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COPEPOD CRUSTACEANS PARASITIC ON ELASMOBRANCH FISHES OF THE HAWAIIAN ISLANDS[1]

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Introduction

This is the second of a series of three papers covering the copepod parasites of Hawaiian fishes. The first (Lewis, 1964) deals with the caligoid copepod parasites of Hawaiian acanthurid fishes (surgeon fishes). The third paper (in preparation) proposes to cover the copepod parasites of teleost fishes of the Hawaiian Islands.

The two references to copepod parasites of Hawaiian elasmobranch fishes are of an incidental nature. Wilson (1924) indicated that *Pandarus satyrus* had been taken from specimens of *Prionace glauca* and (Wilson, 1932) that *Pandarus smithii* had been collected from sharks in Hawaiian waters. Because of the wide distribution of many of the host species it is not surprising that only one of the thirteen species here discussed is described as a new species.

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Many people and institutions have been of significant assistance in the collection of the material and have assisted in other aspects of the study. The author is grateful to the Central University Research Fund of the University of New Hampshire for the assistance that it provided in the purchase of a Bausch and Lomb Tri-Simplex Micro-Projector, and to the Division of Marine Invertebrates of the Smithsonian Institution for working space and use of the specimen collections and the Wilson Library. Although the people and institutions involved in the collection of the specimens are noted in the description of the species, the author is especially grateful to the U.S. Fish and Wildlife Service, the Hawaii Board of Agriculture (Division of Fish and Game), Lester Zukeran, Samuel Kaolulo and Susumo Kato for the collection of both host and copepod material.

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

Leg	Margin	Inter-podal Plate	Protopodite	Exopodite			Endopodite		
				1	2	3	1	2	3
	outer	S	m, d, h, rh, r	r, D, d, p'	dm, H	pH, fmH, mh, mH	C	c	c, p', P', Q
	inner		a, m, b, 1sss, s	c, dfH	c, B	Cl, dmH, dH, H	P	c, p, p'	P, dP, mP

Methods: The external surface, gill cavities, buccal cavity and nasal cavities of the elasmobranch hosts were examined for parasitic copepods. Copepods collected from these regions were killed in either 10 percent formalin or ethyl alcohol and later transferred to 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 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. Both a camera lucida and a Bausch and Lomb Tri-Simplex Micro-Projector were used in making these drawings. The appendages and processes were drawn, either in situ on the specimen or removed and mounted using Hoyer's mounting medium or Turtox' CMC–10. Measurements of the copepods and their component parts were made with an ocular micrometer.

In the following figures the ♀ and ♂ signs are used separately under each drawing to indicate a difference between the appendage of the female and that of the male. The female and male symbols are used together (♀ ♂) to indicate similarity of the appendage or process in both sexes. The sex from which the drawing is made is indicated by a line under the appropriate symbol. If only one sex is represented in the collection and no comparative descriptions or illustrations are given, the male and female symbols are not used.

The terminology used is basically the same as that in Lewis (1964). The terms postantennular adhesion pad, postantennal process, postoral process and postoral adhesion pad imply the position and nature of the structure, not the association of it with any appendage. The

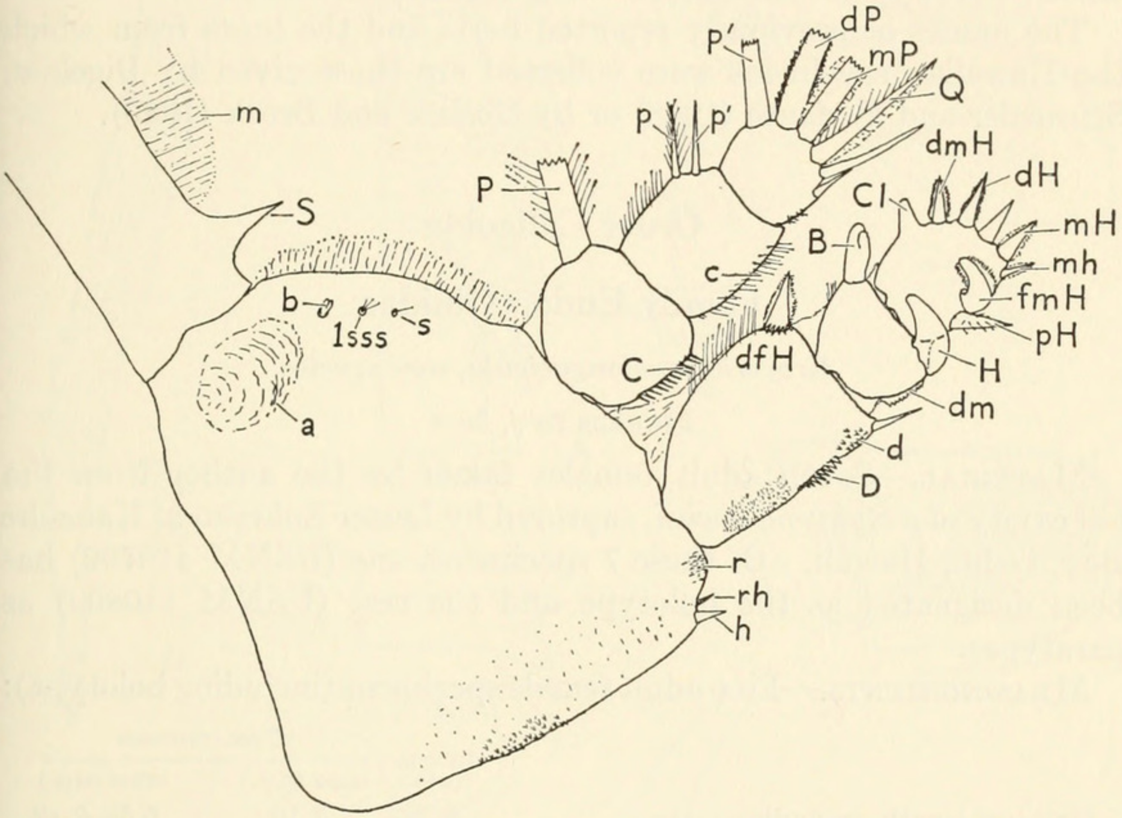

FIGURE 1.—Hypothetical thoracic leg showing various armament components:

a: adhesion pad
B: large bilobed armature element
b: small bilobed membranous process
C: large plumosities
c: small pulmosities
Cl: spikelike extension of segment
D: large denticulations
d: small denticulations
dfH: large spine with frilled membranous margin and denticulations around base
dH: large spine with denticulated membrane along margins
dP: large, denticulated seta
fmH: large spine with frilled membrane along margin
H: large spine
h: small spine
m: membrane
mH: large spine with membranous margin
mh: small spine with membranous margin
mP: large membrane-margined seta
P: large plumose seta
p: small plumose seta
P': large naked seta
p': small naked seta
pH: large plumose spine
Q: seta with membrane along one margin, plumosities along other
r: rugose surface
rh: spinule
S: spikelike projection of interpodal plate
s: small hairlike projection
1sss: 3 hairlike projections from same location

author feels that the terms postantennal process and postoral process, as applied to the structures termed first and second maxilla by Wilson (1907a), are noncommittal terms and should be used until the nature of the two structures in question is better understood. To facilitate the use of the thoracic-leg tables, a hypothetical thoracic leg is shown in figure 1, giving all of the component parts of the armament of the thoracic legs discussed in tabular form in the paper. Further, a table of the hypothetical thoracic leg is given in table 1.

The names of previously reported hosts and the hosts from which the Hawaiian specimens were collected are those given by Bigelow, Schroeder and Farfante (1948) or by Gosline and Brock (1960).

Order Caligoida

Family Eudactylinidae

***Krøyeria praelongacicula*, new species**

Figures 2*a–j*, 3*a–e*

Material.—Seven adult females taken by the author from the gill cavity of a *Sphyrna lewini*, captured by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii. Of these 7 specimens, one (USNM 110799) has been designated as the holotype and the rest (USNM 110800) as paratypes.

Measurements.—Five adult female specimens (including holotype):

	holotype (*mm.*)	*all five specimens*	
		mean (*mm.*)	*range* (*mm.*)
Greatest length, excluding setae	6.79	7.10	6.58–8.12
Greatest length of cephalothorax	0.88	0.87	0.84–0.88
Greatest width of cephalothorax	0.92	0.95	0.90–1.04
Greatest length of free pedigerous segments	1.06	1.02	0.98–1.06
Greatest length of genital segment	3.80	4.00	3.10–5.00
Greatest width of genital segment	0.55	0.58	0.50–0.65
Greatest length of abdomen	1.28	1.24	1.16–1.28
Greatest width of abdomen	0.28	0.26	0.22–0.28
Greatest length of aciculum	1.30	1.25	1.20–1.30
Length of egg string (1 specimen)			2.75 (27 eggs)

Diagnostic description of female.—Cephalothorax (fig. 2*a*) ovoid, consisting of cephalic, maxilliped-bearing and first pedigerous segments. Anterior cephalothoracic margin flatly rounded, curving sharply laterally, sharp lateral curve continued posteriorly as distinct line separating raised median cephalothoracic region from narrow, winglike lateral regions. Lateral regions terminating posteriorly in small, lobate extension marking posterior outer corner of small, irregular sinus. Apex of sinus giving rise, ventrally, to single,

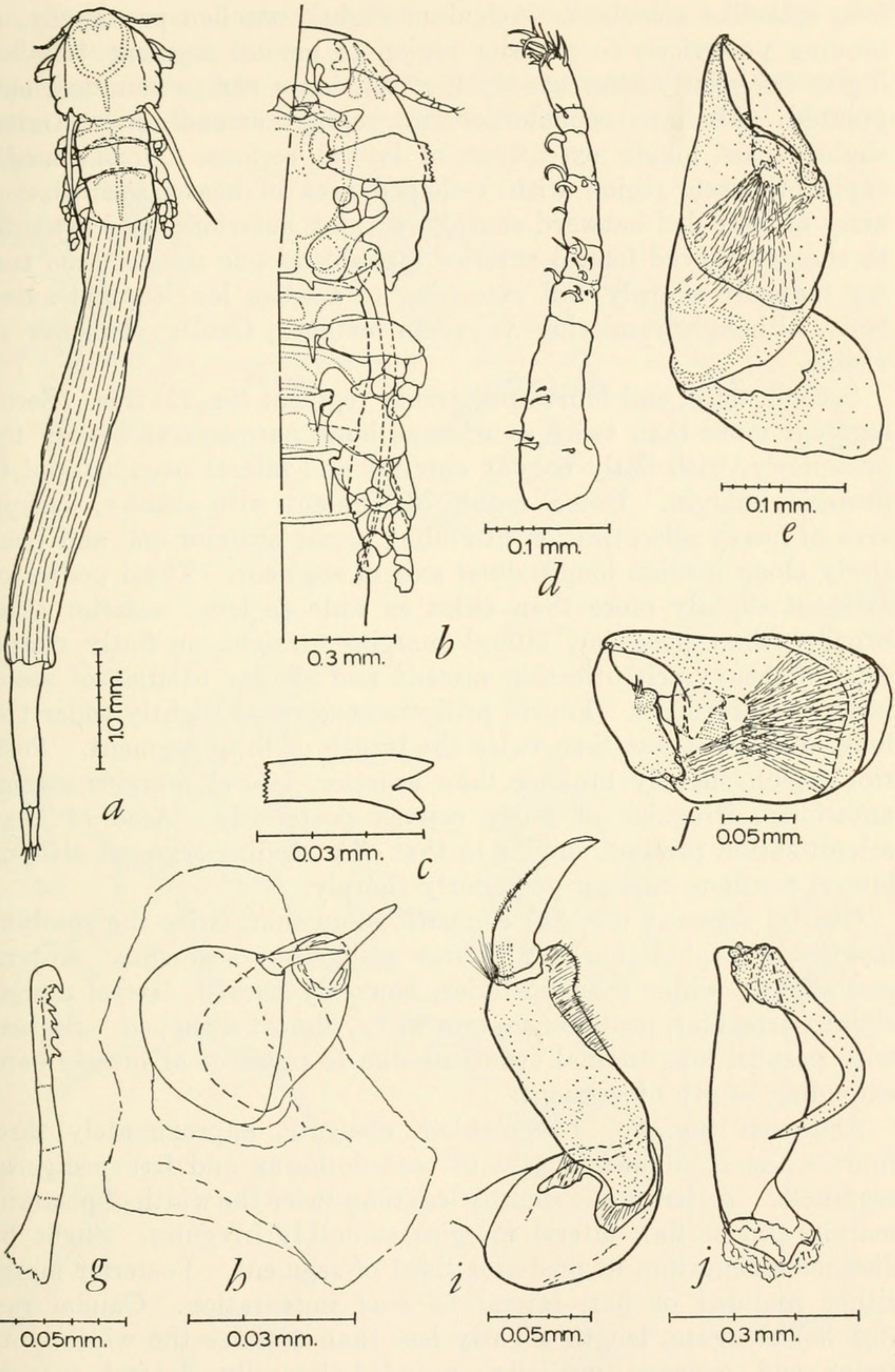

FIGURE 2.—*Kroyeria praelongacicula*, new species, female: *a*, dorsal view; *b*, cephalothorax and free pedigerous segments, ventral view; *c*, tip of aciculum; *d*, left antennule, ventral view; *e*, right antenna, anterior view; *f*, left antenna, anterior view; *g*, left mandible; *h*, right postoral process, ventral view; *i*, right maxilla, posterior view; *j*, right maxilliped, ventral view.

long spikelike aciculum. Aciculum slightly swollen proximally, extending posteriorly to anterior region of genital segment, terminating in irregularly bifurcate tip (fig. 2*c*); inner ramus rounded, outer pointed. Median cephalothoracic region extending posteriorly slightly past lobate extensions of lateral regions. Dorsal median cephalothoracic region with Y-shaped area of heavy sclerotization, arms of Y-angled outward sharply, turning anteriorly and extending to sharply curved lateral anterior cephalothoracic margin then turning medially sharply and extending to median longitudinal axis of body although ramifying to some extent. Ocular elements not visible.

Second, third, and fourth pedigerous segment (fig. 2*b*) free. Second segment more than twice as wide as long, narrower anteriorly than posteriorly, with flatly convex anterior and lateral margins and flat posterior margin. Dorsal region of segment with slender, irregular area of heavy sclerotization extending across anterior end and posteriorly along median longitudinal axis of segment. Third pedigerous segment slightly more than twice as wide as long, anterior region broader than posterior, lateral margins straight or flatly convex. Area of heavy sclerotization present and similar to that of second pedigerous segment. Fourth pedigerous segment slightly wider than long, somewhat less than twice the length of third segment. Posterior region slightly broader than anterior, lateral margins straight anteriorly, irregular or flatly convex posteriorly. Area of heavy sclerotization present, similar to that of preceding segment although lateral portions curving posteriorly sharply.

Genital segment (fig. 2*a*) elongate, more than twice the combined lengths of cephalothorax and free pedigerous segments. Anterior end slightly wider than posterior, convexly curved, lateral margins slightly irregular, posterior margin wavy, almost scalloped. Segment with parallel longitudinal striations due to presence of muscle bands extending length of segment.

Abdomen (fig. 2*a*) 1-segmented, elongate, approximately three-fourths the combined lengths of cephalothorax and free pedigerous segments. Anterior end slightly less than twice the width of posterior, margin almost flat, lateral margins smoothly irregular. Slight but distinct indentation in posterior third of segment. Posterior margin either rounded or flat, lateral to anal indentation. Caudal rami (fig. 3*e*) elongate, length slightly less than 6 times the width. Anterior end concave medially, rounded laterally, lateral margins smoothly irregular although parallel for most of length. Posterior margin rounded, surface bearing 4 large, hook-shaped setae, inner two lightly plumose, larger than outer two. Two additional, hairlike setules present, one on outer posteroventral surface, one on outer posterodorsal surface.

Antennule (fig. 3*d*) 7-segmented, projecting laterally and posteriorly from ventral anterolateral cephalothoracic surface. First segment

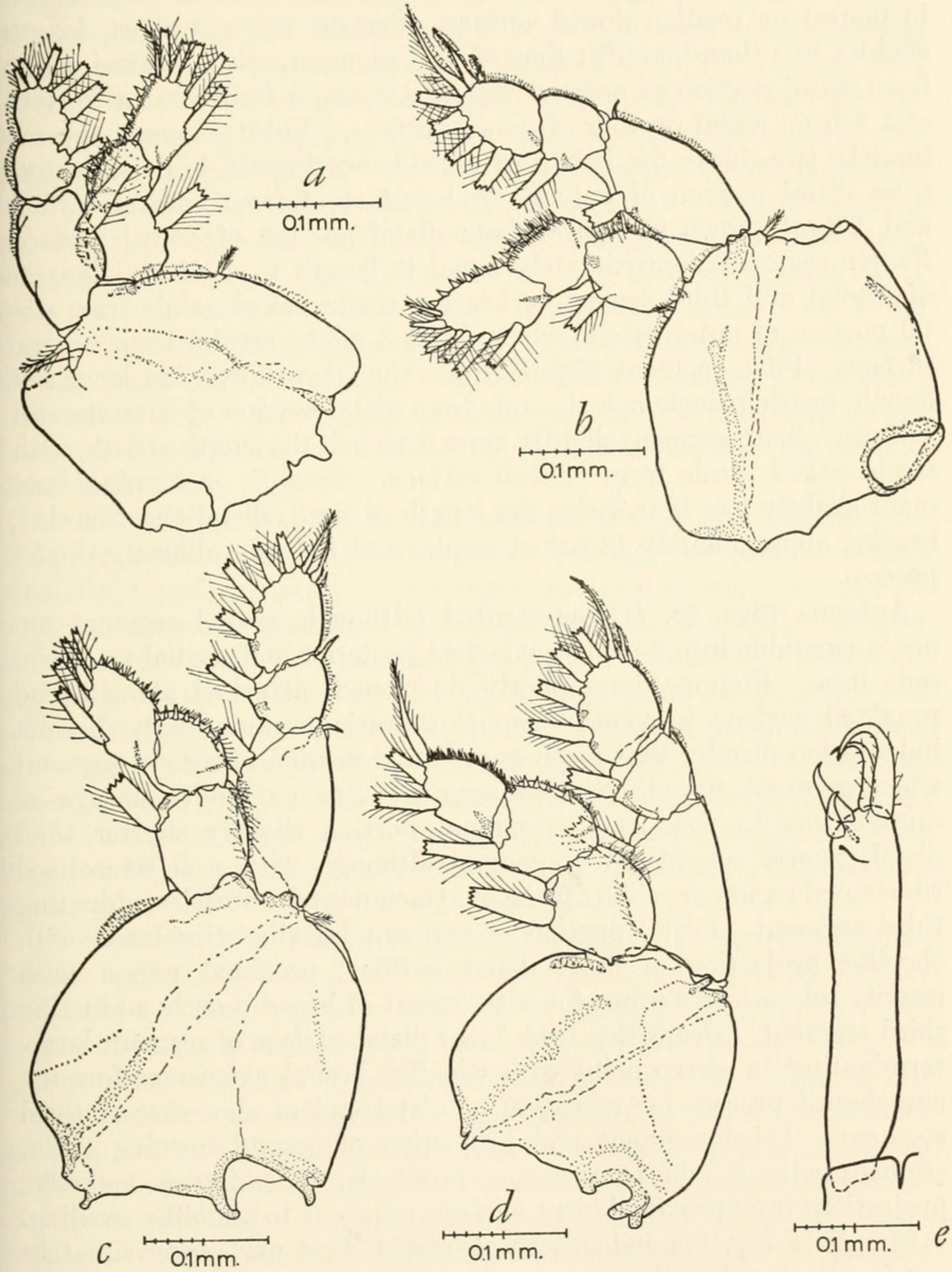

FIGURE 3.—*Kroyeria praelongacicula*, new species, female. Right thoracic legs: *a*, first leg, posterior view; *b*, second leg, anterior view; *c*, third leg, anterior view; *d*, fourth leg, anterior view. Left caudal ramus: *e*, ventral view.

well developed, length slightly less than three-fifths combined lengths of rest of segments, with irregular areas of heavy sclerotization, grooves and other superficial markings in addition to 6 naked setules on proximal half of anterior ventral surface, 1 naked setule on posteroventral surface in proximal region and naked setule (not shown in figure) on median dorsal surface. Second segment short, length slightly less than one-fifth that of first segment, with 1 naked setule from distal portion of anterior lateral surface, 3 from ventral surface and 1 from distal portion of dorsal surface. Third segment approximately two-thirds the length of second, bearing single naked setule from distal portion of anterolateral surface, 4 from ventral surface and 1 (not shown in figure) from distal portion of dorsal surface. Fourth segment approximately equal in length to combined lengths of second and third segments, bearing single naked setule from distal portion of anterolateral surface and 3 naked setules from ventral surface. Fifth segment slightly more than two-thirds the length of fourth, bearing single naked setule from distal portion of anterolateral surface. Sixth segment slightly more than half the length of fifth, with single naked setule from ventral surface. Seventh or terminal segment slightly less than twice the length of sixth, distal end rounded, bearing approximately 13 naked setules and 1 slender, bluntly tipped process.

Antenna (figs. 2*e*, *f*) 3-segmented (although second segment appears separable into 2 parts), attached posterior and medial to antennule base. First segment poorly developed, attached along broad proximal surface to ventral cephalothoracic surface, with distinct indentation distally that receives proximal portion of second segment when segment flexed. Second segment 2-parted (note nature of musculature in figs. 2*e*, *f*), proximal portion slightly shorter than distal, poorly sclerotized in general although with well sclerotized rib-shaped region providing place of attachment for muscles adducting third segment. Distal portion of segment heavily sclerotized, with clawlike projection of inner distal surface; proximal region with heavily sclerotized surface for attachment of broad muscle adducting third segment. Projection from inner distal surface of segment large, terminating in sharp point with winglike lateral extensions forming cup-shaped process for reception of distal end of claw-shaped third segment. Third segment and projection of second forming chela, segment with 2 minute accessory processes, appearing as spikelike projections from proximal inner surface, adjacent to knoblike swelling.

Mandible (fig. 2*g*) indistinctly 4-parted, first part approximately one-fourth the length of appendage. Second part approximately three-fourths the length of first, third part equal to length of first but more slender, with slight taper from proximal to distal regions.

Fourth part approximately one and one-fourth times the length of first, distal end sharply rounded, forming inwardly-directed, hook-shaped process. Fourth part with 4–5 large and several small, toothlike projections on inner margin. Postoral process (fig. 2*h*) consisting of 2 nodules arising from platelike area of heavy sclerotization immediately lateral to mouth cone base; each nodule bearing single, setule-like process distally. Maxilla (fig. 2*i*) 2-segmented, situated lateral and posterior to mouth cone. First segment slightly less than half the length of second; anterior and posterolateral surfaces projecting distally as rounded, lobate processes that articulate in depressions of proximal end of second segment. Second segment more elongate than first, with fan-shaped swelling on inner distolateral surface. Plumosities present on fan as well as ridge leading to it from median inner surface. Outer distolateral corner with small concavity bearing plumosities, plumosities extending around to anterolateral distal surface. Distal end of segment forming articulation surface for large, saber-shaped terminal process bearing frilled membrane along outer surface and flabby, membranous covering around distal end.

Maxilliped (fig. 2*j*) 2-segmented, situated medial and slightly posterior to maxilla base. First segment strongly developed, widest medially, tapering sharply proximally to rounded proximal end, gradually to irregular distal end. Irregular distal surface with V-shaped inner margin, irregularly knobbed anterior and posterior lateral margins and slightly knobbed outer margin. Knobs on both antero- and posterolateral margins articulating in depressions on proximal surface of segment. Second segment incompletely fused with elongate terminal process. Segment and process slightly longer than first segment although segment very short and heavily sclerotized; terminal process long, heavily sclerotized and acuminate, curving sharply inward and posteriorly.

Thoracic legs I–IV biramous, each consisting of 1-segmented protopodite, 3-segmented exopodite and 3-segmented endopodite. Interpodal plate of each leg pair with pair of spikelike projections. For nature of legs and armament, see table 2 and figures 3*a–d*.

Discussion.—*Krøyeria praelongacicula* resembles *K. sublineata* Yamaguti and Yamasu (1959) in the nature of the setation of the thoracic leg endopodites although differing from it primarily in the armament of the rest of the legs as well as in the size of the organism, the nature of the maxilla and aciculum. The bifid aciculum tip of *K. praelongacicula* is found in *K. spatulata* Pearse (1948), although the thoracic leg armature and segment size is different as well as the aciculum length (*K. spatulata* with a shorter aciculum) and the body length relationships (*K. spatulata* with a much longer genital segment than

K. praelongacicula). The diagnostic characteristics of the new species are the setal formula for the exopodite of each of the four pairs of thoracic legs (the total number being 5, 7, 7, 7 for thoracic legs 1–4 respectively), the presence of distinct denticulations on the endopodite of each of the four legs, the length of the aciculum and its peculiarly bifid tip.

TABLE 2.—*Armature of thoracic legs I–IV of the female of* Krøyeria praelongacicula, *new species*

Leg	Surface	Inter-podal Plate	Protopo-dite	Exopodite			Endopodite		
				1	2	3	1	2	3
I	outer	S	p	2m	m	m, mP, P	m	c, 7D	c, 6D, 2P
	inner		m, p, m	m, P	P	3P	P		4P
II	outer	S	p	m, rh	m	m, p, mP, Q, P	m, c	c, 7D	c, 7D, P
	inner		m	c, P	P	3P	P		5P
III	outer	S	p	m, rh	m, h	m, p′, P′ 2P	m, c	c, 7D	c, 9D, P
	inner		m	c, P	P	3P	P		3P
IV	outer	S		rh	m, h	m, p′, mP, Q	m, c	c, 6D	c, 10D, P
	inner		m	c, P	P	4P	P	P	2P

REMARKS.—The name of this species derives from the Latin "praelongus," meaning very long, and "acicula," meaning small needle, both terms descriptive of the extra length of the two needle-like projections from the posterior surface of the cephalothorax.

Family Anthosomatidae

Anthosoma crassum (Abildgaard, 1794)

FIGURES 4*a–h*, 5*a–h*, 6*a–j*

Caligus crassus Abildgaard, 1794, p. 46, pl. 5, figs. 1–3.—Lamarck, 1818, p. 210.
Anthosoma smithii Leach, 1814, pl. 181; 1816, p. 406, pl. 20, figs. 1–6.—Latreille, 1817, p. 198.—Leach, 1819, p. 533.—Latreille, 1829, p. 198.—Burmeister, 1835, p. 328.—Krøyer, 1838, p. 295, pl. 2, fig. 2.—Milne-Edwards, 1840, p. 483, pl. 39, fig. 5.—Guérin-Méneville, 1843, pl. 35, fig. 9.—White, 1857, pp. 124, 323.—Van Beneden, 1870, p. 9.—Richiardi, 1880, p. 5.—Valle, 1880, p. 62.
Caligus imbricatus Risso, 1816, p. 162, pl. 3, fig. 13.—Lamarck, 1818, p. 211.
Caligus smithii.—Lamarck, 1818, p. 210.
Anthosoma crassum.—Latreille, 1825, pl. 335, figs. 11–16.—Gould, 1841, p. 340.—Steenstrup and Lütken, 1861, p. 397, pl. 12, fig. 24.—Stossich, 1880, p. 259.—Rathbun, R., 1884, p. 490.—Carus, 1885, p. 364.—Thomson, 1889, p. 365, pl. 27, fig. 3.—Brian, 1898, p. 5.—Bassett-Smith, 1899, p. 468.—Scott, T., 1905, p. 112, pl. 5, figs. 15–16.—Rathbun, M. J., 1905, p. 97.—Wilson, 1905b, p. 555.—Brian, 1906, p. 62, pl. 3, fig. 1.—Fowler, 1912, p. 477.—Scott and Scott, 1913, p. 108, pl. 23, figs. 5–6.—Wilson, 1922, p. 23, pl. 1, figs. 1–8; 1932,

p. 446, fig. 281.—Leigh-Sharpe, 1933, p. 109.—Yamaguti, 1936, p. 12.—Brian, 1944, p. 208, pl. 5, figs. 43–44.—Fontes, 1949 [paper not seen].—Birkett and Burd, 1952, p. 391, fig. 1 [paper not seen].—Pearse, 1952, p. 28.—Nunes-Ruivo, 1954, p. 19 [paper not seen].—Barnard, 1955, p. 271, fig. 18.—Shiino, 1955c, p. 51, figs. 1–2; 1957, p. 370.—Heegaard, 1962, p. 181.

Otrophesia imbricata.—Risso, 1826, p. 136.

Reported hosts.—*Isurus glaucus, I. oxyrinchus, Carcharias littoralis, Lamna cornubica, L. nasus, Mola mola.*

Distribution.—Cosmopolitan.

Material.—Three ovigerous females and one adult male (USNM 11081) collected by the Hawaii Fish and Game Department from the buccal cavity of a specimen of *Carcharodon carcharias* captured by long line in Pokai Bay, Hawaii. Four other ovigerous female specimens (USNM 11082) taken by E. C. Jones and Kenneth Sherman from the buccal cavity of a "Mackerel Shark" (probably *Isurus oxyrhynchus*) captured at 45°11′N. and 174°54′W., were used as comparative material in the description.

Measurements.—Seven female specimens and one male specimen:

	female mean (mm.)	*female* range (mm.)	*male* (mm.)
Greatest length	11.86	10.85–12.74	10.92
Greatest length of cephalothorax	7.46	6.44– 7.98	6.72
Greatest width of cephalothorax	4.90	4.20– 6.16	3.64
Greatest length of genital segment (5 female specimens)	4.41	3.85– 5.11	2.31
Greatest width of genital segment (5 female specimens)	3.85	3.71– 3.99	1.89
Greatest length of abdomen	0.88	0.70– 0.98	0.70
Approximate length of egg strings (5 female specimens)	20.	17. –30.	

Diagnostic description.—Cephalothorax of female (figs. 4*a*, *b*) irregularly ovoid from dorsal viewpoint, irregularity due to constriction of narrow anterior region at approximate division between cephalon and thorax. Dorsal thoracic surface covered by carapace-like structure; structure continuous over cephalon except for indistinct groove at constriction and slight depression with indistinct, incomplete groove at anterior end of cephalon. Cephalothorax consisting of cephalic, maxilliped-bearing and first pedigerous segments. Pair of small, scoop-shaped lappets (fig. 5*b*) present, projecting ventrally and laterally from ventral and ventrolateral cephalothoracic surface at constriction in anterior cephalothoracic region. Structures not associated with either antennules or antennae but may be comparable to postantennular adhesion pads of pandarids and postantennal process of trebiids, euryphorids and caligids. Carapace-like covering of cephalothorax heavily sclerotized, providing hood completely

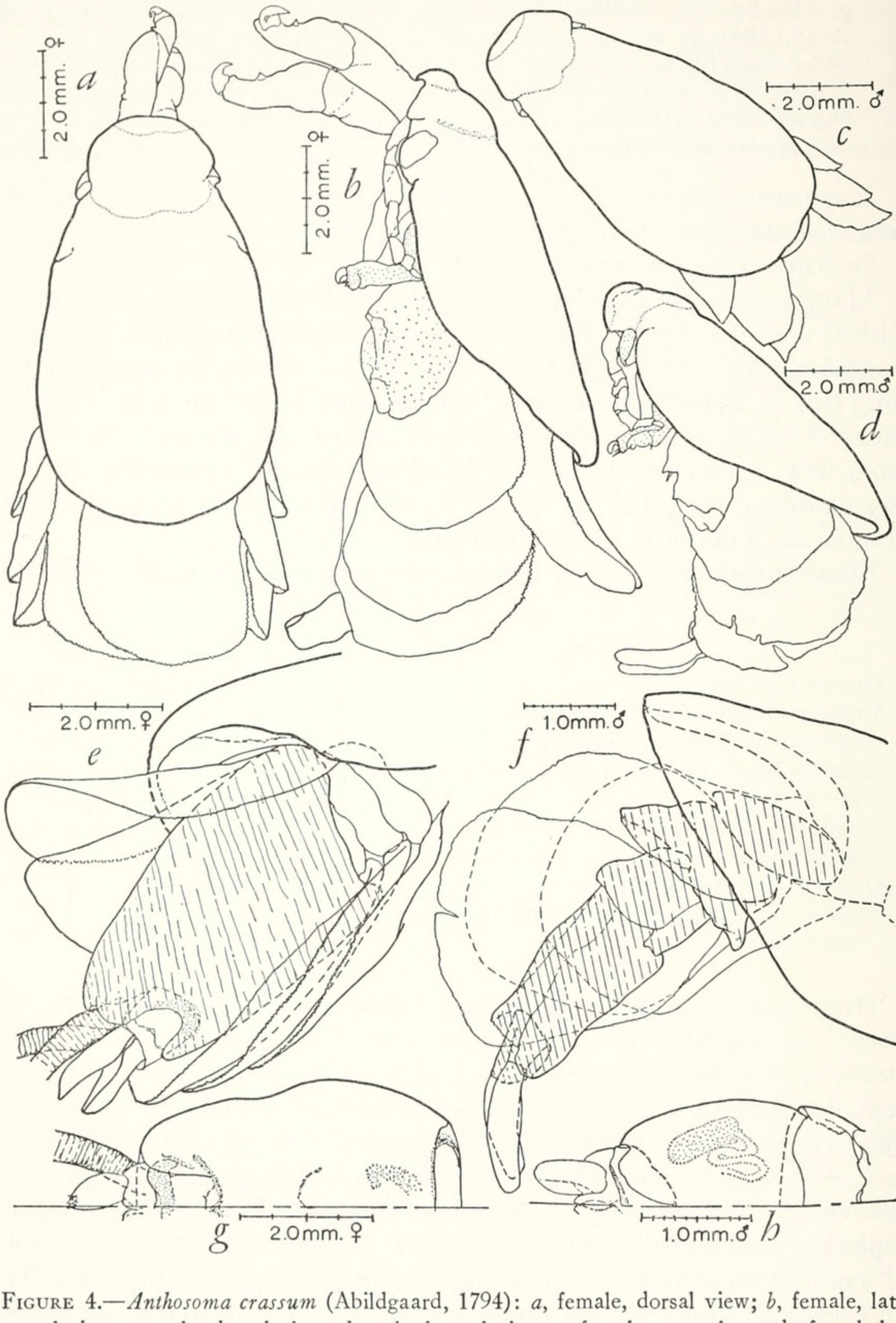

FIGURE 4.—*Anthosoma crassum* (Abildgaard, 1794): *a*, female, dorsal view; *b*, female, lateral view; *c*, male, dorsal view; *d*, male, lateral view; *e*, female, posterior end of cephalothorax, free pedigerous segments, elytra, genital segment, abdomen, caudal ramus;* and egg strings, ventrolateral view; *f*, male, posterior end of cephalothorax, free pedigerous segments, elytra, genital segment, abdomen, and caudal ramus,* ventral view; *h*, male, genital segment, abdomen, and caudal ramus,* ventral view. (*Apparent differences in length and shape of the caudal ramus are due to the angle at which the figure was drawn; see figure 5*a*.)

covering dorsal and lateral surfaces and projecting ventrally below ventral surface of body as well as posteriorly, over free pedigerous segments.

