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Cyclopoid Copepods of the Genus *Lichomolgus*

Associated with Octocorals of the  
Family Nephtheidae in Madagascar

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Only one lichomolgid copepod, *Lichomolgus spinulifer* Humes and Frost, 1964, has been reported as an associate of nephtheid octocorals in Madagascar, where it lives on *Lemnalia* sp. This paper deals with six new species of *Lichomolgus* and with *L. spinulifer* washed from various species of Nephtheidae in the region of Nosy Bé in northwestern Madagascar.

All collections were made by A. G. Humes, those in 1960 during an expedition sponsored by the Academy of Natural Sciences of Philadelphia, and those in 1963-64 as part of the U.S. Program in Biology of the International Indian Ocean Expedition.

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All figures have been drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are:  $A_1$ =first antenna,  $A_2$ =second antenna,  $L$ =labrum,  $MXPD$ =maxilliped, and  $P_1$ =leg 1.

All descriptions are based on type material. The measurements of the length of the body have been made in all cases from specimens in

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lactic acid and do not include the setae on the caudal rami. The lengths of the segments of the first antenna have been measured along their posterior nonsetiferous margins.

We are indebted to Mme. A. Tixier-Durivault of the Muséum National d'Histoire Naturelle, Paris, for the identifications of the octocorals collected in 1960, and to Dr. J. Verseveldt, Zwolle, The Netherlands, for the determinations of those collected in 1963-64.

The new copepods described in this paper comprise the following:

1. *Lichomolgus varirostratus*, new species—from *Dendronephthya mucronata* (Pütter), *D. regia* Verseveldt, *D. stocki* Verseveldt, and *D. köllikeri* Kükenthal.
2. *Lichomolgus exilipes*, new species—from the same four species of *Dendronephthya*.
3. *Lichomolgus gentilis*, new species—from *Dendronephthya mucronata* (Pütter), *D. stocki* Verseveldt, *D. köllikeri* Kükenthal, *Stereonephthya acaulis* Verseveldt, and *S. papyracea* Kükenthal.
4. *Lichomolgus fissisetiger*, new species—from *Stereonephthya acaulis* Verseveldt, *S. papyracea* Kükenthal, and *Lemnalia elegans* (May).
5. *Lichomolgus cuneipes*, new species—from *Stereonephthya acaulis* Verseveldt.
6. *Lichomolgus aculeatus*, new species—from *Nephthea aberrans* Verseveldt, *N. sphaerophora* Kükenthal, *N. crassa* Kükenthal, *N. tixierae* Verseveldt, and *Litophyton arboreum* Forskål.

The following new hosts are recorded for *Lichomolgus spinulifer* Humes and Frost, 1964:

*Lemnalia flava* May, *L. elegans* (May), *L. amabilis* Tixier-Durivault, *L. africana* (May), and *Paralemnalia thyrsoides* (Ehrenberg).

## Family LICHOMOLGIDAE Kossmann, 1877

### Genus *Lichomolgus* Thorell, 1860

#### *Lichomolgus varirostratus*, new species

#### FIGURES 1-31

TYPE MATERIAL.—133 ♀♀, 95 ♂♂, and 7 copepodids from a colony of *Dendronephthya mucronata* (Pütter), in 4 m, on the northeastern coast of Antany Mora, Isles Radama, Madagascar, 14°06'10" S, 47°45'10" E, collected Sept. 30, 1964. Holotype ♀, allotype, and 85 paratypes (50 ♀♀ and 35 ♂♂) deposited in the United States National Museum, the same number of paratypes in the Zoölogisch Museum,

Amsterdam, and the remaining paratypes in the collection of A. G. Humes.

**OTHER SPECIMENS.**—From *Dendronephthya mucronata*: 168 ♀♀ and 118 ♂♂ from 6 colonies, in 1 m, off Ampombilava, Nosy Bé, Madagascar, Sept. 26, 1964; 7 ♀♀ and 8 ♂♂ from 1 colony, in 1 m, Tany Kely, a small island south of Nosy Bé, June 23, 1963; 38 ♀♀, 36 ♂♂, and 4 copepodids from 1 colony, in 2 m, northern end of Nosy Sakatia, near Nosy Bé, Aug. 19, 1963; and 3 ♀♀ and 1 ♂ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963. From *Dendronephthya regia* Verseveldt: 5 ♀♀ and 1 ♂ from 1 colony, in 40 m, Banc de Cinq Mètres, west of Nosy Bé, at about 13°23'39" S, 48°04'00" E, Aug. 19, 1964. From *Dendronephthya stocki* Verseveldt: 3 ♀♀ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963, and 4 ♀♀ and 2 ♂♂ from 1 colony, in 40 m, Banc de Cinq Mètres, Aug. 19, 1964. From *Dendronephthya köllikeri* Kükenthal: 3 ♀♀ and 9 ♂♂ from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59' S, 47°46.5' E, Sept. 30, 1964.

**FEMALE.**—Body (fig. 1) with moderately broad prosome. Length 0.83 mm (0.77–0.90 mm) and greatest width (near middle of cephalosome) 0.47 mm (0.43–0.49 mm), based on 10 specimens. Ratio of length to width of prosome 1.24:1. Segment of first leg separated dorsally and laterally from head by a transverse furrow; lateral areas of this segment rounded posteriorly and not expanded. Lateral areas of segment bearing leg 2 expanded, those of segment of leg 3 expanded and slightly truncated, and those of segment of leg 4 small and rounded.

Segment of leg 5 (fig. 2) about twice as wide as long,  $65\mu \times 120\mu$ . Ventrally between this segment and genital segment a slight intersegmental sclerite. Genital segment (fig. 2) a little longer than wide,  $138\mu \times 118\mu$ , in dorsal view expanded in its midregion, anterior and posterior to which the segment is constricted (anterior constricted area set off ventrally from rest of segment by a weak transverse line). Areas of attachment of egg sacs situated dorsolaterally on posterior part of expanded area. Each area (fig. 3) with 2 naked spini-form setae, both about  $11\mu$  in length, and a prominent unguiform process. Three postgenital segments  $36\mu \times 68\mu$ ,  $26\mu \times 63\mu$ , and  $50\mu \times 62\mu$ , from anterior to posterior.

Caudal ramus (fig. 4) about as long as wide, its greatest dimensions being  $25\mu \times 28\mu$  when measured dorsally and  $29\mu \times 28\mu$  when measured ventrally. Of the usual 6 setae, outer lateral seta  $48\mu$  long, pedicellate dorsal seta  $26\mu$ , outermost distal seta  $73\mu$ , innermost distal seta  $122\mu$ , and the 2 long median terminal setae  $208\mu$  (outer) and  $290\mu$  (inner) and both inserted between dorsal (unornamented) and ventral (with marginal rows of spinules) flaps. All these setae naked except

innermost distal one, which has a row of hairs along inner edge. A few surficial hairs on ramus.

Dorsal surface of prosome and urosome with minute hairs. Ratio of length of prosome to that of urosome 1.9:1.

Most ovigerous females observed carrying clusters of eggs, as in figure 1, rather than complete sacs; egg sacs delicate and easily broken in preserved specimens. One of the few intact egg sacs (fig. 5)  $473\mu \times 180\mu$ , elongated, reaching nearly to ends of ramal setae, with each egg about  $50\mu$ – $55\mu$  in diameter.

Rostral area (fig. 6) broadly rounded posteroventrally.

First antenna (fig. 7) 7-segmented,  $360\mu$  in length, with third segment showing ventrally a proximal sclerotized area suggesting an intercalary segment. Lengths of segments:  $39\mu$  ( $66\mu$  along anterior margin),  $98\mu$ ,  $26\mu$ ,  $50\mu$ ,  $54\mu$ ,  $37\mu$ , and  $28\mu$  respectively. Formula for armature: 4, 13, 6, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. All setae naked except for 2 delicately plumose on last segment.

Second antenna (fig. 8) 4-segmented, with last segment moderately elongated,  $91\mu$  along its outer edge,  $52\mu$  along its inner edge, and  $26\mu$  wide. Each of first 2 segments with a small inner seta and surficial spinules as indicated in the figure, third segment with 3 setae (2 subequal and much longer than third), and last segment with 7 elements: 5 short hyaline elements and 2 long slightly unequal recurved claws  $101\mu$  and  $91\mu$  (measured along greatest axis). All setae naked.

Labrum (fig. 9) with 2 relatively short broadly rounded posteroventral lobes.

Mandible (fig. 10) with basal region distal to constriction bearing on its convex margin a row of spinules followed by a serrated fringe and on its concave margin a row of slender spinules; flagellum elongated with lateral spinules. Paragnath (fig. 11) a small hairy lobe. First maxilla (fig. 12) an elongated segment bearing 3 terminal setae. Second maxilla (fig. 13) 2-segmented, large first segment unarmed, second segment with a small setule on proximal outer margin, a surficial posterior seta barbed along one edge, an inner distal spine with prominent lateral spinules, and the segment produced distally to form a lash with dentiform spines along one edge proximally and fine bilateral spinulation distally. Maxilliped (fig. 14) 3-segmented, first segment with surficial spinules, second with 2 unequal barbed setae and an inner marginal row of small spinules, and third with 2 terminal spiniform barbed setae (producing a bifurcated appearance) and a naked setule. (Articulations of these 2 setae obscure, with inner one perhaps a process rather than an actual seta.)

Area between maxillipeds and first pair of legs (fig. 15) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 16-19) with trimerous rami except for 2-segmented endopod of leg 4. Armature of legs as follows (Roman numerals = spines, Arabic numerals = setae):

P <sub>1</sub>	protopod	0-1	1-0	exp	I-0	I-1	III,I,4
				end	0-1	0-1	I,5
P <sub>2</sub>	protopod	0-1	1-0	exp	I-0	I-1	III,I,5
				end	0-1	0-2	I,II,3
P <sub>3</sub>	protopod	0-1	1-0	exp	I-0	I-1	III,I,5
				end	0-1	0-2	I,II,2
P <sub>4</sub>	protopod	0-1	1-0	exp	I-0	I-1	II,I,5
				end	0-1	II	

Inner seta on coxa of legs 1-3 long and plumose, but in leg 4 very short ( $8\mu$ ) and naked. Row of hairs present on inner margin of basis in all 4 legs. In leg 1 spinules along proximal margins of outer spines of exopod more prominent than those on distal margins. Endopod of leg 4 shorter than exopod. First segment  $49\mu \times 34\mu$  (including terminal spinous processes) bearing a distal inner barbed spine  $32\mu$  long instead of a seta. Second segment  $75\mu \times 29\mu$  (including processes) bearing 2 terminal unequal barbed spines  $29\mu$  (outer) and  $51\mu$  (inner). Both segments with outer margins haired, and second segment with short hairs along proximal inner margin and a row of minute spinules near insertions of terminal spines.

Leg 5 (fig. 20) with free segment elongated and slightly arcuate,  $120\mu \times 36\mu$  in greatest dimensions, but wider proximally than distally; outer convex surface covered with pointed scales (fig. 21); bearing 2 terminal naked setae  $42\mu$  and  $65\mu$  in length. Naked seta on body near free segment  $52\mu$ , with a group of spinules near its insertion.

Leg 6 probably represented by the 2 spiniform elements near areas of attachment of each egg sac (see fig. 3).

Color in life in transmitted light slightly opaque, eye red, ovary and egg sacs gray.

MALE.—Body (fig. 22) resembling in general form that of female. Length 0.73 mm (0.69-0.75 mm) and greatest width 0.32 mm (0.29-0.33 mm), based on 10 specimens. Ratio of length to width of prosome 1.37:1.

Segment of leg 5 (fig. 23)  $41\mu \times 72\mu$ . Genital segment about as long as wide,  $169\mu \times 160\mu$ , in dorsal view with its lateral borders rounded. No intersegmental sclerite ventrally between these 2 segments. Four postgenital segments  $22\mu \times 52\mu$ ,  $21\mu \times 48\mu$ ,  $14\mu \times 45\mu$ , and  $33\mu \times 48\mu$  respectively.

Caudal ramus (fig. 23) relatively slightly longer than in female,  $24\mu \times 22\mu$  when measured dorsally,  $27\mu \times 22\mu$  when measured ventrally. Innermost terminal seta with row of hairlike spinules along both margins proximally.

Surface of prosome and urosome with minute hairs as in female. Ratio of length of prosome to that of urosome 1.48:1.

Rostral area (fig. 24) angular, with a minute median posteroventral knob.

First antenna resembling that of female but with 2 aesthetes about  $100\mu$  long added on segment 2 and another such aesthete on segment 4 (at points indicated by arrows in fig. 7), so that formula is 4, 13+2 aesthetes, 6, 3+1 aesthete, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. Second antenna (fig. 25) resembling that of female, but last segment relatively longer,  $99\mu$  along outer edge,  $68\mu$  along inner edge, and  $21\mu$  wide.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those in female. Maxilliped (fig. 26) slender and 4-segmented (assuming that proximal part of claw represents fourth segment). First segment unornamented. Second segment bearing on medial surface 2 naked setae and 3 rows of spinules, a single row extending the length of segment, other 2 rows close together and restricted to region distal to setae. Third segment very small and unarmed. Claw slender,  $185\mu$  long (measured along its axis), with narrow terminal lamella, slight fringe along its distal concave surface, and 2 very unequal setae near its base, one on postero-inner surface  $86\mu$  long and finely barbed at its tip, other on anterior surface only  $5\mu$  and naked. Claw showing a suggestion of division about midway.

Area between maxillipeds and first pair of legs resembling that of female.

Legs 1-4 segmented as in female and with same spine and setal formula, except for endopod of leg 1 (fig. 27), which has arrangement of 0-1; 0-1; I,I,4. This endopod geniculate, with second and third segments set at an angle to one another. First two segments without outer distal spinous processes. Third segment elongated, nearly as long as first two combined; with 2 terminal spines having strong lateral spinules; a prominent minutely spinose process near insertion of inner of these spines. Last segment of endopod of leg 2 (fig. 28) with 2 of terminal spinous processes larger than in female and bearing numerous minute spines. Legs 3 and 4 like those in female.

Leg 5 (fig. 29) with elongated slender straight free segment,  $33\mu \times 9\mu$ , with nearly parallel sides in dorsal view, bearing a few surficial scales and 2 terminal elements, an outer naked seta  $30\mu$  long and an inner spiniform seta  $20\mu$  long with coarse short lateral spines. No spinules on body near insertion of free segment.

Leg 6 (fig. 30) a posterolateral flap on ventral surface of genital segment bearing 2 naked setae  $22\mu$  and  $27\mu$  long.

Spermatophore (fig. 31), attached to female, elongated,  $172\mu \times 78\mu$  without neck. Spermatophores readily extruded from male when placed in lactic acid, as shown in figure 30.

Color in life resembling that of female.

