

PROCEEDINGS
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CYCLOPOID COPEPODS OF THE GENUS
LICHOMOLGUS ASSOCIATED WITH OCTOCORALS OF
THE FAMILY ALCYONIIDAE IN MADAGASCAR

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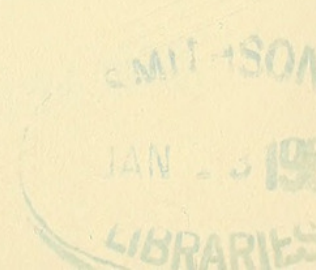
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Three species of *Lichomolgus* are already known to be associated with octocorals of the family Alcyoniidae in Madagascar. These are *L. decorus* Humes and Frost, 1964, from *Cladiella laciniosa* (Tixier-Durivault), *L. squamiger* Humes and Frost, 1964, from *Sinularia polydactyla* (Ehrenberg), and *L. protentus* Humes and Frost, 1964, from *Sarcophyton globosum* Tixier-Durivault. The last named host was listed by Humes and Frost (1964) as *Sarcophyton* sp., but has since been described as new by Tixier-Durivault (1966). This paper concerns seven new species of *Lichomolgus*, two species which are redescribed, and a new host record for *L. squamiger*, all washed from various species of Alcyoniidae in the region of Nosy Bé in northwestern Madagascar.

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

The study of the specimens has been aided by a grant (GB-5838) from the National Science Foundation of the United States.

All figures have been drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are: A_1 = first antenna, A_2 = second antenna, MXP = 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 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 non-setiferous 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. We thank Dr. John O. Corliss of the University of Illinois for the identification of the suctorian attached to *L. singularipes*.

The new copepods described in this paper comprise the following:

- 1) *Lichomolgus cristatus* new species
from *Sinularia leptocladus* (Ehrenberg).
- 2) *Lichomolgus adelphus* new species
from *Sinularia whiteleggei* Lüttschwager, *S. pedunculata* Tixier-Durivault, and *S. polydactyla* (Ehrenberg).
- 3) *Lichomolgus hetaericus* new species
from *Cladiella pachyclados* (Klunzinger) and *C. krempfi* Hickson.
- 4) *Lichomolgus insolens* new species
from *Lobophytum crassum* Marenzeller.
- 5) *Lichomolgus spathophorus* new species
from *Sarcophyton glaucum* (Quoy and Gaimard).
- 6) *Lichomolgus incisus* new species
from *Sarcophyton ehrenbergi* Marenzeller.
- 7) *Lichomolgus singularipes* new species
from *Parerythropodium rubiginosum* Verseveldt.

Of the following two species, females are redescribed and males described for the first time:

- 1) *Lichomolgus dentipes* Thompson and A. Scott, 1903
from *Sinularia humesi* Verseveldt.
- 2) *Lichomolgus foxi* Gurney, 1927
from *Cladiella krempfi* Hickson, *C. laciniosa*

(Tixier-Durivault), and *C. pachyclados* (Klunzinger).

The following is a new host record:

- 1) *Lichomolgus squamiger* Humes and Frost, 1964
from *Sinularia whiteleggei* Lüttschwager.

FAMILY LICHOMOLGIDAE KOSSMANN, 1877

GENUS *LICHOMOLGUS* THORELL, 1859¹

Lichomolgus dentipes Thompson and A. Scott, 1903

Figures 1-28

This species was established on the basis of one female found in washings of dredged invertebrates in Ceylon. It has not been reported again, and the original specimen is presumably lost along with the rest of the Andrew Scott collection (see Humes and Ho, 1967, p. 209). The male has been unknown until now.

