbriate processes, a ventrally directed process basad of gonopore, and a posteriorly directed fimbriate process appressed to side of aedeagus. Female genitalia: lobes of eighth sternum about $\frac{3}{4}$ as broad as long; ninth segment with a shallow pouchlike dorsally directed receptacle and a lateral groove with a heavily sclerotized ventral margin leading to a rounded internal plate.

LARVA.—Length to 17 mm. Head and thoracic notae brown, paler around eyes and posteriorly on head. Process anteroapically on forecoxae arising from inner margin, with setal row passing anteriorly of it. Abdomen covered very densely with erect or decumbent broad, black setae.

PUPA.—Unknown.

MATERIAL.—Grenada, Lake Grand Etang, 4–6 Aug. 1963, O. S. Flint, Jr., 2 ♀. Lake Grand Etang, 2 miles west, 4–8 Aug. 1963, O. S. Flint, Jr., 1 ♂ 2 ♀, 2 larvae. Great River, Balthazar, 8 Aug. 1963, O. S. Flint, Jr., many larvae. St. Vincent, 2 ♂ 1 ♀ recorded by Mosely, 1933, p. 47 and verified by Kimmins (pers. comm.).

BIOLOGY.—The larvae have been taken in both a small tumbling mountain brook and a riffle in a large lowland river. Both, however, are clear and rapid with a bottom of rocks and gravel.

Family HYDROPTILIDAE

This family contains the smallest species of the order. Most of the adults are only a millimeter or two long with the largest reaching about five millimeters. The Lesser Antilles contain at least 23 species in 8 genera, or 50 percent of the total species in the order from these islands.

The larvae undergo hypermetamorphosis in which the first four instars are slender, bear long setae, are free living, and are brief in duration. In the fifth instar, the larvae construct their cases and undergo the greater part of their growth, often changing their shape radically.

Since the cases show good generic differences—except between *Leucotrichia* and *Zumatrichia*, and between *Hydroptila* and *Ochrotrichia*—they are more useful in the placement of the pupal stage than the pupae themselves, which are only slightly different. In the majority of the genera it is impossible to key the immature stages to species. The larvae and pupae of *Bredinia* are unknown.

Key to Genera

LARVAE AND CASES

1. Larvae with abdominal terga bearing sclerites; case flattened and tightly appressed to substrate, never movable 2
Larvae with a sclerite on ninth tergum only; case variously shaped, but carried by larva and attached at pupation 4
2. Abdominal segments 3-6 greatly enlarged; case ovoid, domed, with openings at both ends 3
No abdominal segment enlarged; case nearly circular, flat, with marginal openings **Alisotrichia**
3. Ninth tergum with short, enlarged setae **Zumatrichia**
Ninth tergum with only normal hairlike setae **Leucotrichia**
4. Mid- and hindlegs about 3 times as long as forelegs; case silken, anterior end cylindrical, becoming enlarged and compressed posteriorly . . . **Oxyethira**
All legs of about same length; case generally with some sand or organic matter, differently shaped 5
5. Anal prolegs projecting freely from abdomen; case tubular, made of sand **Neotrichia**
Anal prolegs fused to end of abdomen; case compressed 6
6. Metanotum with anterolateral angle enlarged **Ochrotrichia**
Metanotum with anterolateral angle not enlarged **Hydroptila**

ADULTS

1. Ocelli present 2
Ocelli absent **Hydroptila**
2. Mesoscutellum with a transverse suture between lateral angles 3
Mesoscutellum entire 9
3. Foretibia with an apical spur 4
Foretibia without an apical spur 6
4. Males with basal antennal segment enlarged, covering face, with 2 ocelli **Zumatrichia**
Basal antennal segment unmodified, with 3 ocelli 5
5. Forewing fuscus, with linear, bright green marks **Leucotrichia**
Forewing fuscus, sometimes with silvery-gray blotches
Ochrotrichia (Metricia)
6. Midtibia with a preapical spur 7
Midtibia without a preapical spur 8
7. Male genitalia not greatly modified, claspers large and easily recognizable as such **Ochrotrichia (O.)**
Male genitalia greatly modified, claspers small and often difficult to homologize **Alisotrichia**

8. Male with basal antennal segment enlarged, covering face, 2 ocelli **Alisotrichia**
 Male with antennae unmodified, 3 ocelli **Bredinia**
9. Hindtibia with only a preapical spur **Neotrichia**
 Hindtibia with 2 preapical spurs 10
10. Metascutellum narrow, almost quadrangular **Alisotrichia**
 Metascutellum wider, distinctly triangular **Oxyethira**

Genus *Zumatrichia* Mosely

Zumatrichia Mosely, 1937, p. 187. [Type-species: *Zumatrichia filosa* Mosely, 1937, by original designation.]

The genus has heretofore been known only from several Mexican species. The genus is closely related to *Leucotrichia*, but the males differ greatly in the modified basal antennal segment, in the possession of only two ocelli, and in a different style genitalia.

The immature stages of the genus are herein described for the first time, and as expected they show a close relationship to those of *Leucotrichia*. The larvae of *Zumatrichia* are distinguished by the short, broad, setae on the eighth and ninth terga.

Key to Species

ADULTS

Color gray, mottled with grayish green; forewing of male unmodified.

Z. antilliensis

Color, brown; forewing of male with a basal patch of modified setae.

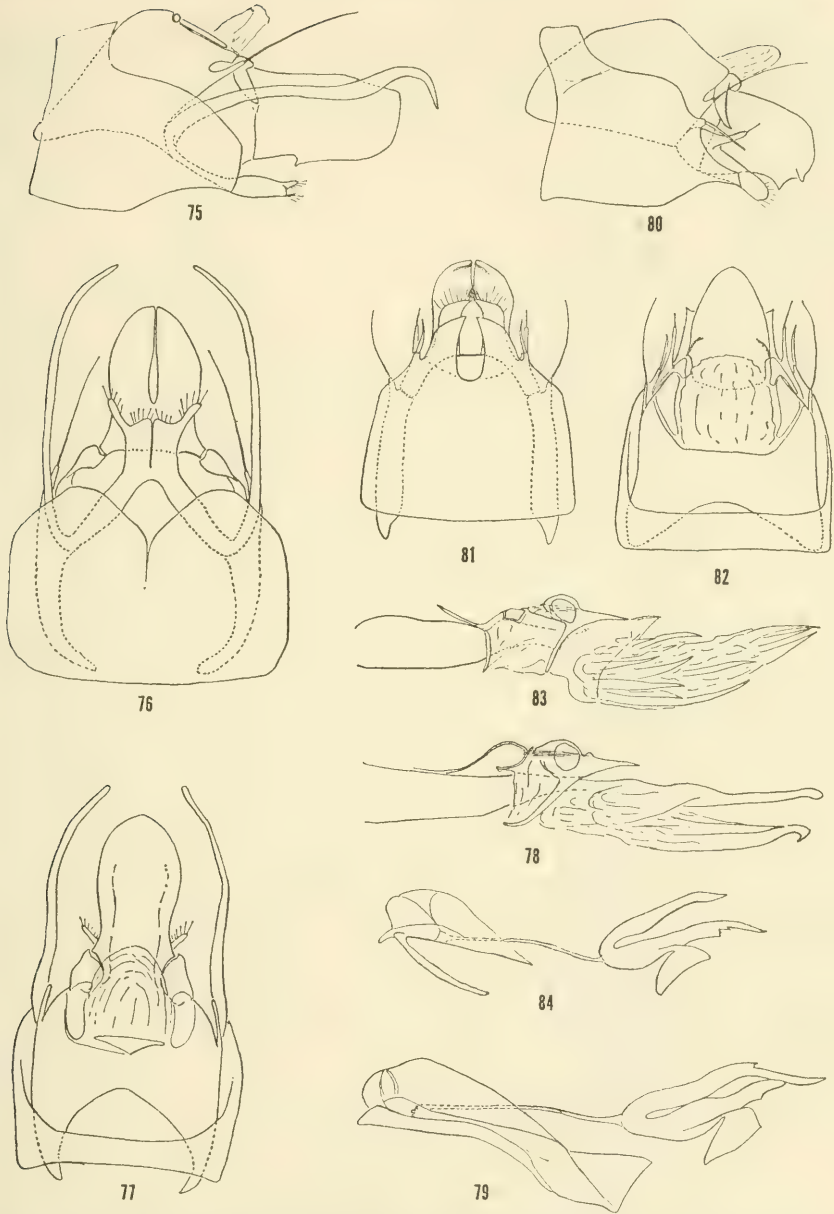
Z. anomaloptera

Zumatrichia antilliensis, new species

FIGURES 75-79, 86, 99-103

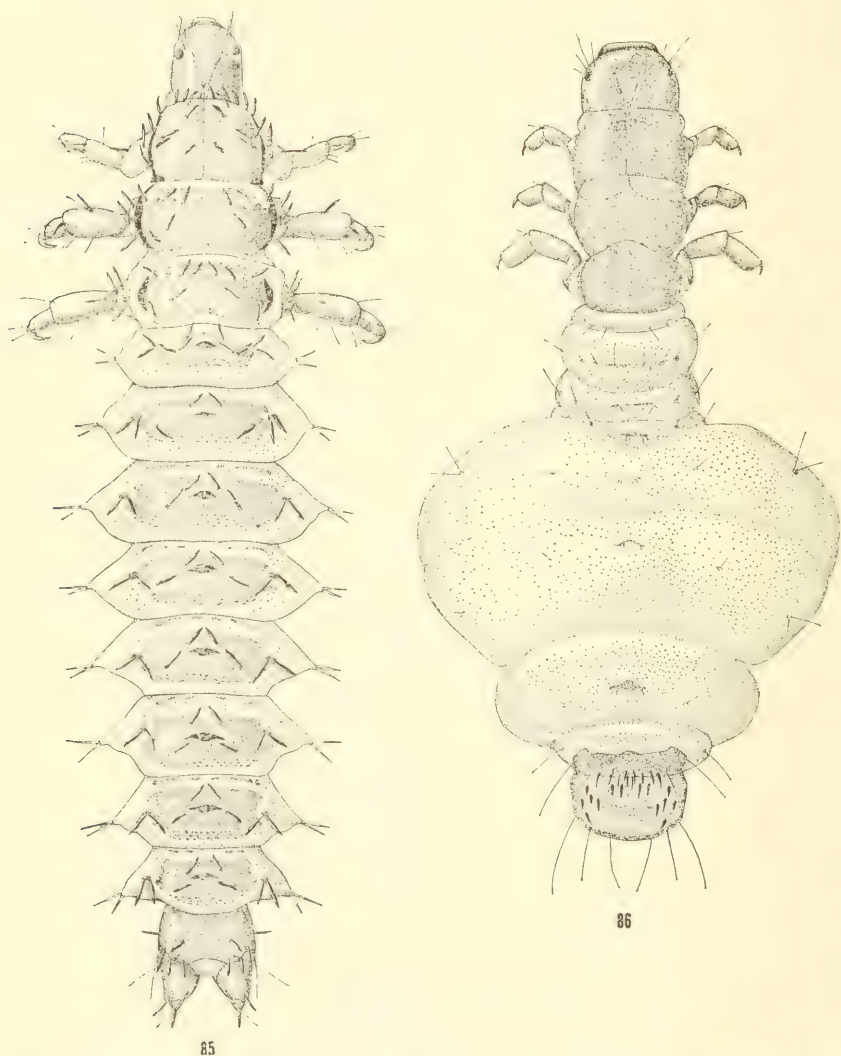
This species has been the most commonly encountered trichopteran on the island of Dominica, and it has also been taken on Guadeloupe, St. Lucia, and Grenada. It is related to *Z. gallena* Mosely from Mexico but is distinguished by the dorsal process of the clasper not being digitate apically and by the long hooked ventral process of the aedeagus.

ADULT.—Length of forewing 3 mm. Color intermingled patches of gray and gray green. Male genitalia: eight sternum with ventrolateral angles slightly produced; ninth segment with anterolateral angles produced as narrow lobes; cercus, rodlike, with a single long apical seta; clasper with a long basodorsal process, slightly sinuate apically; ventral portion with a slender apicolateral lobe; tenth tergum divided into platelike lateral lobes, rounded apically, with a midventral tooth; aedeagus with a middorsal process apically, a pair of lateral spines, and a pair of appressed, hooked, ventral processes; a complex



FIGURES 75-84.—*Zumatrichia antilliensis*, new species, male: 75, genitalia, lateral; 76, genitalia, ventral; 77, genitalia, dorsal; 78, aedeagus, lateral; 79, female, bursa copulatrix, lateral. *Z. anomaloptera*, new species, male: 80, genitalia, lateral; 81, genitalia, ventral; 82, genitalia, dorsal; 83, aedeagus, lateral; 84, female, bursa copulatrix, lateral.

at midlength and a basal loop. Female genitalia: eight and ninth segments weakly sclerotized, with short anterolateral rods; bursa copulatrix with basal group attached to apical group by a slender rod, apical group with long lateral supports.



FIGURES 85-86.—*Alisotrichia* species 2: 85, larva, dorsal. *Zumatrichia antillensis*, new species: 86, larva, dorsal.

LARVA.—Length to 3 mm. Head, thorax slender, abdominal segments 5-7 greatly distended at maturity. Sclerites pale brown, marked with fuscus. Head unmodified. Legs short and broad; all pairs very similar in structure. Meso- and metanota divided mesally.

Abdomen with tergites dorsally on segments 1-9, 1 small lateral sclerite on segments 2 and 8, 2 sclerites on segments 3-7. Anal proleg with basal segment terete, short; claw sharply decurved.

PUPA.—Length 3 mm. Mandible sickle shaped, broad, without serrations. Labrum membranous. Hook-plates anteriorly on segments 3-7, posteriorly on 3-5; each plate with many small teeth. Apex of abdomen with a membranous lobe containing genitalia.

CASE.—Length 3 mm, width $1\frac{1}{2}$ mm. Silken, tightly attached to substrate. Larval case with round anterior and posterior openings. Pupa enclosed in an inner silken cocoon.

MATERIAL.—Holotype, male: Dominica, Clarke Hall, 17 April 1964, O. S. Flint, Jr., USNM type 69892. Allotype, female: same data. Paratypes (many thousands of specimens taken at the following localities, on many dates throughout the year, and by most collectors): Clarke Hall, Fond Figues, Layou Valley, Layou River Mouth, Grand Bay, Rosalie, Cabrit Swamp, Trafalgar, 2.5 and 3.5 miles north of Pont Casse, 1.6 miles west of Pont Casse, 1.3 and 2.2 miles east of Pont Casse. St. Lucia, Cul de Sac River at mile post 9, 29 July 1963, Flint and Cadet, 5♂; Vergallier River near Marquis, 2 Aug. 1963, Flint and Cadet, 2♂. Grenada, 2 miles west of Grand Etang, 4-8 Aug. 1963, O. S. Flint, Jr., many ♂♂ ♀♀; Balthazar, 7 Aug. 1963, O. S. Flint, Jr., 4♂. Guadeloupe, Petit-Bourg, Duclos, March 1966, J. Bonfils, many ♂♂ ♀♀. Other: Dominica, Fond Figues, 3 May 1964, O. S. Flint, Jr., larvae, ♂♀ metamorphotypes; Roseau River, 1 mile above Roseau, 23 July 1963, O. S. Flint, Jr., larvae and pupae; Layou River, 23-25 July 1963, O. S. Flint, Jr., larvae, ♂♀ metamorphotypes; Springfield, 20-26 July 1963, O. S. Flint, Jr., larvae, ♂♀ metamorphotypes; R. Laurent, Bells, 21 July 1963, O. S. Flint, Jr., larvae, ♂♀ metamorphotypes; Pont Casse, 3.5 miles north, 5 Dec. 1964, P. J. Spangler, larvae and pupae.

BIOLOGY.—This is the commonest species of Trichoptera on the island of Dominica. It is the only species that has successfully adapted to breeding in the large lowland rivers. The flat cases are attached in great abundance to the large boulders in the fast-flowing sections of these rivers. A few adults have also been taken near the small streams at high elevations; however, these may well have been carried up by winds from the lowlands.

The species seems less abundant on St. Lucia and Grenada. On the latter, *Z. antillensis* seems to be replaced in the lowland rivers by *Z. anomalopectera*.

Zumatrighia anomalopectera, new species

FIGURES 80-84

On the basis of head, genitalia, and spurs, this species is a typical member of the genus *Zumatrighia*; however, it is the only species so far discovered that has the patch of modified setae present on the basal half of the forewing in the male.

ADULT.—Length of forewing 3 mm. Color brown; basal half of forewing of male with a large patch of deep brown, scalelike setae.

Male genitalia: eighth sternum bearing laterally from posterior margin an enlarged setae from a large base, and ventrally a pair of caliper-like lobes; ninth segment with anterolateral angle broad; cercus rod-like with a single long apical seta; clasper with a short, rodlike basodorsal process, ventral lobes rounded; tenth tergum divided into flat lateral plates, rounded apically, with a subapical ventral tooth; aedeagus with usual mesal and basal structures, apically with a large number of slender spines. Female genitalia: eighth and ninth segments with lateral rods; bursa copulatrix complex, basal group supported by a slender rod from apical group that has short lateral supports.

LARVA, PUPA, AND CASE.—Not different from *Z. antilliensis*.

MATERIAL.—Holotype, male: Grenada, Balthazar, 7 Aug. 1963, O. S. Flint, Jr., USNM Type 69893. Allotype, female: same data. Paratypes: same data, many ♂♂ ♀♀. St. Lucia, R. Galet, south of Dennery, 1 Aug. 1963, Flint and Cadet, 1 ♂; Vergallier River, near Marquis, 21 July 1963, Flint and Cadet, many ♂♂ ♀♀; same, but 2 Aug. 1964, 2 ♂ 4 ♀. Dominica, Clarke Hall, 1-10 March 1965, W. W. Wirth, 1 ♂. Other: Grenada, Great River, at Balthazar, 8 Aug. 1963, O. S. Flint, Jr., larvae, ♂♂ ♀♀ metamorphotypes.

BIOLOGY.—The immature stages were found on large rocks in a large lowland river on Grenada. It thus seems that it has identical breeding habits to the preceding species, but that it has replaced *Z. antilliensis* in the lowlands of Grenada and St. Lucia.

Genus *Leucotrichia* Mosely

Leucotrichia Mosely, 1934, p. 157. [Type-species: *Leucotrichia melleopicta* Mosely, 1934, by original designation.]

This and the preceding genus are closely related, but *Leucotrichia* is found over most of North America as well as Central America. The male of *Leucotrichia* may be recognized by the unmodified antennae and presence of three ocelli.

The larvae are also similar in the two genera, but those of *Leucotrichia* lack the modified setae on the eighth and ninth terga. The immature stages are described in Ross (1944) and Flint (1964b), and so are not treated in detail here.

Leucotrichia sarita Ross

FIGURES 87-91

Leucotrichia sarita Ross, 1944, p. 274.

This species, described from Texas, is common in Mexico and Central America. There are some minute differences in the genitalia between the insular and mainland populations, but these are no greater than differences found on the mainland. The description is based on Grenadan examples.

ADULT.—Length of forewing 3 mm. General color fuscus, with bright green linear marks on forewings, tegulae, and head; antennae alternating black and white. Male genitalia: eighth sternum produced into an acute angle laterally, broadly U-shaped ventrally; ninth segment oblique, open anteroventrally, with a row of stout setae along posterior margin; claspers fused mesally, elongate, with a subapical seta dorsally, dorsally with a pointed mesal structure, partially enclosed by claspers that articulate basally with a linear lateral sclerite; tenth tergite strongly sclerotized, produced into a ventro-lateral point; aedeagus with a pair of small apicolateral rods, a central dome with basolateral rods, and a basal loop. Female genitalia: eighth and ninth segments with anterolateral rods, posterior margin of eighth segment with a row of large setae; bursa copulatrix without an apical complex of supporting sclerites, but with a large complex basal group.

LARVA.—Unknown (from Grenada).

PUPA.—Length 2.5 mm. Mandibles sickle shaped, inner surface smooth. Hook-plates present anteriorly on segments 3-7, posteriorly on 3-5, each with many small hooks.

CASE.—Length 4 mm, width 2 mm. Silken, oval, domed, attached to substrate. Pupal case with a tight inner cocoon.

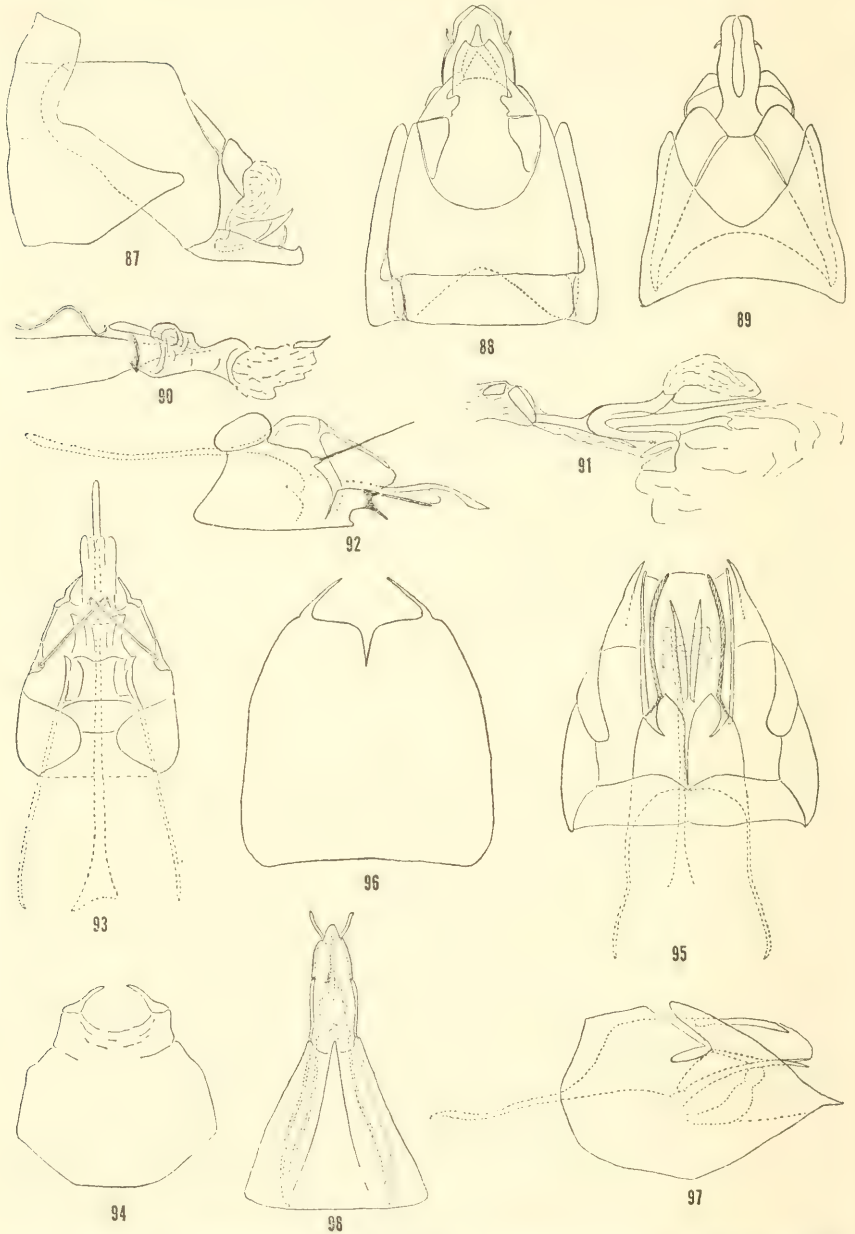
MATERIAL.—Grenada, Beausejour River, 2 miles west of Grand Etang, 4-8 Aug. 1963, O. S. Flint, Jr., many ♂ ♂ ♀ ♀, ♂ ♀ metamorphotypes.

BIOLOGY.—The pupae were taken on rocks in a cascade of a small mountain brook several feet wide by a few inches deep. The adults were attracted to a blacklight placed nearby.

Genus *Alisotrichia* Flint

Alisotrichia Flint, 1964b, p. 46. [Type-species: *Alisotrichia hirudopsis* Flint, 1964b, by original designation.]

Known from Puerto Rico and Jamaica previously, five species are assigned to the genus from Dominica. The typical males have enlarged basal antennal segments that cover the face, only two ocelli, and a spur count of 0, 2, 4. In addition to two species belonging to this typical group, I am assigning three species to this genus that belong to a rather different group. The males of this second group have unmodified antennal segments, three ocelli, and a spur count of 0, 3, 4. The thoracic structure is very similar in the two groups, however, and both have extremely modified genitalia. The female seventh tergum in this second group bears two straplike sclerites, rather than a single triangular one, but both have a simple ringlike bursa copulatrix. The larvae assumed to belong to this second group are very similar to the typical ones but also show several differences. Pending a total review



FIGURES 87-98.—*Leucotrichia sarita* Ross, male: 87, genitalia, lateral; 88, genitalia, dorsal; 89, genitalia, ventral; 90, aedeagus, lateral; 91, female, bursa copulatrix, lateral. *Allotrichia orophila*, new species, male: 92, genitalia, lateral; 93, genitalia, dorsal; 94, eighth sternum, ventral. *A. lobata*, new species: 95, male genitalia, dorsal; 96, male eighth sternum, ventral; 97, male genitalia, lateral; 98, female genitalia, dorsal.

of this group, I prefer to leave both groups in the genus *Alisotrichia*, rather than establish a second genus.

Key to Species

LARVAE

1. Abdominal terga with large, elongate-oval setae *A. species 2*
Abdominal terga with short, truncate setae 2
2. First abdominal tergum with a central dark mark *A. orophila*
First abdominal tergum without a central mark *A. species 1*

ADULTS

1. Midleg without a preapical spur 2
Midleg with a preapical spur 3
2. Eighth sternum of male with a bifurcate ventrolateral lobe; forewing gray, with white patches *A. orophila*
Eighth sternum with a rounded dorsolateral lobe and a pointed ventrolateral lobe *A. lobata*
3. Claspers fused into a single median rodlike process; forewings fuscous with bright green spots *A. septempunctata*
Claspers not fused; without green spots 4
4. With an elongate process extending ventrad from venter of tenth segment *A. dominicensis*
Without an elongate midventral process from tenth sternum *A. wirthi*

Alisotrichia orophila, new species

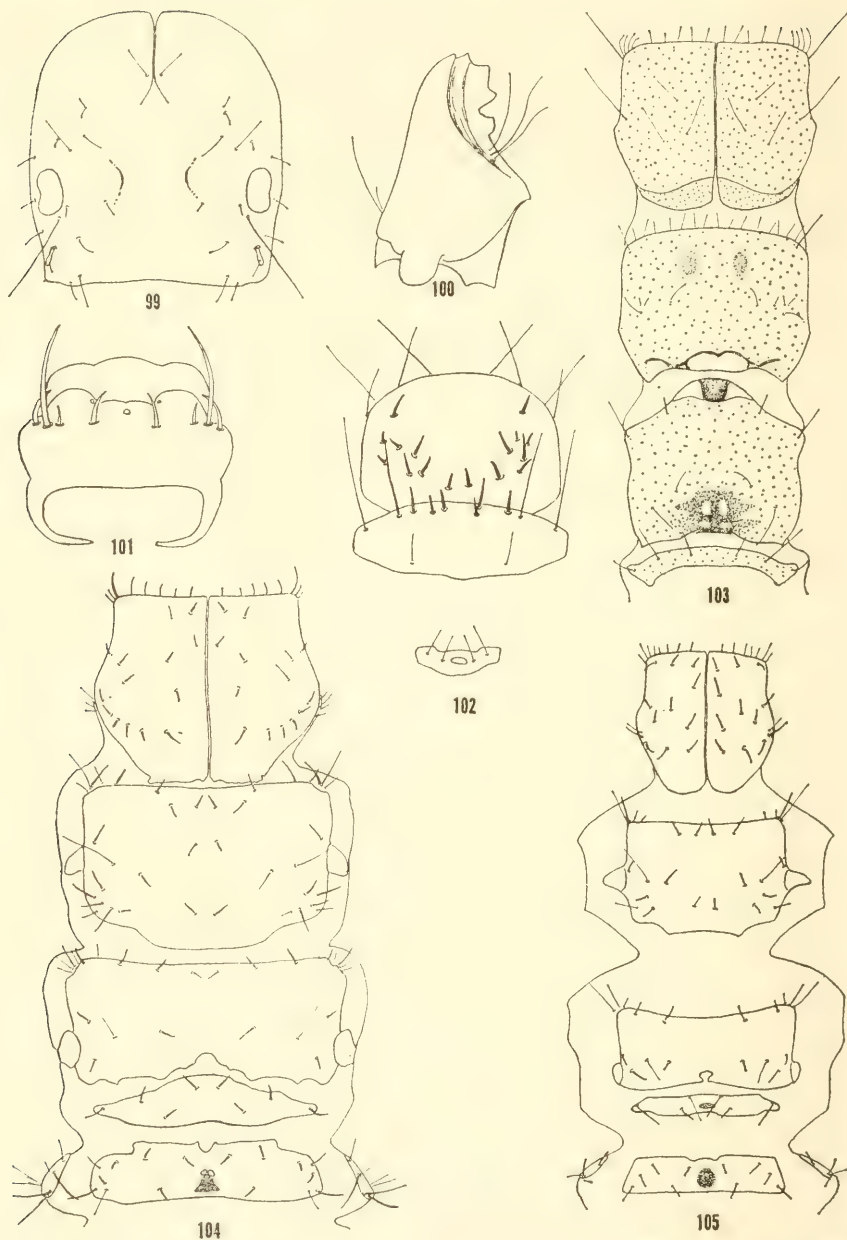
FIGURES 92-94, 105

The species seems to be closely related to the following from which it differs strikingly in the shape of the eighth sternum, which possesses a long dorsolateral spine and a bifurcate apicolateral hook.

ADULT.—Length of forewing 1.5 mm. Color grayish, forewing with alternating bands of silver and fuscous hair. Structure of head and appendages conforming closely to type species. Male genitalia: eighth sternum bearing a long dorsolateral spine, apicolateral angle with a strong mesally directed, shallowly bifurcate hook; ninth segment with extremely long anterolateral rods, with a dorsomesal sclerite; tenth tergum with paired dorsal, straplike sclerites, apex with a semimembranous process; aedeagus tubular, with conical base. Female genitalia: seventh tergum narrowly triangular; eighth and ninth segments with long anterolateral rods; apparently the same as following species.

LARVA.—Length 1.5 mm. Sclerites pale brown. Structurally very similar to larva of type species, but differing in the possession of a tergite on first abdominal segment.

PUPA.—Length 1.2 mm. Mandibles with a short apical blade, lacking mesal serrations. Hook-plates anteriorly on segments 3-7, posteriorly on 3-5; each with many hooks.



FIGURES 99-105.—*Zumatruchia antilliensis*, new species, larva: 99, head, anterior; 100, mandible, dorsal; 101, labrum, dorsal; 102, ninth, eighth, and seventh abdominal terga, dorsal; 103, thorax and first abdominal tergum, dorsal. *Alisotruchia* species 1: 104, larval thorax and first abdominal tergum, dorsal. *A. orophila*, new species: 105, larval thorax and first abdominal tergum, dorsal.

CASE.—Width 1 mm, length 2 mm. Oval, silken, appressed to substrate. Consisting of an outer flange attaching inner cocoon to rock.

MATERIAL.—Holotype, male: Dominica, D'leau Gommier, 15 Feb. 1965, W. W. Wirth, USNM type 69894. Allotype, female: Pont Casse, 2.5 miles east, 16 Jan. 1965, W. W. Wirth, stream margin. Paratype: Pont Casse, .4 miles east, 6 May 1964, O. S. Flint, Jr., 1 ♂. Other: D'leau Gommier, 27 April 1964, O. S. Flint, Jr., 1 larva, 2 pupae, 1 ♂ 1 ♀ metamorphotypes.

BIOLOGY.—The immatures of this species were collected on large stones kept wet by the cascade of a small mountain stream at the place where it emerged from the forest. The habitat is very similar to that of the type-species on Puerto Rico.

Alisotrichia lobata, new species

FIGURES 95-98

The males of this species are easily recognized by the large dorso-lateral lobe of the eighth sternum and the long lateral process of the ninth segment.

ADULT.—Length of forewing 1.5 mm. Color grayish, forewing with alternating bands of silver and fuscus hairs. Corresponding closely to type-species in structure of head and appendages. Male genitalia: eighth tergum narrow, sternum greatly prolonged apicoventrally, with a large dorsolateral lobe, apicoventral angles produced into a sharp spine, midventrally with narrow incision; ninth segment with long, anterolateral, rodlike processes, divided dorsally on midline, with posterolateral swordlike processes; tenth tergum with paired, dorsal, straplike sclerites, with ventrolateral margin sclerotized, ventrally with a complex of sclerites; aedeagus tubular, with base slightly enlarged. Female genitalia: seventh tergum with a narrow, apicomeral, triangular sclerotization; eight and ninth segments with long anterolateral rods; tenth segment with long apical papillae.

LARVA, PUPA, AND CASE.—Not known for certain, but see following species.

MATERIAL.—Holotype, male: Dominica, Clarke Hall, malaise trap, 11-20 Jan. 1965, W. W. Wirth, USNM Type 69895. Allotype, female: Clarke Hall, cocoa trail, 18 Jan. 1965, W. W. Wirth. Paratypes: same data as allotype, 2 ♀; Fond Figues, 3 Feb. 1965, W. W. Wirth, 1 ♂.

BIOLOGY.—The few adults of this species have been taken in proximity to the larger lowland rivers.

Alisotrichia species 1

FIGURE 104

There is a single larva of a species closely related to *A. orophila* in the collections. The larva is a bit larger and the thoracic notae

and abdominal terga possess a few more setae than those of the larvae of *A. orophila*. The first abdominal tergum lacks the central dark mark, and the pores on the following segments are in front of the black mark rather than surrounded by it as in *A. orophila*.

The data with the specimen is: "Pont Casse, .5 miles south, 22-24 July 1963, O. S. Flint, Jr." Because this is a small high altitude stream rather than a lowland stream, I hesitate to definitely attribute this larva to *A. lobata*, to which it may well belong.

Alisotrichia dominicensis, new species

FIGURES 110-114

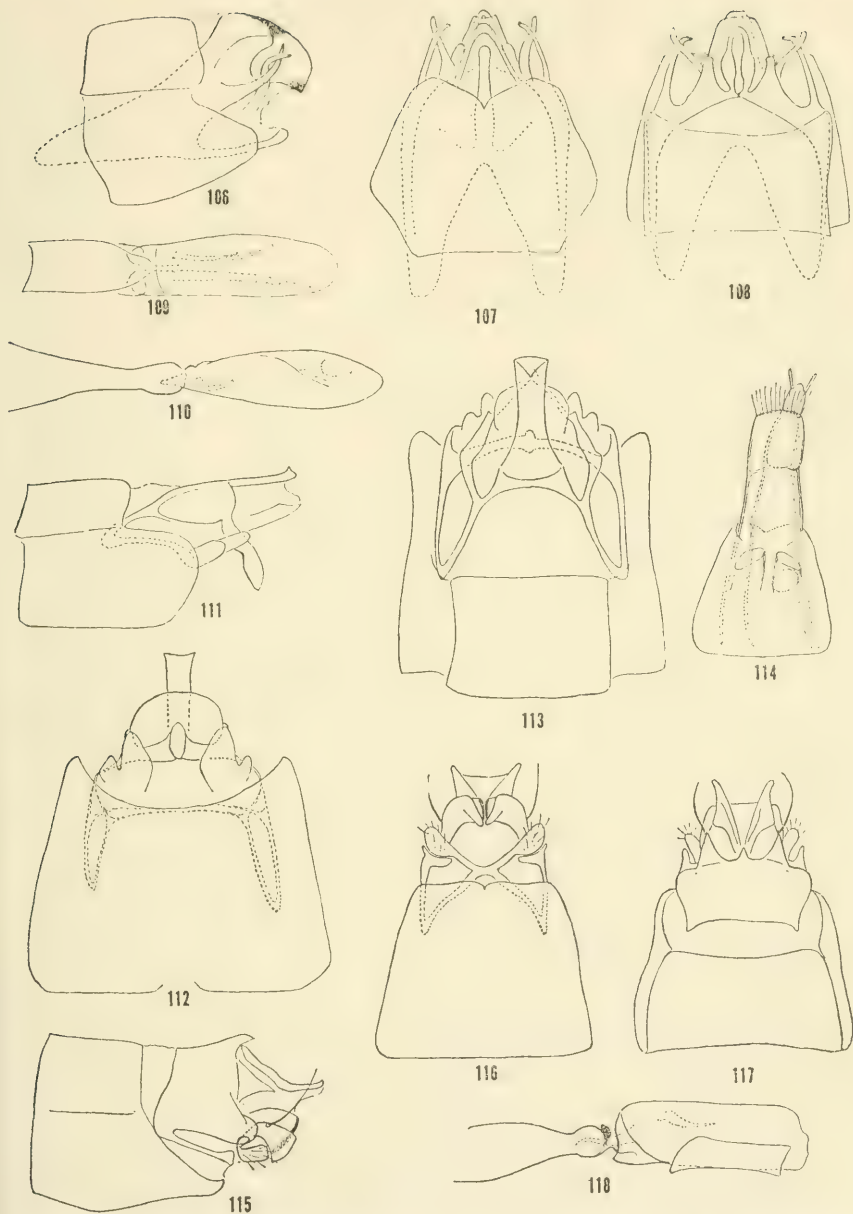
This species is easily recognized by the long ventral process and the middorsal sclerite of the tenth tergum and the bilobed claspers.

ADULT.—Length of forewing 2 mm. Color fuscus; antennae yellowish, face and mesonotum with white hairs, forewing with a white band at midlength and basally. Spurs, 0, 3, 4. Basal antennal segment not modified. Ocelli 3. Maxillary palpus with 2 basal segments minute, third, fourth, and fifth segments elongate, subequal. Male genitalia: seventh sternum with an apicomeresal process; eighth tergum broad, posterior margin of sternum slightly produced laterally, almost squarely truncate lateroventrally; ninth segment produced anterolaterally, with margins heavily sclerotized; claspers arising ventrolaterally from ninth segment, bilobed, semimembranous; tenth tergum with a mesal straplike sclerite upturned apically on dorsum, ventrally with an elongate mesal structure extending directly ventrad; aedeagus mostly membranous, with basal and apical cylindrical portions separated by a constriction, apical portion with indistinct, short, internal spines. Female genitalia: sixth sternum with a small apicomeresal point; seventh sternum with posterior margin slightly bilobed, tergum with a pair of straplike sclerotizations ending in an oval mark; eighth and ninth segments with long lateral rods, eighth with a row of setae along posterior margin; bursa copulatrix an internal sphere.

LARVA, PUPA, AND CASE.—Not known for certain, but see *Alisotrichia* species 2.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 2.2 miles east, 7 May 1964, O. S. Flint, Jr., USNM Type 69896. Allotype, female: Pont Casse, 2.5 miles east, 16 Jan. 1965, W. W. Wirth. Paratypes: same data as holotype, but 3 May 1964, 1 ♀; same data as allotype, 2 ♀; Fond Figues, 25 Jan. 1965, W. W. Wirth, 2 ♂; Morne Nicholls, 9 Nov. 1964, P. J. Spangler, 1 ♀.

BIOLOGY.—The adults were taken near either a small cascading mountain brook or a larger lowland river also with some cascades.



FIGURES 106-118.—*Alisotrichia septempunctata*, new species, male: 106, genitalia, lateral; 107, genitalia, ventral; 108, genitalia, dorsal; 109, aedeagus, dorsal. *A. dominicensis*, new species: 110, aedeagus, lateral; 111, male genitalia, lateral; 112, male genitalia, ventral; 113, male genitalia, dorsal; 114, female genitalia, dorsal. *A. wirthi*, new species, male: 115, genitalia, lateral; 116, genitalia, ventral; 117, genitalia, dorsal; 118, aedeagus, lateral.

Alisotrichia wirthi, new species

FIGURES 115-118

This species is closely related to the preceding, from which it is easily separated by the very different claspers and tenth tergum.

ADULT.—Length of forewing 2.5 mm. Color in alcohol uniformly fuscus. Basal antennal segments unmodified. Ocelli 3. Maxillary palpus with 2 basal segments very short, apical segments long, each slightly longer than preceding. Spurs 0, 3, 4. Abdominal sterna lacking processes. Male genitalia: eighth tergum broad, sternum produced ventrally, truncate in ventral aspect; ninth segment quadrate, with a middorsal point, a small lateral flap, and a ventral rodlike support; claspers with a ventrolateral lobe, and a flattened mesal lobe bearing a stout setae from its dorsal margin; tenth tergum consisting of paired elongate dorsal sclerites, a triangular lateral sclerite, and flattened ventromesal sclerites lying within the mesal lobes of the claspers; aedeagus with cylindrical basal and apical portions separated by a constriction, apical portion with an indistinct internal spine, with outer surface sclerotized in basoventral region.

LARVA, PUPA, AND CASE.—Not known.

MATERIAL.—Holotype, male: Dominica, Fond Figues, 13 March 1965, W. W. Wirth, USNM Type 69897. Paratype: same, but 6 April 1964, O. S. Flint, Jr., 1 ♂.

BIOLOGY.—Both specimens were taken at light near a large, clear, fast-flowing lowland river.

Alisotrichia septempunctata, new species

FIGURES 106-109

Both the coloration of this species and the unique structure of the genitalia are diagnostic.

ADULT.—Length of forewing 2.5 mm. Black, each forewing with 3 bright green spots, mesonotum with a green mesal spot. Basal antennal segment unmodified. Ocelli 3. Maxillary palpus with 2 basal segments very short, third and fifth long, subequal, fourth $\frac{2}{3}$ length of third. Male genitalia: no processes from sterna; eighth tergum broad, sternum produced ventrolaterally, posterior margin broadly V-shaped in ventral aspect; ninth segment with ventrolateral angles prolonged anteriorly, with posterior margin produced into an upturned, swordlike process; claspers completely fused, developed as a long, slender rodlike process from apex of ninth sternum; a terete, semimembranous process arising mesad of lateral process of ninth segment; tenth tergum flattened, developed as broad lateral plates with an apicoventral point, dorsally with a pair of mesal parenthesis-like sclerites; aedeagus with apical and basal cylindrical portions

separated by a constriction, apical portion with several pairs of elongate internal spines.

LARVA, PUPA, AND CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 2.2 miles east, 14 April 1964, O. S. Flint, Jr., USNM Type 69898.

BIOLOGY.—The only known specimen was taken at a black light at a small tumbling brook.

Alisotrichia species 2

FIGURE 85

I am here describing the larvae of a species that is clearly related to *Alisotrichia* although they do possess a number of unique characteristics. The possession of numerous small intercalary sclerites on the thorax and abdomen, and the large, elongate-oval setae are very distinctive.

It seems quite probable that these are the larvae of one of the last three species.

LARVA.—Length 3.5 mm. Sclerites brown. Slightly flattened, abdomen gradually tapering toward posterior. Structurally much like the larva of type-species, differing as follows. Thoracic notae and abdominal tergites bearing long, broad, pointed, black setae; propleuron with 1, meso- and metapleura with 2 of these setae. Meso- and metanota anteriorly and abdominal terga posteriorly with a broad border of sclerotized spots. Small intercalary sclerites present between segments from the mesonotum to the eighth segment. Abdomen with 9 tergites; that of first segment barely different from those of segments beyond.

MATERIAL.—Dominica, R. Laurent, 21 July 1963, O. S. Flint, Jr., 1 larva. Geneva Estate, 9 Dec. 1964, P. J. Spangler, 1 larva. Fond Figues R., 9 Feb. 1965, W. W. Wirth, 1 larva.

BIOLOGY.—The larvae were collected from boulders in rocky sections of swiftly flowing lowland rivers.

Genus *Neotrichia* Morton

Neotrichia Morton, 1905, p. 72. [Type-species: *Neotrichia collata* Morton, 1905, by monotypy.]

The genus contains numerous species, all of New World distribution. The species are all very small, generally being less than two millimeters long.

The larvae were described by Flint (1964b) and Ross (1944). They construct small, cylindrical cases made of very small sand grains.

Key to Species

ADULT

- Male genitalia with subgenital plate elongate, directed posteriad; female eighth sternum with a large heart-shaped midventral lobe *N. iridescens*
 Male subgenital plate with apex slender, angled sharply ventrad; female eighth sternum without midventral lobe *N. corniculans*

Neotrichia iridescens Flint

FIGURES 119-123

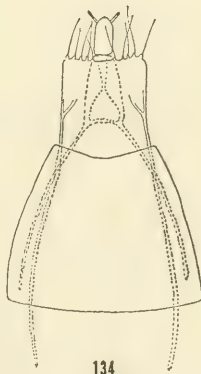
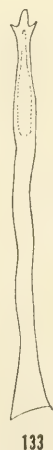
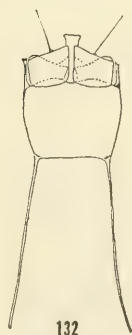
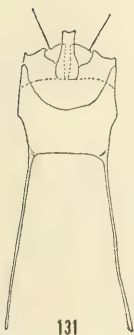
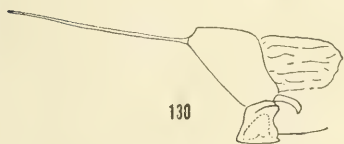
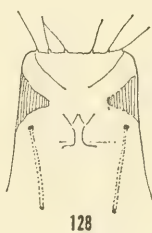
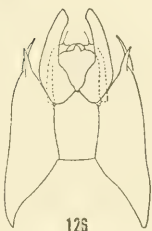
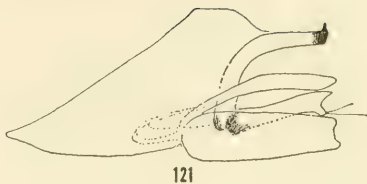
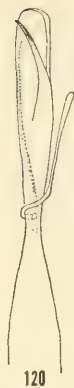
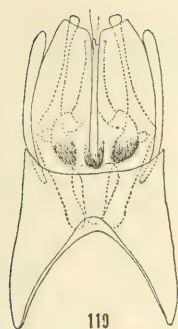
Neotrichia iridescens Flint, 1964b, p. 51; 1968a, p. 37.

Originally described from Puerto Rico, this species has since been recorded from Jamaica and is now recorded from Dominica and St. Lucia.

The Dominican examples agree closely with the type except that the darker ventral processes of the subgenital plate are nearer its apex. The St. Lucian specimens seem to have a narrower and more twisted apex of the aedeagus and the dorsolateral process of the ninth segment has both dorsal and ventral points apically.

ADULT.—Length of forewing 1.5-2 mm. Color mottled grayish brown; forewing of female with a patch of purplish iridescent scales centrally. Male genitalia: ninth segment produced basoventrally, posterior margin with a dorsolateral process whose tip is developed into a dorsal (and sometimes ventral) point; clasper elongate and rectangular in lateral view, in ventral view with apex obliquely truncate; bracteole slender, arising near base of clasper; subgenital plate elongate, slender, with dark, ventrally directed lobes at midlength; aedeagus with a membranous process arising near midlength, and a more strongly sclerotized process near apex, central tube trough shaped apically. Female genitalia: eighth sternum with anterior margin heavily sclerotized, with a pair of short anterolateral rods, mesally with a heart-shaped lobe, and posteriorly with a rectangular sclerite, posterior margin with 3 pairs of setae; bursa copulatrix elongated apically, basolateral angles rodlike, with a basomesal complex.

FIGURES 119-135.—*Neotrichia iridescens* Flint: 119, male genitalia, ventral; 120, aedeagus, dorsal; 121, male genitalia, lateral; 122, female eighth sternum, ventral; 123, bursa copulatrix, ventral. *N. corniculans* new species: 124, male genitalia, lateral; 125, male genitalia, dorsal; 126, male genitalia, ventral; 127, aedeagus, dorsal; 128, female eighth sternum, ventral; 129, bursa copulatrix, ventral. *Bredinia dominicensis*, new species: 130, male genitalia, lateral; 131, male genitalia, dorsal; 132, male genitalia, ventral; 133, aedeagus, dorsal; 134, female genitalia, ventral; 135, bursa copulatrix, ventral.



LARVA.—Length to 2 mm. Nearly cylindrical in outline. Sclerites pale yellowish. Head with a spinelike process behind eyes. Apical abdominal segments with many long, dark setae; anal prolegs elongate.

CASE.—Nearly cylindrical, posterior slightly flattened and tapered. Made of very small sand grains.

MATERIAL.—Dominica, Clarke Hall, 11–20 Jan. 1965, W. W. Wirth, 1 ♂; same, but 21–29 April 1964, O. S. Flint, Jr., 1 ♂ 1 ♀; Pont Casse, .4 miles east, 25 June 1964, O. S. Flint, Jr., 1 pupa; Pont Casse, 1.6 miles west, 24 April 1964, O. S. Flint, Jr., 2 cases. St. Lucia, Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, 6 ♂ 3 ♀, 3 larvae, 2 pupae.

BIOLOGY.—The immature stages are found on rocks in the more slowly flowing sections of both the larger and small rivers.

Neotrichia corniculans, new species

FIGURES 124–129

This species appears to be related to the group of species named *Dolotrichia* by Mosely. From all known species it is easily recognized by the hornlike shape of the tenth tergite and the shape of the claspers.

ADULT.—Length of forewing 1.5 mm. Color silvery gray. Male genitalia: ninth segment rounded anteriorly, posterior margin developed into a thin lateral shelf that bears two pointed processes, dorsal one longest; tenth tergum developed as a pair of curving hornlike processes directed first laterad then posteriad; subgenital plate long, attenuate, and angled sharply ventrad; clasper elongate, slightly narrowed apically; aedeagus with apical half divided into two processes, longer one twisted apically and with a bifid tip, a whiplike process arising at midlength. Female genitalia: eighth sternum with a dark lateral mark and a small raised central structure shaped like an arrowhead; bursa copulatrix elongate with a basal opening and two pairs of lateral pouchlike invaginations.

LARVA, PUPA, AND CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, D'leau Gommier, 16 March 1965, W. W. Wirth, USNM Type 69899. Allotype, female: same data. Paratypes: same data, 1 ♀; same, but 15 Feb. 1965, 3 ♂ 3 ♀; Pont Casse, 1.0 mile east, 29 Jan. 1965, W. W. Wirth, 1 ♀.

BIOLOGY.—Little is known of the biology of this species. The adults have been taken only at higher elevations on the island.

Bredinia, new genus

Three ocelli. Spurs 0, 2, 4. Mesoscutellum divided by a transverse suture, with a broad sclerite along posterior margin. Metascutellum

as wide as scutum, short and rectangular. Wings narrow, evenly acuminate.

Type-species: *Bredinia dominicensis*, new species.

The relationship of the genus is rather obscure. It would seem to be most closely related to *Neotrichia* as is shown by the presence of ocelli, minute size, and wing shape. The spur count is the same as is found in *Mayatrichia*, a genus closely related to *Neotrichia*; however, the structure of the thoracic notae (almost exactly as shown in Ross, 1944, fig. 438) is totally different from *Neotrichia* or *Mayatrichia* in which the mesoscutellum is entire and the metascutellum trianguloid. It may well be that the genus is related to *Alisotrichia* as is suggested by the structure of the thorax and dorsolateral rods of the male ninth segment. The discovery of the larval stages will be necessary to settle the exact relationship of the genus.

It is with great pleasure that I name this genus for Mr. J. Bruce Bredin.

Bredinia dominicensis, new species

FIGURES 130-135

Since this is the only known species in the genus, it is not possible to point out specific characters.

ADULT.—Length of forewing 1.5 mm. Color silvery gray, forewing with bands of white hair apically and basally. Male genitalia: eighth sternum divided midventrally; ninth segment narrow, oblique, lateral halves divided ventrally by the claspers, anterior margin with long, slender supports dorsolaterally; tenth tergum a large membranous lobe; clasper rather quadrate, with narrow dorsal and ventral ridges, a long seta from ventral ridge; subgenital plate elongate, rectangular, slightly widened apically; aedeagus tubular, apex flattened, tridentate, with a central tubule in apical fourth. Female genitalia: seventh segment with apical margin squarely truncate; eighth segment simple, with anterolateral rods, and a row of setae along posterior margin; ninth segment elongate with anterolateral rods; tenth segment trianguloid, with apical papillae; bursa copulatrix with a long basomesal process and a pair of basolateral tubules, a central complex, apically with a pair of dark oval sclerites.

LARVA, PUPA, AND CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, Hodges River mouth, swamp forest, 27 Feb. 1965, W. W. Wirth, USNM Type 69900. Allotype, female: same data. Paratypes: same data, 1 ♂; Fond Figue, 3 Feb. 1965, W. W. Wirth, 1 ♂; same, but 13 March 1965, 2 ♀.

BIOLOGY.—The adults have been taken only near the larger lowland rivers.

Genus *Oxyethira* Eaton

Oxyethira Eaton, 1873, p. 143. [Type-species: *Hydroptila costalis* Curtis, 1834, by original designation.]

Oxyethira is a genus of worldwide distribution, containing numerous species in most regions. Each of the Antillean islands support several species.

The immature stages and the cases they make are very similar throughout the genus. Nielsen (1948) has given an excellent account of the morphology and biology of the immature stages of the type-species.

Key to Species

ADULTS

- | | |
|---|---------------------|
| 1. With aedeagus, etc.: males | 2 |
| Without aedeagus: females | 5 |
| 2. Ninth sternum elongate, scooplike, apex bifid | 3 |
| Ninth sternum not elongated | 4 |
| 3. Ninth sternum deeply and widely divided apically. | <i>O. azteca</i> |
| Ninth sternum with a short, narrow apical division | <i>O. janella</i> |
| 4. Eighth segment dorsally with a sabre-like process, with a broad lateral flap. | |
| | <i>O. cirrifera</i> |
| Eighth segment with a pair of short, flattened dorsal lobes, and erect dorso-lateral lobe | <i>O. tega</i> |
| 5. Bursa copulatrix with paired, long, rodlike, anterior and posterior supports. | |
| | <i>O. janella</i> |
| Bursa without rodlike supports | 6 |
| 6. Eighth sternum with sclerotized apicolateral invaginations | <i>O. cirrifera</i> |
| Eighth sternum without invaginations | 7 |
| 7. Bursa rounded basally, shield shaped, with earlike apical lobes | <i>O. tega</i> |
| Bursa angulate basolaterally and mesally, apical lobes not earlike. | |
| | <i>O. azteca</i> |

Oxyethira janella Denning

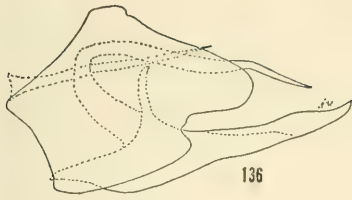
FIGURES 136-137, 148

Oxyethira janella Denning, 1948, p. 397.—Flint, 1968a, p. 42.

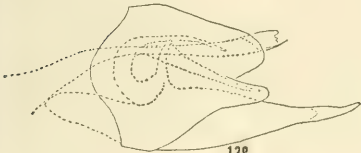
Oxyethira neglecta Flint, 1964b, p. 57; 1968a, p. 42.

This species appears to be the most widespread Antillean caddisfly. It has been found on Jamaica, Puerto Rico, Dominica, St. Lucia,

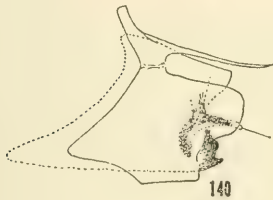
FIGURES 136-149.—*Oxyethira janella* Denning, male genitalia: 136, lateral; 137, dorsal. *O. azteca* Mosely, male genitalia: 138, lateral; 139, dorsal. *O. cirrifera* Flint, male genitalia: 140, lateral; 141, ventral. *O. tega* Flint, male genitalia: 142, lateral; 143, ventral. *O. cirrifera* Flint: 144, aedeagus, lateral. *O. tega* Flint: 145, aedeagus, dorsal; 146, female genitalia, ventral. *O. cirrifera* Flint: 147, female genitalia, ventral. *O. janella* Denning: 148, female genitalia, ventral. *O. azteca* Mosely: 149, female genitalia, ventral.



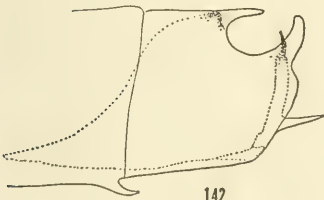
136



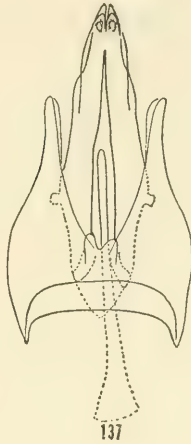
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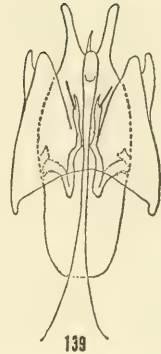
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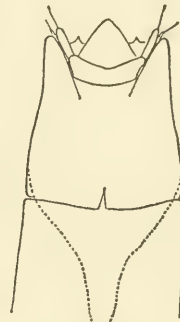
137



139



141



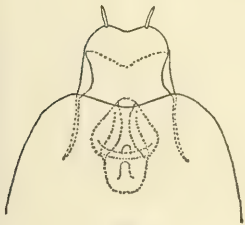
143



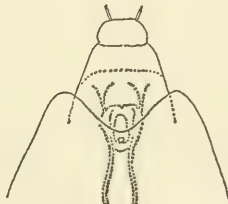
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145



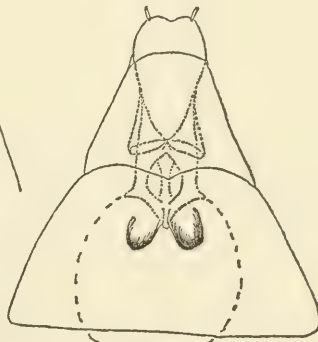
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148



147



149

Grenada, in Florida, and in Central America. It is closely related to *O. puertoricensis* Flint and *O. azteca* Mosely. From both it differs in the male sex in the long narrow ninth sternum.

ADULT.—Length of forewing 2–3 mm. Color various shades of brown and white. Seventh sternum with a small spine posteromesally. Male genitalia: eighth segment surrounding most of genital capsule, divided ventromesally, with dorsolateral lobe surpassing ventrolateral lobe; ventral part of ninth segment narrow, scooplike much surpassing eighth segment, dorsal structure Y-shaped; aedeagus a single spinelike structure resting in fork of the Y. Female genitalia: eighth sternum with posterior margin bilobate; bursa copulatrix with anterior processes twice length of bursa.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Dominica, Clarke Hall, 11–20 Jan. 1965, W. W. Wirth, 2♂ 3♀; same, but 21–30 Jan. 1965, 1♂ 4♀; same, but 27 Jan. 1965, J. F. G. Clarke, 2♀; same, but 1–10 Feb. 1965, W. W. Wirth, 1♀; same, but 11–20 Feb. 1965, 2♂ 13♀; same, but 18 Feb. 1964, D. F. Bray, 1♀; same, but 21–28 Feb. 1965, W. W. Wirth, 2♀; same, but 25 Feb. 1964, D. F. Bray, 4♀; same, but 1–10 March 1965, W. W. Wirth, 6♀; same, but 11–20 March 1965, 3♀; same, but 21–30 March 1965, 3♀; same, but 10–20 April 1964, O. S. Flint, Jr., 12♀; same, but 21–29 April 1964, 7♂ 61♀; same, but 1–10 May 1964, 1♂ 1♀; same, but 11–20 May 1964, 3♂ 19♀; same, but 1–15 June 1964, 11♀; same, but 15–30 June 1964, 11♂ 106♀; Layou Valley, 23–25 July 1963, O. S. Flint, Jr., 1♀; Springfield Estate, 20–26 July 1963, O. S. Flint, Jr., 5♀; Fond Figue, 13 March 1965, W. W. Wirth, 2♂ 32♀; same, but 6 April 1964, O. S. Flint, Jr., 1♂; same, but 7 May 1964, 1♂ 2♀; Grand Bay, 13 March 1964, D. F. Bray, 1♀; same, but 13 April 1964, O. S. Flint, Jr., 3♀; Pont Casse, 1.6 miles west, 24 April 1964, O. S. Flint, Jr., 1♀; same, but 28 April 1964, 1♀; same, but 19 May 1964, 1♂ 4♀; same, but 16 June 1964, 2♂ 4♀; Pont Casse, 3.5 miles north, 5 Dec. 1964, P. J. Spangler, 3♀; Pont Casse, 1.3 miles east, 10 May 1964, O. S. Flint, Jr., 1♀; same, but 12 May 1964, 1♀; Pont Casse, 2.2 miles east, 1 May 1964, O. S. Flint, Jr., 4♀; same, but 19 June 1964, 10♀; Pont Casse, 3 miles east, 13–16 Oct. 1966, A. B. Gurney, 1♂ 3♀; Pont Casse, .4 mile east, 6 May 1964, O. S. Flint, Jr., 2♀; Sylvania, 23 Jan. 1965, W. W. Wirth, 7♂ 14♀. St. Lucia, Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, 1♀; Cul de Sac River, at mile post 9, 27 July 1963, Flint and Cadet, 5♀. Grenada, 2 miles west of Grand Etang, 4–8 Aug. 1963, O. S. Flint, Jr., 7♂ 9♀.