ETYMOLOGY.—The specific name *varirostratus*, from Latin *vari-*us=different and *rostratus*=furnished with a beak, alludes to the different shape of the rostrum in the two sexes of this species.

COMPARISON WITH RELATED SPECIES.—Two features of *L. varirostratus* serve to distinguish it from all other known species in the genus, namely, the presence of a spine instead of a seta on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna. In only one other species, *L. anomalus* A. Scott, 1909, does the endopod of leg 4 appear to have the formula 0-I, II (based on Scott's fig. 15, pl. LXVII); the usual formula in *Lichomolgus* is 0-1, II. Scott's species differs from the new species, however, in having only one claw on the second antenna. The general structure of the endopod in leg 1 of the male of *L. varirostratus* resembles rather closely that of *L. anomalus*. Scott noted that this geniculate form "is quite distinct from what is usually found in males of this genus."

Two unusually long terminal claws occur on the second antenna in four species—*L. canvi* Sars, 1917; *L. ieveri* Thompson and A. Scott, 1903; *L. marginatus* Thorell, 1860; and *L. tenuicornis* Brady, 1910—but in all of these species the formula for the endopod of leg 4 is 0-1, II, thus readily separating them from the new species from Madagascar.

#### *Lichomolgus exilipes*, new species

FIGURES 32-55

TYPE MATERIAL.—31 ♀♀ and 18 ♂♂ from a colony of *Dendronephthya mucronata* (Pütter), in 4 m, on the northeastern coast of Antany Mora, Isles Radama, Madagascar,  $14^{\circ}06'10''S$ ,  $47^{\circ}45'10''E$ , collected Sept. 30, 1964. Holotype ♀, allotype, and 35 paratypes (25 ♀♀ and 10 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Dendronephthya mucronata*: 15 ♀♀ and 8 ♂♂ from 6 colonies, in 1 m, off Ampombilava, Nosy Bé, Madagascar, Sept. 26, 1964, and 6 ♂♂ from 1 colony, in 1 m, Tany Kely, a small island south of Nosy Bé, June 23, 1963. From *Dendronephthya regia* Verseveldt: 2 ♀♀ from 1 colony, in 40 m, Banc de Cinq Mètres, west of Nosy Bé, at about  $13^{\circ}23'30''S$ ,  $48^{\circ}04'00''E$ , Aug. 19, 1964. From *Dendronephthya stocki* Verseveldt: 1 ♀ and 6 ♂♂ from 1 colony,

in 40 m, Banc de Cinq Mètres, Aug. 19, 1964. From *Dendronephthya köllikeri* Kükenthal: 7 ♀♀ and 12 ♂♂ from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59'S, 47°46.5'E, Sept. 30, 1964.

FEMALE.—Body (fig. 32) a little less broadened than in *L. varirostratus*. Length 0.99 mm (0.91–1.09 mm) and greatest width 0.50 mm (0.46–0.52 mm), based on 10 specimens. Ratio of length to width of prosome 1.3:1. Segment of first leg separated dorsally and laterally from head by a furrow. Lateral areas of segments of legs 1–4 shaped as in figure.

Segment of leg 5 measuring  $73\mu \times 151\mu$ . Between this segment and genital segment a slight ventral intersegmental sclerite. Genital segment (fig. 33) slightly longer than wide,  $172\mu \times 156\mu$ , in dorsal view constricted anteriorly and posteriorly but expanded in midregion. A pair of crescentic sclerotized ridges on anterior dorsal surface. Areas of attachment of egg sacs located dorsolaterally at level of expanded part of segment. Each area (fig. 34) bearing 2 naked setae  $11\mu$  and  $20\mu$  in length, with a small digitiform process between them. Three postgenital segments  $34\mu \times 81\mu$ ,  $23\mu \times 68\mu$ , and  $34\mu \times 70\mu$ , from anterior to posterior.

Caudal ramus (fig. 35) only slightly longer than wide, its greatest dimensions being  $30\mu \times 25\mu$  when measured dorsally and  $33\mu \times 25\mu$  when measured ventrally. Outer lateral seta  $109\mu$  and naked, pedicellate dorsal seta  $22\mu$  and naked, outermost distal seta  $180\mu$  and naked, innermost distal seta  $283\mu$  with inner lateral spinules, and the 2 long median terminal setae  $418\mu$  (outer) and  $550\mu$  (inner), both inserted between dorsal (unornamented) and ventral (with marginal row of spinules) flaps, and bearing lateral spinules in their midregions. A delicate setule on proximal outer edge of ramus, and a few surficial hairs dorsally.

Dorsal surface of prosome and urosome with minute hairs. Ratio of length of prosome to that of urosome 2.24:1.

Egg sacs in most ovigerous females observed broken, as in figure 32. One intact egg sac measuring  $430\mu \times 176\mu$ , elongated, reaching well beyond ends of caudal rami, and containing many small eggs, each about  $40\mu$  in diameter.

Rostral area (fig. 36) linguiform, rounded posteroventrally.

First antenna (fig. 37) resembling in general form that of *L. varirostratus*, with same segmentation and formula for armature, but longer,  $480\mu$ . Lengths of segments:  $36\mu$  ( $77\mu$  along anterior margin),  $133\mu$ ,  $32\mu$ ,  $70\mu$ ,  $75\mu$ ,  $56\mu$ , and  $36\mu$  respectively. All setae naked.

Second antenna (fig. 38) also resembling that of *L. varirostratus*, with similar segmentation and armature. Last segment  $135\mu$  along its outer edge,  $86\mu$  along its inner edge, and  $31\mu$  wide. Three setae on



third segment  $42\mu$ ,  $21\mu$ , and  $42\mu$  from proximal to distal, with distal-most spiniform and minutely barbed along one edge. Both claws about  $135\mu$  in length.

Labrum (fig. 39) with 2 posteroventral lobes less broadly rounded than in *L. varirostratus*.

Mandible (fig. 40) resembling that of *L. varirostratus*, but with distinct constriction separating basal region into two parts, convex margin of distal part bearing spinules and projected distally as a short blunt process. Paragnath a small lobe bearing hairs. First maxilla (fig. 41) bearing a small subterminal element in addition to 3 terminal ones. Second maxilla (fig. 42) and maxilliped (fig. 43) segmented and armed as in *L. varirostratus*, but slight differences in ornamentation of elements as shown in figures.

Area between maxillipeds and first pair of legs (fig. 44) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 45-48) segmented as in *L. varirostratus*, with same spine and setal formula. Inner seta on coxa of leg 4 short ( $12\mu$ ) and naked. Inner margin of basis of leg 4 without hairs. In leg 1 spinules along proximal margins of outer spines of exopod longer and coarser than those on distal margins. Endopod of leg 4 only slightly shorter than exopod. First segment  $56\mu \times 35\mu$  (including terminal spinous processes), bearing an inner distal minutely barbed spine  $43\mu$  long. Second segment  $111\mu \times 30\mu$  (greatest dimensions including processes), bearing 2 terminal barbed spines  $39\mu$  (outer) and  $77\mu$  (inner); a few minute spinules along inner margin of segment.

Leg 5 (fig. 49) with free segment much elongated, slender, and slightly arcuate,  $172\mu \times 23\mu$  (width  $35\mu$  at level of proximal inner expansion). Outer convex surface bearing pointed scales. Two terminal naked setae  $122\mu$  and  $190\mu$  in length. Naked seta on body near free segment  $55\mu$ , with a few minute spinules not far from its insertion.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 34).

Color in life in transmitted light as in *L. varirostratus*.

MALE.—Body (fig. 50) resembling that of female in general form. Length 0.78 mm (0.73-0.81 mm) and greatest width 0.34 mm (0.30-0.36 mm), based on 10 specimens. Ratio of length to width of prosome 1.4:1.

Segment of leg 5 measuring  $36\mu \times 101\mu$ . Genital segment (fig. 51) about as long as wide,  $221\mu \times 216\mu$ . No ventral intersegmental sclerite between these segments. Four postgenital segments  $22\mu \times 56\mu$ ,  $17\mu \times 55\mu$ ,  $11\mu \times 51\mu$ , and  $24\mu \times 56\mu$  respectively.

Caudal ramus (fig. 51) somewhat shorter than in female,  $22\mu \times 24\mu$  dorsally,  $23\mu \times 24\mu$  ventrally. Innermost terminal seta with row of

spinules on both sides. Outermost terminal seta with inner spinules proximally.

Surfaces of prosome and urosome with minute hairs as in female. Ratio of length of prosome to that of urosome 1.43:1.

Rostral area as in female.

First antenna resembling that of female, but with 2 long aesthetes added on second segment and another aesthete on fourth segment, so that formula is same as for male of *L. varirostratus*.

Second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla similar to those in female. Maxilliped (fig. 52) less slender than in *L. varirostratus*, but segmented and armed similarly. Claw slender and  $170\mu$  along its axis; proximal region of claw slightly swollen and faintly striated.

Area between maxilliped and first pair of legs as in female.

Legs 1-4 segmented as in *L. varirostratus*, with spine and setal formula as in male of that species. Endopod of leg 1 (fig. 53) slightly geniculate. Third segment elongated, with outer terminal spine straight, having lateral spinules and hyaline tip, inner terminal spine bent, with strong spinules along its inner distal edge; spinous process between these 2 spines enlarged and finely spinose. No obvious sexual dimorphism in legs 2-4.

Leg 5 (fig. 54) with a very elongated slender straight free segment,  $55\mu \times 11\mu$ , bearing on its outer surface a few scales and terminally an outer naked seta  $56\mu$  long and an inner spine  $29\mu$  long with short lateral spinules. No spinules on body near insertion of free segment.

Leg 6 similar to that in *L. varirostratus*, with 2 naked setae  $41\mu$  and  $78\mu$  in length.

Spermatophore (fig. 55), attached to female, elongated,  $174\mu \times 91\mu$ , not including neck.

Color in life as in *L. varirostratus*.

ETYMOLOGY.—The specific name *exilipes*, from Latin *exilis*=slender and *pes*=foot, refers to the elongated slender form of leg 5 in both sexes of this species.

COMPARISON WITH RELATED SPECIES.—Like *L. varirostratus*, this species may be distinguished from all other known species in the genus on the basis of a combination of two characters: the spine (instead of a seta) on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna.

*Lichomolgus exilipes* may readily be separated from *L. varirostratus* by the form of the rostrum, the presence of lateral spinules on the two long setae on the caudal rami, the form of the fifth legs and the genital segment in the female, and the structure of the two spines on the last segment of the endopod of leg 1 in the male.

*Lichomolgus gentilis*, new species

FIGURES 56-69

TYPE MATERIAL.—20 ♀♀ and 28 ♂♂ from a colony of *Dendronephthya mucronata* (Pütter), in 4 m, on the northeastern coast of Antany Mora, Isles Radama, Madagascar, 14°06'10''S, 47°45'10''E, collected Sept. 30, 1964. Holotype ♀, allotype, and 36 paratypes (14 ♀♀ and 22 ♂♂) deposited in the United States National Museum and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Dendronephthya mucronata*: 4 ♀♀ from 6 colonies, in 1 m, off Ampombilava, Nosy Bé, Madagascar, Sept. 26, 1964; 10 ♀♀ and 19 ♂♂ from 1 colony, in 1 m, Tany Kely, a small island south of Nosy Bé, June 23, 1963; 2 ♀♀ from 1 colony, in 2 m, northern end of Nosy Sakatia, near Nosy Bé, Aug. 19, 1963; and 2 ♀♀ and 1 ♂ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963. From *Dendronephthya köllikeri* Kükenthal: 15 ♀♀ and 19 ♂♂ from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59'S, 47°46.5'E, Sept. 30, 1964. From *Dendronephthya stocki* Verseveldt: 1 ♂ from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963. From *Stereonephthya acaulis* Verseveldt: 1 ♀, 2 ♂♂, and 45 copepodids from 1 colony, in 20 m, Tany Kely, Dec. 20, 1963; 5 ♀♀, 22 ♂♂, and 1 copepodid from 1 colony, in 10 m, Tany Kely, Aug. 21, 1964; 11 ♀♀ and 8 ♂♂ from 1 colony, in 1 m, off Ampombilava, Nosy Bé, Sept. 26, 1964; and 15 ♀♀, 9 ♂♂, and 1 copepodid from 1 colony, in 2 m, Andraikarekabe, Nosy Komba, near Nosy Bé, Oct. 9, 1964. From *Stereonephthya papyracea* Kükenthal: 39 ♀♀ and 52 ♂♂ from 1 colony, in 6 m, Tany Kely, Aug. 26, 1963.

FEMALE.—Body (fig. 56) with moderately broad prosome. Length 0.91 mm (0.82–1.03 mm) and greatest width 0.47 mm (0.45–0.49 mm), based on 10 specimens. Ratio of length to width of prosome 1.28:1.

Segment of leg 5 measuring  $52\mu \times 159\mu$ . Between this segment and genital segment no ventral intersegmental sclerite visible. Genital segment (fig. 57) nearly as long as wide,  $148\mu \times 159\mu$ , in dorsal view expanded in its anterior three-fourths but constricted posteriorly. Areas of attachment of egg sacs located dorsolaterally on posterior part of expanded region. Each area (fig. 58) with a slender naked seta  $13\mu$  long, a spiniform unilaterally barbed seta  $18\mu$  long, and an adjacent slender setiform process. Three postgenital segments  $26\mu \times 86\mu$ ,  $20\mu \times 82\mu$ , and  $25\mu \times 77\mu$  from anterior to posterior.

Caudal ramus (fig. 57) a little shorter than wide, its greatest dimensions being  $25\mu \times 32\mu$  when measured dorsally and  $27\mu \times 32\mu$  when measured ventrally. Outer lateral seta  $143\mu$  long and naked, pedicellate dorsal seta  $39\mu$  and naked, outermost distal seta  $235\mu$  and naked, innermost distal seta  $352\mu$  with row of spinules along inner edge, and the 2 long median terminal setae  $517\mu$  (outer) and  $583\mu$  (inner), both inserted between dorsal (unornamented) and

ventral (with marginal row of spinules) flaps, and both with strong coarse lateral spinules in midregion (these spinules much stronger than in *L. exilipes*).

Ratio of length of prosome to that of urosome 2.5:1.

Most ovigerous females observed carrying only clusters of eggs as in figure 56. One of few intact egg sacs measuring  $462\mu \times 198\mu$ , elongated oval, reaching far beyond caudal rami, with each egg about  $44\mu$  in diameter.