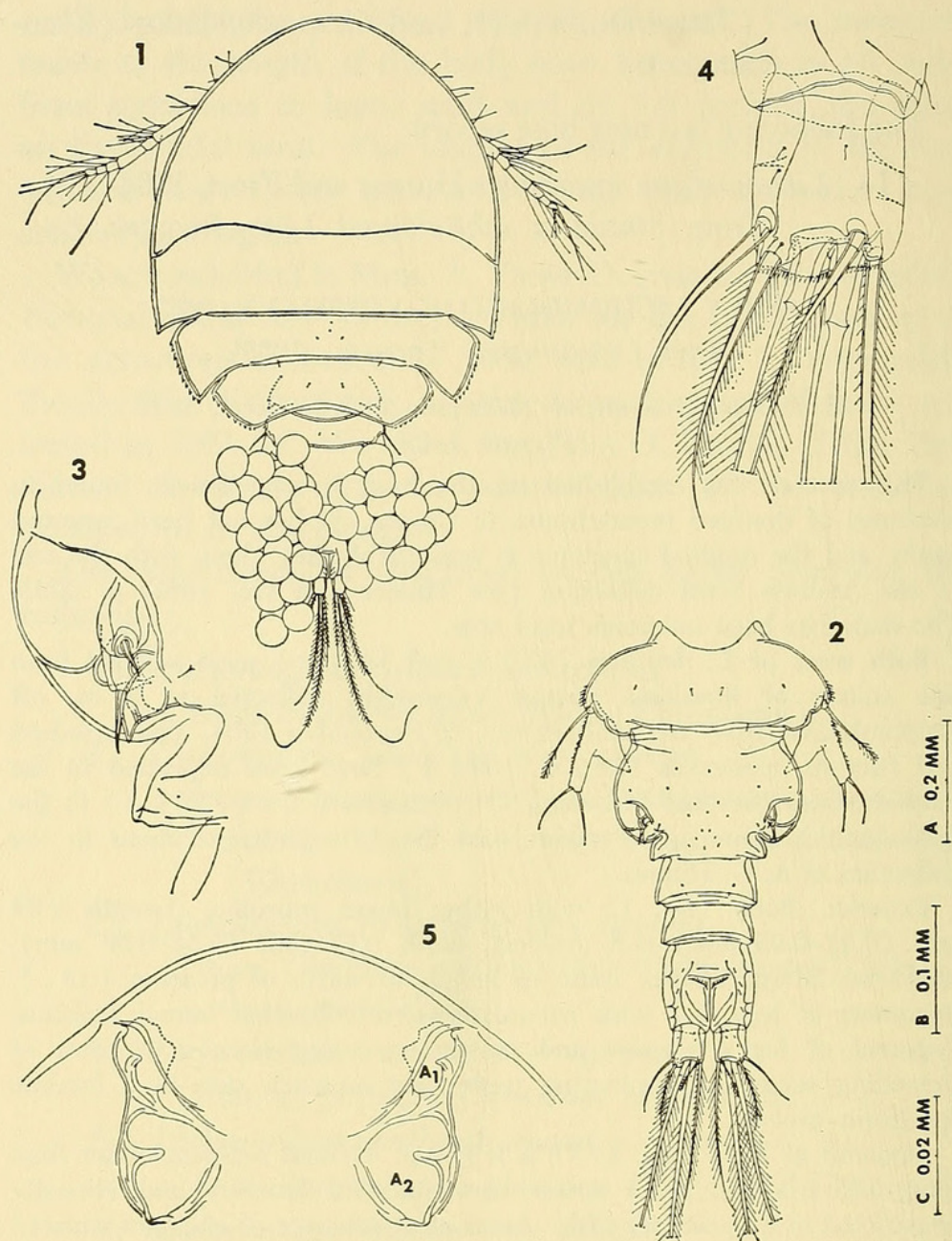
Both sexes of *L. dentipes* (87 ♀ ♀ and 145 ♂ ♂) were washed from one colony of *Sinularia humesi* Verseveldt, collected in 2 m, off Ampombilava, Nosy Bé, Madagascar, 26 September 1964. One hundred and fifty-six specimens (54 ♀ ♀, 102 ♂ ♂) have been deposited in the United States National Museum; 35 specimens (15 ♀ ♀, 20 ♂ ♂) in the Zoölogisch Museum, Amsterdam; and the remaining specimens in the collection of A. G. Humes.