BIOLOGY.—Although the immature stages of this species have not been taken, they will probably be found in most flowing water habitats. Adults have been attracted to lights at most elevations on many of the islands.

Oxyethira azteca (Mosely)

FIGURES 138–139, 149

Loxotrichia azteca Mosely, 1937, p. 165.

Oxyethira azteca (Mosely).—Ross, 1944, p. 295.

This species described from Mexico, where it is quite common, will undoubtedly be found to be widely distributed in Central and northern South America. It is here recorded from Grenada for the first time.

The species is related to *O. janella* but is easily recognized by the more deeply divided ninth sternum and the very different dorsal processes of the same segment.

ADULT.—Length of forewing 2 mm. Color various shades of brown and white. Male genitalia: eighth segment divided midventrally and dorsally, posterolateral margin bilobate; ninth sternum produced posteriorly, deeply divided apically, dorsally giving rise to a pair of curving rods laterad to the aedeagus, each with an apical spine, ventrad to aedeagus a mesal, pointed structure; aedeagus tubular, basally expanded. Female genitalia: eighth sternum with posterior margin slightly bilobate, with a pair of ovate depressions; bursa copulatrix with posteriolateral supports, with basal portion angulate, complex, with a large basal membranous sac.

LARVA, PUPA, CASE.—Not known for certain.

MATERIAL.—Grenada, 2 miles west of Grand Etang, 4–8 Aug. 1963, O. S. Flint, Jr., 24♂ 11♀. Balthazar, 7 Aug. 1963, O. S. Flint, Jr., 1♂ 2♀.

BIOLOGY.—A number of typical larvae and pupae of this genus were taken on rocks in the small brook two miles west of Grand Etang and may belong to either this or the preceding species. The stream is about three feet wide by six inches deep on the average, clear, and tumbling over bedrock and boulders.

Oxyethira cirrifera Flint

FIGURES 140–141, 144, 147

Oxyethira cirrifera Flint, 1964b, p. 57; 1968a, p. 42.

The species was described from Puerto Rico and has since been found on Jamaica, and now Dominica. It is related to the following species, from which it differs most noticeably in the structure of the eighth segment and aedeagus.

ADULT.—Length of forewing 2 mm. Color pale brown with some darker flecks. Male genitalia: eighth tergum produced laterally into a long saber-like process, sternum produced dorsolaterally in a broad flap; clasper dark, tightly attached to ninth sternum, quadrate in ventral aspect; subgenital plate C-shaped in lateral aspect, in ventral aspect produced into 2 submesal points; an elongate, seta-bearing rod dorsal of clasper; aedeagus with a flattened process arising at midlength and twisted around central tube $1\frac{1}{4}$ times; central tube attenuate beyond origin of process, tip slightly twisted. Female genitalia: eighth sternum produced as a semicircular flap mesally, apicolaterally with sclerotized, pouchlike invaginations; bursa copulatrix short with a pair of jawlike apical processes.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Dominica, Cabrit Swamp, 23 Feb. 1965, W. W. Wirth, 12♀; same, but 18 June 1964, O. S. Flint, Jr., 2♂ 2♀.

BIOLOGY.—The species has been taken on the island of Dominica only near a large lowland swamp with slowly flowing streams. It has been found, however, near fast waters on other islands.

Oxyethira tega Flint

FIGURES 142-143, 145-146

Oxyethira tega Flint, 1968a, p. 44.

This species recently described from Jamaica is here recorded from Dominica. The species is easily distinguished from the preceding by the shape of the eighth segment, claspers, and aedeagus.

ADULT.—Length of forewing 2-2.5 mm. Color pale brown, with darker flecks. Male genitalia: eighth segment with a pair of flat dorsomesal lobes, and an erect dorsolateral lobe; anterior margin of ninth segment developed into a rounded lobe; claspers forming a ribbon-like band along ventral margin of ninth segment; subgenital plate developed into a triangular plate beneath aedeagus in ventral aspect, with lateral processes surrounding aedeagus, and developed into dorsal points; two pairs of membranous rods above clasper; aedeagus with apical half divided into 2 processes, 1 of which bears an internal tubule. Female genitalia: eighth sternum slightly bilobate; ninth sternum sclerotized laterally; bursa copulatrix shield shaped with a central opening, and a pair of apicolateral earlike flaps.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Dominica, Freshwater Lake, 21 Jan. 1965, W. W. Wirth, 1♂; same, but 22 Feb. 1964, D. F. Bray, 5♂ 7♀; Sylvania, 23 Jan. 1965, W. W. Wirth, 3♂ 3♀; Clarke Hall, 21-31 Jan. 1965, W. W. Wirth, 1♂; same, but 1-10 Feb. 1965, 1♀; same, but 11-20 Feb. 1965, 2♂ 4♀; same, but 21-28 Feb. 1965, 1♂; same, but 1-10 March 1965, 1♂; same, but 21-31 March 1965, 2♂ 1♀; same, but 21-29 April 1964, O. S. Flint, Jr., 1♀; same, but 15-30 June 1964, 4♂ 4♀; Mannett Gutter, 10 March 1965, W. W. Wirth, 1♀; Grand Bay, 13 April 1964, O. S. Flint, Jr., 1♂; Fond Figures, 13 March 1965, W. W. Wirth, 3♂ 2♀.

BIOLOGY.—The adults have been taken at light both near the larger lowland rivers, and a highland lake.

Genus *Hydroptila* Dalman

Hydroptila Dalman, 1819, p. 125. [Type-species: *Hydroptila tincoides* Dalman, 1819, by monotypy.]

The genus *Hydroptila* has been found in all the faunal realms of the world. One or two species have been encountered on each of the Antillean islands that have been collected in depth.

The immature stages have been described in detail by Nielsen (1948). They inhabit in the final instar a "purse-case" made of silk, often incorporating sand and plant matter.

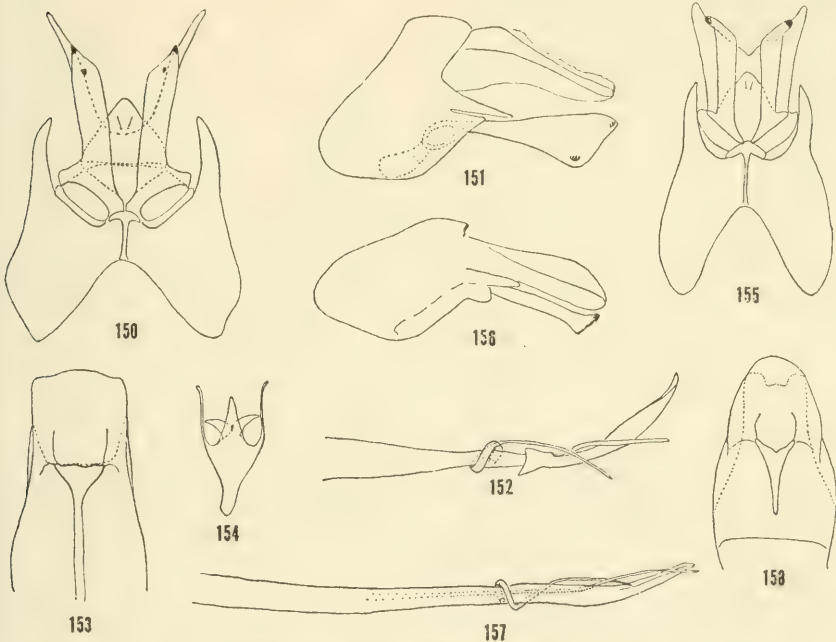
Key to Species

ADULTS

Clasper of male in lateral aspect very narrow, developed into an apicodorsal point; eighth tergum of female slightly less produced than sternum, trilobate.

H. grenadensis

Clasper broader, widening regularly from base to apex; eighth tergum deeply and rectangularly emarginate **H. antillarum**



FIGURES 150-158.—*Hydroptila antillarum*, new species: 150, male genitalia, ventral; 151, male genitalia, lateral; 152, aedeagus, lateral; 153, female eighth sternum, ventral; 154, bursa copulatrix, ventral. *H. grenadensis*, new species: 155, male genitalia, ventral; 156, male genitalia, lateral; 157, aedeagus, lateral; 158, female eighth sternum, ventral.

Hydroptila antillarum, new species

FIGURES 150-154

This species is related to a species from Mexico that I believe to be *H. paschia* Mosely. From this species it differs in the more deeply divided tenth tergum, longer claspers, and smaller membranous process of the aedeagus.

ADULT.—Length of forewing 2 mm. Color brown, mottled with patches of white hair. Male genitalia: ninth segment with anterior margin slightly expanded ventrally, posterior margin developed into a sharp point laterad of clasper; tenth tergum with declivent, sclerotized, lateral band, divided dorsally almost to base; clasper evenly

expanded toward apex in lateral view, with two dark lateral points, in ventral view almost parallel sided; aedeagus with a flattened, heavily sclerotized, apical portion, giving rise subbasally to a membranous process, twisted process wrapped around apical section $1\frac{1}{2}$ times, shorter than apical section. Female genitalia: eighth sternum elongate apically, dorsal margin deeply and rectangularly emarginate, midventral mark goblet shaped, with a long stem; bursa copulatrix with lyre-shaped apicolateral arms, a starlike central complex and a short basal stem.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 1.6 miles west, 27 June 1964, O. S. Flint, Jr., USNM type 69901. Allotype, female: Clarke Hall, 11–20 Feb. 1965, W. W. Wirth. Paratypes: same data as allotype, 1 ♀; same, but 21–31 March 1965, 1 ♀; same, but 11–20 May 1964, O. S. Flint, Jr., 1 ♀; same, but 15–30 June 1964, 1 ♀; Fond Fignes, 7 May 1964, O. S. Flint, Jr., 1 ♀. Other: St. Lucia, Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, 1 ♀.

BIOLOGY.—The adults have been taken at light primarily in the lowlands, but the holotype was taken near a slowly flowing, small highland stream.

Hydroptila grenadensis, new species

FIGURES 155–158

This species is quite closely related to the preceding although there is considerable difference in the shape of the clasper, which is very narrow with an apicodorsal point.

ADULT.—Length of forewing 2 mm. Color pale brown, forewing mottled with brown and white. Male genitalia: ninth segment rounded anteriorly, with a sharp spine from posterior margin laterad of clasper; tenth tergum sclerotized laterally, with dorsum divided mesally about a third of its length; clasper narrow, apex developed into a distinct dorsolateral point bearing a black spot; aedeagus flattened apically with a membranous process exiting from near its base, twisted process wrapped around stem $1\frac{1}{2}$ times, shorter than apical portion. Female genitalia: eighth segment with posteroventral margin evenly rounded, dorsal margin shallowly emarginate, trilobate, ventral surface with a goblet-shaped mark; bursa copulatrix identical to that of preceding.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Holotype, male: Grenada, 2 miles west of Grand Etang, 4–8 Aug. 1963, O. S. Flint, Jr., USNM Type 69902. Allotype, female: same data. Paratypes: same data, 3 ♂ 4 ♀; Bathazar, 7 Aug. 1964, O. S. Flint, Jr., 15 ♀.

BIOLOGY.—The adults have been taken near both a large, rapid lowland river and a small, tumbling mountain brook.

Genus *Ochrotrichia* Moesly

Ochrotrichia Mosely, 1934, p. 162. [Type-species: *Ochrotrichia insularis* Mosely, 1934, by original designation.]

The genus, which is of exclusively New World distribution, is divided into two subgenera, *Metrichia* and *Ochrotrichia*. The adults of the former are easily recognized by the presence of an apical spur on the foreleg.

The mature larvae inhabit compressed, purse-shaped cases, similar in appearance to those of *Hydroptila*. To date no characteristics have been found that will serve to separate the larvae of the two subgenera. The larvae of *Metrichia* were described by Flint (1964b); and *Ochrotrichia*, by Ross (1944).

Key to Species

ADULTS

- 1. With claspers and aedeagus: males 2
Without claspers and aedeagus: females 7
- 2. Foretibia without apical spur 3
Foretibia with apical spur 5
- 3. Clasper short with posterior margin developed into many spurs. **O. spinosissima**
Clasper elongate, not developed into spurs 4
- 4. Clasper elongate, parallel sided, produced into an apicodorsal lobe. **O. brayi**
Clasper shorter, higher, hind margin bilobate **O. ponta**
- 5. Abdominal segments 4 and 5 with hair tufts and internal sacs. **O. exclamatoris**
These segments unmodified 6
- 6. Apicodorsal lobe of clasper narrowed and developed into a spur. . **O. campana**
Apicodorsal lobe pointed, but not spurlike **O. similis**
- 7. Without apical spur on foretibia 8
With apical spur on foretibia 9
- 8. Eighth sternum with a tongue-like process posteriorly . . . **O. spinosissima**
Eighth sternum with a small mesal lobe **O. ponta**
- 9. Eighth sternum with a large internal sclerite **O. species 2**
Eighth sternum with a posterior collar, but no internal plate . . **O. species 1**

Ochrotrichia (O.) spinosissima Flint

FIGURES 159-163

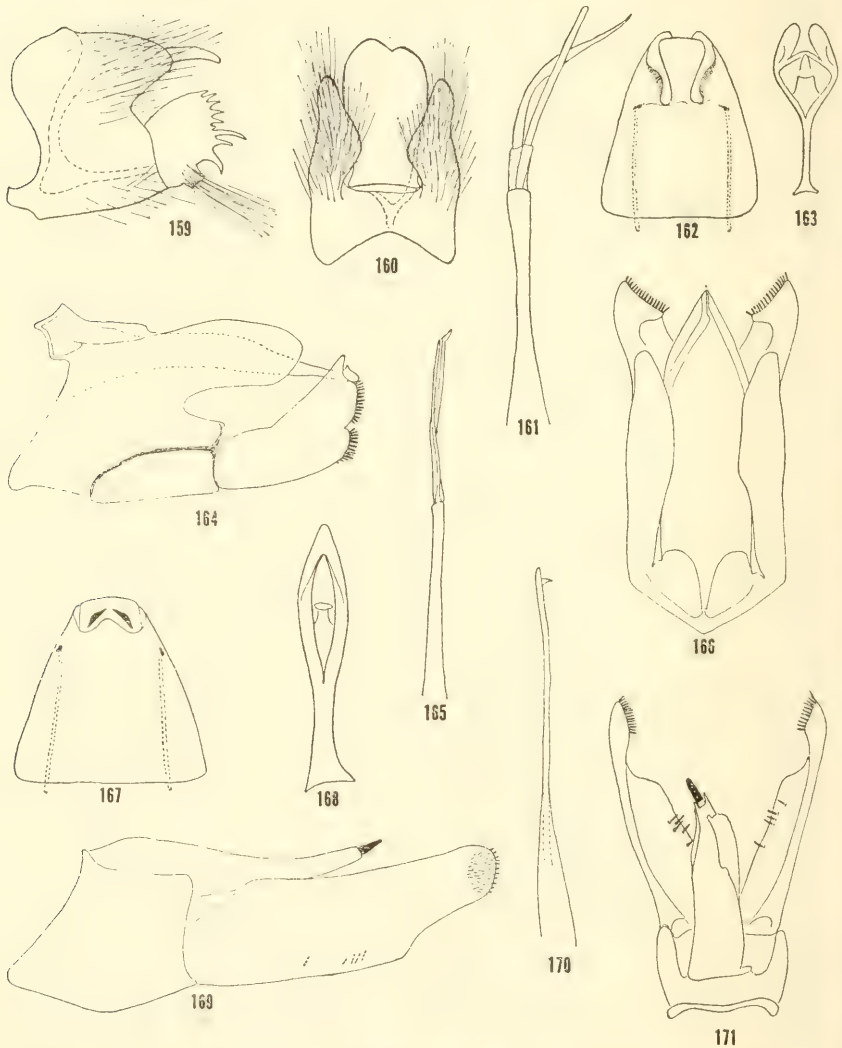
Ochrotrichia spinosissima Flint, 1964b, p. 58.

The species was described from Puerto Rico. The shape of the clasper and aedeagus is distinctive.

The female is ascribed to this species primarily on coloration, which is quite different in *O. brayi*, the only other species of the subgenus in which the female is unknown.

ADULT.—Length of forewing 2-2.5 mm. Color black, legs annulate, forewing with a narrow transverse white band, and small white spots

apically. Male genitalia: ninth segment developed into a large rounded flap dorsolaterally; clasper short, rather quadrate in lateral view, with a small basoventral lobe; posterior margin developed into numerous short spurs, ventral one heaviest and curving mesad; tenth tergum a simple, broad flap, apex slightly bilobed and asymmetrical; aedeagus



FIGURES 159-171.—*Ochrotrichia* (*O.*) *spinosissima* Flint: 159, male genitalia, lateral; 160, male genitalia, dorsal; 161, aedeagus, dorsal; 162, female eighth sternum, ventral; 163, bursa copulatrix, ventral. *O.* (*O.*) *ponta*, new species: 164, male genitalia, lateral; 165, aedeagus, dorsal; 166, male genitalia, dorsal; 167, female eighth sternum, ventral; 168, bursa copulatrix, ventral. *O.* (*O.*) *brayi*, new species: 169, male genitalia, lateral; 170, aedeagus, dorsal; 171, male genitalia, dorsal.

long, with 2 apical processes, 1 heavily sclerotized and gradually decurved, the other membranous and tubular. Female genitalia: eighth sternum with an elongate tongue-like apicomeral process; rods attached apicolaterally; bursa copulatrix expanded apically with a large central opening and a pair of apicolateral earlike lobes.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Dominica, Carholm Estate, 7 Feb. 1965, W. W. Wirth, 3♂. Clarke Hall, 11–20 Jan. 1965, W. W. Wirth, 1♂. Pont Casse, 2.5 miles east, W. W. Wirth, 16 Jan. 1965, 1♀.

BIOLOGY.—Nothing is known of the biology of the species.

Ochrotrichia (O.) brayi, new species

FIGURES 169–171

This new species, like so many others in the genus, is not clearly related to any other described species although the simple aedeagus suggests a relationship with *O. marica* Flint and *O. lobifera* Flint. The rather simple tenth tergum with the heavy apical spine is unique.

ADULT.—Length of forewing 3 mm. Color brown. Male genitalia: ninth segment nearly quadrate, without a dorsolateral lobe; tenth tergum elongate, narrow, right side membranous especially subapically, left side heavily sclerotized, apex with a short, stout, black spine; clasper elongate with an apicodorsal lobe; black peglike setae on mesal face of apicodorsal lobe, and a few near ventral margin at midlength; aedeagus a long, slender tube with a small subapical tooth.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, Freshwater Lake, 22 Feb. 1964, D. F. Bray, USNM Type 69903.

BIOLOGY.—Nothing is known of the biology of this species.

Ochrotrichia (O.) ponta, new species

FIGURES 164–168

The species would seem to be related to *O. insularis* Mosely, from which it differs in possessing a simple tenth tergum and a divided aedeagus.

ADULT.—Length of forewing 2–3 mm. Color fuscus, antennae cream colored, forewing with a narrow, transverse white band at midlength, apically with several small white spots. Male genitalia: ninth segment with a large dorsolateral lobe; tenth tergum elongate, pointed, with a sclerotized band along the dorsolateral margins; clasper elongate with anterodorsal margin straight, hind margin shallowly bilobed, each lobe bearing a patch of dark peglike setae; aedeagus with apical half divided into 2 elongate tubules. Female

genitalia: eighth sternum with posterior margin bearing small mesal lobe, and a thin, projecting sclerite marked with a pair of crescentic dark marks; bursa copulatrix heavily sclerotized, streamlined, with an elongate central opening.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, Pont Casse, .4 miles east, 27 April 1964, O. S. Flint, Jr., USNM Type 69904. Allotype, female: same data. Paratypes: same data, 11 ♂ 1 ♀; same, but 6 May 1964, 1 ♂; same, but 23 June 1964, 2 ♂; Pont Casse, 1.3 miles east, 10 May 1964, O. S. Flint, Jr., 1 ♂; same, but 18 May 1964, 1 ♂ 1 ♀; Pont Casse, 1.7 miles east, 24 Mar. 1965, W. W. Wirth, 1 ♂; Pont Casse, 12-14 Oct. 1964, P. J. Spangler, 1 ♂; Freshwater Lake, 5-8 Nov. 1966, A. B. Gurney, 1 ♀; Mannett Gutter, 7 Mar. 1965, W. W. Wirth, 1 ♂.

BIOLOGY.—Adults of this species have been taken primarily near small, clear brooks, in which the larvae will probably be found.

Ochrotrichia (Metrichia) campana, new species

FIGURES 172-174

This and the following species are very closely related. In this species the dorsal lobe of the clasper is developed into a narrow spurlike process.

ADULT.—Length of forewing 2 mm. Color fuscus, antennae and legs paler. A pair of large pouchlike sacs, each filled with many modified setae, between sixth and seventh terga. Male genitalia: ninth sternum produced and rounded anteroventrally, with a heavily sclerotized dorsal lobe; a lightly sclerotized, elongate lobe dorsally extending posteriad between spinelike process arising from dorso-lateral angles of ninth sternum; clasper broad, with a strong dorso-lateral spur curving mesad, and a broad ventrolateral lobe; aedeagus with 2 subapical spines, a heavily sclerotized central tubule, and a slightly inflated basal half.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, D'leau Gommier, 16 March 1965, W. W. Wirth, USNM Type 69905.

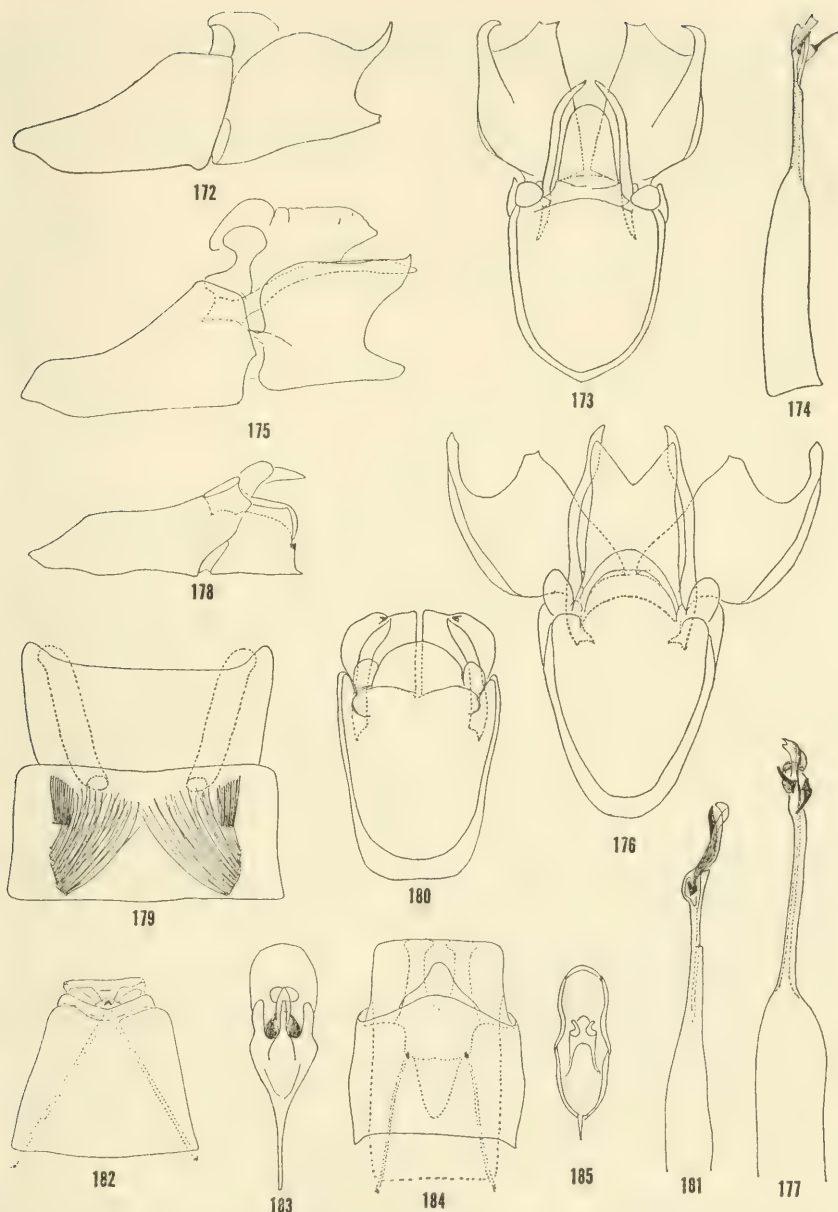
BIOLOGY.—Nothing is known of the biology of the species.

Ochrotrichia (M.) similis, new species

FIGURES 175-177

This species is extremely close to the preceding, differing primarily in the dorsal lobe of the clasper, which is broad in *O. similis* and narrow in *O. campana*. The pouches between terga six and seven also seem different in the two species.

ADULT.—Length of forewing 2.5 mm. Color in alcohol brown. A pair of small pouches between sixth and seventh terga; seventh



FIGURES 172-185.—*Ochrotrichia (Metrichia) campana*, new species, male: 172, genitalia, lateral; 173, genitalia, dorsal; 174, aedeagus, dorsal. *O. (M.) similis*, new species, male: genitalia, lateral; 176, genitalia, dorsal; 177, aedeagus, dorsal. *O. (M.) exclamationis*, new species, male: 178, genitalia, lateral; 179, fourth and fifth abdominal terga, dorsal; 180, genitalia, dorsal; 181, aedeagus, dorsal. *O. (M.)* species 1: 182, female eighth sternum, ventral; 183, bursa copulatrix, ventral. *O. (M.)* species 2: 184, female eighth sternum, ventral; 185, bursa copulatrix, ventral.

tergum with a dark, trianguloid mark mesally. Male genitalia: ninth segment produced and rounded anteroventrally, with a dumbbell-shaped dorsal lobe; apex of lightly sclerotized dorsal lobe with a V-shaped mesal excision; dorsolateral spine long, and slender; clasper, with broad, dorsal and ventral lobes; aedeagus with 2 subapical spines a central tubule, and enlarged base.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, Boiling Lake, 19 Nov. 1964, P. J. Spangler, USNM Type 69906. Paratype: Guadeloupe, altitude 3000 ft., 30 July, A. Busek, 1 ♂.

BIOLOGY.—The immature stages and breeding sites are unknown.

Ochrotrichia (M.) exclamationis, new species

FIGURES 178-181

This species is not clearly related to any other in the subgenus. The long subapical spine of the aedeagus, the short clasper, and the pouches and hair tufts of the abdomen are all extremely distinctive.

ADULT.—Length of forewing 2 mm. Color fuscus, forewing irregularly mottled with silvery patches of hair. A pair of elongate internal tubes arising ventrally between fourth and fifth segments, extending the length of fifth segment; a pair of black, scale-filled sacs posteroventrally on fourth segment; a pair of large, dorsal hair tufts basally on fourth segment. Male genitalia: ninth segment with anteroventral margin extended and rounded; dorsal lobe short, rounded, lightly sclerotized; dorsal lobe rounded, short, and indistinct; dorsolateral spine broad, curved ventrad; clasper short and broad, with a small mesal spine along posterior margin; aedeagus with a long ribbon-like subapical spine, a twisted, lightly sclerotized process on right, an internal tubule, and expanded base.

LARVA, PUPA, CASE.—Unknown.

MATERIAL.—Holotype, male: Dominica, Clarke Hall, cocoa trail, 16 Feb. 1965, W. W. Wirth, USNM Type 69907.

BIOLOGY.—The biology is totally unknown.

Ochrotrichia (M.) species 1

FIGURES 182-183

There are two females of the subgenus *Metrichia* in the collections. On the basis of coloration, they are probably not the female of *O. exclamationis*, but there is no way to assign these to either *O. campana* or *O. similis*.

ADULT.—Length of forewing 2-2.5 mm. Color black, antennae and legs paler. Female genitalia: eighth sternum with a thin apical collar

beyond which extends a thinner, more membranous collar that bears mesally a dark point to which are attached long, internal rods; bursa copulatrix with a short basal stem, a broad rounded apical lobe, and a complex of central structures; ninth and tenth segments extremely long and extensile.

MATERIAL.—Dominica, Freshwater Lake, 14 April 1964, O. S. Flint, Jr., 1 ♀; Pont Casse, .4 miles east, 16 May 1964, O. S. Flint, Jr., 1 ♀.

Ochrotrichia (*M.*) species 2

FIGURES 184–185

On the basis of size and coloration, these are possibly the females of *O. exclamationis*. The structure of the eighth sternum is extremely distinctive.

ADULT.—Length of forewing 1.5–2 mm. Color silver gray, forewing with several transverse bands of white hair, antenna pale basally, dark apically. Female genitalia: eighth sternum with posterior margin slightly lobate mesally; with an internal posteromesal sclerite giving rise to internal rods from its lateral angles and with its posterior margin developed into a projecting mesal lobe; eighth segment dorsally with a pair of knobbed submesal processes; bursa copulatrix ovoid, with lateral margin bandlike and a central complex.

MATERIAL.—Dominica, Pont Casse, 2.5 miles east, 16 Jan. 1965, W. W. Wirth, 3 ♀.

Family LEPTOCERIDAE

The leptocerids are worldwide in distribution but perhaps a little more abundant and diverse in the warmer regions than in the colder. This is probably because they are one of the few families that have successfully invaded the larger, warmer lakes and slowly flowing rivers.

The larvae construct cases that are generally tubular and made of sand or organic matter although a few genera hollow-out twigs or utilize discarded cases of other species. Pupation takes place within the larval case, which has been firmly attached to some object in the substrate.

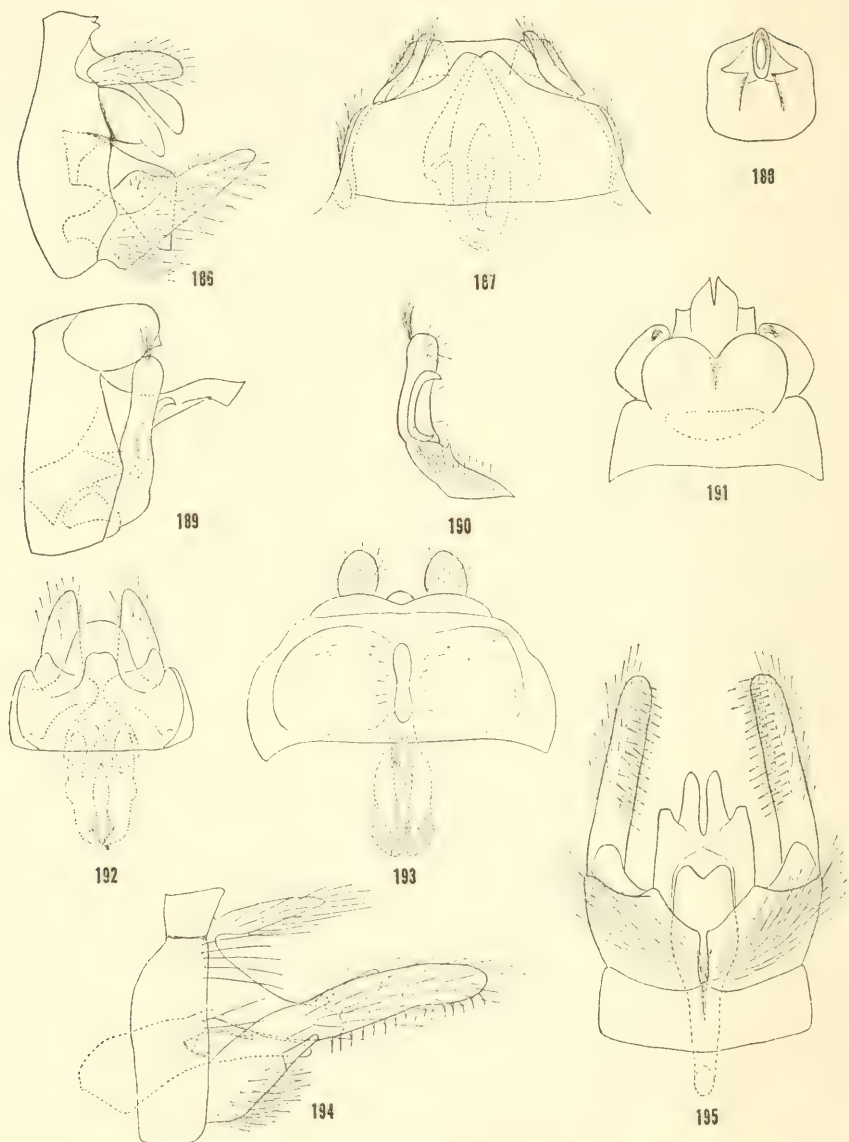
Key to Genera

LARVAE

1. Metanotum with large sclerotized plates *Atanotolica*
Metanotum wholly membranous 2
2. Anal proleg ventrally with linear rows of hairs and spines *Brachysetodes*
Anal prolegs without hairs and spines ventrally *Oecetis*

ADULTS

1. Forewing with M unbranched from base to apex *Oecetis*
Forewing with M branched near wing margin 2



FIGURES 186-195.—*Oecetis pratti* Denning: 186, male genitalia, lateral; 187, female genitalia, ventral; 188, internal structure of female seventh segment. *Brachysetodes insularis*, new species: 189, male genitalia, lateral; 190, clasper, posterior; 191, male genitalia, dorsal; 192, female genitalia, ventral. *Atanotolica dominicana*, new species: 193, female genitalia, ventral; 194, male genitalia, lateral; 195, male genitalia, ventral.

2. Hindwing with anal area expanded, wing broader than forewing.

Atanotolica

Hindwing with anal area compressed, wing narrower than forewing.

Brachysetodes

Genus *Oecetis* McLachlan

Oecetis McLachlan, 1877, p. 329. [Type-species: *Leptocerus ochraceus* Curtis, 1825, by subsequent designation of Ross, 1944.]

A single species of this worldwide genus has been found on Dominica.

The larvae of this genus generally make rather bulky cases of plant material although some make more trim cases of sand grains. The long mandibles and palpi of the larvae are apparently correlated with a trend toward predation.

Oecetis pratti Denning

FIGURES 186-188, 196-201

Oecetis pratti Denning, 1947, p. 656.—Wolcott, 1950, p. 93.—Flint, 1964b, p. 62.—Fischer, 1966, p. 140.

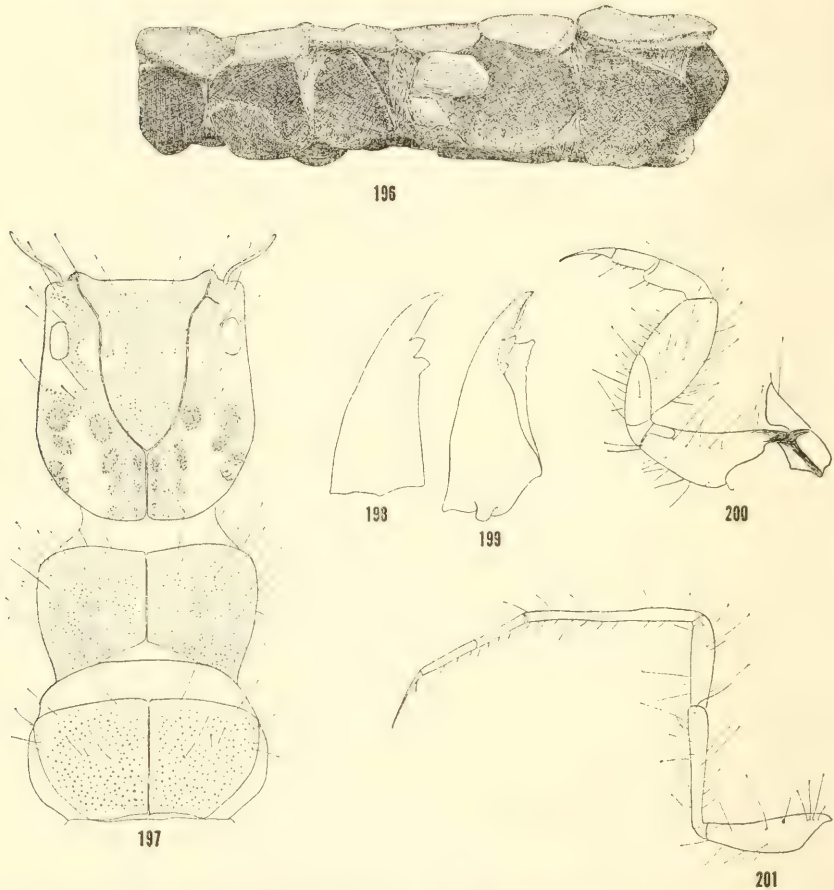
The species has heretofore been known only from Puerto Rico although there are closely related, if not identical, species in Florida and Peru. The Dominican specimens differ slightly from the Puerto Rican in possessing a more elongate tenth tergum.

ADULT.—Length of forewing 7-8 mm. Color brown, forewing with small tufts of black hair where Rs branches and just ventrad on M, where R_{2+3} and Cu_1 branch, and where the branches of Cu meet the wing margin. Male genitalia: ninth segment narrow, slightly widened laterally; cercus ovate about twice as long as broad; tenth tergum rodlike, longer than cerci, slightly expanded apically; a conical process slightly ventrad of tenth tergum; clasper broad basally, tapering to a blunt apex, inner margin near apex bearing short, stout, recurved setae, basomesal lobe with short setae; aedeagus tubular, slightly enlarged apically, internally with a pair of angular sclerites. Female genitalia: eighth sternum without strongly sclerotized marks; bursa copulatrix elongate; seventh segment internally with a hollow, more-or-less spherical structure.

LARVA.—Length to 5 mm. Head mottled yellow and brown; thoracic notae more uniformly brown. Foreleg short and broad, mid- and hind-legs slender, hindleg especially long, with tibia and tarsus divided at midlengths. Spacing humps well developed; gills single; lateral line lacking. Ninth tergum with 3 pairs of long, black setae. Anal claw with 3 small accessory teeth in a transverse row.

PUPA.—Unknown.

CASE.—Length to 9 mm, width 2–3 mm. Constructed of small bits of flat organic matter; occasionally placed to form a case square in cross-section, or more frequently polygonal to round.



FIGURES 196–201.—*Oecetis pratti* Denning, larva: 196, case, lateral; 197, head and thorax, dorsal; 198, left mandible, dorsal; 199, right mandible, ventral; 200, foreleg, posterior; 201, hind leg, posterior.

MATERIAL.—Dominica, Pont Casse, 1.6 miles west, 24 April 1964, O. S. Flint, Jr., 1 ♂, 30 larvae; same, but 28 April 1964, 1 ♀; same, but 29 April 1964, 6 larvae; same, but 18 May 1964, 1 ♀; same, but 16 June 1964, 2 ♀; Pont Casse, .4 mile east, 8 May 1964, O. S. Flint, Jr., 1 larva; same, but 15 June 1964, 2 ♀; Pont Casse, .5 mile east, 27 Jan. 1965, J. F. G. and T.M. Clarke, 1 ♂ 1 ♀; Pont Casse, 1.3 miles east, 18 May 1964, O. S. Flint, Jr., 1 ♀; Pont Casse, 12–14 Oct. 1964, P. J. Spangler, 5 ♀; same, but 23 Nov. 1964, 1 ♀; same, but 8–13 Oct. 1966, A. B. Gurney, 1 ♀; Freshwater Lake, 22 Feb. 1964, D. F. Bray, 1 ♂; Clarke Hall, 14 Oct. 1966, E. L. Todd, 1 ♀.

BIOLOGY.—The larvae were found in pools and other slowly flowing sections of two small mountain streams. On occasion they were found to be abundant, crawling over rocks and leaves in a favored site.

Genus *Brachysetodes* Schmid

Brachysetodes Schmid, 1955, p. 134. [Type-species: *Brachysetodes trifida* Schmid, 1955, by original designation.]

I am placing with some hesitation the following species in the Chilean genus *Brachysetodes*. Although venation is the same in the Dominican species and the type-species, the plan of the male genitalia seems quite different. Perhaps the immature stages of the Chilean species when they are discovered will show that the Dominican species is not congeneric.

The larvae are quite similar to those of *Leptocella* in many characteristics; however, the brushes of hair and spines on the ventral portion of the anal prolegs are unique.

Brachysetodes insularis, new species

FIGURES 189-192, 202-208

This species seems to be closest to *B. bifida* Schmid, from which it differs in the round cerci and in the shorter clasper with a differently shaped appendage.

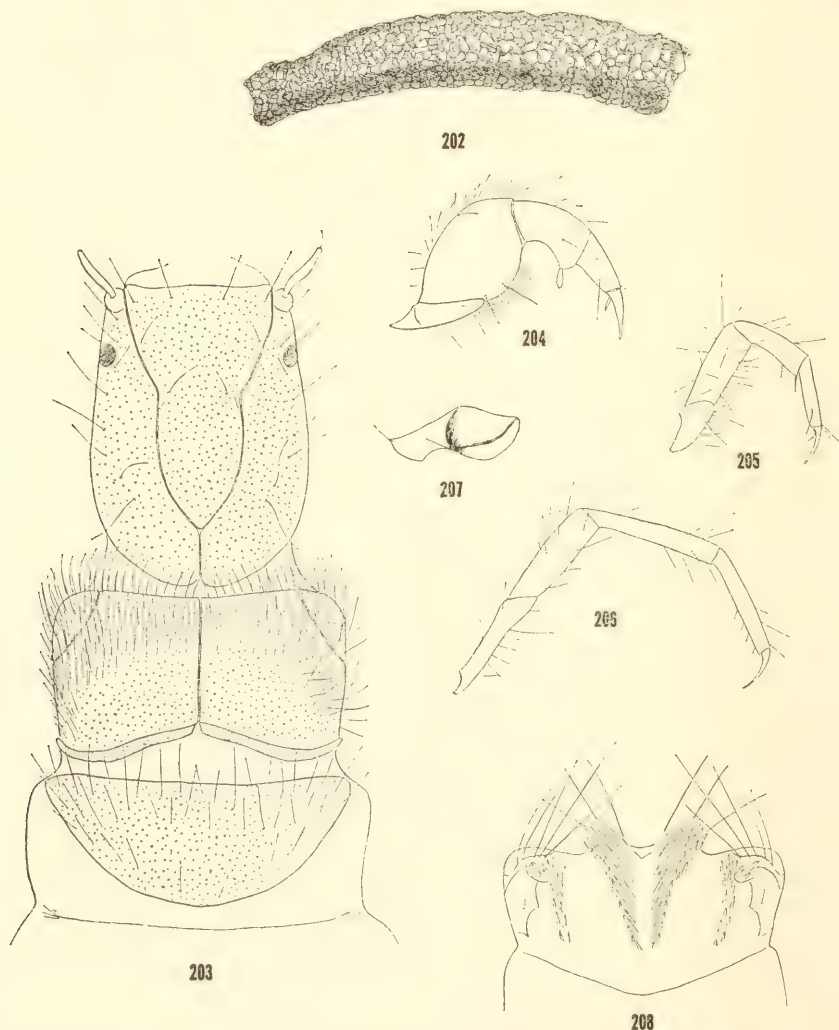
ADULT.—Lengths of forewing 4-5 mm. Color brown, forewing golden, with interspersed brown spots roughly arranged in transverse rows. Male with 2 branches of M in forewing, female with 3 branches. Male genitalia: cercus almost spherical, with a small apicoventral point, cerci broadly united dorsomesally; tenth tergum elongate, with thin lateral expansion; clasper terete, nearly upright, apex with a cluster of setae, posterior face with a hooked process; aedeagus tubular, with an apicoventral liplike expansion. Female genitalia: cerci well developed, united ventromesally by a semicircular plate; bursa copulatrix with apical supports, and central keyhole-like opening.

LARVA.—Length to 6 mm. Sclerites pale yellow brown. Mandibles with 3 apical teeth; maxillary palpi short. Pronotum with many setae on anterior half, anterolateral angles set off by sutures. Metanotum with a group of setae anterolaterally; sternum with a transverse row of about 20 setae. Spacing humps present, lateral ones poorly developed. A few single gill filaments on basal abdominal segments. Ninth tergum with 3 pairs of long setae. Mesal portion of anal prolegs with a linear brush of hairs margined laterally by spinelike setae, another row of spines mesad of claw.

PUPA.—Unknown.

CASE.—Length to 6 mm. Evenly tapered and curved, made of small sand grains.

MATERIAL.—Holotype, male: Dominica, Pont Casse, 1.6 miles west, 24 April 1964, O. S. Flint, Jr., USNM Type 69908. Allotype, female: same data. Paratypes: same data, 22♂ 3♀; same, but 27 April 1964, 1♂; same, but 28 April 1964, 8♂ 5♀; same, but 2 May 1964, 1♀; same, but 9 May 1964, 15♂ 5♀; same, but 16 June 1964, 2♂; same, but 25 June 1964, 2♂; same, but 27 June 1964, 1♂ 1♀; Ponte Casse, .4 mile east, 7 May 1964, O. S. Flint, Jr., 1♂; Pont Casse,



FIGURES 202-208.—*Brachysetodes insularis*, new species, larva: 202, case, lateral; 203, head and thorax, dorsal; 204, foreleg, posterior; 205, midleg, posterior; 206, hind leg, posterior; 207, foretrochantin, lateral; 208, anal prolegs, ventral.

1.3 miles east, 10 May 1964, O. S. Flint, Jr., 2♂; Pont Casse, 1.7 miles east, 12 March 1965, W. W. Wirth, 1♂; Pont Casse, 2.2 miles east, 2 May 1964, O. S. Flint, Jr., 1♂; Pont Casse, .5 mile south, 22–24 July 1963, O. S. Flint, Jr., 1♀; Pont Casse, 1.5 miles north, 12 Feb. 1965, W. W. Wirth, 3♂ 3♀; Brantridge, 30 April 1964, O. S. Flint, Jr., 1♂; D'leau Gommier, 15 March 1965, W. W. Wirth, 1♂; same, but 16 March 1965, 2♂; Freshwater Lake, 2 Oct. 1964, P. J. Spangler, 1♀; Guadeloupe, 4000 feet altitude, 30 July, August Busck, 1♀. Other: Pont Casse, 1.6 miles west, 29 April 1964, O. S. Flint, Jr., 4 larvae,

BIOLOGY.—The larvae were found sparsely in a slowly flowing pool of a small mountain stream. The adults were taken mostly in the daytime when they were easily beaten from the vegetation surrounding the stream.

Genus *Atanatolica* Mosely

Atanatolica, Mosely, 1936, p. 85. [Type-species: *Mystacides brasiliensis* Brauer, 1865, by original designation.]

I place the Dominican species in this genus primarily because of the close similarity of the male genitalia to the type-species. There are a few differences in the venation in the two species: in *A. dominicana*, fork 1 in the forewing is petiolate, and there is no crossvein in the hindwing between R_{2+3} and R_{4+5} .

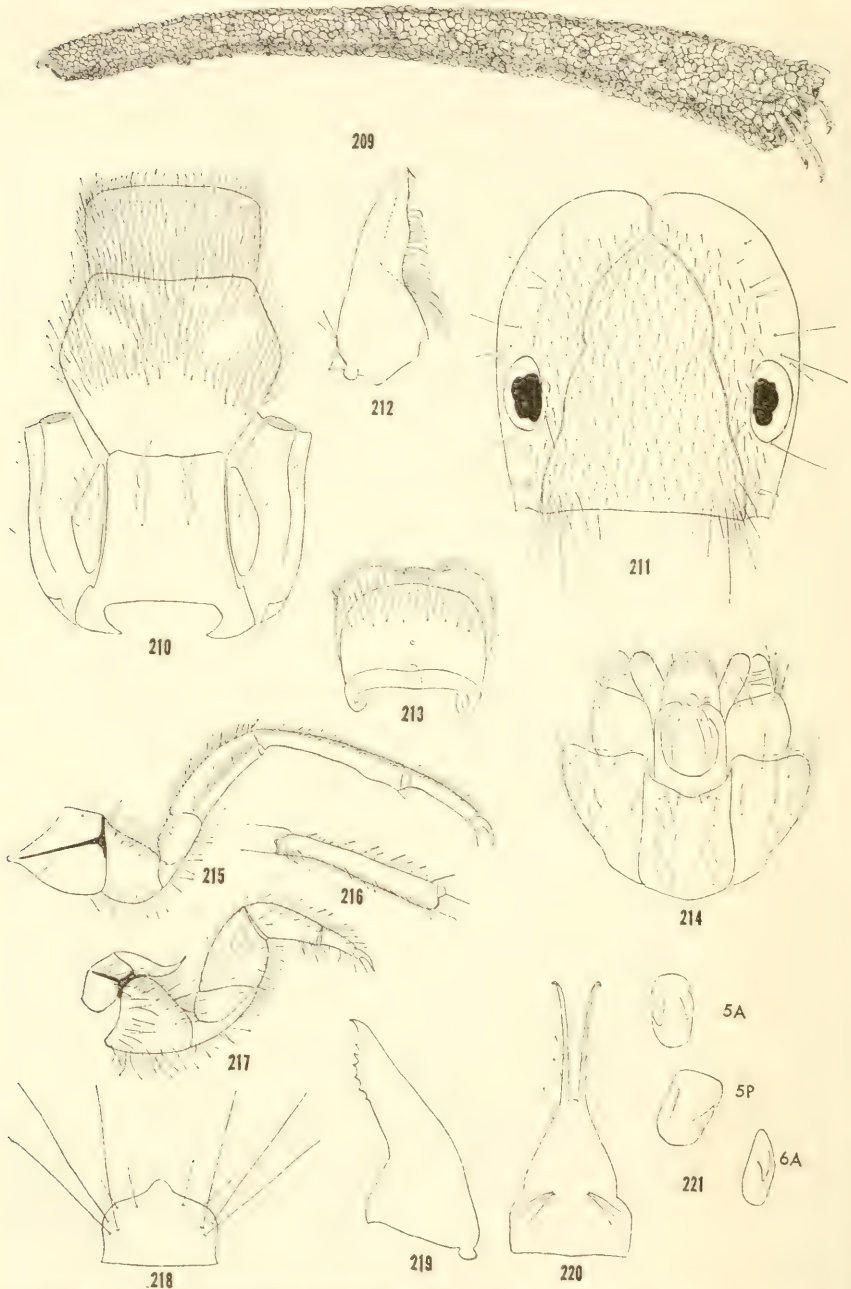
The larvae and pupae of the genus are described herein for the first time. They are especially unusual because they spend most of their time out of water crawling and pupating on moist rocks.

Atanatolica dominicana, new species

FIGURES 193–195, 209–221

On the basis of male genitalia, this species is closely related to *A. brasiliensis* (Brauer), from which it differs in the apicolateral angles of the tenth tergum, which are finger-like rather than truncate; the apex of the aedeagus, which is bilobate; and the apicomeral angle of the basal part of the clasper, which is obliquely truncate. There are also differences in the venation as stated above.

ADULT.—Length of forewing: male 7–9 mm, female 5–6 mm. Head, basal antennal segment with a cream-colored middorsal line, remainder of antennae black with white annulae, forewing brown (darker in female) with apex, apical fringe, and posterior margin cream colored. Male genitalia: ninth segment annular; cercus elongate, narrowing apically; tenth tergum with paired apicodorsal finger-like appendages, and apicolaterally with short digitate lobes; clasper with enlarged basal section whose apicomeral angle is obliquely truncate, a small appressed appendage posteriorly, apical portion with many spinelike setae on mesal surface; aedeagus with an elongate, bilobed, apical lip. Female genitalia: cerci rounded; ventrally to cerci a thin, ventrally



FIGURES 209-221.—*Atanotolica dominicana*, new species, larva: 209, case, lateral; 210, thorax, dorsal; 211, head, anterior; 212, mandible, dorsal; 213, labrum, dorsal; 214, maxillolabium, ventral; 215, hind leg, posterior; 216, hind tibia, dorsal; 217, foreleg, posterior. Pupa: 218, labrum, dorsal; 219, mandible, anterior; 220, apical processes, dorsal; 221, hook-plates, dorsal.

directed shelf best seen in lateral aspect; bursa copulatrix well developed with apicomeral supports, and an elongate central opening.

LARVA.—Length to 9 mm. Head brown, paler anteriorly and around eyes; with many short, pale, secondary setae. Mouthparts as shown; mandibles symmetrical. Thoracic notae brown. Foreleg short and broad, mid- and hindlegs longer; tibia of mid- and hindlegs with a row of spinelike setae anteriorly. Metasternum with lateral groups of 9–12 setae. Spacing humps low. Sternum of first abdominal segment with a pair of short 2 or 3 branched gills; second sternum with a pair of very short protuberances. No lateral line. Eighth segment with a lateral line of 12 small sclerotic points. Ninth tergite with 2 pairs of dark setae. Anal claw with a single large dorsal accessory tooth.

PUPA.—Length 7 mm. Mandibles and labrum as shown. Frons with 2 pairs of long setae; 2 setae between eye and base of mandible; 1 pair between antennae; 4 setae on basal antennal segment. Mesonotum with many setae. Antennae wound around apex of abdomen many times. No tarsal hair fringe. Hook-plates anteriorly on segments 3–6, posteriorly on 5; plates 3, 4, and 5A similar, 6A slightly smaller. Apical processes slightly sclerotized, tip curved sharply dorsad.

CASE.—Length 15 mm. Evenly tapering and conical; made mostly of sand grains, sometimes with large wholly silken areas. Posterior end dorsally with a projecting, hoodlike silken structure, ventral part of hood open to interior.

MATERIAL.—Holotype, male: Dominica, Pont Casse, .4 miles east, emerged 11 May 1964, O. S. Flint, Jr., USNM type 69909. Allotype, female: same data. Paratypes: same, but emerged 9 May 1964, 1 ♂1 ♀; same, but emerged 10 May 1964, 1 ♂; same, but 16 May 1964, 1 ♂; same, but emerged 18 May 1964, 1 ♂1 ♀; same, but 15 June 1964, 2 ♂1 ♀; same, but 23 June 1964, 7 ♂2 ♀; Pont Casse, 1.3 miles east, 10 May 1964, O. S. Flint, Jr., 1 ♀; Pont Casse, 1.6 miles west, 9 May 1964, 1 ♀; same, but 27 June 1964, 2 ♀. Other: Pont Casse, .4 miles east, 8 May 1964, O. S. Flint, Jr., many larvae, ♂♂♀♀ pupae; same, but 20 May 1964, many larvae; same, but 12 June 1964, many larvae.

BIOLOGY.—This species has the most unusual biology of any species of Trichoptera found on Dominica. The larvae and pupae are basically terrestrial, although they do not show any of the morphological adaptations that would be expected for this environment. The immature stages were found around a single small mountain stream that is incised into the rock to a depth of three feet. The larvae were actively crawling over the rock walls and boulders above the level of the water up to three or four feet away. The substrate was moist, and sometimes with a flowing film of water, but never were the larvae actually submerged. The habitat was on occasion so dry that I doubt very much if there could have been free water between the larva and its case. The pupae were tightly attached to rocks in the same habitat, generally in clusters and in some sort of protected niche.

Family CALAMOCERATIDAE

The calamoceratids are a rather small family, the majority of whose numbers are found in the tropical regions of the world. Many of the species are brightly colored and are most active in the daytime.

The immature stages are all case bearers, many making flat cases of leaf fragments, some cylindrical cases of sand, and others hollowing-out a twig. They are generally inhabitants of lotic waters but may congregate in masses of organic trash in slowly flowing pools in the stream.

Genus *Phylloicus* Müller

Phylloicus Müller, 1880, p. 131. [Type-species: *Phylloicus major* Müller, 1880, designated by Flint, 1964b.]

The genus is primarily Neotropical in distribution but does enter the southwestern United States. Most of the species are diurnal and are marked with orange and black.

The larvae construct large, flat cases of leaf fragments. The immature stages were described by Flint (1964b).

Phylloicus monticolus, new species

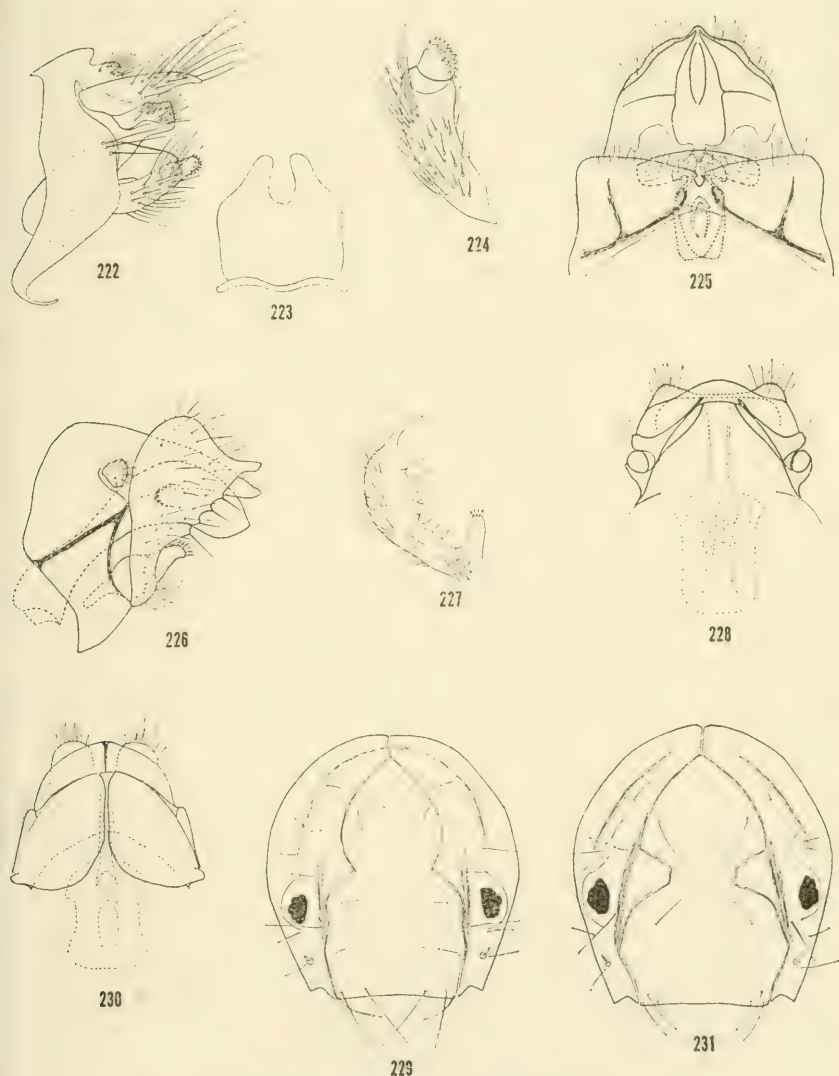
FIGURES 222-225

This species is most closely related to *P. lituratus* Banks from Columbia and Panama. From this species it differs in its coloration, and in the male genitalia by the shorter, broader cercus and broadened apical segment of the clasper.

ADULT.—Length of forewing 8-11 mm. Color basically blue black, marked with orange as follows: pronotum, head and thorax ventrally, femora, and middle tarsi; forewings with two pale pinkish bands, one slightly beyond anastomosis, other basad, and longitudinal stripes basally in cells Cu_2 and 2A. Male genitalia: eighth sternum produced and bifid apically; ninth segment produced ventrally into a sclerotized band articulating with eighth sternum; tenth tergum with a hirsute projection mesally at union with ninth tergum, with a ventrolateral flange, apically truncate; cercus broad basally, tapering to an apical point, slightly longer than tenth tergum; clasper with basal segment cylindrical, apical segment broad and short, with apical peglike setae; aedeagus tubular, slightly C-shaped. Female genitalia: eighth sternum incised mesally, with a heavy brace along anterior margin and sublaterally; ninth sternum with ribbon-like anteromesal sclerites, and a transverse ridge at midlength, basomesally a transverse, striated sclerite; cercus united to tenth segment, very small; bursa copulatrix with laterally expanded, posterior supports, bursa with an A-shaped central structure.