Rostral area and first antenna ( $453\mu$  long) resembling those of *L. exilipes*. Second antenna (fig. 59) formed in general like that of *L. exilipes*, but 3 elements on third segment  $35\mu$ ,  $24\mu$ , and  $25\mu$  from proximal to distal. Last segment  $130\mu$  along its outer edge,  $83\mu$  along its inner edge, and  $31\mu$  wide. Two terminal claws different in form and length, one being slender and  $143\mu$  along its axis, other stout and  $127\mu$ . (Apparently some variation in lengths of claws, with one female  $153\mu$  and  $117\mu$  on one side and  $146\mu$  and  $130\mu$  on other. In one female from *Stereonephthya acaulis*  $120\mu$  and  $99\mu$ , and in another  $125\mu$  and  $107\mu$ . In all cases, however, longer claw slender, shorter one stout.)

Labrum as in *L. exilipes*. Mandible (fig. 60) without blunt process on convex margin of basal region as in *L. exilipes*. Paragnath, first maxilla, and second maxilla similar to those in *L. exilipes*. Maxilliped (fig. 61) differing only slightly from that species.

Area between maxillipeds and first pair of legs not protuberant, with a sclerotized line connecting bases of maxillipeds.

Legs 1-4 segmented as in 2 previous species, with same spine and setal formula. Inner seta on coxa of leg 4 short ( $10\mu$ ) and naked. Inner margin of basis of leg 4 without hairs. In leg 1 (fig. 62) and leg 2 spinules along proximal margins of outer spines of exopod longer and stouter than those on distal margins. Endopod of leg 4 (fig. 63) shorter than exopod. First segment  $55\mu \times 34\mu$  (including terminal spinous processes), bearing an inner distal finely barbed spine  $35\mu$  long. Second segment  $99\mu \times 34\mu$  (greatest dimensions including processes), bearing 2 terminal spines, outer  $44\mu$  and finely barbed, inner  $79\mu$  with lateral spinules; a row of long hairs along proximal two-thirds of inner margin of segment.

Leg 5 (fig. 64) with elongated free segment,  $143\mu \times 20\mu$  (width taken at level of proximal inner expansion). Outer convex surface with pointed scales. Two terminal naked setae  $99\mu$  and  $148\mu$  in length. Seta on body near insertion of free segment  $40\mu$  long and slightly plumose; a few small spinules near this seta.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 58).

Color in life in transmitted light as in 2 previous species.

MALE.—Body (fig. 65) resembling that of female in general aspect. Length 0.72 mm (0.69–0.77 mm) and greatest width 0.34 mm (0.32–0.36 mm), based on 10 specimens. Ratio of length to width of prosome 1.36:1.

Segment of leg 5 measuring  $39\mu \times 104\mu$ . Genital segment (fig. 66) as long as wide,  $200\mu \times 203\mu$ . No ventral intersegmental sclerite between these segments. Four postgenital segments  $15\mu \times 61\mu$ ,  $17\mu \times 57\mu$ ,  $12\mu \times 56\mu$ , and  $22\mu \times 58\mu$  respectively.

Caudal ramus as in female, but proportions slightly different,  $20\mu \times 24\mu$  dorsally,  $27\mu \times 24\mu$  ventrally. As in *L. exilipes*, outermost terminal seta with inner spinules proximally and innermost terminal seta with row of spinules on both sides.

Ratio of length of prosome to that of urosome 1.7:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added (length of proximalmost =  $130\mu$ ) so that formula is same as for males of 2 previous species. Second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla like those of female. Maxilliped (fig. 67) with general form similar to *L. exilipes*, but ornamentation of major setae slightly different. Claw slender and  $172\mu$  along its axis.

Area between maxillipeds and first pair of legs as in female.

Legs 1–4 segmented as in 2 previous species, with spine and setal formula as in males of those species. Endopod of leg 1 (fig. 68) only slightly geniculate. Third segment moderately elongated, with outer terminal spine straight, having lateral spinules and small hyaline tip, inner terminal spine slightly bent (not as strongly so as in *L. exilipes*) with moderately strong spinules along its inner distal edge; spinous process between these 2 spines as in *L. exilipes*. No obvious sexual dimorphism in legs 2–4, except that endopod of leg 4 (fig. 69) has slightly different proportions: first segment  $33\mu \times 25\mu$ , with spine  $25\mu$ , second segment  $70\mu \times 22\mu$  (more elongated than in female, ratio 3.2:1 instead of 2.9:1 as in that sex), with 2 terminal spines  $31\mu$  and  $61\mu$ .

Leg 5 (fig. 66) with elongated free segment,  $57\mu \times 11\mu$ , without pronounced proximal inner expansion, bearing on its outer surface a few scales and terminally an outer naked seta  $71\mu$  and an inner barbed spine  $19\mu$ . No spinules on body near insertion of free segment.

Leg 6 similar to those in 2 previous species, with 2 naked setae  $50\mu$  and  $82\mu$  in length.

Spermatophore, attached to female, as in *L. exilipes*.

Color in life as in 2 previous species.

ETYMOLOGY.—The specific name *gentilis*, from Latin = belonging to the same gens or clan, alludes to the close relationship of this species with *L. exilipes*.

COMPARISON WITH RELATED SPECIES.—Like *L. varirostratus* and *L. exilipes* this species may be distinguished from all other members of the genus by the combination of two characters: the spine (instead of a seta) on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna.

*Lichomolgus gentilis* may be readily separated from *L. varirostratus* by the form of the rostrum, the presence of lateral spinules on the two long setae on the caudal rami, the form of the genital segment in the female, and the structure of the two spines on the last segment of the endopod of leg 1 in the male.

From *L. exilipes* the new species may be separated by the coarser lateral spinules on the two long setae on the caudal rami, the more unequal nature of the two claws on the second antenna, the lack of a blunt process on the inner margin of the mandible, and the form of the fifth legs and the genital segment in the female.

*Lichomolgus fissisetiger*, new species

FIGURES 70-83

TYPE MATERIAL.—24 ♀♀ and 20 ♂♂ from a colony of *Stereonephthya acaulis* Verseveldt, in 2 m, Ambafaho, Nosy Bé, Madagascar, collected Sept. 25, 1964. Holotype ♀, allotype, and 34 paratypes (18 ♀♀ and 16 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Stereonephthya acaulis*: 45 ♀♀ and 89 ♂♂ from 1 colony, in 10 m, Tany Kely, a small island south of Nosy Bé, Aug. 21, 1964; 22 ♀♀, 9 ♂♂, and 2 copepodids from 1 colony, in 1 m, off Ampombilava, Nosy Bé, Sept. 26, 1964; and 9 ♀♀ and 16 ♂♂ from 1 colony, in 2 m, Andraikarekabe, Nosy Komba, near Nosy Bé, Oct. 9, 1964. From *Stereonephthya papyracea* Kükenthal: 53 ♀♀, 80 ♂♂, and 92 copepodids from 1 colony, in 6 m, Tany Kely, Aug. 26, 1963. From *Lemnalia elegans* (May): 3 ♀♀ from 1 colony, in 1 m, Pte. Lokobe, Nosy Bé, Oct. 16, 1960.

FEMALE.—Body (fig. 70) similar to that of *L. exilipes* and *L. gentilis*. Length 0.99 mm (0.92-1.03 mm) and greatest width 0.49 mm (0.46-0.51 mm), based on 10 specimens. Ratio of length to width of prosome 1.5:1.

Segment of leg 5 measuring  $65\mu \times 143\mu$ . Between this segment and genital segment a small ventral intersegmental sclerite. Genital segment (fig. 71) slightly shorter than wide,  $127\mu \times 143\mu$ , in dorsal view with its lateral borders rounded. Areas of attachment of egg sacs located almost laterally (only slightly dorsally) in posterior half of segment. Each area (fig. 72) with 2 small naked setae about  $11\mu$  long and an adjacent small unguiform process. Three postgenital segments  $26\mu \times 82\mu$ ,  $21\mu \times 73\mu$ , and  $26\mu \times 70\mu$  from anterior to posterior.

Caudal ramus (fig. 73) shorter than wide, its greatest dimensions being  $20\mu \times 28\mu$  when measured dorsally,  $21\mu \times 28\mu$  when measured ventrally. Outer lateral seta  $83\mu$  long and naked, pedicellate dorsal seta  $25\mu$  and naked, outermost distal seta  $117\mu$  with proximal inner spinules, innermost distal seta  $208\mu$  with spinules along both sides, and the 2 long median terminal setae  $440\mu$  (outer) and  $590\mu$  (inner), both inserted between dorsal (unornamented) and ventral (with marginal row of spinules) flaps, and both with lateral spinules in midregion (these spinules not as strong as in *L. gentilis*, and more like those of *L. exilipes*).

Ratio of length of prosome to that of urosome 2.9:1.

Egg sac (fig. 70)  $550\mu \times 209\mu$ , elongated, reaching far beyond ends of caudal rami, containing many eggs, each about  $45\mu$  in diameter.

Rostral area and first antenna ( $428\mu$  long) similar to those of *L. exilipes* and *L. gentilis*. Second antenna (fig. 74) resembling that of *L. gentilis*, but differing in details. Three naked elements on third segment  $35\mu$ ,  $21\mu$ , and  $20\mu$  in length from proximal to distal. Last segment  $94\mu$  along outer margin,  $60\mu$  along inner margin, and  $25\mu$  wide. Two terminal claws unequal, not as long as in *L. gentilis*, one  $92\mu$  along its axis and slender, the other  $77\mu$  and stouter.

Labrum as in *L. exilipes* and *L. gentilis*. Mandible (fig. 75) similar to that in *L. gentilis*, but showing an even more pronounced constriction of basal region. Paragnath and first maxilla as in *L. exilipes* and *L. gentilis*. Second maxilla (fig. 76) resembling *L. exilipes* and *L. gentilis*, but spinulation of lash and distal seta slightly different. Maxilliped as in *L. exilipes* and *L. gentilis*.

Area between maxillipeds and first pair of legs not protuberant, with a sclerotized line between bases of maxillipeds.

Legs 1-4 segmented as in 3 previous species, with same spine and setal formula. Leg 1 similar to that of *L. exilipes* and *L. gentilis*. Legs 2 and 3 like those of *L. exilipes*. Leg 4 (fig. 77) resembling that of *L. gentilis*. Endopod shorter than exopod. First segment  $42\mu \times 32\mu$  (including terminal spinous processes), with inner distal minutely barbed spine  $31\mu$  long. Second segment  $90\mu \times 29\mu$  (greatest dimensions including processes), outer terminal spine  $34\mu$  with finely barbed fringe, inner  $72\mu$  with more coarsely spinulose fringe. Proximal inner margin of this segment with row of very short spinules.

Leg 5 (fig. 78) with elongated free segment having prominent inner basal expansion. Greatest length  $148\mu$ , width  $42\mu$  at expansion,  $23\mu$  immediately distal to expansion, and  $16\mu$  near tip. Outer surface with narrow scalelike spines. Two terminal naked setae  $72\mu$  and  $110\mu$  (the latter with a narrow membrane in its midregion). Seta on body near insertion of free segment about  $50\mu$  long and slightly plumose; a few small spinules near this seta.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 72).

Color in life in transmitted light somewhat opaque, eye red, ovary dark gray, egg sacs gray.

MALE.—Body (fig. 79) resembling that of female in general form. Length 0.78 mm (0.74–0.81 mm) and greatest width 0.29 mm (0.27–0.30 mm), based on 10 specimens. Ratio of length to width of prosome 1.48:1.

Segment of leg 5 measuring  $36\mu \times 91\mu$ . Genital segment (fig. 80) as long as wide,  $185\mu \times 185\mu$ . No ventral intersegmental sclerite between these segments. Four postgenital segments  $17\mu \times 50\mu$ ,  $14\mu \times 52\mu$ ,  $12\mu \times 50\mu$ , and  $19\mu \times 52\mu$  respectively.

Caudal ramus resembling that of female but smaller,  $14\mu \times 22\mu$  dorsally,  $18\mu \times 22\mu$  ventrally.

Ratio of length of prosome to that of urosome 1.62:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added as in 3 previous species, so that formula is same as for those males. Aesthetes much longer than in preceding species, proximalmost one  $240\mu$  in length. Second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla like those in female. Maxilliped resembling in general form that of *L. gentilis*, but one of setae on inner surface of second segment terminating in several pointed spiniform elements (fig. 81). Claw  $133\mu$  in length (measured along its axis).

Area between maxillipeds and first pair of legs as in female.

Legs 1–4 segmented as in 3 previous species, with spine and setal formula as in those males. Endopod of leg 1 (fig. 82) only slightly geniculate. Third segment resembling that of *L. gentilis*. Legs 2–4 as in female.

Leg 5 (see fig. 80) resembling that of *L. exilipes*, with free segment  $52\mu \times 9\mu$ , terminally with inner spine  $18\mu$  and barbed, outer seta  $68\mu$  and naked.

Leg 6 (fig. 83) similar to that in 3 preceding species, with 2 naked setae  $44\mu$  and  $66\mu$  in length.

Spermatophore not observed.

Color in life in transmitted light more translucent than in female, eye red, genital segment hyaline.

ETYMOLOGY.—The specific name *fissisetiger*, from Latin *fissus*=split and *setiger*=bearing a seta, refers to the nature of the seta on the second segment of the maxilliped in the male of this species.

COMPARISON WITH RELATED SPECIES.—Like the three preceding species *L. fissisetiger* may be distinguished from all other members of the genus by the combination of two characters: the spine (instead



of a seta) on the first segment of the endopod of leg 4 and the two unusually long terminal claws on the second antenna.

*Lichomolgus fissisetiger* may be separated from *L. varirostratus* by the form of the rostrum, the presence of lateral spinules on the two long setae of the caudal rami, the form of the genital segment and leg 5 in the female, the long aesthetes on the first antenna of the male, and the structure of the two spines on the last segment of the endopod of leg 1 in the male.

It may be distinguished from *L. exilipes* by the form of the genital segment and leg 5 in the female, the more unequal nature of the two claws on the second antenna, the lack of a blunt process on the inner margin of the mandible, the peculiar split seta on the second segment of the maxilliped in the male, and the long aesthetes on the first antenna of the male.

From *L. gentilis* the new species may be distinguished by the form of the genital segment and leg 5 in the female, the pronounced constriction of the basal region of the mandible, the split seta on the second segment of the maxilliped in the male, and the long aesthetes on the first antenna of the male.

*Lichomolgus cuneipes*, new species

FIGURES 84-96

TYPE MATERIAL.—39 ♀♀ and 18 ♂♂ from a colony of *Stereonephthya acaulis* Verseveldt, in 1 m, off Ampombilava, Nosy Bé, Madagascar, collected Sept. 26, 1964. Holotype ♀, allotype, and 46 paratypes (32 ♀♀ and 14 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS (all from *Stereonephthya acaulis*).—6 ♀♀ and 3 ♂♂ from 1 colony, in 2 m, Ambafaho, Nosy Bé, Sept. 25, 1964; 9 ♀♀ and 10 ♂♂ from 1 colony, in 10 m, Tany Kely, a small island south of Nosy Bé, Aug. 21, 1964; and 11 ♀♀ and 9 ♂♂ from 1 colony, in 2 m, Andraikarekabe, Nosy Komba, near Nosy Bé, Oct. 9, 1964.