Although first pedigerous segment considered fused with cephalothorax, indistinct indication of anterior margin present as inverted, V-shaped region of heavy sclerotization between and slightly posterior to maxilliped bases. Second and third pedigerous segments narrow, appearing ringlike from ventral viewpoint. Single pair of plates or elytra present on second pedigerous segment, arising from ventrolateral, lateral, and dorsal surface, projecting posteriorly well past posterior end of carapace-like cephalothoracic covering. Surface of elytra similar to that of thoracic legs, covered with minute, knoblike regions of heavy sclerotization and margined by minute denticulations. Status of fifth thoracic segment (= fourth pedigerous segment if legs were present) uncertain; Shiino (1955c) indicates it is fused with the genital segment but specimens examined for this description indicate that although it is coalesced posteriorly and separable from the genital segment only by an indistinct, incomplete line of division, it does project slightly and is similar to the preceding 2 segments. This segment fits into an indentation in the anterior end of the genital segment and is partially or completely covered by the swollen genital segment (fig. 4*e*).

Genital segment (fig. 4*g*) swollen, lateral margins smoothly biconcave, posterior margin flatly rounded dorsally, irregular ventrally, segment overlapping abdomen laterally and dorsally. Abdomen 1-segmented, irregular, norrower anteriorly than posteriorly although posterior end slightly swollen, with heavily sclerotized band around posterior margin. Proximal ends of caudal rami forming segment-like structure, inner surfaces V-shaped and forming tubelike extensions of proctodaeum. Distal half of each ramus narrower than proximal, from dorsal viewpoints, inner lateral surface convex. Outer mediolateral surface, dorsal surface, and ventral surface with row of spikelike processes that barely break through cuticle, distal end of ramus with concentration of processes, giving thorny appearance (fig. 5*a*).

Cephalothorax of male (figs. 4*c*, *d*) similar to that of female. Free pedigerous segments larger; second pedigerous segment and part of third covered dorsally by carapace-like cephalothoracic covering. Second and third pedigerous segments short, disk-shaped from ventral viewpoint, each with platelike cuticle dorsally, extending posteriorly over part of succeeding segment. Second pedigerous segment without elytra present in female. Fifth thoracic segment incompletely fused with genital segment, division apparent as irregular, incomplete groove and line of heavier sclerotization; segment covered dorsally by platelike formation of dorsal cuticle. Genital segment (figs. 4*f, h*) approximately equal to combined lengths of three free thoracic segments, lateral margins flatly concave, dorsal posterior surface flatly concave, ventral posterior surface with V-shaped incision, apex of V at anterior end of abdomen, lateral surfaces of V covering most of ventral abdominal surface. Abdomen 1-segmented, broader anteriorly than posteriorly. Caudal rami slightly longer than in female, without expanded proximal region.

Antennule (fig. 5*c*) of female and male 6-segmented, attached to ventral cephalothoracic surface just inside anterolateral corner of hood-shaped cuticular covering of cephalon and just anterior to scoop-shaped ventrolateral projections. First segment approximately one-third the total appendage length, slightly swollen proximally and distally, with single, setule-like process on distal inner surface. Second segment approximately one-sixth the appendage length, narrow proximally, flaring somewhat irregularly distally to broad distal end, with minute, spikelike process on inner medial surface and small setule just distal to it. Third segment approximately one-eighth the appendage length, varying little in width. Fourth segment approximately one-sixth the appendage length, narrow proximally, flared slightly towards slightly swollen distal end. Fifth segment approximately one-eighth the appendage length, slightly wider distally than proximally, with minute spike on distal inner surface. Sixth segment short, length approximately one-twelfth that of appendage, slightly wider distally than proximally distal surface rounded, bearing approximately 6 minute, stiff, setule-like projections from inner surface, 4 from medial surface and single, small, spikeline projection from outer surface.

Female antenna (fig. 5*d*) 4-segmented, not 5 as Shiino (1955c) indicates. Proximal half of appendage capable of being withdrawn into deep socket in ventral surface of cephalothorax just medial and slightly posterior to antennule base (fig. 5*b*) but proximal end of appendage with flexible arthrodial membrane that may appear segment-like (see fig. 5*d* for depiction of musculature). First segment approximately one-third the appendage length, relatively narrow although slightly swollen proximally and distally, distal margin irregular. Second segment slightly more than one-fourth the appendage length, angled proximally and distally, overlapping outer surface of first and third segments. Exact nature of second segment questionable due to rather indistinct break between adjacent segments although musculature apparently associated with segment and adjacent segments suggests the term segment is applicable. Third segment slightly more than one-third the appendage length, larger proximally than distally, inner surface with large, roughened, spike-shaped projection medially. Irregular distal margin angled proximally from outer to inner lateral

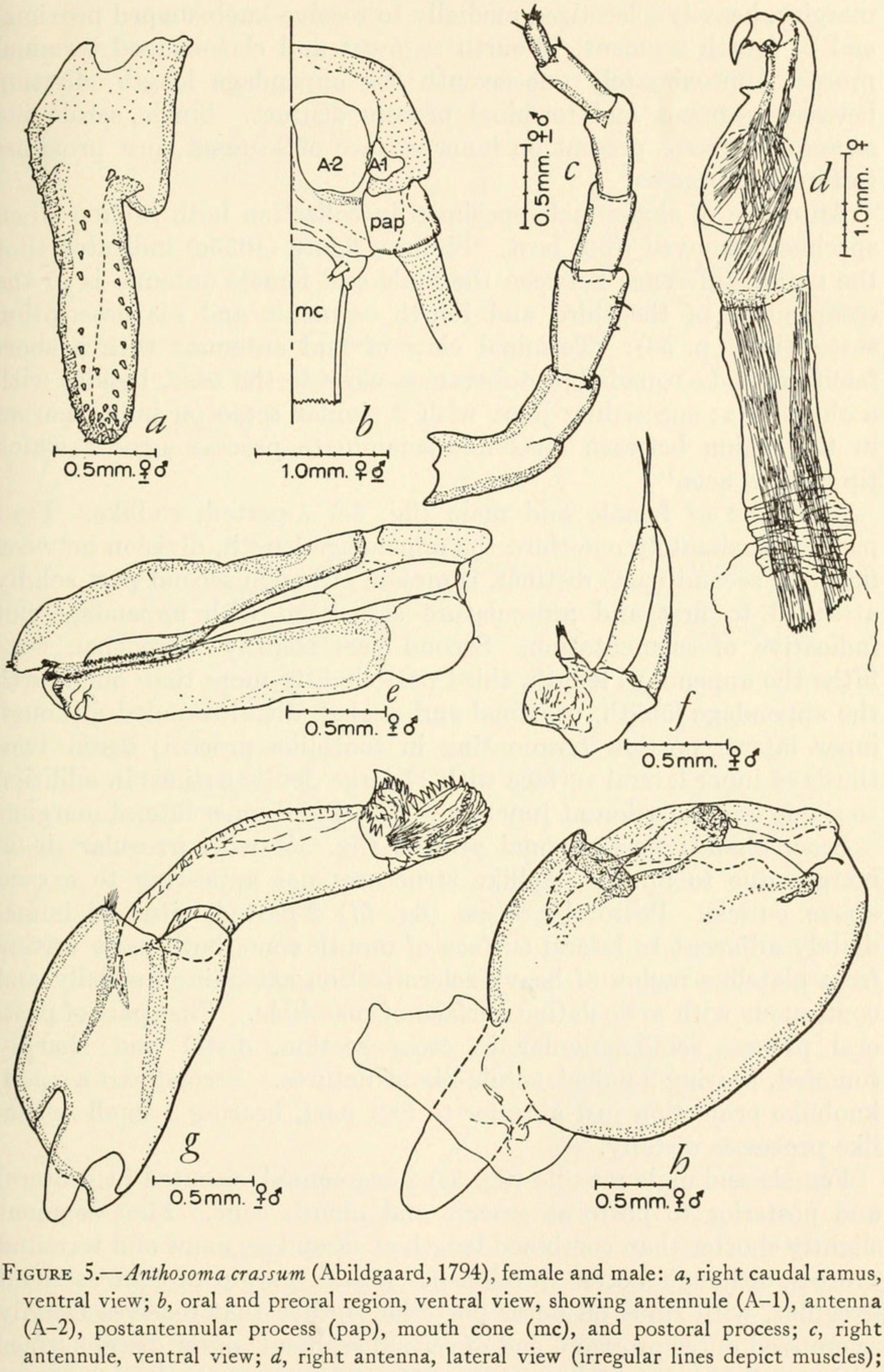

FIGURE 5.—*Anthosoma crassum* (Abildgaard, 1794), female and male: *a*, right caudal ramus, ventral view; *b*, oral and preoral region, ventral view, showing antennule (A–1), antenna (A–2), postantennular process (pap), mouth cone (mc), and postoral process; *c*, right antennule, ventral view; *d*, right antenna, lateral view (irregular lines depict muscles); *e*, mouth cone and right mandible, lateral view; *f*, right postoral process, lateral view; *g*, right maxilla, posterior view; *h*, right maxilliped, anterior view.

margins, heavily sclerotized medially to receive knob-shaped proximal end of fourth segment. Fourth segment and claw-shaped terminal process approximately one-seventh the appendage length, division between segment and terminal process distinct. Single, setule-like accessory process present on inner surface of segment, just proximal to terminal process.

Antennae of single male specimen in collection both broken when specimen removed from host. Shiino's figure (1955c) indicates that the major difference between the male and female antenna is in the composition of the third and fourth segments and his description states (ibid., p. 56): "Terminal claw of 2nd antennae with a short falciform and a rounded protuberances close to the base, besides with a short seta; succeeding joint with 2 similar setae on inner margin in the region between apex and acuminate process against which tip of claw acts."

Mandible of female and male (fig. 5*e*) 3-parted, rodlike. First part approximately one-third the appendage length, division between first and second parts distinct, complete although second part solidly attached to first and musculature associated with appendage not indicative of segmentation. Second part slightly more than two-fifths the appendage length, third part slightly more than one-fourth the appendage length, proximal end angled, distal rounded although inner lateral portion terminating in toothlike process; distal two-thirds of inner lateral surface with 17 large denticulations in addition to single denticulation at junction of distal and inner lateral margins.

Scoop-shaped postantennal process (fig. 5*b*) with irregular distal margin due to minute, rodlike structures not appearing to extend above cuticle. Postoral process (fig. 5*f*) 2-parted, situated immediately adjacent to lateral surface of mouth cone, both parts arising from platelike region of heavy sclerotization extending medially and continuous with articulation surface of mandible. First part of postoral process semitriangular in cross section, distal end sharply rounded, bearing 2 naked, setule-like structures. Second part a small, knoblike projection just anterior to first part, bearing 3 small setule-like processes distally.

Female and male maxilla (fig. 5*g*) 2-segmented, situated just lateral and posterior to postoral process and mouth cone. First segment slightly shorter than combined length of second segment and terminal process, although better developed. Distal margin of first segment irregular, with sinus on outer posterior surface that receives heavily sclerotized outer proximal end of second segment; outer distal surface with small clump of plumosities. Outer surface of second segment with membrane along distal half and spike-shaped protrusion from distal region in addition to denticulated expansion of distal end of

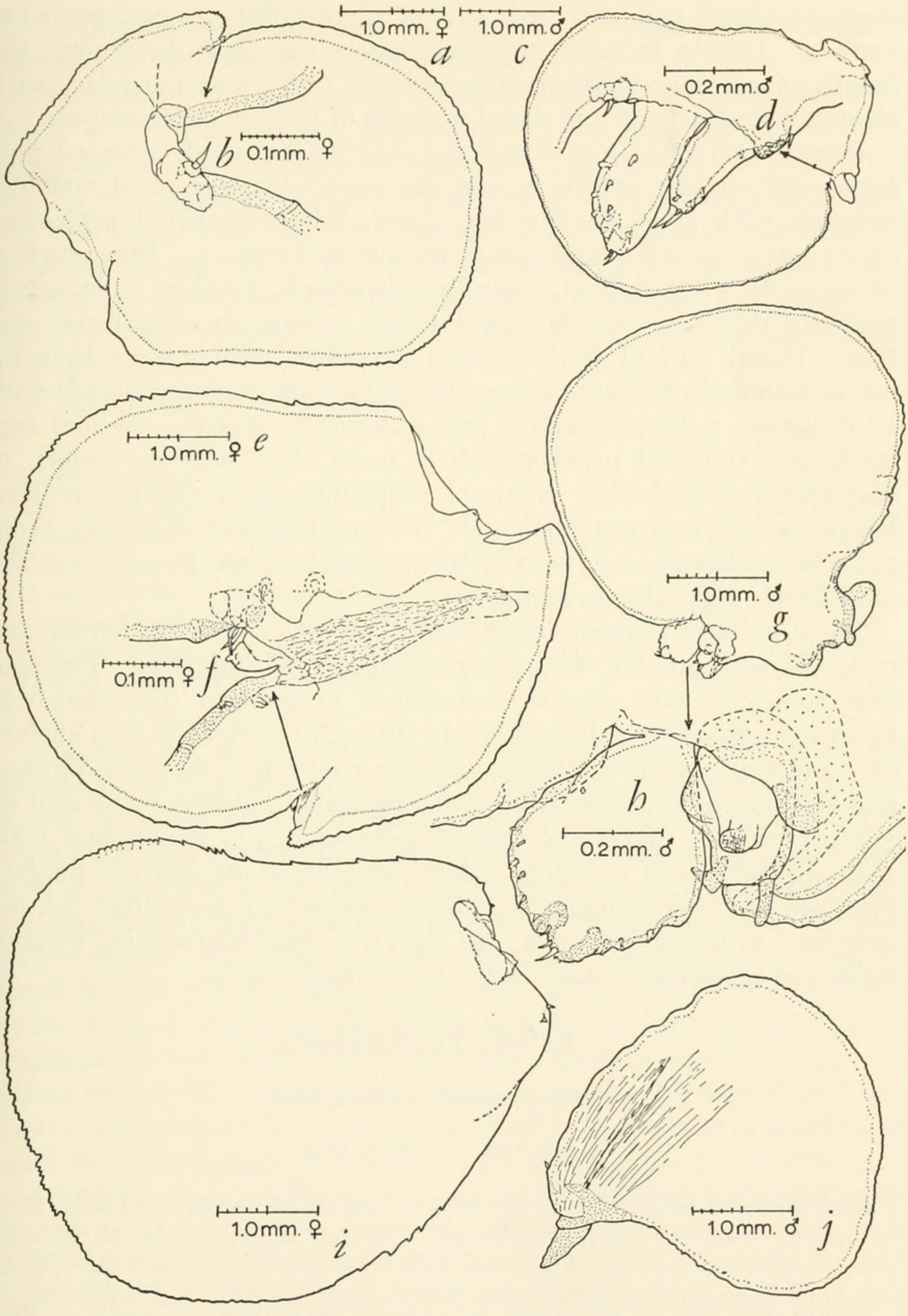

Figure 6.—*Anthosoma crassum* (Abildgaard, 1794), right thoracic legs: *a*, female, first leg, posterior view; *b*, female, enlarged view of notch in first leg, posterior view; *c*, male, first leg, posterior view; *d*, male, enlarged view of notch in first leg, showing rami, posterior view; *e*, female, second leg, posterior view; *f*, female, enlarged view of notch in second leg, posterior view; *g*, male, second leg, posterior view; *h*, male, enlarged view of notch in second leg, showing rami, posterior view; *i*, female, third leg, posterior view; *j*, male, third leg, posterior view.

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segment, distal end also with tuft of plumosities on posteromedial surface. Lobate terminal process slightly less than one-fourth the length of second segment, inner surface puffy and irregular, with minute ridges; lateral and distal margins of process denticulated.

Female and male maxilliped (fig. 5*h*) 2-segmented, situated posterior and slightly medial to maxilla base. First segment well developed, with long, heavily sclerotized, lobate proximal projection serving as articulation and muscle attachment surface. Inner surface of segment with distinct, heavily sclerotized, steplike indentation medially that bears single, spike-shaped protrusion on anterior surface. Distal half of inner surface irregular, with groove that receives terminal process of second segment when segment flexed; with knob-shaped adhesion surface just anterior to groove. Second segment and terminal process slightly more than half the length of first segment, excluding proximal projection, with slightly swollen, heavily sclerotized proximal end. Second segment distinctly separable from claw-shaped, heavily sclerotized terminal process in male, indistinctly separable in female.

Three pairs of thoracic legs present (figs. 6*a–j*) in both female and male, all with greatly enlarged, plate-shaped protopodite. Protopodite margined with minute, rod-shaped projections (not shown in figures) reaching to or just breaking through cuticle. Dorsal surface of protopodite with scattered, circular spots (not shown in figures) and rod-shaped processes scattered irregularly between spots and on ventral surface. First and second thoracic legs of female and male with distinct sinus on inner lateral surface, sinus bearing distinct evidence of rami (exopodite and endopodite) in male (figs. 6*d, h*), indistinct evidence in female (figs. 6*b, f*). Third thoracic leg without sinus and evidence of rami, in both male and female.

Family Pandaridae

Pandarus satyrus Dana, 1849

FIGURES 7*a–d*, 8*a–f*, 9*a–e*

Pandarus satyrus Dana, 1849, p. 59; 1853, p. 1367, p. 95, fig. 2a–c.—Brady, 1883, p.134.—Bassett-Smith, 1899, p. 467.—Wilson, 1907b, p. 415, pl. 31, figs. 162–171; 1914, p. 71, pl. 15, figs. 1–8; 1924a, p. 213.—Yamaguti, 1936, p. 5, pl. 3, fig. 36, pl. 4, figs. 37–41.—Shiino, 1954c (in part), p. 312, figs. 11–17; 1957 (in part?), p. 364; 1959a (in part?), p. 315; 1959b (in part?), p. 352; 1960 (in part), p. 493.

Pandarus zygaenae Brady, 1883, p. 134, pl. 55, fig. 3.

REPORTED HOSTS.—*Prionace glauca, Zygaena malleus* (=*Sphyrna zygaena*, in part, and *Sphyrna diplana*, in part). (The hosts reported by Shiino have not been included.)

DISTRIBUTION.—Kermadec Islands, Cape Verde Island, Gulf of Mexico, Japan, Hawaii, eastern Pacific.

MATERIAL.—Thirteen adult females (USNM 110803) taken by E. C. Jones and Kenneth Sherman from the external surface of a specimen of *Prionace glauca* captured by longline at 40°15′N., 170°16′W. Although this is far removed from the Hawaiian Islands, the species is included here because of the frequent occurrence of *Prionace glauca,* the principal host (Cressey, in correspondence), around the Hawaiian Islands (Gosline and Brock, 1960) and the report of the copepod from the Hawaiian Island region by Wilson, (1907b, 1924b).

MEASUREMENTS.—Thirteen female specimens:

	mean (mm.)	*range(mm.)*
Greatest length	8.57	7.77–9.24
Greatest length of cephalothorax	4.15	3.71–4.41
Greatest width of cephalothorax	4.28	3.92–4.55
Greatest length of genital segment	2.65	2.17–4.07
Greatest width of genital segment	2.93	2.59–3.15
Greatest length of anal lamina (12 specimens)	2.02	1.82–2.38
Greatest length of caudal ramus	0.91	0.70–1.19
Length of egg string (5 specimens)	4.41	3.78–5.74

DIAGNOSTIC DESCRIPTION OF FEMALE.—Cephalothorax (fig. 7*a*) consisting of cephalic, maxilliped bearing and first pedigerous segments, narrower anteriorly than posteriorly, greatest length slightly more than greatest width. Lateral margins flatly convex, with narrow, denticulated membrane along anterior portions; posterior margin irregularly concave, median half irregularly denticulated. Frontal region narrow, with distinct median depression between incompletely fused frontal plates, each frontal plate with dark brown to black ovoid area of pigmentation. Second, third and fourth pedigerous segments incompletely fused ventrally, distinguished dorsally by plates arising as extensions of tergites. Second through fourth pedigerous segments (fig. 7*b*) each with median plate, that of third more than twice the length of second, with median sinus posteriorly, that of fourth approximately one and two-thirds the length of third, with median sinus posteriorly. Second pedigerous segment also with pair of plates originating lateral to median plate, extending laterally and posteriorly on dorsal surface and anteriorly underneath posterior lateral cephalothoracic region to form large, ridged adhesion pad (fig. 7*c*). Plate of fourth pedigerous segment overlapped anteriorly by plate of third pedigerous segment and overlapping anterior half of genital segment.

Genital segment (fig. 7*c*) broader anteriorly than posteriorly, lateral margins flatly convex in anterior two-thirds of segment, sharply concave in posterior third, posterolateral corner forming knob-shaped projection tipped by single spinule. Posterodorsal surface of segment sharply concave, forming articulation surface for large, oval anal lamina

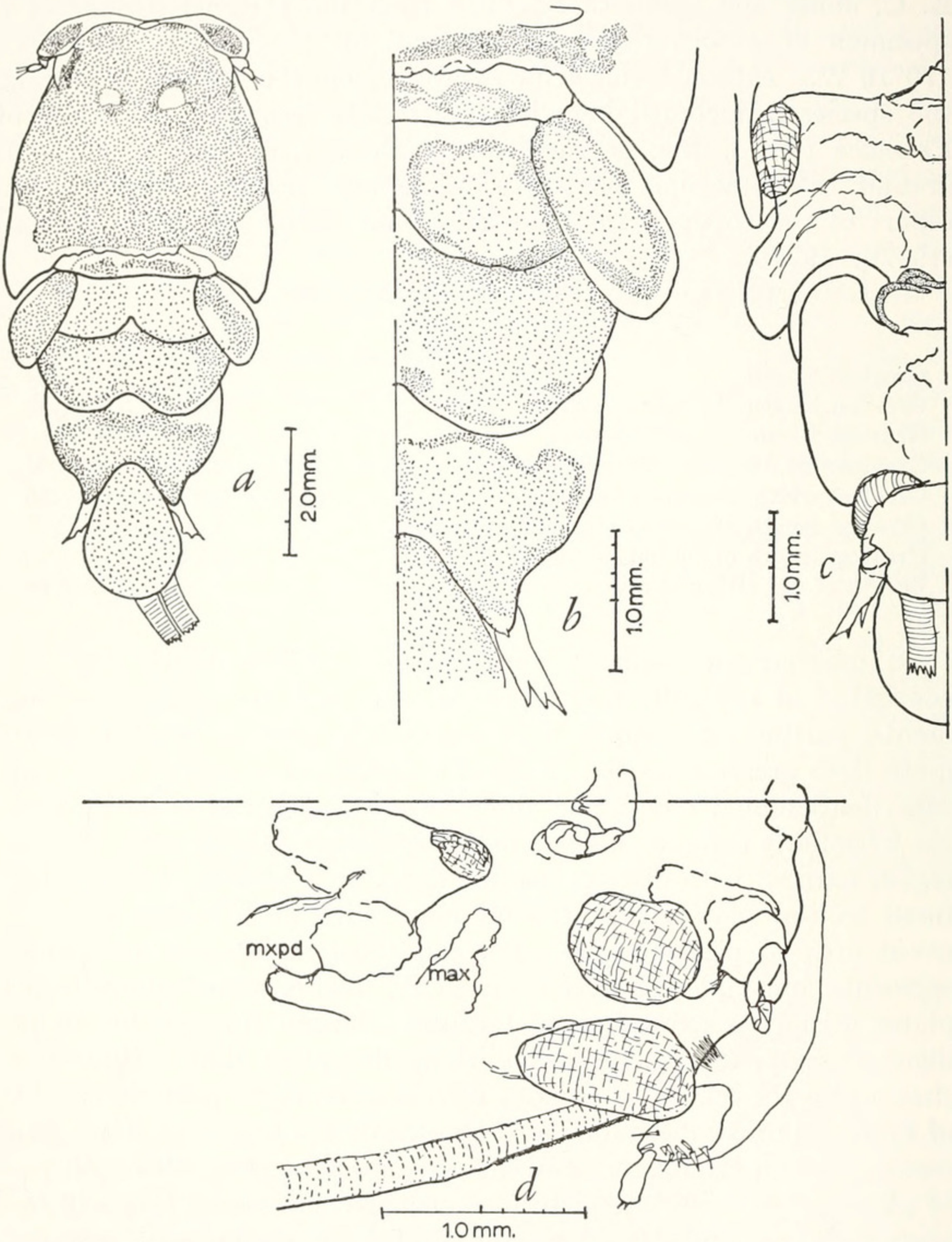

FIGURE 7.—*Pandarus satyrus* Dana, 1849, female: *a*, dorsal view; *b*, postcephalothoracic region, dorsal view; *c*, postcephalothoracic region, ventral view; *d*, pre- and postoral adhesion pads, ventral view.

extending posteriorly well past caudal rami. Abdomen 1-segmented, extending posteriorly, from posteroventral surface of genital segment, slightly past posterior end of knoblike protusions of genital segment.

Lateral abdominal margins convex anteriorly, concave posteriorly, posterior margin biconvex. Caudal rami large, heavily sclerotized, spiniform, arising from concave posterior lateral abdominal surface, extending posteriorly and laterally; ramal surface of attachment narrow.

Cephalothorax dark brown to black dorsally except for posterolateral corners, median portion of frontal region, pair of rounded areas in ocular region and scattered, minute spots. Median plate of second pedigerous segment with light brown pigmentation over most of surface, lateral plates of segment dark brown to black except along extremities. Median plate of third pedigerous segment with pair of large, dark brown to black pigmented areas, one on either side of plate. Fourth pedigerous segment dark brown to black except for margins and for anterior surface, under plate of third pedigerous segment, in addition to pair of small, orbicular areas at apex of indentation of median posterior margin. Genital segment dark brown to black over most of posterior half, anal lamina also dark brown to black except along posterior margin.

Antennule (figs. 7*d*, 8*a*) 2-segmented, situated at lateral junction of cephalothorax and frontal region. First segment approximately 3 times the length of second, broader proximally than distally, ventroanterior and anterior surface with 21 naked and lightly plumose setules, ventrodistal surface with 7. Second segment club-shaped, medial posterior surface with 1 naked setule, distal surface with approximately 9. Antenna (fig. 8*b*) 3-segmented, first segment with closely associated, oval adhesion pad extending anteriorly and ventrally. Some indication present (grooves, lines of sclerotization) indicating process may not be part of antenna although evidence indistinct and contradictory evidence (continuation of heavily sclerotized basal ridge with first segment, nature of the musculature) suggesting that adhesion surface an extension of segment. First antennal segment, excluding adhesion pad, short, well developed, irregularly tapered from proximal to distal end. Second segment slightly more than four-fifths the length of first, width slightly greater than length, outer surface bilobed and compressed. Third segment less than half the width of second, short, bearing hook-shaped terminal process, distinct from segment, and 2 setiform accessory processes, 1 from proximal posterior surface, second from distal inner surface, at junction of segment and terminal process.

Mandible (fig. 8*c*) 2-parted although indistinct evidence of division in distal half of second part; distal region of second part flattened, rounded distally, with 9 denticulations on inner surface. Postantennular adhesion pad (figs. 7*d*, 8*a*) large, oval, situated just posterior to antennule base. Postoral process (figs. 8*c*, *d*) situated immediately

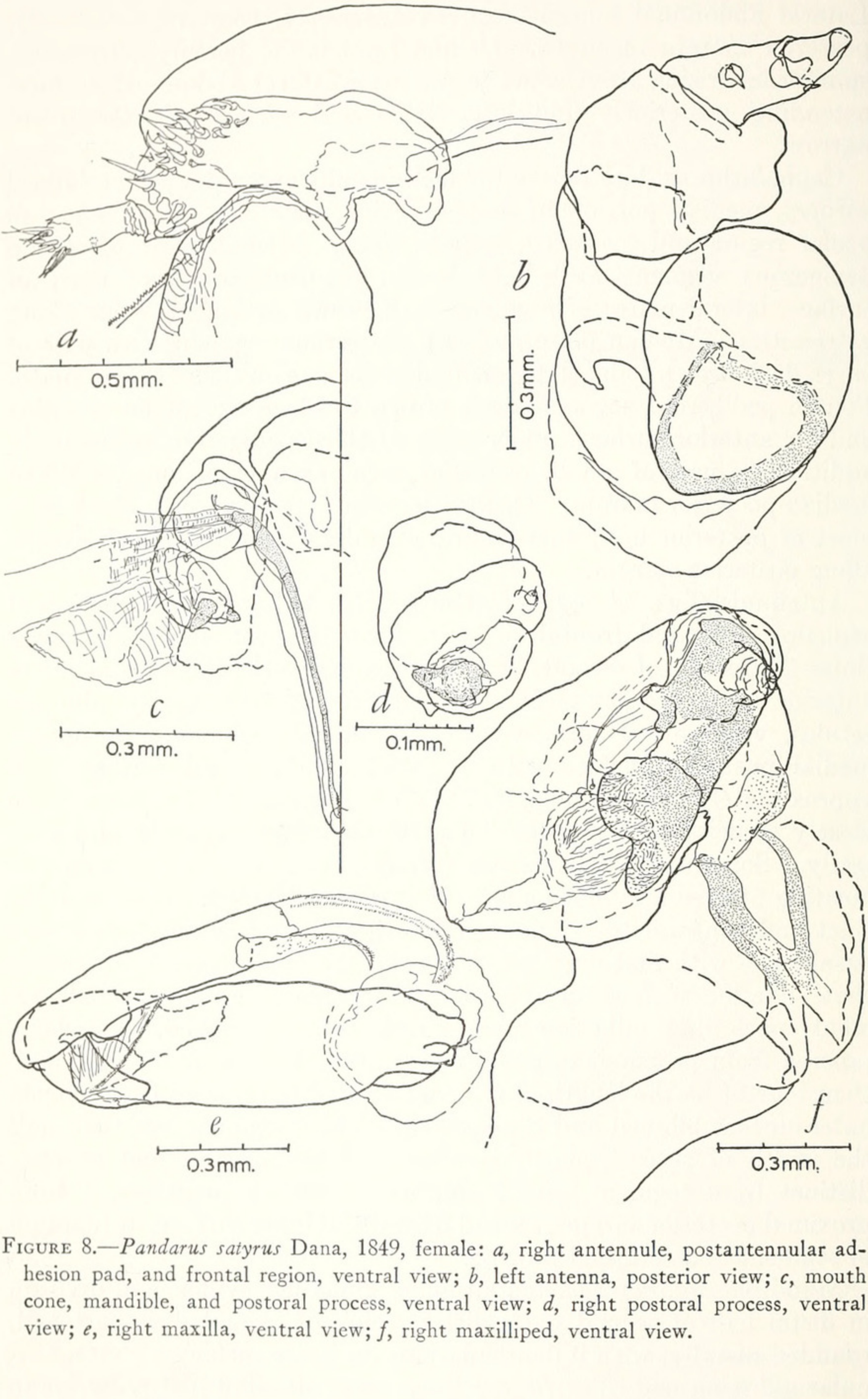

FIGURE 8.—*Pandarus satyrus* Dana, 1849, female: *a*, right antennule, postantennular adhesion pad, and frontal region, ventral view; *b*, left antenna, posterior view; *c*, mouth cone, mandible, and postoral process, ventral view; *d*, right postoral process, ventral view; *e*, right maxilla, ventral view; *f*, right maxilliped, ventral view.

posterior and lateral to mouth cone base, as extension of platelike formation forming attachment and articulation surface for mandible. Postoral process 3-segmented, first and second segments of approximately equal width although first somewhat longer than second and second bearing minute knob on anterior and another on posterior distal surface, anteriormost knob (at least) with spinule. Third segment somewhat narrower than second or first, ovoid in dorsal view, with distinct, marginally denticulated spine distally and small, knoblike accessory process at base of spine. Pair of ovoid adhesion pads (fig. 7*d*) present posterior to mouth cone and postoral process, just medial to maxilla base, at anterior end of heavily sclerotized ridge associated with maxilliped base. Maxilla (fig. 8*e*) 2-segmented, first segment slightly less than one and one-half times the length of second, excluding terminal processes, more strongly developed. Second segment slender, with 2 saber-shaped terminal processes, each with numerous, stiff plumosities.

TABLE 3.—*Armature of thoracic legs I–IV of the female of* Pandarus satyrus *Dana, 1849*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	outer		s, p	dH	d, 3dH, B		d
	inner		d, d, p, (d)*		3dP	a	3dP, d
II	outer	d	lssss, d, p	d, dH	d, 2dH, d	d	d, 2h
	inner		a, d, s, (d, a)*		7H, d, dH		d, 2H
III	outer	d	s, d, p	2s, d, H	d, d, 2h, H	d	d, H
	inner		a, s, d, s, (d, a)*		3H		H
IV	outer		r, 2s, d, p	d, H, d, d, 2h, 2H		d, d	
	inner		a, d, s, (d, s)*	H			

*Armature elements in middle of segment.

Maxilliped (fig. 8*f*) 2-segmented, first segment irregular although of general triangular outline from lateral viewpoint, with adhesion pad on posterodistal surface. Second segment smaller than first, irregular, with knoblike projection from anterior distal surface and bilobed terminal process projecting posteriorly over part of first segment adhesion pad when second segment flexed. Terminal process lightly rugose, inner lobe longer than outer; single, hairlike accessory process present on second segment, underneath terminal process.

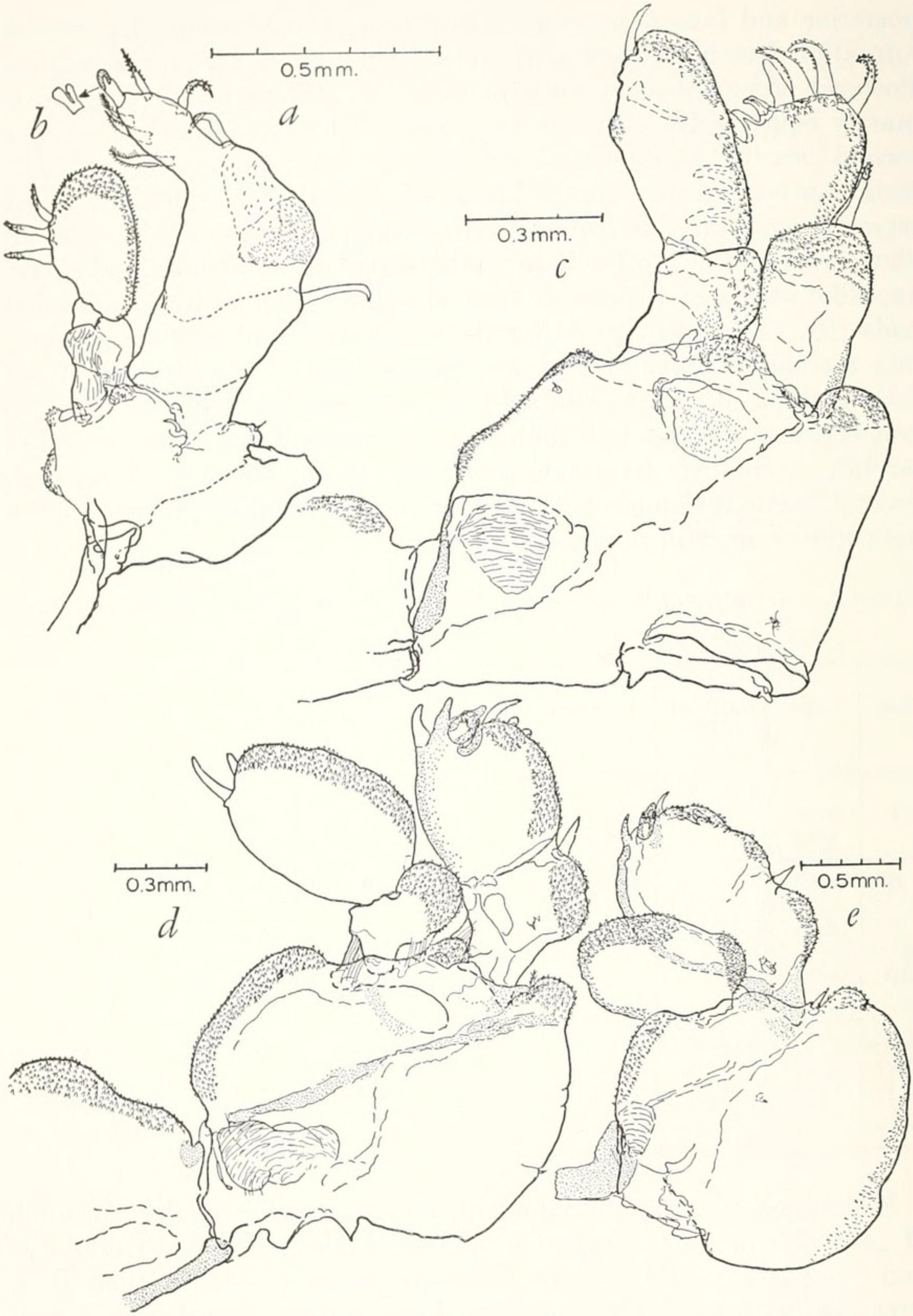

FIGURE 9.—*Pandarus satyrus* Dana, 1849, female: *a*, right first thoracic leg, anterior view; *b*, terminal process of exopodite rotated 90° from figure 9*a*; *c*, right second thoracic leg, anterior view; *d*, right third thoracic leg, anterior view; *e*, right fourth thoracic leg, anterior view.