LARVA.—Length to 14 mm, width 2.5 mm. Sclerites brown; head covered with small spicules, except for posterior and paler muscle scars. Structurally identical to *P. pulchrus*; except for inner surface of forecoxae which bears 6–7 setae (10–12 in *P. pulchrus*).

PUPA.—Length 9 mm, width 2.5 mm. Structurally similar to



FIGURES 222–231.—*Phylloicus monticolus*, new species: 222, male genitalia, lateral; 223, male eighth sternum, ventral; 224, clasper, posteroventral; 225, female genitalia, ventral, *Helicopsyche apicauda*, new species: 226, male genitalia, lateral; 227, clasper, posteroventral; 228, female genitalia, ventral; 229, larval head, anterior. *H.* species 1: 230, female genitalia, ventral. *H.* species 2: 231, larval head, anterior.

P. pulchrus except for hook-plates, which generally bear one more hook per plate.

CASE.—Length 15–20 mm, width 7–9 mm. Constructed of nearly circular pieces of leaf or wood, placed in dorsal and ventral rows.

MATERIAL.—Holotype, male: Dominica, 1.6 miles west of Pont Casse, 9 May 1964, O. S. Flint, Jr., USNM Type 69910. Allotype, female: same, but emerged 6 May 1964. Paratypes: same, but 24 April 1964, 2♂; same, but 28 April 1964, 2♂ 1♀; same, but emerged 2 May 1964, 1♀; same, but emerged 4 May 1964, 1♂; same, but emerged 6 May 1964, 1♀; same, but emerged 7 May 1964, 1♀; same, but 9 May 1964, 4♂; same, but emerged 9 May 1964, 1♂ 1♀; same, but emerged 17 May 1964, 1♂; same, but 16 June 1964, 2♂ 2♀; same, but 27 June 1964, 1♂; Pont Casse, .4 miles east, 6 May 1964, O. S. Flint, Jr., 1♀; same, but 15 June 1964, 1♂ 1♀; Pont Casse, 1.3 miles east, 18 May 1964, O. S. Flint, Jr., 1♂ 1♀; Pont Casse, 3 miles east, 15 Oct. 1966, E. L. Todd, 1♂; Pont Casse, 2 miles northwest, 3 May 1965, D. R. Davis, 1♂; Pont Casse, .5 miles south, 22–24 July 1963, O. S. Flint, Jr., 3♂ 2♀; same, but 8 April 1964, 1♂; same, but 11 April 1964, 1♀; Pont Casse, 12–14 Oct. 1964, P. J. Spangler, 1♀. Other: Pont Casse, 1.6 miles west, 24 April 1964, O. S. Flint, Jr., many larvae, pupae, and metamorphotypes; same, but 29 April 1964, many larvae, pupae, and metamorphotypes; Pont Casse, 2.2 miles east, 15 June 1964, O. S. Flint, Jr., 1 pupa; Pont Casse, .5 miles south, 22–24 July 1963, O. S. Flint, Jr., 2 larvae, 2 pupae, 2 metamorphotypes; same, but 15 June 1964, 1 pupa; Brantridge, 9 May 1964, O. S. Flint, Jr., 3 larvae; Espagnole River east of Syndicate Estate, cascades on Mt. Diablotin, sta. 41, 26 Jan. 1964, H. H. Hobbs, Jr., 1 metamorphotype; Pont Casse, 3 miles north, 6 Oct. 1964, P. J. Spangler, 1 larva; Pont Casse, 2 miles northwest, 5 Oct. 1964, P. J. Spangler, 2 larvae.

BIOLOGY.—This species appears to be another of the species that breeds in the small streams at higher elevations in the mountains of Dominica. The larvae are generally found in the organic matter in the larger pools although they may be found in the cascades as well. The pupae especially are found in the cascades, attached to the underside of some of the larger stones.

Family HELICOPSYCHIDAE

The family Helicopsychidae, which are known as the snail-case makers, are the most diverse in the tropics although a few species range well into the temperate regions.

The snail-like cases constructed by the larvae are very distinctive. A number of these cases were described by the very early malacologists as Mollusca. They are found in flowing water, generally attached to large stones and boulders.

Genus *Helicopsyche* Siebold

Helicopsyche Siebold, 1856, p. 38. [Type-species: *Helicopsyche shuttleworthi* Siebold, 1856, designated by Flint, 1964b.]

This genus, which is primarily tropical, is found over the whole world with the exception of the northwestern Palearctic Region. All

the West Indian islands support one to three or four species, most of which appear to be endemic to one or adjacent islands.

The larvae and pupae inhabit cases made of sand grains in the form of a snail shell. The immatures have been described in detail a number of times (Betten 1934, Botosaneanu 1959).

Key to Species

LARVAE AND CASES

- Sclerites pale yellowish, hind femur with more than 35 setae; case with umbilicus widely open **H. apicauda**
 Sclerites brown, hind femur with about 15 setae; umbilicus almost completely closed **H. species 2**

FEMALES

- Anterolateral angles of subgenital plate with cuplike invaginations . **H. apicauda**
 Subgenital plate without anterolateral invaginations **H. species 1**

Helicopsyche apicauda, new species

FIGURES 226-229

This species is another member of the *Helicopsyche haitiensis* group, and perhaps closest to *H. incisa* Ross. From this it differs in having the mesobasal lobe of the claspers directed more dorsad and in having the anterodorsal angle more rounded and the apicodorsal point narrower in the claspers.

ADULT.—Length of forewing 4-5.5 mm. Color pale brown. Basal abdominal segments reticulate ventrally; sixth sternum with a terete process expanded apically, about as long as sternum. Male genitalia: ninth segment rather wide ventrally; tenth tergum short, slightly arched, apex shallowly bilobate; clasper rounded anterodorsally, apical point elongate, posterior margin almost straight, mesobasal lobe elongate, directed slightly dorsad, and distinctly separated from clasper; aedeagus short and broad, especially apically. Female genitalia: subgenital plate conical, extending almost as far posteriad as cerci, lateral margin sclerotized with anterolateral angles bearing a cuplike pocket; cercus short, ventral plate rounded apically; bursa copulatrix with long slender posterior supports, internally with 2 flattened plates.

LARVA.—Length (straightened) about 6 mm. Sclerites pale yellowish. Head with many small spicules frontally; a slight ridge from eyes to posterior of frontoclypeal suture, ridge well separated from suture, which is indented to a point at midlength. Pronotum with anterior margin and anterior third bearing many pale, bladelike setae. Rather hairy in general; posterior femur bearing about 36 setae.

PUPA.—Length about 5 mm. Mandibles sickle shaped without inner teeth. Hook-plates anteriorly on segments 3-6, posteriorly on

5; anterior plates with 2 obliquely placed hooks on each, posterior plate with large lateral and a small mesal hook. Apical process short and rodlike, each with 4 long setae.

CASE.—Diameter 3–4 mm, height 1.5–2 mm. Made of sand grains in a rather flattened spiral. About $2\frac{1}{2}$ whorls; umbilicus widely open. Anal aperture slightly eccentric and often projecting slightly.

MATERIAL.—Holotype, male: Dominica, Pont Casse, .5 miles south, 22–24 July 1963, O. S. Flint, Jr., USNM Type 69911. Allotype, female: same data. Paratypes: Pont Casse, 1.6 miles west, 28 April 1964, O. S. Flint, Jr., 1 ♀; same, but 9 May 1964, 1 ♂ 2 ♀; same, but 27 June 1964, 1 ♀; Pt. Lolo, .5 miles west, 1600', 19 Feb. 1965, J. F. G. and T. M. Clarke, 1 ♂; Pont Casse, .4 miles east, 21 April 1964, O. S. Flint, Jr., 1 ♂; same, but 27 April 1964, 1 ♀; same, but 6 May 1964, 1 ♀; same, but 15 June 1964, 1 ♂; same, but 23 June 1964, 1 ♂ 1 ♀; Pont Casse, .5 miles east, 1800', 27 Jan. 1965, J. F. G. and T. M. Clarke, 1 ♂ 1 ♀; Pont Casse, 1 mile east, 1600', 29 Jan. 1965, J. F. G. and T. M. Clarke, 1 ♀; Pont Casse, 1.3 miles east, 10 May 1964, O. S. Flint, Jr., 2 ♂; same, but 18 May 1964, 1 ♂; same, but 26 May 1964, 1 ♂ 1 ♀; Pont Casse, 1.7 miles east, 24 March 1965, W. W. Wirth, 3 ♂ 2 ♀; Pont Casse, 2 miles east, 1500', 20 Feb. 1965, J. F. G. and T. M. Clarke, 1 ♀; Pont Casse, 13 Jan. 1965, J. F. G. and T. M. Clarke, 1 ♂; same, but 23 Nov. 1964, P. J. Spangler, 1 ♂; Freshwater Lake, 5–8 Nov. 1966, A. B. Gurney, 1 ♀. Other: Pont Casse, .4 miles east, 8 May 1964, O. S. Flint, Jr., 11 larvae; same, but 20 May 1964, 10 larvae, 10 pupae; same, but 12 June 1964, 7 larvae, 6 pupae; same, but 25 June 1964, 10 larvae, 2 pupae; Pont Casse, .5 miles south, 22–24 July 1963, O. S. Flint, Jr., 1 prepupa, 2 cases; Pont Casse, 1.6 miles west, 24 April 1964, O. S. Flint, Jr., 14 larvae.

BIOLOGY.—This species appears to be limited to the small mountain brooks, where on occasion it is quite plentiful. The larval population found in the brook at .4 miles east of Pont Casse has pale bladeliike setae along the entire anterior margin of the pronotum, whereas the larvae from the other two brooks lack these setae except laterally. I am unable to find other differences between these populations, and so I am considering them to be all the same species.

Helicopsyche species 1

FIGURE 230

I have one female that appears to be a different species from the one above; however, I prefer to leave it unnamed until more examples are found.

The specimen differs most noticeably in lacking the cuplike pockets anterolaterally on the subgenital plate.

ADULT.—Length of forewing 5 mm. Color brown. Female genitalia: subgenital plate conical, lacking anterolateral modifications; cercus short, ventral plate rounded; bursa copulatrix with a pair of broad posterior supports, and an A-shaped central structure.

MATERIAL.—Dominica, Clarke Hall, 21–31 Jan. 1965, W. W. Wirth, 1 ♀.

Helicopsyche species 2

FIGURE 231

There is a distinct species on St. Lucia (and probably also on Grenada). Unfortunately, the genitalia of the only adult from St. Lucia were lost between preparation and illustration. Beyond the fact that the genitalia indicated that the species was quite distinctive, nothing more can be shown now. The larvae also seem to be distinct.

ADULT.—Length of forewing 4 mm. Color in alcohol, pale brown.

LARVA.—Length (straightened) about 6 mm. Sclerites brown. Head with a ridge mesad of eyes, bridging the indentation of the frontoclypeal suture, and another slight ridge posteriad of eyes; frontoclypeus broadly indented at midlength. Pronotum sparsely setate, with anterior margin bearing a row of pale, blade-like setae on all but the central portion. Hind femur with about 15 setae.

CASE.—Diameter 3–4 mm, height 2 mm. Made of sand grains, in typical snail-shell shape. About 3 whorls; umbilicus nearly closed. Anal aperture nearly central, spire moderately high.

MATERIAL.—St. Lucia, Vergallier River, near Marquis, 31 July 1963, Flint and Cadet, 1♂ (without abdomen), 12 larvae, 3 pupae; R. Galet, south of Dennery, 1 Aug. 1963, Flint and Cadet, 34 larvae, 5 pupae.

BIOLOGY.—This species has been taken in two small, comparatively clear streams. They were attached to rocks in more slowly flowing pools in these streams.

Check List of the Antillean Trichoptera

The following list contains the names and distributions of the Trichoptera described or recorded from the Antilles (exclusive of Trinidad), together with references to their original descriptions. Junior synonyms described from the Antilles are listed in italics under the proper name. The locality in italics is the type-locality for the species.

RHYACOPHILIDAE

Atopsyche Banks

- cubana Flint, 1968b, p. 151. *Cuba*
- batesi Banks, 1938, p. 304. *Hispaniola*
- trifida Denning, 1948b, p. 113. *Puerto Rico*
- brachycerca Flint, 1968a, p. 10. *Jamaica*
- macrocerca Flint, 1968a, p. 12. *Jamaica*

GLOSSOSOMATIDAE

Cariboptila Flint

- orophila Flint, 1964b, p. 17. *Puerto Rico*
- jamaicensis Flint, 1968a, p. 16. *Jamaica*

Campsiphora Flint

pedophila Flint, 1964b, p. 15. *Puerto Rico*arawak Flint, 1968a, p. 13. *Jamaica*

Protoptila Banks

dominicensis, new species. *Dominica*

PHILOPTAMIDAE

Wormaldia McLachlan

planae Ross and King, 1956, p. 64. *Grenada, Mexico to Trinidad.*

Chimarra Stephens

pulchra (Hagen), 1861, p. 298. *Cuba**fraterna* (Banks), 1924, p. 449.braconoides (Walker), 1860, p. 179. *Hispaniola*albomaculata (Kolbe), 1888, p. 175. *Puerto Rico**luquillo* Denning, 1947, p. 657.argentella (Ulmer), 1906, p. 92. *Jamaica*moesta (Banks), 1924, p. 449. *Cuba*spinulifera Flint, 1968b, p. 151. *Hispaniola*maldonadoi Flint, 1964b, p. 23. *Puerto Rico*puertoricensis Flint, 1964b, p. 23. *Puerto Rico*jamaicensis Flint, 1968a, p. 18. *Jamaica*machaerophora Flint, 1968a, p. 20. *Jamaica*dominicana, new species. *Dominica*antilliana, new species. *Dominica, St. Lucia*caribea, new species. *Grenada, Trinidad*

PSYCHOMIDAE

Xiphocentron Brauer

cubana (Banks), 1941, p. 401. *Cuba*haitiensis (Banks), 1941, p. 402. *Hispaniola, Puerto Rico*borinquensis Flint, 1964b, p. 29. *Puerto Rico*nesidion Flint, 1968a, p. 22. *Jamaica*fuscum, new species. *Dominica*albolineatum, new species. *Dominica*

Cernotina Ross

caliginosa Flint, 1968a, p. 24. *Jamaica*lutea, new species. *Dominica*cadeti, new species. *St. Lucia*

Polyplectropus Ulmer

bredini, new species. *Dominica, St. Lucia, Grenada*

Polycentropus Curtis

nigriceps Banks, 1938, p. 301. *Cuba*rosarius Kingsolver, 1964, p. 257. *Cuba*domingensis Banks, 1941, p. 399. *Hispaniola*zaneta Denning, 1947, p. 66. *Puerto Rico*jamaicensis Flint, 1968a, p. 25. *Jamaica*insularis Banks, 1938, p. 302. *Grenada, Dominica*

Antillopsyche Banks

wrighti Banks, 1941, p. 400. *Cuba*tubicola Flint, 1964b, p. 30. *Puerto Rico*

HYDROPSYCHIDAE

Hydropsyche Pictet

- calosa Banks, 1938, p. 300. *Cuba*
 darlingtoni Flint, 1962, p. 23. *Cuba*
 cubana Flint, 1962, p. 24. *Cuba*
 domingensis Banks, 1941, p. 398. *Hispaniola*
 batesi Flint, 1962, p. 25. *Hispaniola*
 carinifera Flint, 1962, p. 27. *Hispaniola*
 antilles Ross and Palmer, 1948, p. 182. *Hispaniola*

Smicridea McLachlan

- comma Banks, 1924, p. 451. *Cuba*
 obesa Banks, 1938, p. 303. *Cuba*
 banksi Flint, 1967, p. 13. *Hispaniola*
 unicolor Banks, 1938, p. 303, preoccupied
 completa Banks, 1941, p. 398. *Hispaniola*
 protera (Denning), 1947, p. 658. *Puerto Rico*
 alticola Flint, 1964b, p. 40. *Puerto Rico*
 grandis Flint, 1968a, p. 27. *Jamaica*
 minima Flint, 1968a, p. 27. *Jamaica*
 jamaicensis Flint, 1968a, p. 28. *Jamaica*
 cariba, new species. *Dominica*
 simmonsii, new species. *St. Lucia*
 grenadensis, new species. *Grenada*

Macronema Pictet

- gundlachi Banks, 1924, p. 454. *Cuba*
 matthewsi Flint, 1964b, p. 39. *Puerto Rico*

Leptonema Guerin

- poeyi (Banks), 1938, p. 299. *Cuba*
 insulanum Banks, 1924, p. 455. *Puerto Rico*, *Venezuela*
 archboldi, new species. *Dominica*
 albivirens (Walker), 1852, p. 76. *Grenada*, *St. Vincent*, *Mexico to Venezuela*
 and *Trinidad*

HYDROPTILIDAE

Leucotrichia Mosely

- tubifex Flint, 1964b, p. 44. *Puerto Rico*, *Jamaica*
 sarita Ross, 1944, p. 274. *Grenada*, *Texas to Costa Rica*

Zumatrichia Mosely

- antilliensis, new species. *Dominica*, *St. Lucia*, *Grenada*, *Guadeloupe*
 anomaloptera, new species. *Grenada*, *St. Lucia*, *Dominica*

Alisotrichia Flint

- hirudopsis Flint, 1964b, p. 47. *Puerto Rico*
 argentilinea Flint, 1968a, p. 34. *Jamaica*
 orophila, new species. *Dominica*
 lobata, new species. *Dominica*
 dominicensis, new species. *Dominica*
 wirthi, new species. *Dominica*
 septempunctata, new species. *Dominica*

Neotrichia Morton

- iridescens Flint, 1964b, p. 51. *Puerto Rico*, *Jamaica*, *Dominica*, *St. Lucia*
 alata Flint, 1968a, p. 37. *Jamaica*
 heleios Flint, 1968a, p. 38. *Jamaica*
 corniculans, new species. *Dominica*

Bredinia, new genus

dominicensis, new species. *Dominica*

Oxyethira Eaton

puertoricensis Flint, 1964b, p. 55. *Puerto Rico*, Jamaica

janella Denning, 1948a, p. 397. *Puerto Rico*, Jamaica, *Dominica*, *St. Lucia*,

Grenada, *Florida* to Panama

neglecta Flint, 1964b, p. 57

azteca (Mosely), 1937, p. 165. Grenada, *Mexico* to Panama

cirrifera Flint, 1964b, p. 57. *Puerto Rico*, Jamaica, *Dominica*

tega Flint, 1968a, p. 44. *Jamaica*, *Dominica*

simulatrix Flint, 1968a, p. 43. *Jamaica*

jamaicensis Flint, 1968a, p. 44. *Jamaica*

Orthotrichia Eaton

cristata Morton, 1905, p. 75. *Jamaica*, *Illinois* to *Florida*

Hydroptila Dalman

martorelli Flint, 1964b, p. 52. *Puerto Rico*

medinai Flint, 1964b, p. 54. *Puerto Rico*

ditalea Flint, 1968a, p. 46. *Jamaica*

ancistrion Flint, 1968a, p. 48. *Jamaica*

antillarum, new species. *Dominica*, *St. Lucia*

grenadensis, new species. *Grenada*

Ochrotrichia Mosely

marica Flint, 1964b, p. 60. *Puerto Rico*

gurneyi Flint, 1964b, p. 60. *Puerto Rico*

verda Flint, 1968b, p. 153. *Puerto Rico*

spinosissima Flint, 1964b, p. 58. *Puerto Rico*, *Dominica*

insularis Mosely, 1934, p. 163. *Jamaica*

caligula Flint, 1968a, p. 49. *Jamaica*

lobifera Flint, 1968a, p. 50. *Jamaica*

brayi, new species. *Dominica*

ponta, new species. *Dominica*

juana Flint, 1964b, p. 60. *Puerto Rico*

yalla Flint, 1968a, p. 50. *Jamaica*

campana, new species. *Dominica*

similis, new species. *Dominica*, *Guadeloupe*

exclamationis, new species. *Dominica*

LEPTOCERIDAE

Oecetis McLachlan

pratti Denning, 1947, p. 656. *Puerto Rico*, *Dominica*

inconspicua (Walker), 1852, p. 71. *Puerto Rico*, *Jamaica*, *Cuba*, *Georgia*,

North and Central America

antillana (Banks), 1938, p. 298.

Leptocella Banks

cubana Banks, 1938, p. 229. *Cuba*, *Jamaica*

lewisi Flint, 1968a, p. 55. *Jamaica*

Brachysetodes Schmid

insularis, new species. *Dominica*, *Guadeloupe*

Atanatolica Mosely

dominicana, new species. *Dominica*

CALAMOCERATIDAE

Phylloicus Müller

- chalybeus (Hagen), 1861, p. 285. *Cuba*
 cubanus Banks, 1924, p. 445. *Cuba*
 superbus Banks, 1938, p. 298. *Cuba*
 iridescens Banks, 1941, p. 397. *Hispaniola*
 pulchrus Flint, 1964b, p. 65. *Puerto Rico*
 farri Flint, 1968a, p. 56. *Jamaica*
 monticolus, new species. *Dominica*

ODONTOCERIDAE

Marilia Müller

- wrighti Banks, 1924, p. 446. *Cuba*
 scudderi Banks, 1924, p. 446. *Isle of Pines*
 gracilis Banks, 1938, p. 297. *Hispaniola*
 var. nigrescens, 1941, p. 397. *Hispaniola*
 amnicola Flint, 1968a, p. 60. *Jamaica*

HELICOPSYCHIDAE

Helicopsyche Siebold

- hageni Banks, 1938, p. 296. *Cuba*
 cubana Kingsolver, 1964, p. 259. *Cuba, Jamaica*
 comosa Kingsolver, 1964, p. 259. *Cuba*
 lutea (Hagen), 1861, p. 271. *Hispaniola*
 haitiensis Banks, 1938, p. 296. *Hispaniola*
 ramosi Flint, 1964b, p. 72. *Puerto Rico*
 minima Siebold, 1856, p. 38. *Puerto Rico*
 umbonata Hagen, 1864, p. 128. *Jamaica*
 ochtheiphila Flint, 1968a, p. 65. *Jamaica*
 apicauda, new species. *Dominica*

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| 8 | Ross | Intertidal Cirripedia | 1968 | 125 | 3663 |

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Stomatopod Crustacea from West Pakistan

By Nasima M. Tirmizi and Raymond B. Manning¹

Introduction

As part of a broad program of studies on the larger Crustacea of West Pakistan and the Arabian Sea, one of us (N.T.) initiated a survey of the Stomatopoda occurring off the coast of West Pakistan. Analysis of preliminary collections indicated that the stomatopod fauna of this area is richer in numbers of species than is evident from the literature. Through correspondence in 1966, we decided to collaborate on a review of the Pakistani stomatopods; this report is the result of that collaboration.

This paper is based primarily on collections made by and housed in the Zoology Department, University of Karachi. Specimens in the collections of the Central Fisheries Department, Karachi, and the Zoology Department, University of Sind, were also studied. Unfortunately, only a few specimens from the more extensive stomatopod collections of the Zoological Survey Department, Karachi, were available for study. Material from Pakistan in the collection of the Division of Crustacea, Smithsonian Institution (USNM), material from two stations made off Pakistan by the International Indian

¹ Tirmizi: Reader, Zoology Department, University of Karachi, Pakistan; Manning, Chairman, Department of Invertebrate Zoology, Smithsonian Institution.

Ocean Expedition (IIOE), and a few specimens in the collections of the British Museum (Natural History) (BMNH), are also recorded.

Some species of stomatopods are edible and are relished in various parts of the world. Baig (1954) noted that in Karachi certain people used them for food; however, we learned from fishermen that these animals are considered as "fish lice" and as such are regarded as unfit for human consumption. Large quantities are caught in fishermen's nets and are sold cheaply along with fish-waste to be used as fertilizer or poultry food.

ACKNOWLEDGMENTS.—This study could not have been completed without the help of many individuals and institutions. The Foreign Currency Program of the Smithsonian Institution made it possible for one of us (R.B.M.) to visit West Pakistan, and preparation of some of the illustrations by Lilly Manning was supported by the Smithsonian Research Awards Program. Mr. Robert A. Dietchman and E. J. D'Souza, on the staff of the American Embassy in Karachi, expedited all administrative matters pertaining to the visit to Karachi. Dr. M. A. H. Qadri, Chairman, the Department of Zoology, University of Karachi, kindly made the departmental facilities available to us. Mr. S. S. U. Siddiqui, Officer-in-charge, Zoological Survey Department, Karachi, allowed one of us (N.T.) to study some of the stomatopods from that collection. Mr. Agha Ghulam Hussain, Director, Marine Fisheries Department, Karachi, allowed us to work with all of the stomatopods in his collection. Dr. A. L. Rice and Mr. R. W. Ingle, Crustacea Section, British Museum (Natural History), provided working space for one of us (R.B.M.) and loaned us several specimens for additional study. Miss Quddosi Bashir was most helpful in preparing the specimens for study and in composing the plates.

LITERATURE SURVEY.—Although 40 species of stomatopods are known to occur in the northwestern Indian Ocean, between Bombay and the Red Sea (see table, p. 4), only 11 of these have been recorded from the coastal waters of West Pakistan. Kemp (1913) reported eight species from Karachi: *Squilla microphthalmia*, (*) *S. scorpion*, *S. scorpion* var. *immaculata*, *S. nepa*, (*) *S. interrupta*, *S. raphidea*, (*) *Gonodactylus chiragra*, and *G. demanii*. Baig (1954) recorded the three species marked with an asterisk and *Lysiosquilla maculata* as well, and Tirmizi (1967) reported specimens of *Protoquilla lenzi* and *P. pulchella*, so that 11 species were known from West Pakistan.

Our collections include 17 species, and it seems highly likely that additional collecting in specific habitats with specialized techniques could yield numerous additional species. For example, one collection made off Astola Island with rotenone during the International Indian Ocean Expedition yielded six different species, including one specimen

of an undescribed species of *Manningia*, previously known only from the Gulf of Aden. Additional collecting in such habitats could result in the collection of other species of *Gonodactylus*, *Protosquilla*, and *Pseudosquilla* as well. Other species could be expected to occur offshore in deeper water.

ZOOGEOGRAPHICAL NOTES.—Our knowledge of the stomatopods of the Indian Ocean is still so fragmentary that only preliminary observations can be recorded here. The distribution of the 46 species of stomatopods from the northwestern Arabian Sea is tabulated below (data are from Kemp, 1913; Chhapgar and Sane, 1968; Chopra, 1939; Holthuis, 1967b; Ingle, 1963; and Manning, 1967b). Records for these species from Madagascar and South Africa (including southern Mozambique) (Barnard, 1950; Manning, 1969) are included for comparison. Very little is known of the stomatopods of the East African coast proper.

The fauna of the Red Sea is the best known of the areas in the northwestern Arabian Sea; 31 of the 46 species known from the latter area occur in the Red Sea. Seventeen of these species occur off West Pakistan. Habitats in the Red Sea are undoubtedly more diverse, and the greater diversity is reflected in the presence of species of *Coronida*, *Gonodactylus*, *Protosquilla*, and *Pseudosquilla* there.

Only 16 of the 46 species from the northwestern Arabian Sea occur off Madagascar, and only 12 extend as far southward as southern Mozambique and South Africa. Thirteen of the species recorded from Madagascar by Manning (1968b) and 11 of the species known from South African waters (Manning, 1969) do not occur in the northwestern Arabian Sea. The fauna, however, of the central portion of the western Indian Ocean is somewhat richer than that of either the northern or southern portions of that ocean, for approximately 60 species are known from there. A more detailed analysis of the stomatopod faunal patterns in the Indian Ocean is in preparation in a review by one of us (R.B.M.) of the stomatopods collected during the International Indian Ocean Expedition.

The stomatopod fauna of West Pakistan can be expected to be very similar to that found off Bombay, India, to the south; 17 species are now known from Bombay (Chhapgar and Sane, 1968), and only 9 of these occur off Pakistan. Shallow, muddy bottoms are a predominant coastal environmental feature along much of the eastern shore of the Arabian Sea, and there is little reason not to expect a relatively uniform stomatopod fauna throughout that area.

It seems unlikely that there are any major faunal discontinuities in the Arabian Sea proper, at least as far as the stomatopods are concerned, although some local discontinuities may exist as a result of changes in habitat. The absence of coral reefs off West Pakistan

should limit the occurrence of coral associated species, but some of these, at least, can inhabit rocky areas as well. Other than differences expected as a result of the presence or absence of reefs, the fauna of the Arabian Sea between Bombay and the Red Sea, including the Persian Gulf, can be expected to be relatively uniform. Many of the 29 species occurring in the Arabian Sea, but not now known from West Pakistan, could be expected to occur off Pakistan.

Distribution of Stomatopod Crustacea from the Northwestern Indian Ocean

| | <i>Southern Africa</i> | <i>Madagascar</i> | <i>Bombay</i> | <i>West Pakistan</i> | <i>Northwest- ern Indian Ocean, Per- sian Gulf, Gulf of Oman</i> | <i>Red Sea, Gulf of Aden</i> |
|-----------------------|----------------------------|-------------------|---------------|--------------------------|--|--------------------------------------|
| <i>Acanthosquilla</i> | | | | | | |
| <i>acanthocarpus</i> | + | - | + | + | - | - |
| <i>multifasciata</i> | - | - | + | - | + | + |
| <i>vicina</i> | - | - | - | - | - | + |
| <i>Alima</i> | | | | | | |
| <i>supplex</i> | - | - | + | - | - | - |
| <i>Anchisquilla</i> | | | | | | |
| <i>fasciata</i> | - | - | - | - | - | + |
| <i>Carinosquilla</i> | | | | | | |
| <i>carinata</i> | - | + | - | - | - | + |
| <i>Clorida</i> | | | | | | |
| <i>bombayensis</i> | - | - | + | - | - | - |
| <i>denticauda</i> | - | - | + | - | - | - |
| <i>fallax</i> | - | + | - | - | - | + |
| <i>latreillei</i> | + | - | + | - | + | + |
| <i>microphthalma</i> | - | - | + | + | - | - |
| <i>Cloridopsis</i> | | | | | | |
| <i>immaculata</i> | - | - | - | + | - | - |
| <i>scorpio</i> | - | - | + | + | - | - |
| <i>Coronida</i> | | | | | | |
| <i>trachura</i> | - | - | - | - | - | + |
| <i>Eurysquilla</i> | | | | | | |
| <i>sewelli</i> | - | - | - | - | - | + |
| <i>Gonodactylus</i> | | | | | | |
| <i>chiragra</i> | + | + | + | + | + | + |
| <i>choprai</i> | - | - | - | - | + | + |
| <i>demanii</i> | - | + | + | + | + | + |
| <i>falcatus</i> | + | + | + | - | + | + |
| <i>lanchesteri</i> | + | + | - | + | + | + |
| <i>smithii</i> | - | + | - | + | - | + |
| <i>spinosus</i> | - | - | - | - | ? | - |
| <i>Harpiosquilla</i> | | | | | | |
| <i>annandalei</i> | - | - | - | - | + | - |
| <i>harpax</i> | + | + | + | + | + | + |
| <i>raphidea</i> | - | - | + | + | - | - |

Distribution of Stomatopod Crustacea from the Northwestern Indian Ocean—Continued

| | <i>Southern Africa</i> | <i>Madagascar</i> | <i>Bombay</i> | <i>West Pakistan</i> | <i>Northwest- ern Indian Ocean, Per- sian Gulf, Gulf of Oman</i> | <i>Red Sea, Gulf of Aden</i> |
|---|----------------------------|-------------------|---------------|--------------------------|--|--------------------------------------|
| <i>Leptosquilla</i> <i>schmeltzii</i> | — | — | — | — | — | + |
| <i>Lysiosquilla</i> <i>tredecimdentata</i> | + | + | — | + | — | + |
| <i>Manningia</i> <i>amabilis</i> | — | — | — | + | — | + |
| <i>pilaensis</i> | — | — | + | — | — | — |
| <i>Mesacturus</i> <i>brevisquamatus</i> | — | — | — | — | — | + |
| <i>Nannosquilla</i> <i>hystricotelson</i> | + | — | — | — | — | + |
| <i>Oratosquilla</i> <i>gonypetes</i> | + | + | — | — | + | — |
| <i>hesperia</i> | + | + | — | + | + | + |
| <i>interrupta</i> | — | — | + | + | + | — |
| <i>investigatoris</i> | + | — | — | — | + | + |
| <i>massavensis</i> | — | — | — | — | — | + |
| <i>nepa</i> | + | + | + | + | — | + |
| <i>perpensa</i> | — | — | — | — | + | — |
| <i>quinquedentata</i> | — | — | + | — | — | — |
| <i>simulans</i> | — | — | — | — | — | + |
| <i>Protosquilla</i> <i>lenzi</i> | — | + | — | + | — | + |
| <i>pulchella</i> | — | + | — | + | + | + |
| <i>spinosissima</i> | — | + | — | — | — | + |
| <i>Pseudosquilla</i> <i>ciliata</i> | + | + | — | — | + | + |
| <i>megalophthalma</i> | — | — | — | — | — | + |
| <i>Squilloides</i> <i>gilesi</i> | — | — | — | — | + | + |
| TOTALS 46 | 12 | 16 | 17 | 17 | 18 | 31 |
| | 26% | 35% | 37% | 37% | 39% | 67% |

METHODS.—Synonymies herein have been restricted to the works of Kemp (1913) and Holthuis (1941), where additional and older references may be found, and to one or two recent papers; synonymies are not intended to be complete.

All measurements are given in millimeters (mm). In the material examined, the numerals following the number of specimens is total length (TL) unless carapace length (CL) is specified. Total length is measured along the midline from the anterior margin of the rostral plate to the posterior apices of the submedian teeth of the telson;

carapace length, which does not include the rostral plate, is also measured on the midline.

The count of teeth on the dactylus of the raptorial claw always includes the terminal tooth. An abdominal spine formula of submedian 6, intermediate 4-6, lateral 2-6, marginal 1-5 indicates that the submedian carinae terminate in spines only on the sixth abdominal somite; the intermediate carinae terminate in spines on the

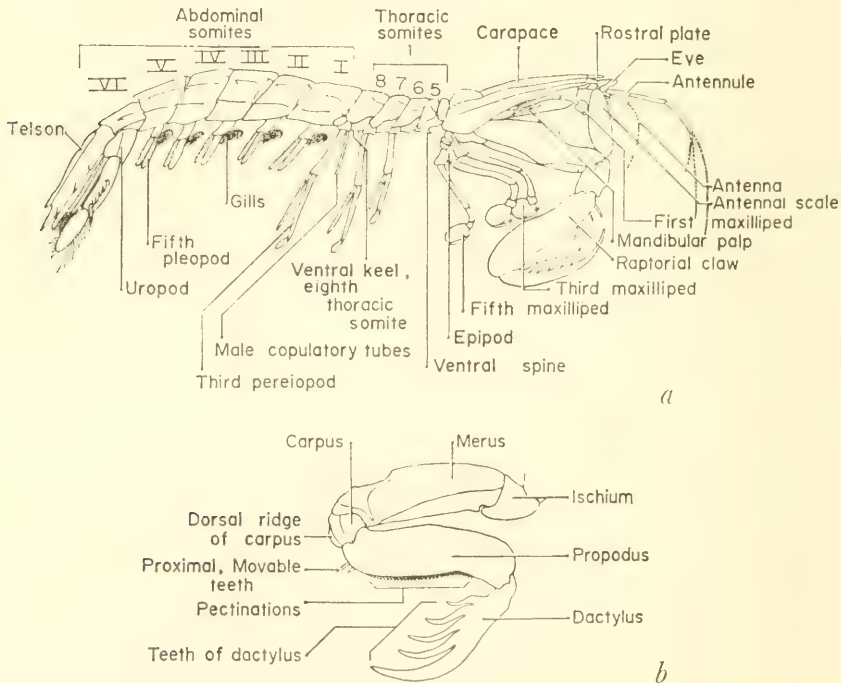
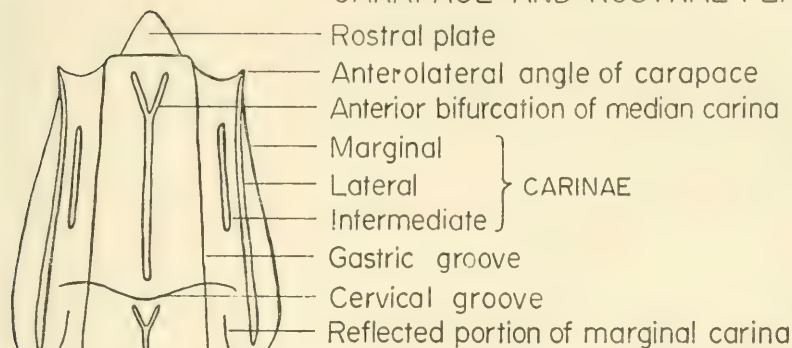


FIGURE 1.—Diagrammatic sketches: *a*, a squillid; *b*, a raptorial claw.

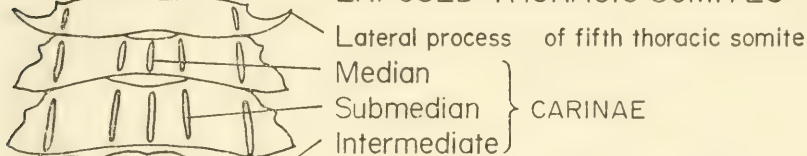
fourth, fifth, and sixth somites; the laterals are spined on the second to sixth somites, inclusive, and the marginals on the first to fifth somites, inclusive. A telson denticle formula of "4, 6-8, 1" indicates that on the margin of the telson, on either side of the midline, there are four submedian denticles, six to eight intermediate denticles, and one lateral denticle.

Many of the terms used in the descriptive accounts are shown in figures 1 and 2. Although the figures are based primarily on squillids,

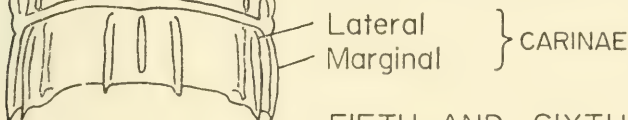
CARAPACE AND ROSTRAL PLATE



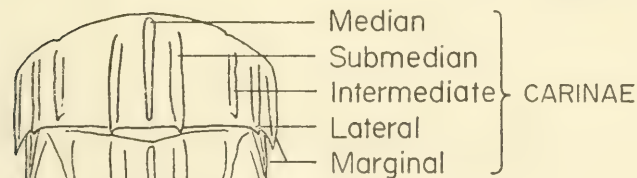
EXPOSED THORACIC SOMITES



FIRST ABDOMINAL SOMITE



FIFTH AND SIXTH ABDOMINAL SOMITES



TELSON

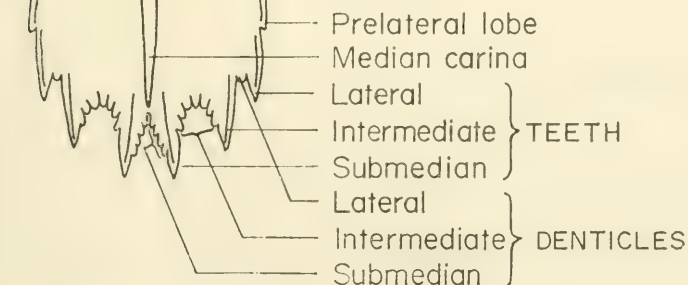


FIGURE 2.—Carinal terminology.

with the characteristic carination of the carapace, thorax, and abdomen, the general features of the carapace, claw, abdomen, telson, and uropod are similar in all of the stomatopods.

We have included sketches and a brief descriptive account of the male petasma (endopod of the first male pleopod) for all species represented by adult males.

Order STOMATOPODA Latreille, 1817

Until recently, this order was considered to include but one Recent family, Squillidae Latreille, 1803, with eight Recent genera. Studies on the classification of stomatopods by Serène (1962), Holthuis (1964), and Manning (1963, 1968a), have shown that the stomatopods comprise four families and 37 genera. The classification proposed by Manning (1968a) is used herein; that paper includes keys to all genera. For more detailed information on the order, the reader is referred to Balss (1938).

Representatives of three of the four families of stomatopods occur in the northwestern portions of the Indian Ocean; these three families may be distinguished by means of the key given below. The fourth family, Bathysquillidae, includes one deep-water genus, *Bathysquilla* Manning, with one Indo-West Pacific species known to occur off Japan and South Africa.

Key to Families of STOMATOPODA Occurring in the Northwestern Indian Ocean

1. Propodi of third and fourth thoracic appendages broader than long, beaded ventrally (fig. 3*d*); telson lacking sharp median carina.

LYSIOSQUILLIDAE, p. 8.

Propodi of third and fourth thoracic appendages longer than broad, not beaded ventrally (fig. 9*b*); telson with sharp median carina 2

2. No more than 2 intermediate marginal denticles present on telson.

GONODACTYLIDAE, p. 14.

More than 4 intermediate marginal denticles present on telson.

SQUILLIDAE, p. 28.

Family LYSIOSQUILLIDAE Giesbrecht, 1910

DIAGNOSIS.—Propodi of third, fourth, and fifth thoracic appendages broader than long, beaded or ribbed ventrally (fig. 3*d*); telson lacking longitudinal median carina on dorsal surface (fig. 4*b*).

DISCUSSION.—Representatives of two of the genera currently assigned to this family occur off West Pakistan; they may be distinguished by means of the following key.

Key to Genera of LYSIOSQUILLIDAE from West Pakistan

Dorsal surface of telson with fan-shaped row of 5 spines; rostral plate subquadrate (fig. 3a): uropodal endopod with strong proximal fold on outer margin.

Acanthosquilla

Dorsal surface of telson unarmed; rostral plate cordiform (fig. 4a); uropodal endopod lacking strong proximal fold on outer margin **Lysiosquilla**

Holthuis (1967a) has compiled synonymies for all known species in the family.

Acanthosquilla Manning, 1963

DIAGNOSIS.—Cornea subglobular; rostral plate subquadrate, trispinous anteriorly or with single apical spine; mesial and ventral antennal papillae present; mandibular palp present or absent; dorsal surface of telson with fan-shaped row of 5 spines; movable submedian marginal teeth present on telson; uropodal endopod with strong proximal fold on outer margin.

TYPE-SPECIES.—*Lysiosquilla multifasciata* Wood-Mason, 1895.

REMARKS.—Manning (1968b) gave a key to the five Indo-West Pacific species of this genus. In addition to the single species *A. acanthocarpus* (Claus) recorded below from West Pakistan, three of the five Indo-West Pacific species are known from the western Indian Ocean and might occur off West Pakistan. *Acanthosquilla humesi* Manning is known only from Madagascar, but both *A. multifasciata* (Wood-Mason) and *A. vicina* (Nobili) were reported from the Red Sea by Ingle (1963).

1. *Acanthosquilla acanthocarpus* (Claus, 1871)

FIGURE 3

Lysiosquilla acanthocarpus.—Kemp, 1913, p. 120.—Chopra, 1934, p. 30.—

Tiwari and Biswas, 1952, p. 359.—Barnard, 1962, p. 243.

Acanthosquilla acanthocarpus.—Holthuis, 1967a, p. 3 [references].—Manning, 1968b, p. 33 [key].—Chhappgar and Sane, 1968, p. 45 [key].

MATERIAL.—1 ♀, 52 mm; Manora Island, Karachi; 17 February 1965; Zoological Survey Reg. no. 1912.

DESCRIPTION.—Eye small, cornea globular, faintly bilobed, slightly wider than stalk (fig. 3b); antennal scale elongate; antennal protopod with 1 mesial and 1 ventral papilla; rostral plate (fig. 3a) as long as broad, subquadrate, with carinate median spine; lateral margins of rostral plate feebly sinuous and slightly convergent anteriorly, anterolateral angles truncate; carapace smooth, rounded anterolaterally and posterolaterally; cervical groove scarcely distinct even on lateral plates; dactylus of raptorial claw with 8 teeth (fig. 3c), penultimate smaller than either ultimate or antipenultimate; outer

margin of dactylus with 2 proximal lobes, distal slightly larger and more obtuse; upper margin of propodus with 4 large, movable, proximal spines and a row of 5 smaller spines extending distally;

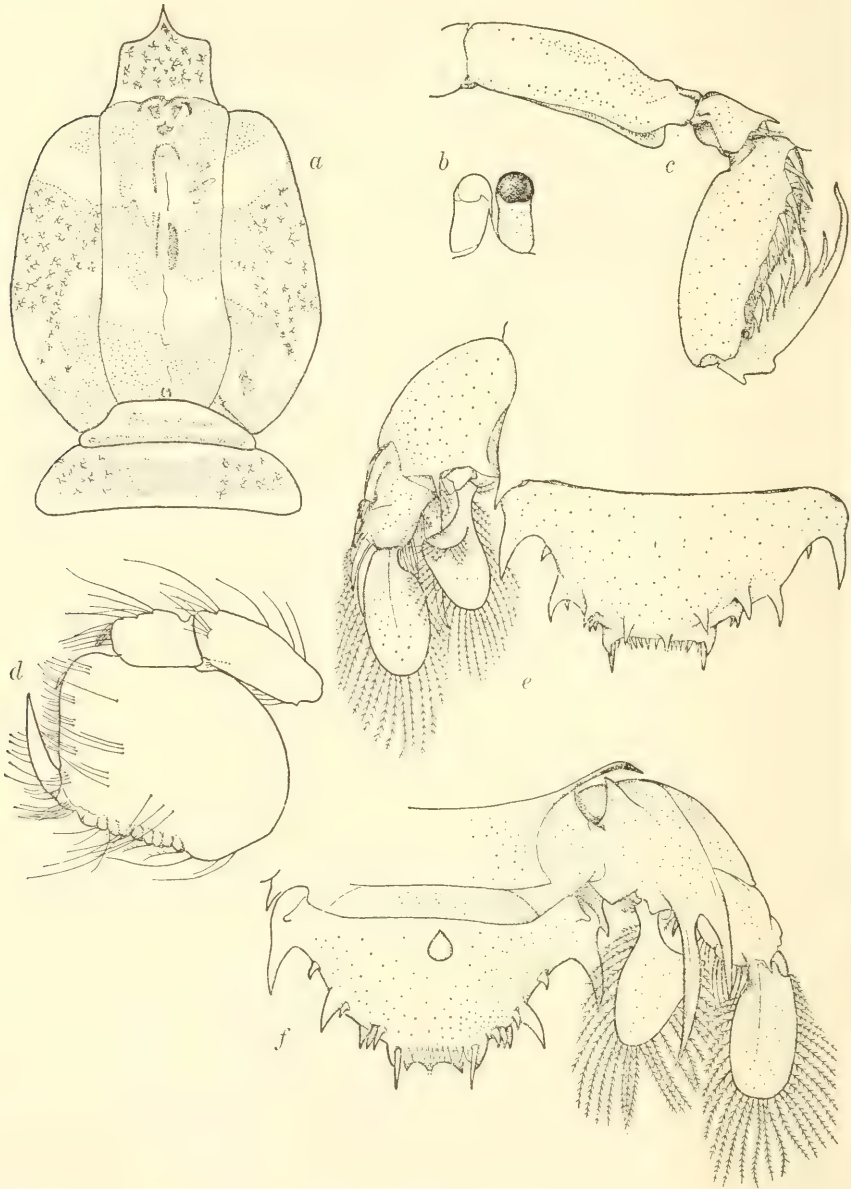


FIGURE 3.—*Acanthosquilla acanthocarpus* (Claus), female, TL 52 mm, Manora Island: *a*, outline of anterior portion of body to show color pattern; *b*, eyes; *c*, raptorial claw; *d*, fourth maxilliped; *e*, telson and uropod, dorsal view; *f*, same, ventral view.

dorsal ridge of carpus produced into a spine; mandibular palp 3-segmented; 5 epipods present; lateral processes of last 3 thoracic somites rounded anterolaterally and posterolaterally; abdomen elongate, depressed, loosely articulated, widest at fourth and fifth somites; posterolateral angles of sixth somite produced into sharp spines; sixth somite also with ventrally directed process on each side in front of articulation of uropods; telson (figs. 3e, f) almost twice as broad as long, with 4 pairs of fixed marginal teeth, submedians movable; 6 submedian denticles present on each side of midline, arranged in a transverse row, and 1 fixed denticle present between each of the marginal teeth; spines of dorsal surface extending to or slightly beyond margin; basal segment of uropod with dorsal spine; outer margin of proximal segment of exopod with 6 graded movable spines, last extending beyond midlength of distal segment; inner spine of basal prolongation of uropod longer and stouter.

COLOR.—Carapace with 3 more or less distinct bands of dark color (fig. 3a), posterolateral angles also dark; rostral plate uniformly dark except at base, speckled with darker chromatophores; fifth thoracic somite light; last 3 thoracic and first 5 abdominal somites each with broad, dark band in middle of segment, median portion of band on each somite darker than lateral portions; band on last abdominal somite lighter than on remainder of body; telson light; uropod with dark proximal patch, exopod with dark spot at articulation of distal segment, endopod dark beyond dorsal fold.

DISCUSSION.—*Acanthosquilla acanthocarpus* can be distinguished from *A. multifasciata* by several features. In the latter species, the two lobes on the dactylus of the claw are not subequal in size, but the distal is much larger than the proximal; the submedian denticles of the telson are not arranged in a transverse row, as in *A. acanthocarpus*, but in two curved rows; and there are but two pairs of marginal teeth on the telson, not four as in the present species.

Acanthosquilla vicina (Nobili), which has been recorded from the Red Sea, differs from both *A. acanthocarpus* and *A. multifasciata* in having 10–11 teeth on the dactylus of the claw, rather than 5 to 8, and in having sharp anterolateral angles on the rostral plate.

DISTRIBUTION.—Indo-West Pacific region, from the western Indian Ocean and Moçambique to Australia and Indo-Malaya. It has not been recorded previously from West Pakistan.

Lysiosquilla Dana, 1852

DIAGNOSIS.—Cornea bilobed; rostral plate cordiform, with apical spine; 1 mesial and 2 ventral antennal papillae present; mandibular palp present; dorsal surface of telson with at most a low median boss,

unarmed; telson usually lacking movable submedian teeth; uropodal endopod lacking strong proximal fold on outer margin.

TYPE-SPECIES.—*Lysiosquilla inornata* Dana, 1852.

REMARKS.—Four species of *Lysiosquilla* occur in the Indo-West Pacific region. One species, *L. capensis* Hansen, is known only from off South Africa; the other three have wider ranges. Only *L. tredecimdentata* Holthuis is known to occur off West Pakistan. The commonest species in the Indo-West Pacific region, *L. maculata* (Fabricius), could be expected off West Pakistan, but there are no authenticated records of that species from the northwestern Indian Ocean. Manning (1968b) gave a key to the Indo-West Pacific species.

2. *Lysiosquilla tredecimdentata* Holthuis, 1941

FIGURE 4

Lysiosquilla maculata.—Chopra, 1939, p. 161.—Holthuis, 1967a, p. 40.

Lysiosquilla maculata var. *tredecimdentata* Holthuis, 1941, p. 273, fig. 6.

Lysiosquilla maculata.—Baig, 1954, p. 143 [erroneous spelling].

Lysiosquilla maculata tredecimdentata.—Manning, 1963, p. 317 [listed].

Lysiosquilla maculata maculata.—Ingle, 1963, p. 23 [part; not figs. 23, 45, 61, 72].

Lysiosquilla tredecimdentata.—Holthuis, 1967a, p. 23 [references].—Manning, 1968b, p. 38, fig. 13.

MATERIAL.—2♂, 120–259 mm; off Karachi; Central Fisheries Department, Karachi.

DESCRIPTION.—Eye large, cornea bilobed, set obliquely on stalk; ocular scales separate, broad, truncate dorsally; anterior margin of ophthalmic somite produced into a median spine; anterior margin of basal segment of antenna with triangular projection (fig. 4a); antennal scale slender, 3 times as long as wide; rostral plate heart shaped, broader than long, with median carina on anterior half; carapace smooth, rounded anterolaterally and posterolaterally; raptorial claw large, dactylus with 11–12 teeth (13 in holotype); dorsal ridge of carpus of claw with deflexed spine; lateral process of fifth thoracic somite inconspicuous, lateral processes of next 2 somites flattened laterally, rounded anterolaterally, more truncate posterolaterally; ventral keel of eighth thoracic somite with acute posterior projection; abdominal somites unarmed, smooth, depressed, sixth somite with irregular surface laterally; telson much broader than long, with low, triangular, median boss, submedian bosses present but less distinct; lateral margin of telson pitted; posterolateral margin of telson with 4 pairs of fixed projections, innermost obtuse, outermost spiniform; submedian margin smooth, unarmed, indented along midline; uropodal exopod with 8 movable spines on outer margin of proximal segment; inner spine of basal prolongation of uropod much the longer.

COLOR.—Carapace with 3 dark bands, posteriormost narrowest and darkest; antennal scale outlined in black color; each body segment with a dark, transverse band; telson with an uninterrupted

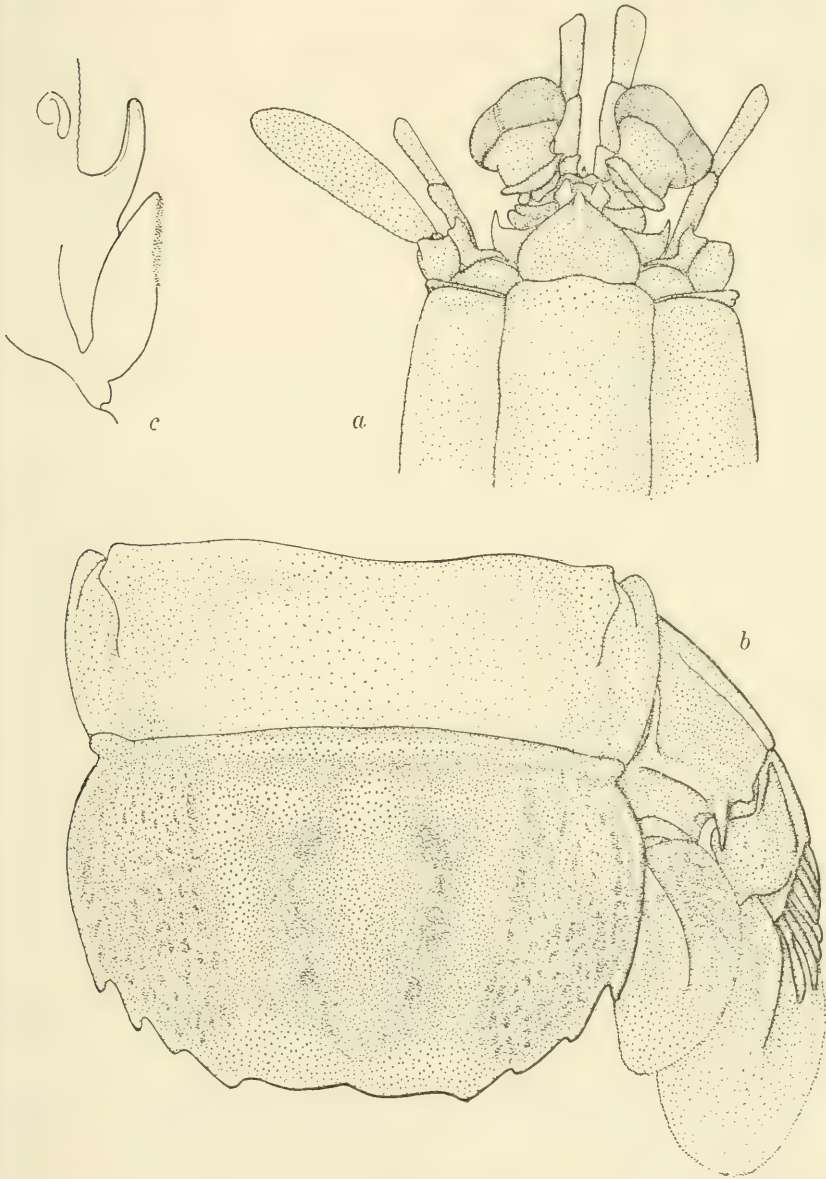


FIGURE 4.—*Lysiosquilla tredecimdentata* Holthuis, male, TL 120 mm, from off Karachi: a, anterior portion of body; b, last abdominal somite, telson, and uropod; c, petasma. (Setae omitted.)

transverse dark band, anterior margin and submedian portion of posterior margin lighter; uropodal exopod with dark spot at articulation of distal segment, apex of distal segment lighter; uropodal endopod dark.

DISCUSSION.—*Lysiosquilla tredecimdentata* is very similar in general appearance to *L. maculata* (Fabricius), a common Indo-West Pacific species, but Holthuis's species differs in several important respects as follows: (1) the ocular scales are broad and truncate dorsally; (2) the anterior margin of the antennal peduncle is produced into an acute projection (fig. 4a) whereas it is straight in *L. maculata*; (3) the antennal scale is slender and outlined in dark color rather than oval with a dark patch on the surface; (4) there are more teeth on the claw, 11–13 rather than 9–11; and (5) the ventral keel of the eighth thoracic somite is produced into a posterior spine and is not evenly rounded.

The petasma of the smaller male is shown in figure 4c. The hook process is extremely reduced; the tube process is slender, and retinaculae are confined to the distal half.

Manning (1968b) gave a detailed account of this species from Madagascar and suggested that the accounts of Chopra (1939) and Ingle (1963) based on a specimen from Aden identified as *L. maculata* might be referable to *L. tredecimdentata*. Since that manuscript was completed, one of us (R. B. M.) has had an opportunity of examining these authors' material at the British Museum. The single specimen from Aden, a female, TL 156 mm, clearly belongs to *L. tredecimdentata*.

The larger of the two specimens reported herein is probably the specimen on which Baig's record of *L. maculata* from Karachi was based.

DISTRIBUTION.—Western Indian Ocean, from Aden, West Pakistan, and Madagascar.

Family GONODACTYLIDAE Giesbrecht, 1910

DIAGNOSIS.—Propodi of third, fourth, and fifth thoracic appendages longer than broad, not beaded or ribbed ventrally (fig. 9b); telson with sharp median dorsal carina and no more than 2 intermediate denticles on margin.

REMARKS.—Three of the genera assigned to this family by Manning (1968a) occur off West Pakistan; they may be distinguished by use of the key given below.

Four species in other genera, reported from the Red Sea by Ingle (1963), could also be expected to occur off West Pakistan. These are: (1) *Pseudosquilla ciliata* (Fabricius), which has a wide distribution

in the Indo-West Pacific and Atlantic regions; (2) *P. megalophthalma* Bigelow, a rare Indo-West Pacific species; (3) *Eury squilla sewelli* (Chopra), known only from the Red Sea; and (4) *Mesacturus brevisquamatus* (Paul'son), known to occur in the Red Sea and western Indian Ocean as well.

Key to Genera of GONODACTYLIDAE from West Pakistan

1. Dactylus of raptorial claw with 4 teeth; basal prolongation of uropod with spines on inner margin.....**Manningia**
 Dactylus of raptorial claw unarmed; basal prolongation of uropod lacking spines on inner margin.....2
2. Rostral plate sharply trispinous (fig. 6a); anterolateral angles of carapace not extending beyond base of rostral plate; sixth abdominal somite fused with telson.....**Protosquilla**
 Rostral plate with median spine, anterolateral angles at most acute, not spiniform (fig. 7a); anterolateral angles of carapace extending beyond base rostral plate; sixth abdominal somite not fused with telson . **Gonodactylus**

Manningia Seréne, 1962

DIAGNOSIS.—Cornea bilobed, outer margin of eye longer than inner; rostral plate pentagonal; carapace unarmed, cervical groove indicated on lateral plates only; raptorial claw stout, dactylus with 4 teeth, propodus fully pectinate, carpus with 2 dorsal spines; fifth and sixth abdominal somites with carinae; telson with median carina and 5 pairs of lateral carinae on dorsal surface; submedian teeth of telson approximated, submedian denticles absent; 2 intermediate denticles present; intermediate and lateral denticles each flanked by sharp ventral denticle; basal prolongation of uropod terminating in 2 spines, with spinules on inner margin.

TYPE-SPECIES.—*Pseudosquilla pilaensis* de Man, 1888.

DISCUSSION.—Manning (1967a) reviewed the known species of *Manningia* and pointed out that the specimen reported from the Gulf of Aden by Nobili (1906) and others probably belonged to a new species. Because of the fragmented nature of the single specimen known from there, the species was not described. Since that study was completed, additional specimens from the Red Sea have been studied by L. B. Holthuis (1967b), who has described species as new. A single specimen of this species is reported herein from West Pakistan.