FEMALE.—Body (fig. 84) resembling that of *L. fissisetiger*. Length 0.94 mm (0.89–0.98 mm) and greatest width 0.48 mm (0.45–0.49 mm), based on 10 specimens. Ratio of length to width of prosome 1.56:1.

Segment of leg 5 measuring  $65\mu \times 138\mu$ . Between this segment and genital segment a small ventral intersegmental sclerite. Genital segment (fig. 85) about as long as wide,  $125\mu \times 120\mu$ , in dorsal view with its lateral borders somewhat irregular. Areas of attachment of egg sacs located dorsolaterally in middle of segment. Each area (fig. 86) with 2 small naked setae about  $8\mu$  long with a pointed sclerotized process between them. Three postgenital segments  $26\mu \times 75\mu$ ,  $21\mu \times 71\mu$ , and  $26\mu \times 71\mu$  from anterior to posterior.

Caudal ramus (fig. 87) shorter than wide, its greatest dimensions being  $22\mu \times 30\mu$  when measured dorsally,  $24\mu \times 30\mu$  when measured ventrally. Outer lateral seta  $75\mu$  long, pedicellate dorsal seta  $28\mu$ , outermost distal seta  $112\mu$ , innermost distal seta  $203\mu$ , and the 2 long median terminal setae  $380\mu$  (outer) and  $495\mu$  (inner), both inserted between dorsal and ventral flaps as in previous species. All setae naked.

Ratio of length of prosome to that of urosome 2.78:1.

Egg sac (fig. 84)  $462\mu \times 187\mu$ , elongated, reaching far beyond ends of caudal rami, containing many eggs, each about  $45\mu$  in diameter.

Rostral area (fig. 88) broadly rounded posteroventrally.

First antenna ( $410\mu$  long) similar to that of *L. exilipes*, the segments  $31\mu$  ( $61\mu$  along anterior edge),  $133\mu$ ,  $28\mu$ ,  $57\mu$ ,  $56\mu$ ,  $42\mu$ , and  $32\mu$  in length respectively. Second antenna (fig. 89) with 4 segments having same formula for armature as in previous species. Three elements on third segment consisting of 2 naked setae  $22\mu$  and  $23\mu$  and a spiniform seta  $11\mu$  long and very finely spinulose. Last segment  $74\mu$  along outer margin,  $40\mu$  along inner margin, and  $22\mu$  wide. Two terminal claws not as long as in 4 previous species and unequal, one being  $46\mu$  and slender, other  $43\mu$  and much stouter.

Labrum as in *L. exilipes*. Mandible as in *L. fissisetiger*. Paragnath and first maxilla as in *L. exilipes*. Second maxilla (fig. 90) resembling in general form that of *L. fissisetiger*, but 4-5 central teeth on lash much stouter than others. Maxilliped much like that of *L. gentilis*.

Area between maxillipeds and first pair of legs not protuberant, with a sclerotized line between bases of maxillipeds.

Legs 1-4 segmented as in 4 previous species, with same spine and setal formula. Legs 1-3 closely resembling those of *L. exilipes*. Leg 4 (fig. 91) with endopod shorter than exopod, its first segment  $41\mu \times 28\mu$  (including terminal spinous processes) with inner distal finely barbed spine  $30\mu$ , second segment  $90\mu \times 24\mu$  (greatest dimensions including processes), outer terminal spine  $29\mu$  with finely barbed margins, inner  $63\mu$  with coarsely barbed fringe on outer margin and very slightly barbed fringe on inner margin. Inner margin of this segment with very short spinules.

Leg 5 (fig. 92) with elongated free segment having a prominent inner basal expansion directed distally. (Shape of this expansion varying somewhat in different individuals, as in figures 93 and 94.) Length of segment  $134\mu$ , width at expansion  $40\mu$ , width just distal to expansion  $26\mu$ . Outer surface with narrow scalelike spines. Two terminal setae  $70\mu$  and  $88\mu$  (the latter with a narrow membrane as in *L. fissisetiger*). Seta on body near insertion of segment about  $40\mu$  long and slightly plumose; a few small spinules near this seta.

Leg 6 probably represented by the 2 setae near areas of attachment of each egg sac (see fig. 86).

Color in life in transmitted light as in *L. fissisetiger*.

MALE.—Body (fig. 95) resembling that of *L. fissisetiger*. Length 0.73 mm (0.69–0.77 mm) and greatest width 0.26 mm (0.22–0.28 mm), based on 10 specimens. Ratio of length to width of prosome 1.73:1.

Segment of leg 5 measuring  $34\mu \times 81\mu$ . Genital segment (fig. 96) about as long as wide,  $169\mu \times 164\mu$ . No ventral intersegmental sclerite between these segments. Four postgenital segments  $16\mu \times 46\mu$ ,  $16\mu \times 45\mu$ ,  $13\mu \times 44\mu$ , and  $18\mu \times 47\mu$  respectively.

Caudal ramus similar to that of female but smaller,  $17\mu \times 22\mu$  dorsally,  $19\mu \times 22\mu$  ventrally.

Ratio of length of prosome to that of urosome 1.7:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added as in 4 previous species, so that formula is same as for those males. Aesthetes long as in *L. fissisetiger*, proximalmost  $200\mu$  in length. Second antenna like that of female, but with a few small spinules along inner margins of first, second, and fourth segments.

Labrum, mandible, paragnath, first maxilla, and second maxilla as in female. Maxilliped as in *L. gentilis*, with claw  $146\mu$  in length (measured along its axis).

Area between maxillipeds and first pair of legs as in female.

Legs 1–4 segmented as in 4 previous species, with spine and setal formula as in those males. Endopod of leg 1 as in *L. fissisetiger*. Legs 2–4 as in female.

Leg 5 as in *L. exilipes*, with free segment  $51\mu \times 8\mu$ , its seta  $53\mu$  and its spine  $19\mu$  in length.

Leg 6 similar to that of *L. fissisetiger*, with 2 naked setae  $26\mu$  and  $53\mu$  long.

Spermatophore not observed.

Color in life as in female.

ETYMOLOGY.—The specific name *cuneipes*, from Latin *cuneus*=a wedge and *pes*=a foot, alludes to the wedgelike form of the inner basal expansion of leg 5 in the female of this species.

COMPARISON WITH RELATED SPECIES.—*Lichomolgus cuneipes* may be differentiated from all other previously known species in the genus by the combination of two characters: the spine (instead of a seta) on the first segment of the endopod of leg 4 and the second antenna bearing terminally two claws and five small hyaline elements.

*Lichomolgus cuneipes* may be separated from all four species described above by the shorter and more unequal two claws on the

second antenna, by the nature of the teeth on the lash of the second maxilla, and by the form of the fifth legs in the female.

*Lichomolgus aculeatus*, new species

FIGURES 97-113

TYPE MATERIAL.—69 ♀♀, 116 ♂♂, and 39 copepodids from a colony of *Nephthea aberrans* Verseveldt, in 10 m, Tany Kely, a small island south of Nosy Bé, Madagascar, collected Aug. 21, 1964. Holotype ♀, allotype, and 154 paratypes (54 ♀♀ and 100 ♂♂) deposited in the United States National Museum, 20 paratypes (10 ♀♀ and 10 ♂♂) in the Zoölogisch Museum, Amsterdam, and the remaining paratypes in the collection of A. G. Humes.

OTHER SPECIMENS.—From *Nephthea sphaerophora* Kükenthal: 33 ♀♀, 17 ♂♂, and 11 copepodids from 1 colony, in 3 m, Pte. Lokobe, Nosy Bé, Oct. 16, 1960. From *Nephthea crassa* Kükenthal: 27 ♀♀, 46 ♂♂, and 33 copepodids from 1 colony, in 2 m, Pte. Mahatsinjo, Nosy Bé, Aug. 8, 1960; 51 ♀♀ and 97 ♂♂ from 1 colony, in 2 m, Tany Kely, Aug. 26, 1960. From *Nephthea tizierae* Verseveldt: 70 ♀♀, 92 ♂♂, and 100 copepodids from 1 colony, in 8 m, Nosy Ovy, Isles Radama, 13°59'S, 47°46.5'E, Sept. 30, 1964. From *Litophyton arboreum* Forskål: 189 ♀♀ and 47 ♂♂ from 1 colony, in 3 m, Andraikarekabe, western shore of Nosy Komba, near Nosy Bé, Oct. 9, 1964.

FEMALE.—Body (fig. 97) with moderately broad prosome. Length 1.26 mm (1.21-1.32 mm) and greatest width 0.57 mm (0.55-0.59 mm), based on 10 specimens. Segment of leg 1 separated from head by a distinct furrow. Epimeral areas of segments of legs 2 and 3 angular. Ratio of length to width of prosome 1.49:1.

Segment of leg 5 measuring  $83\mu \times 190\mu$ . Between this segment and genital segment no ventral intersegmental sclerite. Genital segment (fig. 98) longer than wide,  $221\mu \times 195\mu$ , its lateral areas not expanded. Areas of attachment of egg sacs situated dorsally near middle of segment. Each area with 2 minute naked setae. Three postgenital segments  $75\mu \times 127\mu$ ,  $44\mu \times 107\mu$ , and  $39\mu \times 110\mu$  from anterior to posterior.

Caudal ramus (fig. 99) about 2.2 times longer than wide,  $100\mu \times 48\mu$  when measured dorsally,  $110\mu \times 48\mu$  when measured ventrally. Outer lateral seta  $122\mu$  long and naked; all other setae with prominent lateral spinules. Pedicellate dorsal seta  $55\mu$ , outermost distal seta  $148\mu$ , innermost distal seta  $161\mu$ , and the 2 long median terminal setae  $213\mu$  (outer) and  $230\mu$  (inner), both inserted between dorsal and ventral flanges bearing marginal spinules. Dorsal surface of ramus with fine ornamentation as in figure.

Ratio of length of prosome to that of urosome 1.7:1.

Egg sac (fig. 97) approximately  $380\mu \times 200\mu$ , reaching to insertion of caudal ramus, containing 8–11 eggs, each about  $100\mu$  in diameter.

Rostral area broadly rounded posteroventrally.

First antenna ( $433\mu$  long) similar to that of *L. spinulifer* Humes and Frost, 1964, except that all setae are naked; segments  $29\mu$  ( $68\mu$  along anterior edge),  $125\mu$ ,  $31\mu$ ,  $64\mu$ ,  $68\mu$ ,  $46\mu$ , and  $31\mu$  respectively. Second antenna (fig. 100) with 4 segments having same formula for armature as in previous species. Three elements on third segment consisting of 2 naked setae  $49\mu$  and  $40\mu$  and a spiniform seta  $35\mu$  barbed along one edge. Last segment  $109\mu$  along outer margin,  $73\mu$  along inner margin, and  $30\mu$  wide. Two terminal claws elongated, slender, and nearly equal,  $140\mu$  and  $133\mu$ .

Labrum (fig. 101) with 2 posteroventral lobes. Mandible (fig. 102) similar to that of *L. spinulifer*, but with a pointed prominence on its convex margin distal to proximal spinules. Paragnath and first maxilla as in *L. spinulifer*. Second maxilla (fig. 103) similar to *L. spinulifer*, but with first segment broadened so that convex margin of appendage is angular; long spinules on proximal edge of distalmost seta on second segment; small setule on proximal outer area of second segment (as in *L. spinulifer*). Maxilliped (fig. 104) resembling that of *L. spinulifer*, but differing in fine ornamentation; small seta on third segment (as in *L. spinulifer*).

Area between maxillipeds and first pair of legs as in *L. spinulifer*, with a sclerotized line between bases of maxillipeds as in that species.

Legs 1–4 segmented as in 5 previous species, with same spine and setal formula, and closely resembling those of *L. spinulifer*. Endopod of leg 4 (fig. 105) only slightly shorter than exopod, its first segment  $55\mu \times 42\mu$  (including terminal spinous processes) with an inner distal plumose seta  $104\mu$  long, second segment  $125\mu \times 35\mu$  (greatest dimensions including processes), outer terminal spine  $25\mu$  and finely barbed, inner  $78\mu$  with a finely serrated fringe. Outer margin of second segment with row of spinules (lacking distinct articulations) and inner margin smooth, as in *L. spinulifer*.

Leg 5 (fig. 106) similar to that of *L. spinulifer*, elongated free segment having a small proximal inner expansion. Length of segment  $151\mu$ , width at expansion  $49\mu$ , width near tip  $16\mu$ . Outer surface with scalelike spines. Two terminal naked setae  $39\mu$  and  $88\mu$ . Seta on body near insertion of segment  $45\mu$  and naked.

Leg 6 probably represented by the 2 setae near areas of attachment of egg sac.

Color in life in transmitted light opaque, eye red, ovary gray, egg sacs reddish gray.

MALE.—Body (fig. 107) resembling in general form that of female. Length 1.01 mm (0.96–1.07 mm) and greatest width 0.36 mm (0.35–

0.36 mm), based on 10 specimens. Ratio of length to width of prosome 1.56:1.

Segment of leg 5 measuring  $44\mu \times 107\mu$ . Genital segment (fig. 108) somewhat longer than wide,  $239\mu \times 213\mu$ . No ventral intersegmental sclerite between these segments. Four postgenital segments  $26\mu \times 65\mu$ ,  $23\mu \times 65\mu$ ,  $18\mu \times 63\mu$ , and  $23\mu \times 70\mu$  respectively.

Caudal ramus similar to that of female,  $83\mu \times 39\mu$  dorsally,  $85\mu \times 39\mu$  ventrally.

Ratio of length of prosome to that of urosome 1.45:1.

Rostral area as in female. First antenna similar to that of female, but with 3 aesthetes added as in 5 previous species, so that formula is same as for those males; aesthetes resembling those of *L. spinulifer*. Second antenna (fig. 109) resembling that of female, but with prominent spinules on inner margins of first 2 segments and small spinules added on segments 3 and 4 as in figure.

Labrum, mandible, paragnath, first maxilla, and second maxilla as in female. Maxilliped (fig. 110) resembling that of *L. spinulifer*, with claw  $224\mu$  along its axis.

Area between maxillipeds and first pair of legs as in female.

Legs 1-4 segmented as in 5 previous species, with spine and setal formula as in those males. Endopod of leg 1 (fig. 111) with long terminal spine recurved and concave inwardly, bearing 2 rows of strong spinules: outer spine short and differentially barbed on its 2 margins. Legs 2-4 as in female.