Female: Body (fig. 1) with rather broad prosome. Length 0.94 mm (0.91-0.95 mm) and greatest width 0.57 mm (0.56-0.58 mm), based on 10 specimens. Ratio of length to width of prosome 1.14 : 1. Segments of legs 1-3 with irregularly serrate hyaline lateral margins. Segment of leg 4 narrow and mostly concealed beneath dorsum of preceding segment; terminating posteriorly on each side in a hyaline spiniform process.

Segment of leg 5 (fig. 2) $78 \mu \times 187 \mu$. Genital segment wider than long, $100 \mu \times 148 \mu$, in dorsal view rounded laterally and abruptly constricted in its posterior fifth. Areas of attachment of egg sacs situated dorsolaterally on posterior part of expanded region. Each area (fig. 3) bearing two naked spiniform setae 7μ and 11μ long, with a recurved sclerotized pointed process between them. Three postgenital segments $39 \mu \times 78 \mu$, $31 \mu \times 73 \mu$, and $65 \mu \times 70 \mu$, from anterior to posterior.

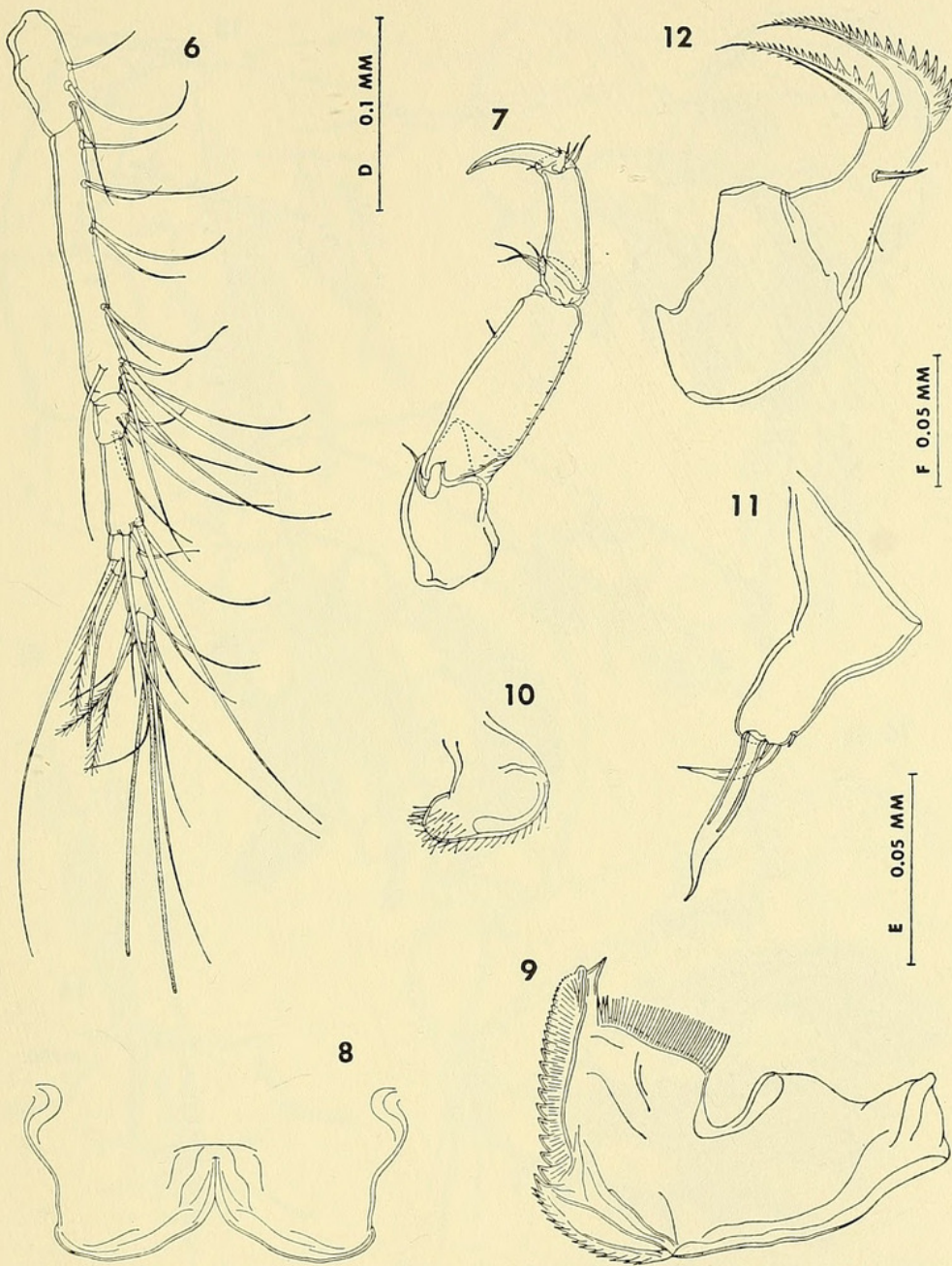
Caudal ramus (fig. 4) slightly longer than wide, its greatest dimen-