All four pairs of thoracic legs (table 3, figs. 9*a-e*) biramous, protopodite 1-segmented although superficial division of posterior surface frequently giving 2-parted appearance; some indication of fusion present in rami. Exopodite of first thoracic leg 2-segmented and boot-shaped although segmentation indistinct and evidence of fusion of segments present; distal end of second segment bearing toe-shaped armature element although shape due to folding of bilobed element (fig. 9*b*). Exopodite of second thoracic leg 2-segmented although indication of segment fusion present. Exopodite of fourth thoracic leg 1-segmented although indistinct suggestion of fusion evidenced.

***Pandarus cranchii* Leach, 1819**

FIGURES 10*a–g*, 11*a–k*, 12*a–f*, 13*a–d*

Pandarus cranchii Leach, 1819, p. 535.—Demarest, 1825, p. 339.—Steenstrup and Lütken, 1861, p. 390, pl. 11, fig. 22.—Brady, 1883, p. 133.—Rathbun, R., 1884, p. 488; 1886, p. 317, pl. 5, fig. 1.—Wilson, 1907b, p. 403, pl. 28; 1908, p. 453.—Brian, 1908, p. 4; 1912, p. 14, pl. 3, fig. 1.—Fowler, 1912, p. 479.—Wilson, 1932, p. 435, fig. 273.—Pesta, 1934, p. 30, fig. 21.—Wilson, 1935, p. 333, pl. 5, figs. 58–70, pl. 6, fig. 71.—Heegaard, 1943, p. 27, figs. 76–78.

Nogaus latreillii Leach, 1819, p. 536.

Pandarus carchariae (?) Leach, 1819, p. 535.—Bassett-Smith, 1899, p. 466.

Pandarus dentatus Milne-Edwards, 1840, p. 469, pl. 38, figs. 19–20.—Thomson, 1889, p. 363.—Bassett-Smith, 1899, p. 466.

Pandarus vulgaris Milne-Edwards, 1840, p. 468.

Pandarus satyrus.—Shiino, 1954c (in part), p. 312, figs. 11–17; 1957 (in part?), p. 364; 1959b (in part?), p. 352; 1959a (in part?), p. 315; 1960 (in part?), p. 493.—Ho, 1963, p. 90, figs. 11–12.

REPORTED HOSTS.—*Carcharinus obscurus*, *C. brachyurus*, *Lamna nasus*. (Other hosts, reported by Shiino, have not been included.)

DISTRIBUTION.—Cosmopolitan.

MATERIAL.—Four adult females and 1 adult male (USNM 110804) collected by Susumo Kato from the external surface of several specimens of sharks captured by longline around Oahu, Hawaii. One adult female (USNM 110805) taken from the external surface of a specimen of *Pterolamiops longimanus*? from the collections of the Honolulu aquarium. One adult male (USNM 110806) collected by Dr. Marietta Voge and Clara MacNamee from the external surface of a specimen of *Sphyrna lewini* captured by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii.

MEASUREMENTS.—Five females and two males:

	female		male
	mean (mm.)	*range (mm.)*	*(mm.)*
Greatest length, excluding setae	8.25	7.84–8.68	7.00, 7.49
Greatest length of cephalothorax	4.14	3.92–4.41	3.92, 4.13
Greatest width of cephalothorax	4.46	4.34–4.62	3.71, 3.85
Greatest length of genital segment	2.69	2.24–3.01	1.82, 2.03
Greatest width of genital segment	3.04	2.94–3.15	1.82, 2.10
Greatest length of caudal rami	1.47	1.33–1.61	0.56, 0.56
Greatest length of anal lamina	1.60	1.54–1.68	
Greatest length of abdomen			0.63, 0.70
Greatest width of abdomen			0.49, 0.77
Length of egg string (1 female specimen)		2.94	

DIAGNOSTIC DESCRIPTION.—Cephalothorax of female (fig. 10*a*) consisting of cephalic maxilliped-bearing and first pedigerous segments, wider posteriorly than anteriorly; frontal region narrow, lateral margins sharply rounded. Lateral cephalothoracic margins flatly convex, medial posterior margin convex, lateral regions projecting slightly past medial posterior surface. Eight denticulations present on medial posterior surface. Ocular region visible as smoothly irregular, clear portion in heavily pigmented anterodorsal surface and irregular, darkly pigmented region just anterior to it.

Cephalothorax of male (fig. 10*b*) consisting of cephalic, maxilliped-bearing and first pedigerous segments, widest medially; posterolateral regions extending well past flat-margined medial posterior region. Frontal region narrow, anterior margin wavy, with small median depression. Anterolateral cephalothoracic margins deeply indented, at junction of frontal region and cephalothorax, generally flatly convex posterior to indentation except for slight indentation in middle of lateral margin. Cephalothoracic grooves present, extending anteriorly from each side of junction of cephalothorax and free second pedigerous segment, terminating at indentation of anterior lateral margin. Inner margins of posterolateral cephalothoracic regions with filmy membrane extending medially and dorsally, covering most of sinus formed by lateral cephalothoracic region and lateral margin of second pedigerous segment. Additional membrane present on each side of median posterior region and directed dorsally and posteriorly.

Female second through fourth pedigerous segments (figs. 10*c*, *d*) free, second pedigerous segment visible dorsally as narrow band slightly overlapped anteriorly by posterior median cephalothoracic region, bearing 4 small denticulations and 2 large lateral plates projecting laterally and posteriorly to middle of genital segment. Third pedigerous segment also appearing as narrow band, overlapped medially by posterior end of second pedigerous segment and laterally by

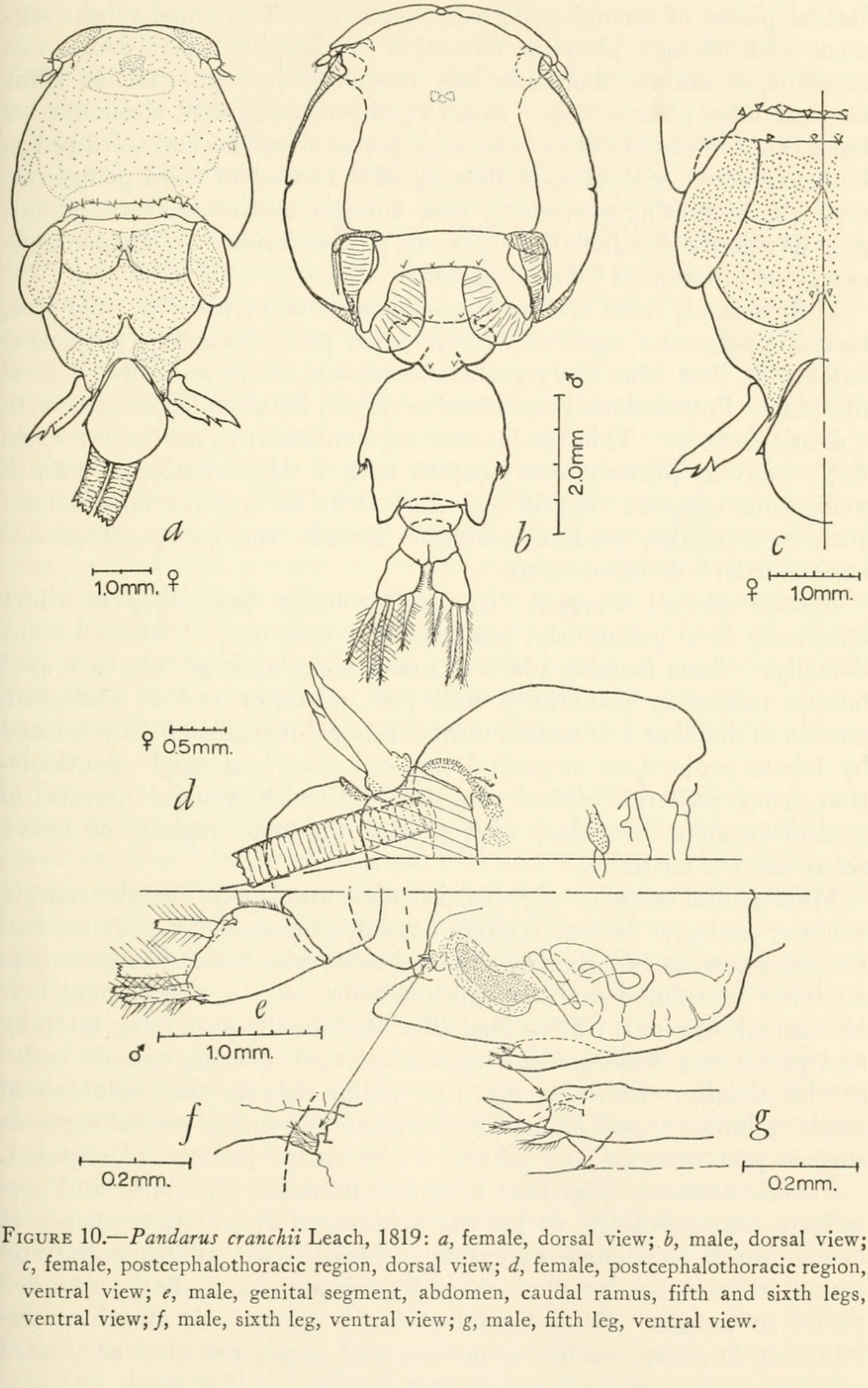

FIGURE 10.—*Pandarus cranchii* Leach, 1819: *a*, female, dorsal view; *b*, male, dorsal view; *c*, female, postcephalothoracic region, dorsal view; *d*, female, postcephalothoracic region, ventral view; *e*, male, genital segment, abdomen, caudal ramus, fifth and sixth legs, ventral view; *f*, male, sixth leg, ventral view; *g*, male, fifth leg, ventral view.

lateral plates of second pedigerous segment. Third pedigerous segment with bilobed, platelike extension overlapping fourth pedigerous segment, 2 minute denticulations medially, just anterior to sinus between lobes of extension. Fourth pedigerous segment also a narrow band, almost completely covered by plates of second and third pedigerous segments, with bilobed plate, similar to that of third pedigerous segment, projecting posteriorly over anterior half of genital segment, pair of minute denticulations present just anterior to V-shaped concavity at junction of lobes of plate.

Male second, third and fourth pedigerous segments (fig. 10*b*) free, second pedigerous segment narrow, with posterolaterally projecting extensions that bear filmy membrane across distal and inner lateral margins. Posterodorsal surface of segment, between extensions, with 4 denticulations. Third pedigerous segment narrow, posterior margin flatly convex, posterodorsal surface with 2 denticulations. Fourth pedigerous segment slightly less than twice as wide as long, lateral surfaces winglike, median posterior margin convex, posterodorsal surface with 2 denticulations.

Female genital segment (fig. 10*d*) roughly heart-shaped, wider anteriorly than posteriorly, posterior end with deep, U-shaped sinus dorsally. Sinus forming place of attachment of large, obovate anal lamina extending posteriorly well past posterior end of abdomen, almost to distal end of caudal rami. Lateral margins of sinus formed by lobate projections of genital segment that bear single denticulation from posterior dorsal surface. Posterior ventral surface of genital segment irregular, with several knoblike regions of heavy sclerotization medially.

Male genital segment (fig. 10*e*) broadest anteriorly, anterior margin convex; posterior lateral regions extending posteriorly past median posterior margin as 2 sharply rounded lobes with minute irregularities on inner margin, dorsal median posterior margin overlapping first abdominal segment. Fifth legs (fig. 10*f*) small, projecting laterally and posteriorly from genital segment margin, bearing spinule and 3 setules distally. Sixth leg (fig. 10*g*) visible only as small spinule and single, plumose setule on padlike swelling of ventral genital segment surface just anterior and medial to lobate projections of segment.

Female abdomen (fig. 10*d*) irregular, narrower anteriorly and posteriorly than medially, at heavily sclerotized articulation surface of caudal rami. Abdomen extending ventrally past anal opening and caudal rami bases as plate-shaped projection with flatly rounded posterior margin. Caudal rami strongly sclerotized, elongate, terminating in sharp, spiniform process and giving rise to 2 additional spiniform processes on dorsal surface, in distal half of rami.

Male abdomen (fig. 10*e*) 2-segmented, first segment shorter than second, broad anteriorly, convexly rounded posteriorly. Second segment flared to V-shaped posterior end. Caudal rami laminate, inner margin plumose, distal surface with 4 plumose setae and 2 minute setules, 1 on each lateral edge of distal surface.

Color of adult female, in alcohol, dark brown or black over most of dorsal cephalothoracic surface, dorsal plates, posterior end of genital segment and anal lamina, light yellowish brown along margins of body parts and caudal rami. Color of adult male, in alcohol, brown or yellowish brown, without distinctive color pattern.

Female antennule (fig. 11*a*) 2-segmented, attached to lateral ventral surface of frontal region although appearing to articulate, at least partially, in small depression on anterior ventral cephalothoracic surface. First segment slightly more than three times the length of second, with 26 roughened setae on anterior ventral surface in distal half of segment. Second segment slender, width varying little throughout length, distal surface rounded, with 6 short, naked setae anteriorly, 2 short, naked setae medially and 2 posteriorly; additional short, naked seta present on posterior lateral surface just proximal to distal end. Male antennule (fig. 11*b*) 2-segmented, first segment approximately two and one-half times the length of second, distal half with approximately 27 stiffly plumose setules on anterior ventral and distal ventral surface. Second segment club-shaped, with approximately 9 naked setules on distal surface and 1 on distal posterior surface.

Female antenna (fig. 11*c*) 3-segmented, situated medial and posterior to antennule base. First segment irregular, outer lateral and distal margins heavily sclerotized, distal forming articulation surface for second segment. Second segment slightly longer than first, proximal margin irregular, projecting anteriorly as lobate surface articulating in slight irregularity on inside of inner distal lateral surface of first segment. Outer lateral margin with large, knob-shaped swelling, distal margin irregular, posterior portion projecting beyond anterior. Length of third segment and terminal process similar to that of second segment, proximal margin irregular, distal distinct although appearing partially fused with clawlike terminal process. Accessory processes consisting of small, knoblike structure on posterior medial surface of segment and single, setiform process on distal inner surface at junction of segment and terminal process. The antenna appears capable of being projected from or withdrawn into the ventral cephalothoracic surface to some extent, the movement being allowed by a rather flexible arthrodial membrane that, in the fully extended appendage, appears segment-like. Large, obovate pad attached to posterior surface of membrane, extending from cephalothorax to middle of second antennal segment. Pad roughened,

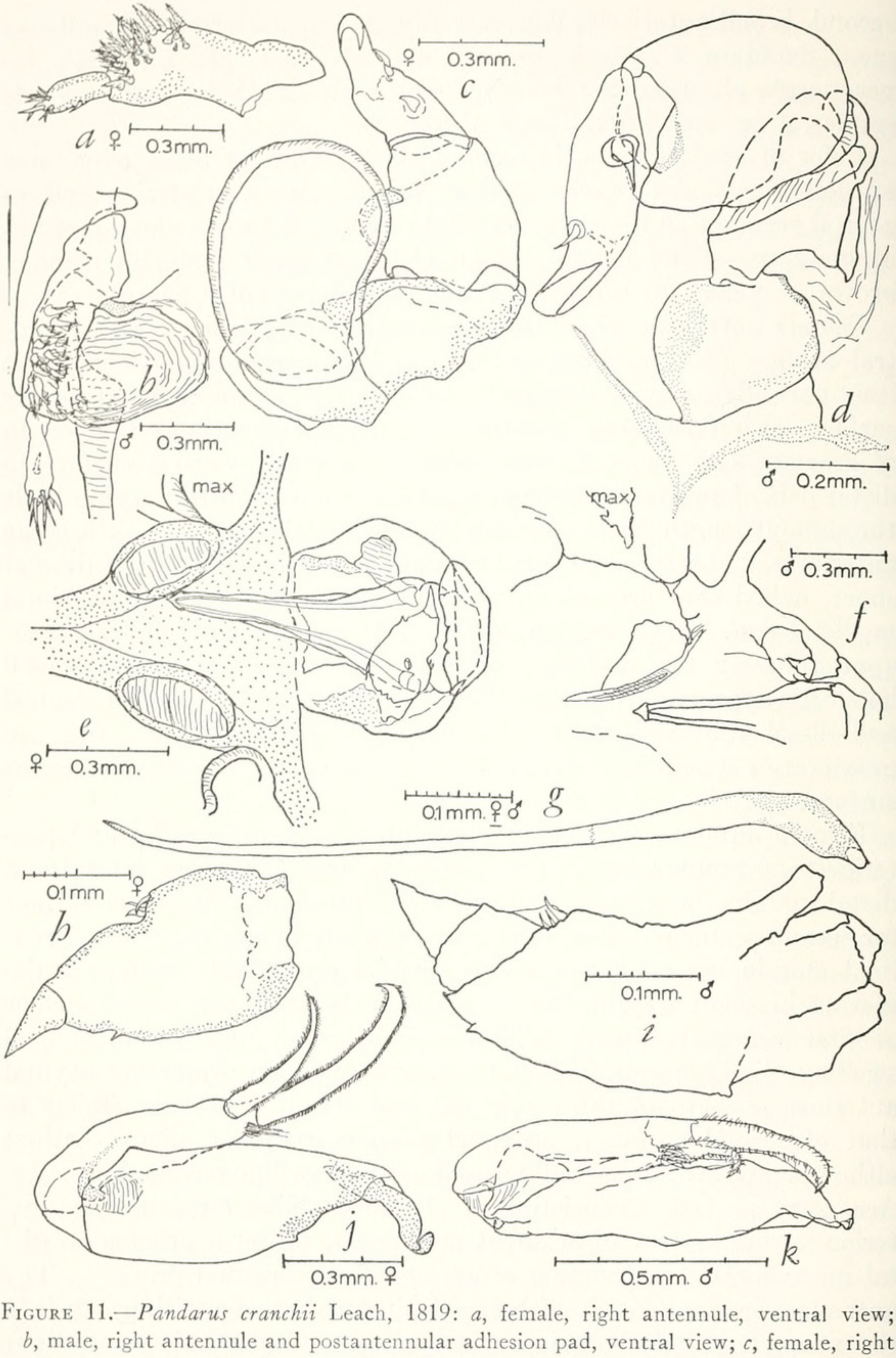

FIGURE 11.—*Pandarus cranchii* Leach, 1819: *a*, female, right antennule, ventral view; *b*, male, right antennule and postantennular adhesion pad, ventral view; *c*, female, right antenna, posterior view; *d*, male, right antenna, posterior view; *e*, female, mouth cone, mandibles, postoral process, postoral adhesion pads, and maxilla bases (max), ventral view; *f*, male, mouth cone, postoral process, postoral adhesion pad, and maxilla base (max); ventral view; *g*, female and male left mandible; *h*, female, left postoral process, posterior view; *i*, male, right postoral process, lateral view; *j*, female, right maxilla, posterior view *k*, male, right maxilla, posterior view.

presumably serving as adhesion pad. Male antenna (fig. 11*d*) 3-segmented, first segment irregular, with slightly ridged adhesion pad, second segment rounded proximally, irregular distally, third segment elongate, with strongly developed, heavily sclerotized, clawlike terminal process in addition to 2 spikelike accessory processes.

Female and male mandible (fig. 11*g*) indistinctly 3-parted, first part short, approximately one-tenth the appendage length, second part slightly less than three times the length of first, broader proximally than distally. Third part longer than combined lengths of preceding parts, tapered slightly towards angled distal region and sharply rounded distal end. Angled distal region with 9 minute denticulations on inner surface. Female postantennular adhesion pad extending posteriorly, from antennule base, past antenna. Male postantennular adhesion pad (fig. 11*b*) paddle-shaped extending laterally from just posterior to antennule base. Female postoral process (figs. 11*e*, *h*) small, palplike, with heavily sclerotized, spikelike terminal process and small, spikelike cuticular projection just proximal to terminal process, on posterior surface, in addition to 3 minute, setule-like processes on indentation of medial anterior surface. Both mandible and postoral process appearing attached to same platelike area of heavy sclerotization. Postoral process of male (figs. 11*f*, *i*) appearing 2-segmented, attached to platelike region of heavy sclerotization on which mandible articulates, first segment approximately 6 times the length of second, with 3 setule-like projections on outer distal surface; second segment with triangular, heavily sclerotized terminal process. Female with pair of oval adhesion pads present posterior to mouth cone (fig. 11*e*), extending posteriorly on V-shaped region of heavy sclerotization connected to maxilliped bases. Male with 2 slender, slightly ridged adhesion pads present posterior to mouth cone base, between maxilla bases and on heavily sclerotized area connected to maxilliped bases.

Female maxilla (fig. 11*j*) 2-segmented, first segment slightly more than one and one-half times the length of second, well developed, with distinct knob-shaped projection of distal inner surface. Second segment tipped by 2 saber-shaped processes and tuft of plumosities. Male maxilla (fig. 11*k*) 2-segmented, first segment slightly less than one and one-half times the length of second, more strongly developed; second segment with 1 plumose, knoblike projection and 2 lightly plumose, seta-like terminal processes, outer almost twice the length of inner.

Female maxilliped (fig. 12*a*) 2-segmented, with broad base situated just posterior and medial to maxilla base, along V-shaped region of heavy sclerotization. First segment with heavily sclerotized proximal projection serving as articulation and muscle attachment surface.

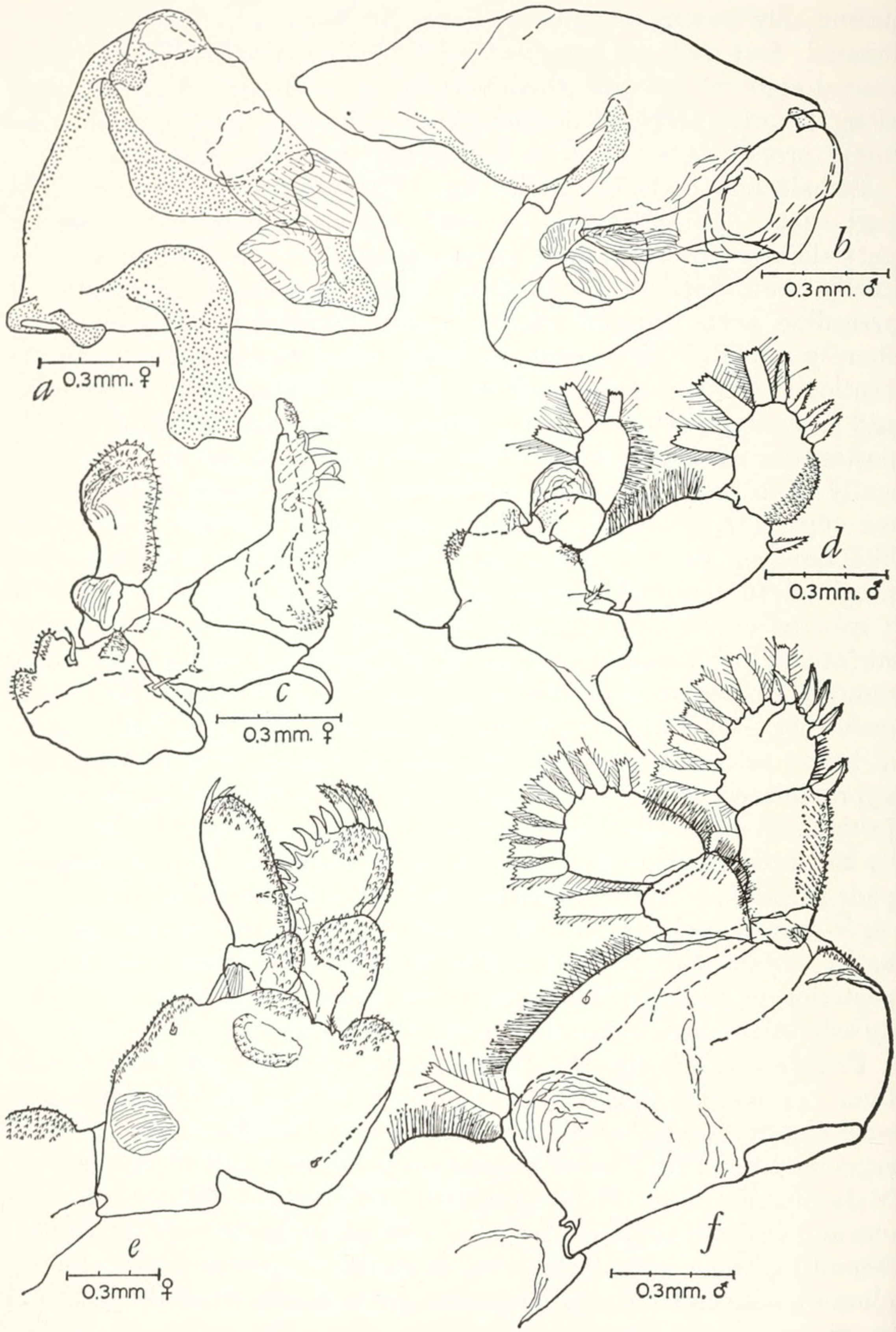

FIGURE 12.—*Pandarus cranchii* Leach, 1819. Right maxilliped, anterior view: *a*, female; *b*, male. Right thoracic legs, anterior view: *c*, female, first leg; *d*, male, first leg; *e*, female, second leg; *f*, male, second leg.

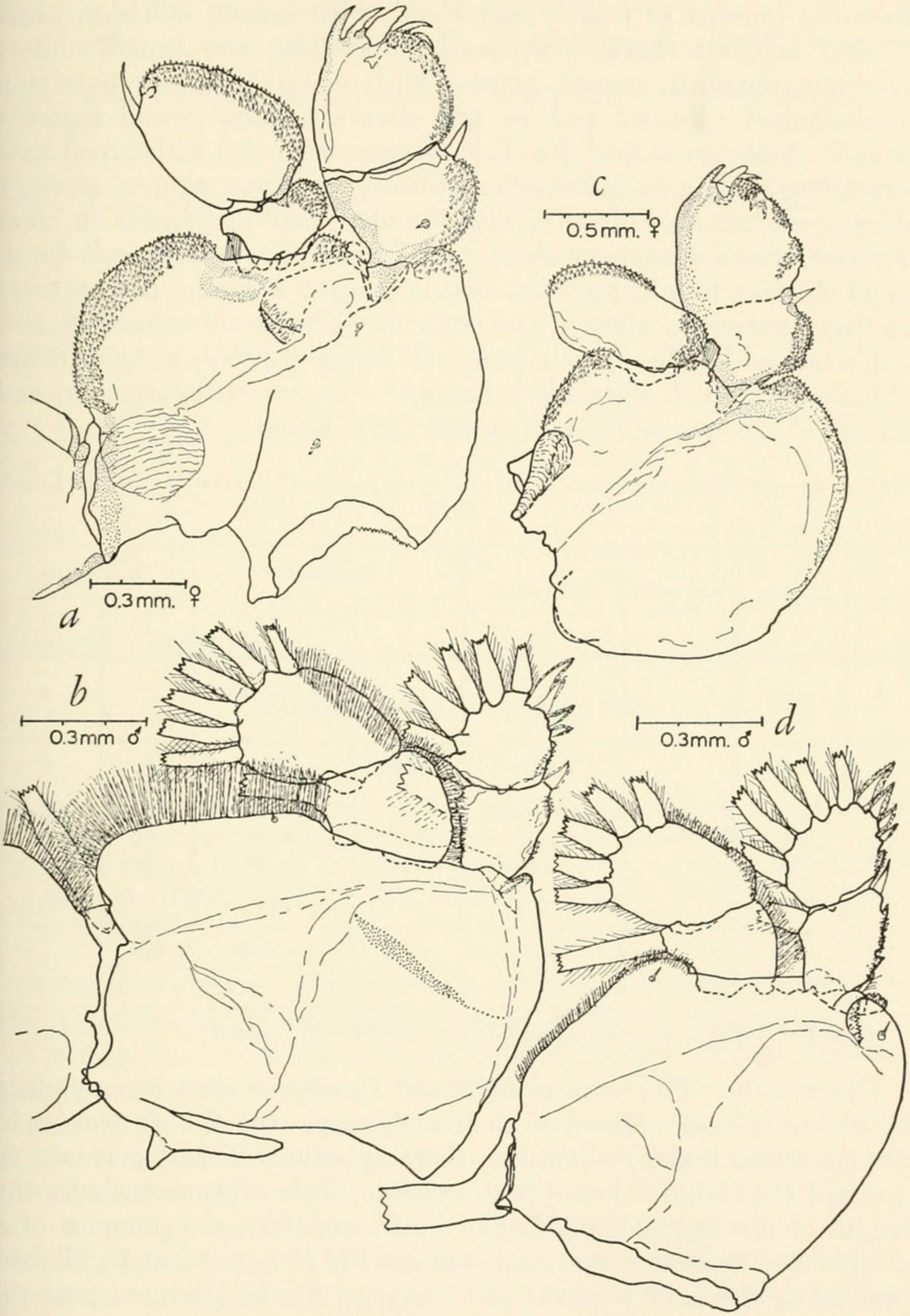

FIGURE 13.—*Pandarus cranchii* Leach, 1819, right thoracic legs, anterior view: *a*, female, third leg; *b*, male, third leg; *c*, female, fourth leg; *d*, male, fourth leg.

Segment tapered to narrow distal end, with several adhesion pads. Second segment short, with proximal swelling and broad, almost laminate terminal process, process with distal concavity overlying knob-shaped adhesion pad on first segment when second segment flexed. Male maxilliped (fig. 12*b*) 2-segmented, also with broad base extending along area of heavy sclerotization. First segment strongly developed, broadest distally, with rounded, padlike process on inner surface. Second segment short, heavily sclerotized, with well developed clawlike terminal process that overlaps 2 adhesion pads present on distal anterior surface of first segment when second segment flexed.

Female and male thoracic legs I–IV biramous, with some evidence of fusion exhibited, especially in female. For anlaysis of armature and nature of legs, see tables 4, 5, figures 12*c–f*, 13*a–d*.

TABLE 4.—*Armature of thoracic legs I–IV of the female of* Pandarus cranchii *Leach, 1819*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite 1	Exopodite 2	Endopodite 1	Endopodite 2
I	outer		p	P	d, 6P, dB*		d
	inner		d, d, p, d			a	3P, d
II	outer	d	s, d, p	d, dH	d, 3dH	d	d
	inner		a, d, s, d, d		6Cl, H		4H, d
III	outer	d	d, p	d, s, H	d, 4H	d	d
	inner		a, d, s		2Cl		2H, d
IV	outer		r, d, s, d, p	d, H	d, d, d, 4H	d, d	
	inner		a, d, s		Cl		

*Process denticulated, appears fused with segment, not distinct as in *P. satyrus*.

DISCUSSION.—*Pandarus cranchii* and *P. satyrus* were synonymized by Shiino (1954c). Based on the female specimens of both species in the collection under description, there appears sufficient evidence to warrant the maintenance of both species. This evidence includes the length of the caudal rami (longer in *P. cranchii*), the presence of a single-lobed process on antennal segment 2 of *P. cranchii* and a bilobed process on the same segment in *P. satyrus*, the 1-segmented postoral process of *P. cranchii* and the 3-segmented postoral process of *P. satyrus*, the presence of a clump of plumosities on segment 2 of the maxilla of *P. cranchii* and their absence on the same segment of *P. satyrus*, the nature of the thoracic leg armature (compare tables 3 and 4). These two species will be discussed more thoroughly in a forthcoming review of the family Pandaridae by Roger Cressey.

TABLE 5.—*Armature of thoracic legs I-IV of the male of* Pandarus cranchii *Leach, 1819*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite 1	Exopodite 2	Endopodite 1	Endopodite 2
I	outer		p	dmH	d, 4dmH		c
	inner		d, p, d*	c	3P	a	3P
II	outer	c	d, p	d, c, mH	d, 3dmH, mH, P	c	c, 4P
	inner		a, P, c, s	c, P	c, 5P	P	c, 4P
III	outer	c	d, p	d, d, mH	d, 4dmH, 2P	c	c, 3P
	inner		P, c, s	c, P	c, 3P	P	c, 3P
IV	outer		d, s, p	d, d, H	d, 3dmH, mH, 2P	c	d, c, 2P
	inner		c, s	c, P	3P	P	c, 3P

*Denticulations between rami.

***Pandarus smithii* Rathbun, 1886**

FIGURES 14*a–d*, 15*a–h*, 16*a–d*

Pandarus smithii Rathbun, 1886, p. 315, pl. 5, fig. 3, pl. 7, fig. 9.—Rathbun, M. J., 1905, p. 95.—Wilson, 1907b, p. 410, pls. 29–30.—Fowler, 1912, p. 479.—Wilson, 1932, p. 434, fig. 272.—Brian, 1944, p. 202, pl. 5, fig. 40.—Carvalho, 1945, p. 110, fig. 28.—Barnard, 1955, p. 259.—Shiino, 1959b, p. 353, fig. 8.

REPORTED HOSTS.—*Carcharhinus milberti, Carcharinus obscurus Carcharias taurus, Carcharodon carcharias, Sphyrna zygaena.*

DISTRIBUTION.—North Atlantic, Gulf of Mexico, Pacific (western, central and southern regions), South Africa.

MATERIAL.—Two ovigerous and 1 nonovigerous adult females (USNM 110807) collected by Susumo Kato from the external surface of several specimens of sharks captured by longline off Oahu, Hawaii. Two nonovigerous adult females (USNM 110808) collected by the Hawaii Fish and Game Department from the buccal cavity of *Carcharhinus melanopterus*? captured by longline in Yokohama Bay, Hawaii. Two nonovigerous adult females (USNM 110809) collected by the Hawaii Fish and Game Department from the external surface of *Carcharhinus melanopterus*? captured by longline in Kealekua Bay, Hawaii.

Measurements.—Seven female specimens:

	mean (mm.)	range (mm.)
Greatest length	8.60	7.84–9.80
Greatest length of cephalothorax	4.37	4.06–4.55
Greatest width of cephalothorax	4.42	4.20–4.55
Greatest length of genital segment	2.69	2.24–3.08
Greatest width of genital segment	3.03	2.73–3.22
Greatest length of caudal rami	1.65	1.61–1.75
Greatest length of anal lamina	1.75	1.47–1.89
Length of egg strings (2 specimens)		7.70, 8.40

Diagnostic description of female.—Cephalothorax (fig. 14*a*) consisting of cephalic, maxilliped-bearing and first pedigerous segments, narrower anteriorly than posteriorly; lateral margins flatly convex, posterior concave, with 8 irregular denticulations medially. Frontal region narrow, with distinct median depression. Second through fourth pedigerous segments (figs. 14*b*, *c*) free, second and third each with single plate covering median dorsal surface, second with pair of ovoid plates originating from lateral dorsal surface, extending posteriorly and laterally; third pedigerous segment with pair of small, posteriorly rounded plates dorsally, extending posteriorly and laterally, slightly overlapped by plates of second pedigerous segment. Fourth pedigerous segment with single, large, apron-shaped plate dorsally, extending posteriorly over most of genital segment.