Leg 5 (fig. 112) with free segment  $55\mu \times 10\mu$  (extremes in 4 males  $53\mu$ - $59\mu \times 9\mu$ - $11\mu$ ), its seta  $44\mu$  and naked, its spine  $20\mu$  with an outer fringe; seta on body near insertion of free segment  $35\mu$  and naked.

Leg 6 similar to that of *L. spinulifer*, the 2 small naked setae about  $8\mu$  long.

Spermatophore (fig. 113), attached to female, elongated,  $195\mu \times 83\mu$ , not including neck.

Color in life as in female.

ETYMOLOGY.—The specific name *aculeatus*, from Latin=provided with prickles, refers to the nature of the terminal spine on the endopod of leg 1 in the male of this species.

COMPARISON WITH RELATED SPECIES.—*Lichomolgus aculeatus* differs from all five species described above in having a seta (instead of a spine) on the first segment of the endopod of leg 4. The new species appears to be closely related to *L. spinulifer* Humes and Frost, 1964, from *Lemnalía* sp. at Nosy Bé, yet differs from it in several significant features: the relatively shorter caudal ramus (2.2:1, instead of 3.3:1 as in *L. spinulifer*), the long terminal claws on the second antenna, the small pointed process on the convex side of the mandible,

and the concave spinulose spine on the last segment of the endopod in the male.

*Lichomolgus spinulifer* Humes and Frost, 1964

This species has been previously recorded from *Lemnalía* sp. at Nosy Bé, Madagascar (Humes and Frost, 1964).

NEW HOST RECORDS.—From *Lemnalía flava* May: 211 ♀♀, 133 ♂♂, and 26 copepodids from 1 colony, in 1 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, Dec. 14, 1963. From *Lemnalía elegans* (May): 815 ♀♀, 1018 ♂♂, and 230 copepodids from several colonies, in 15 cm, Boloboxo, Nosy Faly, east of Nosy Bé, May 13, 1964. From *Lemnalía amabilis* Tixier-Durivault: 22 ♀♀, 26 ♂♂, and 15 copepodids from 1 colony, in 3 m, Pte. Ambarionaomby, Nosy Komba, Oct. 3, 1960. From *Lemnalía africana* (May): 59 ♀♀, 55 ♂♂, and 3 copepodids from 1 colony, in 2 m, Pte. Ambarionaomby, Nosy Komba, Sept. 27, 1964. From *Paralemnalia thyrsooides* (Ehrenberg): 60 ♀♀, 62 ♂♂, and 12 copepodids from 1 colony, in 3 m, Antsamantsara, northwest of Madirokely, Nosy Bé, Sept. 20, 1964.

These specimens conform completely with paratypes of *L. spinulifer*. The figures of Humes and Frost (1964) should be modified in certain details as follows: in their figures 142 and 160 of the second antenna, another minute element is present near the bases of the two terminal claws, making five such elements in all; in their figure 147 of the female second maxilla, there is a small seta on the proximal outer area of the second segment, and the distalmost seta on this segment has a few minute inner spinules near its tip; in their figure 148 of the female maxilliped, a small seta is present near the two terminal elements; and in their figures 151–154 (female) and 162 (male) of legs 1–4, the outer distal corner of the coxa bears a few small spinules.

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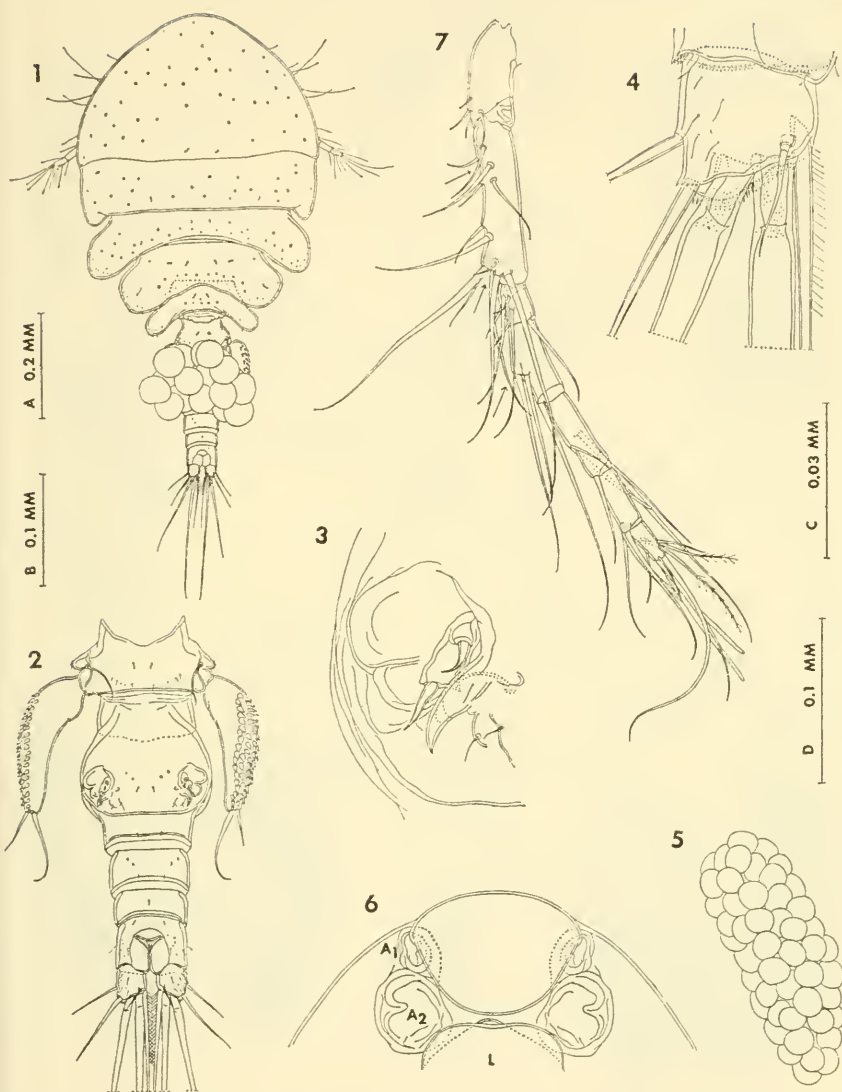
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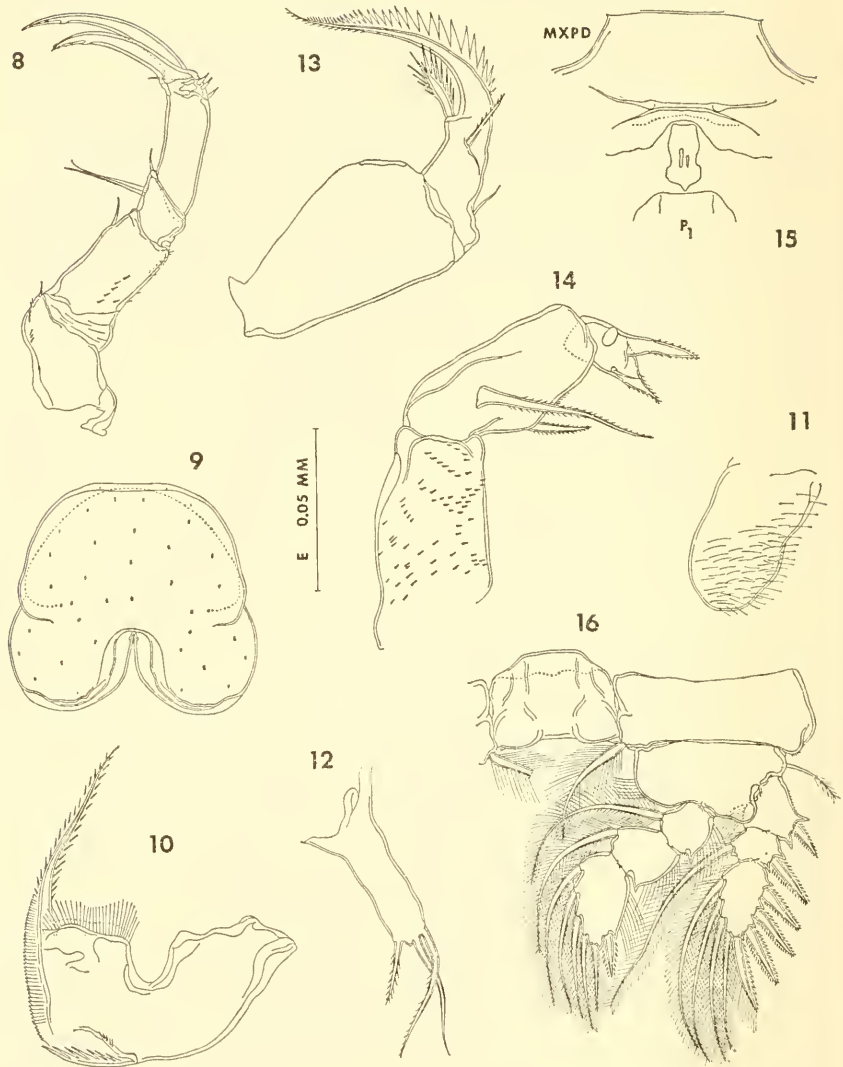
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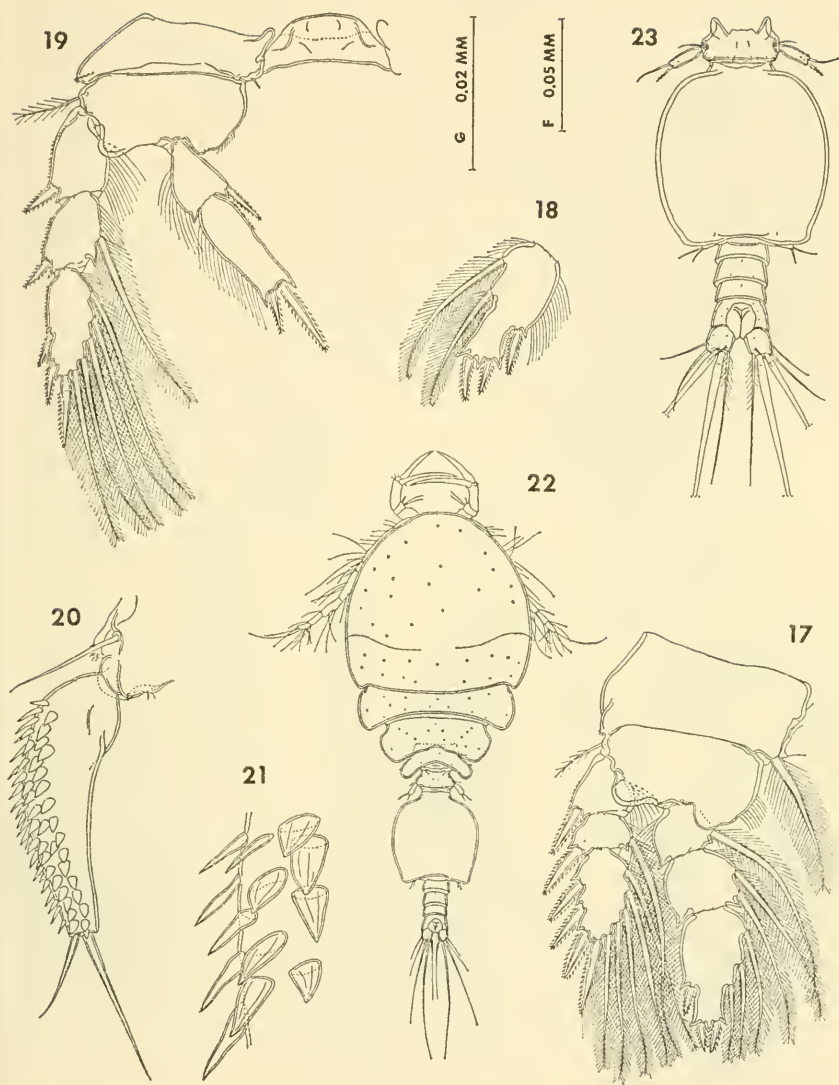




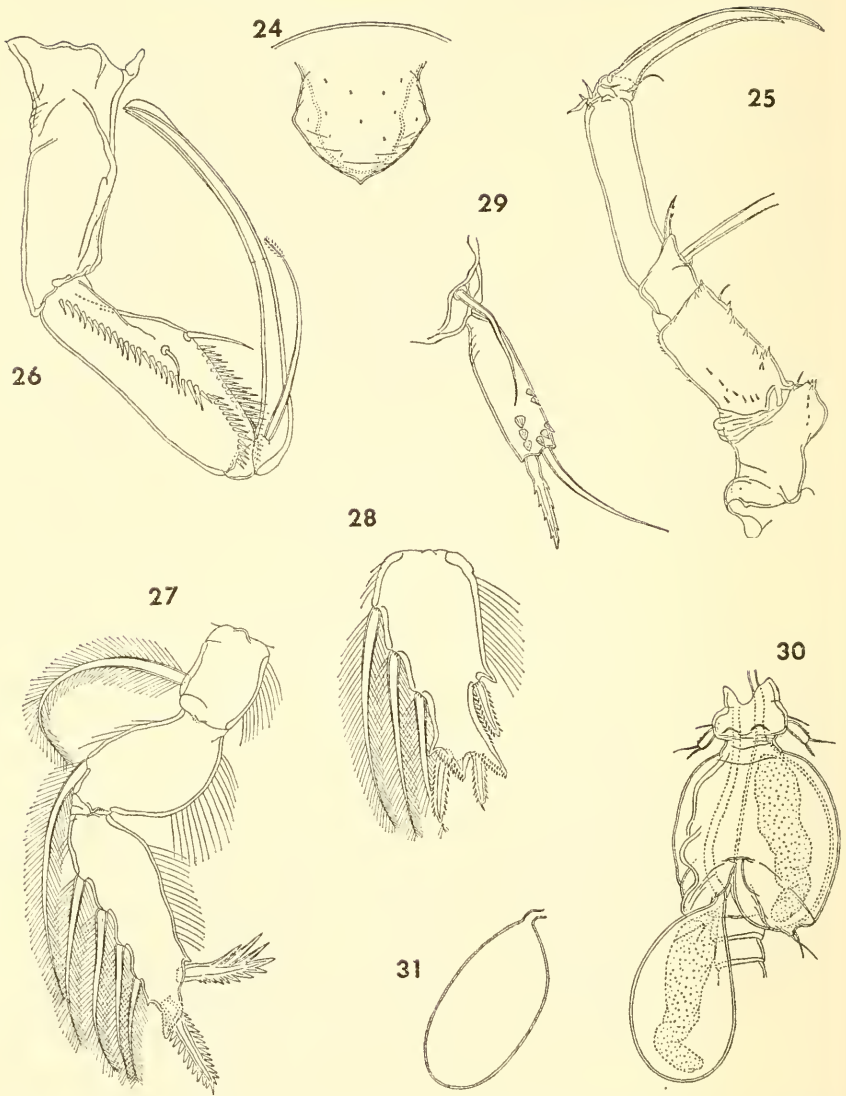
FIGURES 1-7.—*Lichomolgus varirostratus*, new species, female: 1, body, dorsal (A); 2, urosome, dorsal (B); 3, area of attachment of egg sac, dorsal (C); 4, caudal ramus, dorsal (C); 5, egg sac, dorsal (A); 6, rostral area, anteroventral (B); 7, first antenna, dorsal (D).