Manningia pilaensis (de Man), recently recorded from Bombay by Chhappar and Sane (1968), could also occur off West Pakistan.

Two other species of *Manningia* have been recorded from localities in the Indo-West Pacific region, but neither of these are known to occur in the western Indian Ocean. Manning (1967a) provided a key to all of the species then known.

3. *Manningia amabilis* Holthuis, 1967

Manningia amabilis Holthuis, 1967b, p. 16, figs. 4-5.

Manningia species Manning, 1967a, p. 5, fig. 1 [other references].

MATERIAL.—1 ♂, 37 mm; western end of Astola Island, ca. 177 miles west of Karachi; rocks, sand, scanty, scattered coral; 0-8 ft; L. P. Woods, et al.; Sta. LW-1; HIOE; 27 November 1963; USNM.

DIAGNOSIS.—Rostral plate subpentagonal, rounded anterolaterally, lacking apical spine; ocular scales fused basally, apices separate; antennal protopod with 1 ventral papilla; dactylus of claw with 4 teeth; merus of claw lacking inferodistal spine on outer surface; sixth abdominal somite with 3 pairs of dorsal carinae, each armed posteriorly, low accessory carina present between submedians and intermediates; telson with median carina and 5 pairs of dorsal carinae, accessory medians subdivided into 2 tubercles, remainder entire; submedian and intermediate carinae each with blunt posterior lobe; basal prolongation of uropod with teeth on inner margin, lacking rounded lobe between distal spines.

COLOR.—Body completely covered with light brown chromatophores arranged in no particular pattern.

DISCUSSION.—This species of *Manningia* closely resembles *M. notialis* Manning from Australia but differs from it as follows: (1) the ocular scales are fused; (2) the rostral plate is more rounded anterolaterally; (3) there is a low ridge on the sixth abdominal somite lateral to each submedian carina; and (4) the accessory median carinae of the telson are divided into two blunt lobes, not three spined ones.

A more complete account of this species, including illustrations, has been published by L. B. Holthuis (1967b) in a paper on the stomatopods of the Red Sea that was issued after this paper was submitted for publication.

DISTRIBUTION.—Red Sea, Gulf of Aden, and Astola Island, West Pakistan; it has not been recorded previously from the latter locality.

Protosquilla Brooks, 1886

DIAGNOSIS.—Cornea subglobular or bilobed; rostral plate sharply trispinous; anterolateral margins of carapace not extending beyond base of rostral plate; mandibular palp present; sixth abdominal somite fused with telson; basal segment of uropodal exopod not extending beyond articulation of distal segment, marginal spines straight.

TYPE-SPECIES.—*Gonodactylus folini* A. Milne-Edwards, 1868.

REMARKS.—*Protosquilla* includes the species assigned by Kemp (1913) to *Gonodactylus* Group III. Three species of *Protosquilla*

have been recorded from the northwestern Indian Ocean, and two of these occur off West Pakistan. The third species, *P. spinosissima* (Pfeffer, 1888), has been recorded from the Red Sea by Ingle (1963) and could be expected to occur off Pakistan.

Key to *Protosquilla* from West Pakistan

Dorsal bosses of telson not extending posteriorly past midlength; posterior margin of telson with 4 pairs of teeth *P. pulchella*
 Dorsal bosses of telson extending almost to posterior margin; posterior margin of telson with 3 pairs of teeth *P. lenzi*

4. *Protosquilla pulchella* (Miers, 1880)

FIGURE 5

Gonodactylus pulchellus.—Kemp, 1913, p. 177, pl. 10 (figs. 117–118).—Chopra, 1934, p. 41.—Holthuis, 1941, p. 288, fig. 9b [older references].—Ingle, 1963, p. 30, figs. 29, 49.

Gonodactylus pulchellus.—Tirmizi, 1967, p. 35, fig. 2 [erroneous spelling].

Protosquilla pulchella.—Holthuis, 1967b, p. 42.—Manning, 1968b, p. 54.

MATERIAL.—2♀, 28–35 mm; western end of Astola Island, ca. 177 miles west of Karachi; rocks, sand, scanty, scattered coral; 0–8 ft; L. P. Woods, et al.; Sta. LW-1; HIOE; 27 November 1963; USNM.—1♂, 45 mm; off Karachi; University of Karachi; USNM.—4♂, 36–49 mm; 6 fragmented specimens; G. M. Hut, about 22 miles west of Karachi; Zoological Survey no. 1898.—1 broken ♂, CL 8.7 mm; 3♀ (2 broken), 45 mm; off Karachi; University of Karachi.

DESCRIPTION.—Anterior margin of ocular scales sinuous, scales produced laterally into acute lobes; eyes usually extending beyond end of basal segment of antennular peduncle; cornea subglobular; rostral plate sharply trispinous, median spine slenderer and longer than laterals; anterolateral margins of lateral plates of carapace concave, anterolateral angles acute but rounded; mandibular palp 2-segmented; dactylus of claw (fig. 5c) lacking basal notch on outer margin; first 4 abdominal somites almost smooth, at most marked by obscure lateral grooves; fifth abdominal somite with pits arranged in 2 rows on either side of ridge separating the smooth median portion from irregular lateral portions of somite; carinae of sixth abdominal somite and telson covered with short hairs; distal margin of telson (fig. 5d) divided into 2 halves by long, narrow, median fissure, distal margin of each half with 4 teeth or lobes, submedians with movable apices; several small submedian denticles present and 1 denticle present between each of remaining teeth; dorsal surface of telson with 3 bosses (fig. 5d) median triangular, external bosses on each side rounded or oval, not extending much past midlength of telson; surface of telson appearing pitted rather than coarsely reticulate; outer spine of basal prolongation of uropod (fig. 5e) much larger than inner.

COLOR.—Faded in most specimens; male has dark rectangular patches on the sixth thoracic and first and fourth abdominal somites, color most prominent on first abdominal somite; other specimens show traces of light banding over the body.

DISCUSSION.—The presence of short hairs on the dorsal surface of the last abdominal somite and telson, the smaller lateral dorsal bosses on the telson, and the four pairs of marginal teeth on the telson will immediately distinguish this species from *P. lenzi*.

The hook process of the petasma of *P. pulchella* is well developed and extends beyond the tube process. The latter is ornamented with a triangular projection, the margins armed with small blunt spines.

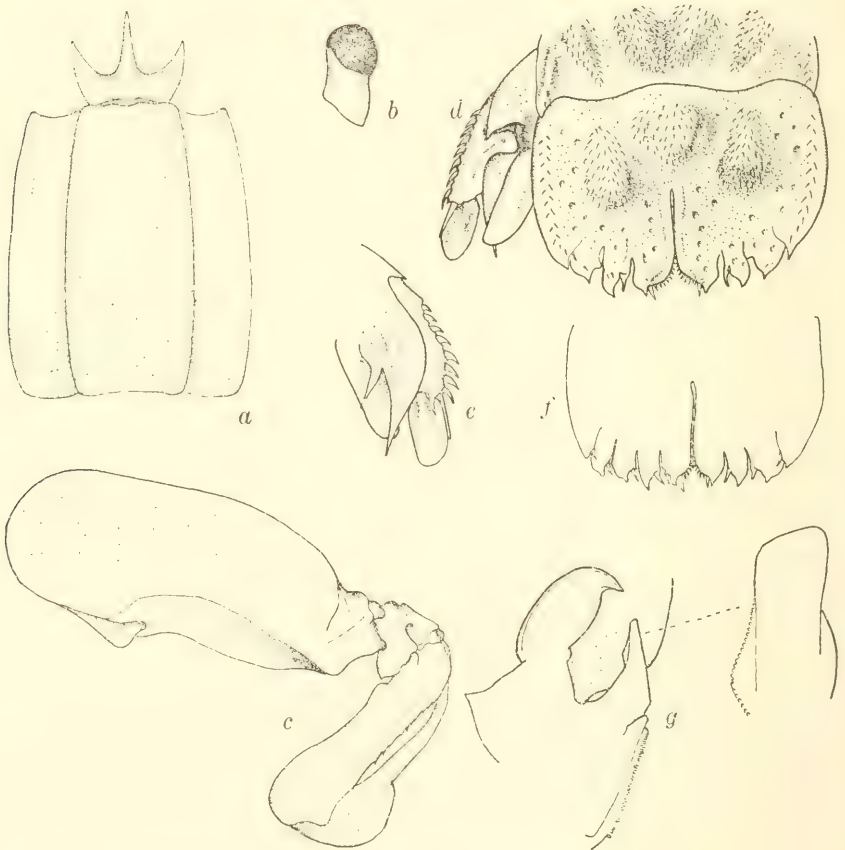


FIGURE 5.—*Protosquilla pulchella* (Miers), female, TL 45 mm, off Karachi: *a*, carapace and rostral plate; *b*, eye; *c*, raptorial claw; *d*, last abdominal somite, telson and uropod; *e*, uropod, ventral view. Female (broken), off Karachi: *f*, outline of telson. Male, TL 45 mm G. M. Hut: *g*, petasma.

One specimen, a female from off Karachi, has an abnormal telson, with five marginal teeth developed on the left side; it is shown in figure 5f.

DISTRIBUTION.—Indian Ocean, from the Red Sea and the coast of Africa to Australia. It was recorded previously from West Pakistan by Tirmizi (1967).

5. *Protosquilla lenzi* (Holthuis, 1941)

FIGURE 6

Gonodactylus glaber.—Kemp, 1913, p. 182, pl. 10 (fig. 121).

Gonodactylus lenzi Holthuis, 1941, p. 288 [older references].—Tiwari and Biswas, 1952, p. 362.—Ingle, 1963, p. 31, fig. 31.

Protosquilla lenzi.—Tirmizi, 1967, p. 32, fig. 1.—Holthuis, 1967b, pp. 36, 42.—Manning, 1968b, p. 54.

MATERIAL.—2 ♀, 27–42 mm; G. M. Hut, about 22 miles west of Karachi; 13 February 1965; University of Karachi.—3 ♂, 21–32 mm; 4 ♀, 24–35 mm; western end of Astola Island, ca. 177 miles west of Karachi; rocks, sand, scanty, scattered coral; 0–8 ft; L. P. Woods, et al.; Sta. LW-1; IIOE; 27 November 1963; USNM.

DESCRIPTION.—Anterior margin of ocular scales rounded, scales acute but rounded laterally; eyes extending beyond end of first segment of antennular peduncle; cornea subglobular; rostral plate

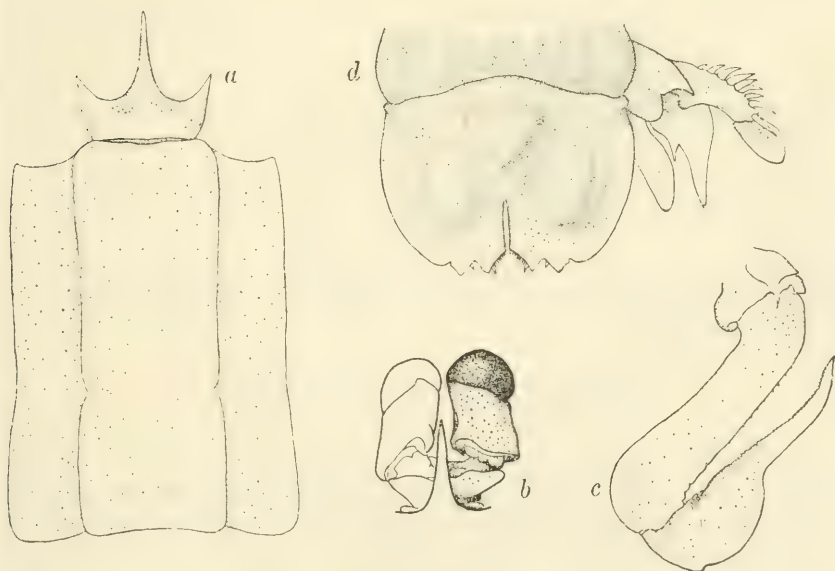


FIGURE 6.—*Protosquilla lenzi* (Holthuis), female, TL 42 mm, G. M. Hut: a, carapace and rostral plate; b, eyes; c, propodus and dactylus of raptorial claw; d, last abdominal somite, telson, and uropod.

sharply trispinous, median spine slenderer and longer than laterals; anterior margins of lateral plates of carapace concave, anterolateral angles rounded; mandibular palp 2-segmented; dactylus of claw with prominent notch on outer margin; first 4 abdominal somites smooth, with lateral groove flanked dorsally by slightly irregular area; fifth somite smooth dorsally, with 2 broad longitudinal swollen areas above lateral margin; carinae of sixth abdominal somite and telson smooth, not ornamented with setae; distal margin of telson (fig. 6*d*) divided into 2 halves by long, narrow, median fissure, distal margin of each half with 3 teeth or lobes, submedians with movable apices; several small submedian denticles present, at most 1 very small intermediate and lateral denticle present, either or both occasionally missing; dorsal surface of telson with 3 bosses, median rounded, smaller than more oval submedians, which extend posteriorly beyond midlength of telson (fig. 6*d*); outer spine of basal prolongation much broader and longer than inner.

COLOR.—Body marked with diffuse bands of dark chromatophores; sixth thoracic somite with median and lateral dark patches, seventh thoracic and first abdominal somites with dark median patch; telson with small dark spot at anterior end of each submedian boss.

DISCUSSION.—These specimens agree well with accounts of this species in the literature.

Protosquilla pulchella (Miers), the only other species of this genus known from West Pakistan, differs in having the dorsal surface of the sixth abdominal somite and telson covered with short hairs, in having smaller submedian bosses on the dorsal surface of the telson, and in having four pairs of marginal teeth on the telson.

One of the males from Astola Island differs from the remainder of the specimens in having but two teeth on one side of the telson margin.

DISTRIBUTION.—Indo-West Pacific region, from the western Indian Ocean to the Philippines. It was recorded from West Pakistan by Tirmizi (1967).

Gonodactylus Berthold, 1827

DIAGNOSIS.—Cornea subglobular; rostral plate with apical spine, anterolateral angles usually rounded, rarely acute, not spiniform; anterolateral margins of carapace extending beyond base of rostral plate; mandibular palp present; dactylus of claw unarmed, inflated basally; sixth abdominal somite free, not fused with telson; basal segment of uropodal exopod extending beyond articulation of distal segment, marginal spines straight.

TYPE-SPECIES.—*Gonodactylus chiragra* (Fabricius, 1781).

REMARKS.—This genus includes the species assigned by Kemp (1913) in his monograph of the Indo-West Pacific stomatopods to *Gonodactylus* Group I. Nine species have been reported from the northwestern Indian Ocean, and representatives of four of these are reported herein. The other five species, not now known to occur off West Pakistan, are: (1) *G. platysoma* Wood-Mason, 1895, a common species characterized by its broad body and by the presence of only two pairs of marginal teeth on the telson, the laterals being absent; (2) *G. falcatus* (Forskål, 1775), also a common species, which has five dorsal carinae in the center of the telson; (3) *G. choprai* Manning, a small, possibly rare species from moderate depths that lacks the fixed distal spine on the ventral surface of the proximal segment of the uropodal exopod; (4) *G. spinosus* Bigelow, a small species related to *G. lanchesteri* Manning and *G. demanii* Henderson (both reported below), which has a narrow telson tapering distally, with the intermediate teeth poorly developed, numerous small dorsal spinules on the telson, and a normal complement of setae on the uropod; and (5) *G. segregatus* Lanchester, a small species inhabiting moderate depths, which resembles *G. choprai* but has the distal ventral spine on the proximal segment of the uropod exopod. Any of these species could occur off West Pakistan if suitable habitats were available.

The four species of *Gonodactylus* now known from West Pakistan may be distinguished by means of the following key.

Key to *Gonodactylus* from West Pakistan

1. Dorsal surface of telson lacking spinules 2
- Dorsal surface of telson with spinules 3
2. Anterolateral angles of rostral plate rounded; carinae of telson inflated, marginal teeth blunt *G. chiragra*
- Anterolateral angles of rostral plate acute; carinae of telson slender, usually with apical spinule, marginal teeth sharp *G. smithii*
3. Uropodal endopod completely fringed with setae *G. lanchesteri*
- Most of inner margin of uropodal endopod smooth, nonsetose, 10 or less proximal setae present *G. demanii*

6. *Gonodactylus chiragra* (Fabricius, 1781)

FIGURE 7

Gonodactylus chiragra.—Kemp, 1913, p. 155, fig. 2 on p. 161, pl. 9 (fig. 107).—Holthuis, 1941, p. 277, fig. 7 [older references].—Barnard, 1950, p. 861.—Baig, 1954, p. 143.—Manning, 1966, p. 113.—Holthuis, 1967b, pp. 25, 41.—Manning, 1968b, p. 43.—Chhappgar and Sane, 1968, p. 45 [key].

MATERIAL.—2♂, 1 soft, other 68 mm; 4♀, 43–78 mm; off Karachi; University of Karachi.—1♀, 74 mm; Hyderabad; University of Karachi.—1♀, 52 mm; Manora Island, Karachi; S. M. H. Balgrammi; 10 October 1953; Zoological Survey reg. no. 272.—1♂, 71 mm; 1♀, 69 mm; same; N. Tirmizi, R. B. Manning,

et al.; 9 March 1967; University of Karachi.—1♂, 77 mm; off Karachi; Mohammed Abdullah el Husseini; USNM.—1♂, 53 mm; 1♀, 52 mm; off Karachi; USNM.—1♀, 73 mm; Pasni, Makran coast; F. Townsend; BMNH reg. no. 1898.5. 23.2.—6♂, 24–66 mm; 7♀, 38–53 mm; western end of Astola Island, ca. 177 miles west of Karachi; rocks, scanty, scattered coral; 0–8 ft; L. P. Woods, et al.; Sta. LW-1; HIOE; 27 November 1963; USNM.—2♀, 50–56 mm; same data; Sta. RF-2; HIOE; USNM.

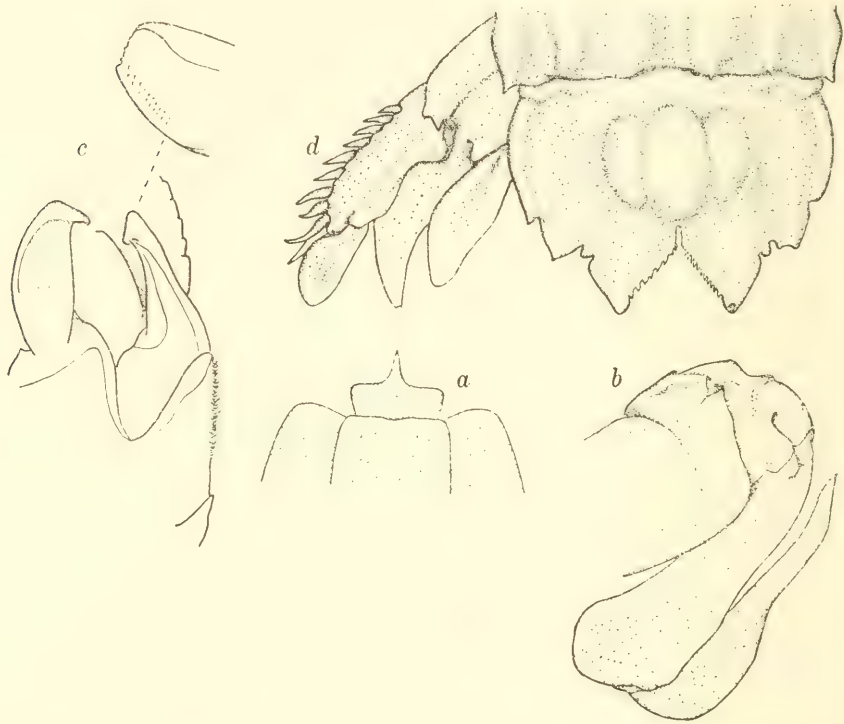


FIGURE 7.—*Gonodactylus chiragra* (Fabricius), male, TL 68 mm, off Karachi: *a*, anterior portion of carapace and rostral plate; *b*, carpus, propodus, and dactylus of raptorial claw; *d*, last abdominal somite, telson, and uropod (setae omitted). Male, TL 71 mm, Manora Island; *c*, petasma.

DIAGNOSIS.—Anterolateral angles of rostral plate rounded (fig. 7*a*), anterior margins straight or with slight anterior slope; ocular scales large, truncate; telson broader than long, dorsal surface unarmed, dorsal carinae each with at most an apical tubercle; accessory median carinae short, forming anchor; 3 pairs of marginal teeth present, submedians with movable apices, intermediates broad, blunt, laterals poorly formed but distinct; carinae of marginal teeth broad, inflated; numerous small submedian denticles and 2 intermediate denticles

present, intermediates recessed anteriorly; uropod with full complement of setae.

COLOR.—Faded in most specimens; in two fresh specimens from Manora Island the male was dark brownish green, the female a lighter green; on both specimens the display patches on the dorsal surface of the merus of the chelae were whitish, lined with light green, with 2 distal spots.

DISCUSSION.—*Gonodactylus chiragra* is the most common species of the genus in the Indo-West Pacific region, and it can be recognized without difficulty through the characters outlined above. *Gonodactylus smithii* Pocock, discussed below, differs in having acute anterolateral angles on the rostral plate and in other features as well. The display patch on the merus of the claw in *G. smithii* is blue or crimson in life, not whitish as in *G. chiragra*.

On the male petasma, the hook process is swollen in the middle and extends as far as or a little beyond the tube process; the latter has a truncated distal margin, armed with small distolateral spines (fig. 7c).

In the largest male examined (CL 18.1 mm) the median carina is so swollen that it completely obliterates the accessory medians with the result that no anchor is visible (fig. 7d). In general, the carinae of the telson in males are more swollen than in females.

The rostral plate figured by Ingle (1963) for a specimen of *G. chiragra* is the typical shape of the rostral plate of *G. smithii*.

The two specimens collected by us at Manora Island were found burrowing in a rocky flat exposed at low tide.

DISTRIBUTION.—Throughout the Indo-West Pacific region, from the Red Sea and East Africa to Japan, with the exception of Hawaii.

7. *Gonodactylus smithii* Pocock, 1893

FIGURE 8

Gonodactylus smithii Pocock, 1893, p. 475, pl. 20B (fig. 1).—Manning, 1966, p. 112.—Holthuis, 1967b, pp. 28, 41.—Manning, 1968b, p. 44 [references].

Gonodactylus chiragra chiragra.—Ingle, 1963, p. 27, figs. 27, 47, 63.

MATERIAL.—1 ♀, 74 mm; off Karachi; University of Karachi.—1 ♂, 29 mm; western end of Astola Island, ca. 177 miles west of Karachi; rocks, sand, scanty, scattered coral; 0–8 ft; L. P. Woods, et al.; Sta. LW-1; IIOE; 27 November 1963; USNM.

DIAGNOSIS.—Anterolateral angles of rostral plate acute, sharp, anterior margins sloping anteriorly; ocular scales large, truncate; sixth abdominal somite with 6 sharp carinae, most ending in spines; telson broader than long, dorsal surface unarmed, dorsal carinae each usually with an apical tubercle; dorsal carinae slender, accessory medians present, fusing with median to form anchor; 3 pairs of marginal teeth present, submedians with movable apices, interme-

diates sharp, laterals poorly formed but distinct; carinae of marginal teeth sharp; numerous small submedian and 2 sharp intermediate denticles present, intermediates recessed anteriorly.

COLOR.—Fresh specimens and most specimens in preservative show traces of a crimson or blue display patch on the dorsal surface of the merus of the claw; the dactylus of the claw is pink.

DISCUSSION.—The sharp anterolateral angles of the rostral plate will immediately distinguish this species from *G. chiragra* as well as most other Indo-West Pacific species of the genus. The only other

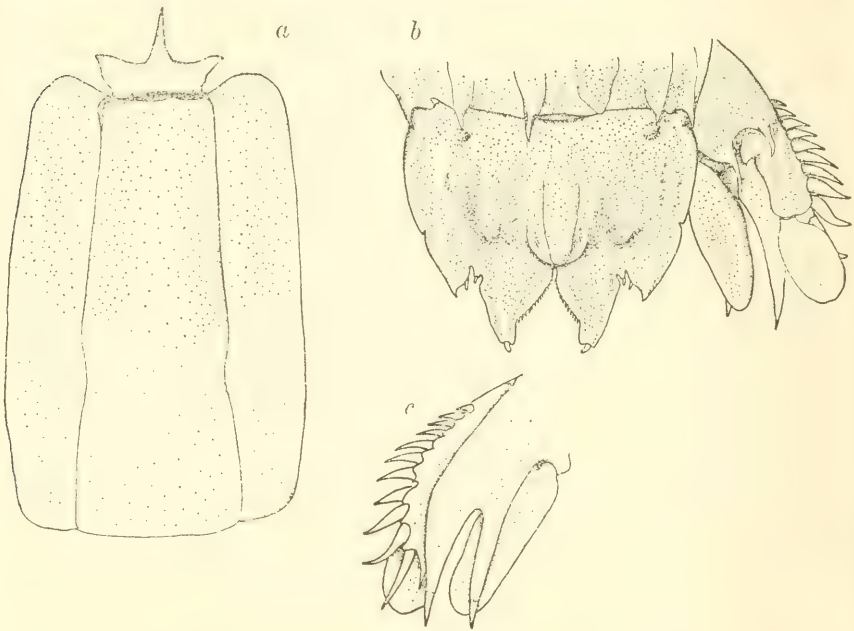


FIGURE 8.—*Gonodactylus smithii* Pocock, female, TL 74 mm, off Karachi: *a*, carapace and rostral plate; *b*, last abdominal somite, telson, and uropod; *c*, uropod, ventral view. (Setae omitted.)

species from the Indo-West Pacific region with a similar rostral plate is *G. hendersoni* Manning (see Manning, 1967b), which differs in numerous features, including the presence of dorsal spinules on the telson.

In his account of this species from Madagascar, Manning (1968b) noted that *G. smithii* and *G. acutirostris* de Man were probably conspecific. Manning also placed Ingle's (1963) record of *G. chiragra chiragra* from the Red Sea in the synonymy of *G. smithii*; the rostral plate of *G. chiragra* illustrated by Ingle is almost certainly that of *G. smithii*.

The small specimen of this species from Astola Island has a faintly sinuate inner margin on the uropodal endopod, as in the specimens from Madagascar reported by Manning (1968b).

DISTRIBUTION.—Indo-West Pacific, from Vietnam, Australia, and the western Indian Ocean. It has not been recorded previously from West Pakistan.

8. *Gonodactylus lanchesteri* Manning, 1967

FIGURE 9

Gonodactylus spinosus.—Holthuis, 1967b, pp. 34, 42.

Gonodactylus lanchesteri Manning, 1967b, p. 11, fig. 4 [other references]; 1968b, p. 51.

MATERIAL.—1♂, 30 mm; 1♀, 24 mm (in 2 lots); off Karachi; University of Karachi.

DIAGNOSIS.—Anterolateral angles of rostral plate rounded or subacute, anterior margins straight, ocular scales small, erect; carinae of sixth abdominal somite swollen, each usually with apical tubercle; telson broader than long, dorsal surface ornamented with numerous small spinules and tubercles; all carinae of dorsal surface inflated; anterior dorsal carinae smooth dorsally, spinulose laterally; carinae of marginal teeth very spinulose dorsally; 3 pairs of marginal teeth present, submedians with movable apices; submedian and intermediate teeth blunt, broad, lateral teeth sharper; numerous small submedian and 2 sharp intermediate denticles present, inner larger and set at level of apex of intermediate tooth, outer more recessed anteriorly; submedian teeth lacking well-marked ventral carinae; uropod with full complement of setae; outer spine of basal prolongation of uropod broader and slightly longer than inner.

COLOR.—Almost completely faded; there are traces of black spots in no particular pattern on the dorsum of the male.

DISCUSSION.—Manning (1967b) noted that specimens of this species showed two different patterns of dorsal spinulation on the telson. The specimens reported herein are of the form with numerous small spinules approaching the condition found in *G. spinosus* Bigelow. The well-developed intermediate teeth of the telson will immediately distinguish this species from *G. spinosus*, to which it is closely related.

The full complement of setae on the uropod will distinguish this species from *G. demanii* (discussed below), in which most of the inner margin of the uropodal endopod and exopod is smooth and devoid of setae.

The larger male specimen differs from the female in having all of the carinae of the telson more inflated and in having fewer, blunter

tubercles on the dorsal surface of the telson. In the male the median carina is almost subglobular. It also differs from the female in having the outer intermediate denticle set slightly posterior to the apex of the intermediate tooth.

The petasma in the male is similar to that of *G. chiragra*.

DISTRIBUTION.—Western Indian Ocean, where it has been recorded from numerous localities. It has not been recorded previously from West Pakistan.

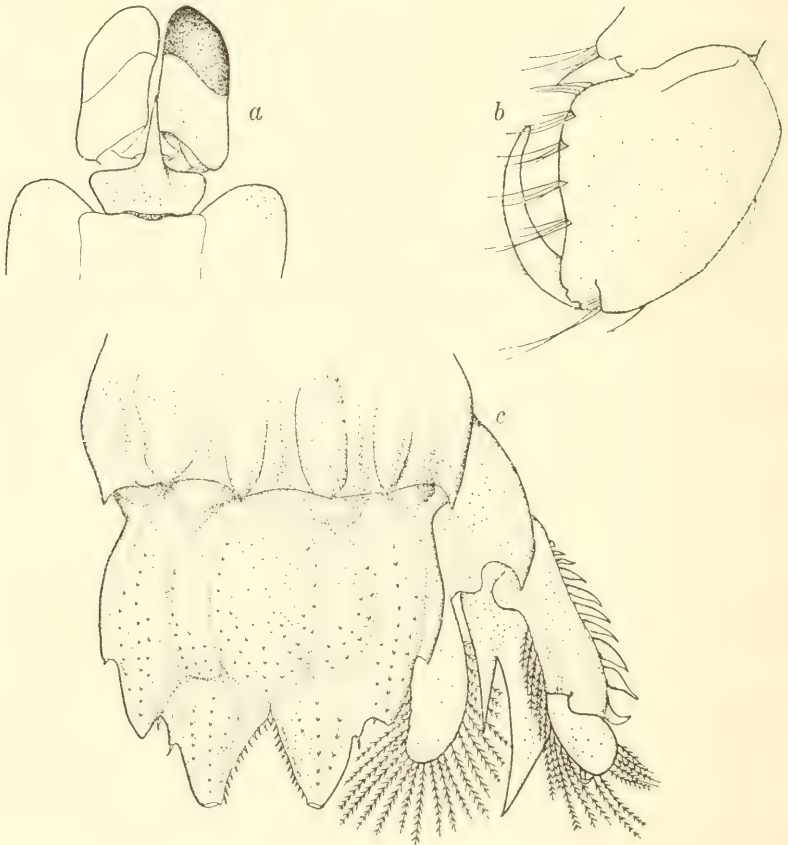


FIGURE 9.—*Gonodactylus lancesteri* Manning, female, TL 24 mm, off Karachi: *a*, anterior portion of carapace, rostral plate, and eyes; *b*, propodus of fourth maxilliped; *c*, last abdominal somite, telson, and uropod.

9. *Gonodactylus demanii* Henderson, 1893

FIGURE 10

Gonodactylus demanii.—Manning, 1967b, p. 8, fig. 3 [older references].—Holthuis, 1967b, pp. 32, 41.—Manning, 1968b, p. 50.

Gonodactylus demani demani.—Chhappgar and Sane, 1968, p. 45 [key].

MATERIAL.—1 ♀, 22 mm; western end of Astola Island, ca. 177 miles west of Karachi; rocks, sand, scanty scattered coral; 0-8 ft; L. P. Woods, et al.; Sta. LW-1; HIOE; 27 November 1963; USNM 120473.

DIAGNOSIS.—Anterolateral angles of rostral plate subacute, usually rounded; ocular scales small, erect; carinae of sixth abdominal somite swollen, each usually with apical tubercle; telson broader than long, dorsal surface ornamented with numerous spinules and small tubercles; anterior dorsal carinae smooth dorsally, spinulose laterally;

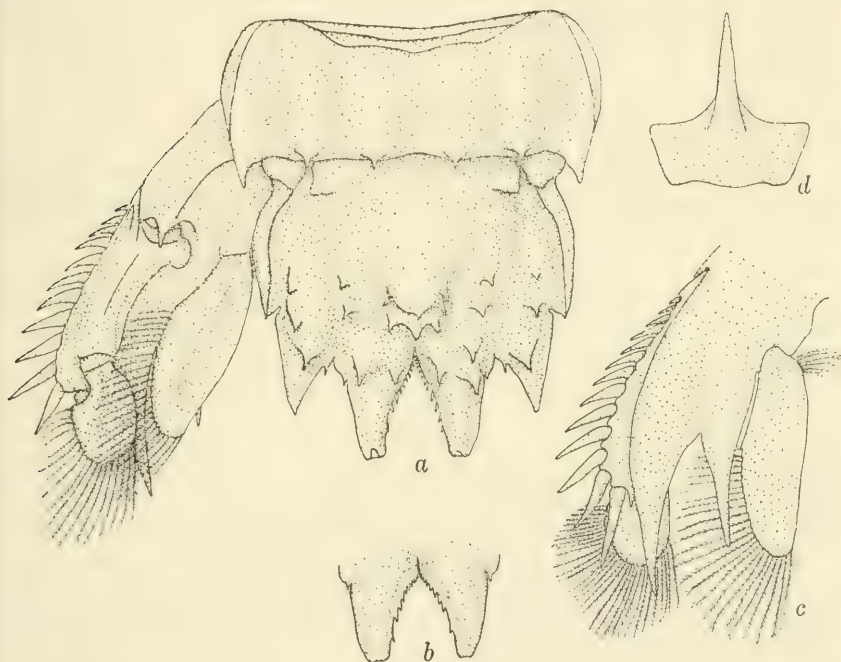


FIGURE 10.—*Gonodactylus demanii* Henderson, female, TL 19 mm, Dahlak, Red Sea: *a*, last abdominal somite, telson, and uropod; *b*, submedian teeth of telson, ventral view; *c*, uropod, ventral view; *d*, rostral plate. (From Manning, 1967b.)

carinae of marginal teeth spinulose dorsally; 3 pairs of marginal teeth present, submedians with movable apices; submedian and intermediate teeth sharper than laterals; numerous small submedian and 2 sharp intermediate denticles present, intermediates both recessed anteriorly; submedian teeth each with low carina on inner ventral surface; endopod slender; most of inner margin of both endopod and exopod of uropod smooth, devoid of setae, endopod with 9-10 small, proximal setae; outer spine of basal prolongation of uropod broader and longer than inner.

COLOR.—Largely faded in the present specimen; there are scattered dark spots on the sixth thoracic and first, third, and fourth abdominal somites, and an anterior pair of dark spots on the telson.

DISCUSSION.—The smooth inner margin on the uropodal endopod and exopod will serve to distinguish this species from the other species of the genus occurring off West Pakistan.

The illustrations that we give herein have been taken from Manning (1967b) because the condition of our single specimen from Astola Island is not good enough to be illustrated.

DISTRIBUTION.—Western Indian Ocean. It has been recorded from Karachi (Kemp, 1913) and from Astola Island (Manning, 1967b).

Family SQUILLIDAE Latreille, 1803

DIAGNOSIS.—Propodi of third, fourth, and fifth thoracic appendages longer than broad, not beaded or ribbed ventrally (fig. 15c); telson with sharp median dorsal carina and 4 or more intermediate denticles on margin.

DISCUSSION.—Representatives of four of the genera assigned to this family by Manning (1968a) occur off West Pakistan. These genera can be distinguished by means of the key given below.

Representatives of five other genera may also occur off West Pakistan; these include: *Carinosquilla carinata* (Serène), known from the Red Sea (Ingle, 1963) and Madagascar (Manning, 1968b); *Squilloides gilesi* (Kemp), which has been reported from the Persian Gulf by Kemp (1913), the Gulf of Oman by Chopra (1939), and the Red Sea by Holthuis (1967b); *Alima supplex* (Wood-Mason), reported from Bombay by Kemp (1913) and Chhapgar and Sane (1968); and both *Anchisquilla fasciata* (de Haan) and *Leptosquilla schmeltzii* (A. Milne-Edwards), recorded from the Red Sea by Holthuis (1967b).

Key to Genera of SQUILLIDAE from Pakistan

1. Cornea small, usually not as broad as stalk; ocular scales fused; submedian teeth of telson with movable apices **Clorida**
Cornea small or large, always broader than stalk; ocular scales separate; submedian teeth of telson with fixed apices 2
2. Carapace with deep posterolateral excavation; propodus of raptorial claw with row of erect spines **Harpiosquilla**
Carapace rounded posterolaterally; propodus of raptorial claw with pectinations but not erect spines 3
3. Lateral processes of fifth, sixth, and seventh thoracic somite single, not bilobed; less than 4 epipods present **Cloridopsis**
Lateral processes of fifth, sixth, and seventh thoracic somites bilobed; 4 or more epipods present **Oratosquilla**

Clorida Eydoux and Souleyet, 1842

DIAGNOSIS.—Eye small, cornea bilobed, rarely broader than dilated stalk; ocular scales fused along midline; carapace rounded postero-laterally; mandibular palp usually present; 2–4 epipods present; dactylus of raptorial claw with 4–5 teeth, upper margin of propodus pectinate; lateral processes of fifth, sixth, and seventh thoracic somites not bilobed, process of fifth somite usually a slender spine; abdomen broad, depressed, carinae usually reduced in number; telson with movable apices on submedian teeth; basal prolongation of uropod with spines on inner margin.

TYPE-SPECIES.—*Clorida latreillei* Eydoux and Souleyet, 1842.

DISCUSSION.—Five species of *Clorida* are known to occur in the northwestern Indian Ocean and one of these is reported herein from West Pakistan. *Clorida fallax* (Bouvier) has been reported from the Red Sea by Holthuis (1967a) and *C. latreillei* has been recorded from the Persian Gulf by Kemp (1913). More recently, Chhapgar and Sane (1967) described two new species from Bombay, *C. denticauda* and *C. bombayensis*. Any of these species could occur off West Pakistan.

Manning (1968b) gave a key to all the species of *Clorida*.

10. *Clorida microphthalmalma* (H. Milne-Edwards, 1837)

FIGURE 11

Squilla microphthalmalma.—Kemp, 1913, p. 31, pl. 1 (figs. 17–20.—Holthuis, 1941, p. 242.—Tiwari and Biswas, 1952, p. 350.—Manning, 1968b, p. 5 [key].—Chhapgar and Sane, 1968, p. 44 [key].

Material.—1 ♀, 32 mm; off Karachi; University of Karachi.

DESCRIPTION.—Eye small, cornea bilobed, set obliquely on stalk; stalk expanded proximally, expanded portion broader than cornea (fig. 11*b*); eyes appressed for most of their length, extending about to end of first segment of antennular peduncle; ocular scales subtruncate; rostral plate triangular, as long as broad, apex rounded; carapace strongly narrowed anteriorly, without carinae except for reflected marginals; anterolateral spines of carapace strong but not extending past base of rostral plate (fig. 11*a*); dactylus of claw with 5 teeth, outer margin sinuous; dorsal ridge of carpus undivided, terminating in blunt angle (fig. 11*c*); mandibular palp present; 4 epipods present; thoracic somites lacking submedian carinae; low, unarmed intermediate carinae present on last 3 somites; lateral process of fifth thoracic somite an angular lobe, directed anterolaterally; fifth somite also with 1 pair of ventrolateral tubercles; lateral processes of sixth and seventh thoracic somites rounded anterolaterally and posterolaterally; abdomen smooth, depressed,

lacking submedian carinae on first 5 somites; abdominal carinae spined as follows: submedian 6, intermediate 5-6, lateral 5-6, marginal 4-5; telson broad, inflated, with 3 pairs of marginal teeth, submedians with movable apices, intermediates and laterals sharp; prelateral lobes not developed; dorsal surface of telson with median carina, a submedian row of tubercles covering under its distal apex, and several curved rows of tubercles or denticles on the lateral surface; marginal denticles spiniform, 1-2, 7-8, 1; postanal keel absent; uropodal exopod with 5-6 movable spines on outer margin of proximal

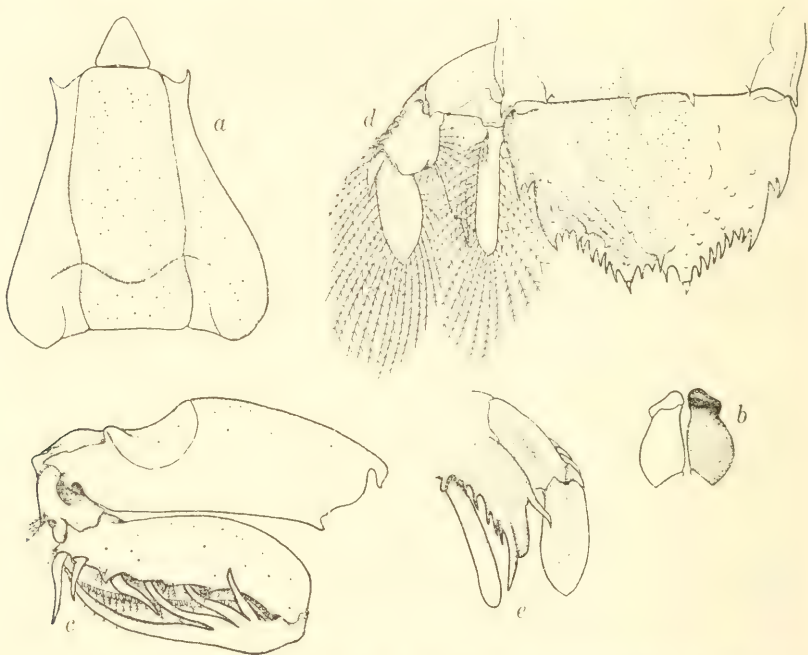


FIGURE 11.—*Clorida microphthalmalma* (H. Milne-Edwards), female, TL 32 mm, off Karachi: *a*, outline of carapace and rostral plate; *b*, eyes; *c*, raptorial claw; *d*, telson and uropod; *e*, uropod, ventral view (setae omitted).

segment; basal prolongation of uropod with 5-6 fixed spines on inner margin and broad, rounded lobe on outer margin of inner spine (fig. 11*e*).

COLOR.—Largely faded in the present specimen, but carapace, last 3 thoracic and first 5 abdominal somites each with posterior black line; anterolateral plates of abdomen darker than body; proximal segment of uropodal exopod dark distally.

DISCUSSION.—Among the characteristic features of *C. microphthalmalma* are the elongate eyes, with a very small cornea, the small lateral processes on the fifth thoracic somite, the lack of submedian carinae

on the last three and first five thoracic somites, and the small number of spines on the abdominal carinae.

DISTRIBUTION.—Indo-West Pacific, from East Africa to China and Australia. Kemp (1913) listed two specimens from Karachi.

Harpiosquilla Holthuis, 1964

DIAGNOSIS.—Eye large, T-shaped, cornea bilobed, distinctly broader than stalk (fig. 13a); ocular scales separate; carapace with deep posterolateral excavations; mandibular palp 3-segmented; 5 epipods present; dactylus of raptorial claw with teeth, upper margin of propodus with row of large, erect spines and intervening smaller spines or denticles (fig. 12e); lateral processes of next 2 somites not strongly bilobed, sinuous, sharp posterolaterally; abdomen broad, submedian carinae usually present; telson with apices of submedian teeth fixed; basal prolongation of uropod with at most tubercles on inner margin.

TYPE-SPECIES.—*Squilla harpax* de Haan, 1844.

DISCUSSION.—This genus now includes four species, all of which occur in the western Indian Ocean. Two of the species, *H. harpax* (de Haan) and *H. raphidea* (Fabricius), occur off West Pakistan. A third species, *H. annandalei* (Kemp), has been recorded from the Gulf of Oman by Chopra (1939), and the fourth species, *H. melanoura* Manning, is known only from Madagascar.

We have included here an account of a single specimen of *H. raphidea* from East Pakistan from the collection of the Zoological Survey Department.

The two species known from Pakistan may be distinguished by means of the following key.

Key to Species of *Harpiosquilla* from West Pakistan

- Lateral process of fifth thoracic somite spined; propodus of claw with alternate long and short spines. ***H. raphidea***
 Lateral process of fifth thoracic somite rounded; propodus of claw with more than 1 short spine between longer ones. ***H. harpax***

11. *Harpiosquilla raphidea* (Fabricius, 1798)

FIGURE 12

Squilla raphidea.—Kemp, 1913, p. 88, pl. 7 (fig. 77) [part; older references].—

Tiwari and Biswas, 1952, p. 356, figs. 3a, c, e.

Harpiosquilla raphidea.—Manning, 1968b, p. 14 [key].—Chhapgar and Sane, 1968, p. 45 [key].

MATERIAL.—1 ♀, 261 mm: Cox's Bazaar, Chittagong, East Pakistan: Zoological Survey reg. no. 88S.—1 ♀, 189 mm; Fish Harbour, Karachi; 17 April 1967; University of Karachi.

DIAGNOSIS.—Size large to very large, TL 300 mm or more; rostral plate triangular, apex blunt; carinae of carapace well developed; dactylus of raptorial claw with 8 teeth; upper margin of propodus of claw with widely separated alternate long and short spines; lateral process of fifth thoracic somite produced into an acute spine, ventral process on each side acute; last 3 thoracic somite with well-formed

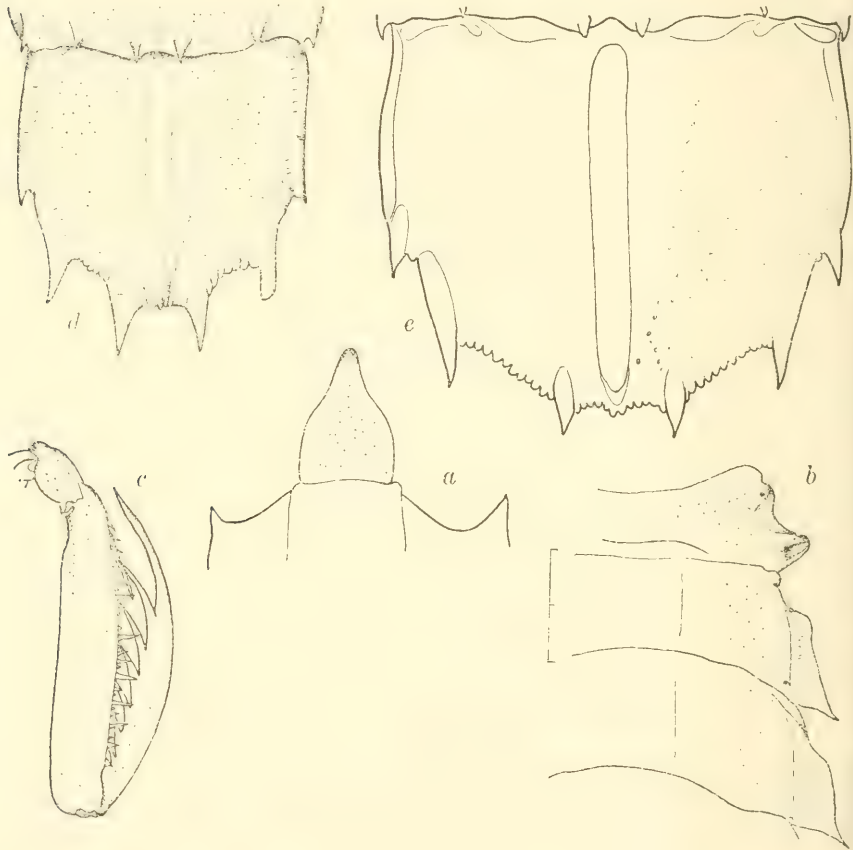


FIGURE 12.—*Harpiosquilla raphidea* (Fabricius), female, TL 261 mm, Cox's Bazaar: *a*, rostral plate; *b*, lateral processes of exposed thoracic somites; *c*, raptorial claw; *d*, telson. Female, TL 189 mm, Karachi: *e*, telson.

submedian and intermediate carinae, intermediates of sixth and seventh somites armed posteriorly on large specimens; submedian carinae of abdomen well developed; abdominal carinae spined as follows: submedian 6, intermediate 1-6, lateral 1-6, marginal 1-5; telson with broad median carina and 3 pairs of marginal teeth; prelaterals lobes absent; denticles rounded, 5-6, 7, 1; outer margin of basal

segment of uropodal exopod with 8 spines, last short; lobe on outer margin of inner spine of basal prolongation rounded, margin concave.

COLOR.—Faded in the specimen from East Pakistan. The specimen from Karachi was examined while fresh; one of us (N.T.) made the following color notes: ocular peduncles light pink; posterior border of carapace with a black band; antennal scale yellowish, outlined with dark pigment; claw with merus pink, also marked with a greenish-yellow patch; distal end of propodus with bright yellow streak; thorax and abdomen appearing speckled; last 3 thoracic and first 3 abdominal somites pink, last 3 abdominal somites more cream-colored; tips of spines of last 4 abdominal somites yellow; posterior margin of first 4 abdominal somites black; carinae of telson bluish, apices of teeth yellow; telson with pair of submedian yellow-brown spots; uropod lightly marked with yellow and black, inner half of distal segment of exopod grayish, outer half yellow.

DISCUSSION.—The large size of this species and the acutely pointed lateral process of the fifth thoracic somite will immediately distinguish it from *H. harpax*. Other differences have been noted under the account of the latter species.

DISTRIBUTION.—Indian Ocean, from East Africa to Australia. Kemp (1913) recorded it from Karachi.

12. *Harpiosquilla harpax* (de Haan, 1844)

FIGURE 13

Squilla raphidea.—Kemp, 1913, p. 88 [part].—Chopra, 1939, p. 158.—Barnard, 1950, p. 851, figs. 1c, g.

Squilla harpax.—Tiwari and Biswas, 1952, p. 358, figs. 3b, d, f.—Ingle, 1963, p. 18, figs. 9, 59.

Harpiosquilla harpax.—Holthuis, 1967b, pp. 14, 40.—Manning, 1968b, p. 15, fig. 4.—Chhapgar and Sane, 1968, p. 45 [key].

MATERIAL.—1 ♂, 107 mm; Ahsan; University of Karachi.—1 ♀, 142 mm; off Karachi; Central Fisheries Department.—1 dry ♀, CL 35.6 mm; near Karachi; Mohammed Abdullah el Husseini; USNM.

DIAGNOSIS.—Size moderate to large, TL 200 mm or less; rostral plate acutely pointed, lateral margins sinuous (fig. 13a); dactylus of raptorial claw with 8 teeth; upper margin of propodus of claw with series of long, erect spines, with 1 or more shorter spine or spinule between the long ones (fig. 13c); lateral process of fifth thoracic somite rounded (fig. 13b), ventral process on each side acute; last 3 thoracic somites with submedian and unarmed intermediate carinae, submedians low; submedian carinae of abdomen poorly developed but present; abdominal carinae armed as follows: submedian 6, intermediate 1-6, lateral 1-6, marginal 1-5; telson with sharp median carina and 3 pairs of sharp marginal teeth, prelateral lobes

absent; denticles spiniform, 5, 13, 1; outer margin of basal segment of uropodal exopod with 9-10 spines, last short; lobe on outer margin of inner spine of basal prolongation rounded, margin concave.

COLOR.—Fresh specimens are brightly colored, as follows: eye-stalks bright yellow; antennal peduncle and scale with pink patches; carinae of carapace lined with dark spots; merus and carpus of rap-

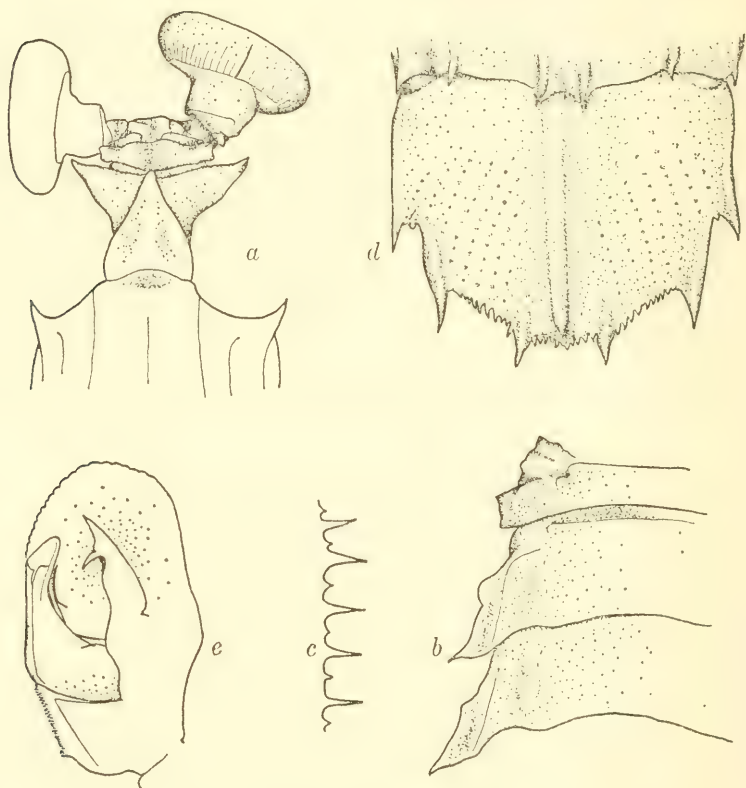


FIGURE 13.—*Harpiosquilla harpax* (de Haan), male, TL 107 mm, Ahsan: *a*, anterior portion of carapace, rostral plate, and eyes; *b*, lateral processes of exposed thoracic somites; *c*, spines on upper margin of propodus of claw; *d*, telson; *e*, petasma.

torial claw with pink patches; posterior margin of each of thoracic and abdominal somites lined with black spots; lateral portions of abdominal somites pink; sixth abdominal somite pink between submedian carinae; spines on abdomen, telson, and uropod yellow; telson with grey pits and carinae except for red median carina; proximal submedian patches of telson maroon (black in preservative); base of uropod pink.

DISCUSSION.—Tiwari and Biswas (1952) were the first to show that *H. harpax* (de Haan) is distinct from the larger *H. raphidea* (Fabricius), which is also widely distributed in the Indo-West Pacific region. *Harpiosquilla harpax* differs from *H. raphidea* in having a shorter rostral plate, in lacking the lateral spine on the fifth thoracic somite, in having more than one spine or spinule between the major spines on the propodus of the claw, and in having the carinae of the abdomen less well developed. In *H. harpax* the submedian carinae of the abdomen are present but they are poorly-defined.

The petasma is illustrated in figure 13e. The tube process is well developed; the hook process has an additional hook-like projection on its inner, distal margin.

DISTRIBUTION.—Indo-West Pacific region, from the Red Sea and South Africa eastward to Japan.

Cloridopsis Manning, 1968

DIAGNOSIS.—Eye small, stalk dilated or margins subparallel, cornea broader than stalk; ocular scales separate; carapace rounded posterolaterally; mandibular palp present or absent; 2-3 epipods present; dactylus of raptorial claw with 5-6 teeth, upper margin of propodus pectinate; lateral processes of fifth, sixth, and seventh thoracic somites not bilobed, process of fifth somite a broad, curved spine; abdomen broad, submedian carinae present; telson with apices of submedian teeth fixed; basal prolongation of uropod with at most tubercles on inner margin.

TYPE-SPECIES.—*Squilla scorpio* Latreille, 1825.

DISCUSSION.—Two species of *Cloridopsis* occur in the north-western Indian Ocean, and both are reported herein from West Pakistan. They may be differentiated by means of the key given below.

Key to *Cloridopsis* from West Pakistan

- Lateral process of fifth thoracic somite with a large black spot; apex of rostral plate narrow *C. scorpio*
 Lateral process of fifth thoracic somite lacking a large black spot; apex of rostral plate broad *C. immaculata*

13. *Cloridopsis scorpio* (Latreille, 1825)

FIGURES 14a-e

Squilla scorpio.—Kemp, 1913, p. 42, pl. 2 (fig. 30).—Holthuis, 1941, p. 243 [older references].—Tiwari and Biswas, 1952, p. 353.—Baig, 1954, p. 143.—Chhappgar and Sane, 1968, p. 44 [key].

MATERIAL.—2 ♀, 72 mm (1 broken); off Karachi; University of Karachi.—1 ♂, 81 mm; off Karachi; Mohammed Abdullah el Hussein; USNM.

DESCRIPTION.—Eye small, cornea bilobed, broader than stalk and set obliquely on it; ocular scales rounded laterally, separated by median indentation; rostral plate as long as broad, narrowed anteriorly, apex truncate, with median carina on anterior half; carapace narrowed anteriorly, anterior width slightly less than one-half median length; anterolateral spines of carapace strong but not extending to base of rostral plate, each spine with a rounded ventral lobe; median carina of carapace lacking anterior bifurcation, intermediate carinae

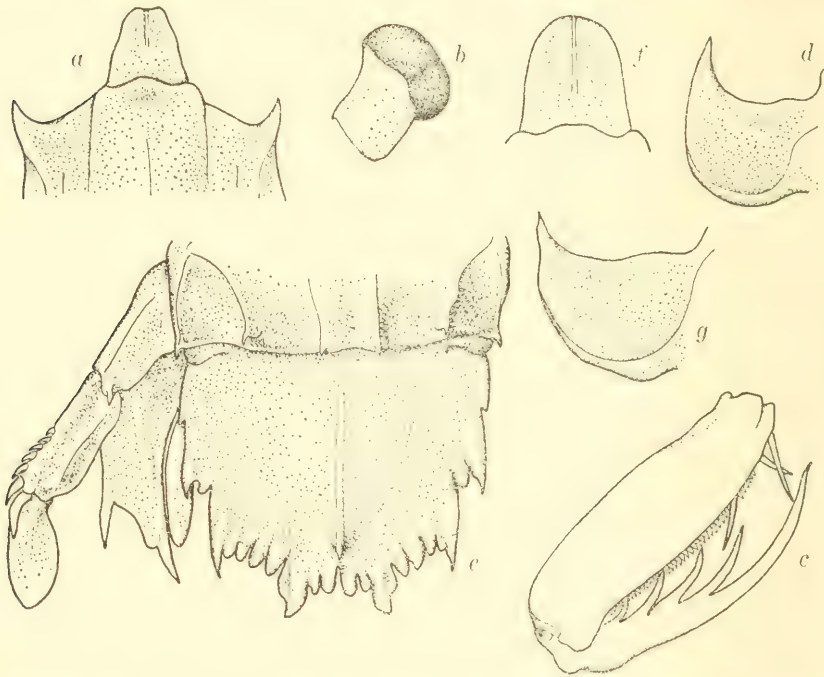


FIGURE 14.—*Cloridopsis scorpio* (Latreille), female, TL 72 mm, off Karachi: *a*, anterior portion of carapace and rostral plate; *b*, eye; *c*, propodus and dactylus of raptorial claw; *d*, lateral process of fifth thoracic somite; *e*, last abdominal somite, telson, and uropod (setae omitted). *Cloridopsis immaculata* (Kemp), female, CL 16.5 mm, off Karachi: *f*, rostral plate; *g*, lateral process of fifth thoracic somite.

present, poorly marked, not extending to anterior margin of lateral plates; dactylus of raptorial claw with 5 teeth, outer margin of dactylus sinuous, with shallow proximal notch; dorsal ridge of carpus undivided; mandibular palp absent; 2 epipods present; lateral process of fifth to seventh thoracic somites each composed of a single lobe, that of fifth somite broad, produced into an anteriorly directed spine; lateral processes of next 2 somites triangular, rounded posterolaterally; last 3 thoracic somites with submedian and intermediate carinae,

intermediates unarmed; submedian carinae present on abdomen; abdominal carinae spined as follows: submedian 6, intermediate 5-6, lateral 5-6, marginal 2-5; telson broader than long, with 3 pairs of marginal teeth, submedians fixed, prelateral lobes present, denticles large, rounded, 2, 3-4, 1; postanal keel absent; outer margin of uropodal exopod with 7 short, movable spines; lobe on outer margin of inner spine of basal prolongation of uropod large, rounded.

COLOR.—Lateral process of fifth thoracic somite with large, well-marked black spot; last 3 thoracic and all abdominal somites with dark posterior line; second abdominal somite with rectangular dorsal patch of dark color; proximal segment of uropodal exopod with dark spot.

DISCUSSION.—Living or freshly caught specimens of *C. scorpio* can immediately be recognized by the presence of the black spot at the base of the lateral process of the fifth thoracic somite; the spots can persist for many years in preservative. *Cloridopsis immaculata*, which is discussed below, lacks these black spots and exhibits other differences as well.