¹The year of publication of Thorell's genus has been cited by some authors as 1859, by others as 1860. The source of this confusion lies in the fact that Thorell published *Lichomolgus* as a new generic name in two different papers (1859, p. 340, and 1860, p. 64). Although the title page of Arg. 16 of the Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar for 1859 bears the year 1860, the actual year of publication for *Lichomolgus* appears to be 1859, since the last page of no. 8 (in which Thorell's paper appears) bears that year.



FIGS. 1-5. *Lichomolgus dentipes* Thompson and A. Scott, 1903, female: 1, body, dorsal (A); 2, urosome, dorsal (B); 3, area of attachment of egg sac, dorsal (C); 4, caudal ramus, dorsal (C); 5, rostral area, ventral (B).

sions being $33 \mu \times 26 \mu$. Outer lateral seta 50μ , pedicellate dorsal seta 40μ , outermost distal seta 55μ , innermost distal seta 109μ , and the two long median terminal setae 220μ (outer) and 360μ (inner) and both inserted between dorsal (unornamented) and ventral (with marginal row of spinules) flaps. All these setae with lateral hairs except outer lateral seta which is naked.



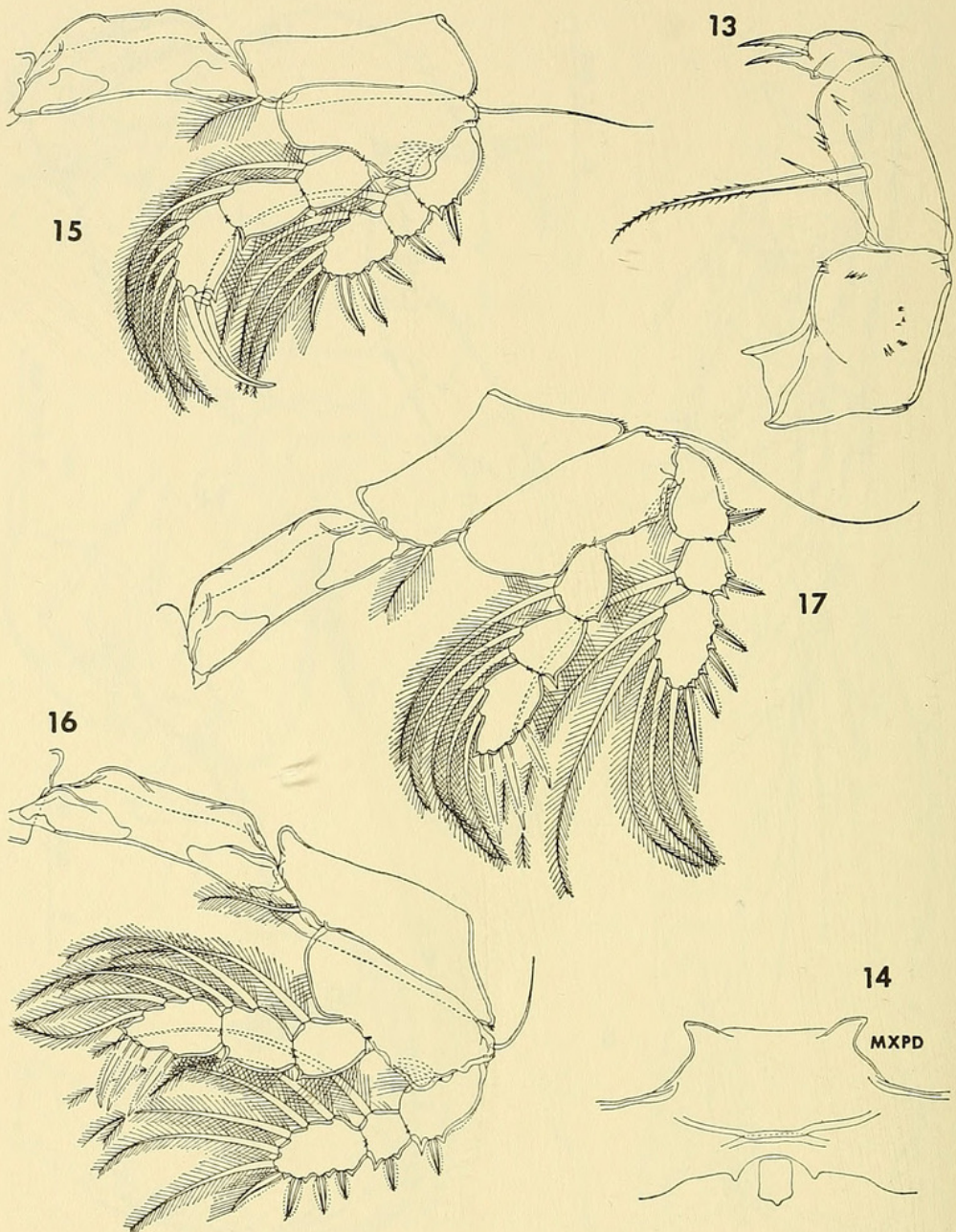
FIGS. 6-12. *Lichomolgus dentipes* Thompson and A. Scott, 1903, female: 6, first antenna, ventral (D); 7, second antenna, anterior (inner) (D); 8, labrum, ventral (E); 9, mandible, posterior (C); 10, paragnath, ventral (C); 11, first maxilla, posterior (C); 12, second maxilla, posterior (E).

Ratio of length of prosome to that of urosome 2.24 : 1.

Egg sacs incomplete on females examined. Each egg about 55μ in diameter.

Rostral area (fig. 5) without well defined posterior margin.