Genital segment (figs. 14*b*, *c*) wider than long, slightly narrower posteriorly than anteriorly; lateral margins flatly convex, posterior and anterior margins concave laterally, irregular medially, posterolateral projection each tipped by single denticulation. Large, rounded anal lamina attached to dorsal surface of posterior concavity, extending posteriorly to distal end of caudal rami. Abdomen (fig. 14*c*) 1-segmented, extending posteriorly from posteroventral surface of genital segment; narrower anteriorly, broadly rounded posteriorly, bearing pair of heavily sclerotized, distally pointed caudal rami directed posteriorly and laterally. Caudal rami attached to abdomen by broad base formed of cuticular extension of proximal half of ramus.

Color pattern of alcohol preserved material similar to that of *Pandarus satyrus*.

Antennule (figs. 14*d*, 15*a*) 2-segmented, first segment more than twice the length of second, curved posteriorly in distal region; with approximately 23 naked setae on anterior ventral surface. Second segment rounded distally, with approximately 7 fine setules on distal surface and 1 on medial posterior surface. Antenna (figs. 14*d*, 15*b*) 3-segmented, proximal segment with oval adhesion pad, smaller than postantennular adhesion pad, extending across ventral surface of most of cephalic depression bearing antenna. Second antennal segment longer than first, with heavily sclerotized, knob-shaped projection on distal outer surface. Third segment short, with heavily sclerotized, strongly curved, clawlike terminal process and 2 small, spikelike accessory processes. Mandible (figs. 15*c–e*) 2-parted although proximal part with indistinct break in cuticle; distal end of second part

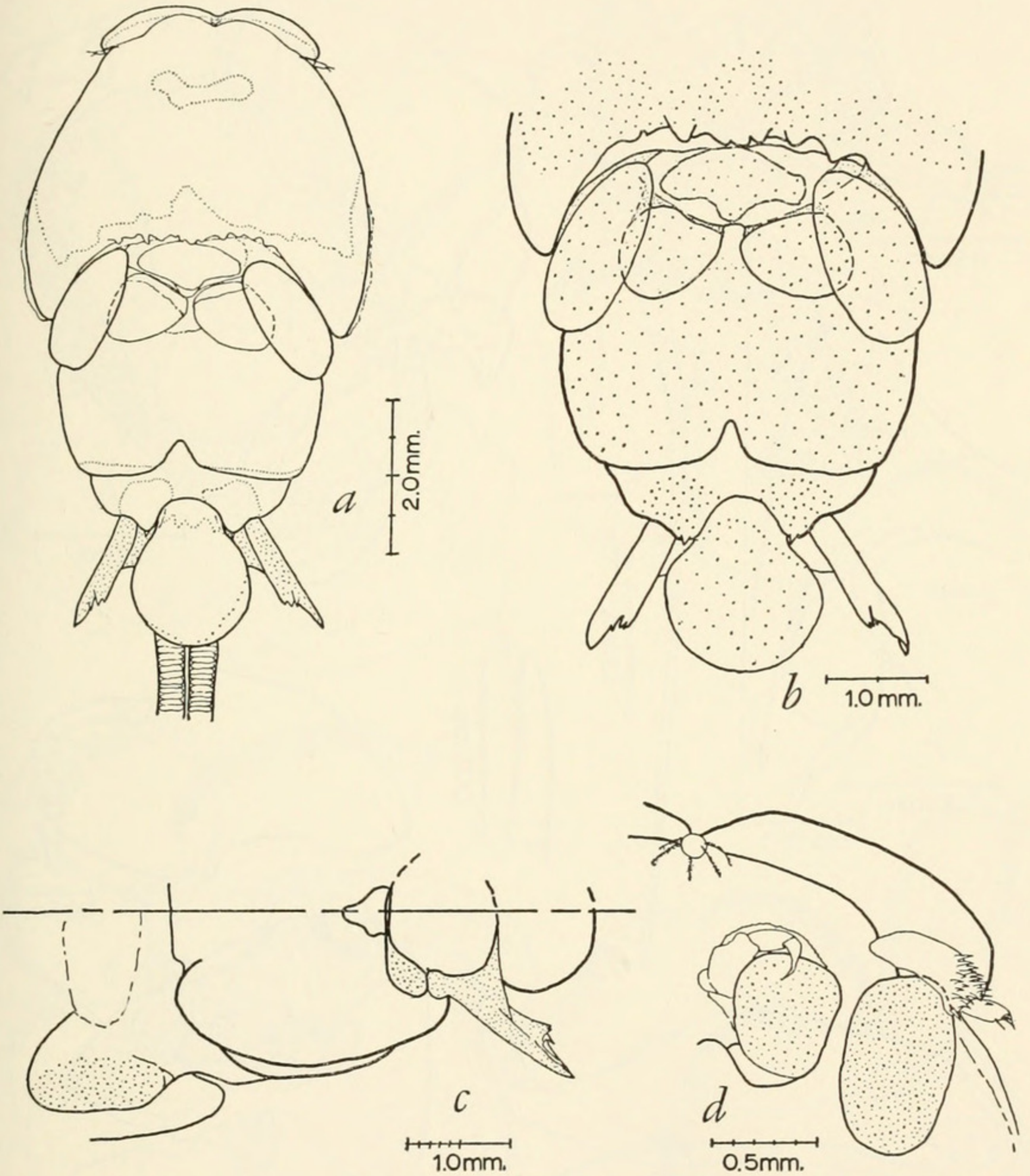

FIGURE 14.—*Pandarus smithii* Rathbun, 1886, female: *a*, dorsal view; *b*, postcephalothoracic region, dorsal view; *c*, third pedigerous segment, genital segment, abdomen, caudal ramus, and anal lamina, ventral view (fourth pedigerous segment not visible); *d*, postantennular and antennal adhesion pads, ventral view.

curved slightly, with 9 denticulations. Postantennular adhesion pad (fig. 14*d*) large, oval, extending posteriorly past antenna. Postoral process (figs. 15*c, f*) irregularly lobate, with spinelike terminal process, minute and knob-shaped accessory process on medial outer surface and indentation on distal inner surface. Postoral adhesion pad (fig. 15*c*) situated just medial to maxilla base, on heavily sclerotized ridge extending to maxilliped base. Maxilla (fig. 15*g*) 2-segmented, first segment more strongly developed than second and

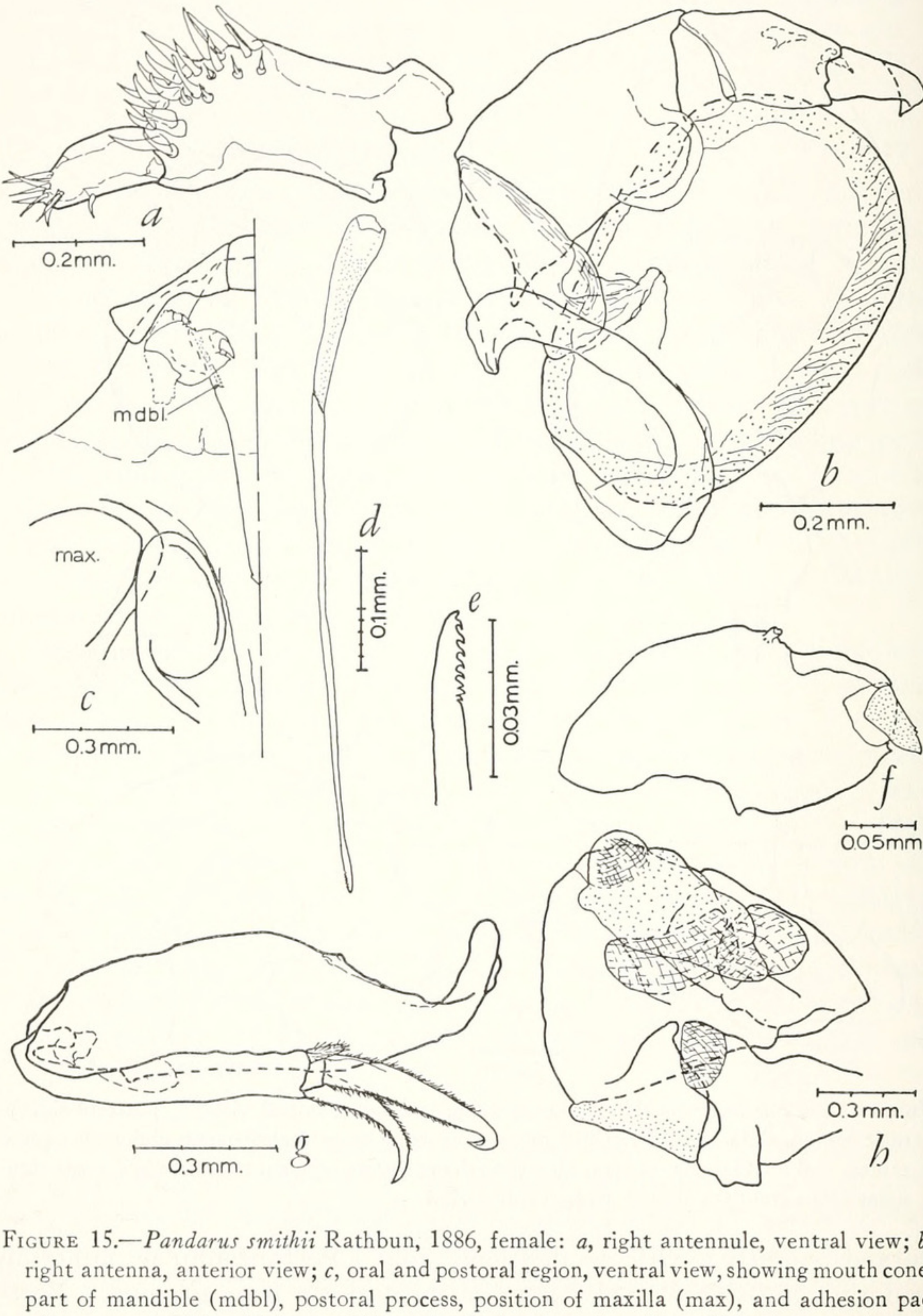

FIGURE 15.—*Pandarus smithii* Rathbun, 1886, female: *a*, right antennule, ventral view; *b*, right antenna, anterior view; *c*, oral and postoral region, ventral view, showing mouth cone, part of mandible (mdbl), postoral process, position of maxilla (max), and adhesion pad adjacent to maxilla; *d*, left mandible; *e*, denticulated portion of mandible; *f*, postoral process; *g*, maxilla; *h*, maxilliped.

more than one and one-half times its length, excluding terminal processes. Second segment with 2 saber-shaped terminal processes and small, plumose knob adjacent to terminal processes.

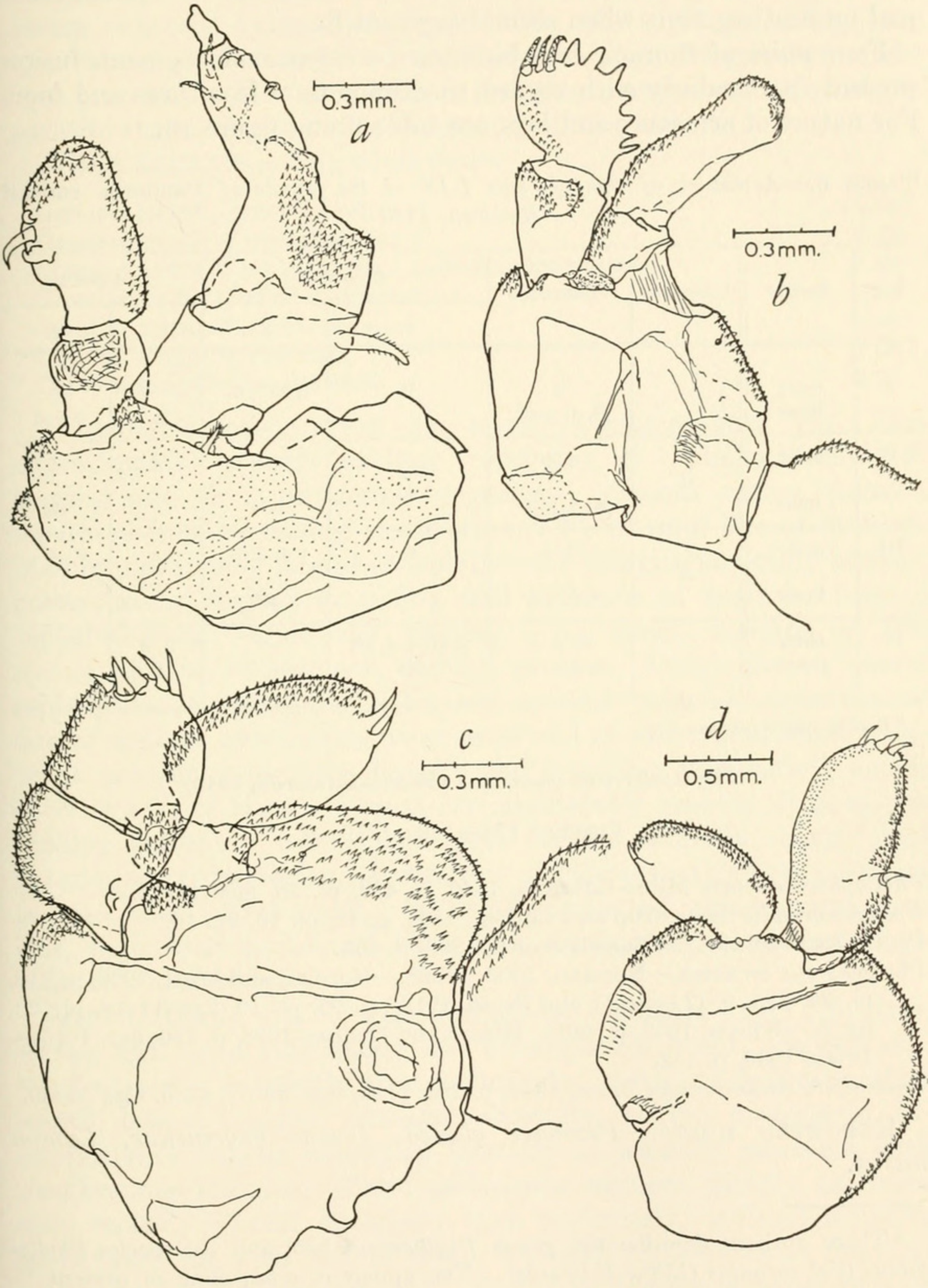

FIGURE 16.—*Pandarus smithii* Rathbun, 1886, female, right thoracic legs: *a*, first leg, anterior view; *b*, second leg, posterior view; *c*, third leg, posterior view; *d*, fourth leg, anterior view.

Maxilliped (fig. 15*h*) 2-segmented, first segment well developed, irregularly triangular, with several heavily sclerotized adhesion pads and processes. Second segment short, with proximal knoblike projection and bilobed, lappet-like terminal process that overlaps adhesion pad on first segment when second segment flexed.

Four pairs of thoracic legs biramous, evidence of segment fusion present, particularly with regard to exopodite of legs three and four. For nature of armature and legs, see table 6 and figure 16.

TABLE 6.—*Armature of thoracic legs I-IV of the female of* Pandarus smithii *Rathbun, 1889*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	outer		p	P	d, 6P′, B		d
	inner		d, d, p, d*			a	3H, d
II	outer	d	d, p		3rH	d	d
	inner		a, d, s, d*		7Cl		4H
III	outer	d	d, p	d	d, 3H	d	d
	inner		a, d, s, d*		2H		2H
IV	outer		d, s, p	d, H, d, d, 3H		d, d	
	inner		a, d, s, d*	2H		h	

* Denticulations between rami.

***Phyllothyreus cornutus* (Milne-Edwards, 1840)**

FIGURES 17*a–e*, 18*a–f*, 19*a–d*

Phyllophora cornuta Milne-Edwards, 1840, p. 472, pl. 38, figs. 13–14.
Nogagus grandis Steenstrup and Lütken, 1861, p. 46, pl. 10, fig. 19.
Phyllophorus cornutus.—Bassett-Smith, 1899, p. 465.
Phyllothyreus cornutus.—Norman, 1903, p. 368.—Norman and Scott, 1906, p. 212, pl. 24, figs. 9–17.—Scott and Scott, 1913,[3] p. 92, pl. 19, figs. 11–18, pl. 23, fig. 3.—Wilson, 1932, p. 440.—Monod and Dollfus, 1938, p. 196, figs. 1–15.—Brian, 1946, p. 142.
Laminifera doello-juradoi Brian, 1944, p. 205, pl. 4, figs. 30–37, pl. 5, figs. 38–39.

REPORTED HOSTS.—*Prionace glauca, Isurus oxyrinchus, Lamna nasus.*

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[3] These authors describe the genus *Phyllothreus* [sic] and the species *Phyllothreus* [sic] *cornutus* (Milne-Edwards). The apparent misspelling is present in every citation.

Distribution.—Mediterranean, England, warmer parts of the Atlantic (Steenstrup and Lütken, 1861), Tongatabu (Friendly Islands).

Material.—One adult male (USNM 110810) collected by E. C. Jones and Kenneth Sherman from the fin of a specimen of *Prionace glauca* captured by longline at 40°15′N., 170°16′W. Although the specimen was collected out of the Hawaiian area, the presence of the host around the Hawaiian Islands and the known distribution of the parasite suggest its probable occurrence in the area.

Measurements.—One adult male:

	(*mm.*)
Greatest length, excluding setae	15.54
Greatest length of cephalothorax	7.42
Greatest width of cephalothorax, excluding membranes	7.42
Greatest length of genital segment	3.85
Greatest width of genital segment	3.36
Greatest length of abdomen	1.68
Greatest length of caudal rami	2.73

Diagnostic description of male.—Cephalothorax (fig. 17*a*) approximately as wide as long, consisting of cephalic maxilliped-bearing and first pedigerous segments. Frontal region narrow, separated from remaining cephalothorax by distinct line of division. Membrane-rimmed lateral cephalothoracic margins smoothly convex, posterolateral regions extending well posterior of posterior median cephalothoracic region and forming, with lateral margins of free second pedigerous segment, distinct sinuses. Membrane on lateral cephalothoracic margins continuous around posterior extension of lateral regions, terminating at anterior end of sinus; additional membrane present, projecting dorsally and extending transversely across anterior end of sinus. Dorsal cephalothoracic grooves distinct, extending anteriorly from sinus apex, curving laterally sharply just anterior to ocular region, terminating at lateral margin just posterior to antennule. Eyes small, with small pigmented region around each lens, pigmented regions of both eyes contiguous on median longitudinal axis of body.

Second, third, and fourth pedigerous segments (fig. 17*b*) free, second and third indistinctly and incompletely fused. Second segment narrower anteriorly than posteriorly, width much greater than length, lateral margins concave anteriorly, convex posteriorly, lateroposterior regions extending laterally as winglike processes with membranous margins. Third pedigerous segment slightly narrower than second, broader anteriorly than posteriorly, without winglike projections but with pair of small, knoblike projections at junction with second pedigerous segment. Fourth pedigerous segment distinct

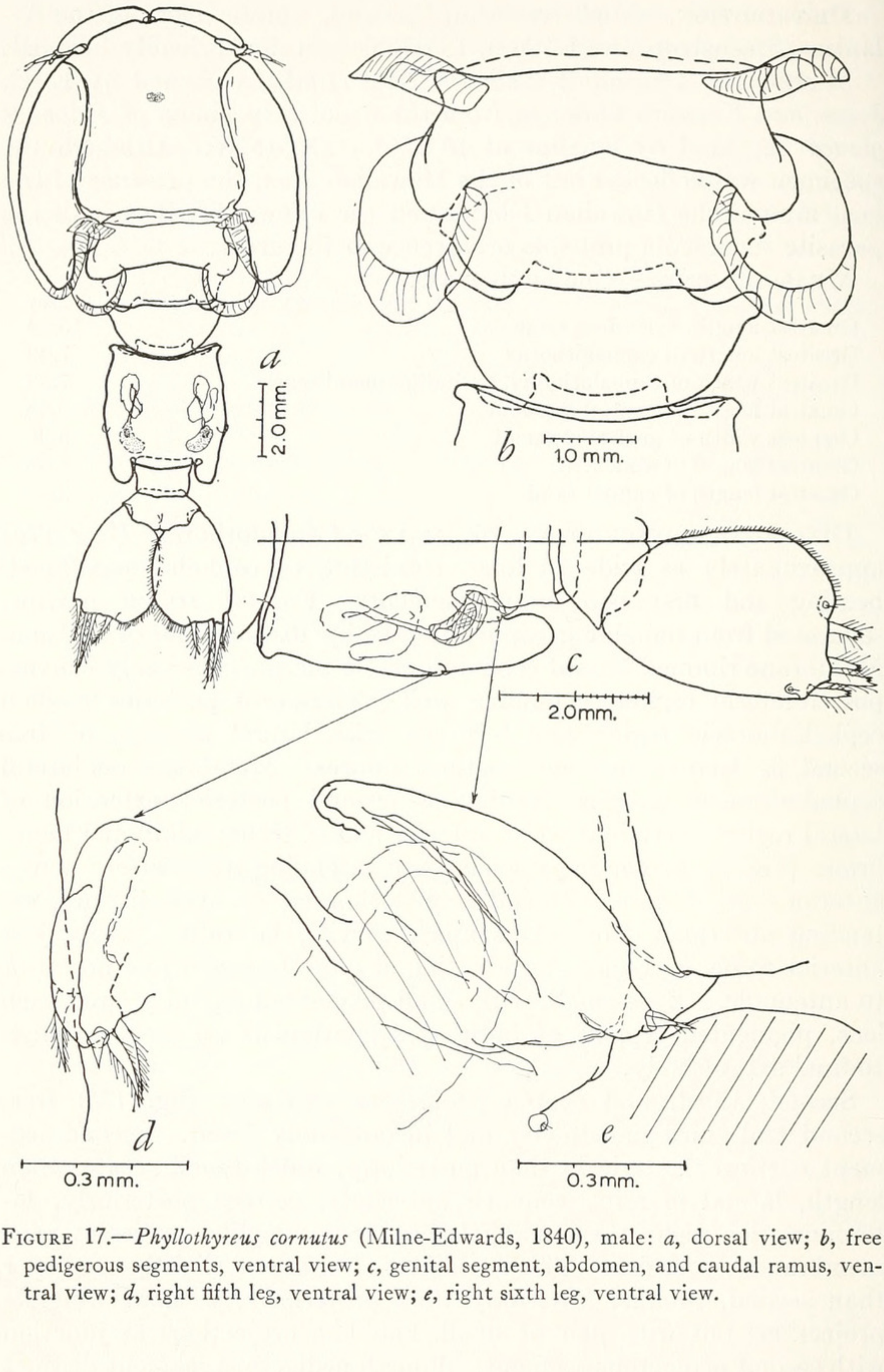

FIGURE 17.—*Phyllothyreus cornutus* (Milne-Edwards, 1840), male: *a*, dorsal view; *b*, free pedigerous segments, ventral view; *c*, genital segment, abdomen, and caudal ramus, ventral view; *d*, right fifth leg, ventral view; *e*, right sixth leg, ventral view.

from both third and genital segments, lyre-shaped although anterior end with large, heavily sclerotized, knob-shaped anterior lateral projections.

Genital segment (fig. 17*c*) barrel-shaped except for lappet-like lateral posterior projections, anterolateral corners of segment forming small, knoblike, heavily sclerotized projections. Fifth leg (fig. 17*d*) small, slightly irregular, projecting from ventral lateral surface of genital segment just posterior to middle of segment, bearing single, small, spiniform projection and 3 plumose setules. Sixth leg (fig. 17*e*) consisting of small, spiniform projection and single setule at posterior end of oval irregularity of ventral genital segment surface in region of genital opening.

Abdomen (fig. 17*c*) 2-segmented, first segment subrectangular, wider than long; second segment narrow anteriorly, flared to middle of segment then curved irregularly to anal concavity. Caudal rami (fig. 17*c*) greatly enlarged, slightly shorter than genital segment, excluding projections, laminate, with inner lateral margins plumose, bearing 4 large, plumose setae from distal surface and 2 small setules, one on each posterolateral surface.

Antennule (fig. 18*a*) 2-segmented, attached to irregularity of anteroventral cephalothoracic surface and posteroventral surface of frontal region. Both segments of general elongate nature, first approximately one and one-third times the length of second, flattened ventrally, rounded dorsally, bearing approximately 22 plumose and naked setules. Second segment rounded distally, with 6 small, spinelike projections and 4 naked setules from distal surface, 1 naked setule from distal dorsal surface. Antenna (fig. 18*b*) 3-segmented, situated medial and posterior to antennule base and lateral to oral region. First segment flattened, proximal end abutting against small, heavily sclerotized, padlike projection of cephalothorax. Third segment and terminal process fused, clawlike, with 2 setule-like accessory processes, 1 medially, second proximally. Mandible (fig. 18*c*) 2-parted, proximal end articulating in circular depression in platelike region of heavy sclerotization; appendage rodlike, distal end sharply rounded, distal inner surface denticulated. Postantennular adhesion pad (fig. 18*a*) similar to that of *Pandarus* but not as well developed, with irregular cross striations. Postoral process (fig. 18*d*) irregularly lobate, tipped by spiniform process. Postoral adhesion pads (fig. 18*e*) small, knob-shaped, situated slightly posterior to mouth cone, at beginning of heavily sclerotized region forming articulation surface for maxilla and maxilliped. Maxilla (fig. 18*e*) 2-segmented, first segment approximately one and one-third times the length of the second, with proximally projecting articulation surface (not visible in figure). Second segment narrower proximally than distally, tipped by 2 saber-shaped processes, innermost approximately one and one-half times the length of the outer, outer with rows of short, stiff plumosities.

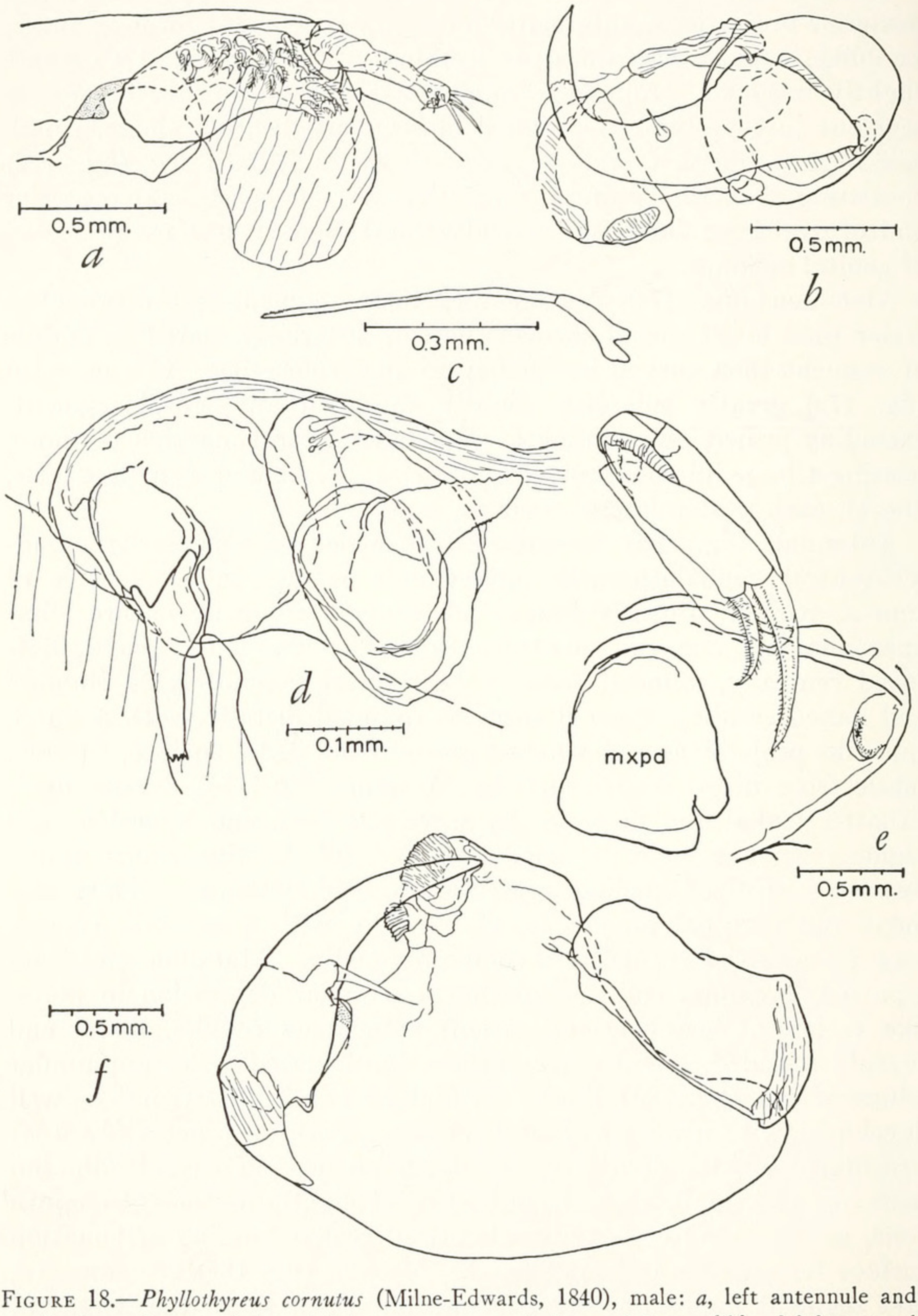

FIGURE 18.—*Phyllothyreus cornutus* (Milne-Edwards, 1840), male: *a*, left antennule and adhesion pad, ventral view; *b*, left antenna, ventral view; *c*, left mandible; *d*, left postoral process and mouth cone base, ventral view; *e*, right maxilla and maxilliped base (mxpd), ventral view; *f*, right maxilliped, lateral view.

Maxilliped (fig. 18*f*) 2-segmented, attached immediately posterior and medial to maxilla base. First segment strongly developed, broad proximally, narrow distally, with 2 small adhesion projections on anterior lateral surface against which second segment terminal process shuts when second segment flexed. Second segment short,

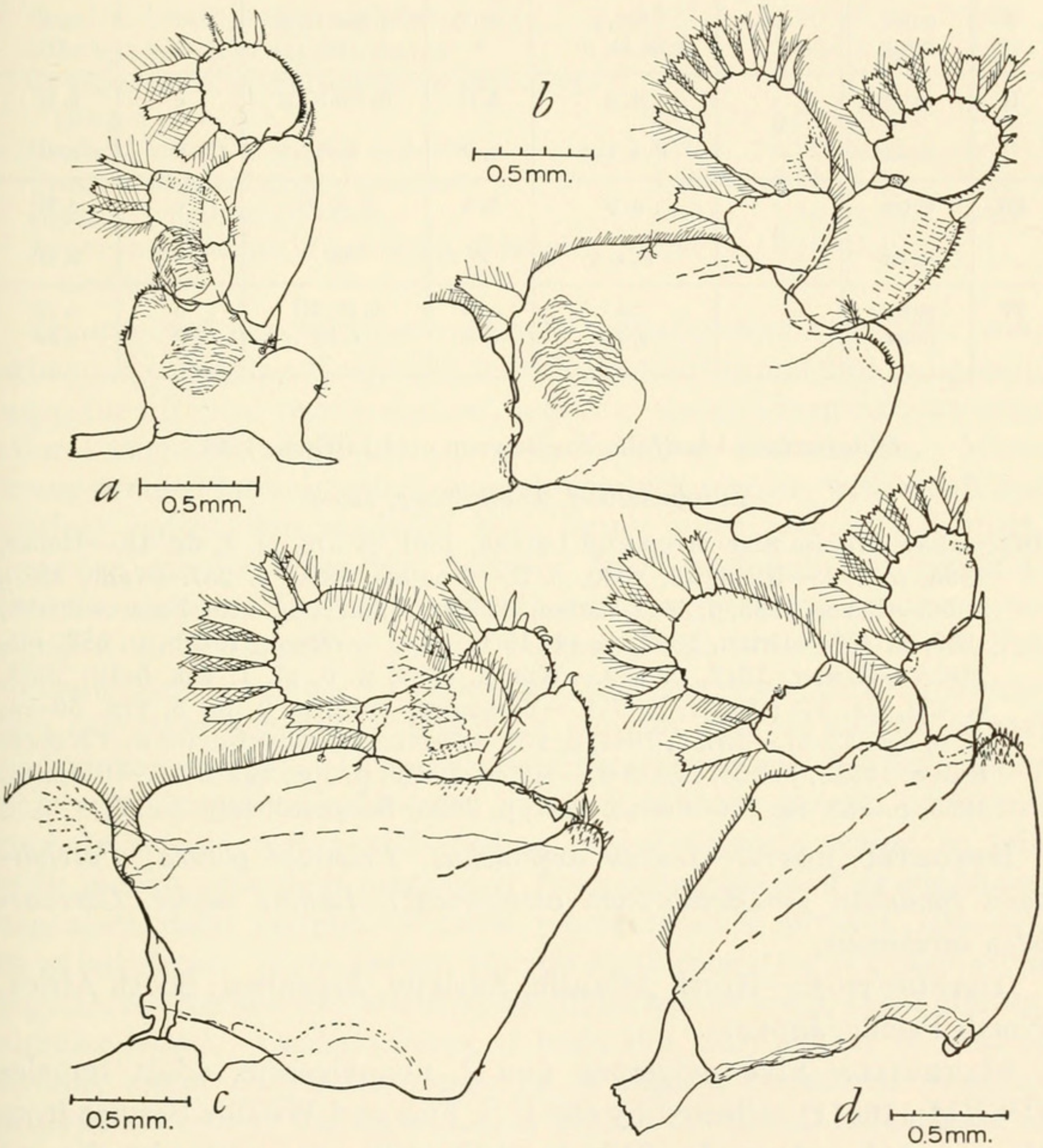

FIGURE 19.—*Phyllothyreus cornutus* (Milne-Edwards, 1840), male, right thoracic legs, anterior view: *a*, first leg; *b*, second leg; *c*, third leg; *d*, fourth leg.

terminal process longer than segment, together forming clawlike structure. Long, seta-like accessory process present at junction of second segment and terminal process.

Thoracic legs I–IV biramous, protopodite 1-segmented, rami 2-segmented. For nature of armature and legs see table 7 and figures 19*a–d*.

TABLE 7.—*Armature of thoracic legs I–IV of the male of* Phyllothyreus cornutus (*Milne-Edwards, 1840*)

Leg	Margin	Interpodal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	outer		1sss, p	dmH	d, 3dmH, H		c, P
	inner		2d, 2a, p	c	3P	a	2P
II	outer	c	d, p	d, H	d, 3fmH, H	c	c, 5P
	inner		P, c, 1sss	c, P	c, 6P	P	c, 3P
III	outer	c	d, p	d, h	d, 3h, H	c	c, 2P
	inner		P, c, s	P	5P	P	c, 4P
IV	outer		d	c, H	c, 2h, 2H	c	c, 2P
	inner		c, 1ss	c, P	c, 5P	P	c, 3P

Dinematura[4] *latifolia* Steenstrup and Lütken, 1861

FIGURES 20*a–f*, 21*a–h*, 22*a–g*, 23*a–b*

Dinematura latifolia Steenstrup and Lütken, 1861, p. 378, pl. 8, fig. 16.—Heller, 1865, p. 199.—Richiardi, 1880, p. 3.—Stossich, 1880, p. 257.—Valle, 1880, p. 60.—Carus, 1885, p. 360.—Brian, 1898, p. 14, pl. 2, fig. 10.—Bassett-Smith, 1899, p. 463.—Brian, 1902, p. 44; 1906, p. 52.—Wilson, 1907b, p. 383, pls. 24–25.—Fowler, 1912, p. 479.—Wilson, 1923, p. 6, pl. 1, figs. 6–10; 1932, p. 432, fig. 271; 1935c, p. 778.—Yamaguti, 1936, p. 9, pl. 5, figs. 50–52; pl. 6, figs. 53–61.—Brian, 1944, p. 201.—Delamare-Deboutteville and Nunes-Ruivo, 1953b, p. 204, figs. 2–3.—Shiino, 1954c, p. 308, figs. 9–10.—Barnard, 1955, p. 263, fig. 16.—Shiino, 1957, p. 365.—Heegaard, 1962, p. 177.