One of the specimens has only three intermediate denticles on one side of the margin of the telson although there is an indication of a fourth denticle appressed to the outer margin of the submedian tooth. Kemp (1913) reported three to six intermediate denticles in his material.

DISTRIBUTION.—Indo-West Pacific region, throughout the Indian Ocean into the western Pacific. Both Kemp (1913) and Baig (1954) have reported the species from Karachi.

14. *Cloridopsis immaculata* (Kemp, 1913)

FIGURES 14*f, g*

Squilla scorpio var. *immaculata* Kemp, 1913, p. 45, pl. 2 (fig. 31).

MATERIAL.—1 fragmented ♀, CL 16.5 mm; off Karachi; University of Karachi.

DISCUSSION.—This specimen is so fragmented that it is not possible to prepare a description, but from what we can see of the specimen it agrees well with Kemp's account. Kemp treated this species as a "variety" of *Squilla scorpio*, but there seems to be no good reason not to recognize it as a distinct species. Both species are distinct throughout their range.

Cloridopsis immaculata differs from *C. scorpio* as follows: (1) the rostral plate is longer and has a broader apex; (2) the median and lateral carinae of the carapace are more distinct; (3) the lateral processes of the sixth and seventh thoracic somites are slightly more upturned; and (4) the lateral process of the fifth thoracic somite is never marked with a conspicuous black spot.

DISTRIBUTION.—Northern Indian Ocean. It was recorded from Karachi by Kemp (1913) but is known from no other localities in the Arabian Sea.

Oratosquilla Manning, 1968

DIAGNOSIS.—Eye large, cornea bilobed, noticeably broader than stalk; ocular scales separate; carapace rounded posterolaterally; mandibular palp usually present; 4 epipods present; dactylus of raptorial claw with 5 or more teeth (usually 6), upper margin of propodus pectinate; lateral processes of fifth, sixth, and seventh thoracic somites bilobed; abdomen with paired submedian, intermediate, and lateral carinae; telson with fixed apices on submedian teeth; basal prolongation of uropod with at most serrations or tubercles on inner margin.

TYPE-SPECIES.—*Squilla oratoria* de Haan, 1844.

DISCUSSION.—Nine species of *Oratosquilla* have been recorded from the northwestern Indian Ocean; three of these are recorded herein from West Pakistan. The other species which are known from the general area are: (1) *O. quinquedentata* (Brooks, 1886), reported from Bombay by Kemp (1913); (2) *O. investigatoris* (Lloyd, 1907), reported from the Persian Gulf by Kemp (1913) and the South Arabian coast by Chopra (1939); (3) *O. gonypetes* (Kemp, 1911), recorded from the Persian Gulf by Kemp (1913) and the Gulf of Oman by Chopra (1939); (4) *O. perpensa* (Kemp, 1911), reported from the Persian Gulf by Kemp (1913); (5) *O. massavensis* (Kossmann, 1880) from the Red Sea (records summarized by Holthuis, 1967b); and (6) *O. simulans* (Holthuis, 1967) from the Red Sea.

Kemp (1913) also reported *O. woodmasoni* (Kemp) and *O. massavensis* from localities in the western Indian Ocean; those specimens are probably referable to *O. hesperia* (Manning) (see below).

All three of the species discussed below are extremely abundant in the waters off West Pakistan; most of the specimens were obtained at the local fish market in Karachi.

Key to *Oratosquilla* from West Pakistan

1. Median carina of carapace distinct throughout its length, bifurcation open posterior to dorsal pit; anterior lobe of lateral process of sixth thoracic somite with apex truncate ***O. nepa***
 Median carina of carapace either interrupted or indistinct anteriorly; anterior bifurcation, if present, open anterior to dorsal pit; anterior lobe of lateral process of sixth thoracic somite with apex acute 2
2. Anterior width of carapace less than one-half median length; lobe on outer margin of inner spine of basal prolongation of uropod rounded, margin convex ***O. interrupta***
 Anterior width of carapace more than half median length; lobe on outer margin of inner spine of basal prolongation of uropod sharp, acute, margin concave ***O. hesperia***

15. *Oratosquilla nepa* (Latreille, 1825)

FIGURE 15

Squilla nepa.—Kemp, 1913, p. 60, pl. 4 (fig. 49).—Chopra, 1934, p. 23.—Holthuis, 1941, p. 245 [older references].—Barnard, 1950, p. 847, figs. 1b, 2a.—Kurian, 1954, p. 85.—Holthuis, 1967b, p. 7.—Manning, 1968b, p. 31, fig. 10.—Chhappgar and Sane, 1968, p. 45 [key].

MATERIAL.—6 ♂, 72–93 mm; 6 ♀, 53–83 mm (in 8 lots); off Karachi; University of Karachi.—2 ♂, 75–92 mm; 1 ♀, 80 mm; same; USNM.—1 ♂, 99 mm; off West Pakistan; A. H. Qadri; USNM.

DESCRIPTION.—Eye of moderate size, cornea bilobed, set almost transversely on stalk, cornea width less than length of stalk; ocular scales subquadrate or rounded, inclined laterally; rostral plate subquadrate, tapering distally, apex truncate or rounded, lateral margins upturned, obscure median tubercle occasionally present; anterior bifurcation of median carina of carapace uninterrupted, bifurcation opening posterior to dorsal pit, secondarily closing anterior to pit in some specimens; intermediate carinae of carapace not extending to anterior margin, converging anteriorly with laterals; anterolateral spines of carapace strong, extending to or beyond base of rostral plate; dactylus of claw with 6 teeth, outer margin sinuous; dorsal ridge of carpus irregular, with 2–3 large tubercles; inferodistal angle of merus with blunt spine; mandibular palp present; 4 epipods present; last 3 thoracic somites rough, pitted, with submedian and intermediate carinae, neither armed, intermediates pitted; anterior lobe of lateral process of fifth thoracic somite a slender, anteriorly directed spine, posterior lobe shorter, slender, apex acute but rounded; lateral processes of next 2 somites bilobed, anterior lobe on sixth somite large, obliquely truncate, posterior lobe larger, triangular, apex blunt, anterior lobe of lateral process of seventh somite an acute but rounded lobe, posterior lobe larger, triangular, apex rounded; abdomen rough, pitted, surface irregular; abdominal carinae spined as follows: submedian 4–6, intermediate 3–6, lateral 2–6, marginal 1–5; telson flattened, about as long as broad, with 3 pairs of marginal teeth, submedians and intermediates slender, elongate; prelateral lobes present; denticles large, rounded, 2–4, 6–9, 1; dorsal surface of telson, either side of median carina, with lines of pits, but lacking rows of tubercles or carinae except for carinae of marginal teeth; long postanal keel present; uropod with 8–9 short, movable spines on outer margin of proximal segment; lobe on outer margin of inner spine of basal prolongation of uropod low, rounded, margin concave.

COLOR.—Most specimens faded in preservative; some show traces of dark, rectangular patches on the second and fifth abdominal somites; uropod with dark color on exopod at articulation of distal

segment, inner half of distal segment dark, endopod dark distally. Fresh specimens may be brightly colored, with the median carina of the carapace red, remainder of carinae and grooves on the carapace light green or orange; display patch on merus of claw light blue with green anterior border; carinae of abdomen light green, some with distal portions orange or red; carinae of telson green, apices of median carina and submedian and intermediate marginal teeth reddish; uropods marked with blue, green, yellow, and black, spines orange.

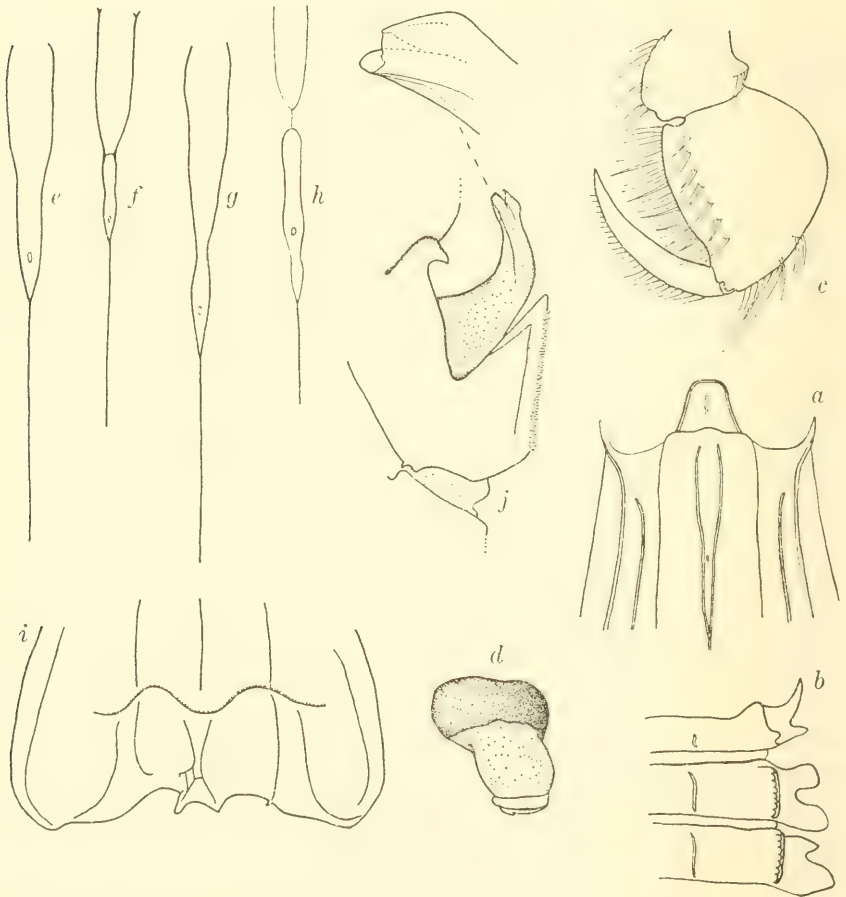


FIGURE 15.—*Oratosquilla nepa* (Latreille), male, TL 77 mm, off Karachi: *a*, outline of anterior portion of carapace and rostral plate; *b*, outline of lateral processes of fifth, sixth, and seventh thoracic somites; *c*, propodus and dactylus of third maxilliped. Male, TL 87 mm; *d*, eye; *e*, median carina of carapace. Median carina of carapace: *f*, male TL 72 mm; *g*, female, TL 79 mm; *h*, male, TL 93 mm. Female, TL 83 mm: *i*, abnormally developed posterior portion of carapace. Male, TL 93 mm: *j*, petasma.

Not all fresh specimens exhibit dark patches on the second and fifth abdominal somites, but these are well marked in a few specimens.

DISCUSSION.—The relatively small eyes, long anterior bifurcation on the median carina of the carapace, and large, truncate anterior lobe on the lateral process of the sixth thoracic somite will immediately distinguish *O. nepa* from the other two species of the genus found in the waters off West Pakistan, *O. interrupta* and *O. hesperia*. *Oratosquilla nepa* is the least abundant of the three species, but it still occurs in relatively large numbers.

Several of the specimens show unusual variation in the configuration of the anterior bifurcation of the median carina of the carapace; these variations are shown in figures 15e-h. The typical shape of the bifurcation is shown in figure 15e; in some specimens the arms of the bifurcation converge anteriorly, beyond the dorsal pit, but do not meet. In one specimen the bifurcation is closed by a short bar (fig. 15f). Finally, in each of a series of three specimens the bifurcation closes anterior to the dorsal pit, continues anteriorly for a short distance as a single ridge, and reopens again (fig. 15h). There does not seem to be any correlation of these variations with sex or size, and the specimens are typical of the species in all other respects.

Some specimens exhibit a uniform dusky-gray color pattern, whereas others show distinct rectangular patches on the second and fifth abdominal somites, suggesting a possible dimorphism in color. Kemp (1913) noted similar variation in other collections.

In one of the specimens the posterior margin of the carapace is deformed, and the median posterior projection is bifurcate (fig. 15i).

DISTRIBUTION.—Widely distributed in the Indo-West Pacific region, from West Pakistan and Moçambique to Hong Kong and Australia. It recorded from Karachi by Kemp (1913).

16. *Oratosquilla interrupta* (Kemp, 1911)

FIGURE 16

Squilla interrupta.—Kemp, 1913, p. 72, pl. 5 (figs. 60-62).—Chopra, 1934, p. 25.—Holthuis, 1941, p. 253 [older references].—Baig, 1954, p. 143.—Manning, 1966, p. 97, fig. 4.—Chhapgar and Sane, 1968, p. 45 [key].

MATERIAL.—1 ♀, 71 mm; off Karachi; Central Fisheries Department.—10 ♂, 88-113 mm; 5 ♀, 93-123 mm (in 7 lots); off Karachi; University of Karachi.—1 dry ♀, CL 17.2 mm; near Karachi; Mohammed Abdullah el Husseini; USNM.—1 ♂, 128 mm; West Pakistan; A. H. Qadri; USNM.—1 ♂, 100 mm; off Karachi; University of Karachi; USNM.

DESCRIPTION.—Eye large, cornea bilobed, set obliquely on stalk; ocular scales subtruncate, inclined laterally; rostral plate subquadrate, without carinae, lateral margins upturned, apex truncate; anterior bifurcation of median carina of carapace with basal interruption,

carina and arms of bifurcation distinct anterior and posterior to smooth interrupted portion; intermediate carinae of carapace not extending to anterior margin; anterolateral spines of carapace strong but not extending to base of rostral plate; dactylus of raptorial claw with 6 teeth, outer margin sinuous; dorsal ridge of carpus of claw with 2 tubercles; inferodistal angle of merus of claw with broad, blunt spine;

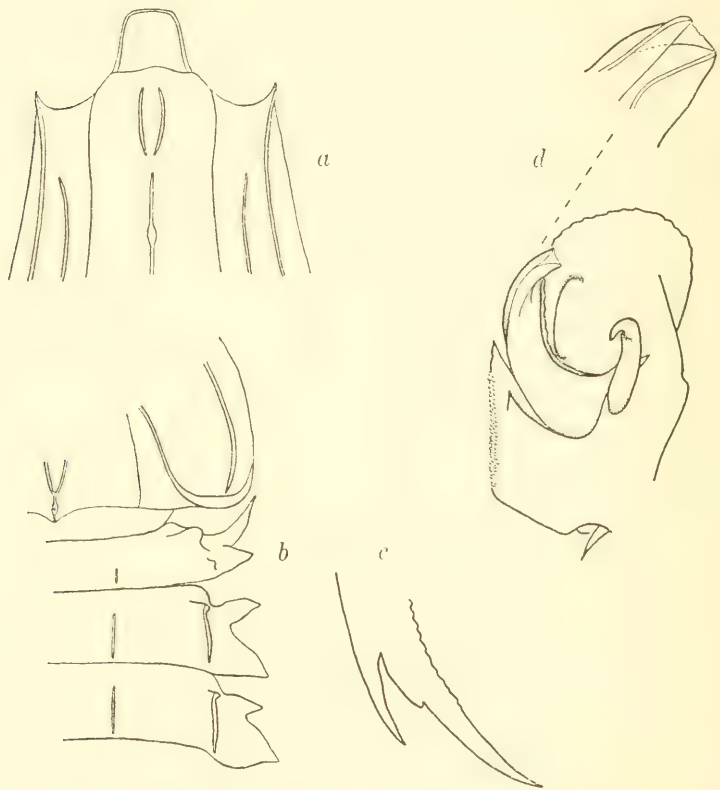


FIGURE 16.—*Oratosquilla interrupta* (Kemp), male, TL 95 mm, off Karachi: *a*, outline of anterior portion of carapace and rostral plate; *b*, lateral processes of fifth, sixth, and seventh thoracic somites. Male, TL 98 mm, off Karachi: *c*, outline of basal prolongation of uropod; *d*, petasma.

mandibular palp present; 4 epipods present; last 3 thoracic somites with submedian and intermediate carinae, none armed; anterior lobe of lateral process of fifth thoracic somite an anteriorly directed spine, posterior lobe slender, acute, directed laterally; lateral processes of next 2 somites bilobed, anterior lobe smaller than triangular posterior lobe on both somites, anterior lobe of process of sixth somite slenderer

and longer than that of seventh somite; abdominal carinae spined as follows: submedian 5-6, intermediate 4-6, lateral 3-6, marginal 1-5; telson broad, with 3 pairs of slender marginal teeth, prelateral lobes present; denticles rounded, 2-3, 7-9, 1; dorsal surface of telson lacking well-marked tubercles or ridges lateral to median carina other than short carinae of marginal teeth; postanal keel present; uropodal exopod with 8-9 movable spines on outer margin of proximal segment; lobe on outer margin of inner spine of basal prolongation of uropod rounded, margin convex.

COLOR.—Usually faded in preservative. Fresh specimens have median carina and gastric grooves of carapace red; posterior margin of carapace, last 3 thoracic somites, and first 5 abdominal somites red; median carinule and submedian and intermediate carinae of body red, color most intense on submedians; carinae of marginal teeth of telson green, apices of teeth reddish; telson with a prominent, large red or green spot on the anterior portion of the median carina; spine of uropod pink. There may be considerable variation in overall pattern.

DISCUSSION.—The specimens examined by us agree well with accounts of the species in the literature. The best feature for recognition of *O. interrupta* is the convex lobe on the outer margin of the inner spine of the basal prolongation of the uropod; in no other species is this lobe so shaped.

This is the second most abundant stomatopod taken by local fisherman off Karachi.

DISTRIBUTION.—Widely distributed in the Indo-West Pacific, from the Persian Gulf to Australia and Formosa. Both Kemp (1913) and Baig (1954) recorded its occurrence off Karachi.

17. *Oratosquilla hesperia* (Manning, 1968)

FIGURE 17

Squilla nepa.—Miers, 1880, p. 25 [part; specimen from Zanzibar].

Squilla woodmasoni.—Kemp, 1913, p. 74 [part; specimens from Zanzibar, Muscat, and Aden reidentified].

Squilla massavensis.—?Kemp, 1913, p. 76 [part; specimens from the Gulf of Oman and Persian Gulf].—Ingle, 1963, p. 15 [part; specimens from Zanzibar and the Persian Gulf reidentified].

Squilla hesperia Manning, 1968b, p. 25, fig. 8.

MATERIAL.—1 ♂, 62 mm; fish market, Fish Harbour, Karachi; 24 November 1966; University of Karachi.—6 ♂, 52-89 mm; 3 ♀, 66-101 mm (in 5 lots); off Karachi; University of Karachi.—1 ♀, 89 mm; off Karachi; University of Karachi; USNM.—1 ♀, 113 mm; off Karachi; Central Fisheries Department.—1 ♂, 89 mm; 1 ♀, 66 mm; off Karachi; Zoological Survey Department reg. no. 1877.—8 ♂, 60-80 mm; 8 ♀, 66-102 mm; 25°04' N, 65°24'-26'E; off West Pakistan; 26 m; hard packed mud; *Anton Bruun* Sta. 237A; IIOE; 22 November 1963; USNM.

DESCRIPTION.—Eye large, cornea bilobed, set obliquely on stalk; ocular scales subtruncate, inclined laterally; rostral plate as long as broad, or broader than long, trapezoidal, upturned lateral margins converging on truncate or rounded apex, median carina absent; median carina of carapace lacking well-marked anterior bifurcation; intermediate carinae of carapace not extending to anterior margin; anterolateral spines of carapace well developed but not extending to base of rostral plate; dactylus of raptorial claw with 6 teeth, outer margin sinuous; dorsal ridge of carpus of claw with large, irregular tubercles; inferodistal angle of merus of claw with broad, obtuse projection; mandibular palp present; 4 epipods present; last 3 thoracic somites with submedian and intermediate carinae, none armed; anterior lobe of lateral process of fifth thoracic somite a slender, anteriorly directed spine, posterior lobe short, slender, apex rounded, directed laterally; anterior lobe of lateral process of sixth thoracic somite slender, posterior lobe much larger, triangular, apex acute but not spiniform; anterior lobe of lateral process of seventh thoracic somite more obtuse than on sixth, posterior lobe similar to that of sixth somite; second to fifth abdominal somites with anterior tubercles between intermediate and lateral carinae; abdominal carinae spined as follows: submedian (3-4) 5-6, intermediate 3-6, lateral (1) 2-6, marginal 1-5; telson broad, with 3 pairs of marginal teeth, submedians and intermediates slender, sharp; prelateral lobes present; denticles rounded, 2-4, 7-9, 1; dorsal surface of telson roughened, with submedian row of tubercles converging under posterior apex of median carina, lateral surface between lines of pits raised, irregular, almost carinate; margin of telson in males more swollen than in females; postanal keel present; uropod with 8-9 movable spines on outer margin of proximal segment of exopod; basal prolongation of uropod with small rounded lobe, margin concave, on outer margin of inner spine in adults, lobe spiniform in juveniles and subadults.

COLOR.—In preservative, carapace with median oval patch and posterior dark line, body segments each with posterior dark line; second and fifth abdominal somites with broad, dark median patch; narrower on fifth somite; uropodal exopod with dark spot at articulation of distal segment, inner half of distal segment dark; distal half of endopod dark.

Color in living specimens may be bright and variable; there is also evidence of sexual dimorphism in color of the telson. The carinae and gastric grooves of the carapace are orange, and the posterior margin is orange and yellow. The submedian carinae of the abdomen are orange, and each abdominal somite is lined posteriorly with orange; other carinae are blue or green anteriorly, more yellow posteriorly, and the intermediate and lateral carinae of the sixth

somite are green. In females, the telson carinae and margins are primarily orange, whereas in males they are green and blue green.

DISCUSSION.—Manning (1968b) described *O. hesperia* from a single female taken off Madagascar. In his account, he pointed out that *O. hesperia* was very similar to *O. massavensis* in general appearance and he suggested that records of *O. massavensis* from localities south of the Red Sea actually might be referable to *O. hesperia*. Examination

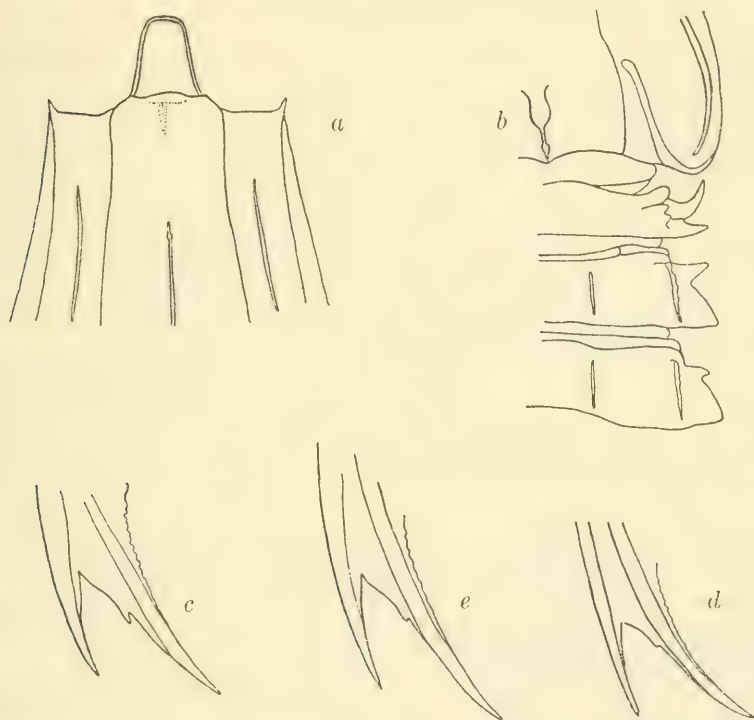


FIGURE 17.—*Oratosquilla hesperia* (Manning), female, TL 92 mm, off Karachi: *a*, outline of anterior portion of carapace and rostral plate; *b*, lateral processes of fifth, sixth, and seventh thoracic somites. Basal prolongation of uropod: *c*, male, TL 52 mm; *d*, female, TL 92 mm; *e*, female TL 101 mm.

of specimens in the British Museum from Zanzibar (1♂, 104 mm; 1♀, 75 mm; not registered), Muscat (1♂, 34 mm; reg. no. 87-16), and Aden (1♂, 42 mm; reg. no. 1894.5.16.4), all of which are *O. hesperia* rather than *O. massavensis*, bear out this suggestion.

Oratosquilla hesperia differs from *O. massavensis* in several important features as follows: (1) the rostral plate is shorter and broader, and the lateral margins are rarely markedly concave as in *O. massavensis*; (2) the submedian carinae of the abdomen are divergent on each so-

mite rather than subparallel; (3) there is a dark patch of chromatophores on both the second and fifth abdominal somites; and (4) there are many less tubercles on the telson (in *O. massavensis* there are two rows of erect tubercles flanking the median carina, one row on each side of the convergent lines of pits; in *O. hesperia*, only the inner of these two rows is well developed; the tubercles on the anterior half of the lateral surface of the telson, which are present in *O. massavensis*, are rarely developed in *O. hesperia*).

The two dark dorsal patches on the abdomen are not visible on the type; they are not always visible on the specimens from Karachi reported herein.

Both *O. hesperia* and *O. massavensis* resemble *O. woodmasoni* (Kemp) in several features, but both of the former species can be distinguished from *O. woodmasoni* by the presence of dorsal tubercles on the telson and by the well-developed lobe on the inner spine of the basal prolongation of the uropod. All three species have a smooth, polished carapace, lacking a well-developed anterior bifurcation on the median carina, and in all three the anterior width of the carapace is greater than half the median length of the carapace.

Small specimens of *O. hesperia* have a sharp spine instead of a rounded lobe on the inner spine of the basal prolongation of the uropod; in adults the lobe is rounded and may be very inconspicuous. The lobe is illustrated in figures 17*c-e* for three specimens, TL 52, 92, and 101 mm.

In adult males (TL 75 mm or more) the margin of the telson is noticeably more inflated than in the females. The denticles and carinae of the teeth may all be affected by the enlargement.

Oratosquilla hesperia is the most abundant stomatopod in the fishing grounds off Karachi.

DISTRIBUTION.—Western Indian Ocean, from Muscat, Aden, West Pakistan, Zanzibar, and Madagascar.

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Benthic Polychaetes from Puget Sound, Washington,
with Remarks on Four Other Species¹

By Karl Banse and Katharine D. Hobson²

We describe here eight new polychaete species, give 25 new records, and discuss 35 other forms. Forty-one species (including one unnamed species discussed below, and three new species and four new records to be published by K. Banse and F. H. Nichols in other papers) are added to 394 benthic polychaetes previously known from waters of Washington and British Columbia. The new records probably reflect incomplete knowledge of the region rather than recent immigration into the area. There is no trend toward predominantly arctic or warm water additions, as one would expect with new immigration resulting from climatic changes. Incomplete knowledge of the polychaete fauna of this area is suggested further by the fact that the 41 additions mentioned above were among 162 named polychaete species in our collection. For comparison, there is no new record among 49 named bivalve species of the same collection (Mr. D. Kisker, pers. comm.).

Polychaetes were identified from 116 samples taken in 1963 at eight subtidal stations in Puget Sound by the Department of Oceanography, University of Washington, under the direction of U. Lie

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and K. Banse. Samples were collected with a 0.1-m² van Veen grab and washed through a screen with square meshes of 1 mm side length. The formalin-preserved animals were separated from the residue in the laboratory under slight magnification. The nomenclature follows Hartman (1959, 1965b) except as noted otherwise. A reference to other descriptions is omitted if the species is included in Berkeley and Berkeley (1948, 1952). All colors refer to formalin-preserved material. Drawings illustrating new species are made from holotypes if not stated otherwise. Station numbers are given only for new species and new records. A list of all species in our collection with specimen numbers per station and dates of sampling is contained in Lie (in press). A set of identified species is deposited in the U.S. National Museum.

The station characteristics are given below (from Lie, in press). The mean depth is calculated from seven quarterly visits (this is given on the labels of the material in the U.S. National Museum). The depth range, however, refers to the recordings of those visits when polychaetes were identified. Quarterly samples were studied for stations 2 and 7, whereas for the other stations polychaetes were identified only from winter and spring collections. Sediment was subsampled for particle size analysis from about one-third of the grab samples from the winter and spring collections. The average results are presented below ("clay" refers to particles smaller than 0.0031 mm, "silt" to particles between 0.0031 and 0.0625 mm in diameter, and "gravel" to particles larger than 2.0 mm).

- Station 1 (47°41'33" N, 122°24'18" W). Mean depth 23 m, range 15–24 m.
Mean particle size 0.139 mm (fine sand). Clay 3.0%, silt 11.1%, sand 84.2%, gravel 1.7%.
- Station 2 (47°42'16" N, 122°26'24" W). Mean depth 196 m, range 172–210 m.
Mean particle size 0.0067 mm (silt). Clay 34.0%, silt 59.3%, sand 6.8%.
- Station 3 (47°44'31" N, 122°31'53" W). Mean depth 22 m, range 17–22 m.
Mean particle size 0.126 mm (fine sand). Clay 4.7%, silt 11.3%, sand 83.9%.
- Station 4 (47°44'31" N, 122°32'41" W). Mean depth 12 m, range 10–18 m.
Mean particle size 0.104 mm (very fine sand). Clay 3.0%, silt 18.8%, sand 77.9%, gravel 0.4%.
- Station 5 (47°10'48" N, 122°50'00" W). Mean depth 22 m, range 17–37 m.
Mean particle size 0.43 (medium sand). Clay 4.5%, silt 5.5%, sand 82.8%, gravel 7.2%.
- Station 6 (47°10'40" N, 122°48'48" W). Mean depth 35 m, range 30–40 m.
Mean particle size 0.22 mm (fine sand). Clay 5.9%, silt 20.5%, sand 66.2%, gravel 7.5%.
- Station 7 (47°13'30" N, 122°49'36" W). Mean depth 68 m, range 47–84 m.
Mean particle size 0.009 mm (silt). Clay 26.7%, silt 59.3%, sand 13.8%, gravel 0.2%.
- Station 8 (47°07'24" N, 122°50'06" W). Mean depth 15 m, range 9–21 m. Mean particle size 0.37 mm (medium sand). Clay 3.6%, silt 7.3%, sand 79.4%, gravel 9.7%.

The annual temperature range of the shallow stations during 1964 was 8–13° C, that of station 7 was 8–12° C, and that of the deepest station (2) was 8–10.5° C. The average salinity for stations 1–4, off Seattle, was 29.8‰; that for stations 5–8 in the southern Sound (Case Inlet) was 29.2, with very little variation. At station 8, the shallowest of the eight stations, the seasonal range was 28.0 to 29.7‰ S, and at station 2, the deepest one, it was 29.4 to 30.8‰ S. The oxygen concentrations were between 58% and 87% of saturation. The data of 1964 were representative for other years (Lie, in press). Water movement near the sea bed was always noticeable at the stations during studies with a television camera.

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Family POLYNOIDAE

Eunoe uniseriata, new species

FIGURE 1

Eunoe sp. I Banse et al. [in press].

TYPES.—Holotype: USNM 36273, from Station 2, 47°42'16" N, 122°26'24" W (November 1963). Paratype: USNM 36274 (1, in fragments) from Station 7, 47°13'30" N, 122°49'36" W (February 1963).

There are eight anterior and some posterior fragments from stations 2 and 7. The holotype has 18 setigers and is 12 mm long without cirri. It is 7 mm wide without cirri or setae and 2.5 mm without parapodia. The width of a mature female (paratype, 32 setigers) is 8 and 3 mm, respectively.

DESCRIPTION.—The prostomium (fig. 1a), slightly broader than long, is divided by a mid-dorsal furrow, is blunt anteriorly and without peaks. There are two pairs of eyes, which, after two years of preservation, have disappeared in some specimens. The appendages of the prostomium bear scattered short filiform papillae. The antennae arise from large cirrophores. The median antenna of the paratype is as long as the tentacular cirri. The lateral antennae insert terminoventrally. The styles are disproportionately thin and short compared with the cirrophores. The palps are about 4.5 mm long. There are two smooth spines in the base of each dorsal tentacular cirrus.

The dorsal and ventral surfaces of the body are smooth save for the distinct segmental borders. The first segment with elytra forms a low collar behind the prostomium. Its ventral cirri are elongated, almost approaching the tentacular cirri in length. Median parapodia (fig. 1*b*) have long dorsal cirri with numerous long papillae. Neuropodia

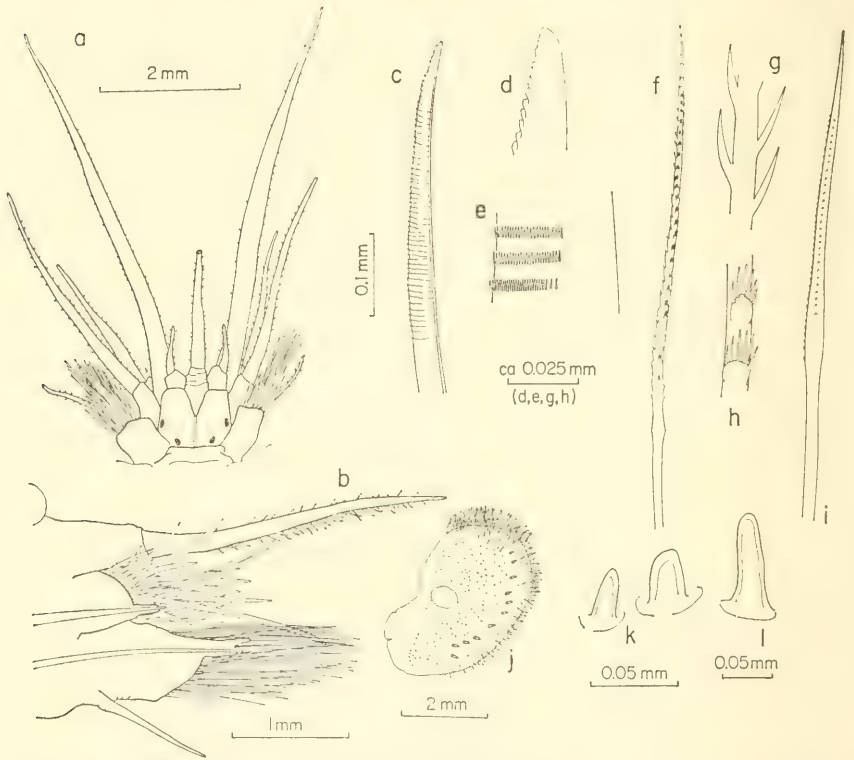


FIGURE 1.—*Eunoe uniseriata*, new species: *a*, dorsal view of anterior end, without elytra; *b*, anterior view of seventh parapodium; *c-e*, notoseta, with detailed views of tip and middle section; *f-h*, upper neuroseta, with details of scales (*g*, optical section); *i*, lower neuroseta; *j-l*, elytron, microtubercles, and macrotubercle.

are longer than the notopodia and terminate in finger-like extensions above the aciculae. The ventral cirri are smooth. The presence of elytraphores on a tail end (paratype) indicates that the elytra cover most of the body.

All setae have entire tips. Notosetae are stouter than neurosetae; they are yellowish and finely serrated almost to the pointed tip; the distal rows of spines are irregularly spaced (figs. 1*c-e*). There are two kinds of neurosetae. The upper neurosetae (figs. 1*f-h*) have two longitudinal rows of spinose scales. Similar but more delicate scales are

present on the lower neurosetae (fig. 1i); with spines, they are 20μ – 25μ long. It could not be made out whether there are two or three rows, but in any case, the rows of scales are restricted to one-half to three-fifths of the circumference of the setae so that, in side view, usually only the cutting edge of the seta appears as pectinated. The spines on these scales are finer than those of the upper neurosetae, and there are almost twice as many spines per scale.

Only two thin, wrinkled, and colorless elytra (fig. 1j) are left. Among fairly numerous conical microtubercles of 20μ – 30μ height (fig. 1k) there are some filiform papillae, which become very numerous toward the outer margin of the elytron. Very conspicuous is a row of conical macrotubercles about 110μ high (fig. 1l).

The color of the body is yellow brown in reflected light. The parapodia of the paratype, collected in February, are filled with exceedingly numerous, loose, and almost round eggs of about 65μ diameter from setigers 7 or 8 onward.

The fragment of a juvenile collected in July, with a width of almost 2 mm with parapodia but without cirri, and 0.7 mm without parapodia, shows the same characters as the adults, except that the prostomium is more pointed and the number of setae is small; all elytra had been lost.

The name refers to the row of macrotubercles on the elytra.

DIAGNOSIS.—A *Eunoe* species with blunt prostomium and disproportionately slender paired antennae. Notosetae with pointed tips. Two kinds of neurosetae. Elytra with conical microtubercles and one row of conical macrotubercles, and numerous filaments on the margins.

DIFFERENTIAL DIAGNOSIS.—*Eunoe uniseriata* is best characterized by its blunt prostomium, the slender paired antennae, the arrangement and form of the elytral macrotubercles, and the tips of the notosetae. There are few species with a blunt prostomium or reduced prostomial peaks among the *Eunoe* species listed by Hartman (1959, 1965b). Among these, *E. eura* Chamberlin, *E. sentiformis* Ushakov, *E. shirikishinai* Imajima and Hartman, *E. spinicirris* Annenkova, *E. subtruncata* Annenkova, and possibly *E. oerstedii* Malmgren have notosetae with blunt tips, which is not the case in *E. uniseriata*. Notosetae are pointed in *E. crassa* (Treadwell) and *E. nodosa dybowskyi* Augener, but the conical and other macrotubercles on the elytra are arranged differently from those on *E. uniseriata*. *Eunoe nodosa* (Sars) as described by Pettibone (1954, 1963) can have a blunt prostomium; there are papillae, however, in addition to the dorsal tubercles above the base of the dorsal cirri. Further, the very conspicuous row of macrotubercles near the external borders of the elytra are broad and rounded or jagged, not pointed as in the present species. Only one kind of neurosetae has been reported for *E. nodosa*.

Harmothoe fragilis Moore

Evarnella fragilis.—Hartman, 1959, p. 69.

Harmothoe fragilis.—Pettibone, 1963, p. 39.

One damaged incomplete specimen with eggs was collected in February 1963. Only the supracicular neurosetae are bidentate. The single remaining elytron conforms to figure 4, table 1, by Annenkova (1937) and figure b, table 6, by Imajima and Hartman (1964) for *H. impar* (Johnston). Pettibone (1963) already included Annenkova's record (as reported by Ushakov, 1955) in the synonymy of *H. fragilis*. We consider our specimen to belong to Moore's species because the European representatives of *H. impar* as described by McIntosh (1900) and Fauvel (1923) have inverted-conical or droplike papillae on the margins of the elytra, which is not the case with *H. fragilis*. Imajima and Hartman (1964) have doubted the justification of the genus *Evarnella* Chamberlin, and we follow them herein.

Found on station 6. New for Puget Sound. Previously recorded from southern California and the northwestern Pacific.

Hesperone complanata (Johnson)

Johnson (1901) stated that the paired antenna is less than half the length of the prostomium (cf. Pettibone, 1953, pl. 18: fig. 155). Johnson's largest animal was 21 mm long. In a small, incomplete animal, as well as in an incomplete specimen of 30 mm length with 26 segments, and in another fragment of about the same size, we find that the antennae are slightly more than half as long as the prostomia.

Family POLYODONTIDAE

Peisidice aspera Johnson

A 5-mm-long specimen collected in May contains moderately numerous polygonal eggs of up to $105\mu \times 95\mu$, and one-third to one-half of this in the third dimension.

Four specimens of about 5 mm length, collected in daytime, have empty intestines, excepting one from station 6 that contains two sand grains of about 0.35 mm diameter.

Family CHRYSOPETALIDAE

Paleanotus bellis (Johnson)

Paleanotus bellis.—Hartman, 1961, p. 57.

In California material examined by Hartman (1961), the ventral tentacular cirri of the right side were lacking, and this asymmetry was thought to be characteristic of the species. The type-locality is Monterey, Calif. In Puget Sound material, the cirri are present in

five animals (apparently damaged in one); the cirrus is rudimentary in one. Thus, asymmetry of the front end is not the rule.

Family PHYLLODOCIDAE

Eulalia (*Hypoeulalia*) *bilineata* (Johnston)?

Eulalia bilineata.—Imajima and Hartman, 1964, p. 61.

Although there are great similarities of characters, the first segments in our six specimens are clearly separated from the prostomia as in *Eulalia* *sensu stricto*, rather than being fused with them as reported by Bergström (1914) for European material. Imajima and Hartman (1964) have found the same separation in Japanese animals, a fact that suggests the Pacific form is not identical with the European species. The ventral cirri of the second tentacular segments of our specimens are not filiform but slightly broader than the others.

Eulalia (*Eulalia*) *levicornuta* Moore

FIGURES 2a-c

Eulalia levicornuta Moore, 1909a, p. 346.

Not *Eulalia levicornuta*.—Berkeley and Berkeley, 1943, p. 130.

We consider a well-preserved anterior fragment to represent this species although it does not completely agree with the type-specimen (USNM 17288). Some additions to the description follow, based on the Puget Sound specimen.

The length (without proboscis, 125 segments) is about 20 mm. The greatest width (without parapodia) is 0.65 mm. The prostomium is quadrate except for the narrower anterior part (fig. 2a). The unpaired (broken) antenna inserts between the small eyes. The partially everted proboscis is densely covered with rounded, conical papillae except proximally; the smooth section is shorter than the proboscis is wide.

There is a fairly distinct dorsal furrow between the prostomium and the first segment. The first segment is not reduced dorsally and is enlarged laterally. The tentacular cirri are filiform except the ventral one on the second segment, which is slightly flattened. The dorsal tentacular cirri on the second and the third segments are about one-and-a-half times the length of the normal anterior dorsal cirri. There are setae on the second segment.

The parapodia (fig. 2b) have rounded lips of equal length. The dorsal cirri are thick and of a broad shape. The ventral cirri are slightly longer than the parapodia. There are approximately 15 setae per parapodium. The shaft of each seta ends in a conspicuous spine with secondary teeth on both sides (fig. 2c); the blade is long.

The color of the animal is pale brown; the dorsal cirri have a greenish tint.

Comparing our specimen with the description by Moore (1909a) we find that the form of the shafts of the setae is characteristic of *E. levicornuta*. In our animal, the median as well as the accessory spines are slightly stronger than in the type specimen, and are exactly as in Moore's figure (1909a, pl. 16: fig. 30). Moore stated that although

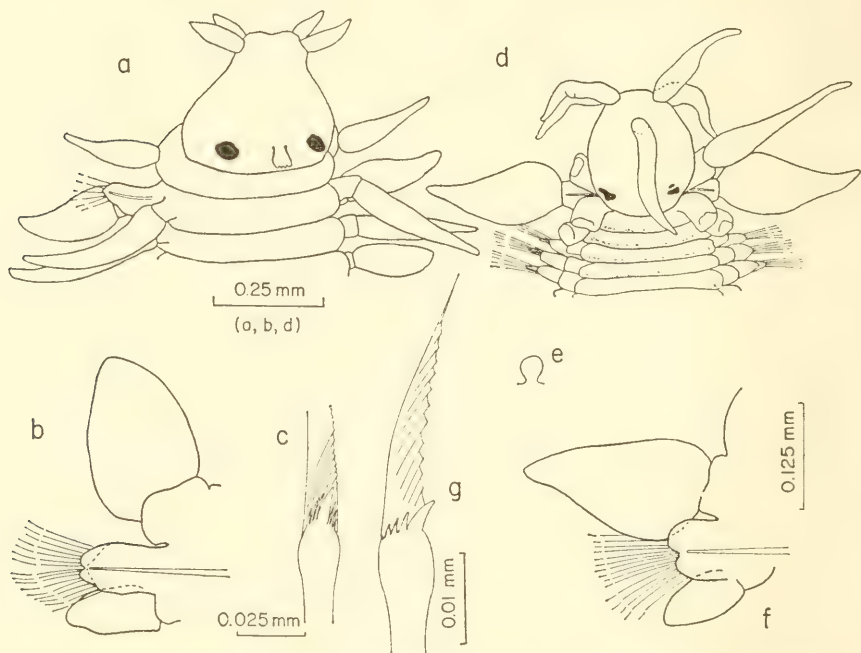


FIGURE 2.—*Eulalia levicornuta*: *a*, anterior end, from above and slightly from the left (proboscis and parapodium with ventral cirrus on third segment omitted); *b*, posterior view of 80th parapodium; *c*, terminal end of shaft of seta. *Eulalia parvoseta*, new species: *d*, dorsal view of anterior end (all dorsal cirri and part of tentacular cirri missing); *e*, papilla of proboscis; *f*, anterior view of 19th parapodium; *g*, seta.

the first segment is usually sharply separated from the prostomium, in one of his specimens they were dorsally almost continuous; this approaches the situation in our animal. The ventral cirrus of the second segment is flattened in the Puget Sound specimen contrary to the California material, but this character may be of lesser importance in view of the variability reported for *E. viridis* (Bellan, 1964). The length of the parapodia of our specimen is about one-third the body width, not one-fourth as with Moore's animals. The dorsal cirri in the type are rather leaflike, whereas in our animal they are fleshy.

Found on station 2. New for Puget Sound. Previously known from California. Berkeley (1924) had recorded a specimen for the coast of Vancouver Island but did not include it in the "Canadian Pacific Fauna" (Berkeley and Berkeley, 1948). This specimen is not in the Berkeley Collection of the U.S. National Museum (Dr. M. H. Pettibone, pers. comm.).

Two specimens collected in Wakeham Bay, near Ungava (Canada), on 2 September 1927 by Johansen and identified by Berkeley and Berkeley (1943) as *E. levicornuta* (USNM 32672) belong to another species of *Eulalia* sensu stricto. Among other characters, the shafts of the setae end in long spines of equal thickness.

Eulalia (Pterocirrus) parvoseta, new species

FIGURES 2*d*–*g*

Eulalia (Pterocirrus) sp. I Banse et al. [in press].

Holotype, USNM 36269, from station 5, 47°10'48'' N, 122°50'00'' W (February 1963).

There is one complete specimen (holotype), with about 50 segments, of 3.0 mm length (without proboscis) and 0.55 mm greatest width (without parapodia). An anterior fragment (fig. 2*d*) from station 4 with seven setigerous segments of slightly greater width was lost after the figure had been drawn.

DESCRIPTION.—The oval prostomium carries five long antennae. The unpaired antenna inserts somewhat posterior to the paired ones and reaches the third segment. The small eyes, without lenses, are near the posterior margin of the prostomium. The everted proboscis is 1.5 mm long and is densely covered with clavate papillae (fig. 2*e*), about 50 μ high.

The first two segments seem to be fused ventrally. The first one is reduced dorsally. The four pairs of tentacular cirri originate from large cirrophores; that of the ventral cirrus of the second segment (V. II) is supported by a large acicula. All tentacular cirri are filiform except V. II, which is leaflike with a tip; its posterior margin is thicker than the anterior margin. The tentacular cirrus of the first segment is about as long, the cirrus of the second segment is about twice as long, and the one of the third segment is about two-and-one-half times as long as V. II (see fig. 2*d*). There are no setae on the second and third segments, but on the third segment there is a reduced parapodial lobe, about two-fifths the length of the following one. Its acicula is much thinner than that in the cirrophore of V. II.

The tentacular formula thus is $1 + 0\frac{01}{a1} + 0\frac{01}{aN}$.

The parapodia have rounded lips of about equal length. The dorsal cirri are broadly lanceolate (fig. 2*f*); toward the posterior end of the

animal their length is about twice their width. The ventral cirri are oval and slightly longer than the parapodia. In the type specimen, the number of setae per parapodium is about 10, and in the second fragment it is about 15. The ends of the shafts of the setae are 6μ – 7μ thick and have large fangs with a few secondary teeth (fig. 2g). The blades are very short (20μ – 25μ). Anal cirri were lost.

The color of the animals is pale greenish with marked black pigment bands dorsally on the posterior margin of each segment.

The name refers to the noticeably short blades of the setae.

DIAGNOSIS.—A small *Pterocirrus* species with an oval prostomium, small eyes, and a long unpaired antenna. Clavate papillae on proboscis. First segment dorsally reduced. Shafts of setae with large fangs and very short blades.

DIFFERENTIAL DIAGNOSIS.—The species belongs to the subgenus *Pterocirrus* Claparède of *Eulalia*, as defined by Banse (1959; see also Day, 1960). It is distinguished from the type-species, *E. (Pterocirrus) macroceros* (Grube) (cf. Banse, 1959), by the oval shape of the prostomium, the small size of the eyes, the clavate papillae on the proboscis, the toothed tips of the shafts, and the short blades of the setae. Possibly also *E. marginata* Claparède (see Rullier, 1964) belongs to *Pterocirrus* as defined now, although Claparède (1868) stated that all cirrophores of the second and third segments are supported by aciculae. The new species differs from *E. marginata* in this character, the small eyes, the toothed ends of the shafts, and the short blades of the setae.

Phyllodoce (Anaitides) nr. multiseriata Rioja

FIGURE 3a

Phyllodoce (Anaitides) multiseriata Rioja, 1941, p. 684.

There is one broken specimen, presumably a mature male, from station 2, August 1963. The animal is at least 25 mm long and about 0.75 mm broad (without parapodia). It is particularly distinguished by the proximal papillae of the proboscis, which form seven or eight fairly irregular rows of about nine round papillae each on both sides. The papillae leave broad mid-dorsal and midventral gaps, the dorsal one tending to be V-shaped. Because of its broad base, the shape of the dorsal gap is not nearly as regular as shown by Rioja (1941, pl. 1: fig. 2). There is a tiny nuchal papilla. Only the ventral tentacular cirri of the second segment are left, which are filiform and three-fourths as long as the body is wide. Setae start on the third tentacular segment.

The parapodia have large supra-acicular lips (fig. 3a). Cirri are preserved only in median-posterior segments. There are about a dozen setae per parapodium. Their shafts end in numerous small teeth; the

blades are long. The color of the animal is pink with dark intersegmental furrows.

The form bears some resemblance to *P. multiseriata* Rioja, which, however, has 12 pairs of rows of papillae with 11–15 papillae in the long rows. Also, Rioja (1941) emphasized the V-shaped form of the dorsal gap. On the other hand, the large supra-acicular lips of the parapodia (stressed by Rioja in the text rather than in the figures) support our tentative identification. Hartman (1961) has described

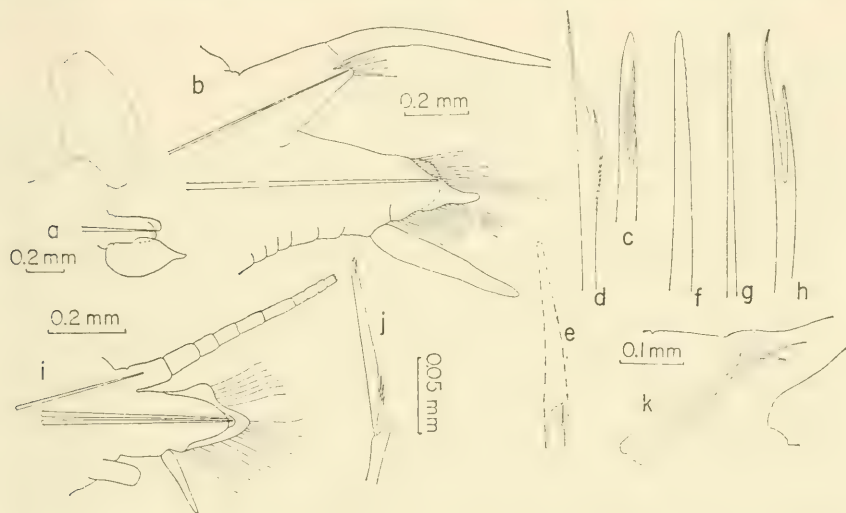


FIGURE 3.—*Phyllodoce* nr. *multiseriata*: a, posterior view of medioposterior parapodium. *Gyptis brevipalpa* (setae not drawn to scale): b, anterior view of median parapodium; c, thick notopodial spine; d, forked notopodial seta; e, tip of neuropodial compound seta; f–h, notopodial setae, including a thick capillary seta, from type of *G. brevipalpa* (figs. f–h by G. Hartmann-Schröder). *Micropodarke dubia*: i, posterior view of median parapodium; j, compound seta. *Sigambra tentaculata*: k, seta and acicula of a median notopodium squeezed under the cover glass (outline of basis of dorsal cirrus sketched).

an *Anaitides* nr. *multiseriata* with 12 pairs of lateral papillae. Her specimen had a nuchal papilla that in Rioja's animals was reported to be wanting.

Our form is not similar to any other known member of the subgenus *Anaitides* from the temperate northeastern Pacific.

Phyllodoce (*Anaitides*) *williamsi* (Hartman)

Anaitides williamsi Hartman, 1936, p. 126.

Our six specimens have about nine papillae per row on the proboscis, approximately rectangular dorsal cirri, rounded ventral cirri, and three bars across the dorsum of median segments, all of which support the identification. Adding to the description, we note that there are no

setae on the second tentacular segment, as to be expected in the subgenus *Anaitides*. A female with polygonal eggs of up to 75μ diameter was collected in February.

Found at stations 1, 5, and 8. New for Puget Sound. Previously known from Oregon and California.

Family HESIONIDAE

Gyptis brevipalpa (Hartmann-Schröder)

FIGURES 3b-h

Oxydromus brevipalpa Hartmann-Schröder, 1959, p. 105.

Oxydromus arenicola glabra Hartman, 1961, p. 68.

Many specimens are available that are referred to *G. brevipalpa*, originally described from El Salvador, despite minor differences in the notopodial setae. The largest, though incomplete, specimen is 17 mm long.

No cilia are visible between the 10 widely spaced terminal papillae of the proboscis. Occasionally the unpaired antenna seems to arise from a small elevation rather than from the straight anterior margin of the prostomium. Also, the posterior margin of the prostomium is straight. The longest tentacular cirri reach the twelfth setiger. Tentacular as well as dorsal cirri on body segments can be annulated with the joints being slightly shorter than wide, or they can appear pseudoannulated. The dorsal cirri are alternately short and long; the long cirri surpass the short cirri by about one-half their length and are almost as long as the body (without parapodia) is wide. Anal cirri are smooth.

Notosetae are absent on the first three or four setigers although aciculae are present dorsally. In posterior notopodia (fig. 3b) there are three to four short, nearly smooth spines about one-half as thick as the aciculae (fig. 3c) and about twice as many forked setae with flattened blades and short spurs, distinctly serrated (fig. 3d). The greatest width of the blades is about 5μ . In addition, two very long slightly curved capillaries can occur, which are finely serrated on the convex sides. The neurosetae have serrated blades that are almost smooth distally. The tips are excavated (fig. 3e). The blades may occasionally have hoods as indicated by the broken line in the figure; also one of the notopodial forked setae was found with such a hood. The tips of the shafts of the ventral neurosetae are slightly bifid when seen from below. The proximal parts of all setae, but not of aciculae, are distinctly 2-layered, the core being transversely barred. A specimen collected in February is packed with many polygonal eggs of about 60μ - 70μ diameter.

Dr. G. Hartmann-Schröder inspected the type of *G. brevipalpa*, provided drawings, and permitted us to add the following to the description:

Notopodial setae appear on the fifth setiger. There is an upper short, needle-like bristle, subdistally finely serrated [fig. 3f]. There are two thin, smooth capillaries almost twice as long [fig. 3g]. There are usually three forked bristles which appear to be smooth with 20×100 magnification [fig. 3h]. With the same magnification, a very fine serration of the blades of neuropodial setae can barely be seen.

The type of *O. arenicola glabra* was studied at the Allan Hancock Foundation and was found to have forked setae, as in figure 3d, from the fourth and fifth setigers. Also, some neuropodial setae are hooded. Another specimen, studied in sample 4829, has notopodial setae as in figure 3c.

The forms differ from *G. arenicola* (La Greca) in the absence of cilia on the proboscis and the presence of the forked notosetae. Apparently, the articulation of cirri is not a useful character, in view of the variability of the present material and our experience with *Micropodarke dubia*, wherein regenerating cirri are not clearly annulated (see below). The insertion of the unpaired antenna does not seem to be of significance either. Neither Dr. O. Hartman nor we wish to separate material from California and Washington from the Central American species on the basis of details in notopodial setae. *Gyptis capensis* (Day) seems very close to *G. brevivalpa* and is perhaps identical.

Found at stations 2, 4, 5, 7, and 8. New for Puget Sound. Previously known from California and Central America.

Micropodarke dubia (Hessle)

FIGURES 3i, j

Kefersteinia dubia Hessle, 1925, p. 32.

Micropodarke dubia.—Imajima and Hartman, 1964, p. 83.

There are many broken specimens that agree with the description by Hessle (1925) except that the everted proboscis has about 25 fairly regularly spaced terminal papillae with some additional supernumerary ones, rather than "about 20."

Adding to Hessle's description, the dorsal tentacular cirri can be quite long, the longest reaching the fourteenth setigerous segment. Regenerating cirri are not clearly annulated. The ventral tentacular cirri are about as long as the body is wide. Lobes that originate slightly posteriorly to the bases of the parapodia reach two-thirds the length of the parapodia in the first three or four setigerous segments; they are about four times as long as they are wide. Posteriorly they are much shorter (fig. 3i). The anterior lips of the first parapodia are almost bilobed as described by Okuda (1938) for *M. anemiyai* Okuda (this record has already been considered a synonym of *M. dubia*

by Imajima and Hartman, 1964). A compound seta is shown in figure 3j.

Fairly numerous polygonal eggs of up to 60μ diameter are filling the parapodia of a specimen collected in May at station 5. The species seems to be a selective deposit feeder: Intestines of specimens from station 5 (mean particle size 0.45 mm) are primarily filled with fine materials; in addition, there are sand grains smaller than 0.05 mm. Some sand grains and diatom frustules of more than 0.1 mm shortest dimension are also present.

There is no doubt that our specimens belong to Hessle's species; however, the genus *Micropodarke* Okuda, based on only one specimen of *M. anemiyai*, is said to have no notopodial aciculae, that is, to have uniramous parapodia. In view of the variability in the number of notopodial aciculae reported by Hessle (1-3; in the specimens checked by us, 1-2), it is feasible that Okuda's specimen was exceptional. If this is the case, the generic diagnosis for *Micropodarke* should be amended. The genus would then be very close to *Nereimyra*, except that there are no jaws in *Micropodarke*. Also *N. punctata* (Müller) has the mentioned lobes (fig. 3i) mediad to the ventral cirri (Banse, 1956). Other close genera are *Parasyllidea* Pettibone and possibly *Neopodarke* Hartman, both with slightly different termination of the proboscis; the latter genus lacks notopodial aciculae. Since the armature of the proboscis is not a very practical character, it is doubtful that all of these mostly monospecific genera should be retained. *Nereimyra* would take precedence over the other names.

Found at stations 1, 4, 5, and 8. New for the eastern Pacific. Previously known from Japan.

Family PILARGIDAE

Sigambra tentaculata (Treadwell)

FIGURE 3k

Ancistrosyllis tentaculata.—Hartman, 1947a, p. 498.

Sigambra tentaculata.—Pettibone, 1966, p. 182.

There are several animals. The longest one has at least 135 setigers and is 2 cm long.

The deeply indented posterior margin of the prostomium is rarely visible. The proboscis has 12-13 triangular closely spaced terminal papillae of equal size and also some medium-sized papillae on the outside. There seems to be some variability of this character—14 in the type (Pettibone, 1966), 8 in other Atlantic material (Hartman, 1965a). The curved notopodial hooks are usually found from the third setigerous segments onward, rather than from the fourth as in the type material from Long Island Sound (Pettibone, 1966); occasionally they begin with the fourth setigerous segment in our material. A fine

short capillary seta may be present (fig. 3*k*). In the median and posterior parapodia short, thick spines occur, which are not as strongly bent as the aciculae. Neurosetae are all spinose. In short ones, the hairs are as long as the shafts are wide, so that the setae appear comblike. In the longest thin setae, the serration becomes just visible under $\times 400$ magnification.

Found at stations 6-8. New for Washington waters. Previously known in the North Pacific from southern California.