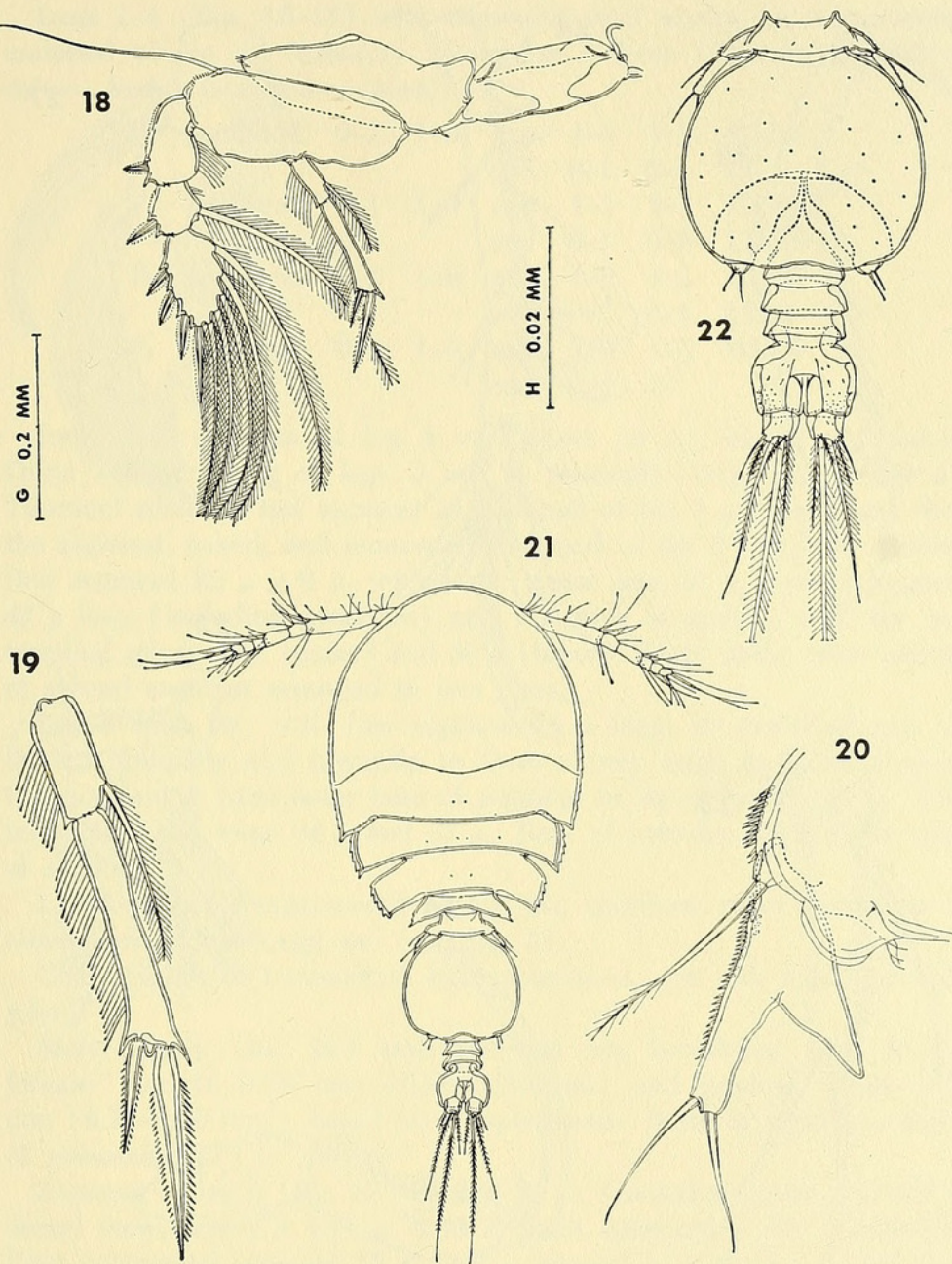
First antenna (fig. 6) 7-segmented, 326μ long. Lengths of segments:



FIGS. 13-17. *Lichomolgus dentipes* Thompson and A. Scott, 1903, female: 13, maxilliped, posterior (E); 14, area between maxillipeds and first pair of legs, ventral (D); 15, leg 1 and intercoxal plate, anterior (F); 16, leg 2 and intercoxal plate, anterior (F); 17, leg 3 and intercoxal plate, anterior (F).

30 μ (58 μ along anterior margin), 138 μ , 21 μ , 50 μ , 23 μ , 19 μ , and 17 μ respectively. Formula for armature: 4, 13, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete.