REPORTED HOSTS.—*Isurus oxyrinchus, Prionace glauca, Carcharodon rondeletti* (=*Carcharodon carcharias*?), *Lamna nasus, Carcharodon carcharias.*

DISTRIBUTION.—North Atlantic, Adriatic, Argentina, South Africa, North Pacific, Japan.

MATERIAL.—Five ovigerous and 1 nonovigerous adult females (USNM 110811) collected by the U.S. Fish and Wildlife Service from the external surface of a "Mackerel Shark" captured by longline at 45°58′ N., 162°33′ W. One nonovigerous adult female (USNM 110812) collected by Susumo Kato from the external surface of an unknown shark captured by longline off Oahu, Hawaii. Seven nonovigerous and 1 ovigerous adult females in addition to 1 adult male (USNM

[4] The references using the spelling *Dinemoura* are not designated in the synonymy. The improper latinization of the generic name (*Dinemoura*) by Latreille (1829) was corrected to *Dinematura* by Burmeister (1835).

110813) collected by the Hawaii Division of Fish and Game from the external surface of a specimen of *Carcharodon carcharias* captured by longline at Pokai Bay, Hawaii.

MEASUREMENTS.—Sixteen females, one male:

	female		*male*
	mean (mm.)	*range (mm.)*	*(mm.)*
Greatest length, excluding setae	12.47	11.20–14.28	8.80
Greatest length of cephalothorax	5.91	5.04– 6.65	4.60
Greatest width of cephalothorax, excluding flanges	6.75	5.81– 7.63	4.10
Greatest length of genital segment	5.73	4.90– 6.58	2.30
Greatest width of genital segment	3.96	3.01– 4.34	1.15
Greatest length of abdomen	1.66	1.40– 1.89	0.90
Approximate length of egg string (6 female specimens)	26.27	8.40–37.10	

DIAGNOSTIC DESCRIPTION.—Female cephalothorax (fig. 20*a*) suborbicular, consisting of cephalic, maxilliped-bearing and first pedigerous segments; frontal region narrow, anterior margin irregular, anterior lateral cephalothoracic margin with indistinct indentation. Membrane-rimmed lateral cephalothoracic margins regular, with small but distinct indentation medially that forms outer end of indistinct, irregular groove extending laterally from posteromedial cephalothoracic region. Lateral cephalothoracic regions extending posteriorly to anterior end of genital segment, well posterior to median cephalothoracic region. Posteromedian region with narrow, flange-like extension dorsally, overlapping anterior half of narrow second pedigerous segment. Dorsal cephalothoracic grooves distinct, major pair extending anteriorly from junction of inner margin of lateral cephalothoracic region and median cephalothoracic region to join with groove extending posteriorly from indentation of anterolateral cephalothoracic margin. Several minor grooves present although most indistinct. Eyes distinct though small consisting of 2 pigmented regions, contiguous on median longitudinal axis of body, and 2 minute, circular lenses. Cephalothorax of male (fig. 20*b*) similar to that of female, major differences consisting of regular instead of irregular anterior margin of frontal region, 2 instead of 1 small indentation of lateral cephalothoracic margin and with major dorsal cephalothoracic grooves appearing to terminate before joining groove extending posteriorly from indentation of anterolateral cephalothoracic margin.

Female second through fourth pedigerous segments (fig. 20*a*) free, second with 2-parted lateral extensions, anterior part heavily sclerotized, rodlike except for adhesion pad formed by swollen distal end; posterior part of extension heavily sclerotized anteriorly, with membranous margin posteriorly, both parts forming extension projecting under lateral cephalothoracic region and under anterior end of fourth

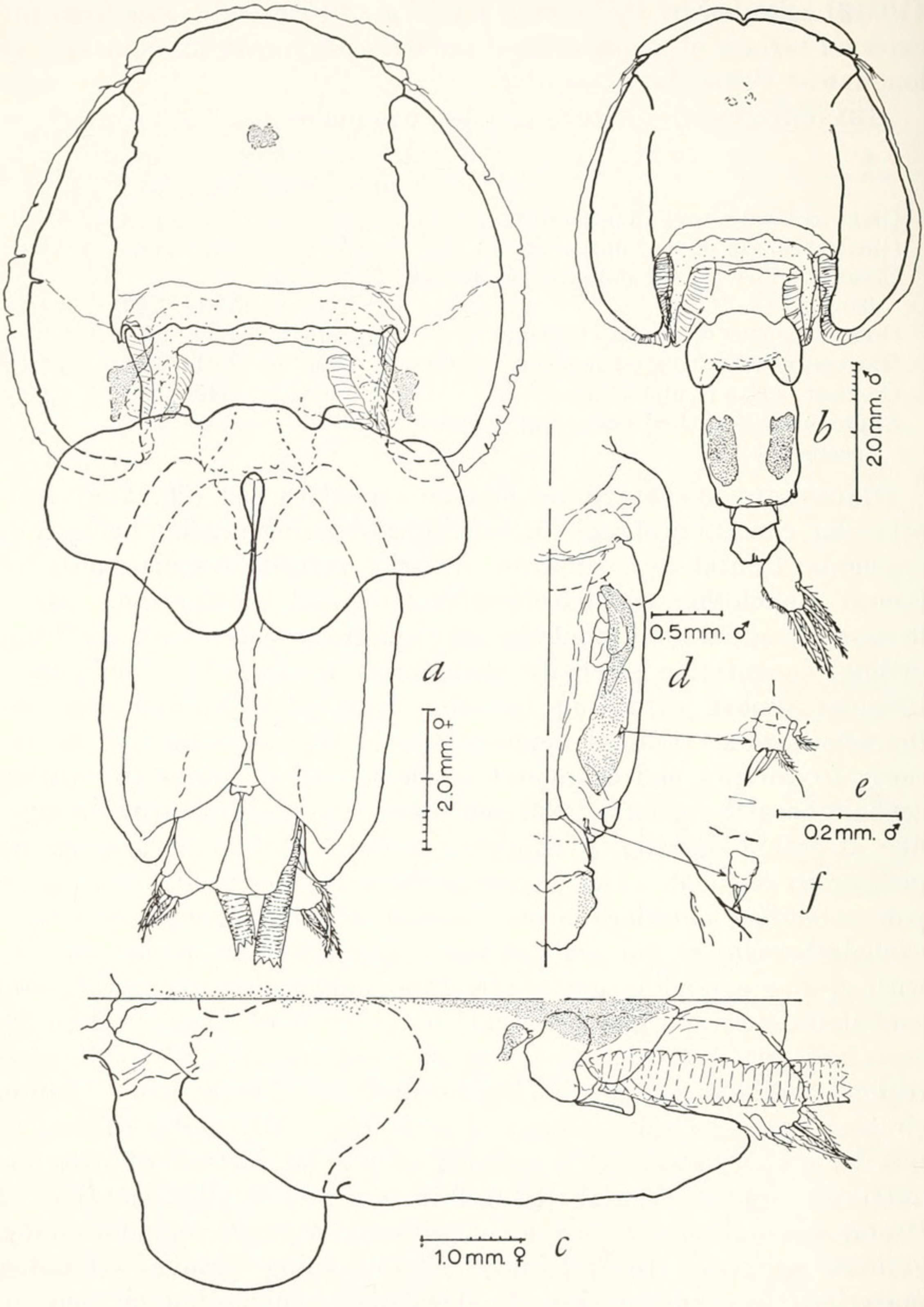

FIGURE 20.—*Dinematura latifolia* Steenstrup and Lütken, 1861: *a*, female, dorsal view; *b*, male, dorsal view; *c*, female, genital segment, abdomen, caudal ramus, and egg string, ventral view; *d*, male, genital segment, fifth and sixth legs, and abdomen, ventral view; *e*, male, fifth leg; *f*, male, sixth leg.

pedigerous segment ala. Third pedigerous segment width approximately twice the length, with knoblike swelling on lateral surface forming attachment and articulation surface for third thoracic leg, with pair of small, knoblike protrusions posteriorly, overlapping short anterior end of fourth pedigerous segment. Fourth pedigerous segment distinct from genital segment dorsally although fused ventrally; segment small, slightly longer than wide, lateral surfaces distinct ventrally although tapered into large ala. Ala extending laterally, across dorsal surface of posterior end of lateral cephalothoracic region, extending posteriorly and covering anterior third of genital segment. Median posterior region of ala bilobed, with deep sinus separating lobes. Second through fourth pedigerous segments of male (fig. 20*b*) free, lateral projection of second not as well developed as in female. Third pedigerous segment as in female; ala of fourth pedigerous segment much smaller in male than in female, bilobed posteriorly although without deep sinus, overlapping anterior end of genital segment.

Female genital segment (fig. 20*c*) large, anterolateral corners rounded, median anterior surface concave; lateral margins flatly convex, posterolateral surfaces lobate, projecting posteriorly almost to end of caudal rami. Dorsal surface with platelike processes extending over most of segment and overlapping part of abdomen. Medial posterior surface forming place of attachment of large, orbicular projection (sixth segment of Wilson, 1907b) and pair of large, lobate laminae. Abdomen 1-segmented, projecting from ventral genital segment surface immediately posterior to attachment of orbicular projection and laminae (not attached to orbicular projection but to genital segment). Proximal end of abdomen broad, tapered sharply posteriorly. Caudal rami arising from sharp taper of abdomen. Rami strongly flattened, outer lateral portion folded, bearing 4 lightly plumose setae from distal region and minute setule medial to innermost seta.

Male genital segment (fig. 20*d*) slender, barrel-shaped, lateral regions appearing slightly swollen, posterolateral regions each with slender, knoblike area of heavy sclerotization distinct from rest of segment. Fifth leg (fig. 20*e*) consisting of knob-shaped protrusion bearing 1 plumose and 2 naked setules, single, plumose setule present just lateral to protrusion. Sixth leg (fig. 20*f*) a minute nodule bearing 2 naked setules. Abdomen 2-segmented, arising from posteroventral genital segment surface. First segment narrower anteriorly than posteriorly, length approximately three-fourths the width, posterior end with flattened, V-shaped outline. Second segment slightly longer than first, outline irregular, lateral regions curved ventrally and more heavily sclerotized than rest of segment, lateral posterior margins angled, surfaces forming attachment for caudal rami. Caudal rami damaged although appearing similar to those of female except for greater plumosity of inner margin.

Female antennule (fig. 21*a*) 2-segmented, attached to lateral anterior ventral cephalothoracic surface at junction of lateral cephalothoracic margin and frontal region. First segment approximately two and one-half times the length of second, broader proximally than distally, with approximately 18 naked or finely plumose setules along edge of ridge extending along anterior and distal portions of ventral surface and terminating in small, subtriangular projection of distal posterior surface. Second segment club-shaped, with 2 naked terminal setules. Antennule of male (fig. 21*b*) with first segment slightly more than twice the length of second, bearing approximately 14 setules, distal 7 densely plumose; second segment with 1 short and 4 elongate, naked setules. Female antenna (fig. 21*c*) 3-segmented, first and second segments short, strongly developed, first with small adhesion pad; third segment and fused terminal process clawlike, terminal process strongly curved, segment with 2 setule-like accessory processes. Antenna of male (fig. 21*g*) 3-segmented, first segment without adhesion pad, second segment slightly shorter than first, with distinct adhesion surface on anterior distal surface, third segment and terminal process complex, segment short, distinct from terminal process, with small adhesion pad, terminal process short, clawlike.

Female and male mandible (figs. 21*d, e*) appearing 2-parted, rod-like, first part short, second part elongate, distal region of second part slightly flattened, rounded distally, inner margin with 12 denticulations. Female and male postantennular adhesion pad (fig. 21*a*) 2-parted, consisting of small, cup-shaped structure situated just posterior and lateral to antennule base, and just anterior to large, ovoid adhesion pad extending posteriorly and slightly medial. Postoral process of female (figs. 21*c, f*) appearing 4-segmented, proximal segment attached to rib-shaped region of heavy sclerotization connected to Y-shaped region surrounding mouth and extending anteriorly, rib-shaped region also forming attachment and articulation surface for mandible. Proximal segment of postoral process strongly developed, with at least 1 plumosity-bearing nodule (Shiino, 1954c, and others report 2 nodules); second and third segments elongate, subrectangular, fourth segment lamellate and folded and may be terminal process of third segment. Postoral process of male (fig. 21*g*) 3-segmented although third segment with irregularity attached to distal end that may be remains of fourth segment or terminal process. Female and male with pair of oval adhesion pads just posterior to mouth cone base (figs. 21*g, h*), situated on extensive region of heavy sclerotization forming articulation and muscle at-

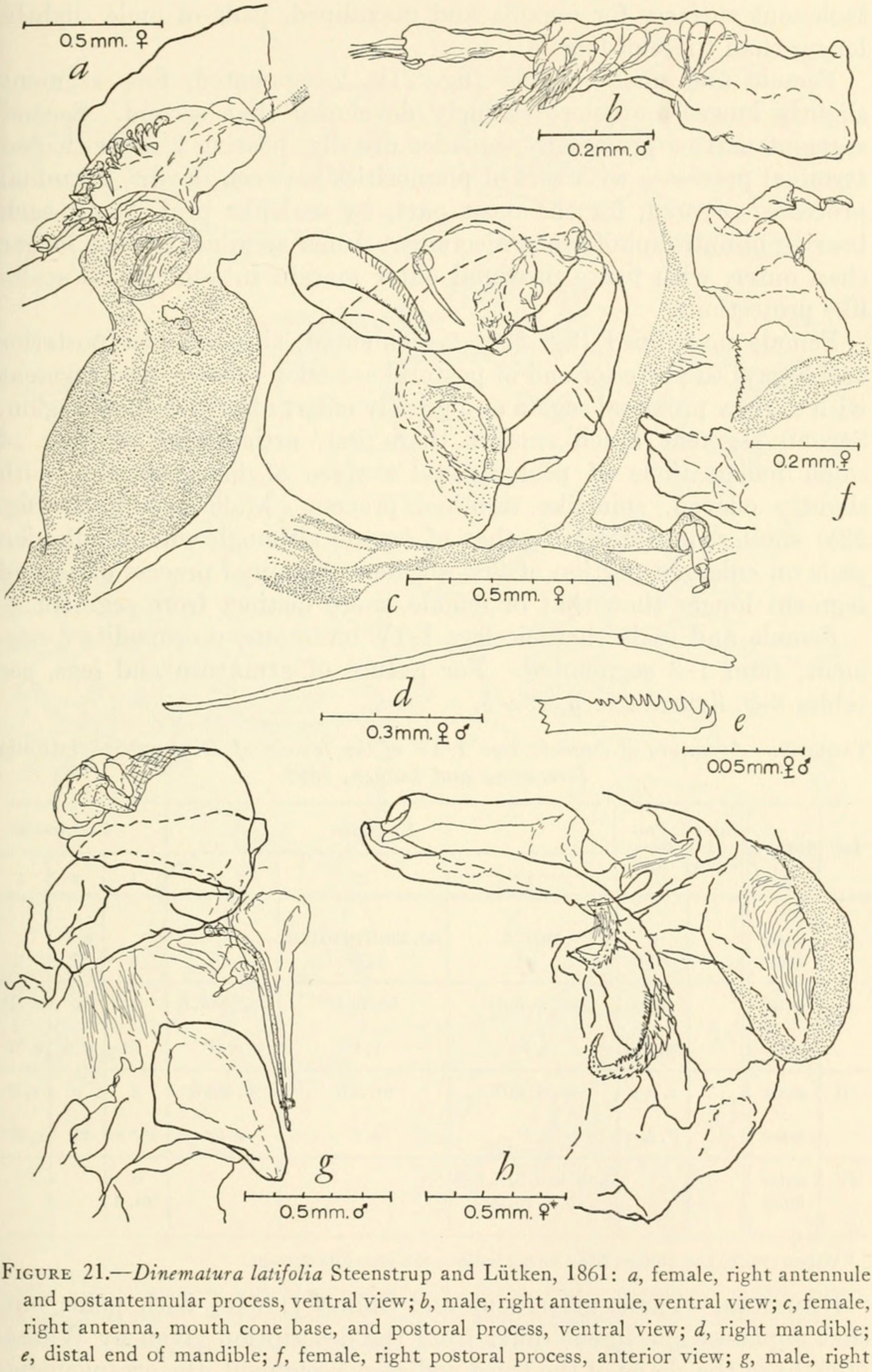

FIGURE 21.—*Dinematura latifolia* Steenstrup and Lütken, 1861: *a*, female, right antennule and postantennular process, ventral view; *b*, male, right antennule, ventral view; *c*, female, right antenna, mouth cone base, and postoral process, ventral view; *d*, right mandible; *e*, distal end of mandible; *f*, female, right postoral process, anterior view; *g*, male, right antenna, mouth cone, mandible (only one shown), postoral process, postoral adhesion pad, and maxilla base (max), ventral view; *h*, female, right maxilla and postoral adhesion pad (male maxilla similar).

tachment surfaces for maxilla and maxilliped, pads of male slightly longer than those of female.

Female and male maxilla (fig. 21*b*) 2-segmented, first segment slightly longer and more strongly developed than second. Second segment narrow proximally, broader distally, bearing 2 saber-shaped terminal processes with tuft of plumosities between them. Terminal processes covered, for the most part, by scalelike projections, each bearing minute, spiniform projections. Inner terminal process longer than outer, with fuzzy proximal outer margin in addition to scale-like projections.

Female maxilliped (fig. 22*a*) 2-segmented, situated just posterior and lateral to posterior end of postoral adhesion process, first segment with narrow proximal region and greatly enlarged, ovoid distal region. Second segment much smaller than first, articulating on pair of small indentations of posterodistal surface of first segment, with slightly curved, spinelike terminal process. Male maxilliped (fig. 22*b*) similar, in outline, to that of female although with 2 adhesion pads on enlarged portion of first segment, terminal process of second segment longer than that of female, more distinct from segment.

Female and male thoracic legs I–IV biramous, protopodite 1-segment, rami 1–3 segmented. For nature of armature and legs, see tables 8–9, figures 22*c*–*g*, 23*a*–*b*.

TABLE 8.—*Armature of thoracic legs I–IV of the female of* Dinematura latifolia *Steenstrup and Lütken, 1861*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite			Endopodite		
				1	2	3	1	2	3
I	outer		p	fmH, d	fm, 2fmH, dmH, H			c, P	
	inner		2a, p	c	c, 3P		a	2P	
II	outer	c	2a, p	fm, d, fmH	fm, fmH	fm, 2fmh, fh	c	c	c, 3P
	inner		3a, P, c	c, P	c, P	c, 5P		c, 2P	c, 3P
III	outer	c	a, c, a	m, d, mH	m, mH	m, 3fmH	c	c	c, P
	inner		P, c, a	c, P	c, P	c, 5P	P,* c	2P	c, 3P
IV	outer			d, rh, h, d, h, d, h, d			d		
	inner			rh, d, rh, 2h			2rh, d		

* Wilson (1907b) and Shiino (1954c) do not indicate this armature element.

REMARKS.—Yamaguti (1936) and Shiino (1954c) both point out that Japanese specimens differ from the description given by Wilson (1907b) in the shape of the third pedigerous segment, the arrangement of the adhesion pads, and the number of spines on the thoracic legs. I am indebted to Dr. S. M. Shiino for the loan of a female specimen

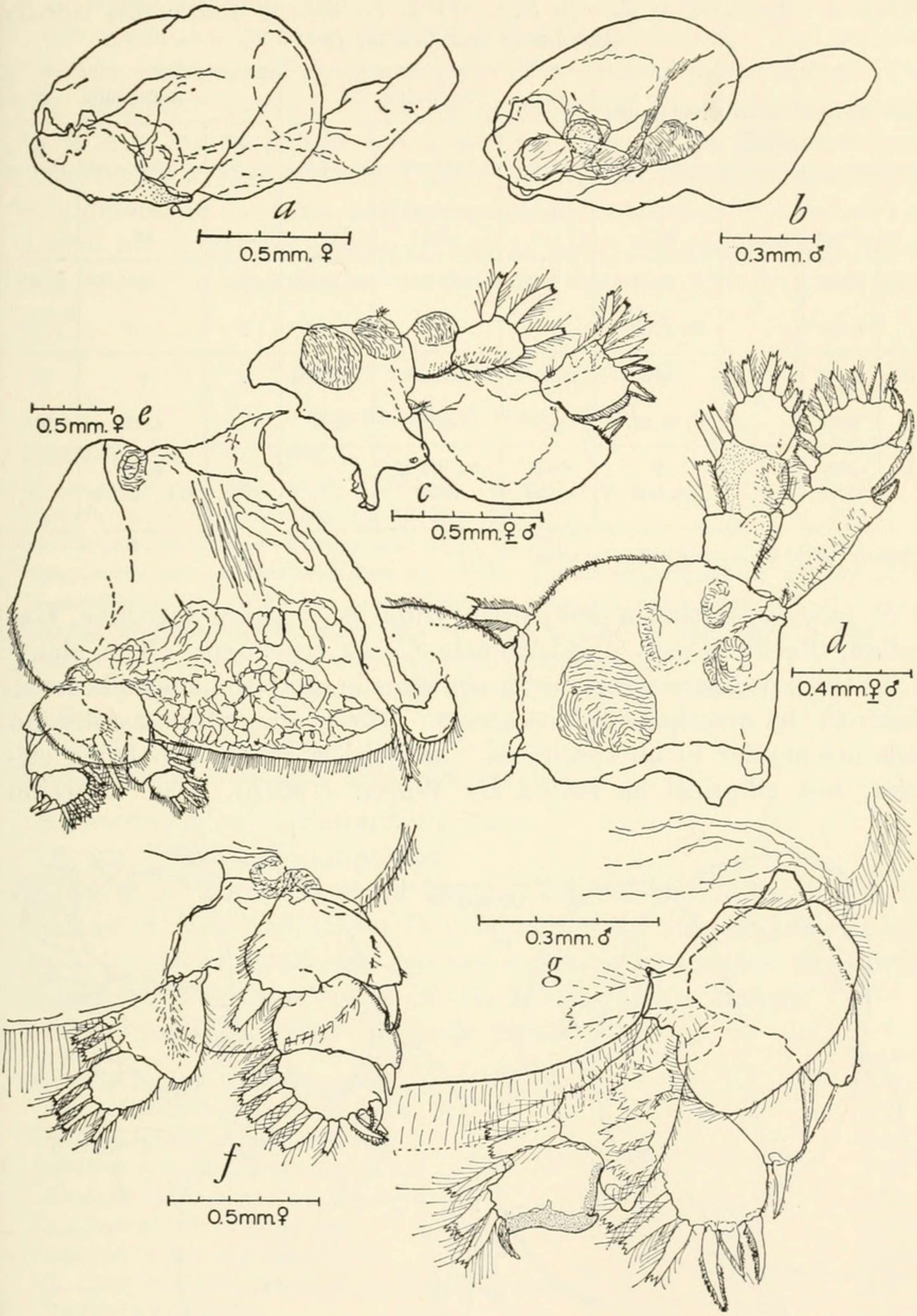

FIGURE 22.—*Dinematura latifolia* Steenstrup and Lütken, 1861. Maxilliped, ventral view: *a*, female; *b*, male. Right thoracic legs, anterior view: *c*, first leg; *d*, second leg; *e*, female, third leg. Rami, right third thoracic legs, posterior view: *f*, female; *g*, male.

TABLE 9.—*Armature of thoracic legs I–IV of the male of* Dinematura latifolia *Steenstrup and Lütken, 1861*

Leg	Surface	Inter-podal Plate	Protopodite	Exopodite			Endopodite		
				1	2	3	1	2	3
I	outer		p	mh, d	fm, 3fmH, H		c	c, P	
	inner		2a, p	c	3P		a	2P	
II	outer	c	2a, p	c, fmH	fm, mH	fm, 3fmH	c	c	c, 3P
	inner		3a, P, 3s, c	c, P	c, P	c, 5P	P	c, 2P	c, 3P
III	outer	c	a, c	m, mH	m, mH	m, 3mH	c	c	2h
	inner		P, 3s, m, a	c, P	c, P	c, 5P	P, c	c, 2P	3P*
IV	outer		p	fmH	fm, 4fmH			c, rh	
	inner		c, 1sss	c, pH	c, 3P		P′	c, P, 2PH, p	

*Wilson (1907b) figures only 2 plumose setae.

of *D. latifolia* so that a comparison could be made of Japanese, Hawaiian, Pacific Coast and Atlantic Coast specimens. The shape of the third pedigerous segment is the same in all specimens and corresponds to the description given above. The postantennular adhesion pads are similar in all specimens, the smaller of the two being circular, not elliptical as stated by Wilson (1907b). The adhesion

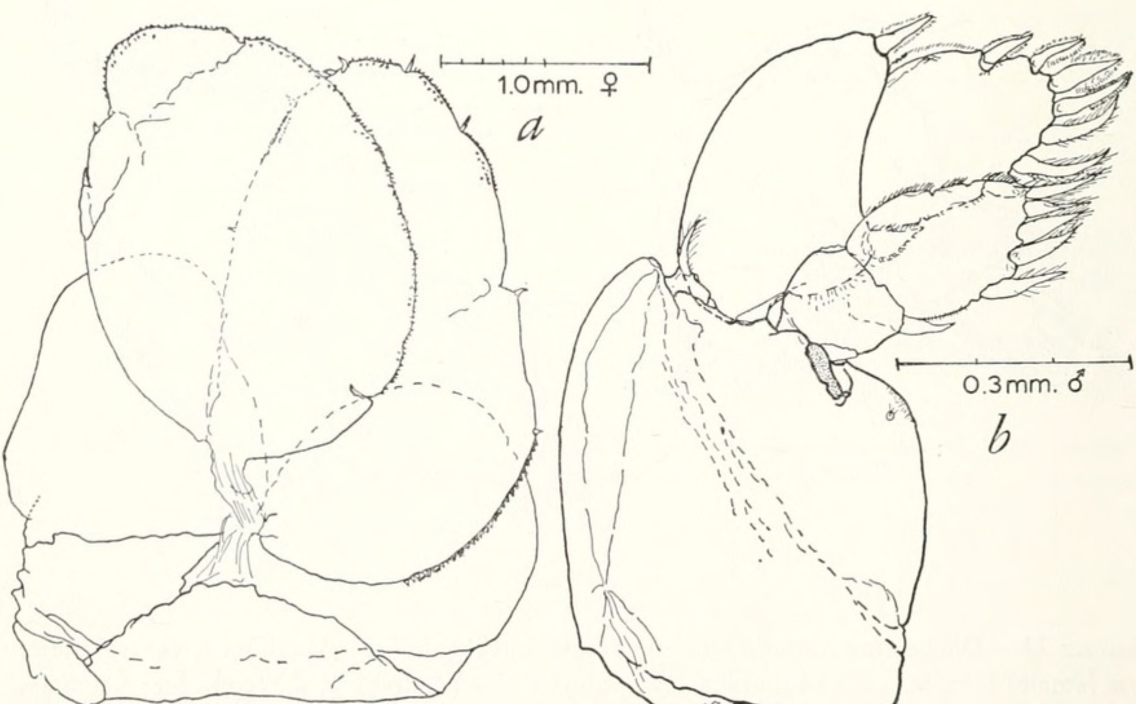

FIGURE 23.—*Dinematura latifolia* Steenstrup and Lütken, 1861, fourth thoracic leg, anterior view: *a*, female, right leg; *b*, male, left leg.

pads associated with the antennae are not as large in the Atlantic Coast specimens as they are on the Pacific specimens. The postoral adhesion pads, in all specimens, are of a general ovoid shape. The only difference in the thoracic leg armature of the specimens is that the fourth leg exopodite has 5 small spines in the Japanese specimens and 8 in the Atlantic, Pacific Coast, and Hawaiian specimens. This difference does not appear significant inasmuch as most of the margin has numerous denticulations in all specimens and the difference between a large denticle and a small spine or spinule is not very great.

Demoleus heptapus (Otto, 1821)

FIGURES 24*a–d*, 25*a–g*, 26*a–d*

Caligus heptapus Otto, 1821, p. 15.
Caligus paradoxus Otto, 1828, p. 352, pl. 22, figs. 5–6.
Binoculus sexsetaceus Nordmann, 1832, p. 32.
Dinematura sexsetacea.—Burmeister, 1835, p. 331.
Nogagus [*paradoxus*] Milne-Edwards, 1840, p. 460 (statement of affinity of *C. paradoxus* Otto with the genus *Nogagus*, no new combination).
Nogagus productus Gerstaecker, 1853 (in part), p. 64.—Wilson, 1907, p. 441.
Nogagus paradoxus.—Steenstrup and Lütken, 1861, p. 369.
Demoleus paradoxus.—Heller, 1865, p. 199, pl. 19, fig.3 .—Carus, 1885, p. 361.—Pearson, 1905, p. 26.—Brian, 1906, p. 50.—Wilson, 1907b, p. 349.—Scott and Scott, 1913, p. 79, pl. 12, figs. 4–5.
Demoleus heptapus.—Dollfus, 1943, p. 1, figs. 1–2.

REPORTED HOST.—*Hexanchus griseus*.

DISTRIBUTION.—Cosmopolitan.

MATERIAL.—One ovigerous female (USNM 110814) collected by the Hawaii Fish and Game Department from the external surface of a specimen of *Hexanchus griseus*? captured by longline in approximately 100 fathoms of water off Ala Moana, Oahu, Hawaii.

MEASUREMENTS.—One ovigerous female:

	(*mm.*)
Greatest length, excluding setae	13.86
Greatest length of cephalothorax	5.04
Greatest width of cephalothorax	4.90
Greatest length of genital segment	7.14
Greatest width of genital segment	3.71
Greatest length of abdomen	0.84
Greatest width of abdomen	1.33
Greatest length of caudal rami, excluding setae	2.87
Length of egg string	45.78

DIAGNOSTIC DESCRIPTION OF FEMALE.—Cephalothorax (fig. 24*a*) consisting of cephalic, maxilliped-bearing and first pedigerous segments; frontal region narrow, extending ventrally more than horizontally. Posterolateral cephalothoracic regions extending posteriorly well past median cephalothoracic region, to posterior end of free third pedigerous segment. Lateral cephalothoracic regions extending ventrally, giving arched appearance to cephalothorax. Dorsal cephalothoracic grooves distinct, extending posteriorly from indentation marking junction of lateral cephalothoracic margin and frontal region to posterior end of median cephalothoracic region.

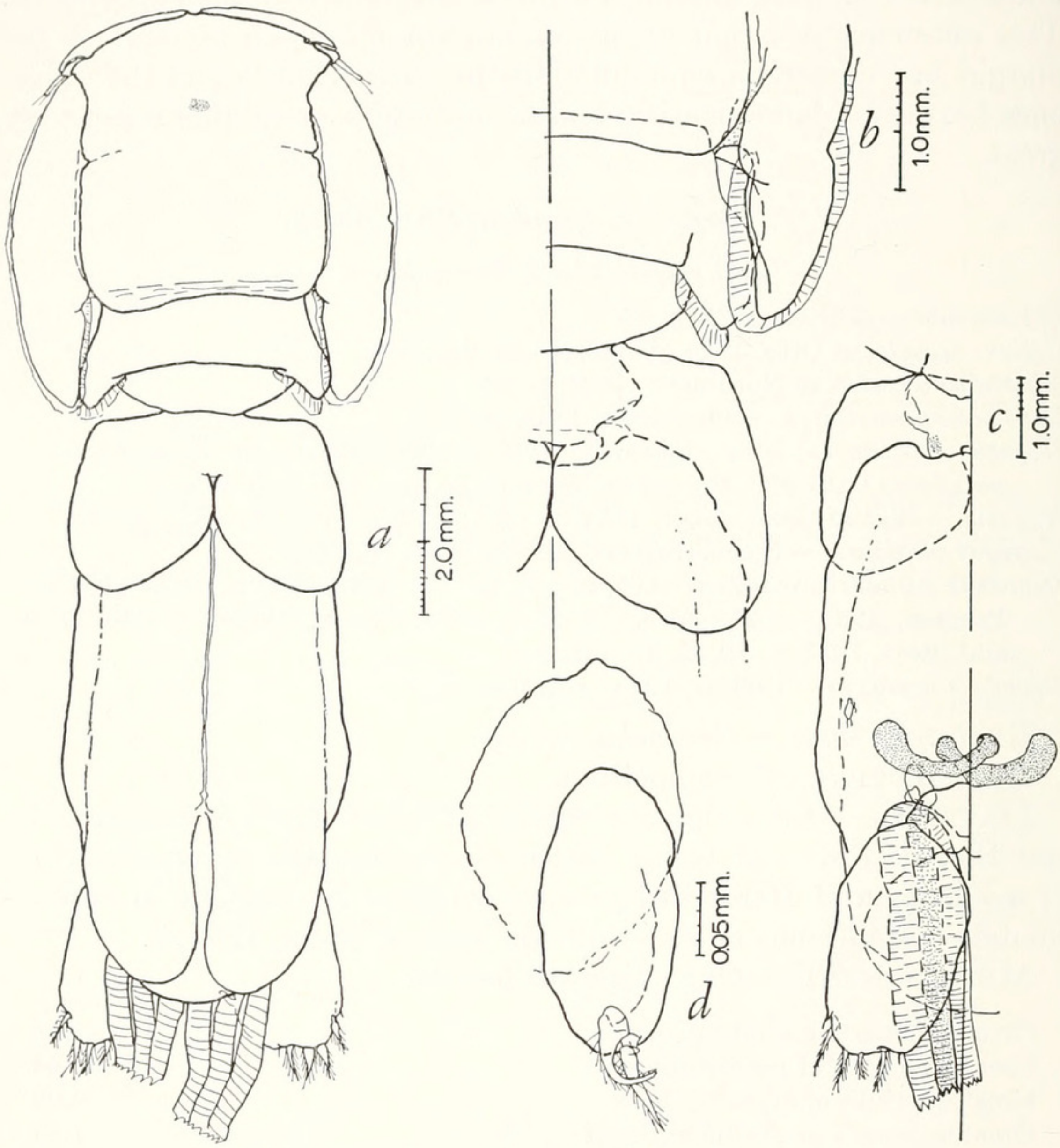

FIGURE 24.—*Demoleus heptapus* (Otto, 1821), female: *a*, dorsal view; *b*, free pedigerous segments, dorsal view; *c*, genital segment, abdomen, anal lamina, and caudal ramus, ventral view; *d*, fifth leg.

Ocular region visible only after clearing of specimen, consisting of 2 small, circular areas contiguous on median longitudinal axis of body, in anterior portion of cephalothorax.

Second through fourth pedigerous segments (fig. 24*b*) free, second more than twice as wide as long due to winglike lateral extensions bearing membranous border posteriorly. Third pedigerous segment partially covered by second, slightly more than twice as wide as long, rounded posteriorly, without winglike extensions. Fourth pedigerous segment with large, posteriorly bilobed ala covering anterior end of genital segment, sinus between lobes deep, similar to that of *Dinematura latifolia*.