Family SYLLIDAE

Eusyllis blomstrandii Malmgren

FIGURES 4a-c

Adding to the description of the Pacific and Arctic material (Pettibone, 1954), we note that the pharynx opening in our material is

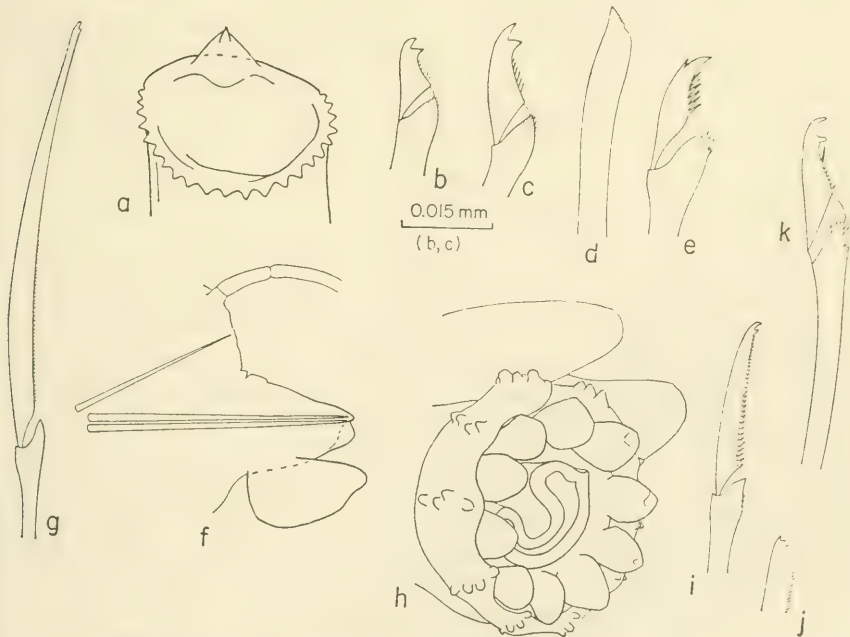


FIGURE 4.—*Eusyllis blomstrandii*: a, opening of pharynx; b and c, setae from a median parapodium. *Exogone lourei* (setae not drawn to scale): d, tip of upper simple seta, e, compound seta with short blade. *Pionosyllis uraga*: f, posterior view of median parapodium with a dorsal acicula (neurosetae not shown); g, compound seta with long blade. *Syllis harti*: h, partly everted pharynx from the lower right hand side (the palps are indicated); i, blade of median seta from 41st parapodium of type. *Dorvillea pseudorubrovittata* (setae not drawn to scale): j, tip of simple, flattened seta; k, compound seta.

chitinous with the usual large dorsal tooth and small teeth on about three-fourths of the circumference (fig. 4a); it thus differs from the material of Malmgren (1867) and Imajima (1966). Two rows of soft papillae encircle the outside of the pharynx. The proventricle has 50 to 70 rows of papillae and is followed by a pair of spherical caeca. The dorsal cirri, annulated in the anterior region of the body, are smooth in the middle and posterior regions. Setae from the middle region of the body have short blades (figs. 4b, c). Setae with long, straight blades as reported by Berkeley and Berkeley (1945) for animals from Vancouver Island are absent in our animals. Swimming setae occur from setigers 17 or 18 onward.

Exogone lourei Berkeley and Berkeley

FIGURES 4d-e

There are several specimens. An inspection of the type (USNM 32895) showed that the proventricle is rather long, extending from the third to the sixth setiger (fourth to seventh in our specimens). In a median parapodium of one of our specimens, the tip of the simple dorsal seta is slightly serrated (fig. 4d); compound setae with short blades have small teeth above the main fangs (fig. 4e).

Pionosyllis uraga Imajima

FIGURES 4f, g

Pionosyllis uraga Imajima, 1966, p. 114.

There are many anterior fragments with up to about 30 setigers, 4 mm long and 0.7-0.8 mm at greatest width (without parapodia). Commenting on the description by Imajima (1966), we note that the proventricle of our specimens has about 35 rows of papillae and extends through 12-14 setigers. The dorsal cirri alternate in length. The long ones of the anterior setigers as well as the dorsal tentacular cirri are 1.5-2 mm long. Farther posteriorly, the dorsal cirri decrease in size and are twice the body width at about the thirtieth setiger although there are cirri of 2 mm length even on the twentieth setiger.

Neuropodial setae are numerous in the anterior 12-15 setigers and appear faintly yellow in direct light. Subsequently the number of setae is sharply reduced to approximately 20 or less. In this region, there are up to four neuropodial aciculae. In one animal there is a dorsal acicula but natatory setae are absent (fig. 4f). The uppermost setae with very long blades (about 100 μ , fig. 4g) have faintly serrated cutting edges at their bases and bidentate tips. The compound setae with blades of ordinary length (25 μ -40 μ) have strongly spinose cutting edges, except the lowermost ones with the shortest blades. The ends of the shafts of these setae are slightly serrated but do not

have hairs as stated by Imajima (1966). There is very faint serration at the tips of the shafts of the upper compound setae as well.

Found at stations 5 and 6. New for the eastern North Pacific. Previously known from Japan.

Syllis (Typosyllis) harti Berkeley and Berkeley

FIGURES 4*h*, *i*

Our many specimens have been compared with the type material (USNM 32671), and we can add to the description by Berkeley and Berkeley (1938): The pharynx extends through the tenth to twelfth setigers. There are the usual 10 soft papillae on the outside and, alternating with them, rows of four small soft papillae (fig. 4*h*). The proventricle has 40–60 rows of papillae and extends in the type through 12 setigers and in our material through 9–11 setigers. The ends of the shafts of median (fig. 4*i*) and lower setae from the thirteenth and forty-first feet of the type bear minute teeth. The blades are coarsely serrated and have subbidentate tips. The blades of the upper setae are about twice as long as those of the median setae but are less coarsely serrated and have bidentate tips (fig. 4*i*; see also original description, Berkeley and Berkeley, 1938).

The species reproduces by stolons. The intestines of all our specimens are empty.

Family NEREIDAE

Platynereis bicanaliculata (Baird)

Platynereis dumerilii agassizi.—Berkeley and Berkeley, 1948, p. 60.

Paragnath groups VII and VIII of specimens from the San Juan Archipelago collected by M. H. Pettibone (USNM 28458, 28460, 28463, and 28464) form five subgroups of pectinate paragnaths (sometimes in a double row), rather than a continuous band as stated by Hartman (1954) for *P. bicanaliculata* from Vancouver Island. Ehlers (1868) described six subgroups of two rows each for his *P. agassizi* from the Strait of Georgia and from Mendocino (see also Izuka, 1912).

Family NEPHTYIDAE

Nephtys assignis Hartman

Nephtys assignis Hartman, 1950, p. 112.

A fairly relaxed specimen with about 145 setigers is just 20 cm long. Found at stations 2 and 7. New for Puget Sound. Previously known from southern California and Guatemala.

Nephtys ferruginea Hartman

This species has not been reported previously to possess recurved aciculae, but they are clearly recurved in our many specimens. The interramal cirri usually point downward or may appear to be involute; however, the pigmentation pattern, the appearance of the interramal cirri on the third setiger, and the shape of the posterior neuropodial acicular lobe make identification certain.

Usually, the intestinal content is not conspicuous even in transparent posterior ends. A specimen with sediment boluses in the posterior intestine was dissected and was found to have numerous syllid bristles engulfed in the sediment.

Females with eggs and young specimens, the latter presumably belonging to this species, were observed from February through July.

Family SPHAERODORIDAE

Sphaerodoridium sphaerulifer (Moore)

Sphaerodorium sphaerulifer.—Ushakov, 1955, p. 222.

Sphaerodoridium sphaerulifer.—Lützen, 1961, p. 415.

Found at stations 4 and 7. New for Puget Sound. Previously known from California, the Sea of Okhotsk, and the Sea of Japan.

Family GLYCERIDAE

Glycera Savigny

In addition to a note on *G. siphonostoma* (della Chiaje), we report observations on the intestinal contents of other species of this genus, occurring locally.

Glycera siphonostoma (della Chiaje)

Glycera siphonostoma. —Imajima and Hartman, 1964, p. 164.

Our specimens agree with the description by Imajima and Hartman (1964): Each aileron has a connecting plate, there are ridges on the proboscoidal organs, the prostomium is 9-ringed, branchiae are absent, there are pointed postsetal lobes that are much shorter than the pre-setal lobes, and there are large ventral cirri. The ventral cirri of middle parapodia of our specimens reach nearly to the pre-setal lobes, agreeing with the figures given by McIntosh for the species (1910; pl. 76; fig. 2b).

Found at stations 2, 7, and 8. New for Puget Sound; hitherto known in the Pacific from Japan.

Intestinal Contents of Local *Glycera* species

Intestinal contents of the midportion of animals were studied, or squeezed specimens were inspected (as indicated). All the material had been collected in the daytime. Three specimens of *G. americana* Leidy (about 3.5, 5, and 10 cm long) had empty intestines. A 5-cm-long specimen of *G. capitata* Oersted (including *G. nana* Johnson; see Banse et al., in press) had an empty intestine as seems to be the rule with the species (from inspection). A 4-cm-long animal from station 7 contained a few boluses of sediment that were full of setae of *Sigambra tentaculata*, together with fine sediment material and sand grains up to about 0.075 mm diameter. Specimens of *G. siphonostoma* (two of 2 cm, one of 6 cm length; from inspection) had empty intestines. A 35-cm-long specimen of *G. robusta* had an empty middle intestine; a 25-cm-long animal contained a small amount of sediment particles together with many bristles, possibly of Aphroditidae.

The observations of largely empty intestines corroborate the findings by earlier investigators (see Klawe and Dickie, 1957; Sanders et al., 1962). According to these authors, who quote earlier studies, Glyceridae may be considered deposit feeders that swallow larger animals incidentally. Our material is not large enough to investigate whether the grain size composition of the intestinal content is that of the habitat; the organization of the proboscis would suggest non-selective deposit feeding only.

Family GONIADIDAE

Goniada maculata Oersted

Goniada maculata.—Støp-Bowitz, 1941, p. 209.—Hartman, 1950, p. 20.

Found at stations 1, 3, 4, 6, and 8. New for Puget Sound. Previously known in the Pacific from Kodiak Island and the northwestern Pacific.

Family LUMBRINERIDAE

Lumbrineris Blainville

In addition to a morphological note on *L. californiensis* Hartman, we make observations on the intestinal contents of several other species of this genus occurring locally.

Lumbrineris californiensis Hartman

Lumbrineris californiensis Hartman, 1944, p. 163.

In specimens of 4–5 cm length and about 1 mm width (without parapodia), composite hooks are found only to the fifteenth or six-

teenth setiger, rather than to the twenty-fourth to thirtieth or a little beyond as in California material 8.5–13 cm long (Hartman, 1944).

Found at stations 1, 3–6, and 8. New for Puget Sound. Previously known from California.

Intestinal Contents of Local *Lumbrineris* species

From inspection of entire animals, we note that the intestines of specimens of the local species of one to a few cm length are filled only to about one-fourth of their length, sometimes less. The sediment occurs in boluses at least in the middle and posterior sections of the body. Dissection of two specimens each of four species showed the following (width is without parapodia; all animals had been collected in the daytime):

LUMBRINERIS BICIRRATA TREADWELL.—The intestinal contents of a posterior fragment from station 4 of 3 mm width contained sand grains up to 0.2 mm wide, inbedded in a fair amount of organic and inorganic fine material. The intestinal contents of an almost 10-cm-long specimen of 6 mm greatest width from station 2 were a large amount of fine sediment with some diatom frustules and sand of up to 0.15 mm diameter. In neither case could recognizable organic remains be seen.

LUMBRINERIS CALIFORNIENSIS HARTMAN.—The hind intestine of a small individual (about 1 mm wide) from station 7 contained very fine sediment of less than 0.01 mm grain size and two healthy looking nematodes. A specimen about 1.5 cm long and 1 mm wide from station 1 contained fine detrital material, with a few sand grains up to 0.15 mm in diameter, and several pieces of a terrestrial plant epidermis about the same size.

LUMBRINERIS CRUZENSIS HARTMAN.—A young specimen about 1 cm long in length and <1 mm wide from station 1 contained fine detrital material, with a few sand grains ≤ 0.07 mm in diameter. Many other specimens of approximately the same size from this station and station 7 had empty intestines.

LUMBRINERIS LUTI BERKELEY AND BERKELEY? (for identification, see Banse et al., in press).—Two posterior fragments 1.5 cm long and about 1 mm wide from station 4 contained largely coarse material, including unbroken *Coscinodiscus* species frustules 0.2 mm in diameter.

Most specimens had sediment about the same grain size or particles smaller than the mean grain size of their habitat in their intestines, suggesting predominantly selective feeding. Because of the partial filling of the guts, it may be doubtful whether the species are exclusively selective deposit feeders as these have to cope with large amounts of sediment to obtain enough organic material. The absence

of animal remains (except for one specimen of *L. californiensis*), is certainly striking.

Earlier studies have suggested that *Lumbrineris* species are not carnivorous: *L. impatiens* Claparède feeds on macroscopic algae (Hempelmann, 1931); *L. minima* Hartman is a detrital feeder (deposit feeder) (Reish, 1959); *L. tenuis* (Verrill) and probably *L. fragilis* (Müller) are selective feeders as is the related *Drilonereis longa* Webster (Sanders et al., 1962).

Family ARABELLIDAE

Notocirrus californiensis Hartman

Notocirrus californiensis Hartman, 1944, p. 175.

Found at stations 1, 3, 4, and 6. New for Puget Sound. Previously known from California.

Family DORVILLEIDAE

Dorvillea pseudorubrovittata Berkeley

FIGURES 4j, k

The setae were studied in the syntypes (USNM 32674). There are some superior thin capillary setae, slightly broadened in the distal third, where they are finely serrated. The bidentate tips have the same outline as those of the thicker spines below (fig. 4j), which are slightly broadened and coarsely serrated in the distal halves. The serration near the bifid tips is fine. Rioja (1962) has not mentioned the bifid tips. The ends of the compound setae are serrated (fig. 4k). The spurs below the secondary teeth of the blades can be as small as in our figure, or they can form a membrane on the cutting edges of the blades reaching their tips.

Family PARAONIDAE

Aricidea (Aricidea) ramosa Annenkova

FIGURES 5a-d

Aricidea? (Aedicira) ramosa.—Hartman, 1957, p. 312, p. 327; 1959, p. 371.

Aricidea (Aedicira) ramosa.—Hartman, 1963, p. 37.

Aedicira ramosa.—Hartman, 1965b, p. 50.

We have 15 individuals, 2 of which are complete and have about 80 setigers. The antenna is short and palmately divided into three to five fairly equal lobes (fig. 5a); Annenkova described longer lobes. There are 13-17 pairs of gills beginning on setiger 4. Notopodial

postsetal lobes are short in the anterior and longer in the posterior segments.

The character of the neuropodial setae changes at the fortieth to fiftieth setigers, where some setae taper abruptly (fig. 5*b*). Two or three setigers farther, modified setae, usually with an arista, are also present (fig. 5*c*). The pygidium of one specimen is well preserved and has three ventral cirri, a short median one and two longer ventrolateral ones (fig. 5*d*).

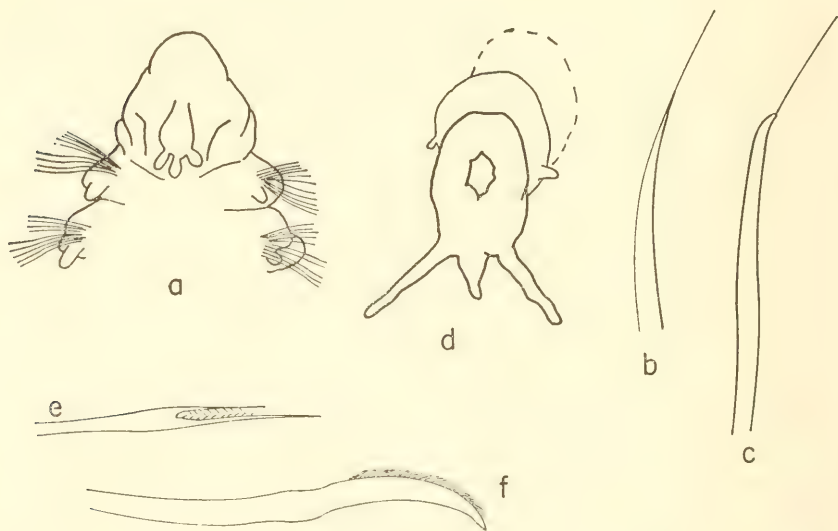


FIGURE 5.—*Aricidea ramosa*: *a*, dorsal view of anterior end; *b*, seta from about the 40th neuropodium; *c*, modified neuropodial seta; *d*, posterior view of pygidium. *Paraonis lyra*: *e*, furcate seta from posterior notopodium. *Paraonis ivanovi*: *f*, posterior neuropodial hook.

The neuropodial hooks place this species in *Aricidea* sensu stricto not in *Aedicira* as tentatively suggested by Hartman (1957).

Found at stations 4, 6, and 7. New for Puget Sound. Previously known from the Sea of Japan and southern California.

Paraonis (Paradoneis) lyra Southern

FIGURE 5e

Paraonis (Paraonides) lyra Southern, 1914, p. 94.

Paradoneis lyra.—Hartman, 1965a, p. 140.

Our single specimen has a prostomium longer than wide. It lacks the ciliated papilla on the anterior margin figured by Southern (1914), but this may be an artifact of preservation. There are 14 pairs of

gills beginning on the fourth setiger. Furcate setae are present in the notopodia beginning on the last few branchial segments (fig. 5e). They differ from those figured by Southern in having spines on the inside of both arms, rather than on the inside of the long arm only.

Found at station 4. New for the temperate northeastern Pacific. Previously known from the northern Atlantic and southern California.

Paraonis (Paraonis) ivanovi Annenkova

FIGURE 5f

Paraonis ivanovi.—Hartman, 1957, p. 333.

Our specimens have conical prostomia and no eyes, five to six prebranchial setigers, and 10–16 (usually 13) pairs of gills. The modified neuropodial, acicular setae are curved, and have hoodlike structures on the convex sides. The hooks resemble the figure of Annenkova (1934, fig. 1a) for *P. ivanovi* under $\times 400$. Under $\times 1000$, however, the hood appears to be feathered (fig. 5f), and further, it is noticeable only on the convex side of the hook, whereas Annenkova showed it on both sides of the hook. The pygidium of one specimen consists of one large median ventral lobe from which arise two lateral cirri.

Ushakov (1950) regarded *P. ivanovi* and *P. gracilis* Tauber as the same species; however, we find that the modified neuropodial acicular setae of *P. gracilis* specimens from near the type-locality (kindly sent by Dr. A. Eliason, from his station 2 in the southern Öresund; Eliason, 1920) are without hoods or any similar structures. We therefore consider the two forms to be different species, which are distinguished only by these setae, as far as we can see from the descriptions. The Swedish material did not allow a detailed comparison of other characters.

Found at stations 2–4 and 6–8. New for the eastern Pacific. Previously known from the Sea of Okhotsk and possibly from Murmansk (fide Ushakov, 1950). Ushakov (1955) has recorded *P. gracilis* sensu lato also from the Bering Strait, and Chukchi Sea.

Family APISTOBRANCHIDAE

Apistobranchus ornatus Hartman

Apistobranchus ornatus.—Hartman, 1965a, p. 144.

Numerous specimens were found in January at station 4 but not in April. They are characterized by their palps, if present, reaching to the fourth setiger, the absence of the ventral cirrus on the first setiger, the serrated postsetal neuropodial lamella on the fifth, and the large lobes on the postsetal neuropodial lamella on the seventh setiger. Notopodia

are present at least through the twenty-second setiger, and interramal cirri are present from the first through at least the seventh setiger. The setae of the first six (sometimes seven) parapodia appear bushy, as in California animals (Hartman, 1961), but contrary to Hartman's (1965a) description.

New for Puget Sound. Previously known from California.

Family SPIONIDAE

Laonice Malmgren

While describing a new species from Puget Sound, we found it necessary to study the types of *L. antarcticae* Hartman and *L. japonica* (Moore). We add here to the original descriptions of these species.

Laonice antarcticae Hartman

Laonice cirrata antarcticae Hartman, 1953, p. 40; 1959, p. 378.

Laonice antarcticae.—Hartman, 1965a, p. 147.

We consider *L. cirrata antarcticae* Hartman a species of its own as did Hartman (1965a), for the following reasons: In the two types of *L. antarcticae* (Naturhistoriska Riksmuseet, Stockholm, type no. 613), the dorsal sense organ reaches to about the thirteenth setiger. The gills start, barely visible, on the second setiger. On the fourth setiger, they are one-fourth as long as the notopodial postsetal lamella, and only on the sixth to tenth setiger do they attain the same length as the lamellae. In the segments immediately posterior to the gill-bearing region, the ridges connecting the notopodial lamellae with the dorsum occupy about one-fourth of the distance between the lamellae, as in *L. pugettensis*, and are otherwise inconspicuous. Hooks in the forty-sixth and fifty-seventh setigers have two teeth, side by side above the main fangs, as in Brazilian material (Hartman, 1965a).

Laonice cirrata (Sars)?

Our specimens differ from the European representatives as described by Söderström (1920) by having two small teeth rather than one, side by side above the main fangs of the ventral hooks (no exception in the four parapodia of two specimens studied). This is one of the characters by which Söderström distinguished his *L. bahusiensis* from *L. cirrata* (later authors have not separated these forms). According to Söderström, genital pouches begin with the former species at the fifteenth to seventeenth setiger, with the latter at the twenty-eighth to thirty-fifth setiger. Hartmann-Schröder (1965) has reported *L. cirrata* from Chile, with similar hooks as in our form. The Chilean form is clearly different from ours, as well as from Söderström's form, because of its short dorsal sense organ, although the beginning of brood pouches is not known.

In our material, the occipital tentacle inserts at the level of the first parapodium. The dorsal sense organ reaches the twenty-sixth to thirty-fourth setiger (average 29, S.D. 3.7, $n=6$). The first occurrence of genital pouches ranges from the twelfth to twenty-eighth setiger (average 20, S.D. 4.5, $n=13$). In the largest animals, which are mature females, neuropodial hooks start at the forty-eight and sixty-second setigers; hooks occur in more anterior segments (thirtieth to thirty-fifth) in younger animals. In view of this variability we include our material, for the time being, in *L. cirrata* in spite of differences in the shape of the hooks.

Egg-carrying females are dark reddish-brown. The largest anterior fragment, with 62 setigers, is 5.5 cm long and 3.5 mm wide, without parapodia. The diameter of eggs taken from the coelom is slightly larger than 200μ , similar to Swedish material of both forms.

A juvenile animal had been regenerating the prostomium and five anterior setigers. The U.S. National Museum has an uncataloged adult specimen, also regenerating the anterior end.

Found at stations 1-4 and 6-8.

Laonice japonica (Moore)

Spionides japonicus Moore, 1907, p. 204.

Laonice cirrata.—Imajima and Hartman, 1964, p. 281 partim.

Not *Laonice japonica*.—Monro, 1933, p. 1047.

We consider *L. japonica* to be a species separate from *L. cirrata* (Sars), as suggested by Monro (1933), because of the beginning of genital pouches at the fourth to fifth setiger. Also, the dorsal sense organ reaches only to the eighteenth setiger in the holotype of *L. japonicus* (Acad. Nat. Sci., Philadelphia, type no. 1055) rather than to the twenty-eighth to thirtieth setiger as in *L. cirrata* (Söderström, 1920). The gills on the second setiger are half as long, and on the third setiger about as long as the notopodial postsetal lamellae. The holotype of *L. japonicus* has been collected off Japan at Albatross station 3771, not 5771 as stated by Moore (1907).

Monro (1933) has observed gills from the third setiger on a fragment from the Gulf of Panama identified as *L. japonica*; the dorsal sense organ extended to the twelfth setiger. Therefore, his form seems to be a different species.

Laonice pugettensis, new species

FIGURE 6a

Laonice cirrata.—Berkeley and Berkeley, 1936, p. 27 partim.

Laonice sp. I Banse et al. [in press].

Types.—Holotype: USNM 36263. Paratypes: USNM 36262 (4). Both from station 5, $47^{\circ}10'48''$ N, $122^{\circ}50'00''$ W (February 1963).

There are many anterior fragments from stations 1-3, 5, 6, and 8: mature females with up to 70 setigers about 3 cm long and almost 2.5 mm wide without parapodia, some posterior fragments that presumably belong to this species, and several anterior fragments of small individuals about 0.5 cm long and 0.5 mm wide.

DESCRIPTION.—The prostomium is broader than long and anteriorly flattened. There are two large crescentic eyespots and a distinct occipital antenna. The dorsal sense organ (caruncle) reaches to about the twenty-fifth setiger. The palps are lost in all specimens. Gills start at the second setiger and number 24 pairs in a well-preserved young animal, and 27, 32, and 33 pairs in mature females. The first pair is not quite as long as the notopodial lamella; the next two or three pairs, as well as the last one or two pairs, are shorter than the rest. A fully developed gill is shown in figure 6*a*. Notopodial postsetal lamellae in the middle of the gill-bearing region are auricular ventrally. Their distal ends are fairly blunt in adults (fig. 6*a*), whereas in younger specimens the tip is tapering in the long axis of the lamella so that the lamella appears to point upward. Posterior to the gill-bearing region a ridge from the notopodial lamella on to the dorsum occupies about one-fourth the distance between the cirri on each side in the holotype but is not distinct in the other large specimens. Genital pouches occur from the second to seventh setiger onward through at least the seventieth setiger.

Neuropodial hooks are found in an old and a young specimen from the thirtieth to thirty-third setiger onward. There are two secondary hooks side by side above the main fang. Dorsal hooks are absent on the anterior ends, as well as on the posterior end checked. Stout ventral neurosetae begin on the twenty-sixth and thirty-third setiger with two old individuals, at the twenty-fourth with the young animal mentioned above, and farther forward with another young specimen.

The pygidium has nine slender cirri that are slightly longer than the pygidium is wide; possibly their number varies. Polygonal eggs from genital pouches are about 125μ in diameter. The animals are yellowish pink.

The name refers to the type-locality.

DIAGNOSIS.—A small *Laonice* species with genital pouches from the second to seventh setiger. Dorsal sense organ (caruncle) to about the twenty-fifth setiger. Approximately 30 pairs of gills. Dorsal ridges posterior to the gill-bearing region inconspicuous. Dorsal hooks absent. Ventral hooks with two secondary teeth side by side above the main fangs.

DISCUSSION.—We follow Söderström (1920) in using the occurrence of genital pouches for separating species of the genus. Söderström has found a fairly close relation between the end of the atokous region

and the beginning of the brood pouches in three spionid genera. We note, however, that eggs can be seen through the body wall of three specimens of *L. pugettensis* only at the twenty-fifth setiger or slightly posterior to this segment although genital pouches start at the second to seventh setiger.

Omitting Monro's form, the known *Laonice* species with brood pouches starting before the tenth setiger may be distinguished as follows:

1. Dorsal sense organ (caruncle) to about the 25th setiger; dorsal ridges behind the gill-bearing region inconspicuous *L. pugettensis* new species
Dorsal sense organ not reaching the 20th setiger; dorsal ridges present or absent 2
2. Neuropodial hooks occurring before the 20th setiger. *L. appeloefi* Söderström
Neuropodial hooks starting posterior to the 20th setiger 3
3. Gills distinct from second setiger onward; conspicuous dorsal ridges behind gill-bearing region *L. japonica* (Moore)
Gills distinct only posterior to second setiger; dorsal ridges inconspicuous.
L. antarcticae Hartman

Laonice pugettensis is different from the incompletely known *Aricideopsis megalops* Johnson (1901) from Puget Sound, considered to be a species of *Laonice* (Hartman, 1959), because of hooks on the seventeenth somite in the latter. Also, neither the occipital antenna nor the gills on the tenth setiger of old or young specimens of the new species are as large as figured by Johnson.

A few records of *L. cirrata* from waters of British Columbia must refer also to *L. pugettensis* as evident from the description of the former species by Berkeley and Berkeley (1952). Further, an unnumbered sample in the U.S. National Museum, collected in Departure Bay, B.C., between 1918 and 1925, contains 15 *L. cirrata* and 2 *L. pugettensis* (cf. Berkeley and Berkeley, 1936).

Paraspio cirrifera, new species

FIGURES 6b-f

Paraspio sp. I Banse et al. [in press].

Types.—Holotype: USNM 36270. Paratypes: USNM 36271 (2) and 36272 (3). All come from station 3, 47°44'31" N, 122°31'53" W (February 1963).

Twenty-four specimens from stations 1, 3, 4, 6, and 8 are available. About half of our specimens come from station 3. The largest anterior fragment of a mature female has 73 setigers and a length of 21 mm. One complete animal possesses about 85 setigers.

DESCRIPTION.—The prostomium (fig. 6b) is rounded anteriorly. In most specimens there is a high bilobed protuberance on the upper side; in such a case, the eyes are not visible when the animal is seen

from the front (fig 6c). The posterior end of the prostomium is obtuse. Palps have been lost. There is a very small gill on the first setiger. In a well-developed parapodium (fig. 6d), the notopodial and neuropodial postsetal lamellae are present as usual. Also, there is a fairly large neuropodial presetal lamella and an interrampal papilla. The gills are partially fused with the notopodial lamellae. Near the pos-

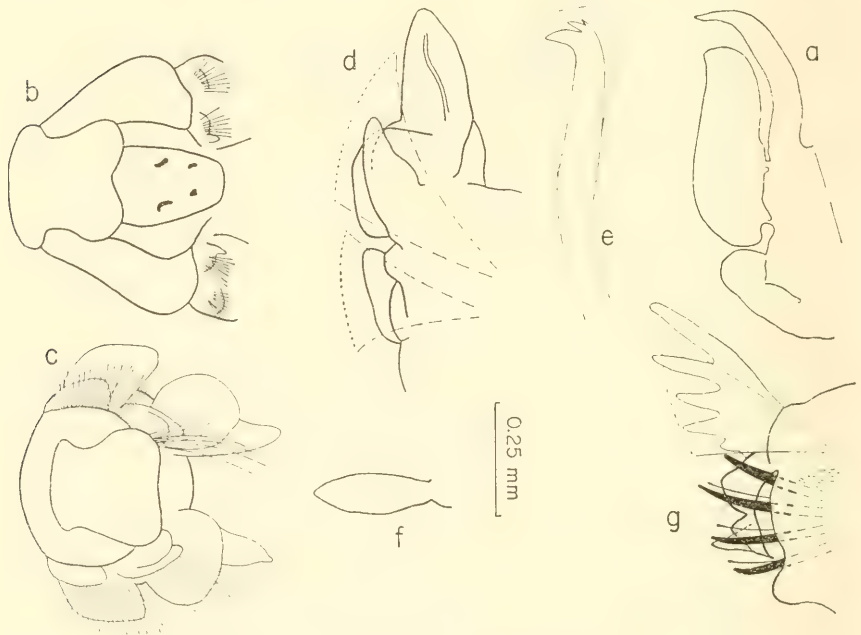


FIGURE 6.—*Laonice pugellensis*, new species: a, median parapodium (setae omitted). *Paraspio cirrifera*, new species: b, dorsal view of anterior end; c, frontal view of anterior end (setae of the first setiger are shown on the animal's right side, setae of the second setiger on the left side); d, anterior view of parapodium of 10th setiger (light broken lines indicate setae); e, hook from 25th parapodium; f, anal cirrus. *Trochochaeta multi-setosa*: g, anterior view of third setiger (light broken lines indicate notosetae).

terior end of the animals, the lamellae are reduced, and the gills are long and straplike. In the tenth parapodium, a dorsal extension of the gill reaches forward, toward the origin of a most characteristic notopodial presetal cirrus, which is fairly round in cross-section. This cirrus is present at least through the twenty-fifth setiger but visible only in well-preserved material without dissection.

There are notopodial and neuropodial setae in the first setiger. The number of neurosetae is about 20. Apart from the wings, the setae appear dotted rather than striated. Tridentate neuropodial hooks

(fig. 6e) begin on the sixteenth to seventeenth setiger in young and mature specimens. There are fewer than 10 hooks per parapodium. Two ventral stout bristles start from the thirty-second or thirty-third setigers. Notopodial hooks are absent. There are four anal cirri (fig. 6f), round in cross-section and about 0.4 mm long.

Two large brown pigment spots occur on the prostomium behind its anterior constriction; sometimes similar pigmentation is present also on the anterior end of the lateral wings of the prostomium. There is some irregular pigment pattern dorsally behind the prostomium, and a thick band of pigment is found laterally on the peristomium. In the first 8 to 10 setigers, some brown pigment occurs in the intersegmental borders between the neuropodia and ventrally on both sides of the midline, separated by the pigment-free midline.

Polygonal eggs of about 250μ diameter are observed in one specimen (February). The animals construct a transparent fragile mucus tube.

The name refers to the presetal notopodial cirrus.

DIAGNOSIS.—A *Paraspio* species with an anteriorly rounded prostomium. Notosetae and a small gill on the first setiger. Dorsal presetal cirri in the anterior region of the body. Tridentate neuropodial hooks from setiger 16 or 17, ventral neuropodial acicular setae from setiger 32 or 33. Four elongated anal cirri.

DIFFERENTIAL DIAGNOSIS.—The new species may be distinguished from the members of the genus listed by Hartman (1959, 1965b; including *Microspio*) as follows: *P. africana* (Rullier), *P. armata* (Thulin), *P. minuta* Hartmann-Schröder, *P. kussakini* (Chlebovich), *P. theeli* (Söderström), and *P. wireni* (Augener) do not have tridentate hooks. Among the *Paraspio* species with tridentate hooks, *P. mecznikowiana* (Claparède) and *P. rolasiana* (Augener) lack setae in the first notopodium (as does *P. minuta*); *P. arctica* (Söderström) has a pointed prostomium (as does *P. theeli*). The presetal dorsal cirrus has been reported only for *P. africana* and *P. atlantica* (Langerhans); the latter species has been separated from *P. arctica* by Hannerz (1956). *Paraspio africana* has unidentate hooks and peculiar limbate notosetae; *P. atlantica* has a rather pointed prostomium, and its tridentate hooks start on the ninth segment.

Prionospio pinnata Ehlers

In our material, the third pair of gills is always only half as long as the first two pairs. There is no appendix on the third pair of gills as reported by Caullery (1915) for Malayan material.

Ehlers (1901) has implied that the species is a selective deposit feeder. Specimens from station 3 (mean grain size diameter 0.126 mm) have numerous sand grains not exceeding 0.07 mm imbedded in fine detrital material, which confirms Ehlers' observation.

Family DISOMIDAE

Trochochaeta multisetosa (Oersted)

FIGURE 6g

Disoma multisetosum.—Hartman, 1959, p. 394.

Trochochaeta multisetosa.—Pettibone, 1963, p. 312.

There is one incomplete specimen from station 2. The dorsal postsetal lip of the third setiger is strongly digitate (fig. 6g); on the undissected animal, the uppermost lobe of the lip protrudes like a cirrus, which is not so on the preceding and following parapodia. There is no acicula in the notopodium. The shape of the notopodial lamella on the third setiger is very close to that drawn by Friedrich (1938, fig. 88b) from material close to the type-locality. We therefore assign the specimen to *T. multisetosa* rather than to *T. franciscanus* (Hartman). A detailed comparison of better preserved material from Puget Sound with the description of *T. franciscanus* by Hartman (1947b) would be desirable. *Trochochaeta franciscanus* is considered a synonym of *T. multisetosa* by Pettibone (1963).

New for Puget Sound. Previously known in the Pacific from Sakhalin.

Family CIRRATULIDAE

Caulleriella alata (Southern)?

Because of the differences in the insertion of the palps and in the setation, we have some doubt that our animals are identical with the European *C. alata* (Southern), but we do not wish to decide on this before having studied material from other localities on the west coast of the Americas. As in *C. viridis pacifica* (Berkeley), the palps insert on the first setiger rather than on the preceding segment. *Caulleriella viridis pacifica* is considered a synonym of *C. alata* (Berkeley and Berkeley, 1950). In the first neuropods of our animals are 8 to 10 winged, bifid hooks and 1 to 2 capillary setae in small and large specimens (about 2–3 mm long, with 0.4–0.5 mm greatest width, and 1–1.5 mm long and 0.6–0.8 mm greatest width, respectively). Capillary setae can be absent in posterior neuropodia. Notopodial hooks are found from the forty-fifth to fifty-fifth setigers on, rather than from about the twentieth as in the European representatives (Southern, 1914). Notopodial hooks from the twentieth setiger have also been reported for *C. alata* from southern California (Hartman, 1961). Hartmann-Schröder (1962) has recorded hooks starting from the sixth and the seventeenth notopodia in Chilean material. Our form is certainly different from *C. alata maculata* (Annenkova).

Caulleriella annulosa (Hartman), new combination

FIGURE 7a

Tharyx annulosus Hartman, 1965a, p. 167; 1965b, p. 59.

Among *Tharyx* species kindly sent by Dr. O. Hartman, there are specimens of *T. annulosus* from station SL 4, off New England (Hartman, 1965a). There are acicular spines (fig. 7a) in neuropodia of the middle section of the body, and in both rami of the posterior section, in addition to capillary setae. These spines were not mentioned in the original description. We transfer the species therefore into *Caulleriella* as defined by Hartman (1961).

Chaetozone Malmgren

Because we have seen six North Pacific species of *Chaetozone*, a key for the temperate and subarctic North Pacific species is given. It considers primarily characteristics of the front end. *Chaetozone abranchiata* Hansen is not included in the genus on the basis of the original description (from Hansen, 1882; Levinsen, 1883) and that by Moore (1903), which report only capillary setae but not acicular spines. There are two North Pacific records that are not included in the key: Ushakov (1950) briefly described a *Heterocirrus* species with unidentate acicular spines starting in the fifteenth neuropod, which well might have been a *Chaetozone* species. Hartman (1963) mentioned a *Chaetozone* species from California with neuropodial spines present from the fifteenth segment.

1. Neuropodial spines from 1st setiger; spines posteriorly arranged in cinctures.
 - C. corona** Berkeley and Berkeley
 - Neuropodial spines absent on 1st setiger but starting anterior to 15th to 20th setiger 2
 - Neuropodial spines starting posterior to 15th to 20th but anterior to 35th setiger; spines posteriorly not arranged in cinctures 3
 - Neuropodial spines starting posterior to about 35th setiger 4
2. Neuropodial spines from 7th to 10th setiger; spines posteriorly not arranged in cinctures. Serrated capillary setae after the 7th to 10th neuropodium.
 - C. berkeleyorum**, new species
 - Neuropodial spines from about the 10th setiger; long buccal region. Smooth capillary setae only. Posteriorly, 2 to 3 spines per ramus tending to form cinctures **C. multioculata** Hartman
3. Neuropodial spines, fairly curved, from about the 17th setiger. Posteriorly, single spines without capillary setae in each ramus. **C. armata** Hartman
 - Neuropodial spines from about 26th (18th to 40th) setiger. Short capillary setae in the middle region of body that appear to be broken off obliquely.
 - C. acuta**, new species
 - Neuropodial spines from about 30th setiger. Long, ordinary, almost smooth capillary setae **C. gracilis** Moore

4. Neuropodial spines, serrated at the tip, from the 35th to 40th setiger, posteriorly not arranged in cinctures. Capillary setae ordinary.

C. gracilis sensu Hartman (1961) (see below)

Neuropodial spines from the 45th to 90th setiger, posteriorly arranged in very marked cinctures. Capillary setae ordinary. . . *C. setosa* Malmgren

Neuropodial spines from about 70th neuropod, tending to form cinctures posteriorly. Long, threadlike capillary setae from about the 13th setiger.

C. spinosa Moore

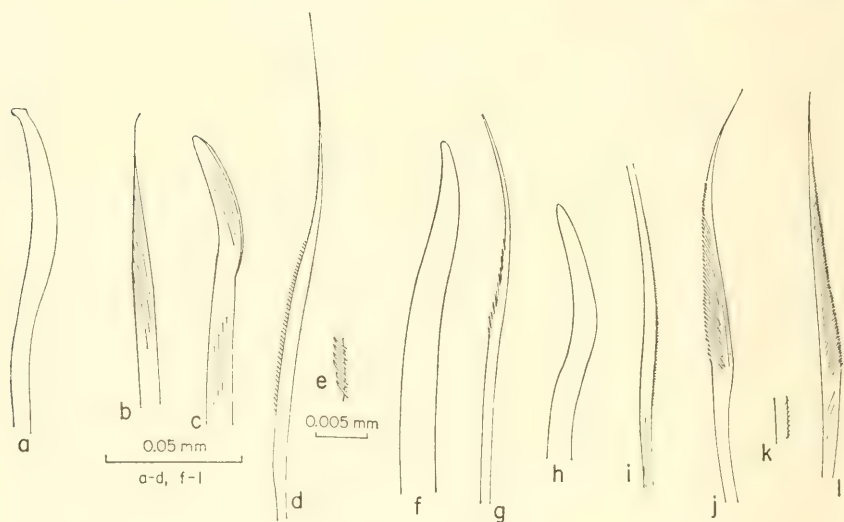


FIGURE 7.—*Caulleriella annulosa*: *a*, acicular spine. *Chaetozone acuta*, new species (seta from median foot): *b*, capillary seta; *c*, acicular spine. *Chaetozone berkeleyorum*, new species (setae from 40th neuropodium): *d* and *e*, capillary setae; *f*, acicular spine. *Chaetozone gracilis* (holotype, setae from about 85th setiger): *g*, capillary seta; *h*, acicular spine. *Tharyx secundus*, new species: *i*, detail of anterior capillary seta; *j*, neuroseta with short tip from 43rd setiger. *Tharyx serratisetis*, new species: *k*, detail of notoseta from 10th parapodium; *l*, serrated neuroseta from median region of body.

Chaetozone acuta, new species

FIGURES 7*b, c*

Chaetozone sp. I Banse et al. [in press].

TYPES.—Holotype: USNM 36275, from station 5, 47°10'48" N, 122°50'00" W (May 1963). Paratypes: USNM 36276 (2) and 36277 (2), from the same station (February and May 1963).

Many complete immature specimens of up to 155 setigers, 15 mm long and 1.1 mm wide, are at hand from stations 3, 5, 6, and 8, but no complete, mature individuals are available.

DESCRIPTION.—A cirratulid species with a conical prostomium on which one pair of eyespots is visible in freshly preserved material. There is a 2-ringed achaetous region that is about as long as it is

wide. Palps and the first pair of gills insert prior to the first setiger. Gills, which can be 5–7 mm long anteriorly, occur throughout the body but are mostly lost. The anterior setigers (at least 50) are crowded; posteriorly, the length of the segments becomes almost one-half their width. The setae of the posterior region originate from slight ridges which, however, are not nearly so pronounced as in *C. setosa* Malmgren. The anus is dorsal, with a crenulated margin dorsal and a ventral semicircular lip.

Anteriorly, there are about one dozen long capillary setae in each ramus, which are only slightly limbate. When bent, their fibers tend to separate with the result that the former cutting edges of the setae appear to be feathered. In the notopodia, prior to the occurrence of acicular spines, these setae gradually are replaced by shorter setae, which resemble obliquely broken-off bristles and have a finely drawn tip (fig. 7*b*). In the middle region of the body they are the only capillary setae present in noto- and neuropodia (two to four per ramus). In young animals near the end of the body, they are replaced by ordinary capillary setae. Acicular spines are slightly curved and have rounded tips and slight wings (fig. 7*c*). Ventrally, they occur from the eighteenth to thirty-eighth setigers onward (average 26; $n=11$). Dorsally, they begin 30–40 setigers posterior to the ventral spines. There are usually five to seven neuropodial, and two to five notopodial spines. Posteriorly, notopodial and neuropodial rami are only slightly separated laterally, but the spines do not nearly encircle the body. A posterior end of 51 setigers (10 mm long, 1.2 mm wide), apparently of a maturing female, and collected in May, carries in the last setigers dorsally four to five, ventrally five to six spines, with almost the same number of the described capillary setae (fig. 7*b*) between them. The setae are restricted to the sides of the body. There are numerous polygonal eggs of 50μ – 60μ freely floating in the body cavity, including the last setigers.

The species seems to be a selective deposit feeder. The largest particles in the intestines of two specimens from station 5 (mean particle size 0.43 mm) are 0.05 mm in diameter; most are below 0.02 mm in diameter.

The name refers to the capillary setae of the middle region of the body.

DIAGNOSIS.—A *Chaetozone* species with ventral and dorsal acicular spines starting ventrally from approximately the twenty-sixth (range, eighteenth to fortieth) setiger, with slight wings. Short capillary setae, which appear to be obliquely broken-off, in the middle region of the body.

DIFFERENTIAL DIAGNOSIS.—For the characterization of the new species, it seems questionable how much significance is to be attached

to the wings of the acicular spines since they occur also in the local representatives of *C. setosa* Malmgren; this feature seems not to have been reported previously for *C. setosa*. Among the *Chaetozone* species listed by Hartman (1959, 1965b) to which *C. berkeleyorum*, new species, and *C. curvata* Hartmann-Schröder are to be added, the new species seems to be unique by the character of the capillary setae in the middle part of the body. For the characters distinguishing *C. acuta* from the other Pacific species, see page 31.

Chaetozone berkeleyorum, new species

FIGURES 7d-f

Caullericiella viridis pacifica.—Berkeley and Berkeley, 1942, p. 197.—Not Berkeley, 1929, p. 307 [fide Berkeley and Berkeley, 1950, p. 57].

Caullericiella gracilis.—Berkeley and Berkeley, 1950, p. 57; 1952, p. 37 partim. [Not *Chaetozone gracilis* (Moore); see p. 35 of this paper].

Chaetozone sp. II Banse et al. [in press].

TYPES.—Holotype: USNM 35286. Paratypes: USNM 36251 (2). All from the littoral of Skidegate Narrows, Queen Charlotte Islands. (Collected in 1935.)

There are two complete specimens and an anterior fragment from the littoral of Skidegate Narrows in the Queen Charlotte Islands, which are in the Berkeley Collection of the U.S. National Museum and which have been reported by Berkeley and Berkeley (1950), and one badly damaged anterior fragment from our station 7. The holotype is the largest specimen, has 72 setigers, and is 12 mm long, with 1 mm greatest width.

DESCRIPTION.—The prostomium is triangular but unusually blunt by being slightly broader than long. Eyes are not visible. The palps seem to insert on the anterior margin of the first setiger. In the vial from Skidegate Narrows, detached grooved palps of 4–5 mm length are present. In the Canadian animals, the segments lengthen in the general region of the fortieth setiger. In the Puget Sound specimen, only the approximate 10 first setigers are fairly crowded; thereafter they are about half as long as they are wide. There are very short gills above some of the notopodia, at least to about the sixtieth setiger. Even in posterior setigers, the segments are fairly cylindrical although with clear demarcations, in contrast to those of *C. setosa* Malmgren. The anus appears to be displaced dorsally.

In the anterior 8 to 10 setigers, there are less than a dozen each of dorsal and ventral capillary setae, some of them one-third the body width. Subsequently, the notosetae shorten. From the seventh to tenth neuropodium, one to three capillary setae appear that are slightly widened in their middle portion (fig. 7d). Two-thirds of the widened portion is finely serrated when seen under $\times 400$. Scales

(rather than teeth) are well visible under $\times 1000$ (fig. 7e). These capillary setae occur dorsally at least from the twenty-fifth setiger together with smooth ones. Starting from the seventh to tenth neuropodia, the widened capillary setae are accompanied by two to three smooth acicular yellow spines without wings (fig. 7f). About two to three notopodial acicular hyaline spines appear at about the forty-fifth setiger (not the twenty-fifth as stated by Berkeley and Berkeley, 1950). They are straighter than the neuropodial ones, and only as thick as the accompanying capillary setae. The spines do not encircle the posterior portion of the body. The serration of the notopodial capillary setae is weak.

The specimens from Skidegate Narrows had originally been misidentified as *Caulleriella viridis pacifica*, according to Berkeley and Berkeley (1950). The authors state in the same paper that *C. viridis pacifica* as described by Berkeley (1929) is a synonym of *C. alata* (Southern). The specimens on which the 1929 paper has been based are no longer available (Pettibone, 1967).

The new species is named for Edith and Cyril Berkeley.

DIAGNOSIS.—A *Chaetozone* species with blunt prostomium and fairly smooth posterior region. Smooth neuropodial spines without wings and serrated capillary setae from the seventh to tenth setiger. Thin notopodial spines from the forty-fifth setiger. Some notopodial serrated capillary setae.

DIFFERENTIAL DIAGNOSIS.—Among the *Chaetozone* species listed by Hartman (1959; 1965b) to which *C. acuta*, new species, and *C. curvata* Hartmann-Schröder are to be added, *C. abranchiata* Hansen, *C. atlantica* McIntosh, and *C. pacifica* McIntosh have only capillary setae, according to the original descriptions (for *C. abranchiata*, see p. 31). Among the others, neuropodial spines occur before the twentieth setiger in *C. andersensis* (Augener) (see Hartman, 1967; spines from ninth neuropodium; posteriorly, one to two per ramus); *C. armata* Hartman; *C. carpenteri* McIntosh (spines from about the tenth notopodium and neuropodium, with some very large spines among them); *C. multi-oculata* Hartman; and *C. gayheadia* Hartman (nearly straight spines from the first neuropodium; apparently no posterior cinctures). Spines can occur in *C. acuta* from the eighteenth neuropodium. None of the above species has serrated capillary setae. The distinguishing features for the North Pacific species are given on p. 31.

Chaetozone gracilis (Moore)

FIGURES 7g, h

Tharyx gracilis Moore, 1923, p. 187, partim.

Not *Caulleriella gracilis*.—Berkeley and Berkeley, 1950, p. 57; 1952, p. 37 [see p. 34 of this paper].—Hartman, 1960, p. 125.

Not *Chaetozone gracilis*.—Hartman, 1961, p. 111.

We include here a study of Moore's original material made when describing *Chaetozone berkeleyorum*. In the holotype of *C. gracilis* (USNM 17398) neuropodial hooks start at about the thirtieth setiger. They are smooth and have rounded tips (fig. 7*h*; also checked near the fiftieth setiger). The acicular spines are fairly inconspicuously arranged and do not encircle the posterior part of the body. The accompanying capillary setae (fig. 7*g*), which are quite similar to those in the notopodia, seem to be serrated, but this is irregular and might rather be a sign of decay of the setae. The oval eggs are up to 120μ by 95μ .

Moore's description fits the holotype only. The cotype (Acad. Nat. Sci., Philadelphia, no. 3097) had been dried up at some time but is clearly another species. Notopodial capillary setae, slightly longer than the body is wide, occur throughout the body. There are only capillary setae on the twenty-eighth to thirtieth setigers. The neuropodia of posterior setigers (past the hundredth) have only broad capillary setae with serration of the edges well visible under $\times 400$, which are similar to those of *Tharyx secundus*, new species (p. 37). All setae are hyaline. The cotype thus seems to be a *Tharyx* species. Dr. O. Hartman (in litt.) suggested already that the holotype and the cotype of Moore's material may be different forms.

Neither species is identical with *Chaetozone gracilis* of Hartman (1961). This form is characterized by serrated neuropodial spines and is a species to be named.

Chaetozone setosa Malmgren

In our material, neuropodial spines occur from the forty-fifth to sixty-fifth setigers onward, and even from about the thirty-fifth to fortieth in specimens under 1 cm length, whereas Hartman (1961) reported for California animals a beginning at the seventy-ninth to nintieth setigers. The spines are faintly winged, similar to those of *C. acuta* described above although they are more pointed than in the latter species.

The species occurs at all stations, but, regardless of the sediment composition, the intestine is filled with masses of fine detritus, among which are some sand grains or diatom frustules that do not surpass 0.05–0.06 mm in diameter. The species is thus a selective deposit feeder, at least in coarse sediment.

Chaetozone spinosa Moore

Chaetozone spinosa.—Imajima and Hartman, 1964, p. 297.

There is one anterior fragment with 36 setigers, which is about 4 mm long. The first 12 setigers are crowded; the body attains its great-

est width of 0.5 mm here. Thereafter the setigers become longer, but the width is only 0.3 mm. Rudiments of palps and gills are visible. Whereas the neuropodial bristles in the crowded section of the body are all about normal length, there are some threadlike setae in the notopodia. From about the thirteenth setiger these occur in notopodia and neuropodia, with a length of 0.5–0.6 mm. At the beginning of the exposed part, their width is about 4μ , farther out only 3μ ; the thickness is about 1μ here. These setae are "striated having a slight turn" as described by Moore (1903, p. 470); however, the scales observed on the large specimen from Japan could not be seen with $\times 1000$ magnification in our material.

Acicular spines occur in the species from the seventieth neuropod onward (Hartman, 1960). Our identification is based on the threadlike setae.

Found at station 6 in May. New for Puget Sound. Previously recorded from Japan and California.

Tharyx multifilis Moore

Contrary to the original description by Moore (1909b), the anus of one complete specimen from Puget Sound is displaced dorsally by a very pronounced triangular ventral lip. This holds also for an individual from *Velero IV* station 5027–57 off Pt. Fermin, kindly sent by Dr. O. Hartman. Thus the separation from this species of *T. pacifica* Annenkova continues to be doubtful as also pointed out by Chlebovich (1961); *T. pacifica* has eyes, *T. multifilis* does not. The caudal ends of our two specimens are very slightly thickened (inflated), whereas Moore (1909b) and Hartman (1961) reported a slender tapering posterior end.

A large portion of the intestinal contents of two specimens from two hauls at the fine-sand station 4 (mean diameter 0.10 mm) is made up of grains of 0.07–0.10 mm diameter, with a very few larger (0.15 mm) particles present. Thus there seems to be only slight selection of particles when feeding.

Tharyx secundus, new species

FIGURES 7i, j

Tharyx sp. II Banse et al. [in press].

TYPES.—Holotype: USNM 36278. Paratype: USNM 36279 (1 drawings from paratype). All from station 3, $47^{\circ}44'31''$ N, $122^{\circ}31'53''$ W (February 1963).

There are several anterior and posterior fragments 1–2 cm long and 0.3–0.5 mm wide. In all, there are at least 100 setigers.

DESCRIPTION.—A pointed prostomium without eyes is followed by a 3-ringed achaetous region. The scars left by the broken-off palps at

the anterior margin of the first setiger are separated from each other by a gap that is as wide as their diameter. The gills of this segment arise between the palps and the notopod; on the following segments, they insert just above the notopod. Gills are at least 2 mm long and are found at least to the seventieth setiger (length of the largest anterior fragment, apparently a juvenile). Approximately the first 20 setigers are widened laterally, but the dorsum is low and not inflated. The external borders of the segments are dorsally well visible. In an anterior fragment of 65 setigers, 13 mm long, this anterior region is 2 mm long (of which the achaetous rings contribute 0.4 mm) and 0.5 mm wide. The anterior region is followed by more than 40 setigers, which are about as wide as they are long and are separated from each other by deep furrows. Sometimes they appear beadlike. Near the fortieth setiger, segments are 0.3 mm long and 0.3 mm wide. The parapodia arise on the hindmost portion of the segments. The posterior region consists of about 30 setigers, which are crowded and laterally widened (inflated). A posterior portion is 1.5 mm long. The anus is dorsal.

In the anterior region, all setae are capillary. Notosetae are half as long as the body is wide. By the twentieth to twenty-fifth setiger, the setae of both rami become limbate and weakly serrated (fig. 7*i*). The neurosetae shorten in the subsequent parapodia, become very broad, and are beset with distinct hairs on the cutting edge (fig. 7*j*). The serration is just visible under $\times 400$, and thus the setae are not as strongly serrated as in *T. serratisetis* described below (under oil immersion, the neurosetae of local specimens of *T. multifilis* Moore are not quite smooth either but do not appear to be hairy). In the forty-fifth setiger of an apparently mature male, there are about 20 of these setae in each ramus. In the posterior region, neurosetae are narrow and limbate again, similar to figure 7*i*. The tube is apparently ephemeral, being made of soft and fairly transparent mucoid material.

The name refers to the provisional name used by us prior to the description.

DIAGNOSIS.—A *Tharyx* species with beadlike setigers in the middle section of body. Posterior end inflated. Anus dorsal. Very broad neurosetae with distinct hairs on cutting edge in the middle section of body.

DIFFERENTIAL DIAGNOSIS.—Among the *Tharyx* species in Hartman (1959, 1965b) but omitting *T. annulosus* (see p. 31), and adding *Tharyx* sp. described by Berkeley and Berkeley (1941, from California) and *T. serratisetis*, new species, the following have serrated (or apparently so) neurosetae: *T. dorsobranchialis* (Kirkegaard), *T. serratisetis*, new species, *T. tessellata* Hartman, and the mentioned *Tharyx* sp. Among these, *T. tessellata* has an inflated posterior end like *T.*

secundus, but the middle segments are short, whereas there is a bead-like middle section in the new species.

Tharyx serratisetis, new species

FIGURES 7*k*, *l*

Tharyx sp. I Banse et al. [in press].

TYPES.—Holotype: USNM 36266 (possibly the posterior fragment in the vial is of a second individual), from station 3, 47°44'31" N, 122°31'53" W (February 1963). Paratypes: USNM 36267 (2) and 36268 (1), from the same station (February and April 1963).

There are numerous fragments, in part of mature animals, from several stations, with up to about 125 setigers, 2 cm long and 2 mm greatest width. The total length is more likely to be 4 cm, and the number of setigers may well reach 200. Most specimens come from station 3, fewer come from stations 6 and 8, some were found at station 7 (in 2 of 35 hauls from the station), where an egg-bearing female occurred.

DESCRIPTION.—The prostomium is conical and can be slightly longer than wide. Eyes are not visible. The achaetous region appears to consist of three indistinct rings. Palps are lost. Gills are rare on the preserved material and not longer than the body is wide; they arise just above the notopod. The anterior setigers are very crowded, and external borders of segments are not well visible. The dorsum is high. Starting from the fifth to tenth setiger, the ventrum is glandular through the sixtieth to seventieth setiger in mature specimens, and to the forty-fifth in one young, complete animal 2 cm long and 0.5 mm at greatest width. In moderately contracted animals, segments become about three times as long as in the anterior region from about the fiftieth to seventy-fifth setiger. From about the one hundred twenty-fifth setiger, segments are about five times as long as the anterior ones. The middle region of the body is not beadlike. The body tapers gradually to the pygidium, which carries a semicircular ventral lip with the result that the anus is dorsal.

Notosetae are long thin capillaries that are one-half to three-fourths as long as the body is wide; neurosetae are one-third to one-half as long as the notosetae of this region. All these setae are slightly limbate and have cutting edges with fine hairs (fig. 7*k*) that are just visible under $\times 400$ magnification. The hairs appear to be outcroppings of the fibers that make up the setae. After the seventy-fifth to one-hundredth setigers, these thin neurosetae are replaced by flattened serrated setae, measuring about 75μ from the beginning of the serrated region to the tip (fig. 7*l*), and by about a dozen that are twice as long owing to a

long drawn-out tip. When the preparation of a parapodium is squeezed under the cover glass, the long and short setae seem to alternate.

Tubes are not known. Exceedingly numerous polygonal eggs, about 150μ by 110μ , are observed in a female in May. The intestinal content of two specimens from station 3 (mean particle size 0.126 mm) contains many sand grains 0.2 mm in diameter and even an unbroken *Coscinodiscus* species test 0.25 mm in diameter, in addition to smaller grains and much fine detritus. Thus, the species may be a not very selective deposit feeder.

The name refers to the serrated neurosetae.

DIAGNOSIS.—A *Tharyx* species with serrated neurosetae after the seventy-fifth to one-hundredth setigers. Median segments not bead-like. Posterior end not inflated. Anus dorsal.

DIFFERENT DIAGNOSIS.—Among the *Tharyx* species in Hartman (1959, 1965b), but omitting *T. annulosus* Hartman (p. 31) and adding *T. secundus*, new species, and *Tharyx* sp. described by Berkeley and Berkeley (1941, from California), only *T. dorsobranchialis* (Kirkegaard), *T. tessellata* Hartman, and the mentioned *Tharyx* sp. are known to have serrated setae. Of these, *T. dorsobranchialis* has a very peculiar arrangement of gills. *Tharyx secundus* has a beadlike middle body region and an inflated posterior end. *Tharyx tessellata* has an inflated posterior end and a characteristic tube. Also, the serrated broad neurosetae start very roughly at the fiftieth setiger (from material kindly sent by Dr. O. Hartman). The Berkeleys' species has four achaetous rings following the prostomium, and the serrated setae seem to start at a low-numbered setiger. Thus, the new form is easily distinguished from the species with serrated setae. The form seems also to be different from all those species that are known to have flattened posterior neurosetae for which serration has not been described. We note, however, that there is a very minute serration on the flattened neurosetae of *T. multifilis* Moore from our samples; in fact, we cannot distinguish anterior fragments of the new species from those of *T. multifilis*.

Family FLABELLIGERIDAE

Brada sachalina Annenkova?

Brada sachalina.—Ushakov, 1955, p. 310.