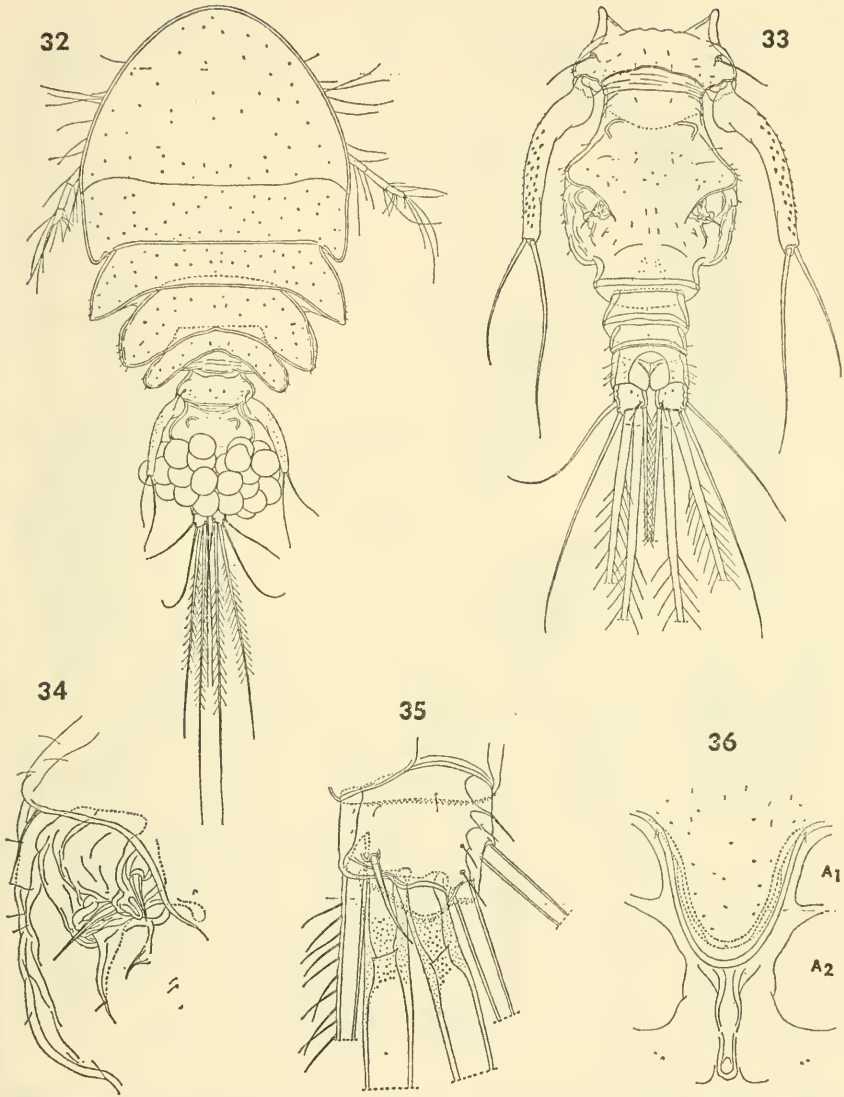
FIGURES 8-16.—*Lichomolgus varirostratus*, new species, female: 8, second antenna, anterior (inner) (D); 9, labrum, ventral (D); 10, mandible, posterior (E); 11, paragnath, ventro-inner (C); 12, first maxilla, anterior (E); 13, second maxilla, posterior (E); 14, maxilliped, postero-inner (E); 15, area between maxillipeds and first pair of legs, ventral (D); 16, leg 1 and intercoxal plate, anterior (D).



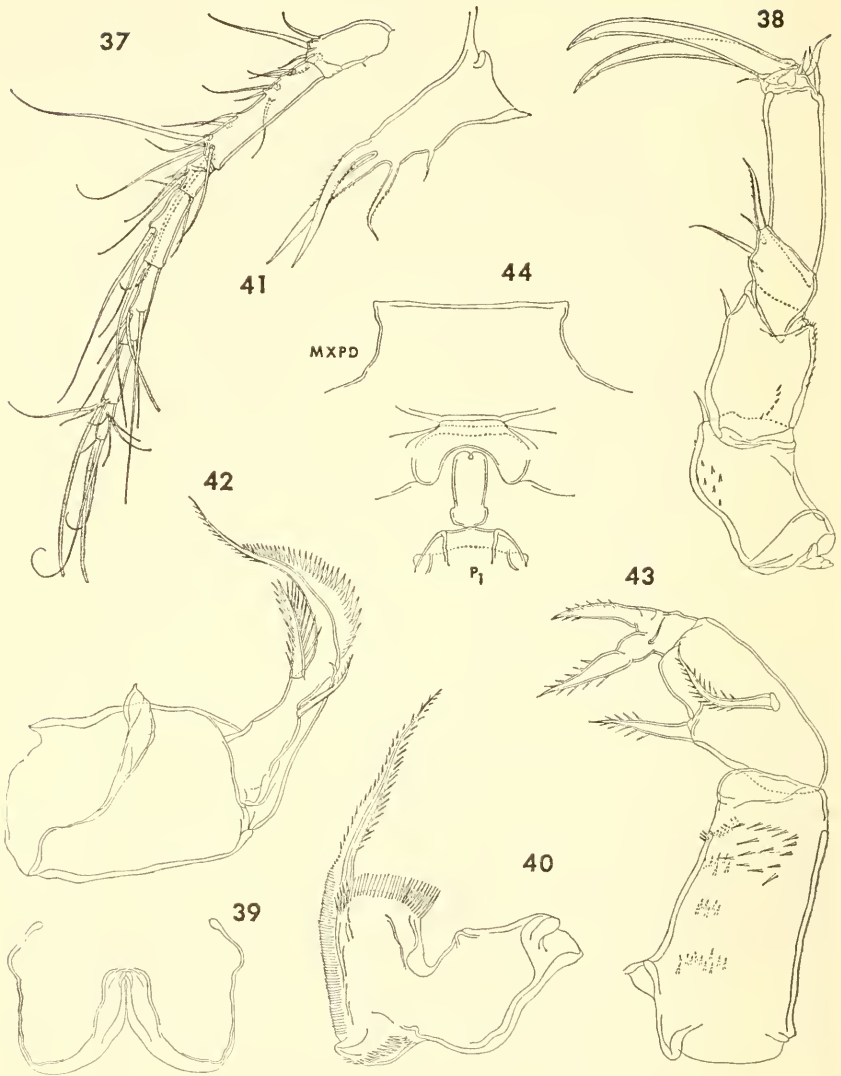
FIGURES 17-23.—*Lichomolgus varirostratus*, new species, female: 17, leg 2, anterior (D); 18, last segment of endopod of leg 3, anterior (D); 19, leg 4 and intercoxal plate, anterior (D); 20, leg 5, dorsal (F); 21, scalelike spines on leg 5, dorso-outer (G). Male: 22, body, dorsal (A); 23, urosome, dorsal (B).



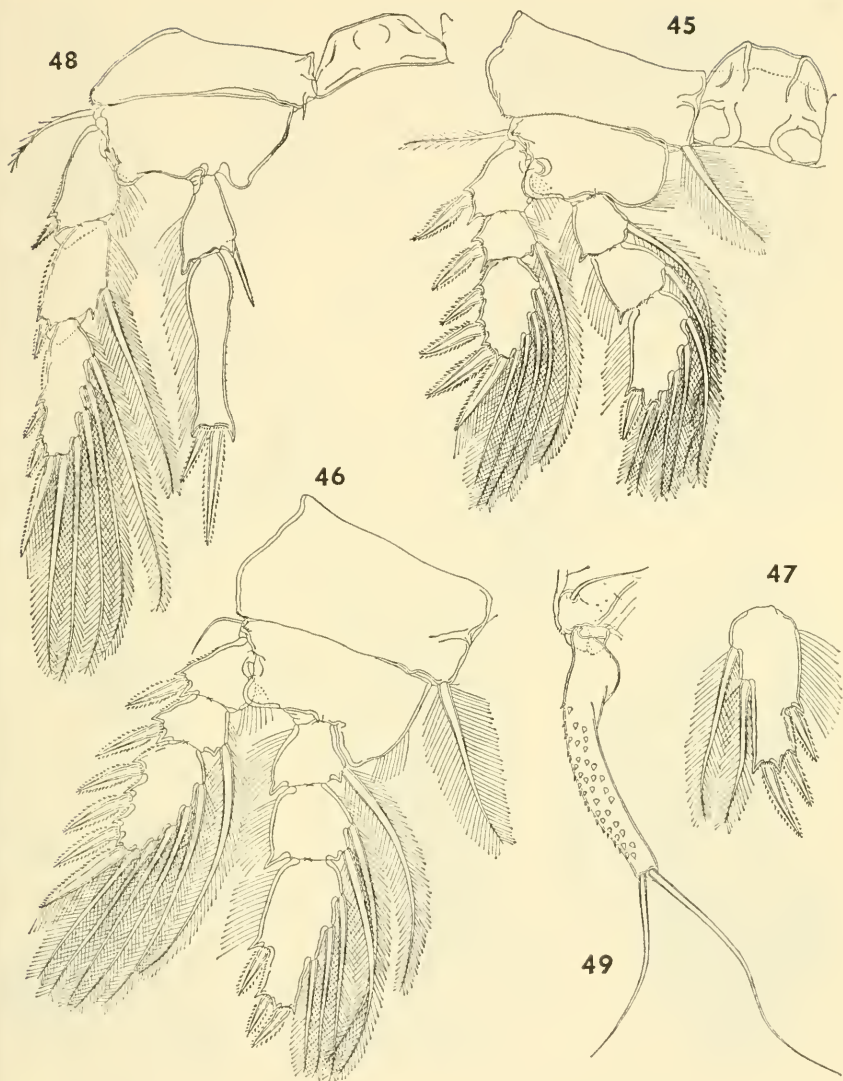
FIGURES 24-31.—*Lichomolgus varirostratus*, new species, male: 24, rostral area, ventral (D); 25, second antenna, anterior (inner) (F); 26, maxilliped, postero-inner (F); 27, endopod of leg 1, anterior (E); 28, last segment of endopod of leg 2, anterior (E); 29, leg 5, dorsal (C); 30, anterior part of urosome, showing extrusion of spermatophore in lactic acid, ventral (B); 31, spermatophore, attached to female, lateral (B).



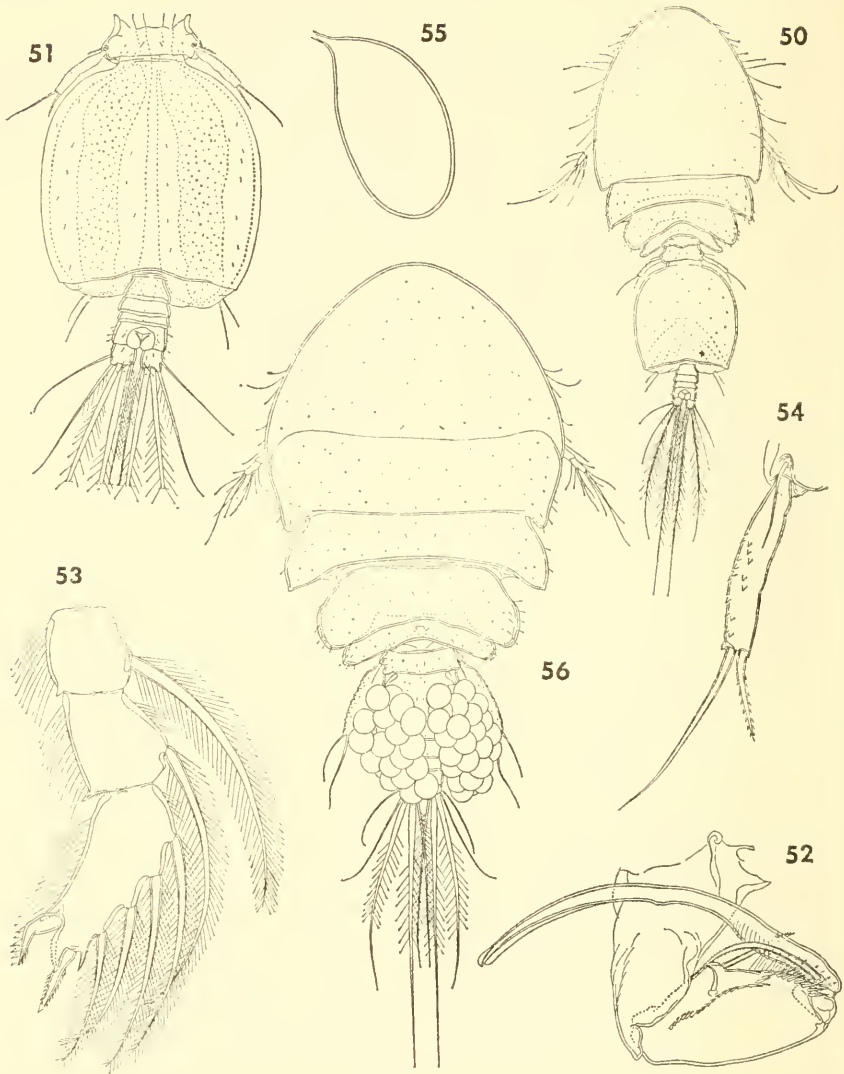
FIGURES 32-36.—*Lichomolgus exilipes*, new species, female: 32, body, dorsal (A); 33, urosome, dorsal (B); 34, area of attachment of egg sac, dorsal (E); 35, caudal ramus, dorsal (C); 36, rostral area, ventral (D).



FIGURES 37-44.—*Lichomolgus exilipes*, new species, female: 37, first antenna, ventral (B); 38, second antenna, anterior (inner) (D); 39, labrum, ventral (F); 40, mandible, posterior (E); 41, first maxilla, posterior (E); 42, second maxilla, postero-inner (E); 43, maxilliped, postero-inner (E); 44, area between maxillipeds and first pair of legs, ventral (D).