Genital segment (fig. 24*c*) distinct from fourth pedigerous segment, with 2 lobate posterior projections formed as extensions of pair of longitudinal swellings extending most of dorsal length of segment. Median posterior surface forming place of attachment of orbicular plate (sixth segment of Wilson, 1907b) extending posteriorly ventral to lobate posterior projections of segment. Fifth leg (fig. 24*d*) a minute, lobate projection from lateral ventral surface anterior to seminal receptacles, bearing 2 plumose setules. Abdomen (fig. 24*c*) 1-segmented, attached to slight swelling on ventral surface of genital segment, just posterior to seminal receptacles (each receptacle bearing large club-shaped spermatophore). Caudal rami (fig. 24*c*) large, laminate, with 4 plumose setae from posterior margin in addition to 2 setules, 1 on either side of group of setae.

Antennule (fig. 25*a*) 2-segmented, attached to lateral ventral cephalothoracic surface just posterior to division between cephalothorac and frontal region. First segment approximately one and two-thirds the length of second, slightly broader proximally than distally, appearing twisted so that anterior surface forms ventral surface distally, surface bearing approximately 22 setules and plumose setae. Second segment elongate, distal end with approximately 8 naked setules. Antenna (fig. 25*b*) indistinctly 3-segmented, poorly developed, attached medial and posterior to antennule base. First and second segments forming club-shaped structure, segments partially fused, division incomplete, visible at base of swollen distal end of club-shaped formation. Swollen end with irregular, narrow, platelike regions of heavy sclerotization that form adhesion surface. Third segment and terminal process claw-shaped. Mandible (figs. 25*c*, *d*) long, rodlike, articulating in plate-shaped region of heavy sclerotization closely associated with plate forming base of postoral process. Distal region of mandible not curved although slightly flattened, inner margin with 12 denticulations. Postantennular adhesion pad (fig. 25*a*) irregularly ovoid, with indistinct ridges. Postoral process (figs. 25*c*, *e*) elongate, lateral margins irregular, with small, 2-parted, conical subterminal process. Postoral adhesion (fig. 25*e*) pads elongate, situated at anterior medial end of region of heavy sclerotization associated with maxilla and maxilliped bases. Maxilla (fig. 25*e*) 2-segmented, first segment slightly longer than second and larger, second segment narrow proximally, flaring distally, distal end bearing 2 saber-shaped terminal processes and tuft of plumosities between processes. Inner

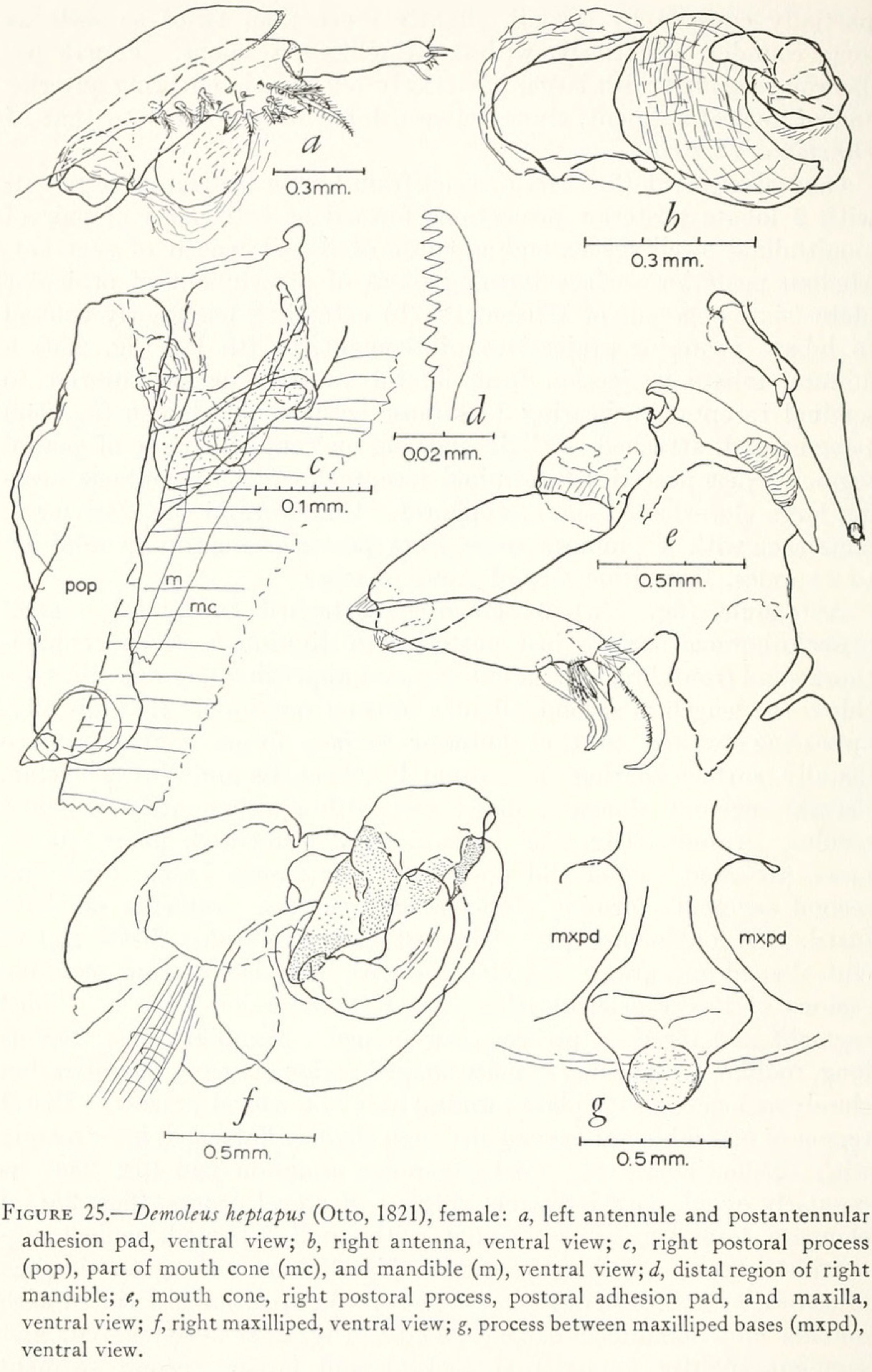

FIGURE 25.—*Demoleus heptapus* (Otto, 1821), female: *a*, left antennule and postantennular adhesion pad, ventral view; *b*, right antenna, ventral view; *c*, right postoral process (pop), part of mouth cone (mc), and mandible (m), ventral view; *d*, distal region of right mandible; *e*, mouth cone, right postoral process, postoral adhesion pad, and maxilla, ventral view; *f*, right maxilliped, ventral view; *g*, process between maxilliped bases (mxpd), ventral view.

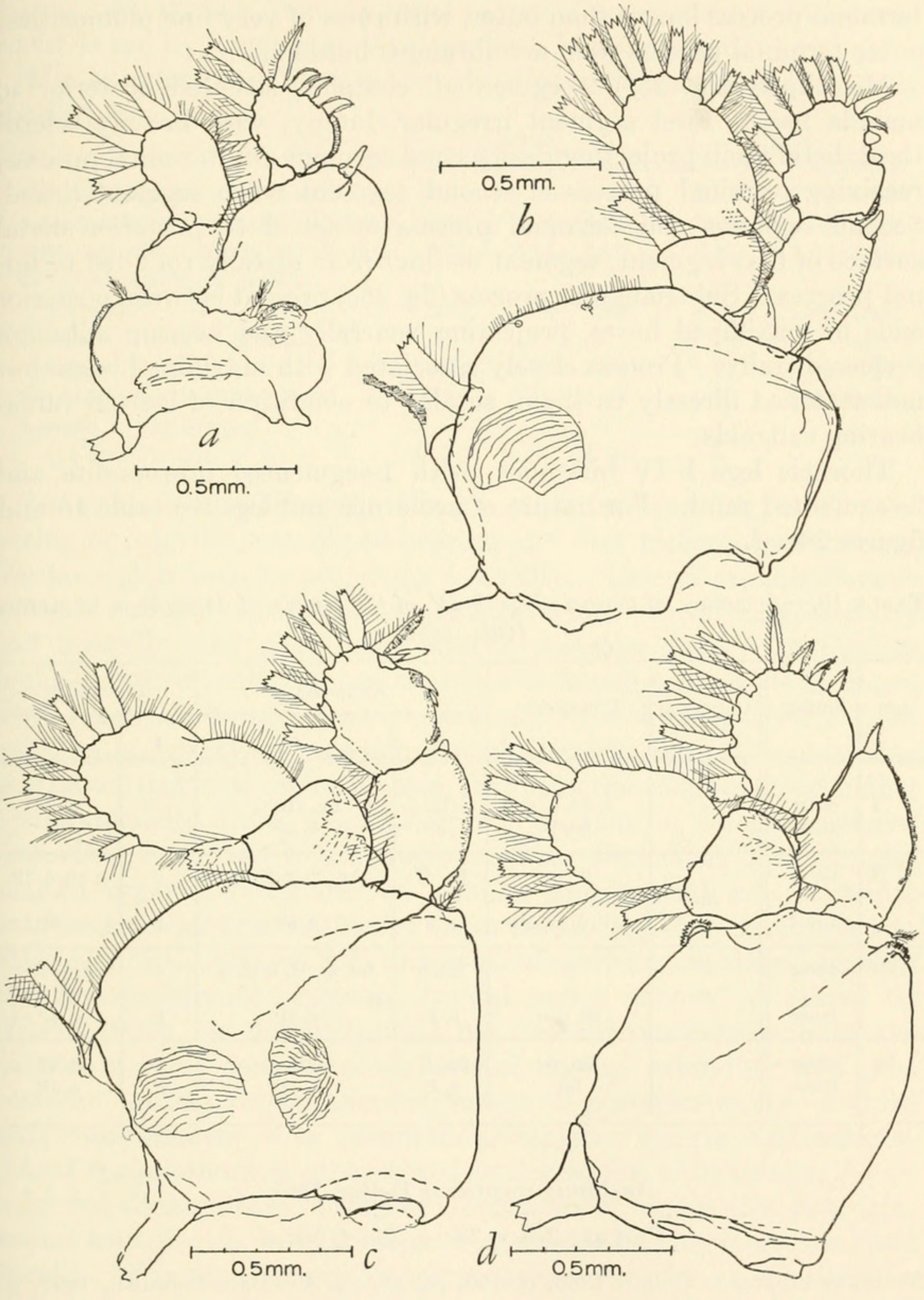

FIGURE 26.—*Demoleus heptapus* (Otto, 1821), female, right thoracic legs, anterior view: *a*, first leg; *b*, second leg; *c*, third leg; *d*, fourth leg.

terminal process longer than outer, with rows of very fine plumosities, outer terminal process with membranous borders.

Maxilliped (fig. 25*f*) 2-segmented, complex, situated posterior to maxilla base. First segment irregular, lumpy, with heavily sclerotized distal knob projecting past second segment and terminal process, receiving terminal process of second segment when segment flexed. Second segment and terminal process attached to posterior distal surface of first segment, segment distinct from distally rounded terminal process. Subtriangular process (fig. 25*g*) present between posterior ends of maxilliped bases, projecting ventrally and bearing adhesion surface distally. Process closely associated with maxilliped bases but not attached directly to them, similar to condition of sternal furca-bearing caligoids.

Thoracic legs I–IV biramous, with 1-segmented protopodite and 2-segmented rami. For nature of armature and legs see table 10 and figures 26*a–d*.

TABLE 10.—*Armature of thoracic legs I–IV of the female of* Demoleus heptapus *(Otto, 1821)*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite 1	Exopodite 2	Endopodite 1	Endopodite 2
I	outer		s, fm, a, p	H	fm, 3H, Q		c, P
	inner		fm, p	c	c, 3P		2P
II	outer	fm	fm, p	fm, H	fm, 2h, mH, Q	c	c, rh, c, 3P
	inner		a, P, c, 2s, 1sss	c, P	c, 5P	P	c, 5P
III	outer	c	p	fm, h	fm, 2h, H, mH, Q	c	c, c, 2P
	inner		2a, p, c	c, P	c, 5P	P	c, 4P
IV	outer		fm, p	fm, H	3mH, Q	c	c, 2P
	inner		fm	c, P	c, 5P	P	c, 3P

Nesippus crypturus Heller, 1865

FIGURES 27*a–e*, 28*a–g*, 29*a–f*, 30*a–d*

Nesippus crypturus Heller, 1865, p. 196, pl. 18, fig. 4.—Bassett-Smith, 1899, p. 459.—Wilson, 1907b, p. 425 (in key); 1935b, p. 3, pl. 1, figs. 11, 13, 14, pl. 3, figs. 28–32.

REPORTED HOST.—*Sphyrna zygaena.*

DISTRIBUTION.—Java, Puerto Rico.

MATERIAL.—Eleven ovigerous, 13 nonovigerous adult females and 4 adult males (USNM 110815) collected by the Hawaii Fish and

Game Department from the nasal cavity of a specimen of *Galeocerdo cuvier* taken by longline at Maalaea Bay, Maui, Hawaii.

Measurements.—Twenty-four female specimens and four male specimens:

	female		male	
	mean (mm.)	range (mm.)	mean (mm.)	range (mm.)
Greatest length, excluding setae	6.53	5.46– 7.42	5.93	5.81–6.16
Greatest length of cephalothorax	3.48	2.94– 3.85	3.01	2.94–3.08
Greatest width of cephalothorax	3.61	3.15– 3.99	3.03	2.94–3.15
Greatest length of genital segment	3.27	2.80– 3.85	1.40	1.33–1.47
Greatest width of genital segment	2.79	2.38– 3.15	1.45	1.40–1.54
Greatest length of abdomen	0.75	0.63– 0.91	0.33	0.28–0.35
Length of egg strings (11 specimens)	17.79	10.71–24.50	–	–

Diagnostic description.—Female cephalothorax (fig. 27*a*) consisting of cephalic, maxilliped-bearing and first pedigerous segments, frontal region narrow, projecting ventrally. Lateral cephalothoracic margins strongly convex, posterolateral regions projecting posteriorly and medially well past flatly convex posterior margin of median cephalothoracic region to posterior end of fourth pedigerous segment. Dorsal cephalothoracic grooves distinct, extending anteriorly from junction of lateral and median cephalothoracic regions, terminating in anterior region of cephalothorax, just posterior to grooves extending posteromedially from indentation at junction of lateral cephalothoracic margin and frontal region. Eyes distinct as 2 small, pigmented regions contiguous on median longitudinal axis of body, between anterior terminations of major dorsal cephalothoracic grooves. Male cephalothorax (fig. 27*b*) consisting of cephalic, maxilliped-bearing and first pedigerous segments, frontal region narrow (as stated by Wilson, 1907b, but not as figured), not directed ventrally as in female. Lateral margins convex, posterolateral regions extending well past posterior median cephalothoracic region to posterior region of third pedigerous segment, with membrane along inner margin of extensions. Dorsal cephalothoracic grooves and ocular region as in female.

Second through fouth pedigerous segments of female (fig. 27*a*) free, second broad, with winglike lateral extensions bearing large, oval pad distally. Third pedigerous segment narrow, broader anteriorly than posteriorly. Fourth pedigerous segment slender, with pair of small alae laterally. Second through fourth pedigerous segments of male (fig. 27*b*) free, division between second and third evidenced only by indistinct line, second segment with small, lateral, membrane-margined extensions similar to posterior extensions of lateral cephalothoracic regions and, with anterolateral margin of third pedigerous segment, forming sinus. Fourth pedigerous segment broader than long, dis-

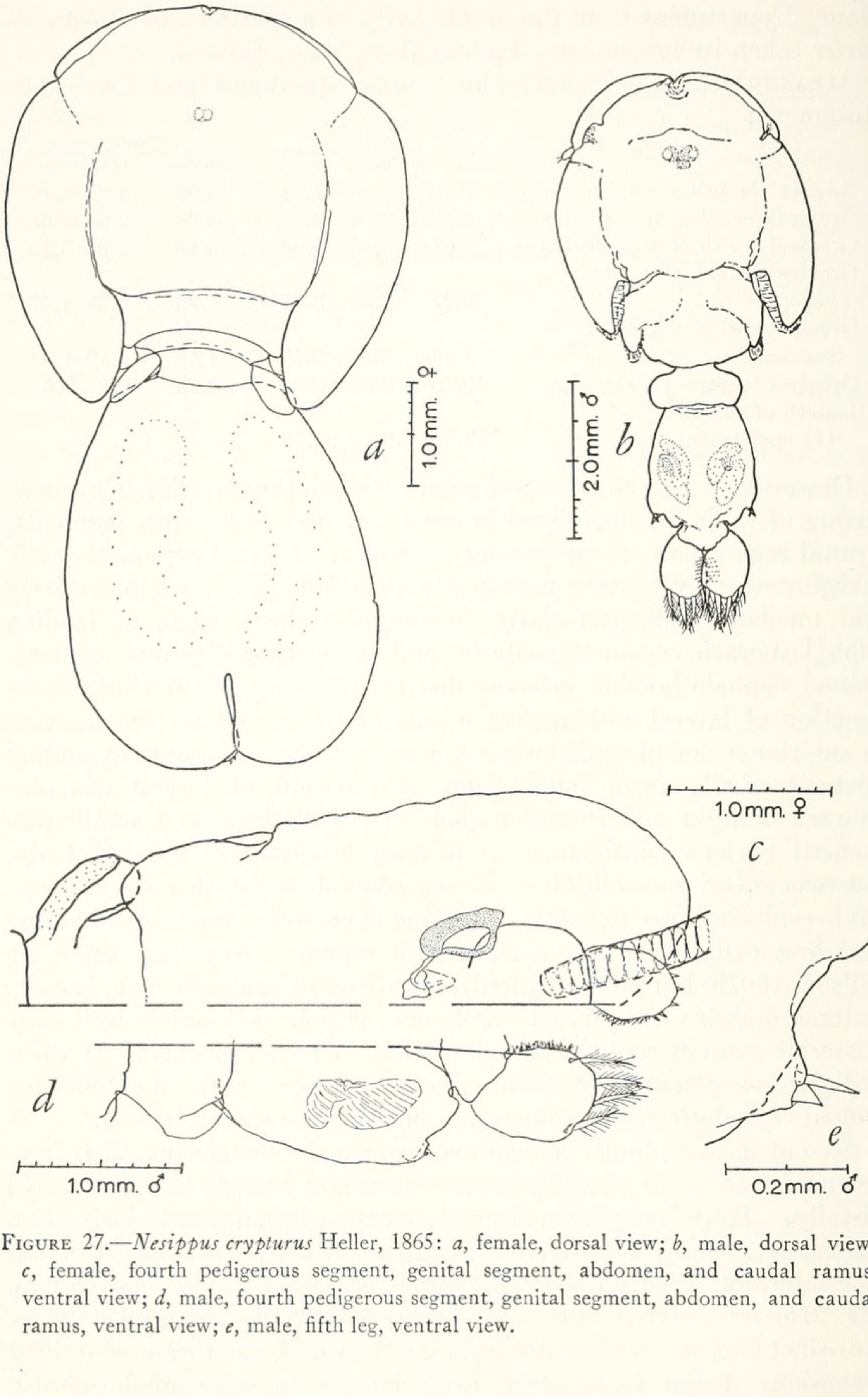

FIGURE 27.—*Nesippus crypturus* Heller, 1865: *a*, female, dorsal view; *b*, male, dorsal view; *c*, female, fourth pedigerous segment, genital segment, abdomen, and caudal ramus, ventral view; *d*, male, fourth pedigerous segment, genital segment, abdomen, and caudal ramus, ventral view; *e*, male, fifth leg, ventral view.

tinctly separated from third pedigerous segment and genital segment.

Female genital segment (fig. 27*c*) large, appearing swollen. Posterior end of segment wider than anterior, lateral margins flatly convex, posterior region bilobed, sinus between lobes narrow and deep. Male genital segment (fig. 27*d*) narrower anteriorly than posteriorly, lateral margins flatly convex, posterior with pair of lobes, just lateral to junction of abdomen and genital segment. Fifth legs (fig. 27*e*) small, lobate projecting just anterior to genital segment lobe, projection bearing triangular spinule and single, naked setule; sixth legs not visible.

Female abdomen (fig. 27*c*) 1-segmented, attached to ventral surface of genital segment just anterior to apex of posterior sinus, covered by genital segment lobes. Abdomen slightly wider anteriorly than posteriorly, lateral margins flatly convex, posterior margin flat except for anal indentation. Caudal rami lobate, projecting to posterior end of genital segment, with 6 naked, spike-like setules from distal and distal inner-lateral margin. Male abdomen (fig. 27*d*) 1-segmented, distinctly divided from genital segment ventrally, indistinctly dorsally. Segment widest medially, tapered anteriorly and posteriorly. Caudal rami similar in shape to those of female, with 4 plumose setae on medial distal surface, 1 naked setule at each lateral posterior corner.

Female and male antennule (figs. 28*a–c*) 2-segmented, situated on lateral ventral cephalothoracic surface, at division between frontal region and cephalothorax. First segment almost twice the length of second, broader distally than proximally, with approximately 16 naked or lightly plumose setules from distal third of posterior and ventral surfaces. Second segment club-shaped, with approximately 9 naked setules distally, additional naked setule on distal posterolateral surface. Female and male antenna (figs. 28*a*, *b*, *d*) 3-segmented, attached medial to antennule base. First segment slightly larger than second, both irregular in outline. Length of third segment and terminal process slightly less than combined lengths of first 2 segments, third segment tapered to sharply rounded proximal end; division between third segment and terminal process distinct, slightly moreso in male than in female, terminal process strongly curved and clawlike. Two setule-like accessory processes present, 1 from middle of segment second from junction of segment and terminal process.

Female and male mandible (figs. 28*e*, *f*) rodlike, curved inwards very slightly distally, inner margin of distal region with approximately 12 denticulations. Immediately posterior and lateral to antennule base of both male and female specimens is a single, spike-shaped process comparable, in position only, to postantennular adhesion pads of *Pandarus* and comparable, in shape only, to postantennal process of caligids. Female and male postoral process

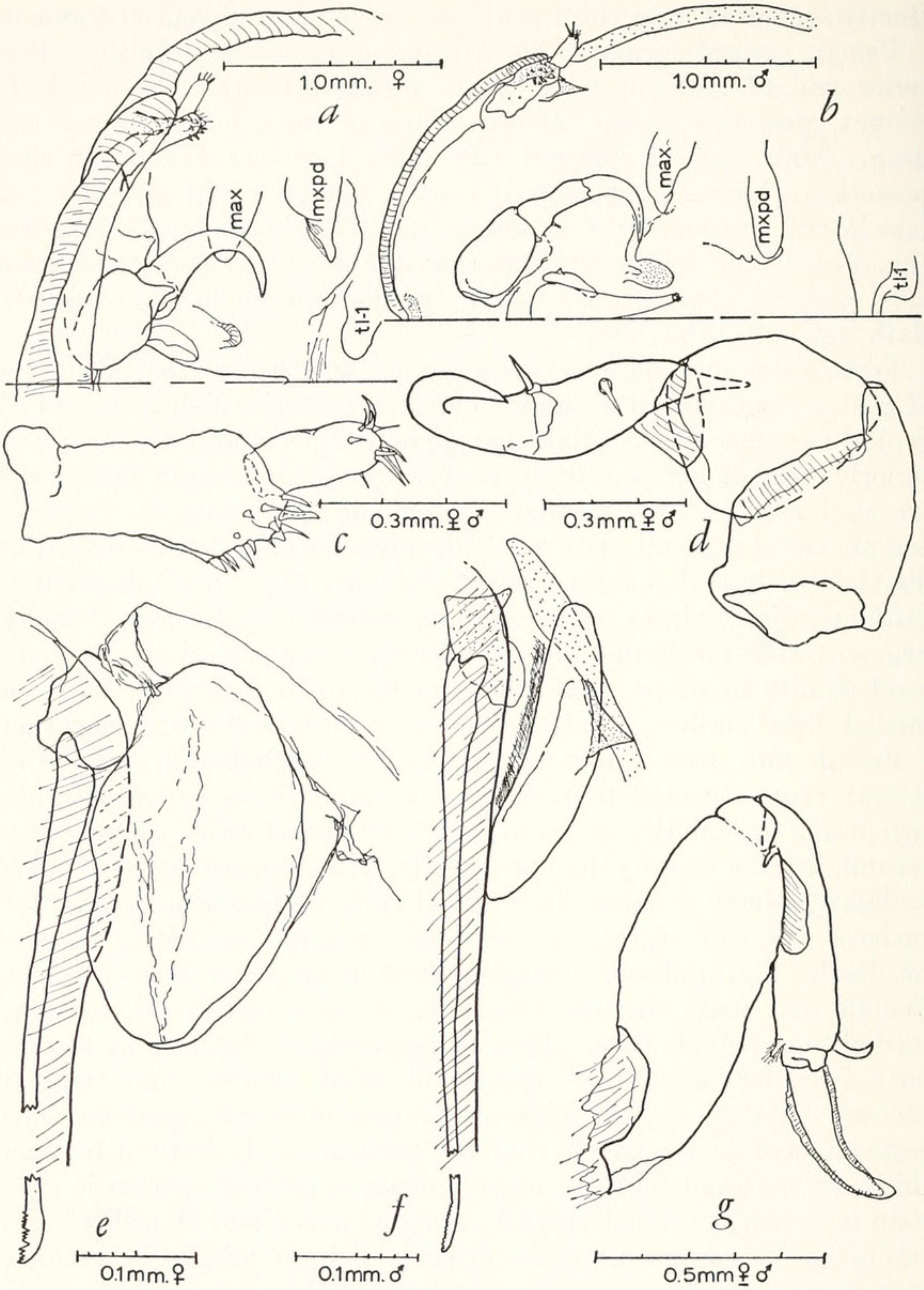

FIGURE 28.—*Nesippus crypturus* Heller, 1865: *a*, female, anterior cephalothoracic region, ventral view; *b*, male, anterior cephalothoracic region, ventral view; *c*, right antennule, ventral view; *d*, left antenna, ventral view; *e*, female, mouth cone base, mandible, and postoral process, ventral view; *f*, male, mouth cone base, mandible, and postoral process, ventral view; *g*, right maxilla, posterior view.

(figs. 28*e, f*) consisting of pad, immediately lateral to mouth cone, with pair of minute setules in female and subtriangular projection in male. Postoral process attached to platelike area of heavy sclerotization contiguous but not continuous with platelike area forming articulation surface for mandible. Female and male postoral adhesion pads (figs. 28*a, b*) lappet-like, heavily sclerotized, situated posterior and slightly lateral to postoral process.

Female and male maxilla (fig. 28*g*) 2-segmented, situated just lateral to postoral adhesion pads. First segment approximately one and one-half times the length of second, second segment slender, distal region with 1 short and 1 long, membrane-margined, saber-shaped process in addition to plumose, knob-shaped projection.

Female maxilliped (fig. 29*a*) 2-segmented, first segment appearing 2-parted and strongly developed. Proximal part broader distally than proximally, distal part large, knob-shaped, at right angles to first part, with adhesion pad distally; both parts connected, without segmental division separating them. Second segment short, irregular, situated on distal surface of knob-shaped distal part of first segment and bearing single, clawlike terminal process. Male maxilliped (fig. 29*b*) also with 2-parted first segment although second part in line with first, bearing 2 adhesion pads and spike-shaped protrusion. Second segment with distal end of clawlike terminal process denticulated. Single, setule-like accessory process at distinct division between segment and terminal process.

Thoracic legs I–IV biramous, first 3 with 2-segmented rami, fourth with 1-segmented although slight indication of segmentation present in male endopodite as indistinct line. For nature of armature and legs see tables 11–12 and figures 29*c–f*, 30*a–d*.

Remarks.—The armature of the male thoracic legs differs from that given by Wilson (1935) although the presence of a copulating pair in the collection suggests that the male and female specimens are of the same species. Further, an examination of the males of Wilson's collection (USNM 64057) verified the identification of the male and indicated that the thoracic leg armature in table 12 is correct for the male of the species. Some variation is present, both in Wilson's collection and in the Hawaiian collection, especially in the shape of the posterior end of the male genital segment and the size of the postoral adhesion pads. The nature of the body and the appendages, especially the thoracic legs, indicates however, that the specimens in both collections are conspecific.

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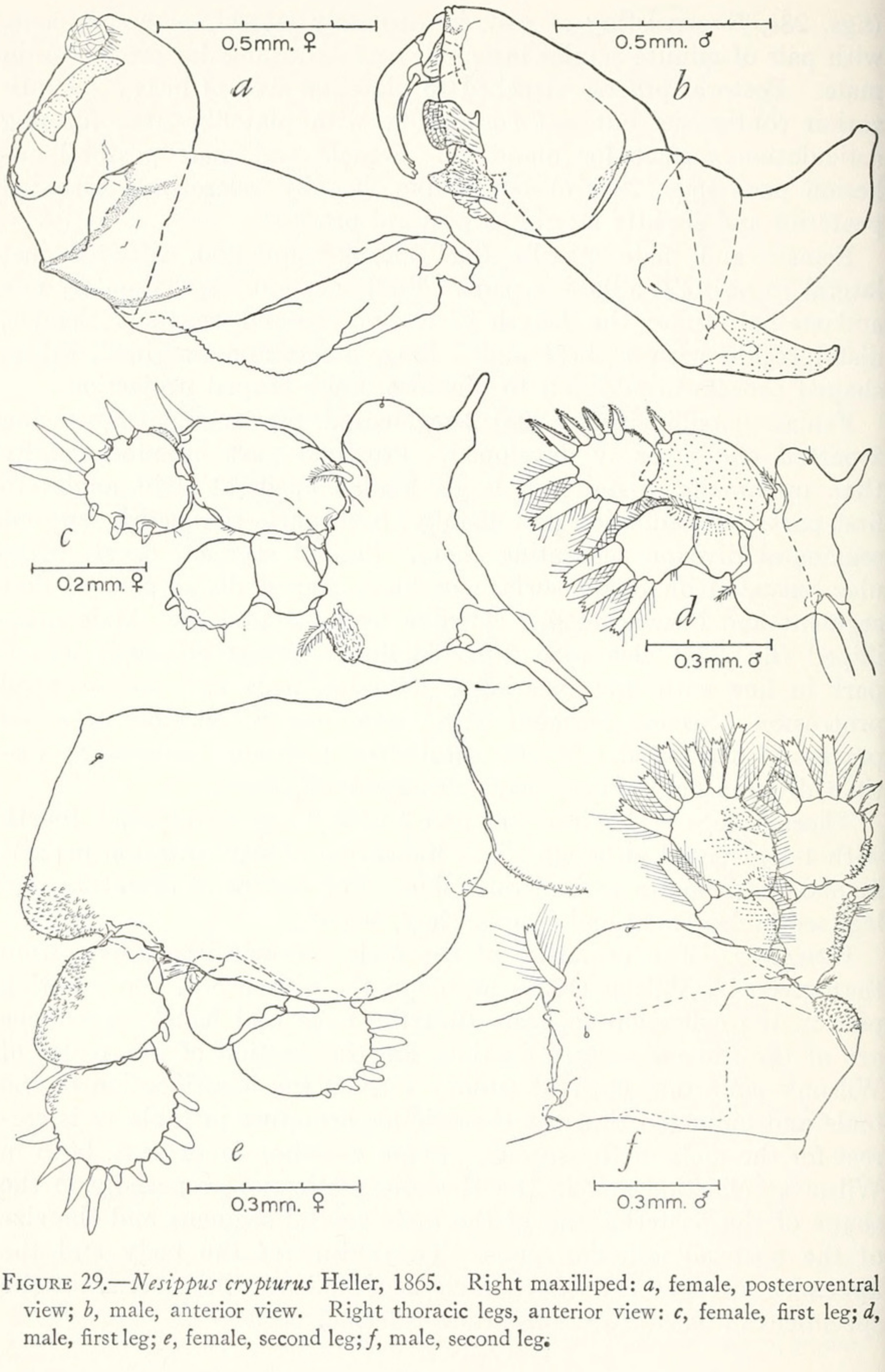

FIGURE 29.—*Nesippus crypturus* Heller, 1865. Right maxilliped: *a*, female, posteroventral view; *b*, male, anterior view. Right thoracic legs, anterior view: *c*, female, first leg; *d*, male, first leg; *e*, female, second leg; *f*, male, second leg.

TABLE 11.—*Armature of thoracic legs I–IV of the female of* Nesippus crypturus *Heller, 1865*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	outer		s, p	H	d, 4H		
	inner		p	c	c, 3h		3h
II	outer	d	d, p′	d, H	d, 4H		4h
	inner		h	h	c, 5h	h	3h
III	outer		2s, d, p	m, H	m, 4H		2h
	inner		h, s	c, h	4h	h	2h
IV	outer		p′	d, 4H			
	inner						

TABLE 12.—*Armature of thoracic legs I–IV of the male of* Nesippus crypturus *Heller, 1865*

Leg	Surface	Inter-podal Plate	Protopodite	Exopodite		Endopodite	
				1	2	1	2
I	outer		lssss, p	mH	d, 4mH		c, 2P
	inner		p	c	c, 3P		c, P
II	outer		s, d, p	d, c, mH	d, H, 3mH, 2P	c	c, 5P
	inner		2ss, P, 1ss	c, P	c, 3P	P	c, 2P
III	outer		d, p	s, m, H	m, 4H	c	c, B, 2P
	inner		2s, P, s	c, P	c, 4P	P	c, 2P
IV	outer		p	m, d, mh, m, 2h, H		c	
	inner		p′	c, 3P		c, P, c, 3P	

Family Trebiidae

***Trebius caudatus* Krøyer, 1838**

FIGURES 31*a–d*, 32*a–f*

Trebius caudatus Krøyer, 1838, p. 30, pl. 1, fig. 4.—Milne-Edwards, 1840, p. 458.—Thompson, 1847, p. 248.—White, 1857, pp. 121, 317.—Krøyer, 1863, p. 149, pl. 10, fig. 1a–k.—Norman, 1869, p. 300.—Stossich, 1880, p. 257.—Valle, 1880, p. 60.—Carus, 1885, p. 360.—Bassett-Smith, 1896, p. 158; 1899, p. 461.—Scott, T. 1900, p. 155, pl. 6, figs. 20–26.—Thompson and Scott, 1900, p. 143.—Brian, 1902, p. 33.—Pearson, 1905, p. 26.—Wilson, 1907a, p. 681, pl. 15, figs. 11–13; pl. 16, figs. 14–22.—Gurney, 1934, p. 192, figs. 18–21.—Sproston and Hartley, 1941, p. 393.—Barnard, 1955, p. 255, figs. 13b–f.—Nunes-Ruivo, 1956, p. 16.

Reported hosts.—*Squalus acanthias, S. fernandinis, Dasyatis centroura, Raja batis, R. marginata.*

Distribution.—Cosmopolitan (not reported from South Pacific).

Material.—Nine ovigerous females (USNM 110816) collected from the external surface of a "large sting ray" (probably *Aetobatus narinari*) at Coconut Island, Oahu, Hawaii.

Figure 30.—*Nesippus crypturus* Heller, 1865, right thoracic legs: *a*, female, third leg, anterior view; *b*, male, third leg, anterior view; *c*, female, fourth leg, posterior view; *d*, male, fourth leg, anterior view.