There are about 10 specimens up to 3 cm long that are profusely covered with sand grains and usually have 23 setigers (22–25). The notosetae (three to five per bundle) are longer and thinner than the neurosetae (five per bundle). The dermal papillae are dome shaped with a short filiform tip; there are two (sometimes three) rows per segment. The nephridial papillae arise on the anterior portion of the

fifth setiger but are barely noticeable. From Annenkova's description (1922), *B. sachalina* is distinguished from *B. ochotensis* Annenkova mainly by the number of segments. Our specimens are intermediate in this respect. Both species have been described from the southern Sea of Okhotsk and occur also in the Bering Sea.

Found only at station 2. Neither species has been found in the eastern Pacific before.

Family OPHELIIDAE

Travisia brevis Moore

Our specimens, about 1.5 cm long, have 25 setigers followed by four achaetous segments, whereas Hartman (1961) stated that there are only two achaetous rings. Imajima (1963) has reported 24 setigers and four achaetous segments for specimens from the Okhotsk Sea, and Imajima (1964) has found 23 setigers in animals collected off Hokkaido.

Family MALDANIDAE

Isocirrus longiceps (Moore)

Very numerous spherical (or slightly depressed) eggs about 250μ in diameter were observed in November.

Macroclymene? species

FIGURES 8a-f

Macroclymene? sp. I Banse et al. [in press].

Incomplete mature specimens with up to 27 setigers are about 6 cm long and 1 mm thick. The longest animal is without the anterior three setigers and the rear end and must thus have had at least 30 setigers; probably it had at least 34 setigers.

The cephalic plate (figs. 8a, b) has a low rim that dorsally is almost absent; there is no dorsal incision. The palpode is obtuse. Nuchal grooves are straight and one-half to three-fifths as long as the cephalic plate. The proboscis has conspicuous papillae that are triangular in side view. There are two to three slightly bent acicular spines (fig. 8c) in each parapodium of the first three setigers. These setigers are glandularized over their entire length. There are two bundles of 14-18 limbate capillary setae each per ramus in the fifth and sixth setiger, with the fibrilles arranged as in figure 8d. The edges of the setae are not quite smooth (not shown in fig. 8d). There are six to seven short and long capillary setae each per ramus in the middle part of the body. The shorter ones are beset with hairs (fig. 8e) up to the tip; the longer ones seem to carry hairs only in the proximal half. Thoracal unieni (14 per ramus in the fifth setiger) have one or two fewer secondary

teeth than the abdominal ones (fig. 8f; 10 per ramus). The pygidium is not known in spite of very many specimens obtained with a grab digging to about 15 cm depth.

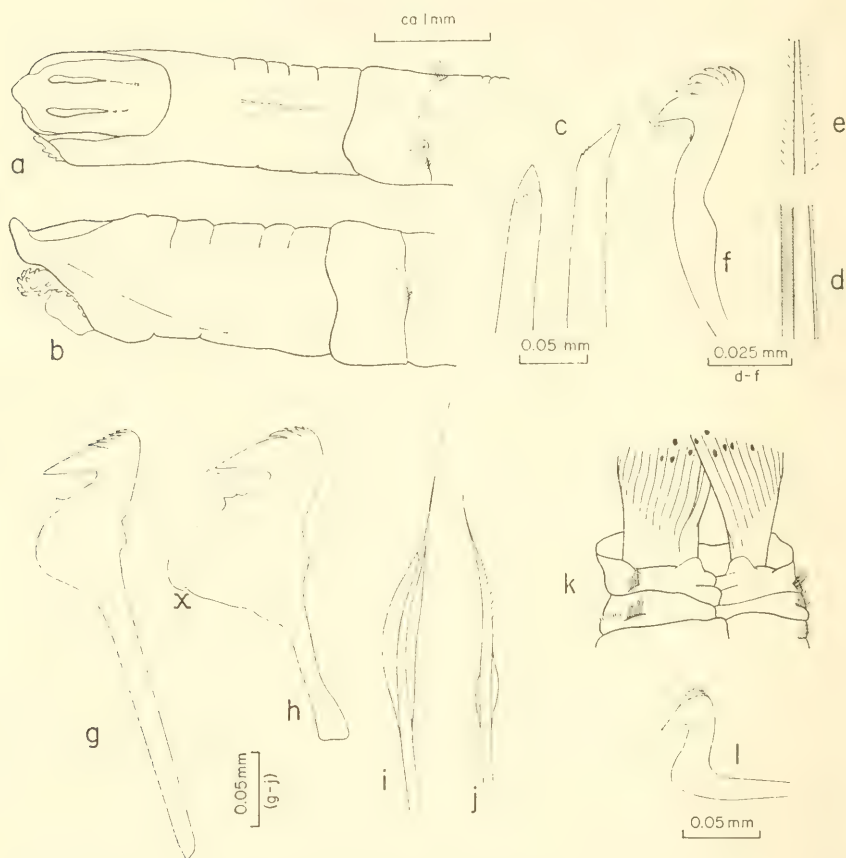


FIGURE 8.—*Macroclymene?* species: *a*, anterior end from above and slightly from the left side; *b*, left side view of anterior end; *c*, acicular spines from second setiger; *d*, detail of capillary seta from fifth setiger; *e*, detail of short capillary seta from middle portion of body; *f*, hook from middle portion of body. *Pista fasciata*: *g*, thoracic hook from third setiger; *h*, thoracic hook from 17th setiger. *Scionella japonica*, setae from median thoracic setiger: *i*, long capillary seta; *j*, short capillary seta. *Potamilla myriops*: *k*, dorsal view of anterior segments; *l*, thoracic hook.

The tube is made of a fairly firm, thin layer of very fine sand. Immature flattened eggs taken in August from an anterior end of 12 setigers of 35 mm length and 1.1 mm width measured up to 250 μ across.

This is not one of the species known from this area and may well represent the genus *Macroclymene*, not yet recorded for the northern Pacific. Found at station 2. The drawings are of a mature specimen taken in August 1963.

Praxillella affinis pacifica Berkeley

Having many specimens, we add the following to the descriptions by Berkeley (1929) and Berkeley and Berkeley (1952): The dorsal rim of the cephalic plate can be split or more or less united. The proboscideal papillae are pointed as in *P. gracilis* (Sars) rather than smooth as in our specimens of *P. affinis* (Sars). The fourth setiger is the first fully glandular one as in *P. gracilis*, rather than the third setiger as in *P. affinis*. Feathered setae occur also in the posterior bundle of the twelfth setiger, rather than in the tenth or tenth and eleventh only. The constriction preceding the pygidium, emphasized by Berkeley (1929) for the subspecies, is much more marked in our material of *P. gracilis* than in the form discussed here.

Numerous eggs of 240μ - 280μ diameter are observed in animals collected in November. Young specimens occur together with adults in February.

Rhodine bitorquata Moore

Posterior ends of this species have apparently not been described yet. From one specimen we find that double rows of uncini occur through the fifteenth setiger and the first posterior collar occurs on the seventeenth setiger, as in *R. loveni* Malmgren. Arwidsson (1907) has stressed that these characters seem to be completely constant within species.

The papillae of the proboscis of our specimen seem to have about the same form as in *R. loveni*, but details could not be made out. The margin of the posterior collar of many fragments is practically smooth with a slight dorsal notch; the hooks of our specimens also agree with the figure given by Arwidsson (1907, fig. 235 for *R. loveni*) so that the only gross difference of *R. bitorquata* from *R. loveni* continues to be the sharply bent nuchal groove of the former, as emphasized by Berkeley and Berkeley (1950).

Individuals with moderately numerous, lens-shaped eggs of up to 140μ largest diameter are observed in January. Young animals are found in February.

Two individuals from station 4 (mean grain size 0.104 mm) have very coarse sediment (many particles of 0.15-0.20, up to 0.25 mm) and two specimens from station 7 (mean grain size 0.009 mm) have fine material (few grains reaching 0.05 mm) in their intestines. On the sediment studied, the species thus seems to be a nonselective deposit feeder.

Family PECTINARIIDAE

Pectinaria (Cistenides) granulata (Linné)

Pectinaria granulata.—Pettibone, 1954, p. 312.

Pectinaria brevicoma.—Berkeley and Berkeley, 1952, p. 106.

We follow Pettibone (1954) and include *P. brevicoma* Johnson described from Puget Sound in *P. granulata* because of the variability of some characters used for separation of the species. In our animals there are 10–11 pairs of brassy cephalic spines, about 20–40 papillae on the antennal membrane, and 5–7 scaphal hooks. The uncini have three to four major teeth.

In small specimens, there can occur on one torus uncini with one row of major teeth, as typical for the subgenus *Cistenides*, and uncini with a double row, as in the subgenus *Pectinaria*. The large specimens all have a single series of major teeth in their uncini. Moore (1923) has stated that "this species unites *Pectinaria* and *Cistenides*."

Family AMPHARETIDAE

Ampharete acutifrons (Grube)

The tentacles of our specimens are smooth contrary to the generic diagnosis by Malmgren (1866) and Day (1964). Mature females are about 15 mm long and 1 mm thick but there are two broken specimens, otherwise very well preserved, that are at least 20 mm long and 2.5 mm thick, and apparently are not mature. Pettibone (1954) has stated a length of 55 mm and a width of 8 mm as the greatest size for the species. The species is a selective deposit feeder, as seen from the comparison of intestinal content with the sediment of the habitat.

There are animals from all seasons. Many specimens collected in August and one found in May carry fairly numerous oval-lens-shaped eggs, up to $240\mu \times 200\mu \times 50\mu$ in size.

Ampharete gagarae Ushakov

Ampharete arctica gagarae.—Ushakov, 1955, p. 369.

In this form, which we consider to be a species of its own, the neuropodial lappets of the middle region of the abdomen are about one-fourth as long as the segments, whereas they are nearly as long as the segments in one specimen of *A. arctica* from Puget Sound. No anal cirri were found even in well-preserved animals. The species is a selective deposit feeder.

Very few (50–100) irregular oval-lens-shaped eggs of about $220\mu \times 190\mu \times 50\mu$ – 70μ dimensions are observed in one specimen collected in January.

Found at stations 1-4 and 6-8. New for the northeast Pacific. Previously known from the Sea of Okhotsk.

Melinna elisabethae McIntosh

Melinna elisabethae.—Ushakov, 1955, p. 363.

There are four moderately well-preserved specimens. The gills form groups of one anterior and three posterior filaments. The thoracal setigers are arranged as in *M. cristata* (Sars) although the fourth bundle of the fine ventral capillary setae is visible only in transparent animals. The strong dorsal hooks have relatively short and broad bases, and the tips are bent backward by almost 180°, more so than pictured by Ushakov (1955, fig. 134D). There is no canal in the tip. The uncini have four teeth. The species is a selective deposit feeder. Found at stations 1, 3, and 4. New for the northeastern Pacific. Previously known from the Sea of Okhotsk and the Arctic.

Family TERESELLIDAE

Neoamphitrite edwardsi (Quatrefages), new combination

Amphitrite edwardsii.—Fauvel, 1923, p. 245.—Hartman, 1961, p. 497.—Imajima and Hartman, 1964, p. 335.

There are three large specimens up to 13.5 cm long. Eyes appear to be absent. Seventeen setigers have notosetae; double rows of uncini occur from the eighth to the seventeenth setiger. Lateral folds are large on the two first segments bearing gills and are practically absent on the third one. Nephridial papillae are present on 9 consecutive segments, not on 12 as in *N. robusta* (Johnson), starting on the second segment with gills. There are 11 or 12 ventral shields.

We place the species into the genus *Neoamphitrite* because of the arborescent gills, but we have not studied the nephridia. Hessle (1917) has tentatively suggested this action.

Found at station 2 and near station 7. New for Puget Sound. Previously known in the North Pacific from Japan.

Pista fasciata (Grube) sensu Marenzeller

FIGURES 8g, h

Pista fasciata.—Imajima and Hartman, 1964, p. 343.

Since there is some confusion about this species in the literature, the following may be observed: Our specimens, which are more than 10 cm long, agree well with the accounts of Marenzeller (1884) and Imajima and Hartman (1964). The lateral folds are shaped as described by the latter authors. Dorsally, the fourth segment (first setiger) is very much higher than the preceding ones. Nephridial

pores are present on setigers 3 and 4 (segments 6 and 7), contrary to Indian material (Fauvel, 1932). Nearly rectangular ventral shields occur through the thirteenth setiger. From the first setiger onward a wide glandular band is present ventrally and laterally behind the tori (without a torus being on the first, it is in the corresponding place). In the anterior part of the thorax it is laterally as broad as the tori but is hardly visible ventrally between the ventral shields. In the middle region of the thorax, glands occupy laterally all the space between the tori and the posterior border of the segments. Between the tori and the shields, they occupy one-half to over three-fourths of the length of the setigers. Ventrally, on the last four thoracic setigers, only the anterior one-third to one-half of the segments is free of glands.

All thoracic uncini have narrow, long, thin shafts (figs. 8*g*, *h*). In side view, the number of teeth above the rostrum appears to be five to six in anterior segments, and four to five in posterior segments of the thorax. The protuberance ("x" in fig. 8*h*) on the lower anterior curvature of the posterior thoracic hooks is often less pronounced than shown.

Proclea graffi (Langerhans)

Proclea graffi.—Ushakov, 1955, p. 395.

There are three fairly well-preserved specimens from three hauls at station 3 in February.

New for Puget Sound. Previously known in the North Pacific from the Bering Sea.

Scionella japonica Moore

FIGURES 8*i*, *j*

The gills of our two specimens from station 7 agree with the description by Moore (1903) and are like those of *S. vinogradovi* (Ushakov, 1955, figs. 143*D*, *E*), but not like those of *S. japonica* Berkeley and Berkeley (1952, fig. 176). Since the differences between these two species do not seem to be very clear, we give figures for the thoracal setae (figs. 8*i*, *j*). Strong, long setae with very broad blades alternate with slightly more slender, shorter capillary bristles whose shafts are serrated above the short and narrow wings. Berkeley and Berkeley (1950) have pointed out that Moore figured only the larger setae.

Family SABELLIDAE

Potamilla (*Pseudopotamilla*) *myriops* (Marenzeller)

FIGURES 8*k*, *l*

Pseudopotamilla myriops.—Imajima and Hartman, 1964, p. 360.

One anterior end of about 8 cm total length (about 2 cm for the tentacular crown) and 6 mm greatest width with nine thoracic and 30 abdominal setigers comes from station 7. Several other pieces in the sample appear to be from the same specimen, adding to about 21 cm total length and 195 setigers. The pygidium is missing.

The species is particularly distinguished by the eyespots on the slightly more than 30 pairs of radioli. Ventrally there are about 10, dorsally up to 20, eyes per radiolus, the most distal ones leaving the last third of the rachis free. The basis of the most dorsal radiolus on each lophophore is widened on its dorsal side to give a sharp, straight edge. Ventrally, the lophophores are slightly rolled inwardly. The collar (fig. 8*k*) is reduced dorsally; ventrally it is drawn out into two fairly long lips separated by a cleft.

In a median thoracic setiger, there are 20 limbate capillary setae, about 55 spatulate bristles with fine tips, and almost 70 hooks and as many pickaxe-shaped setae. A hook is depicted (fig. 8*l*) to show the length of the manubrium. The number and length of the hooks is about the same in the last thoracic setiger. The abdominal setae are as figured by Marenzeller (1884, pl 3: fig. 2E).

The color of the trunk of the animal is red brown; the parapodia are only slightly lighter. The ventral shields are cream white. There are no colored bands in the tentacular crown in the preserved material.

Augener (1914) has included this species with hesitation among the synonyms of *P. oligophthalmos* Grube, and Ushakov (1955) has followed him. Our specimens seems to be different from *P. ehlersi* (Gravier), another synonym of *P. oligophthalmos*, because of the different size of the ventral lobe of the collar alone. The two records by Zachs (1933) and Annenkova (1938) of *P. oligophthalmos* included by Ushakov (1955) are certainly not concerned with *P. myriops*.

Found at station 7. Also collected in March and September 1966 at 47°12'00'' N, 122°44'45'' W at 18 m and about 10 m depth. New for the northeastern Pacific. Previously known from Japan.

Summary

Eight species are newly described: *Eunoe uniseriata*, *Eulalia* (*Pterocirrus*) *parvoseta*, *Laonice pugettensis*, *Paraspio cirrifera*, *Chaetozone acuta*, *C. berkeleyorum*, *Tharyx secundus* and *T. serratisetis*. Information on type material is provided for *Eulalia* (*Eulalia*) *levicornuta*, *Gyptis brevipalpa*, *Exogone lourei*, *Syllis* (*Typosyllis*) *harti*, *Dorvillea pseudorubrovittata*, *Laonice antarcticae*, *L. japonica*, and *Chaetozone gracilis*. *Caulleriella annulosa* and *Neoamphitrite edwardsi* are new combinations. New characters are described for *Micropodarke dubia*, *Pionosyllis uraga*, *Aricidea* (*Aricidea*) *ramosa*,

Paraonis (Paraonis) ivanovi, *Praxillella affinis pacifica*, *Rhodine bitorquata*, *Scionella japonica* and *Potamilla (Pseudopotamilla) myriops*. Twenty-four new records for Washington and British Columbia waters are given. Intestinal contents of local species of *Glycera* and *Lumbrineris* suggest deposit feeding but it is not certain that it is the exclusive mode of nutrition.

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The Genus *Pterodrilus*
(Annelida: Branchiobdellida)

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The branchiobdellid worms, once greatly neglected, have received somewhat more attention in recent years. Occurring as epizoites on freshwater decapods and, in a few cases, on other crustaceans of the Northern Hemisphere, their distribution, evolution, and relationships with their hosts furnish several interesting problems. In spite of increased interest in them, however, the systematic account of no genus of North American branchiobdellids is at a stage adequate for a satisfactory consideration of many of these broader problems.

Such is the case for the genus *Pterodrilus*, whose members form a distinctive part of the branchiobdellid fauna of eastern North America. In the last 20 years, however, I have gathered together a large number of specimens of the previously known species of the genus plus material representing five new species.

It is now possible, therefore, to present a more nearly adequate definition of the genus, redescriptions and new distributional data for the previously described species, descriptions of the new species, and a discussion of the evolutionary and geographical relationships of the genus. These are the objectives of the present paper.

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METHODS AND DISPOSITION OF MATERIAL.—The material used in this study that was collected by persons other than Mrs. Holt and myself was collected and preserved in 70% ethyl alcohol. My collecting methods and procedures have been described elsewhere (Holt, 1960a, p. 57). Except for some paratypes of new species and a small number of specimens retained for reference purposes in my collections at the Virginia Polytechnic Institute, the material is deposited in the collections of the United States National Museum. Where appropriate, United States National Museum catalog numbers (USNM) and my personal catalog numbers (PCH) are listed with the locality data given for a species. In all cases, complete locality data are available from my files or from the Registrar, United States National Museum. The terminology used in branchiobdellid taxonomy and evaluation of the taxonomic utility of various characters have also been discussed previously and the reader is referred to these papers (Holt, 1953, 1960a, Holt and Hoffman, 1959), but some relevant explanations and anatomical comparisons are presented, where appropriate, in discussions of certain species.

REVIEW OF THE LITERATURE.—Knowledge of the genus *Pterodrilus* dates from Moore's paper entitled "*Pterodrilus*, a remarkable discodrilid" (Moore, 1895a). He separated the genus from previously known branchiobdellids (= "discodrilids" of authors, e.g., Vejdovsky, 1884) on the basis of the striking dorsal "appendages" of the two species (*P. aleicornus* and *P. distichus*) that he described and assigned to his new genus. His descriptions are excellent for the state of knowledge of the branchiobdellids of his time, and his species are easily recognized. Since then, Pierantoni (1912, pp. 24-25) and Stephenson (1930, p. 801) mentioned the genus in their literature survey. Ellis (1918, pp. 49-51), by means of a key, assigned his species *durbini* to *Pterodrilus*; subsequently (1919, pp. 254-255), he formally described and illustrated *P. durbini*, described *P. mexicanus*, and listed new locality records for

P. distichus. Goodnight (1940, pp. 58-63) quoted the original descriptions of the four nominal species of *Pterodrilus* and added a new locality record for *P. durbini*. Later, he recorded the presence of *P. alcornus* in Sinking Creek, Giles County, Va. (Goodnight, 1941b, p. 468). A new species was recognized and previously known ones of the genus were redescribed in my unpublished dissertation (Holt, 1951, pp. 100-148). Later I reassigned *P. durbini*, placing it in the newly established genus *Ellisodrilus* (Holt, 1960b, pp. 173-176). Recently, *P. alcornus* and its distribution have been discussed (Hobbs, Holt and Walton, 1967, pp. 61, 71, 73-74). Causey (1955, p. 44) recorded the presence of *P. mexicanus* in Arkansas. Other than passing references (e.g., Hoffman, 1963, pp. 294, 295) or mention in various keys, nothing else has been written about the genus *Pterodrilus* by North American authors. In Europe, however, Moszyński (1937, pp. 71-72; 1938, pp. 99-103) and Georgévitch (1955, pp. 200-203; 1957, p. 14) described species that they had assigned to *Pterodrilus*, but Pop (1965, pp. 223-225) pointed out the obvious fact that these European species were based upon material belonging to the genus *Branchiobdella* and synonymized them with *B. parasita* Henle, 1835. They are as follows: *Pterodrilus karamani* Moszyński, 1937; *Pterodrilus bidens* Georgévitch, 1955; *Pterodrilus megas* Georgévitch, 1955; *Pterodrilus prion* Georgévitch, 1955; *Pterodrilus megodont* Georgévitch, 1955; *Pterodrilus aliata* Georgévitch, 1957; *Pterodrilus dantata* Georgévitch, 1957.

Pterodrilus Moore, 1895

TYPE-SPECIES.—*Pterodrilus alcornus* Moore, 1895a, pp. 449-450, by subsequent designation (Goodnight, 1940, p. 58).

DIAGNOSIS.—Small branchiobdellids (known forms less than 2.0 mm in length) of delicate appearance; cylindrical; prosomite of segment VIII always with elevated dorsal ridge, those of other segments often so, dorsal ridges often bearing fan- or finger-like projections; jaws delicate, light in color or colorless, triangular in shape, dental formula 5/4; prostate present, incompletely divided from spermiducal gland; bursa ovoid to pyriform, penis sheath short, penis non-eversible; spermatheca with long ectal duct, bulb clavate or spatulate; anterior nephridia open by common dorsal pore on segment III.

AFFINITIES.—The close relationship of the species of *Pterodrilus* to those of *Cambarincola* has been discussed earlier (Hoffman, 1963, pp. 294-295), and the exclusion of the species at present assigned to *Cambarincola* from the older genus *Pterodrilus* has elements of arbitrariness that require discussion.

Part of the argument for maintaining the generic status of the two groups of closely related species is based upon a conservative desire

to preserve nomenclatural stability. The genus *Cambarincola*, as presently understood, is composed of, by far, the largest number of species of any genus of the order Branchiobdellida. With the exception of the Eurasian genus *Branchiobdella*, it has the greatest geographical range of any genus now known. In almost all localities where they occur, the species of *Cambarincola* are the dominant elements of the branchiobdellid fauna. To transfer all these species to the much less well-known and smaller genus *Pterodrilus* could result only in a period of nomenclatural confusion.

This argument alone, however, cannot justify excluding the species now assigned to *Cambarincola* from *Pterodrilus*. Moore was struck with the unusual appearance of *P. alcicornus* and *P. distichus* with their ornamentation of dorsal projections, and he established a new genus for them. Although he described the male reproductive system of both species (Moore, 1895a, pp. 453, 454), the importance of this system to the systematics of the branchiobdellids was not appreciated at that time, nor, indeed, by Ellis who did, however, present a diagram of it in his paper establishing the genus *Cambarincola* (Ellis, 1912, p. 483).

The difficulty arises from the fact that the basic plan of the reproductive system of species of *Pterodrilus* does not differ from that of the members of *Cambarincola* as much as it does from other genera of the order. Recent workers (Holt, 1960a, 1960b, 1967a, 1967b, Hoffman, 1963; Laing, 1963) have derived their generic concepts from the major variations in pattern of the male reproductive system, and I regard these variations as furnishing the most usable characters for marshalling groups of species into genera. Also, the jaws of species of *Pterodrilus* are quite similar in shape and arrangement of the teeth to those of species of *Cambarincola*. But the jaw patterns are shared by two or more genera in other cases, and the jaws of all species of *Pterodrilus* are of essentially the same form.

We have, however, in *Pterodrilus* a group of distinctive species that obviously belong together as a specialized offshoot from the main direction of the evolution of *Cambarincola*. A formal diagnosis obscures by its brevity and technical language the distinctiveness of such a group. The species of *Pterodrilus* are smaller than those of *Cambarincola* and are characteristically delicate in appearance. The jaws are correspondingly reduced in size and pigmentation. Always there are ridges on some of the segments and usually these ridges bear projections. It is true that both segmental ridges, produced by supernumerary muscles (Holt, 1960b, p. 172), and projections of various sorts occur in other genera and that several species of *Cambarincola* have such ridges. None of the latter species, however, are easily confused with those of *Pterodrilus*. The male reproductive systems of species of *Pterodrilus* vary, but the spermiducal gland is relatively short and

thick and the prostate is less completely divided from the spermiducal gland than in any species of *Cambarincola*.

The dorsal projections of such species as *P. alcornus*, *P. distichus*, *P. mexicanus* and three of the five new species described herein readily set them apart from *Cambarincola*. There would be no difficulty in maintaining the generic separateness of these species except for the last two of the new species treated herein, which are closely related to the others but lack fan- or finger-like projections on the ridge of segment VIII. This is not unexpected: the species assigned to *Pterodrilus* are believed to have arisen from a generalized stock of *Cambarincola* as animals adapted to a niche that favored a reduction in size and the production of the ridges and their projections.

The species of *Pterodrilus* are a distinct group that might be placed within a larger group which includes the species assigned at this time to *Cambarincola*. Since, however, generic status has been accorded these two groups for many years, I prefer to retain both names and assign such taxa as the new species without dorsal projections to one or the other of the existing genera on the basis of judgments as to the closeness of affinities with species previously assigned to them. There are precedents for such decisions in many groups; for instance, among the hosts of the branchiobdellids, the genera *Procambarus* and *Orconectes* are united by intermediate species that must be assigned rather arbitrarily to either genus (Hobbs, 1967, p. 8).

One species, *P. durbini* Ellis (1919, pp. 254-255), previously assigned to *Pterodrilus* has been removed from the genus and referred to the genus *Ellisodrilus* Holt (1960b, pp. 173-176). *Ellisodrilus* is one of a group of genera related to *Cambarincola* and hence to *Pterodrilus*. It differs from *Pterodrilus* in the absence of a spermatheca and the asymmetry and other unique features of the bursa. *Ceratodrilus*, *Oedipodrilus*, and *Magmatodrilus* are other related genera. *Magmatodrilus* Holt (1967b) lacks a prostate, the bursa is proportionally quite large and there are no dorsal projections; the penial sheath of *Oedipodrilus* is elongated, enclosing an eversible penis, the prostate is relatively very small and dorsal projections are absent (Holt, 1967a, p. 58); *Ceratodrilus* Hall (1914, p. 191) is composed of larger worms in which the prostate is extremely reduced in size and the penis is eversible (Holt, 1960a, p. 57).

DISTRIBUTION.—The genus *Pterodrilus* is confined to eastern North America including Mexico. Within this area there are three distinct centers of distribution: the Southern Appalachians with adjacent portions of the Interior Plateau east of the Mississippi River and the glaciated region north of the Ohio River to the Great Lakes and the Saint Lawrence River; the Ozarkian uplift

north of the Arkansas River in Arkansas, Missouri, and Oklahoma; the eastern slopes of the Sierra Madre Oriental in Veraacruz. Obviously, this fragmented range must at some time have been continuous. A discussion of possible migration routes and the evolution of the genus follows the systematic accounts.

Key to the Species of Genus *Pterodrilus*

1. Dorsal projections present 3
Dorsal projections absent, prosomite of segment VIII raised 2
- 2(1). Dorsal ridges on segments I-VIII *P. missouriensis*, new species
Dorsal ridge on segment VIII only *P. choritonamus*, new species
- 3(1). Dorsal projections on raised prosomite of segment VIII only 4
Dorsal projections on raised prosomites of other segments in addition to segment VIII 6
- 4(3). Segments I-VIII with ridges *P. cedrus*, new species
Segments other than VIII without ridges 5
- 5(4). Fanlike dorsal projection of segment VIII with 5 prongs; bursa small, ejaculatory duct long *P. hobbsi*, new species
Fanlike dorsal projection of segment VIII with 4 prongs; bursa large, ejaculatory duct short *P. mexicanus* Ellis
- 6(3). Two finger-like dorsal projections on segments II-VII, 5 on segment VIII *P. distichus* Moore
Fanlike dorsal projections on segments III-V, VIII 7
- 7(6). Fanlike dorsal projection lacking on segment II . . . *P. alcicornus* Moore
Fanlike dorsal projection present on segment II . . . *P. simondsi*, new species

Pterodrilus alcicornus Moore

FIGURES 1, 10

Pterodrilus alcicornus Moore, 1895a, pp. 450-453.—Pierantoni, 1912, p. 25.—Ellis, 1919, p. 254.—Goodnight, 1940, pp. 58-50; 1941, p. 468.—Hobbs, Holt, and Walton, 1967, pp. 61-62.

TYPE-SPECIMENS.—The material from Johns River, Watauga County, N.C., upon which Moore based this species, has not been found among Moore's collections now in the U.S. National Museum nor among the collections of the Academy of Natural Sciences of Philadelphia. The species is distinctive, subsequent identifications are not disputed, and no neotype has been designated.

DIAGNOSIS.—Dorsal ridges on segments II-VIII; those of III-V, VIII bearing fanlike dorsal projections; bursa ovoid, less than $\frac{1}{2}$ body diameter in length; ejaculatory duct of medium length; length of spermiducal gland about 3 times its diameter; prostate subequal in diameter to that of spermiducal gland and $\frac{1}{2}$ to $\frac{2}{3}$ its length, histologically differentiated from the latter; spermatheca longer than body diameter, bending dorsad to gut, ectal duct long and narrow, bulb clavate, ental process absent.

DESCRIPTION.—The length of individuals of *Pterodrilus aleicornus* (based on 10 specimens) is about 1.3 mm. The head is slender, its length about $\frac{1}{6}$ that of the body and its diameter about $\frac{1}{2}$ that of the greatest body diameter. The intersegmental grooves of the head, except for that setting off the peristomium, are indistinct.

The trunk or body is cylindrical throughout and increases gradually in diameter up to the reproductive segments (V-VII), which are all essentially the same diameter (about 0.25 mm). The sucker, formed from segment XI, is subequal to or slightly greater than the head in diameter.

The dorsal appendages or projections are borne on ridges of the prosomites. In *P. aleicornus*, they are paired lobes that diverge somewhat and extend laterally and anteriorly in the case of the anterior three to form forward-facing concavities. The projection of segment VIII is similar, except that it faces posteriorly. The lobes ("wing-like" projections) bear conical prongs, usually three on each side, although the number varies from one to four prominent prongs, with smaller ones frequently present. The lobes of the projection of segment V do not flare out quite so much as do those of the others and the prongs project more nearly upward. Dorsal ridges are present on the prosomites of segments VI and VII.

The spermiducal gland is thick for its length, with a length-diameter ratio of about 3:1. In length and diameter, the prostate is about $\frac{3}{4}$ of these dimensions of the spermiducal gland though it often appears in whole mounts to be subequal in diameter to that of the latter. The prostate is differentiated. The ejaculatory duct is about $\frac{1}{2}$ the length of the bursa and slightly expanded along its midlength. The diameter of the bursa is approximately $\frac{3}{4}$ its length. The bursal glands mentioned by Moore (1895a, p. 454) are not present. He described as glands the fold of the wall of the bursal atrium that becomes the "rim of the cup" of the everted bursa.

The ectal duct of the spermatheca is long and slender, widening gradually into the bulb, which is also long and bends over the gut dorsally; the total length of the spermatheca exceeds the body diameter. There is no ental process of the spermatheca though the ental end of the bulb may resemble such a process when incompletely filled with spermatozoa.

DISCUSSION.—The following account of the anatomy of *P. aleicornus* is a condensation of my unpublished earlier treatment (Holt, 1951, pp. 101-115). Serial sections were used as well as whole mounts and the earlier observations confirmed by more recent examination of many specimens. The abundance of this material affords an opportunity to describe *P. aleicornus* in some detail and, thereby, present

a treatment of the anatomy of the species that will serve to introduce the reader more fully to features common to all species of the genus and as a basis for the shorter descriptions of the other species of *Pterodrilus* that follow.

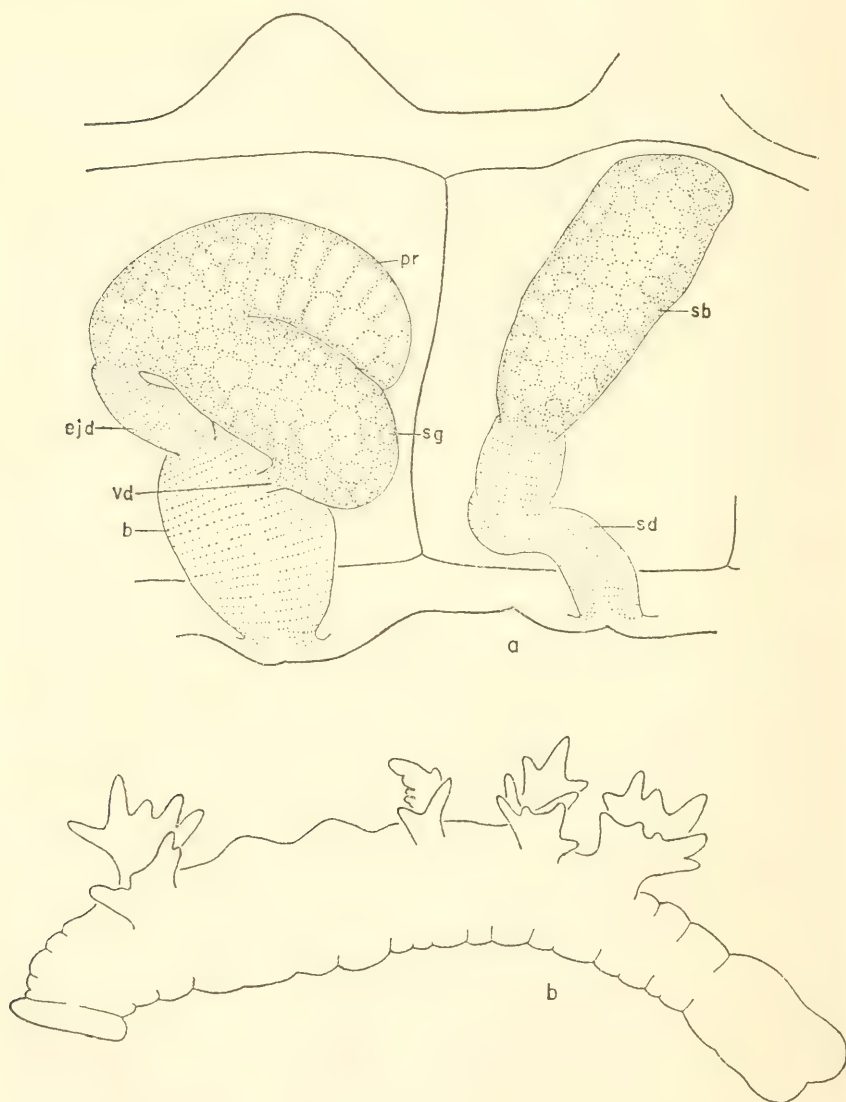


FIGURE 1.—*Pterodrilus alcicornus*: *a*, lateral view of reproductive systems; *b*, animal from Giles County, Va. (*b*=bursa; *ejd*=ejaculatory duct; *pr*=prostate; *sb*=bulb of spermatheca; *sd*=spermathecal duct; *sg*=spermiducal gland; *vd*=vas deferens.)

The dorsal ridges, which may bear projections in *P. alcornus* and other species of *Pterodrilus* and may occur without projections in species of other genera, are formed by the attachment of muscles ("supernumerary muscles," Holt, 1960b, pp. 171-172) that are shorter than the segment to the cuticle and that, by their contraction, differentially shorten the dorsal surface of the prosomites in which they occur. There has been no suggestion by anyone, nor is it indicated in their structure, as to the function of the dorsal projections. They consist of flat "wing-like" or cylindrical "finger-like" (prongs) extensions of the epidermis covering the dorsal ridges. The wall of the projections is a single-cell-layer thick (as is the epidermis) with unicellular glands as a prominent feature. The interior of the projections is an irregular cavity that does not appear to communicate with the coelom. The finger-like projections are usually set off by a slight constriction. Dorsal ridges that are present on segments VI and VII do not bear projections on these reproductive segments in any species of the genus.

Since the jaws of all species of *Pterodrilus* are monotonously similar, they have not been illustrated for all the species included in this study (see, however, figs. 2, 4, 5, 7). They are small, delicate and light yellowish brown (but see p. 11, below). The upper jaw bears five sharply pointed teeth, the lower four (dental formula 5/4); and they are more nearly quadrate in shape than is usual among species of *Cambarincola* with the same dental formula. Moore (1895a, p. 425) believed both jaws of *P. alcornus* to be quadridentate, but this was probably because of the smallness of the lateral teeth of the upper jaw, which may cause one of them to be overlooked.

All branchiobdellids possess two pairs of nephridia and the anterior pair may open by either separate pores or by a common pore on the dorsum of segment III. The anterior nephridia of *Pterodrilus* and related genera open by a common pore, which in *P. alcornus* is located at the base anteriorly of the dorsal projection. The nephridiopore usually cannot be seen in animals mounted entire, but there is little doubt that this arrangement is consistently present in *Pterodrilus*.

The innermost parts of the branchiobdellid male reproductive system consist of testes in segment V or in segments V and VI, a pair of sperm funnels and sperm ducts (vasa efferentia) in each testicular segment, and a vas deferens from each of these segments that is formed by the union of the sperm ducts. These elements are quite similar throughout the order and will not be described here (but see Moore, 1895b, pp. 519-521; Holt, 1949, pp. 538-541, 550-552).

The spermiducal gland is formed by the union of the vasa deferentia and does vary in shape and structure. Other than its peritoneal

covering and a very thin layer of circular muscles, the gland consists of a tube composed of a single layer of columnar epithelium, the individual cells of which open into a narrow lumen. All of these gland cells are filled with granules though differences in the secretory cycle of individual cells can be detected in sectioned material. There are no apparent differences in the histological appearance of the spermiducal gland of *P. aleicornus* and the other species of *Pterodrilus* and that previously described for a species of *Cambarincola* (Holt, 1949, p. 552).

The prostate is a glandular diverticulum of the spermiducal gland that lies along the anteriodorsal border of the latter, ends blindly entally and opens either into the spermiducal gland somewhere along its ectal portion or with it into the ejaculatory duct. In *P. aleicornus* and the other species of *Pterodrilus*, the prostate opens into the spermiducal gland somewhat entally to the junction with the ejaculatory duct; that is, it is incompletely divided from the former. The prostate is of the same basic structure as the spermiducal gland from which it arises, but in *P. aleicornus* its glandular epithelium consists of highly vacuolated cells with different staining properties from those of the spermiducal gland. This histological difference between the two glands is readily apparent in well-prepared whole mounts and is present in all mature individuals of species of *Pterodrilus* with the exceptions mentioned below (pp. 16, 25). The expressions "differentiated" and "undifferentiated" are used to distinguish between such prostates as those of *P. aleicornus* and those that are histologically like the spermiducal gland in both sectioned material and whole mounts. In many species of the genus *Cambarincola*, the ental end of the prostate consists of a thin-walled bulb, the interior of which is a cavity (Holt, 1949, p. 553; 1960a, p. 63). There is no prostatic bulb in *P. aleicornus*.

The ejaculatory duct is a muscular tube which is found in most branchiobdellids and unites, if present, the spermiducal gland and the copulatory bursa. That of *P. aleicornus* is not unlike that of other species of the genus except in length.

The copulatory bursa of *P. aleicornus* and other species of the genus is quite similar to that of members of the genus *Cambarincola*. The penial sheath region of the bursa in *P. aleicornus* is not demarcated externally from the bursal atrium and composes about half of the organ. When the atrial portion of the bursa is everted, the penis is protruded as a short and relatively slender tube surrounded by the cuplike everted bursal atrium. More detailed descriptions of the type of bursa found in the species of *Pterodrilus* may be found in Holt (1949, pp. 553-555) and Hoffman (1963, pp. 289-290).

The ovaries and ovipores of all branchiobdellids seem to be basically similar (Moore, 1895b, pp. 524-525; Holt, 1949, pp. 545-547, 560).

The spermatheca, however, does vary. The length and diameter of both the ectal duct and bulb may differ among the species of *Pterodrilus*; the bulb may be thin walled as it is in *P. alcicornus* and many other branchiobdellids (Holt, 1949, p. 560, fig. 18), and an ental process may be present. The terms used for these parts of the spermatheca are defined in Holt (1960a, p. 64).

The organ systems of *P. alcicornus* and its congeners, with the exception of those discussed above, are not noticeably different from those of other branchiobdellids.

VARIATIONS.—The foregoing description and discussion of *P. alcicornus* is based primarily upon specimens from the New River drainage in Virginia. Differences in methods of killing and preservation, that is, the use of dilute solutions of alcohol, produce some distortion of the specimens. There is little of note in the way of intrapopulational variation, except for differences in the number of prongs of the dorsal projections. A count of these for 10 specimens from Giles County, Va., gave the following results:

| segment III | segment IV | segment V | segment VIII |
|-------------|------------|-----------|--------------|
| 5 | 4 | 5 | 7 |
| 7 | 6 | 6 | 7 |
| 5 | 5 | 5 | 7 |
| 7 | 5 | 5 | 7 |
| 6 | 6 | 5 | 6 |
| 8 | 7 | 7 | 7 |
| 7 | 5 | 5 | 6 |
| 7 | 5 | 5 | 6 |
| 5 | 3 | 4 | 5 |
| 5 | 5 | 3 | 5 |

Similar results were obtained from specimens from other parts of the range of the species.

The "wings" of the dorsal projections of at least some specimens from the Watauga River system in North Carolina and Tennessee and the headwaters of the New River in North Carolina are of greater extent than those of specimens from other parts of the species' range. The latter material, however, is poorly preserved, which may account for the apparent differences.

The jaws of some specimens from Alleghany County, N.C., are much darker than usual. That this may reflect something other than geographical variability is indicated by the presence of dark jaws in at least one collection from Giles County, Va., where most specimens have lightly colored jaws.

The extent of variability in the species is not enough, or at least it is not well enough defined geographically, to allow one to consider the erection of subspecies.

AFFINITIES.—*Pterodrilus alcicornus*, in external appearance, is

most like *P. simondsi* and *P. distichus*. It differs from both in the absence of dorsal projections on segment II and from *P. distichus* in the fanlike instead of finger-like nature of the projections. The reproductive systems of *P. alcicornus* differ in only minor details, mostly in length and shape of the spermatheca, from those of *P. hobbsi* and *P. distichus* and in the fully differentiated prostate and thin-walled spermathecal bulb from *P. simondsi*.

HOSTS.—*Pterodrilus alcicornus* was found with the following crayfishes: *Cambarus sciotensis* Rhoades, *C. bartonii bartonii* (Fabricius), *C. robustus* Girard, *C. bartonii* subspecies, *C. longulus longirostris* Faxon, *C. longulus chasmodactylus* James, *Cambarus* species, *Orconectes juvenilis* Hagen, *Cambarus parvovulus* Hobbs and Shoup, *C. bartonii cavatus* Hay, *C. veteranus* Faxon, *C. acuminatus* Faxon, *C. longulus longulus* Girard, *Orconectes sanborni sanborni* (Faxon). The most frequent hosts are *C. sciotensis* and *C. bartonii bartonii*.

DISTRIBUTION.—*Pterodrilus alcicornus* is widespread in the streams of the Tennessee and New Rivers in Tennessee, North Carolina, and Virginia. In addition, it has moved—apparently recently since it is not common there—into other adjacent drainages: the Savannah River in Transylvania County, N.C., the James River drainage in Craig County, Va., the Roanoke River drainage in Franklin and Patrick Counties, Va., the Big Sandy River drainage in Buchanan and Dickenson Counties, Va., and Wyoming County, W. Va. (fig. 10). Most of my collections of *P. alcicornus* are from Virginia, and the greater number of known localities for the species in the New River drainage in Virginia may be, but probably is not, a peculiarity of collecting. The range as given here may not be complete for it is possible that *P. alcicornus* occurs in other adjoining drainages.

MATERIAL EXAMINED.—Several hundred specimens from 122 collections were studied. The bulk of this material is deposited in the U.S. National Museum (USNM 36184–36250).

Pterodrilus distichus Moore

FIGURES 2, 10

Pterodrilus distichus Moore, 1895a, pp. 453–454.—Pierantoni, 1912, p. 25.—Hall, 1914, pp. 190, 193.—Ellis, 1919, p. 254.—Goodnight, 1940, pp. 60–61; 1943, p. 100.

TYPE-SPECIMENS.—The material from western New York, upon which Moore based this species, has not been found. The species is distinctive, subsequent identifications are not disputed, and no neotype has been designated.

DIAGNOSIS.—Low, somewhat indistinct ridges on segments I–VIII, those of segments II–VII each with two bluntly pointed cylindrical



FIGURE 2.—*Pterodrilus distichus*: *a*, lateral view of reproductive systems; *b*, en face view of jaws, upper jaw above; *c*, animal from Seneca County, N.Y.

dorsal projections, that of segment VIII with five projections; bursa subspherical, small, hardly reaching ventral border of gut; ejaculatory duct of medium length; prostate broadly joined to spermiducal gland, subequal in length and diameter to latter, differentiated; spermiducal gland small, its length about twice its diameter; spermatheca clavate, length subequal to body diameter, ectal duct gradually merging into bulb, without ental process.

DESCRIPTION.—In size the members of this species differ very little from those of *P. alcicornus*, but are perhaps slightly larger, with an average length of 1.4 mm. The dorsal ridges would hardly attract attention if they did not bear projections. The latter are relatively short and about $\frac{1}{10}$ the greatest body diameter in length. There are two of these on segments II–VII and five on segment VIII.

The spermiducal gland, ejaculatory duct, bursa, and penis differ from those of *P. alcicornus* only in their smaller size.

The spermatheca is not proportionally as long as that of *P. alcicornus* and does not bend appreciably over the gut although its length is approximately equivalent to the body diameter; the ectal duct appears to be somewhat wider than that of *P. alcicornus* and is not greatly different in diameter from the bulb at the union of the two.

VARIATION.—Minor differences that may be noted in the size of specimens, the length of the dorsal projections, and the size and proportions of the reproductive systems perhaps are best correlated with differences in age or nutrition and in the methods of killing and preserving.

AFFINITIES.—The differences between *P. distichus* and *P. alcicornus* have been noted (p. 12). The two species are closely related. In the number of dorsal appendages, *P. distichus* agrees with *P. simondsi*, but the reproductive systems of these two species are significantly different (p. 25).

HOSTS.—*Pterodrilus distichus* has been associated with *Oreonectes propinquus* (Girard), *O. immunis* (Hagen), *O. obscurus* (Hagen), *O. juvenilis* (Hagen), *O. rusticus rusticus* (Girard), *Cambarus robustus* Girard, *C. bartonii bartonii* (Fabricius) and *C. longulus chasmodactylus* James, of which the two most frequent hosts are *O. propinquus* and *C. robustus*.

DISTRIBUTION.—*Pterodrilus distichus* has been taken from the states of New York, Ohio, Kentucky, Indiana, Illinois, and Michigan (fig. 10). All of these records are from regions covered by ice during the Wisconsin glaciations except those from Breathitt, Madison, Jessamine, and Harrison Counties, Ky. The first three of these Kentucky records are from the Kentucky River drainage, the last from the Licking River system, both streams of the Ohio drainage. The conclusion is that the ancestors of *P. distichus* have moved from some-

where near the Kentucky River across the Ohio into the glaciated areas of the Ohio-Mississippi and Great Lakes drainage systems since the melting of the Wisconsin glacier.

MATERIAL EXAMINED.—Approximately 200 specimens from 25 collections have been examined. Specimens from all these collections are deposited in the U.S. National Museum (USNM 17651-17653, 36160-36183).

Pterodrilus mexicanus Ellis

FIGURES 3, 9

Pterodrilus mexicanus Ellis, 1919, p. 254.—Goodnight, 1940, p. 63.—Causey, 1955, p. 44.

TYPE-SPECIMEN.—Holotype, USNM 17654, from Mirador, Veracruz, Mexico. Host: *Cambarus mexicanus* Erichson; Nelson and Goldman, collectors.

DIAGNOSIS.—Dorsal ridge on segment VIII, typically bearing four conical projections, remainder of segments without ridges; bursa large, elongate, length exceeding $\frac{1}{2}$ body diameter; ejaculatory duct short; prostate about $\frac{1}{2}$ diameter of and subequal in length to spermiducal gland, undifferentiated; spermatheca shorter than body diameter, bulb thick walled.

DESCRIPTION.—*Pterodrilus mexicanus* differs externally from other species of *Pterodrilus* in the arrangement and number of the dorsal ridges and projections. There are no ridges present, except that on segment VIII, which has four finger-like, conical projections, very similar to those of *P. distichus*. The total length averages 1.1 mm.

The spermiducal gland is about three times its diameter in length and lies along the upper border of the gut. The prostate, subequal in length to and about half the diameter of the spermiducal gland, is histologically undifferentiated in most specimens although some specimens show a vacuolation of some cells along its ental and dorsal borders. The ejaculatory duct is very short. The bursa, however, is large, about $1\frac{1}{2}$ times longer than that of *P. alcornus* and 3 times that of *P. distichus*. This great increase in size is primarily accounted for by an increase in the length of the atrial area, which is not only larger but has additional inwardly directed folds of the bursal wall. The penial sheath region and the penis itself is as in other species of *Pterodrilus*. Specimens with the bursa everted have not been seen; but one would expect a cup-within-a-cup structure to be produced by eversion.

The spermatheca of *P. mexicanus* is shorter than that of most species of the genus, hardly extending above the upper border of the gut. The inner part of the ectal duct is often enveloped in an expanded ectal part of the bulb. The blind end of the spermatheca frequently

resembles an ental process, except that often it is distended with spermatazoa. The wall of the spermathecal bulb is thicker than in all other species of the genus except *P. simondsi*.

VARIATION.—One or two specimens have only three dorsal projections on segment VIII instead of four. The length of the prongs vary, those of the type are larger than those of most specimens. This difference appears to be of sporadic occurrence and of no systematic importance. The prostate of some specimens is partially vacuolated (cf. *P. simondsi*, p. 25, below).

AFFINITIES.—*Pterodrilus mexicanus* is related to *P. missouriensis*, *P. choritonamus*, *P. cedrus*, and *P. hobbsi*. In features of the reproductive system, *P. mexicanus* is most similar to *P. missouriensis*. These two Ozarkian species differ in that in *P. mexicanus* the ejaculatory duct is short, the bursa is larger, the prostate is partially differentiated, the spermatheca is shorter and the wall of the spermathecal bulb is thicker, and there are no dorsal ridges on segments I–VII. The absence of dorsal ridges except on segment VIII ally *P. mexicanus* with *P. hobbsi*, a more advanced member of the same lineage (see below, p. 36), which differs from *P. mexicanus* in the fully differentiated prostate, long ejaculatory duct, small bursa, and thin-walled spermathecal bulb. *Pterodrilus mexicanus* shares the absence of dorsal ridges, except on segment VIII, with *P. choritonamus*, which, however, lacks projections on this dorsal ridge. In addition, the latter species differs from *P. mexicanus* in that the bursa is smaller, the ejaculatory duct is longer, the prostate is differentiated, and the spermatheca has an ental process. *Pterodrilus cedrus* belongs in the same lineage as *P. missouriensis* and differs from *P. mexicanus* in the presence of dorsal ridges on segments I–VII, a smaller, more nearly spherical bursa, a longer ejaculatory duct, a differentiated prostate, and a longer spermatheca without an ental process.

HOSTS.—*Pterodrilus mexicanus* has been taken from 10 species of the genus *Orconectes*: *O. punctimanus* (Creaser), *O. ozarkae* Williams, *O. meeki meeki* (Faxon), *O. neglectus neglectus* (Faxon), *O. nana nana* Williams, *O. nais* (Faxon), *O. luteus* (Creaser), and *O. hylas* (Faxon).

DISTRIBUTION.—Two of my collections are from the Arkansas River drainage in northwestern Arkansas and eastern Oklahoma; four are from the St. Francis River system in Missouri; the remainder are from the White River drainage in Arkansas and Missouri. All of these streams, however, drain the Ozark highlands centered in south-central Missouri. The range of *P. mexicanus*, thus, is compact and well delimited except for the type-locality, Veracruz, Mexico.

MATERIAL EXAMINED.—Approximately 100 specimens from 22 collections from Arkansas, Missouri, and Oklahoma were studied.

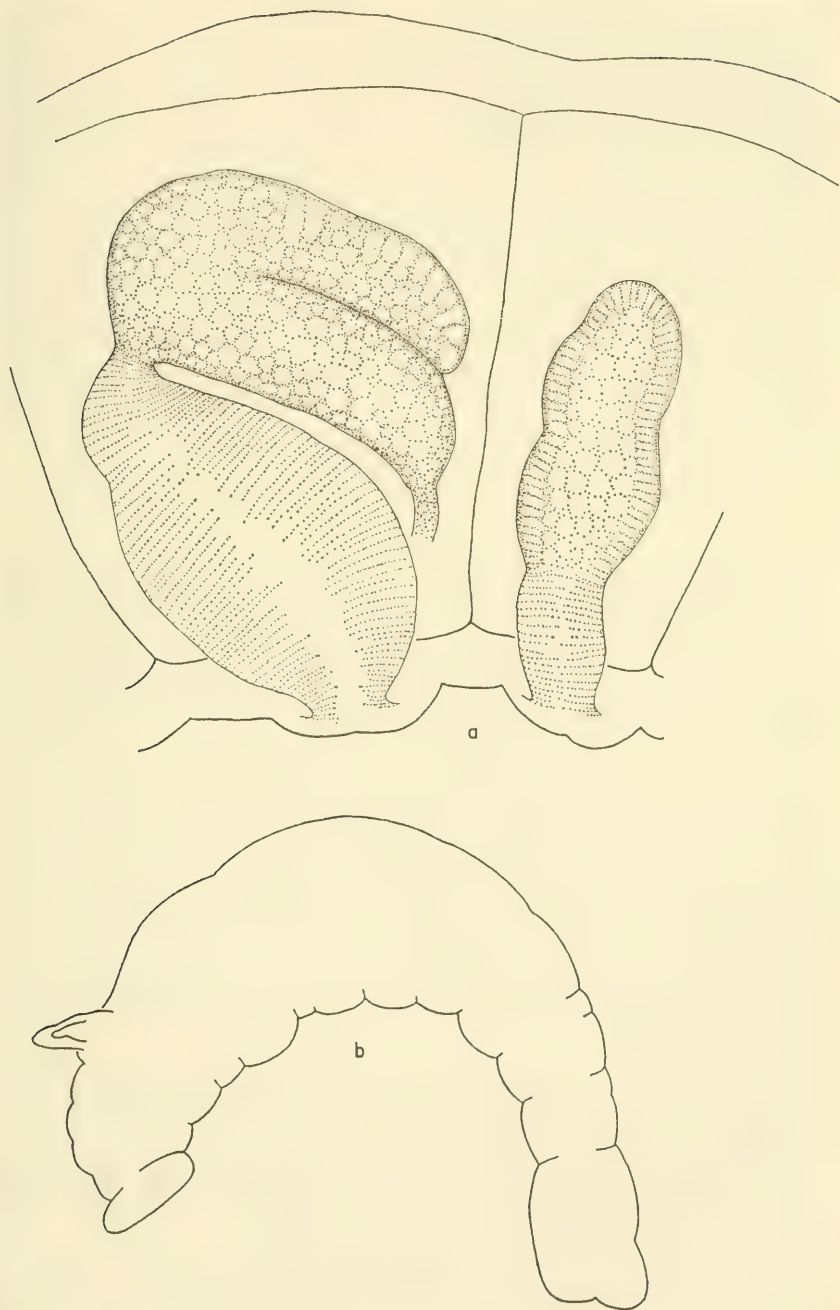


FIGURE 3.—*Pterodrilus mexicanus*: a, lateral view of reproductive systems; b, animal from Wayne County, Mo.

This material, for the most part, is deposited in the U.S. National Museum (USNM 36138-36159).

REMARKS.—The holotype of *P. mexicanus* Ellis (1919) from Mirador, Veracruz, Mexico, is poorly preserved, making a study of the internal structures impossible; it was separated from other branchiobdellids by Ellis (1919, p. 254) on the sole basis of the "simple four-horned appendage like that on the same segment of *P. distichus*." I have collected branchiobdellids in Mexico and unsuccessfully have tried to locate Mirador. Among the 64 collections from Mexico that I have studied, there are no specimens that can be assigned to the genus *Pterodrilus*. I have, therefore, with considerable hesitation, referred my material from the Ozarks to *P. mexicanus*. The possibility remains that a future discovery of *P. mexicanus* at or near the type-locality will necessitate the renaming of the Ozarkian animals.

Pterodrilus hobbsi, new species

FIGURES 4, 9

TYPE-SPECIMENS.—Holotype, USNM 36486, and five paratypes, USNM 36487, from *Cambarus rusticiformis* Rhoades, *Orconectes juvenilis* (Hagen), and *O. placidus* (Hagen) taken from Spring Creek, 1.4 miles north of the Putnam County line on State Highway 43, Overton County, Tenn., by Perry C. and Virgie F. Holt, July 26, 1961.

DIAGNOSIS.—Dorsal ridge present on segment VIII, bearing fanlike projection with five prongs, other segments without dorsal ridges and projections; bursa small, ovoid, length less than half body diameter; ejaculatory duct of normal length; spermiducal gland relatively large; prostate about $\frac{3}{4}$ diameter of and subequal in length to spermiducal gland; spermatheca clavate, bending dorsally over gut.

ETYMOLOGY.—I take great pleasure in naming this species in honor of Dr. Horton H. Hobbs, Jr., as a token of my gratitude for the many years of friendly help he has given me in my study of the branchiobdellids.

DESCRIPTION.—In shape and size, *P. hobbsi* is much like other members of the genus, differing from all except *P. choritonamus* and *P. mexicanus* in the absence of ridges on the prosomites of all segments except the eighth. The dorsal projection of this segment is fanlike and bears five tapering prongs of which the median is the longest. The length ranges from about 1.3 to 1.7 mm.

The spermiducal gland is not markedly different from that of *P. mexicanus*; the prostate, however, is distinctly vacuolated; that is, it is histologically differentiated, but there is no distinct prostatic bulb. The two organs are broadly joined and often the spermiducal

gland lies so that the true extent and appearance of the prostate is obscured. The ejaculatory duct is markedly longer than that of the unusually short one of *P. mexicanus* and is expanded along its mid-length. The bursa is small and ovoid, intermediate in size between those of *P. alcornus* and *P. distichus*, and much smaller than that of *P. mexicanus*.