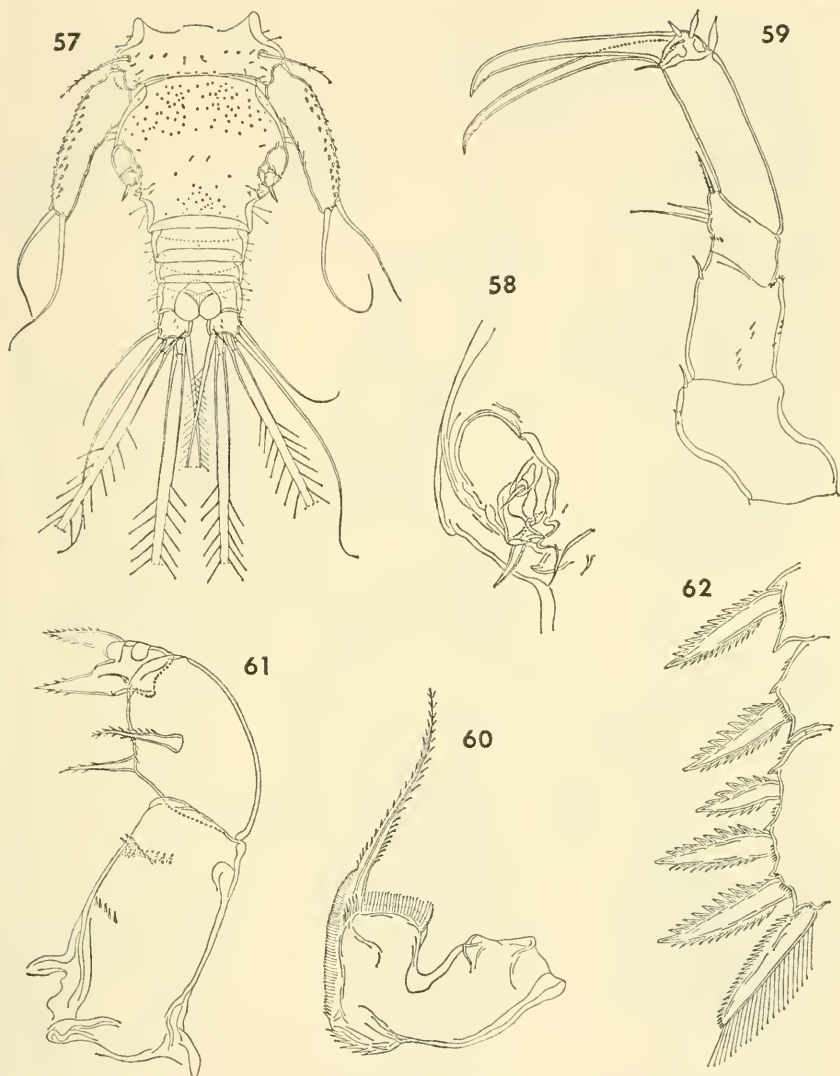


FIGURES 45-49.—*Lichomolgus exilipes*, new species, female: 45, leg 1 and intercoxal plate, anterior (D); 46, leg 2, anterior (D); 47, last segment of endopod of leg 3, anterior (D); 48, leg 4 and intercoxal plate, anterior (D); 49, leg 5, dorsal (D).

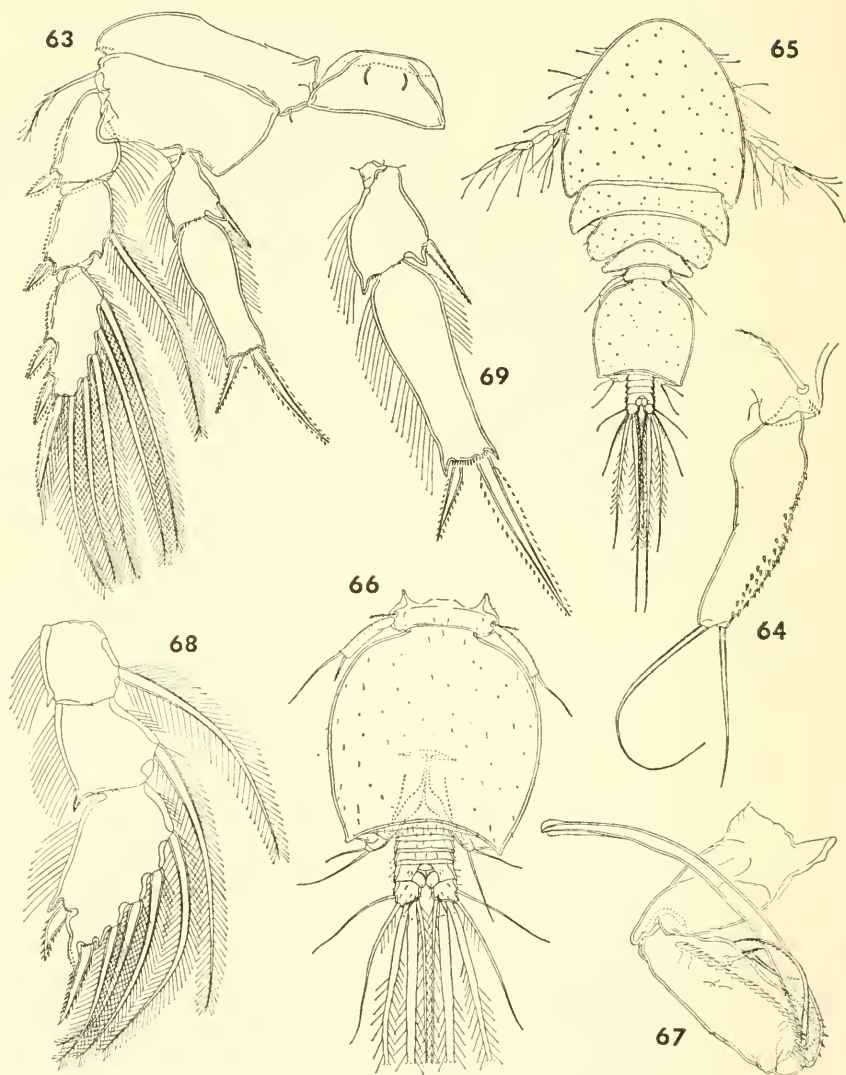


FIGURES 50-56.—*Lichomolgus exilipes*, new species, male: 50, body, dorsal (A); 51, urosome, dorsal (B); 52, maxilliped, postero-inner (F); 53, endopod of leg 1, anterior (E); 54, leg 5, dorsal (E); 55, spermatophore, attached to female, dorsal (B). *Lichomolgus gentilis*, new species, female: 56, body, dorsal (A).

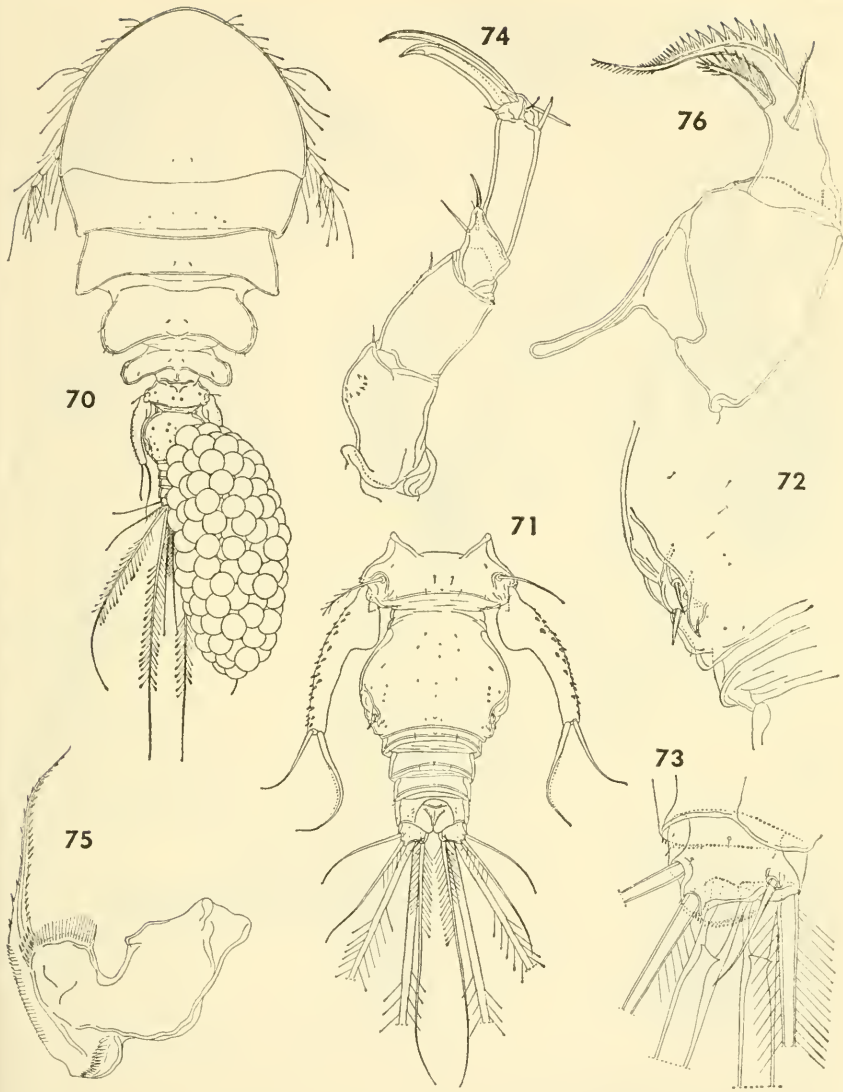




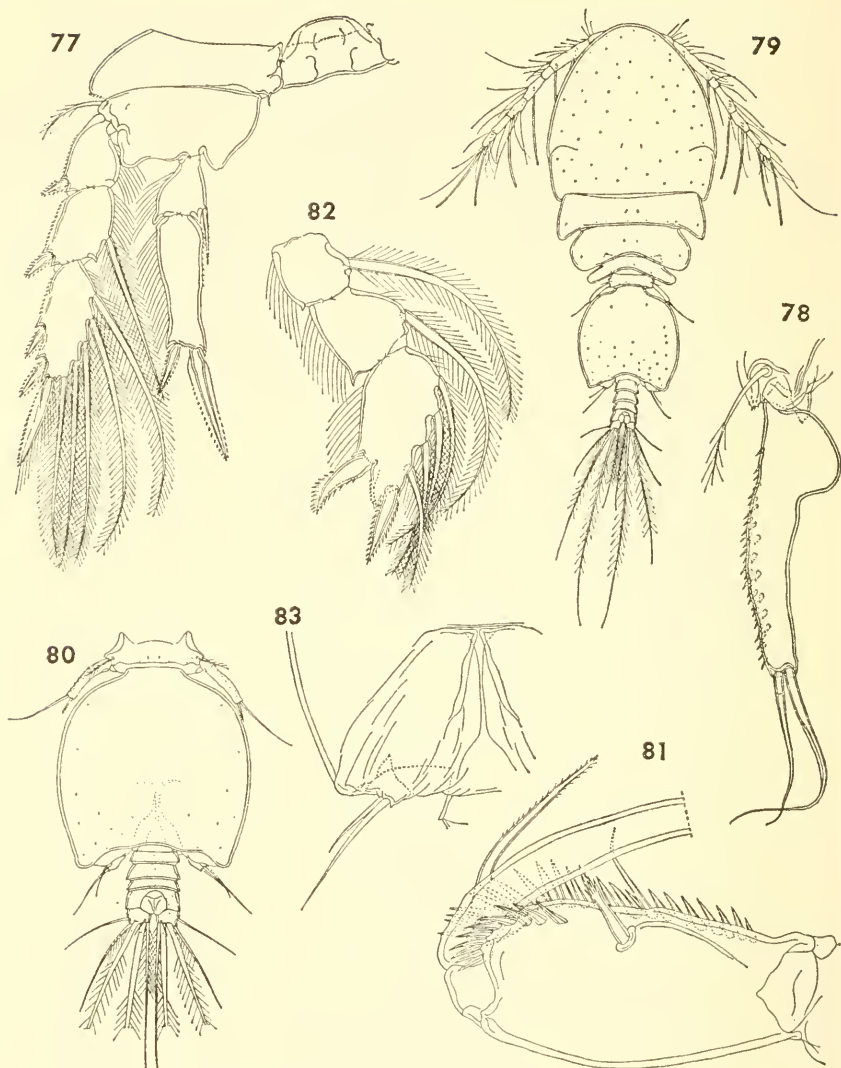
FIGURES 57-62.—*Lichomolgus gentilis*, new species, female: 57, urosome, dorsal (B); 58, area of attachment of egg sac, dorsal (E); 59, second antenna, anterior (inner) (D); 60, mandible, posterior (E); 61, maxilliped, postero-inner (E); 62, spines on exopod of leg 1, anterior (E).



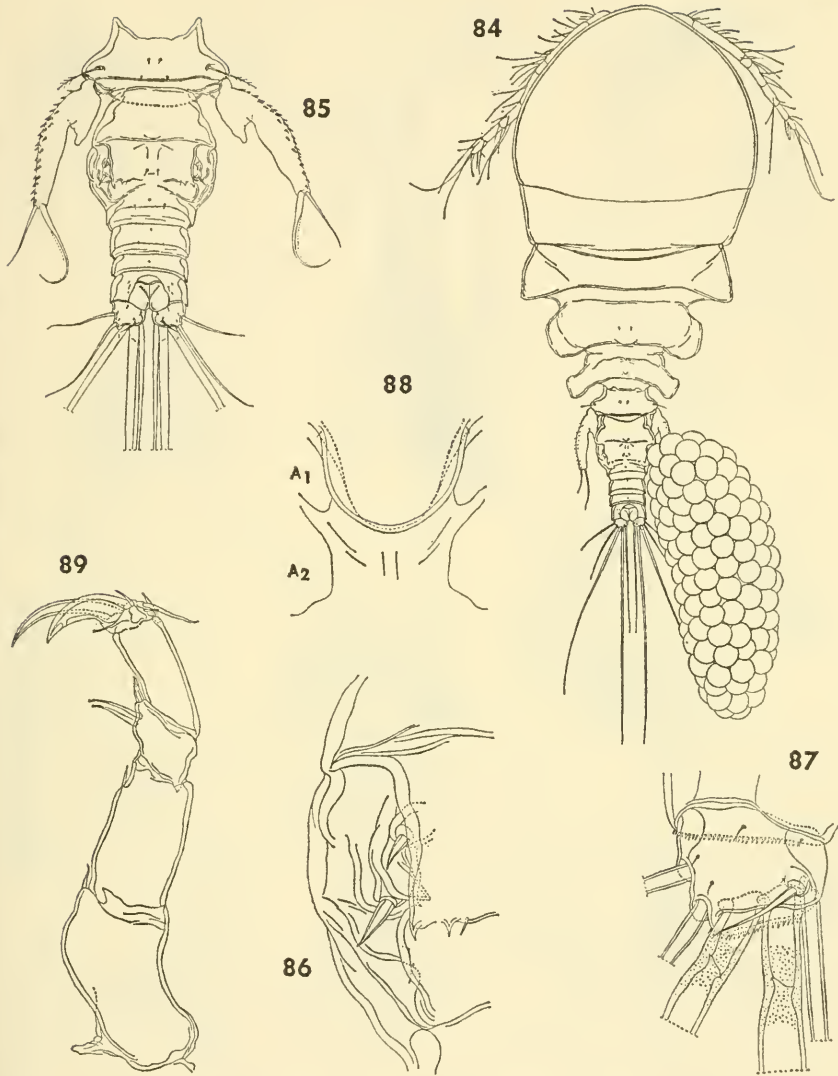
FIGURES 63-69.—*Lichomolgus gentilis*, new species, female: 63, leg 4 and intercoxal plate, anterior (D); 64, leg 5, dorsal (D). Male: 65, body, dorsal (A); 66, urosome, dorsal (B); 67, maxilliped, postero-inner (F); 68, endopod of leg 1, anterior (E); 69, endopod of leg 4, anterior (E).