MEASUREMENTS.—Nine female specimens:

	mean (mm.)	*range (mm.)*
Greatest length, excluding setae	7.59	7.00–8.45
Greatest length of cephalothorax	2.33	2.15–2.55
Greatest width of cephalothorax	2.39	2.20–2.45
Greatest length of fourth pedigerous segment	0.67	0.55–0.75
Greatest width of fourth pedigerous segment	0.71	0.40–0.80
Greatest length of genital segment	1.48	1.35–1.60
Greatest width of genital segment	1.21	1.05–1.50
Greatest length of abdomen	2.79	2.40–3.45
Greatest width of abdomen	0.43	0.40–0.45
Length of egg strings	2.41	1.55–3.10

DIAGNOSTIC DESCRIPTION OF FEMALE.—Cephalothorax (figs. 31 *a, b*) suborbicular, consisting of cephalic, maxilliped-bearing and first 2 pedigerous segments. Frontal region broad, with narrow membrane on anterior margin; lateral cephalothoracic margins convex, bordered by narrow membrane. Posterior end of lateral cephalothoracic regions sharply curved, inner margin free at distal end of region, attached to lateral margin of second pedigerous segment for most of its length, line of division between second pedigerous segment and rest of cephalothorax convex. Major dorsal cephalothoracic grooves extending anteriorly and slightly laterally from division between second pedigerous segment and rest of cephalothorax, terminating in anterior third of cephalothorax. Several short grooves present, projecting medially from irregularities of lateral cephalothoracic margins. Groove separating second pedigerous segment forming, with major dorsal cephalothoracic grooves, irregular H, similar to that of caligids. Second pedigerous segment broad, width more than twice the length, lateral regions projecting laterally and curving posteriorly, with membrane on inner margin of posteriorly curved portion (fig. 31*b*). Inner margin of segment forming, with outer margin of free third pedigerous segment, distinct sinus.

Third and fourth pedigerous segments (fig. 31*b*) free, width of third more than 3 times the length, separated from second pedigerous segment by flatly convex line of division dorsally. Lateral surfaces of segment irregular dorsally, forming, knob-shaped structure ventrally, similar to that found in *Dinematura latifolia*. Fourth pedigerous segment distinct from third, swollen at region of fourth leg attachment. Division between fourth pedigerous and genital segments incomplete, visible on ventral and lateral surfaces but not on dorsal surface.

Genital segment (fig. 11*c*) variable in shape, dependent upon egg content, broader posteriorly than anteriorly, anterior region forming posterior portion of necklike connection between fourth pedigerous and genital segments. Lateral posterior margin of segment with 3

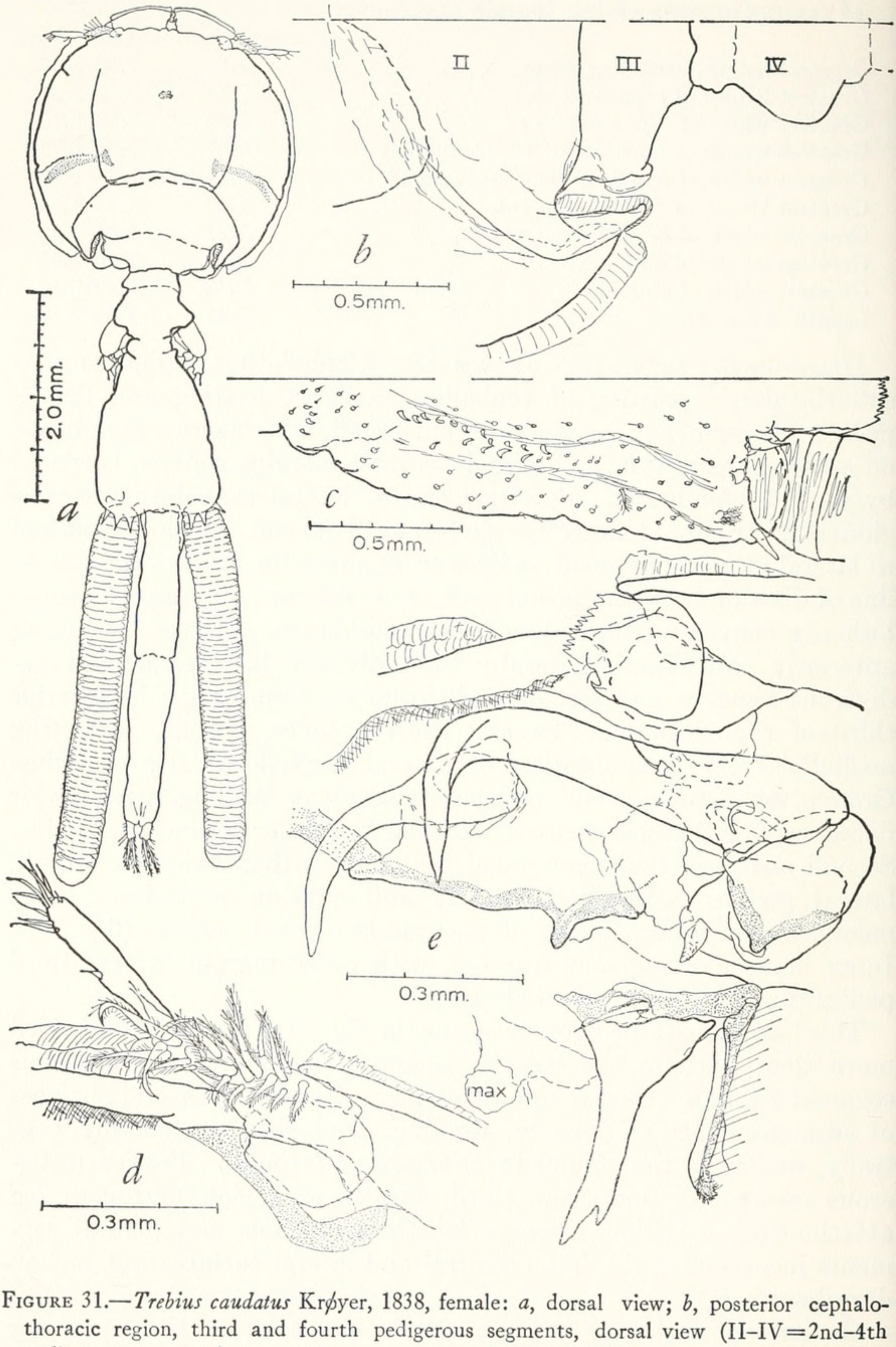

FIGURE 31.—*Trebius caudatus* Krøyer, 1838, female: *a*, dorsal view; *b*, posterior cephalothoracic region, third and fourth pedigerous segments, dorsal view (II–IV=2nd–4th pedigerous segments); *c*, genital segment, ventral view; *d*, right antennule, ventral view; *e*, right antennule base, antenna, postantennal process, mandible, postoral process, and maxilla base (max), ventral view.

spikelike processes dorsally, 1 ventrally, processes adjacent to oviducal opening. Fifth thoracic leg (presumably) a plumose setule in posterior third of genital segment, arising from swollen lateral ventral surface. Sixth leg (presumably) a nodule bearing 3 plumose setules, situated lateral and just anterior to oviducal opening. Ventral surface of genital segment with numerous minute, clawlike processes on lateral ventral surface in anterior half in addition to numerous minute, hairlike processes over most of ventral surface.

Abdomen (fig. 31*a*) elongate, 2-segmented, first segment slightly shorter than second, second segment swollen posteriorly and, in some specimens, with indistinct, incomplete line at anterior end of swelling that suggests a 3-segmented condition as described by Wilson (1907a). Abdomen distinct from genital segment dorsally, fused ventrally; posterior end of second segment angled to anal indentation. Caudal rami longer than wide, lateral margins almost parallel except at anterior and posterior ends; inner margin plumose, posterior margin irregular, posterior surface bearing 2 long, plumose setae medially, 2 short setae from outer lateral surface and 1 minute setule from inner surface. Both abdomen and caudal rami with numerous minute, hairlike projections.

Antennule (figs. 31*d*, *e*) 2-segmented, attached to lateral-antero-ventral cephalothoracic surface. Second segment slightly less than three-fourths the length of first, first broader proximally than distally, with ridge along most of ventral surface bearing approximately 19 plumose setae. Second segment elongate, slightly narrower proximally than distally, bearing single naked setule from middle of posterior surface, 10 naked setules from distal surface. Antenna (fig. 31*e*) 3-segmented, attached posterior and medial to antennule base. First and second segments short, irregular, combined lengths approximately one-third the length of third segment and terminal process; first segment with small, conical process bearing minute plumosites. Third segment and terminal process fused, forming long, claw-shaped structure, with 2 setule-like accessory processes, proximalmost appearing finely plumose. Mandible (fig. 31*e*) rod-shaped, slightly swollen proximal end articulating in platelike region of heavy sclerotization. Distal end of mandible flattened, curved medially, inner margin with 12 denticulations. Postantennal process (fig. 31*e*) long and clawlike, situated lateral to antenna base and posterior and lateral to antennule base, without process-bearing nodules present on euryphorids and caligids. Postoral process (fig. 31*e*) 2-parted, appearing to originate from platelike area of hairy sclerotization forming articulation surface for mandible. Posterior part of process elongate, bifurcate distally, outer tine longer than inner; anterior part a nodule bearing single, naked setule. Maxilla 2-segmented, situated posterior

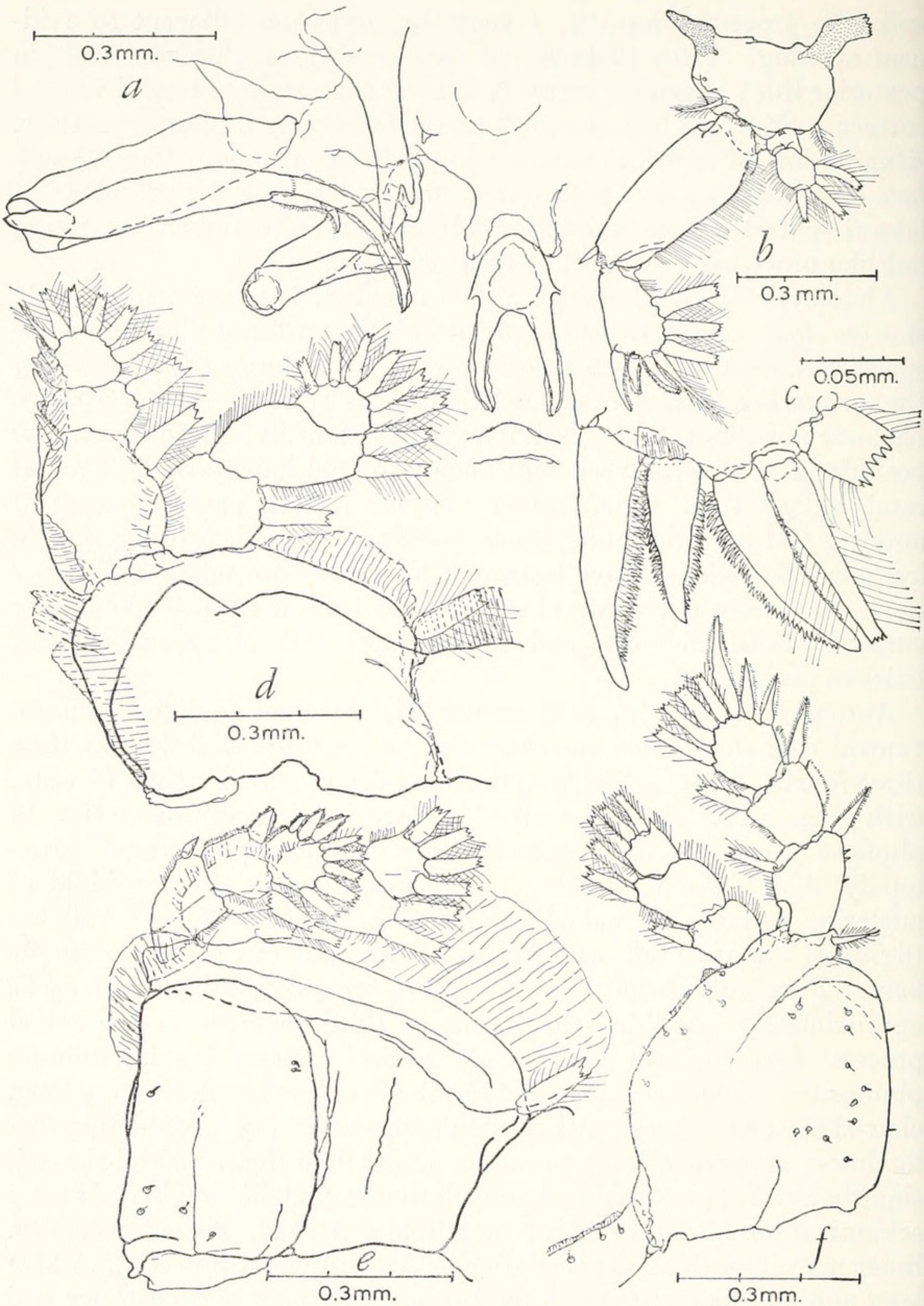

FIGURE 32.—*Trebius caudatus* Krøyer, 1838, female. Postoral process, maxilla, maxilliped, sternal furca: *a*, ventral view. Right thoracic legs: *b*, first leg, anterior view; *c*, distal region of second segment of exopodite of first leg, anterior view; *d*, second leg, posterior view; *e*, third leg, posterior view; *f*, fourth leg, anterior view.

and lateral to postoral process. First and second segments of approximately equal length, first more strongly developed, with tapered and curved proximal end forming articulation and muscle attachment surface; second segment elongate, narrower proximally than distally, with pair of saber-shaped terminal processes, inner approximately twice the length of outer, with pair of fine, filmy membranes, outer terminal process with fuzzy membrane along inner and outer lateral margins.

Ventral surface of cephalothorax with several irregularities, 2 of notable value. First a lobate projection (fig. 31*e*) of heavily sclerotized ridge extending laterally from base of antenna. Second a pair of minute, subtriangular projections (fig. 32*a*) between maxilla bases and just anterior and medial to maxilliped bases, in region of postoral adhesion pads found in pandarids, euryphorids and some caligids.

TABLE 13.—*Armature of thoracic legs I–IV of the female of* Trebius caudatus *Krøyer, 1838*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite			Endopodite		
				1	2	3	1	2	3
I	outer		p	h	3dmH			c, 2P	
	inner		p	c	c, 4P			P	
II	outer	m	m, p	m, fmH	m, fmH	m, fmH, 3P	c	c	c, 3P
	inner		P, m	c, P	c, P	c, 3P	P	c, 2P	3P
III*	outer		m, p	c, fmH	fm, fmH	fm, 3fmH, 2P	c	c	c, rh, 2P
	inner		P, m	c, P	c, P	c, 3P	P	c, 2P	c, 2P
IV*	outer		c, p	5s, fmH	fm, fmH	fm, 3fmH	c	c	c, rh, P
	inner		fm	c, P	c, P	c, 4P	P	c, 2P	c, 2P

*Small, hairlike spicules on protopodite and exopodite not included.

Maxilliped (fig. 32*a*) 2-segmented, situated posterior and medial to maxilla base. First segment longer than second, with spikelike projection from posteroproximal surface. Second segment slender, tapered slightly from proximal to distal regions, with small, clawlike terminal process distinct from segment, also with setule-like accessory processes adjacent to terminal process. Sternal furca (fig. 32*a*) large, situated between and slightly posterior to maxilliped bases, consisting of anteriorly rounded, heavily sclerotized plate bearing pair of slightly diverging tines, tines approximately one and one-fourth times the length of plate.

Thoracic legs I–IV biramous, protopodite 1-segmented, rami of first leg 2-segmented, of others 3-segmented. For nature of armature and legs see table 13 and figures 32*b–f*.

Family Euryphoridae

Alebion echinatus Capart, 1953

FIGURES 33*a–c*, 34*a–e*, 35*a–g*

Alebion enchinatus Capart, 1953, p. 655, fig. 4.—Shiino, 1955a, p. 177, figs. 1–3.—Vaissière, 1959, p. 544, fig. 5.

REPORTED HOSTS.—*Sphyrna diplana*, *S. zygaena*.

DISTRIBUTION.—Gulf of Sénégal, Japan.

MATERIAL.—One nonovigerous adult female (USNM 110817) collected by the author from the external surface of a specimen of *Galeocerdo cuvier* collected by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii. Two ovogerous and 1 nonovigerous adult females (USNM 110818) collected by the author from the external surface of a specimen of *Sphyrna lewini* collected by Lester Zukeran in Kanoehe Bay, Oahu, Hawaii.

MEASUREMENTS.—Four female specimens:

	mean (mm.)	*range (mm.)*
Greatest length, excluding setae	15.16	14.35–15.89
Greatest length of cephalothorax	8.03	7.49– 8.54
Greatest width of cephalothorax excluding marginal flange	9.03	8.75– 9.24
Greatest length of genital segment excluding posterior processes	4.87	4.48– 5.25
Greatest width of genital segment	5.76	5.53– 6.09
Greatest length of genital segment processes	2.94	2.87– 3.01
Greatest length of abdomen	1.58	1.33– 1.75
Length of egg strings (2 specimens)		20.65, 21.00

DIAGNOSTIC DESCRIPTION OF FEMALE.—Cephalothorax (fig. 33*a*) suborbicular, consisting of cephalic, maxilliped-bearing and first three pedigerous segments. Frontal region distinct, with very narrow, membranous flange projecting posteriorly from ventral-lateral anterior surface; lateral cephalothoracic margins with sharp indentation anteriorly, at junction with groove separating frontal region from rest of cephalothorax. Lateral cephalothoracic margins with membranous flange extending posteriorly, around posterior extensions of lateral cephalothoracic regions, terminating at beginning of U-shaped posterior sinuses. Posterior sinuses each with heavily sclerotized ridge along most of outer lateral margin, also with 2 membranes, 1 extending posteriorly from outer posterior end of each sinus, second extending along outer lateral margin (fig. 33*b*). Posterior end of median cephalothoracic region with 10 poorly sclerotized spinules and pair of small, platelike projections dorsally, just medial to spinules, projections covering lateral regions of short, necklike extension joining free fourth pedigerous segment with cephalothorax.

Dorsal cephalothoracic grooves distinct, forming irregular H, cross groove of H in posterior half of cephalothorax, joined to anterior longitudinal grooves at anterior end of sclerotized ridge projecting anteriorly from posterior sinus. Anterior longitudinal grooves

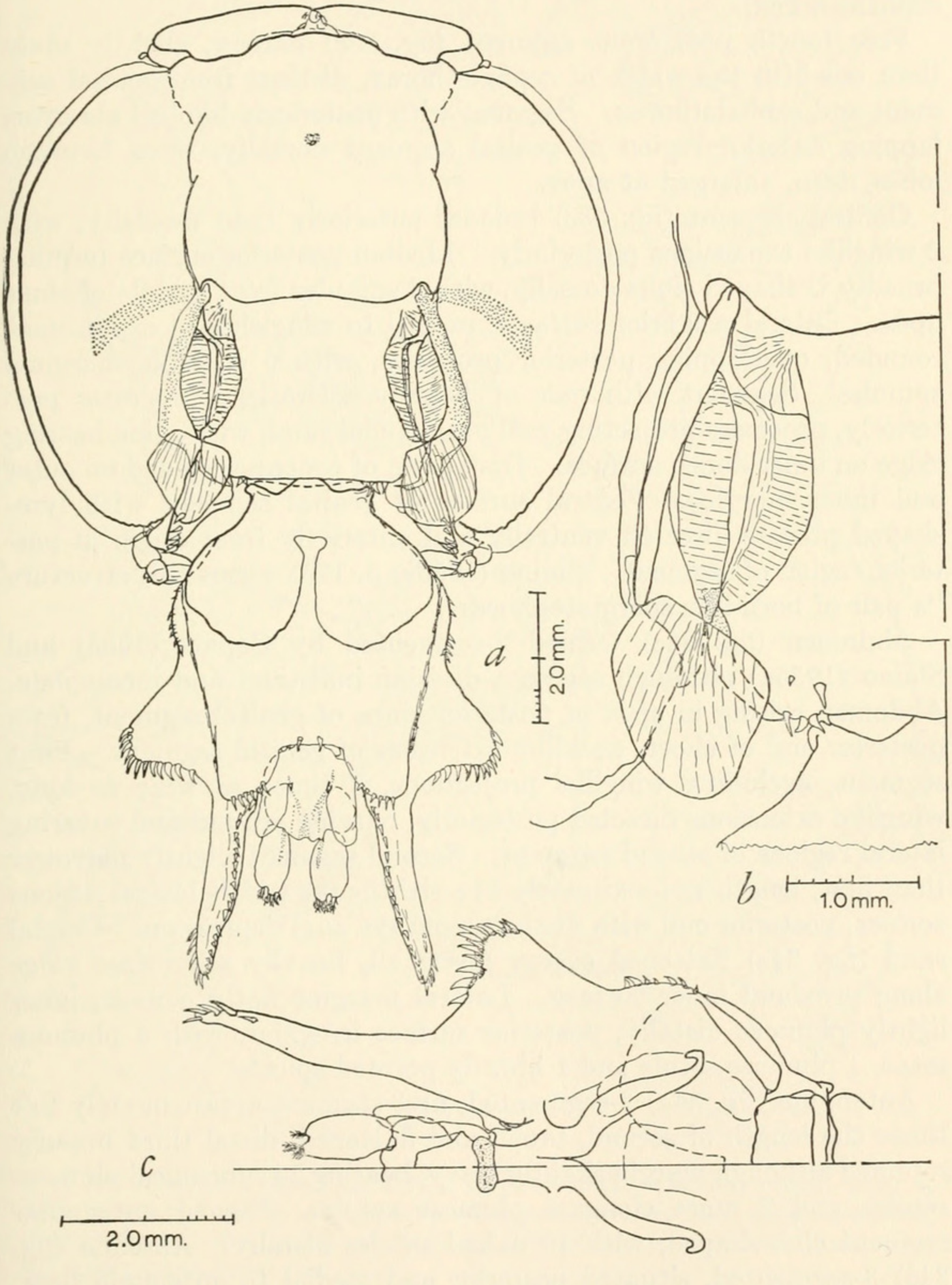

FIGURE 33.—*Alebion echinatus* Capart, 1953, female: *a*, dorsal view; *b*, region of cephalothoracic sinus, dorsal view; *c*, fourth pedigerous segment, genital segment, abdomen, and caudal ramus, ventral view.

wavy, extending to ocular region, terminating in close proximity to small grooves proceeding posteriorly from indentation of lateral cephalothoracic margin. Eyes distinct, small, with small orbicular crystalline body at outer edge of suborbicular region of dark pigment, pigmented region contiguous on median longitudinal axis of cephalothorax.

Free fourth pedigerous segment (fig. 33*c*) narrow, slightly more than one-fifth the width of cephalothorax, distinct from genital segment and cephalothorax. Segment with posteriorly bilobed ala overlapping anterior region of genital segment dorsally, sinus between lobes, deep, enlarged at apex.

Genital segment (fig. 33*c*) broader anteriorly than medially, with 2 winglike expansions posteriorly. Median posterior surface forming broadly U-shaped sinus dorsally, with 2 spinules from middle of sinus apex. Lateral posterior surfaces, medial to wing-shaped expansions, rounded, overlapping posterior processes, with 6 clawlike marginal spinules. Segment with pair of heavily sclerotized processes posteriorly, processes projecting well past caudal rami, with spine-bearing ridge on inner dorsal surface. Distal end of processes spined on outer and inner margins. Ventral surface of genital segment with lyre-shaped process directed ventrally and anteriorly from origin in posterior region of segment. Shiino (1955a, p. 179) terms this structure "a pair of horn-like spermatophores . . . ."

Abdomen (fig. 33*c*) termed 2-segmented by Capart (1953) and Shiino (1955a) although segment division indistinct and incomplete. Abdomen arising in apex of posterior sinus of genital segment, from posterior end of short, necklike extension of genital segment. First segment, excluding winglike projections, 3 times as wide as long, winglike extensions directed posteriorly, curving around and covering lateral regions of second segment. Second segment slightly narrower than first, length approximately five-eighths the width, lateral regions convex, posterior end with distinct, concave anal depression. Caudal rami (fig. 34*e*) flattened except for small, heavily sclerotized ridge along proximal inner surface. Lateral margins flatly convex, inner lightly plumose distally, posterior surface irregular, with 4 plumose setae, 1 plumose setule and 1 bluntly pointed spicule.

Antennule (fig. 34*a*) 2-segmented, first segment approximately five times the length of second, broad and flattened, distal third broadly rounded although margin slightly wavy, bearing 20 subconical plumose setules and 2 more elongate plumose setules. Second antennular segment club-shaped, with 10 naked setules distally. Antenna (fig. 34*b*) 3-segmented, situated posterior and medial to antennule base; first segment broader proximally than distally, with knob on proximal-outer lateral surface, second segment narrow proximally, broad

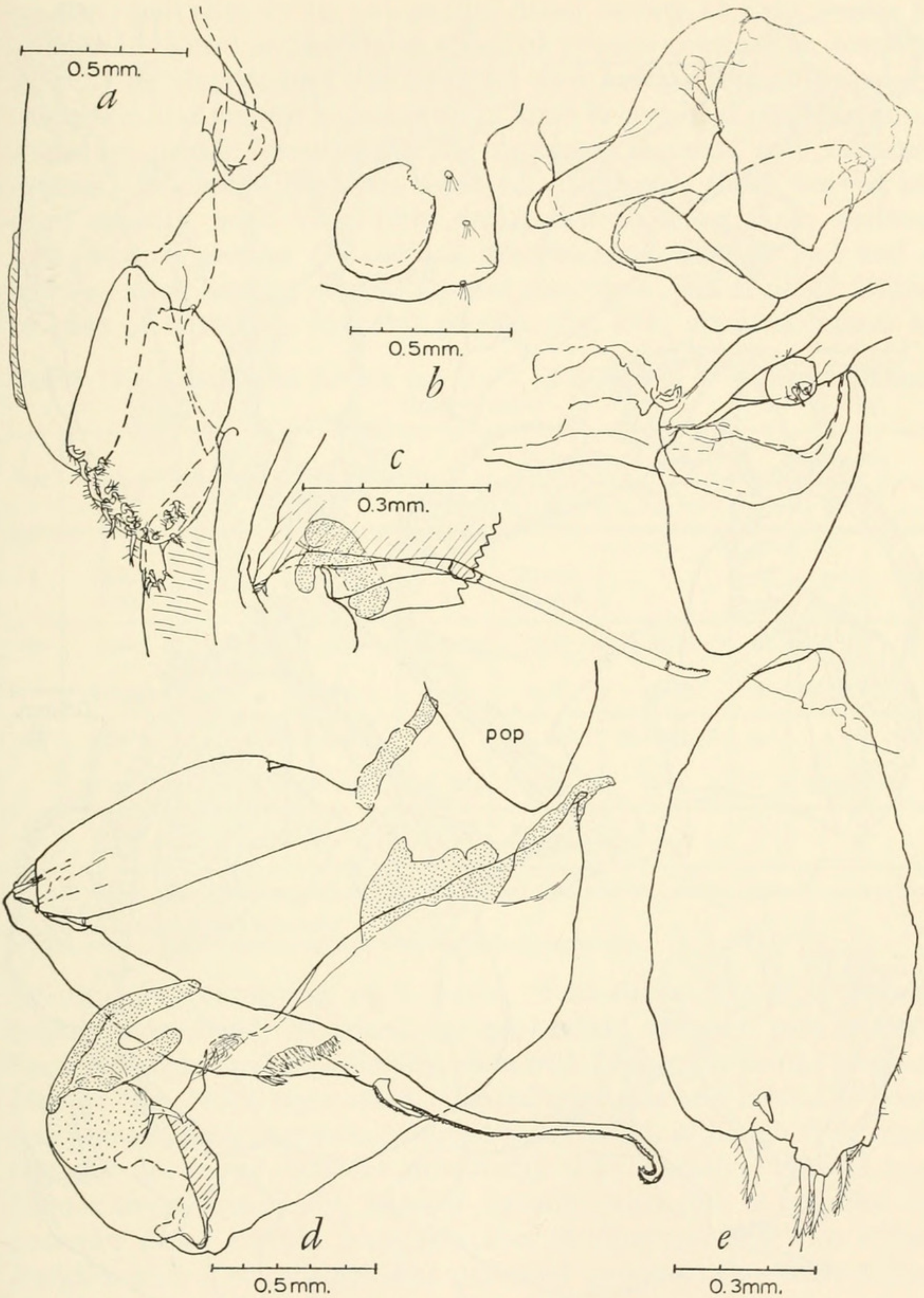

Figure 34.—*Alebion echinatus* Capart, 1953, female: *a*, right antennule, ventral view; *b*, right postantennal process, antenna, and postoral process, ventral view; *e*, right mandible, anterior view; *d*, right maxilla and maxilliped, ventral view (pop=postoral process); *e*, left caudal ramus, dorsal view.

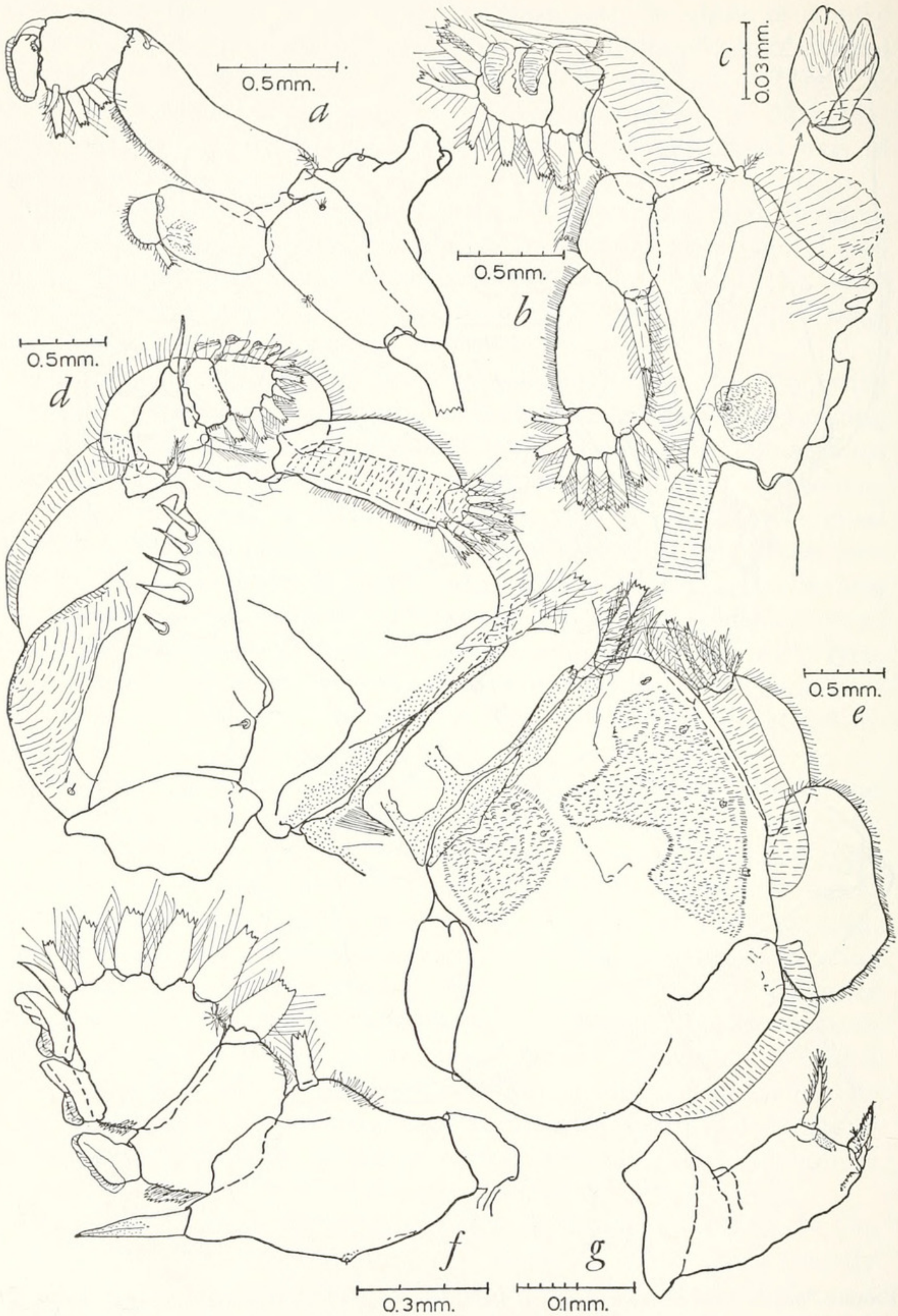

FIGURE 35.—*Alebion echinatus* Capart, 1953, female, right thoracic legs: *a*, first leg, anterior view; *b*, second leg, anterior view; *c*, process on second segment of protopodite of second leg; *d*, third leg, posterior view; *e*, third leg, anterior view of protopodite and endopodite; *f*, third leg, posterior view of exopodite; *g*, fourth leg.

medially and sharply curved so that distal surface at right angles to proximal. Third segment and terminal process continuous, forming strongly developed, heavily sclerotized claw bearing 2 small accessory processes; first process a spinule from knob in proximal region, second a slender setule from middle of combined segment and terminal process. Mandible (fig. 34*c*) 4-parted, distal part short, curved inward slightly, with 12 minute denticulations along inner surface. Postantennal process (fig. 34*b*) a suborbicular adhesion pad and 3 nodules, each bearing several hairlike processes, pad situated lateral to base of antenna. Postoral process (fig. 34*b*) situated lateral to

TABLE 14.—*Armature of thoracic legs I–IV of the female of* Alebion echinatus *Capart, 1953*

Leg	Surface	Interpodal Plate	Protopodite	Exopodite			Endopodite		
				1	2	3	1	2	3
I	outer		p, 1sss	rh	H, mH′			c	
	inner		p	c	3P, p, h			3P, c	
II	outer	m	m, p	m, mfH	mH	mH, 2P	c	c	c, 3P
	inner		P, b*,m	c, P	c, P	c, 4P	P	c, 2P	3P
III	outer**	m	s, a, m, p	s, H	C, mH	C, 2mH, H	c	c	2P
	inner**		P, m4b*	c, P	c, P	c, 5P		c, 2P	2P
IV	outer			3p***					

* Small, bilobed membranous process presumably modified from hairlike processes normal to members of the genus.
** Only marginal armature included.
*** The origin of the armature elements is presumed to be the exopodite.

mouth cone, consisting of 2 parts. Posteriormost part a broad, heavily sclerotized, subtriangular projection, anterior part a node bearing 2 slight swellings distally, each with flabby, setule-like process. Maxilla (fig. 34*d*) 2-segmented, situated posterior and lateral to postoral process, both segments of about equal length although first more strongly developed, broader proximally than distally. Second segment narrow proximally, broader distally, with row of spinules on posterior distal surface, long, whiplike terminal process with frilled margins and short, dagger-like terminal process, also with frilled margins.

Maxilliped (fig. 34*d*) 2-segmented, situated posterior and medial to maxilla base. First segment strongly developed, slightly less than twice the length of second segment and terminal process, with narrow proximal end, small concavity of inner medial surface, and small, knoblike adhesion process just distal to concavity. Second segment short and chunky, divided, by regions of sclerotization, from bifurcate terminal process and bearing either naked or very lightly plumose spinelike accessory process on inner surface, proximal to terminal process.

Thoracic legs I–III biramous, leg IV uniramous and poorly developed. For nature of armature and legs, see table 14 and figure 35.

Alebion gracilis Wilson, 1905

FIGURES 36*a–c*, 37*a–d*, 38*a–e*

Alebion gracilis Wilson, 1905a,[4] p. 128; 1907a, p. 704, pl. 18, figs. 35–48; 1932, p. 420, fig. 264.—Shiino, 1959a, p. 316, figs. 19–21.