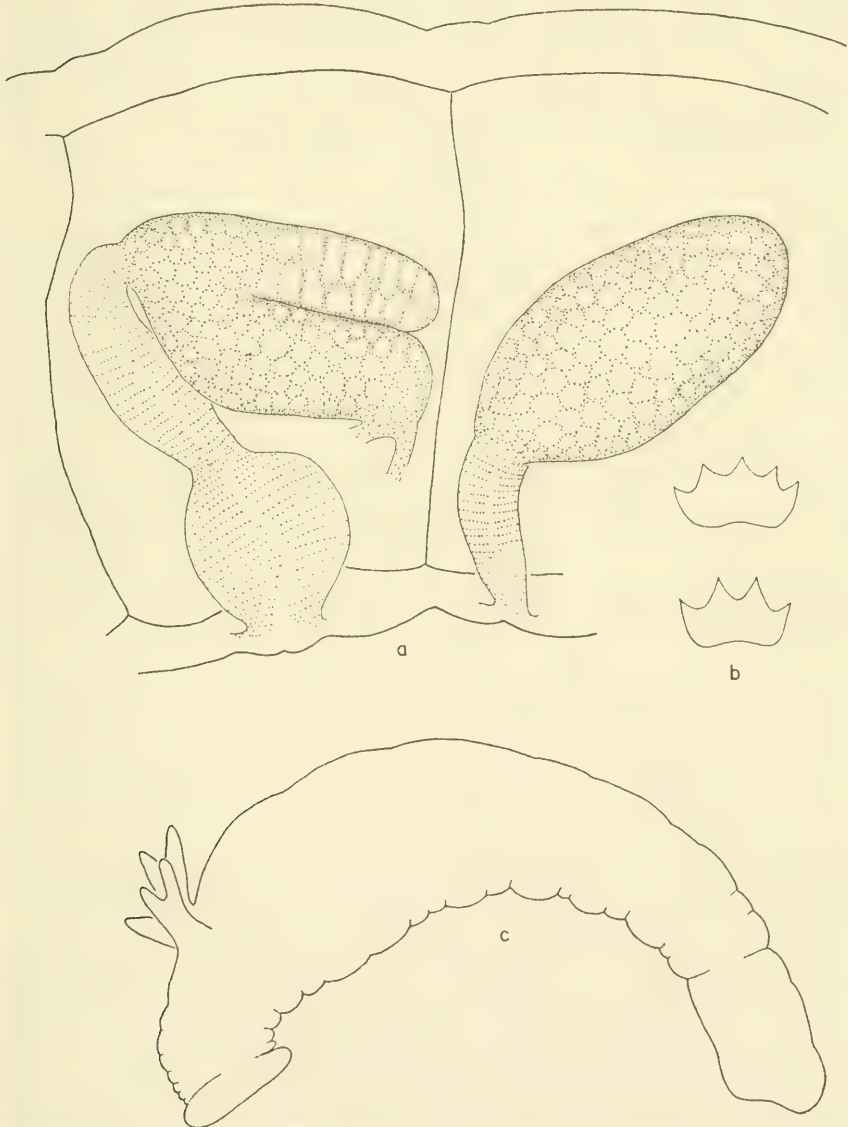


FIGURE 4.—*Pterodrilus hobbsi*: a, lateral view of reproductive systems; b, en face view of jaws, upper jaw above; c, animal from Lee County, Va.

The spermatheca is quite similar to that of *P. distichus*, perhaps slightly broader along the midlength of the bulb. It is approximately as long as the body diameter and bends dorsad over the gut. The ental end is composed of larger cells and in many specimens there is a small ental process.

VARIATION.—The prongs of the dorsal projections vary in length, but this may be related in part to differences in the degree of contraction. The reproductive organs show only minor differences in apparent shape and proportions—except for the prostate, which appears to be variable in length, and the extent of vacuolation. The ectal portion near its junction with the spermiducal gland is often not differentiated, but in all individuals the blind end is vacuolated to a greater extent and more consistently than in *P. mexicanus*.

AFFINITIES.—*Pterodrilus hobbsi* is similar to *P. choritonamus* and *P. mexicanus* in the absence of dorsal ridges on all segments except the eighth, but it differs from both of these species in the smaller bursa and from *P. mexicanus* in the presence of five instead of four prongs of the dorsal projections and in the consistently differentiated prostate (see p. 16). The reproductive systems are most like those of *P. distichus* and *P. alvicornus*, species with dorsal projections on several segments.

HOSTS.—*Pterodrilus hobbsi* has been taken in association with 17 species and subspecies of *Cambarus* and 4 species of *Orconectes*: *Cambarus tenebrosus* Hay, *C. longulus longirostris* Faxon, *C. parvovulus* Hobbs and Shoup, *C. longulus chasmodyctylus* James, *C. robustus* Girard, *C. veteranus* Faxon, *C. friaufi* Hobbs, *C. extraneus* Hagen, *C. bartonii cavatus* Hay, *C. sciotoensis* Rhoades, *C. distans* Rhoades, *C. bartonii bartonii* (Fabricius), *C. longulus longulus* Girard, *C. latimanus* (LeConte), *C. striatus* Hay, *Cambarus* species, *C. bartonii* subspecies; *Orconectes erichsonianus* (Faxon), *O. juvenilis* (Hagen), *O. rusticus forceps* (Faxon), and *Orconectes* species. The most common hosts were *Cambarus longulus longirostris*, *C. bartonii cavatus*, and *Orconectes juvenilis*.

DISTRIBUTION.—*Pterodrilus hobbsi* inhabits most of the upper Tennessee drainage system and is especially common in tributaries of the Nolichucky, Watauga, Holston, Powell, and Clinch Rivers. It has also invaded the New River in Bland and Carroll Counties, Va., and Alleghany County, N.C.; the Big Sandy in Dickenson County, Va.; and is at home in a wide stretch of the Cumberland River drainage in Tennessee and Kentucky (fig. 9).

MATERIAL EXAMINED.—Types and over 300 specimens from 62 collections have been examined. The major part of this material is deposited in the U.S. National Museum (USNM 36488–36508).

REMARKS.—Unfortunately, much of the material on which the description of *P. hobbsi* is based is poorly preserved since it was collected by students of crayfishes whose requirements are such that the branchiobdellid material in their collections often proves unsuitable for careful study or positive identifications. There is no doubt that *P. hobbsi* is a distinct species occupying an extensive range; future studies based upon larger series of collections that are better preserved may reveal the presence of other and similar species among the animals presently assigned to this species (see below, p. 32).

Pterodrilus cedrus, new species

FIGURES 5, 10

TYPE-SPECIMENS.—Holotype and five paratypes, USNM 36464, from *Orconectes placidus* (Hagen) and *Cambarus tenebrosus* Hay taken in a small stream at the intersection of State Highways 52 and 53 at Celina, Clay County, Tenn., by Perry C. and Virgie F. Holt, July 25, 1961.

DIAGNOSIS.—Dorsal ridges on segments I–VIII, that of VIII bearing four short conical projections; bursa subspherical, small, reaching ventral border of gut; ejaculatory duct of medium length; prostate about $\frac{2}{3}$ diameter of and equal in length to spermiducal gland, differentiated; spermatheca frequently exceeding body diameter in length, strap shaped to clavate, ectal duct long.

ETYMOLOGY.—Latin, *cedrus*, the cedar tree, by extension as a common name, the red cedar, *Juniperus virginiana*, for the cedar glades that are such a conspicuous part of the landscape of middle Tennessee.

DESCRIPTION.—*Pterodrilus cedrus* is a small worm, about 1.0 to 1.3 mm long; the combination of dorsal ridges on the first eight body segments and the four finger-like projections borne on the ridge of segment VIII are distinctive. These projections are short and resemble closely those of the corresponding segment of *P. distichus*.

The spermiducal gland is small, approximately twice its diameter in length. The prostate is broadly joined to the spermiducal gland and composed of highly vacuolated cells that end abruptly at the level of the separation of the two. It extends entally to the ental end of the spermiducal gland. The ejaculatory duct is about equal in length to the bursa and therefore longer than that of *P. mexicanus* and perhaps somewhat shorter, relative to the size of the organs, than that of *P. hobbsi*. The bursa is much like that of all members of the genus, except *P. mexicanus*, *P. choritonamus*, and *P. missouriensis*, that is, small and subspherical in shape.

The spermatheca is long, with a long ectal duct. The bulb is elongate oval and usually bent mesiad over the gut dorsally. There is no ental

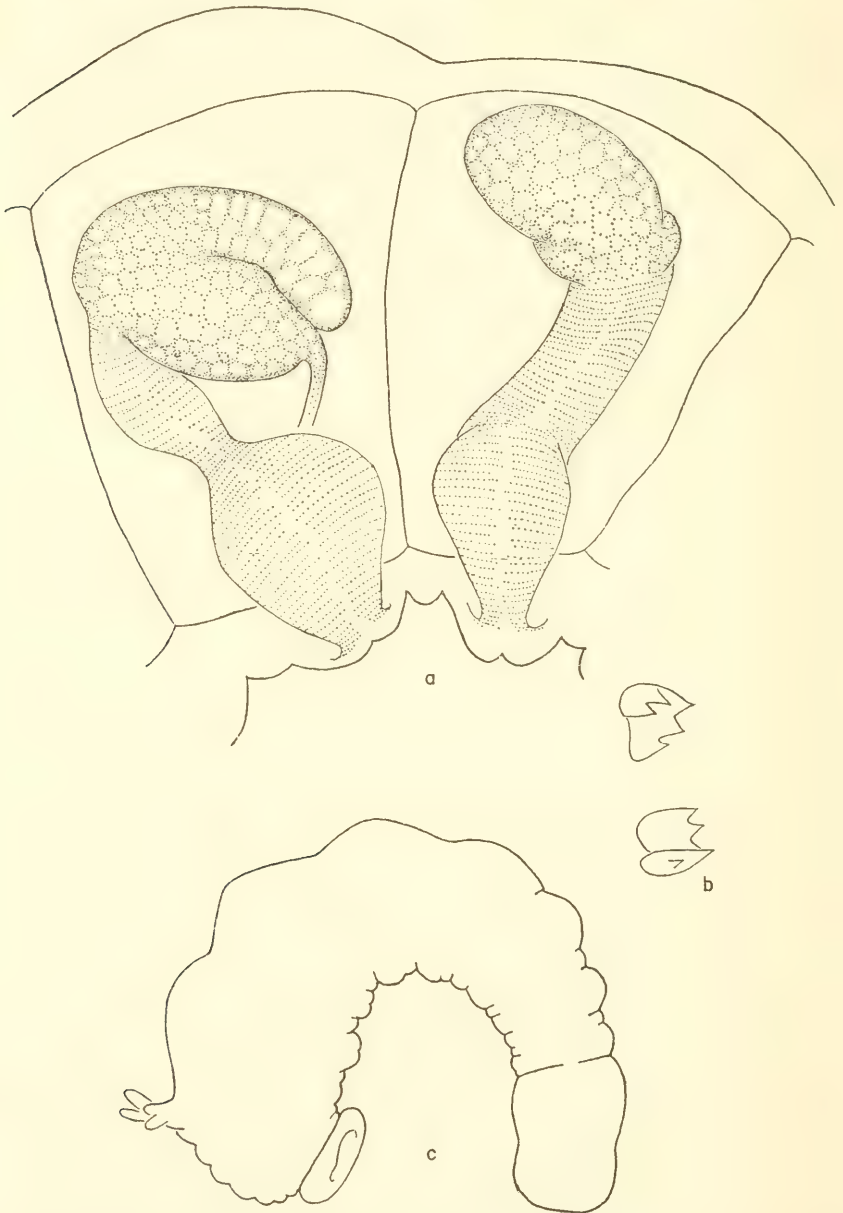


FIGURE 5.—*Pterodriliu cedrus*: a, lateral view of reproductive systems; b, oblique view of jaws; c, holotype.

process. The organ is narrower and the ectal duct is longer than is usual in the genus.

VARIATION.—Observable variability is confined to the spermatheca and seems to depend upon the degree of distension of the bulb with spermatozoa. When incompletely distended, there appears to be an ental process and the ectal duct is long; when fully distended, the ental process disappears and the ectal duct is shorter; that is, the ental part of the duct becomes part of the bulb. A cursory inspection might lead to the conclusion that there are structural differences of the spermatheca among individuals of the same population.

AFFINITIES.—*Pterodrilus cedrus* is superficially most like *P. hobbsi* but differs in having dorsal ridges on segments I–VIII, the shorter and finger-like dorsal projections of segment VIII instead of the fanlike projection with five prongs of the latter, the longer ectal duct of the spermatheca, and the narrower spermathecal bulb. The dorsal ridges of *P. cedrus* allies it, however, with the lineage culminating in *P. alcornus*. Among these species (*P. simondsi*, *P. distichus*, and *P. alcornus*), *P. cedrus* differs from *P. distichus* most markedly in the absence of two finger-like projections on the dorsal ridges of segments II–VII and the presence of four, instead of five projections on segment VIII.

HOSTS.—*Pterodrilus cedrus* has been taken with the following crayfishes: *Orconectes placidus* (Hagen), *O. rusticus* subspecies, *O. juvenilis* (Hagen) and *Cambarus tenebrosus* Hay.

DISTRIBUTION.—*Pterodrilus cedrus* is known only from a small series of collections taken in the eastern Highland Rim and Nashville Basin regions of Tennessee (fig. 10). Both its anatomical features and restricted distribution impute to it the status of a phylogenetic relict.

MATERIAL EXAMINED.—Types and 37 additional specimens. With the exception of three paratypes (PCH 1396) from the type-locality, this material is deposited in the United States National Museum (36465–36468).

Pterodrilus simondsi, new species

FIGURES 6, 10

TYPE-SPECIMENS.—Holotype, USNM 36477, five paratypes, USNM 36478, from *Cambarus bartonii bartonii* (Fabricius) taken in a tributary to the Ocoee River, 12.2 miles south of Morganton, on State Highway 60, Fannin County, Ga., by Kenneth W. Simonds, Nov. 6, 1958; four paratypes, PCH 989, from *Cambarus bartonii bartonii* taken in a tributary to the Ocoee River, 8.8 miles south of Morganton, Fannin County, Ga., on State Highway 60, by Kenneth W. Simonds, Nov. 6, 1958.

DIAGNOSIS.—Dorsal ridges on segments II–VIII, those of segments II–V, VIII bearing fanlike projections; bursa of medium size, with expanded atrial region; spermiducal gland relatively long, exceeding slightly anteroposterior dimension of segment VI in length; prostate $\frac{2}{3}$ to subequal to spermiducal gland in diameter, subequal in length,

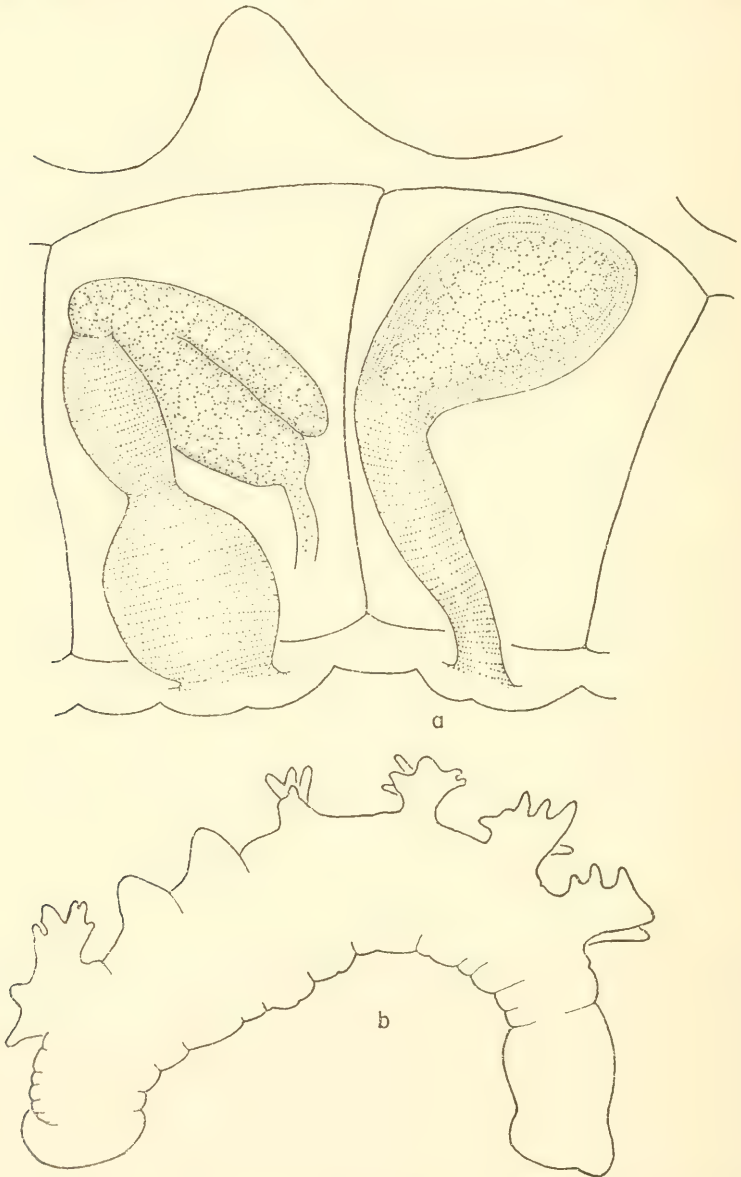


FIGURE 6.—*Pterodrilus simondsi*: a, lateral view of reproductive systems; b, holotype.

histologically differentiated in some specimens, not in others; spermatheca slightly longer than body diameter, ectal duct long, bulb clavate with thick muscular wall.

ETYMOLOGY.—I am pleased to name this species in honor of its discoverer, Mr. Kenneth W. Simonds.

DESCRIPTION.—The dorsal ridges reach a greater height than in other species and more of them bear the expanded projections with prongs that may in turn be bifurcated or bear secondary prongs. The generalized description of the dorsal projections of segments III and VIII of *P. alcicornus* apply to those of segments II–IV and VIII of *P. simondsi*. The dorsal projection of segment V of *P. simondsi*, however, lacks the membranous lateral expansions of those of the other segments and are similar to the projections of segment VIII of *P. distichus*. *Pterodrilus simondsi* is composed of small worms about 0.9 to 1.3 mm long.

The bursa is smaller than that of *P. mexicanus*, but still larger, or at least longer, than is usual. The ejaculatory duct is prominent and rather noticeably expanded along its midlength. The spermiducal gland is somewhat longer than the anteroposterior dimension of the segment in which it lies and is usually oriented diagonally in the segment, extending dorsally above the gut. The diameter of the prostate ranges from $\frac{2}{3}$ to subequal that of the spermiducal gland and extends entally to the ental end of the latter. It is more nearly separated from the spermiducal gland than in other species of the genus, the separation between the two extending almost to the junction of the spermiducal gland with the ejaculatory duct.

The spermatheca of *P. simondsi* is comparable in length and general shape to that of such species as *P. alcicornus* and *P. hobbsi*, but it differs in the heavier muscular investment of the bulb that distinctly persists even when the bulb is distended to the maximum with spermatozoa. There is no ental process.

VARIATION.—The only detectable variations in the material I have studied are those involving the prostate, which is, in some specimens, histologically identical to the spermiducal gland; in others it is composed of large, clear cells (vacuolated cells); and in still others some of the cells are composed of dense cytoplasm with many granules, and others are filled almost entirely with a clear material. In other words, in this species, the distinction between differentiated and undifferentiated prostates breaks down. The degree of distension of the spermathecal bulb is also variable. There can be no doubt that these are individual, intrapopulational variations.

AFFINITIES.—*Pterodrilus simondsi* is closest in external appearance to *P. alcicornus*, from which it differs most noticeably in the presence of an additional dorsal projection on segment II, but the

reproductive systems of these two species are quite dissimilar. The prostate of *P. alcicornus* is always differentiated and its spermatheca lacks the muscular investment of the bulb characteristic of *P. simondsii*. *Pterodrilus simondsii*, then, is a less advanced member of a lineage derived from ancestors much like *P. missouriensis* and *P. cedrus* (see p. 21) that has also produced *P. distichus* and *P. alcicornus*.

Hosts.—The following crayfishes were found associated with *P. simondsii*: *Cambarus bartonii bartonii* (Fabricius), *C. latimanus* (LeConte) and *Cambarus* species. This is the only species of *Pterodrilus* for which no species of *Orconectes* is known to serve as a host (but see p. 32 below). Moreover, only once was it found in the absence of *C. b. bartonii*, the one record outside the Ocoee River, where it is associated with an unnamed species of *Cambarus*.

DISTRIBUTION.—*Pterodrilus simondsii* is known only from the collections taken by Mr. Simonds from small tributaries to the Ocoee River in Fannin County, Ga., and Cherokee County, N.C., and one collection from a tributary to the Nottely River in Union County, Ga. In 1958–59 Mr. Simonds took 84 collections of crayfish from the Hiwassee River drainage to which the Ocoee and Nottely Rivers are tributary. Of his 19 stations in the upper Ocoee, *P. simondsii* was present at 14. The streams in which these stations were located are described as “small . . . with cold cascading waters, the bottoms of which are composed almost entirely of large flat stones often with several layers superimposed In such streams the water is clear even after heavy rains” (Simonds, unpubl. ms.). The thoroughness of Mr. Simonds’ collecting efforts in similar streams of the Hiwassee River system to the north (75 collections, only one of which contained *P. simondsii*) leads to the conclusion that *P. simondsii* is a highly localized species. It should be searched for in the headwaters of the Savannah River to the east, the Chattahoochee River to the southeast, and the Coosa River to the southwest, but presumably *P. simondsii* is a relic of an early invasion of the area by primitive relatives of *P. alcicornus* that were adapted to cold, clear mountain streams.

MATERIAL EXAMINED.—Types and 53 specimens from 15 localities. The major part of this material is deposited in the U.S. National Museum (USNM 36479–36485).

Pterodrilus choritonamus, new species

FIGURES 7, 9

TYPE-SPECIMENS.—Holotype, USNM 36471, and two paratypes, USNM 36472, from *Cambarus tenebrosus* Hay taken in a tributary to

Eagle Creek (Holt Spring Branch) about 4.5 miles north of Livingston, Overton County, Tenn., by Perry C. and Virgie F. Holt, July 24, 1961; five paratypes, PCH 1393, from *Cambarus tenebrosus* and *Orconectes placidus* (Hagen) taken in Little Eagle Creek about 0.5 miles above confluence with Eagle Creek and about 6.0 miles north of Livingston, Overton County, Tenn., by Perry C. and Virgie F. Holt, July 24, 1961.

DIAGNOSIS.—Without dorsal projections, dorsal ridge present on segment VIII; bursa pyriform, small, extending at most to ventral border of gut; ejaculatory duct of medium length; prostate subequal to or shorter than spermiducal gland, diameter about $\frac{2}{3}$ that of latter, differentiated; spermatheca with long ectal duct, median bulb and ental process.

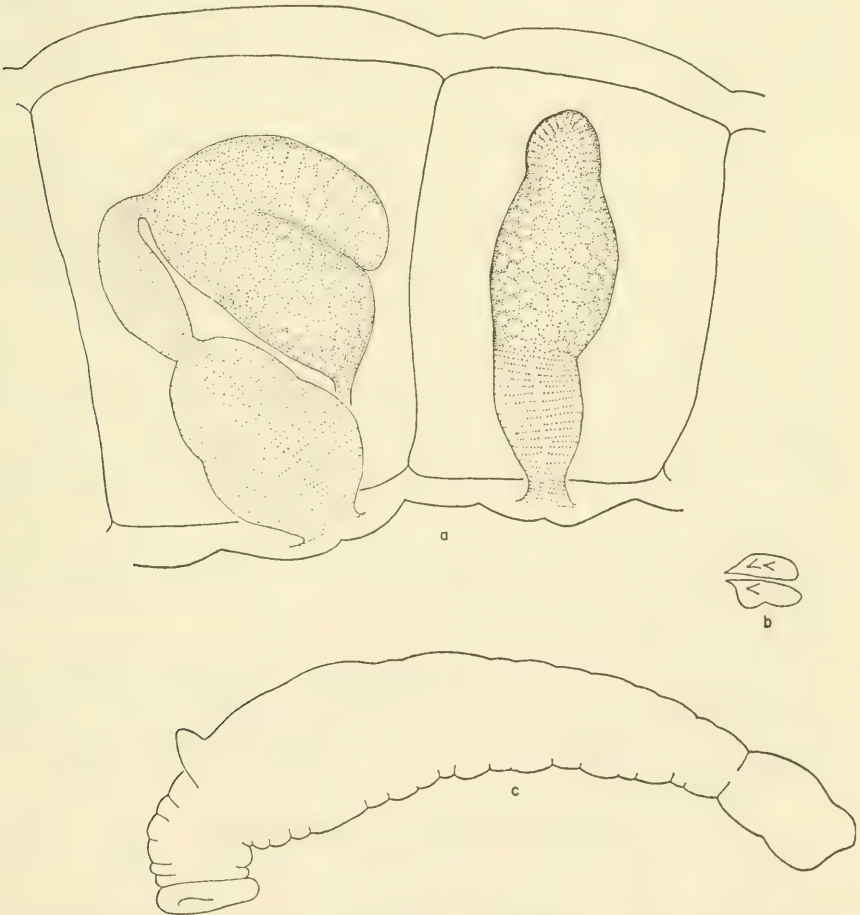


FIGURE 7.—*Pterodrilus choritonamus*: a, lateral view of reproductive systems; b, lateral view of jaws; c, holotype.

ETYMOLOGY.—From Greek, *choritos*, native, and *namos*, spring or stream, native spring, for the spring branch of my boyhood home.

DESCRIPTION.—*Pterodrilus choritonamus* is a small and delicate worm about 1.1 to 1.5 mm long. In body proportions and outline it is similar to *P. hobbsi* and *P. mexicanus*, differing in the absence of projections on the dorsal ridge of segment VIII.

The bursa approaches half the body diameter in length and is pyriform in shape: the penial sheath region is set off externally by a slight constriction and is less in diameter than the atrial portion of the bursa.

The spermatheca has the midlength of the organ (the spermathecal bulb) normally expanded, the ental portion not, so that there is an ental process that is lined with a columnar epithelium instead of a thin layer of flattened cells as is the bulb. Although the total length of the spermatheca is subequal to the body diameter, it is not as long as that of the other species of the genus except that of *P. mexicanus*, which it exceeds in length.

VARIATIONS.—The prostate varies in length, the ental end usually approaching the ental end of the spermiducal gland, but sometimes not. The spermatheca varies in the degree of the distension of the bulbular region, with the result that the extent of the ental process is reduced by a greater expansion of the bulb, but in the specimens I have seen the process is present and may, then, be a constant feature of the species.

AFFINITIES.—*Pterodrilus choritonamus* is related to *P. missouriensis*, *P. cedrus*, *P. mexicanus*, and *P. hobbsi*. Its affinities with the first three of these species have been discussed (p. 16). It differs from *P. hobbsi* in the absence of projections on the dorsal ridge of segment VIII, in the larger bursa and in having an ental process of the spermatheca.

HOSTS.—The known crayfish hosts of *P. choritonamus* are *Cambarus tenebrosus* Hay, *C. extraneus* Hagen, *Orconectes placidus* (Hagen) and *Orconectes* species.

DISTRIBUTION.—*Pterodrilus choritonamus* frequents tributaries of the Cumberland River in the Eastern Highland Rim in Tennessee.

MATERIAL EXAMINED.—Types and 28 specimens. The material for the most part is deposited in the United States National Museum (USNM 36473-36476).

Pterodrilus missouriensis, new species

FIGURES 8, 9

TYPE-SPECIMEN.—Holotype, USNM 36469, two paratypes, USNM 36470, and two paratypes, PCH 1476, from *Orconectes luteus* (Creaser)

taken in Whetstone Creek on U.S. Highway 60, 5 miles west of Mountain Grove, Wright County, Mo., by Perry C. Holt, August 23, 1961.

DIAGNOSIS.—Low dorsal ridges on segments I–VII, higher one on VIII, no dorsal projections; bursa large, its length equalling or ex-

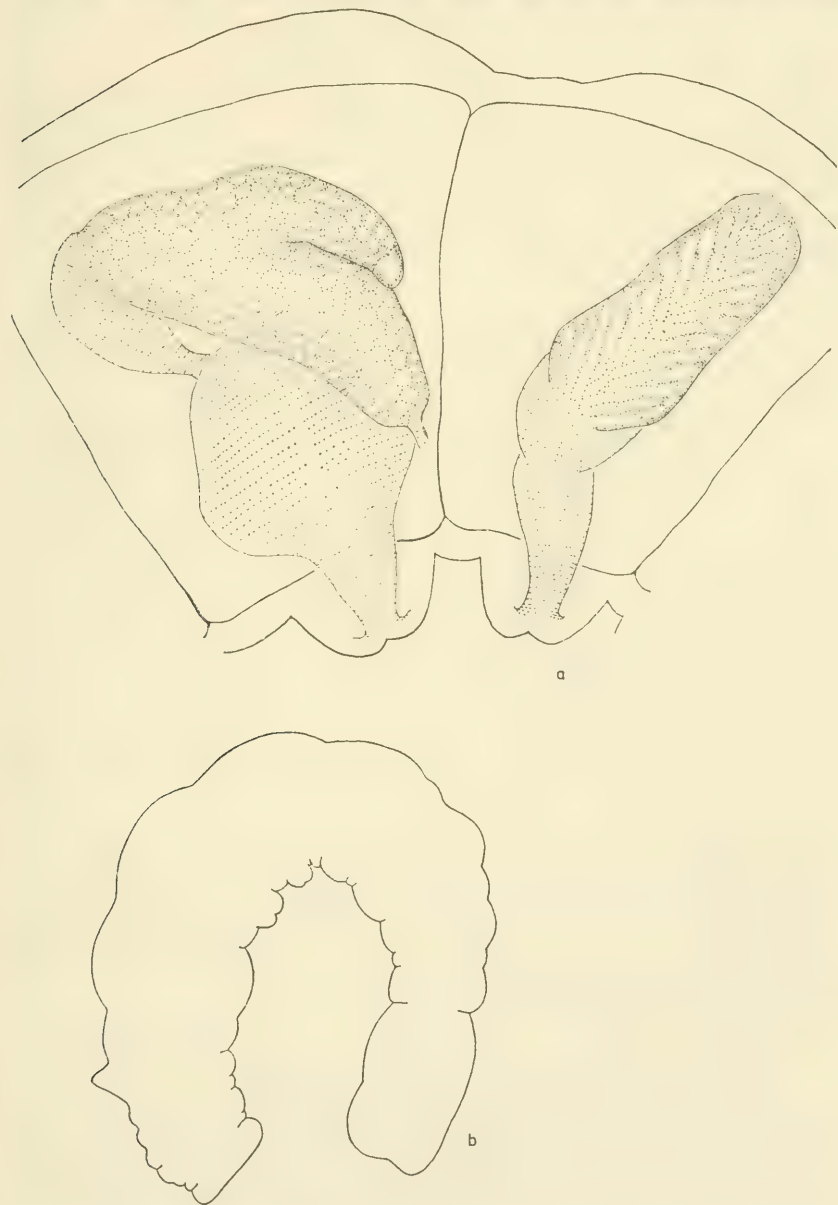


FIGURE 8.—*Pterodrilus missouriensis*: *a*, lateral view of reproductive systems; *b*, holotype.

ceeding $\frac{1}{2}$ body diameter; spermiducal gland relatively long, its length equalling or exceeding anteroposterior dimension of segment VI, narrowing at ectal end; prostate short, in diameter about $\frac{1}{2}$ that of spermiducal gland, incompletely divided from latter, histologically undifferentiated, with ental bulb; spermatheca spatulate, its length subequal to body diameter, ectal duct long, ental process absent.

ETYMOLOGY.—The adjectival form of Missouri.

DESCRIPTION.—The length, based on five animals, averages 1.6 mm (range 1.5–1.8 mm). The dorsal ridges of segments I–VII are poorly developed and in some extended specimens might be overlooked. That of segment VIII, however, is well developed. The anterior nephridiopore is clearly visible on the dorsum of segment III. The teeth of the jaws appear to be longer and more sharply pointed than is usual.

The male reproductive system in the totality of its primitive aspects, is unlike that of any other species of *Pterodrilus*. The spermiducal gland is relatively long and slender, its length more than three times its diameter. The prostate arises as a diverticulum of the gland rather far from the latter's junction with the ejaculatory duct. There is an abrupt narrowing at the point of origin of the prostate, from which point the spermiducal gland continues to decrease in diameter until it passes into the ejaculatory duct. The prostate has a diameter of about half that of the spermiducal gland and its ental end is located about $\frac{1}{3}$ of the length of the latter from its ental end: in all, the prostate is about $\frac{1}{3}$ the length of the spermiducal gland and lies along the median third of the gland. The prostate is not histologically differentiated, but there is an ental "bulb", a cavity of rather small extent. The ejaculatory duct is prominent and noticeably expanded along its midlength. The bursa is large, exceeding half the body diameter in length. The penis is prominent and the penial sheath region of the bursa is larger than usual.

The spermatheca has a long ectal duct that expands entally before it merges into the elongated, spatulate bulbular portion. There is no ental process, but in at least some specimens the entire wall of the bulb appears to be composed of large, granular cells with the result that the wall is much thicker than usual.

VARIATION.—The prostate appears to be of variable length, but this is probably because of the difficulty of estimating the comparative lengths of the prostate and spermiducal gland in specimens in which these organs are viewed from different directions. The ental part of the spermathecal bulb does not always appear to be filled with a glandular epithelium, but this is most likely a reflection of differences in degree of distension of the bulb with spermatozoa.

AFFINITIES.—*Pterodrilus missouriensis* is a primitive pterodrilid related to *P. choritonamus*, *P. mexicanus*, and *P. cedrus* (p. 21). It shares with *P. cedrus* the dorsal ridges of segments I–VIII but differs in the absence of projections on the dorsal ridge of segment VIII, the undifferentiated prostate, the shape of the spermiducal gland, the larger size of its bursa, and in the thicker-walled spermathecal bulb. *Pterodrilus missouriensis* and *P. choritonamus* both lack dorsal projections on segment VIII and have large bursae but differ in the presence of dorsal ridges on other segments, the undifferentiated prostate, the thicker-walled spermathecal bulb in the former, and an ental process

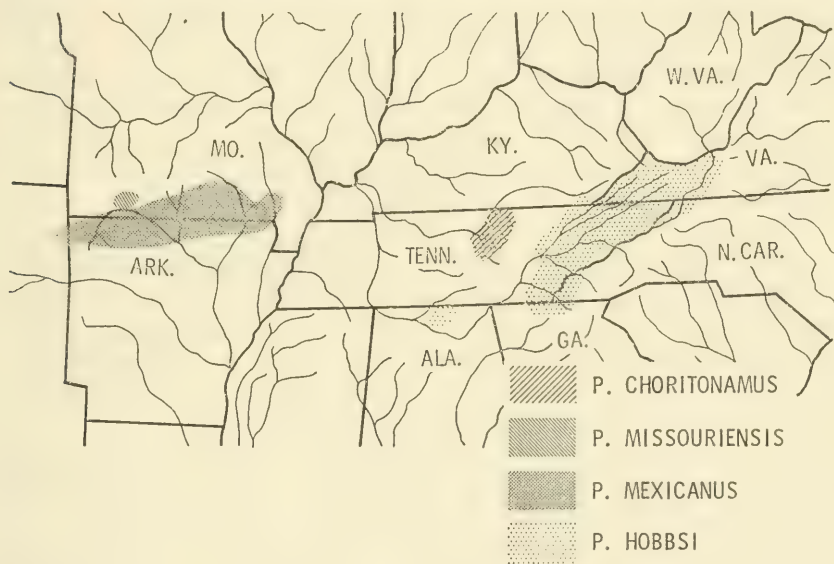


FIGURE 9.—Distribution of certain species of *Pterodrilus*.

of the spermatheca in the latter. *Pterodrilus missouriensis* shares with *P. mexicanus* the primitive nature of the prostate (p. 15) (though that of the latter is often partially differentiated), the large size of the bursa, and a spermatheca with a thicker-walled bulb; it differs from the latter in its much longer ejaculatory duct, the presence of dorsal ridges on segments anterior to segment VIII, and in the absence of dorsal projections.

HOSTS.—The only known host is *Orconectes luteus* (Creaser).

DISTRIBUTION.—*Pterodrilus missouriensis* is known only from the type locality, Whetstone Creek in Wright County, Mo. The one collection was taken from shallow pools in the headwaters of the stream, where there was little or no flow at an elevation of approximately 1260 feet. This locality is near the divide between the south-

ward-flowing White River drainage system and the northward-flowing Gasconade River and is a part of the latter system. There is no other record of a species of *Pterodrilus* from the Missouri River basin.

MATERIAL EXAMINED.—Five type-specimens.

Pterodrilus species

Poorly preserved material taken from three localities in the Hiwassee River drainage in Union County, Ga., and Cherokee County, N.C. (PCH 915, 974, 979), by Mr. Kenneth W. Simonds may well represent another species of *Pterodrilus*. These specimens appear to differ from those of other species of *Pterodrilus* in that there are three or four prongs of the dorsal projection on segment VIII, there appear to be dorsal ridges without projections on the other segments, and the prostate seems to be undifferentiated with a a thick-walled "prostatic bulb." The latter two points cannot be confirmed in my material, which raises the question as to whether the differences in the number of prongs of the dorsal projection may not be due to intraspecific variability in *P. hobbsi*. If the prostate should be differentiated and there are no dorsal ridges other than that bearing the projection on segment VIII, these animals could be distinguished from *P. hobbsi* only by the number of prongs of the dorsal projection. Better preserved material will almost surely show that these specimens represent a new species, but I am unwilling to describe a species on the basis of such poor material.

These specimens are from the following localities in the upper Hiwassee drainage: Union County, Ga., 2.6 miles east of the Fannin County line on U.S. Highway 76, hosts *Cambarus latimanus* (LeConte), *C. bartonii bartonii* (Fabricius), Nov. 5, 1958, K. W. Simonds, coll. (PCH 915); Union County, Ga., 0.5 mile north of Vogel State Park on U.S. Highway 19, hosts *Cambarus longulus longirostris* Faxon, *C. carolinus* Erichson, *Cambarus* species, Nov. 5, 1958, K. W. Simonds, coll. (PCH 979); Cherokee County, N.C., 1.4 miles off Joe Brown Road, in Grape Creek, hosts *Cambarus bartonii bartonii* (Fabricius), *Cambarus* species, June 6, 1959, K. W. Simonds, coll. (PCH 974).

Evolutionary Considerations

The genus *Pterodrilus* is a group of closely related species derived from a primitive stock of the genus *Cambarincola* that specialized in the direction of small size and presumably a relatively narrow niche on the crayfish host. It would be of considerable importance if we knew more precisely what this niche is. Brown (1961, p. 25) has shown that *P. aleicornus* is randomly distributed over the ventral surface of the hosts. The other species of the genus almost surely

occupy the same microhabitat. Diatoms make up a goodly part of the food of the species of *Pterodrilus* and they inhabit creeks and branches in upland regions, but nothing else is known about their ecological requirements. One is forced, then, to discuss their primitive characteristics and their subsequent specializations as adaptations fitting them for unknown ways of life. I shall proceed by describing the

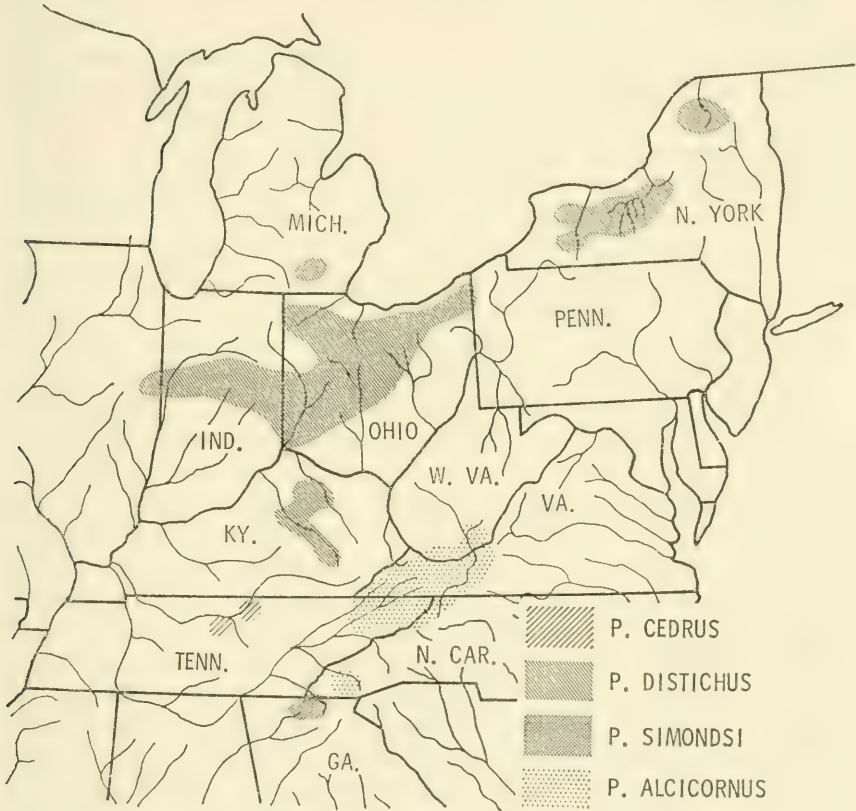


FIGURE 10.—Distribution of certain species of *Pterodrilus*.

hypothetical primitive pro-pterodrilus as I conceive it to have been and by defending, along the way, the reasons its various characteristics must be considered primitive. From these hypothetical considerations a tentative phylogeny will be derived and this in turn will be tested against the distributional data. Thus, a reasonable, if not necessarily true, story of the evolution of the genus can be written.

THE PRIMITIVE *PTERODRILUS*.—The ancestors of *Pterodrilus* were the smallest of the North American branchiobdellids, not

greatly, if at all, exceeding 2.0 mm in length. As branchiobdellids go, they were graceful animals, and their size was probably an adaptation that enabled them to escape competition with their larger relatives by retreating farther into the smaller crevices found on the underside of a crayfish than their relatives could and there exploiting the food found in such crannies.

The dorsum of the prosomite of segment VIII on these animals was raised into a ridge by the existence of supernumerary muscels. Such ridges are found on the prosomites of one or several segments of a number of branchiobdellids in genera that are not closely related to *Pterodrilus*, as well as among the species of the genera *Cambarincola* and *Oedipodrilus* Holt (1967a, p. 58). Perhaps this arrangement of the body-wall musculature is related in a mechanical sense to the hirudinoid mode of locomotion adopted by the branchiobdellids. One might conclude, then, that the absence of these ridges on all segments other than segment VIII is a primitive condition and that the evolutionary trend in *Pterodrilus* has been in the direction of an increasing number of such ridges.

The tendency in the genus *Pterodrilus* for the dorsal ridges to bear projections of unknown adaptive significance is shared with *Ceratodrilus* and the Asian *Cirrodrilus*, genera that are dissimilar to *Pterodrilus* in most other respects. The primitive progenitor of *Pterodrilus* lacked these projections, as the species *P. missouriensis* and *P. choritonamus* attest. In spite of our ignorance of the adaptive significance of these projections, it is assumed that the species with few or none are more primitive in this respect than are those with dorsal projections on several segments.

The jaws of pro-pterodrilus were generally small and delicate in appearance: the upper bore five teeth; the lower, four. Except for the reduction in size, this is the usual, and probably primitive, pattern in the genus *Cambarincola* and that found in all species of *Pterodrilus*. The cylindrical body shape, common anterior nephridiopore and 5/4 dental formula are features shared by *Pterodrilus* and *Cambarincola* and hence by the progenitor of *Pterodrilus*.

The innermost parts of the male reproductive system are basically the same in all branchiobdellids (Holt, 1965, p. 26) and nothing needs to be said about the testes in segments V and VI, the efferent funnels and ducts, or the deferent ducts. The spermiducal gland received the deferent ducts entally without the deferent lobes (Hoffman, 1963, p. 286) that are found in some putatively primitive species of *Cambarincola*. The gland had a lesser relative diameter and a proportionally greater length than that in all the species of today except *P. missouriensis* and, to a lesser extent, *P. mexicanus*.

The prostate was a small gland, about $\frac{1}{3}$ the length of the spermiducal gland, that arose about $\frac{1}{3}$ the latter's length from its junction with the ejaculatory duct. The prostate of the more advanced species of *Cambarincola* and *Pterodrilus* is differentiated. In pro-pterodrilus it was undifferentiated and consisted of a lobe of glandular epithelium that was histologically indistinguishable from that of the spermiducal gland. There may have been a prostatic "bulb" at the ental end that consisted of a few differentiated cells. In more advanced species of *Cambarincola*, the bulb is a distinctive and specialized part of the prostate. In all species of *Pterodrilus* the lumen of the prostate opens into that of the spermiducal gland some distance entad to the junction of the latter with the ejaculatory duct. In *Cambarincola*, the prostate and spermiducal gland usually open together into the ejaculatory duct. That the prostatic glands of the two genera are homologous cannot be doubted, but that of *Pterodrilus* is closer in this respect than is *Cambarincola* to *Ceratodrilus* Hall (Holt, 1960a, p. 57), *Ellisodrilus* Holt (1960b, p. 172), and *Oedipodrilus* Holt (1967a, p. 58). The latter genera must on this account and others be considered as primitive relatives of *Cambarincola*. The histological differentiation of the prostate occurs in the more advanced species of both *Cambarincola* (Hoffman, 1963, pp. 287, 301, et seq.) and *Pterodrilus* (only *P. missouriensis* has a completely undifferentiated prostate). The evolutionary trend in the specialization of the prostate seems to be clear.

The ejaculatory duct was probably short; though this supposition is based upon the length of the ejaculatory duct of *P. mexicanus*, it is strengthened by the fact that in the presumably primitive genera of the branchiobdellids, the ejaculatory duct is absent or short (Holt, 1968).

The bursa of pro-pterodrilus was proportionally larger than that found in *Cambarincola* and all the pterodrilids except *P. missouriensis* and *P. mexicanus*. The penial sheath region of the bursa may not have been unusually large, but the penis may have been partially eversible. This conjecture is based upon the opinion (Holt, 1968) that the primitive members of the lineage leading to *Cambarincola* and *Pterodrilus* possessed an eversible as opposed to a protrusible penis. The known members of this lineage (*Magmatodrilus* Holt, 1967b, and an unnamed Mexican genus), which lack a prostate, possess a bursa with a large penial sheath enclosing an eversible or semi-eversible penis; those (*Oedipodrilus* and *Ceratodrilus*) with incompletely separated prostates likewise have large bursae with eversible penes. Arguments based on the spacial relationships of the set of tubes that is the male reproductive system of the branchiobdellids and the conditions in other annelids have been set forth elsewhere

(Holt, 1968) supporting the hypothesis that an eversible penis, as opposed to the protrusible one, is primitive. If these arguments be allowed, it would be expected that pro-pterodrilus may have been provided with a penis that was proportionally longer and less in diameter than the cone-shaped one of *Cambarincola*. Such a penis is found in *P. missouriensis*, *P. mexicanus*, and *P. choritonamus*.

The spermatheca had an ectal duct that was heavily muscular and entally expanded at its junction with the spermathecal bulb, which in turn was provided with a muscular wall or a thick lining of tall columnar epithelial cells. There may have been an ental process, but in any case the spermatheca consisted of more diverse elements than the simple muscular tube that is the spermathecal duct and the thin-walled expanded bulb without an ental process characteristic of the advanced members of the genus and of *Cambarincola*. This opinion is based upon conditions in related but more primitive genera (Holt, 1960a, 1967b, 1968) and upon a consideration of conditions in what are otherwise thought to be primitive species of *Pterodrilus*, i.e., those with an undifferentiated prostate.

A PHYLOGENY OF THE GENUS *PTERODRILUS*.—Except that it has low dorsal ridges on segments I to VII and that the spermatheca varies in ways difficult to evaluate, *P. missouriensis* fits remarkably well the above description of the primitive *Pterodrilus*. But three other species form with this one a group of primitive phylogenetic relicts in the genus: *P. choritonamus*, *P. mexicanus*, and *P. cedrus*. The major problem remaining in the attempt to reconstruct the history of the genus is that of convergence. If one bases a proposed phylogeny on the evolution of dorsal ridges and projections, a quite satisfactory scheme is produced except that there are two distinct lineages of which the more advanced members of each have very similar reproductive systems. Conversely, a phylogeny based on the evolution of the reproductive systems produces a phylogenetic dendrogram that is almost a straight line and places closely together such species as *P. hobbsi* and *P. alcicornus* that otherwise are unlike. The solution has been a modified compromise (fig. 11) that assumes a considerable degree of convergence in the evolution of the reproductive systems, mostly because the alternative would suggest that at least some lineages alternately acquired and lost dorsal ridges and projections, an inherently improbable hypothesis.

Two levels of structural specialization were reached in the evolution of *Pterodrilus* and two minor radiations occurred. Four species (*P. missouriensis*, *P. choritonamus*, *P. mexicanus*, and *P. cedrus*) compose a group, derived from the original pro-pterodrilus stock, that is characterized by primitive features of the reproductive system and dorsal projections on only one segment or none at all. From the



FIGURE 11.—A phylogeny of the genus *Pterodrilus*.

radiation that produced these species, a form similar to *P. mexicanus* gave rise to *P. hobbsi*, which evolved a more advanced type of reproductive system and stands at the second evolutionary level. *Pterodrilus cedrus* is the survivor of a stock with dorsal ridges and projections that gave rise to the other main lineage composed of *P. distichus*, *P. alcicornus*, and, at a more primitive stage of the development of the reproductive systems, *P. simondsi*, the members of the second radiation.

PLACES OF ORIGIN AND MIGRATIONS.—When the distribution of the species of *Pterodrilus* (figs. 9, 10) is considered along with the hypothesis of their phylogeny that has been sketched here, some conclusions immediately emerge. The phylogenetically primitive species are scarce and localized. The most primitive of all, *P. missouriensis*, is known from a single location in the headwaters of the Gasconade River in Missouri. The more abundant but still relatively scarce *P. mexicanus* is essentially confined to the White River system in Missouri and Arkansas since it is otherwise known only from the nearby St. Francis River in Missouri, a tributary to the Arkansas River in Oklahoma, and Veracruz, Mexico. *Pterodrilus choritonamus* and *P. cedrus* are inhabitants of tributaries to the Cumberland River in the Eastern Highland Rim and Nashville Basin regions of Tennessee, *P. hobbsi* is a widespread and successful species of the Cumberland and Tennessee River systems with outliers in the Big Sandy and New Rivers. Of the species of the lineage with dorsal projections on multiple segments, the most primitive, *P. simondsi*, is localized in the Hiwassee River drainage of the Tennessee basin; *P. distichus* is a species of the Kentucky River that has crossed the Ohio to invade the eastern Great Lakes and St. Lawrence drainages; *P. alcicornus* is found in the Tennessee and New River systems, again with outliers to the east and north in the Savannah, Roanoke, James, and Big Sandy Rivers.

The ancestral home of the genus *Pterodrilus* most likely is in the headwaters of the Cumberland River in the Eastern Highland Rim region of Tennessee. Two of the four most primitive species, *P. choritonamus* and *P. cedrus*, still persist as phylogenetic and geographic relicts in this region. The other species are arranged radially around this center in a fashion that almost requires that their ancestors come from the Cumberland (fig. 12).

The same general region was the postulated home of the ancestors of the host animals, primitive *Procambarus* crayfishes that gave rise to the genera *Orconectes* and *Cambarus*, with *Orconectes* spreading mostly to the north and west, *Cambarus* to the east and south, and some stocks of *Procambarus* southwestward into Mexico (Hobbs, 1967, p. 15). The modern host relationships of species of *Pterodrilus* can

afford little insight into the problems of evolution and migrations of either the hosts or their epizootes: it is well established (Goodnight, 1940, p. 65; Hobbs, Holt, and Walton, 1967, p. 75) that host specificity in the classical sense of a species-to-species correspondence does not occur. Yet it is worthy of note that the crayfish-branchiobdellid associations as recorded under "Hosts" for each species is consistent with the hypothesis that *Pterodrilus* originated in the Cumberland basin and spread from there with the ancestors of the hosts of today, mostly species of *Orconectes*.

An attempt is made (fig. 12) to diagram more precisely the geo-

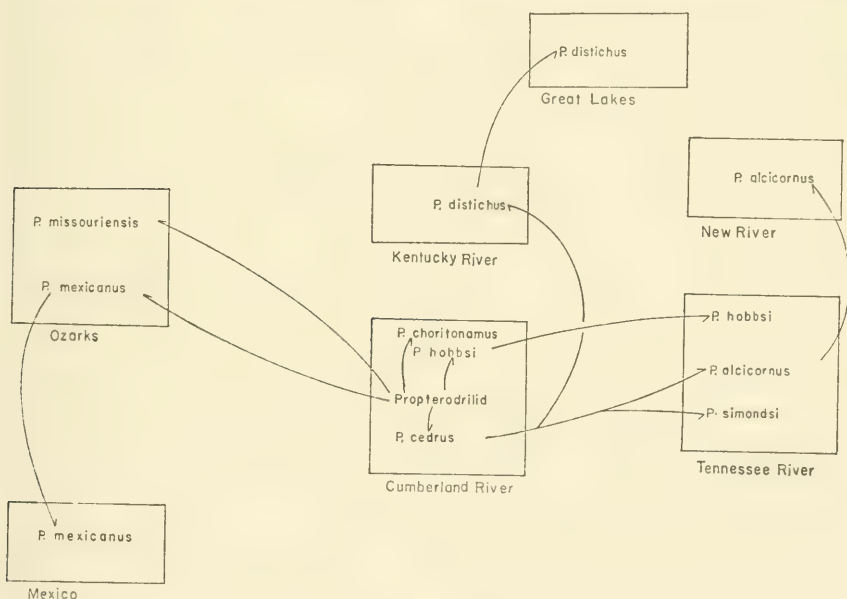


FIGURE 12.—The evolution of the genus *Pterodrilus*.

graphical relationships of the species of *Pterodrilus*. The times at which all these migrations occurred cannot be determined on the basis of the evidence now available, but the original diversification of the early *Pterodrilus* stock took place well back in the Tertiary, and the movement of *P. distichus* into the glaciated regions of the north, of necessity, has happened since the last glaciation. Without attempting to pinpoint the events in time on the basis of the hypothesis developed, we can note that an early diversification of pro-pterodrilid stocks occurred in the Cumberland basin. Of this radiation, *P. choritonamus* and *P. cedrus* remain in the general area of their ancestral home as relict forms. A primitive species, represented today by *P. missouriensis*, moved early into the northward-flowing streams of the Missouri

Ozarks. Whether *P. mexicanus* is a descendant of this stock that moved over the Ozarkian divide into the White River and adjacent drainages cannot be determined with certainty: the postulated phylogeny suggests that it likewise came into the Ozarks by the same route, but if so, it seems somewhat strange that it is unknown from the Missouri basin. Yet few collections have been taken from the northern Ozarks in Missouri, and further field work may well reveal the presence of *P. mexicanus* there. But *P. mexicanus* is obviously extinct over much of the route it or its ancestral form must have taken to reach the Ozarks, and the same or similar factors that caused this restriction of range may operate in the streams of the Missouri River system in southern Missouri. It is not surprising that an early stock of *Pterodrilus* may have moved into Mexico: the crayfish hosts did so sometime before the end of the Miocene (Hobbs, 1967, p. 15). The possibility remains that the Ozarkian worms are not conspecific with the type of *P. mexicanus* (see p. 18 above), but any solution of the problem of the status of *P. mexicanus* will fit these ideas; for if it is recovered from Mexico and a new name assigned to my specimens from the Ozarks, the Mexican worms are, on the basis of my study of the type, very similar to the Ozarkian ones. Such a solution, however, would date the early migrations of *Pterodrilus* stocks in the Miocene or earlier (Hobbs, 1967, p. 15).

Turning now to the north and east, we note that there are large gaps in the range of *P. distichus* (fig. 10) that can only be attributed to inadequate collecting. The records from the Kentucky and Licking Rivers are near the postulated place of origin of the species and may represent the Pleistocene refugium from which *P. distichus* has moved north and northeastward, most likely by way of the Miami and Scioto Rivers, since the Wisconsin glaciation. The gap in the range of *P. distichus* in the Lake Erie basin in Pennsylvania and New York surely represents inadequate collecting.

Pterodrilus hobbsi has arisen from a stock that also produced *P. mexicanus*, but it has reached a higher level of development in the structures of the reproductive systems. Its sympatry with its primitive relative *P. choritonamus* argues for its origin in a part of the Cumberland basin, perhaps the headwaters of the Cumberland in southeast Kentucky, not inhabited by the latter and a reinvasion of the homeland. From such a region, the invasion of the Tennessee basin, where *P. hobbsi* is widespread and successful, of the Big Sandy, and of the New River is entirely possible. There are, however, gaps in its known range, and other histories of the species are possible. Its absence from the central part of the Cumberland Plateau in Tennessee appears to be real, but further collecting can be expected

to connect the parts of its range that now appear to be disjunct. If so, the upper reaches of the Cumberland in Kentucky remain the likely site of origin for *P. hobbsi*. The few scattered records from the Big Sandy and the New Rivers indicate that the species is still actively extending its range, and much of the spreading of *P. hobbsi* may well have occurred quite recently.

The migrations of *P. distichus*, *P. hobbsi*, and *P. alcicornus* may have occurred rather recently, but the movement of the stock that gave rise to *P. simondsi* must be older. Although it is believed that a common ancestor gave rise to both *P. simondsi* and *P. alcicornus*, the former clearly stands at a lower level of evolutionary advance as is indicated by the primitive nature of its reproductive systems. It is known only from the tributaries to the Ocoee River and one locality in the Nottely, both parts of the Hiwassee River system of the Tennessee River basin. *Pterodrilus simondsi* is found, then, at the southeastern periphery of the range of the genus in an isolated part of the somewhat isolated Hiwassee basin. Its ancestors came from the Cumberland and its known distribution can be explained by postulating that the species was once widespread in the Tennessee basin but has been eliminated throughout all of its range except the small part in the Hiwassee by the more advanced, successful, and widespread species, *P. hobbsi* and *P. alcicornus*. In any case, though the origins of *P. simondsi* may not be as ancient as those of the relict species in middle Tennessee and the Ozarks, it is an older relative of *P. alcicornus* holding out in a relict status in a part of the Tennessee basin not yet successfully invaded by the latter.

If the *hobbsi*-like animals mentioned above (p. 32) are conspecific with other populations of *P. hobbsi*, the Hiwassee drainage is being invaded by this more advanced species, but if, as seems more likely, these specimens represent a survival of the primitive stock that gave rise to *P. cedrus*, we have at the periphery of the present range of the genus a relict of the first radiation within *Pterodrilus*.

Pterodrilus alcicornus is the most advanced and successful species of the genus. It is a native of the New River basin that has in recent times extended its range, probably by stream captures, into the James and Roanoke basins to the east, into the Big Sandy to the north, and, amazingly, into the Savannah in the south. The latter invasion can only have occurred by means of the streams of the Tennessee system that lie between the headwaters of the New and the Savannah in western North Carolina, a region that has been inadequately sampled. Still earlier, *P. alcicornus* had moved into the upper reaches of the Tennessee River system in southwestern Virginia and north-eastern Tennessee, where it is sympatric with *P. hobbsi*, often occupy-

ing the same streams and presumably the same hosts. A *cedrus*-like stock that gave rise to *P. distichus* to the north and a more primitive member, *P. simondsi*, to the south, moved by way of former connections with the Cumberland into the New River basin to produce *P. alcicornus*.

The history of the genus *Pterodrilus* is conceived in broad outline, then, to be like this: In early Miocene or pre-Miocene times a primitive stock of cambarincoloid branchiobdellids were epizoites carried by the progenitors of the modern crayfish fauna of the upland regions of eastern North America. These animals lived along the slopes of the present Appalachian uplift, represented today by the Cumberland Plateau and the Highland Rim, which was drained by a stream that corresponded to the present day Cumberland. From this center, early stocks moved into the Ozarks and perhaps on into Mexico with the progenitors of the Mexicanus Section of the crayfish genus *Procambarus* (Hobbs, 1967, pp. 13-15) and produced the species *P. missouriensis* and *P. mexicanus*. *Pterodrilus choritonamus* and *P. cedrus* are the survivors (and representatives of the two lineages produced) of this early diversification that remained in the area of their origin and *P. hobbsi* is a more advanced member of the *choritonamus-mexicanus* lineage that has not only remained in the Cumberland basin but has successfully invaded the Tennessee system and more recently the New River drainage. Some of the early members of the *missouriensis-cedrus* lineage have also moved eastward, with one and possibly two (*P. simondsi* and the unnamed animals) remaining today in the Hiwassee basin as relicts. This lineage also gave rise to the advanced species, *P. alcicornus*, in the New River basin. Moving to the north, most likely by way of the Kentucky River or a nearby stream, another branch of this lineage gave rise to *P. distichus*, which remained in the Kentucky region throughout the Pleistocene, and in Recent times has followed its crayfish hosts (primarily species of *Orconectes*) into the Great Lakes and the St. Lawrence basins.

These migrations have left three regions in which primitive species remain today: the original home, the Cumberland basin; the Ozarks in the Missouri and Arkansas river systems (and possibly the eastern slopes of the Sierra Madre Oriental in Veracruz); and the Hiwassee basin along the southwestern slope of the Blue Ridge. Of the dominant members of the genus, *P. hobbsi* is a product of the original diversification in the Cumberland that today is most successful in the Tennessee basin; while of a second radiation of the *P. cedrus* lineage, *P. distichus* has invaded the recently glaciated areas to the north, and *P. alcicornus* has made its principal home in the valley of the New River.

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