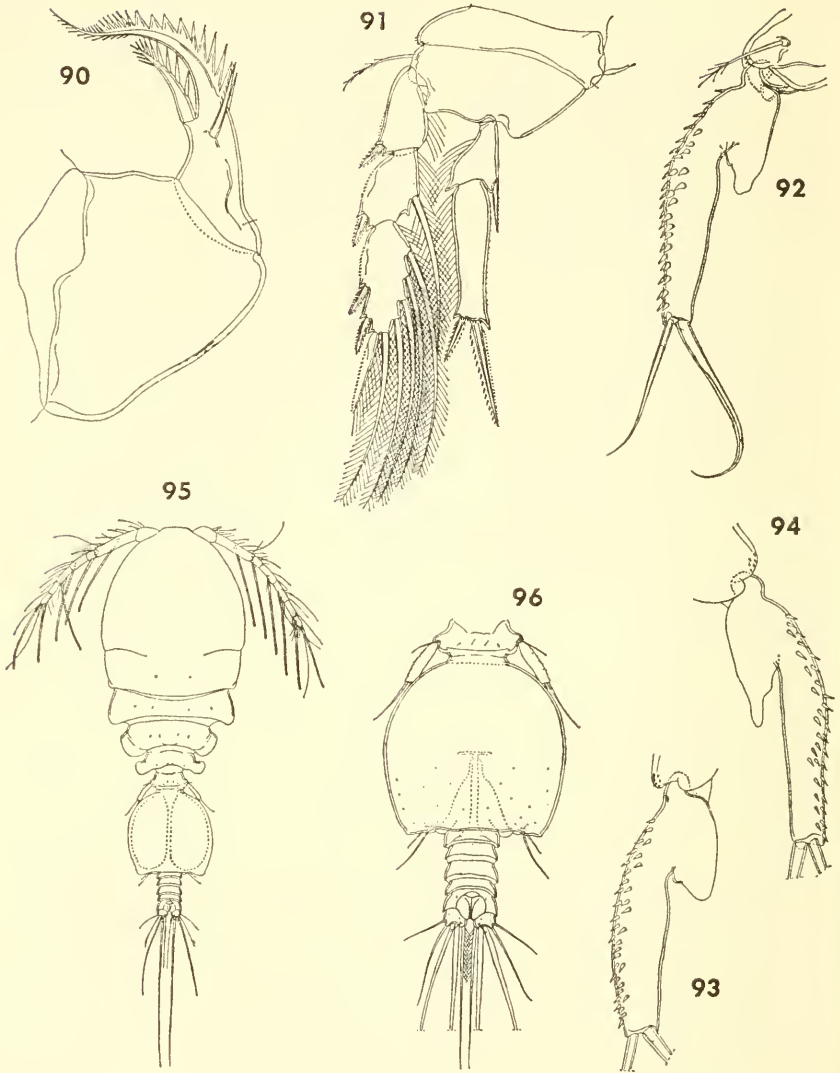
FIGURES 70-76.—*Lichomolgus fissisetiger*, new species, female: 70, body, dorsal (A); 71, urosome, dorsal (B); 72, area of attachment of egg sac, dorsal (E); 73, caudal ramus, dorsal (C); 74, second antenna, anterior (inner) (D); 75, mandible, posterior (E); 76, second maxilla, posterior (E).



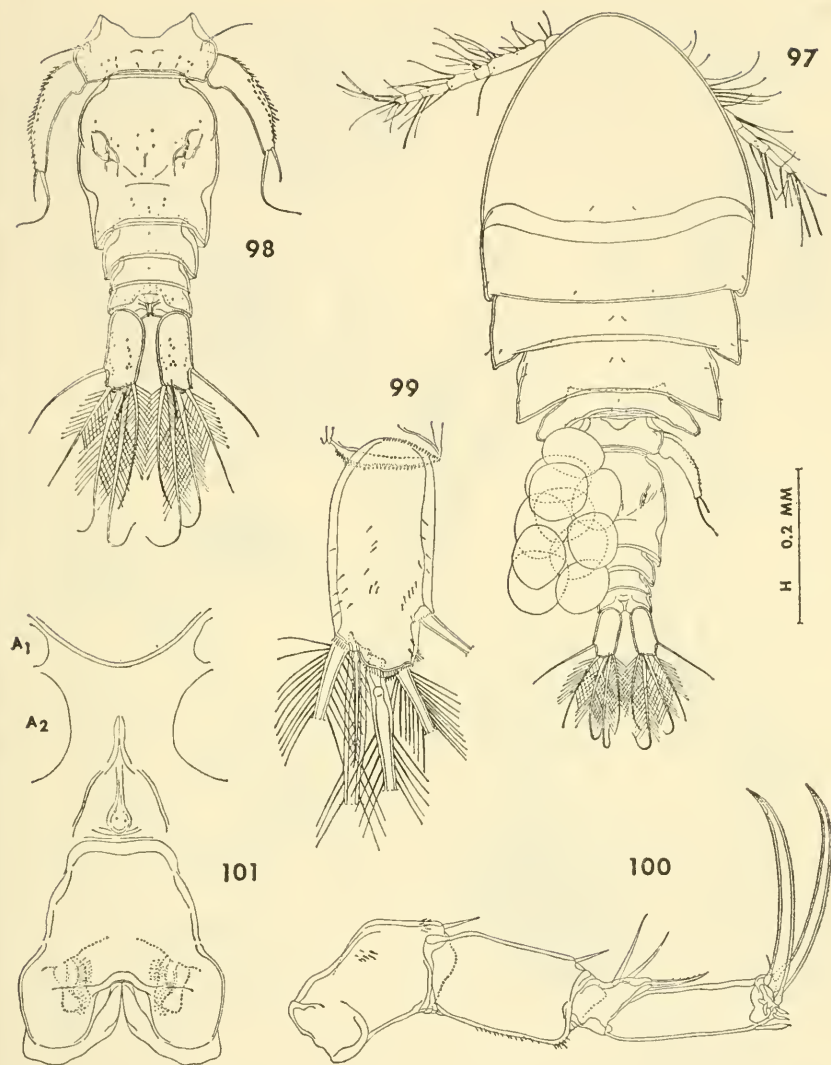
FIGURES 77-83.—*Lichomolgus fissisetiger*, new species, female: 77, leg 4 and intercoxal plate, anterior (D); 78, leg 5, dorsal (F). Male: 79, body, dorsal (A); 80, urosome, dorsal (B); 81, maxilliped, second and third segments and proximal part of claw, ventro-outer (C); 82, endopod of leg 1, anterior (E); 83, leg 6, ventral (F).



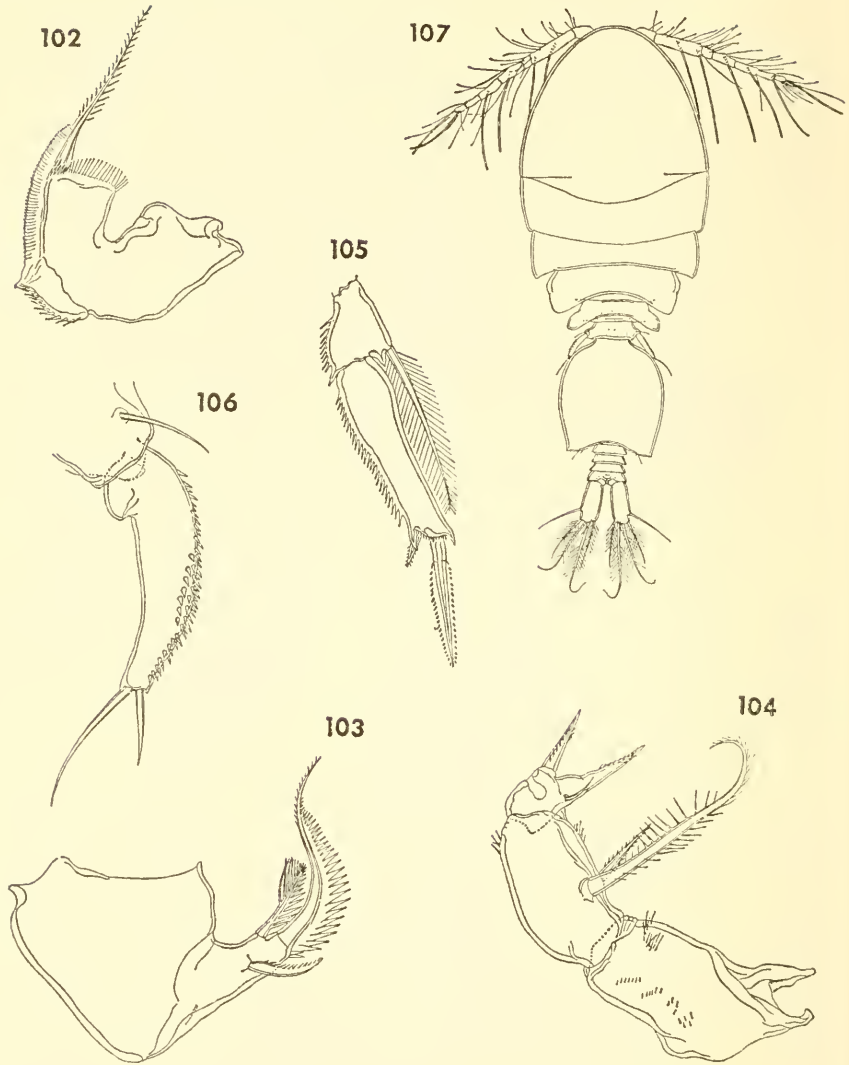
FIGURES 84-89.—*Lichomolgus cuneipes*, new species, female: 84, body, dorsal (A); 85, urosome, dorsal (B); 86, area of attachment of egg sac, dorsal (C); 87, caudal ramus, dorsal (C); 88, rostral area, ventral (D); 89, second antenna, anterior (inner) (F).



FIGURES 90-96.—*Lichomolgus cuneipes*, new species, female: 90, second maxilla, postero-inner (E); 91, leg 4, anterior (D); 92, leg 5, dorsal (F); 93, free segment of leg 5, dorsal (F); 94, free segment of leg 5, dorsal (F). Male: 95, body, dorsal (A); 96, urosome, dorsal (B).

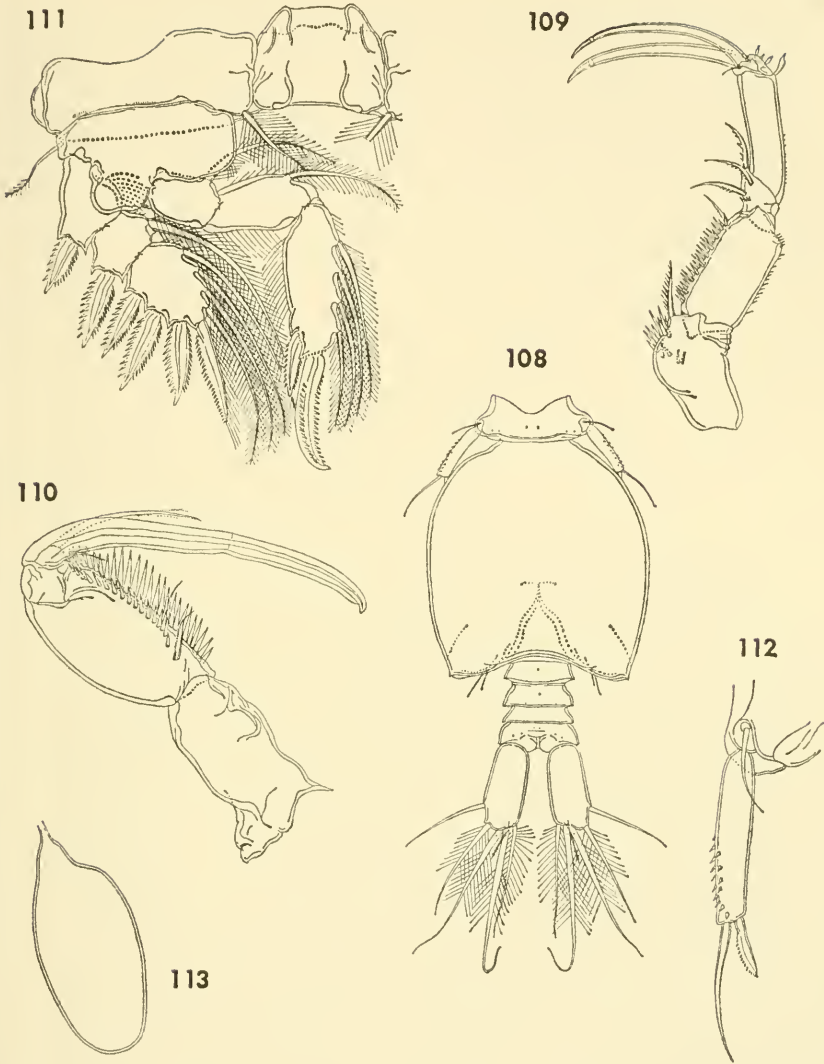


FIGURES 97-101.—*Lichomolgus aculeatus*, new species, female: 97, body, dorsal (A); 98, urosome, dorsal (H); 99, caudal ramus, dorsal (F); 100, second antenna, anterior (inner) (D); 101, rostral area and labrum, ventral (D).



FIGURES 102-107.—*Lichomolgus aculeatus*, new species, female: 102, mandible, posterior (F); 103, second maxilla, posterior (F); 104, maxilliped, posterior (F); 105, endopod of leg 4, anterior (D); 106, leg 5, dorsal (D). Male: 107, body, dorsal (A).





FIGURES 108-113.—*Lichomolgus aculeatus*, new species, male: 108, urosome, dorsal (B); 109, second antenna, posterior (outer) (D); 110, maxilliped, ventro-outer (D); 111, leg 1 and intercoxal plate, anterior (F); 112, leg 5, dorsal (E); 113, spermatophore, attached to female, ventral (B).