REPORTED HOSTS.—*Mustelus canis*, *Carcharias taurus*, *Carcharhinus obscurus*, *Carcharhinus platyrhynchus*, *Carcharhinus lamiella*, *Squalus acanthias*, "*Trygon*" species, *Pollachius virens*, "Bonito."

DISTRIBUTION.—Revillagigedo Islands, Woods Hole Region. (Wilson, 1907a lists the cotypes as coming from Clarion Island, a member of the Revillagigedo Islands.)

MATERIAL.—Three ovigerous and 2 nonovigerous adult females (USNM 110819) collected by Susumo Kato from the external surface of several specimens of sharks (no identification made) captured by longline off Oahu, Hawaii.

MEASUREMENTS.—Five female specimens:

	mean (mm.)	*range (mm.)*
Greatest length	9.66	9.31–10.01
Greatest length of cephalothorax	4.72	4.55– 4.83
Greatest width of cephalothorax, excluding marginal flanges	4.65	4.41– 4.90
Greatest length of genital segment, excluding posterior processes	2.66	2.45– 3.01
Greatest width of genital segment	2.73	2.66– 2.80
Greatest length of genital segment processes	1.60	1.54– 1.68
Greatest length of abdomen	1.12	1.05– 1.26
Egg string length (3 specimens)	5.72	4.55– 7.00

DIAGNOSTIC DESCRIPTION OF FEMALE.—Cephalothorax (fig. 36*a*) ovoid, consisting of cephalic, maxilliped-bearing and first 3 pedigerous segments. Frontal region distinct, with narrow membranous flange projecting posteriorly from anteroventral surface, lateral cephalothoracic margins with distinct indentation at anterior end, with narrow membranous flange extending along most of margin and around broadly curved posterolateral cephalothoracic region, terminating at beginning of U-shaped posterior sinus. Posterior sinus with 2 membranes, 1 extending posteriorly from outer posterior end of sinus, second extending along outer lateral margin. Posterior end of median cephalothoracic region with 8 spines. Major dorsal

[4] The author used the name *A. gracile* but, in 1907a, corrected the improper latinization of the term to *A. gracilis*.

cephalothoracic grooves forming irregular H, cross groove in posterior third of cephalothorax; anterior longitudinal grooves extending anteriorly, in irregular manner, to ocular region, turning laterally abruptly and terminating at indentation of anterior lateral cephalothoracic margin. Eyes distinct, with two small orbicular crystalline body at outer edge of regions of dark pigmentation, pigmented regions contiguous on median longitudinal axis of body.

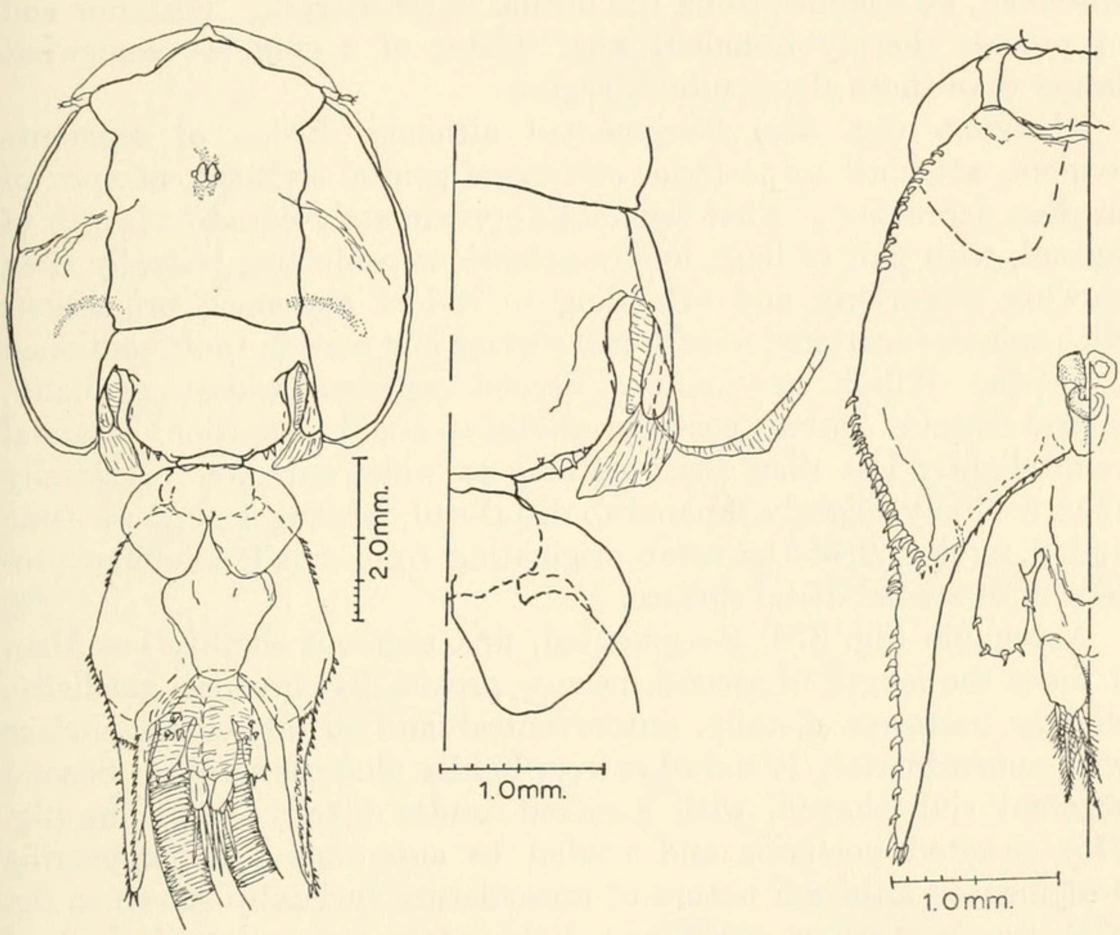

FIGURE 36.—*Alebion gracilis* Wilson, 1905, female: *a*, dorsal view; *b*, posterior cephalothoracic region and fourth pedigerous segment, dorsal view; *c*, fourth pedigerous segment, genital segment, abdomen, and caudal ramus, ventral view.

Free fourth pedigerous segment (figs. 36*b*, *c*) narrow, slightly less than one-fourth the width of cephalothorax, distinct from cephalothorax and genital segment, attached to short, necklike extension of median cephalothoracic region. Segment with pair of alae projecting posteriorly from dorsal surface, covering anterior end of genital segment. Wilson (1932) indicates that the distal ends of the alae are squarely truncated. The inner margins of the alae are basically flat, giving the form figured by Wilson (1907a, 1932) but the distal ends are sharply rounded, not truncated.

Genital segment (fig. 38*c*) of general heart-shape with posterior end forming sinus. Anterior lateral margins with row of spinules. Pair of long, subconical projections extending from posterolateral surfaces, projecting posteriorly well past caudal rami, with heavily sclerotized, spinule-bearing ridge extending along dorsal surface of process, continuing, without spinules, along margin of medial posterior end of genital segment. Outer margin of process usually with some spinules although number variable, from the more heavily spined condition shown in figures 36*a*, *c* to a condition in which there are few or, in one specimen, no spinules along the medial outer margin. Posterior end of process sharply rounded, with cluster of 4 spinules, somewhat larger than those along outer margin.

Abdomen (fig. 36*c*) 2-segmented although fusion of segments evident, attached to posterior surface of genital segment, at apex of median depression. First segment approximately equal to length of second, with pair of long, lobate extensions projecting laterally then curving posteriorly and extending to end of abdomen, projections with spinules scattered over dorsal surface and margin (not mentioned by either Wilson or Shiino). Second segment widest medially, lateral margins convex, posterior angled to anal indentation. Caudal rami slightly less than twice as long as wide, narrower proximally than medially, slightly tapered to distal end, bearing 4 plumose setae and 2 setules, 2 of the setae originating from small, knoblike projection of medial distal surface.

Antennule (fig. 37*a*) 2-segmented, first segment slightly less than 3 times the length of second, narrow proximally, broadest medially, slightly narrower distally, anteroventral and distal-ventral surface with approximately 19 naked or very lightly plumose setules. Second segment club shaped, with 8 naked setules distally. Antenna (fig. 37*b*) situated posterior and medial to antennule base, appearing 4-segmented although nature of musculature (partially shown in fig. 37*b*) suggests either secondary division (or incomplete fusion) of proximal 2 parts or that first part a projection of cephalothorax. Penultimate segment large, oval; distal segment and terminal process slightly shorter than penultimate, segment not distinct from distally curved terminal process. Accessory processes 2 in number, 1 long, setule-like process arising from middle of fused segment and terminal process, second short and knoblike, situated at proximal end of segment.

Mandible (fig. 37*b*) rodlike, appearing 4-parted, distal part bluntly rounded distally, inner margin with 12 denticulations. Postantennal process (fig. 37*b*, "pap") a small adhesion pad lateral and slightly posterior to antenna base, with 3 nodules, bearing hairlike projections, just medial to pad. Postoral process (fig. 37*b*) 2-parted, posterior part a broad, padlike structure with narrow membrane along distal surface, anterior part a node bearing 3 projections, each with single setule. Heavily sclerotized regions underlying both mandible and postoral process not appearing continuous. Pair of small, postoral adhesion pads (fig. 37*c*) present just posterior to postoral process, between and slightly posterior to maxilla bases.

Maxilla (fig. 37*c*) 2-segmented, situated just posterior and lateral to postoral process. First segment slightly more than two-thirds the

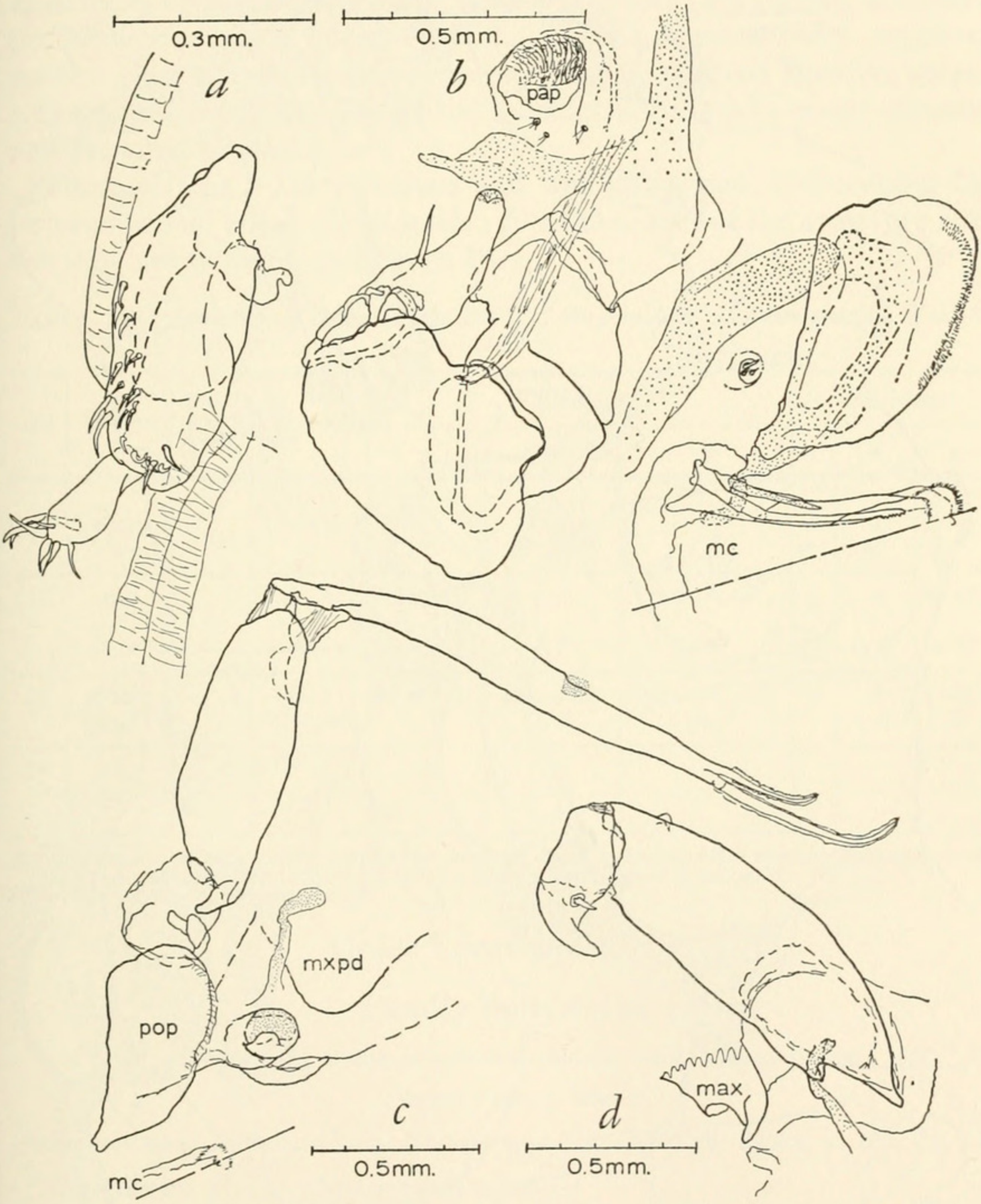

FIGURE 37.—*Alebion gracilis* Wilson, 1905, female, ventral view: *a*, right antennule; *b*, left antenna, postantennal process (pap), mouth cone (mc), mandible, and postoral process; *c*, left postoral process (pop), maxilla, and maxilliped base (mxpd); *d*, left maxilla base (max) and maxilliped.

length of second, with small, knoblike projection proximally, forming articulation and muscle attachment surface. Second segment elongate, narrower proximally than medially, tapered to narrow distal end, with small membrane arising from middle of segment and 2 saber-shaped terminal processes from distal end. Innermost terminal process

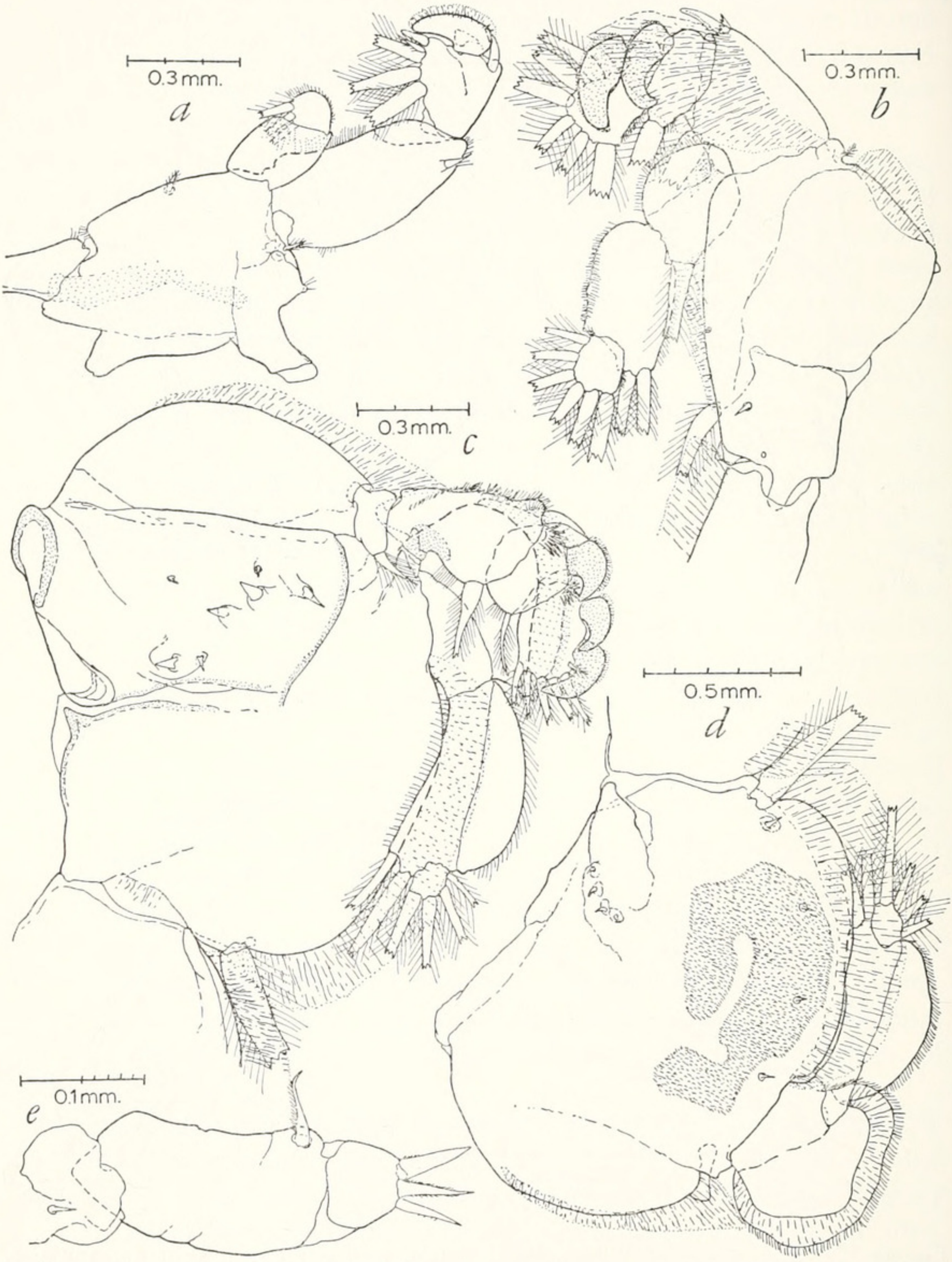

FIGURE 38.— *Alebion gracilis* Wilson, 1905, female, right thoracic legs: *a*, first leg, anterior view; *b*, second leg, anterior view; *c*, third leg, posterior view; *d*, third leg, anterior view; *e*, fourth leg, anterior view.

almost twice the length of outer, with fine membranous margin along inner surface, outer process with frilled membrane along outer and inner surface.

Maxilliped (fig. 37*d*) 2-segmented, situated immediately posterior and medial to maxilla base. First segment approximately 3 times the length of second, tapered to sharply rounded articulation and muscle attachment surface proximally, widest medially, with small, knoblike protrusion on distal outer surface. Second segment and terminal process claw shaped, terminal process bluntly pointed distally; accessory process setule-like, located at indistinct division between segment and terminal process.

Thoracic legs I–III biramous and well developed, thoracic leg IV uniramous and poorly developed. For the nature of the armature and the legs, see table 15 and figure 38.

Table 15.—*Armature of thoracic legs I–IV of the female of* Alebion gracilis *Wilson, 1905*

Leg	Surface	Inter-podal Plate	Protopodite	Exopodite 1	Exopodite 2	Exopodite 3	Endopodite 1	Endopodite 2	Endopodite 3
I	outer		1sss, p	h, c	H, mH			c	
	inner		p	c	3P, p, H			3P	
II	outer	m	m, p	m, dfH	mH	mH, *, 3P	c	c	c, 4P
	inner		P, 2rh, m	c, P	c, P	c, 3P	P	c, 2P	c, 2P
III	outer**		m, p	c, 4rh, fH	dm, c, mH	dm, 2mH, p, 2P	c	c	3P
	inner**		P, m, 3rh	c, P	c, P	3P		c, 2P	P
IV	outer			2h					
	inner		p	h					

*Shiino indicates the presence of a spinule that was not found on the Hawiian specimens although there was a heavily sclerotized projection extending into the large, curved spine (mH).
**Includes only marginal armature.

Order Lernaeopodoida

Family Sphyriidae

***Paeon vaissierei*(?) Delamare-Deboutteville and Nunes-Ruivo, 1953**

Figures 39*a–f*, 40*a–h*

Paeon vaissierei Delamare-Deboutteville and Nunes-Ruivo, 1953a, p. 161, fig. 15.

Reported host.—*Sphyrna couardi.*

Distribution.—Sénégal.

Material.—One complete ovigerous female, two incomplete ovigerous females and one mature male (USNM 110820) collected by author from gill cavity of specimen of *Sphyrna lewini* captured by longline by Lester Zukeran in Kaneohe Bay, Oahu, Hawaii.

Measurements.—One complete, two incomplete females (male not measured):

	mean (mm.)	range (mm.)
Greatest length, excluding caudal filaments (1 specimen)		21.84
Greatest length of cephalothorax (1 specimen)		4.27
Greatest width of cephalothorax (1 specimen)		5.25
Greatest length of neck (1 specimen)		7.42
Greatest length of trunk or genital segment (3 specimens)	11.29	10.64–12.04
Greatest width of trunk or genital segment (3 specimens)	3.38	2.87– 3.64
Greatest length of caudal filaments (2 specimens)		11.34, 10.71
Length of egg strings (3 specimens)	18.08	16.66–19.39

Diagnostic description of female.—Body (fig. 39*a*) divisible into 3 regions, multilobed anterior region (cephalothorax), elongate neck, and irregular trunk (genital segment). Trunk with small, bilobed abdomen posteriorly, abdomen with pair of smooth elongate processes (caudal filaments) whose place of origin suggests possible association with the caudal rami.

Cephalothorax (fig. 39*b*) and most of neck embedded in host, cephalothorax consisting of 2 large knobs forming anterior region; single flaplike lobe arising from posteromedian dorsal surface of knobs and projecting posteriorly over anterior end of neck; 6 pairs of knobs arising from ventral surface. Anteriormost pair of ventral knobs almost contiguous on median longitudinal axis, overlapping oral region. Neck 2-parted, slender, width approximately one-eighth that of cephalothorax although varying somewhat throughout length. Anteriormost part of neck less than twice the length of posterior, appearing as extension of median posterior cephalothoracic surface; second part appearing as extension of trunk. Trunk narrower anteriorly than posteriorly, with constrictions on anterior end giving annulated appearance. Lateral margins irregular; posterior end (fig. 39*c*) with distinct sinus medially, slightly projecting lateroposterior regions rounded. Single abdominal segment (fig. 39*c*) arising at apex of sinus, not projecting past lateroposterior regions of trunk, posterior end indented at anal opening, with pair of caudal filaments arising from dorsal surface. Caudal filaments slightly shorter than trunk, rod-shaped, without distinct irregularities. Egg strings projecting from oviducal openings situated just lateral to abdomen, on lateral surfaces of sinus in posterior end of trunk.

Appendage complement consisting of pair of mandibles, 2 pairs of maxillae (using Wilson's 1919 appendage designation) and pair of small, irregular processes, posterior to maxillae, that may be maxillipeds. Mandibles (fig. 39*d*) minute, rodlike, structural details not determined. Maxillule (?) (fig. 39*d*) minute, situated just lateral to

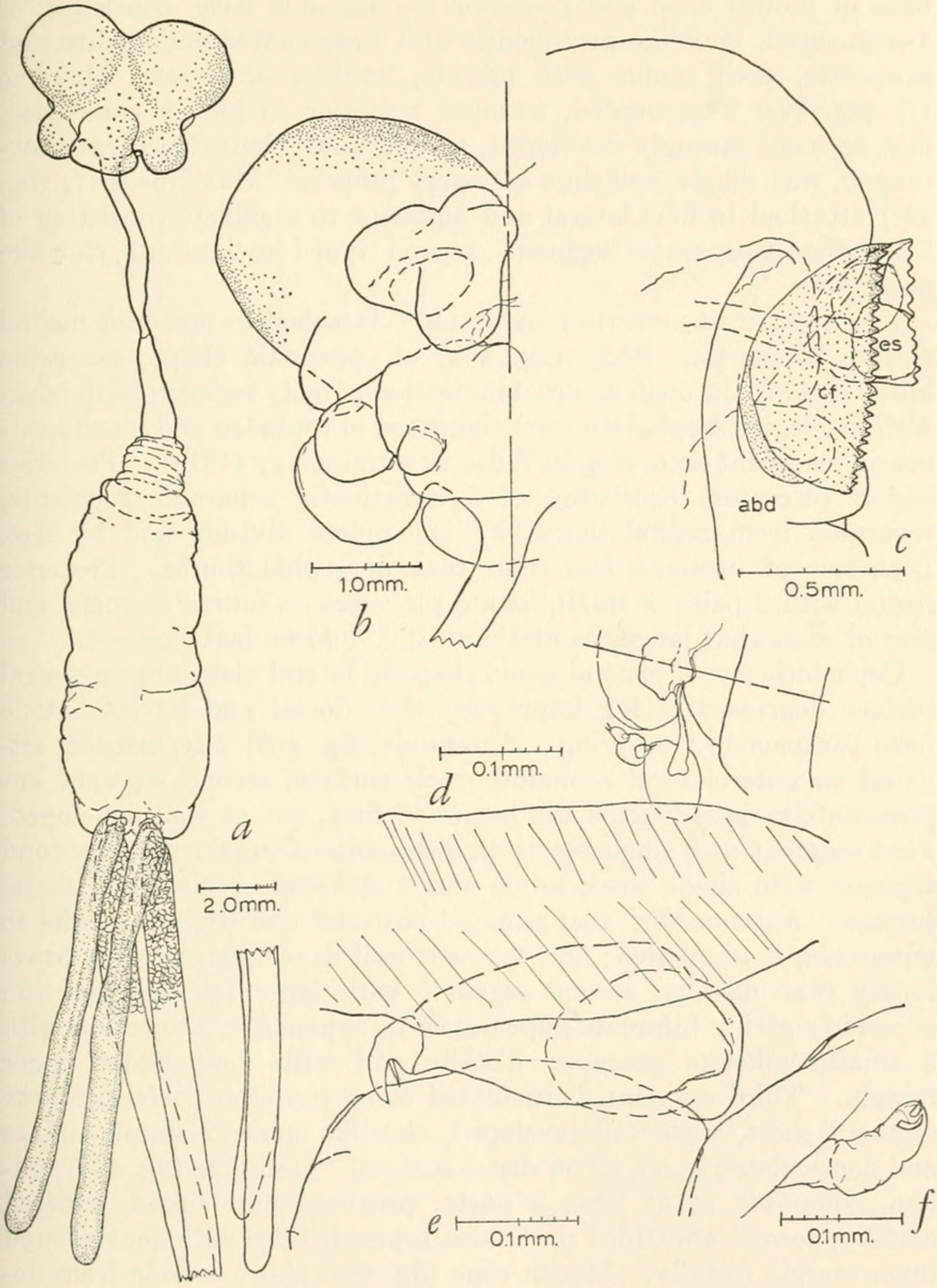

FIGURE 39.—*Paeon vaissierei* Delamare-Deboutteville and Nunes-Ruivo, 1953, female: *a*, dorsal view; *b*, cephalothorax and anterior neck region, ventral view; *c*, posterior end of trunk, anterior end of egg string (es), abdomen (abd), and caudal filament (cf), dorsal view; *d*, mouth cone, mandible, and maxillule (?), ventral view; *e*, maxilla (?), ventral view; *f*, maxilliped (?), ventral view.

base of mouth cone and posterior to mandible base, consisting of 1-segmented, knoblike protopodite and 1-segmented endopodite and exopodite, each ramus with minute, hairlike processes. Maxillae (?) (fig. 39*e*) 2-segmented, situated posterior to mouth cone base, first segment strongly developed, second and terminal process claw-shaped, with single, spikelike accessory process. Maxillipeds (?) (fig. 39*f*) attached to lobe lateral and posterior to maxillae, consisting of 2 indistinctly separated segments, second tipped by 2 minute, clawlike processes.

Diagnostic description of male.—Attached to posterior medial surface of female. Body (fig. 40*a*) of copepodid shape, separable into 2 regions although external indication of body segmentation faint. Anterior region (cephalothorax) composed of cephalon and maxilliped-bearing segment according to Wilson's terminology (1919). Posterior region (urosome) consisting of 5 indistinctly separable segments, separated from cephalothorax by incomplete division and by size. Diameter of urosome less than that of cephalothorax. Posterior region with 2 pairs of small, lobate processes on fourth segment and pair of somewhat longer caudal rami (fig. 40*h*) on last segment.

Cephalothorax of general ovoid shape in lateral view, anteroventral surface depressed giving impression that dorsal and lateral cuticle form carapace-like covering. Antennule (fig. 40*b*) 2-segmented, situated on anterolateral cephalothoracic surface; second segment approximately three-fourths the length of first, not as well developed. First segment with single setule on distal anterolateral surface, second segment with single weak setule and 2 spikelike setules from distal surface. Antenna (fig. 40*c*) situated posterior and slightly medial to antennule, 4-segmented; first segment well developed, broader proximally than distally, second segment with large lobate projection anteriorly giving bifurcate appearance to appendage, projection with 3 small, spikelike processes distally and with denticulated inner margin. Third segment denticulated along posterior surface, fourth segment short, with well-developed, clawlike spine, 2 simple spines and denticulated knob, all on distal surface. Mandible (fig. 40*d*) rod-like, composed of at least 3 parts; proximal part broad, tapered distally, second and third parts also tapered, third with denticulated inner margin distally. Mouth cone (fig. 40*a*) short, arising from depression in anterior ventral cephalothoracic surface, distal end fringed with plumosities. Maxillule (?) (fig. 40*e*) arising from ventral cephalothoracic surface posterior to mandible and adjacent to mouth cone, composed of 2 subequal segments, first overlapping second distally, with flimsy, conical process on distal outer surface; second segment with 3 flimsy, conical processes on distal outer and distal surfaces, all processes indistinctly separable from segments. Maxilla (?) (fig.

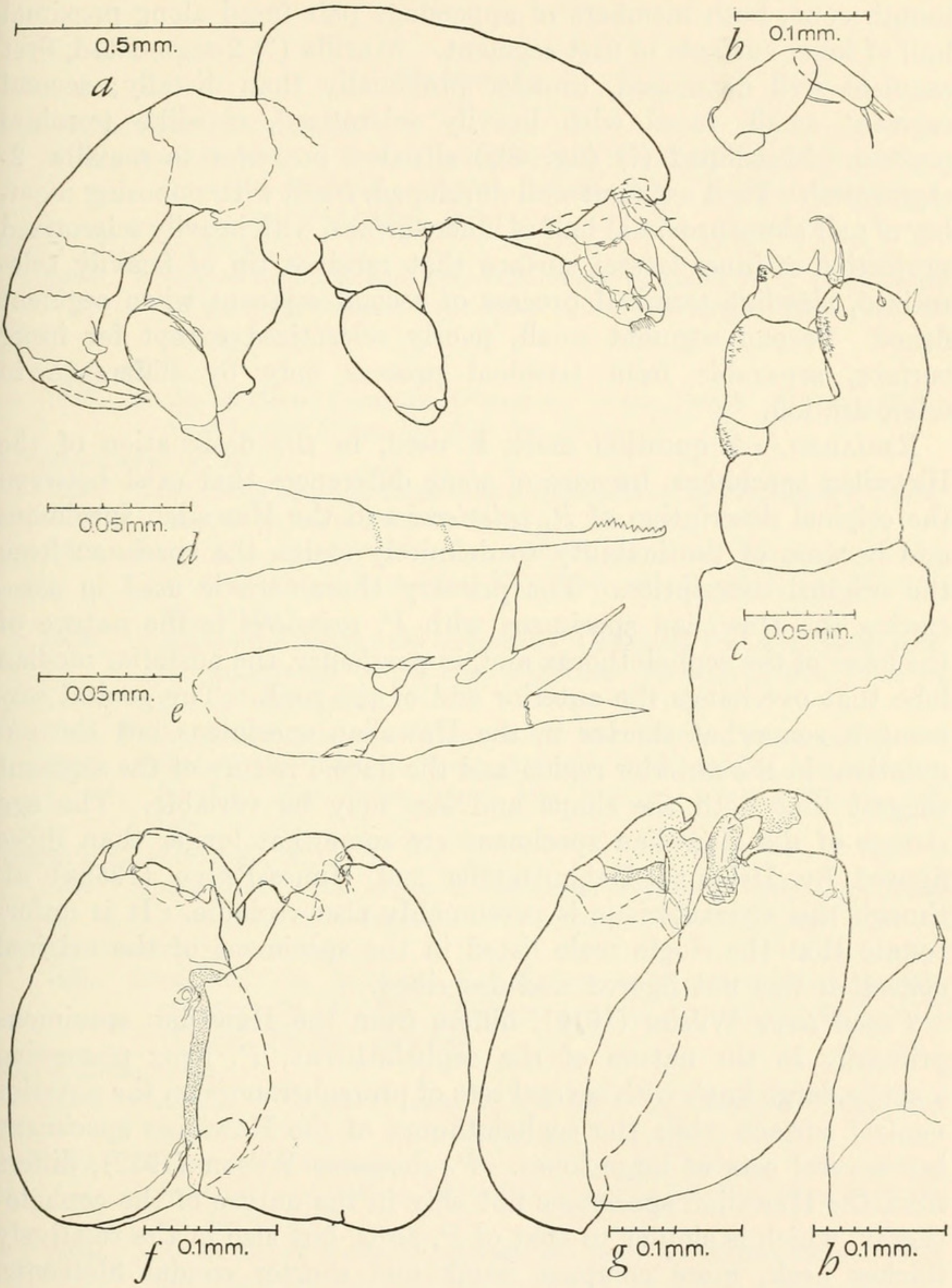

FIGURE 40.—*Paeon vaissierei* Delamare-Deboutteville and Nunes-Ruivo, 1953, male: *a*, lateral view; *b*, left antennule, dorsolateral view; *c*, left antenna, lateral view; *d*, mandible; *e*, maxillule (?), lateral view; *f*, maxilla (?), posterior view; *g*, maxilliped (?), posterior lateral view; *h*, caudal ramus, lateral view.

40*f*) arising from ventral cephalothoracic surface well posterior to mouth cone, both members of appendage pair fused along proximal half of inner surfaces of first segment. Maxilla (?) 2-segmented, first segment well developed, broader proximally than distally; second segment small, fused with heavily sclerotized, clawlike terminal process. Maxilliped (?) (fig. 40*g*) situated posterior to maxilla, 2-segmented. First segment well developed, fused with opposing member of pair along proximal half of inner surface, with heavily sclerotized projection at inner lateral surface that receives tip of heavily sclerotized, clawlike terminal process of second segment when segment flexed. Second segment small, poorly sclerotized except for inner surface, separable from terminal process only by difference in sclerotization.

Remarks.—A question mark is used, in the designation of the Hawaiian specimens, because of some differences that exist between the original description of *P. vaissierei* and the Hawaiian specimens and because of the inability to definitely assign the specimen from the original description. The primary characteristic used in associating the Hawaiian specimens with *P. vaissierei* is the nature of the lobes of the cephalothorax and, in particular, the posterior median lobe that overhangs the anterior end of the neck. The genital segment is somewhat shorter in the Hawaiian specimens but the annulations in the anterior region and the flaccid nature of the segment suggest that both the shape and size may be variable. The egg strings of the Hawaiian specimens are somewhat longer than those figured by Delamare-Deboutteville and Nunes-Ruivo (1953a) although this characteristic is presumably also variable. It is unfortunate that the single male listed in the specimens of the original collection was not figured and described.

Paeon ferox Wilson (1919), differs from the Hawaiian specimens primarily in the nature of the cephalothorax, *P. ferox* possessing a single, large knob with several sets of protruberances on the anterior ventral surface while the cephalothorax of the Hawaiian specimens has several sets of large lobes. *P. elongatus* Wilson (1932), differs from the Hawaiian specimens not only in the nature of the cephalothorax, which is similar to that of *P. ferox,* but also in the relatively thicker neck, more compact trunk and shorter caudal filaments. *P. versicolor* Wilson (1919) differs from the Hawaiian specimen in having a much shorter, heart-shaped genital segment, a thicker and annulated neck and a broad, laterally ovoid cephalothorax with heavily sclerotized knobs on the anterior surface.

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