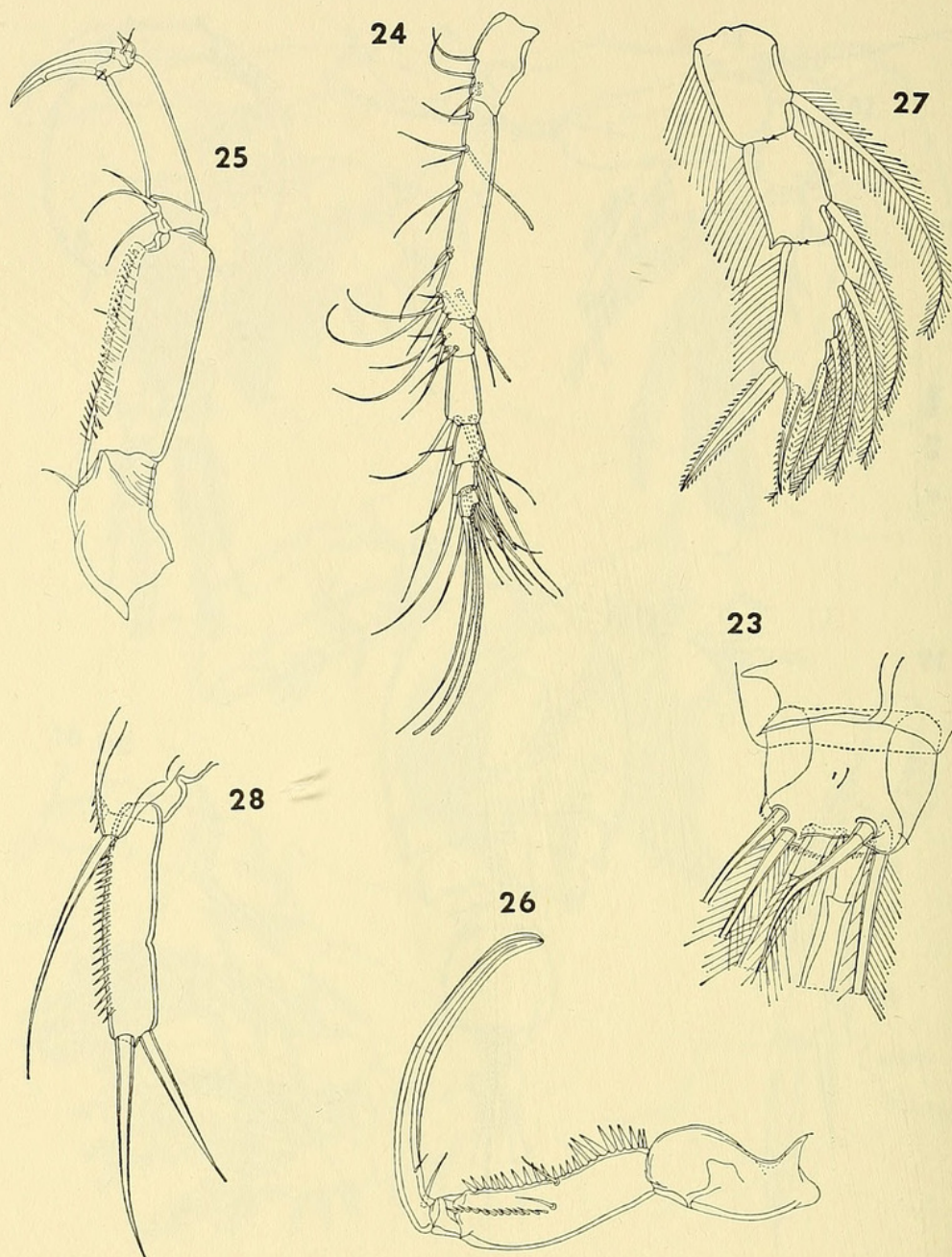
Second antenna (fig. 7) 4-segmented, last segment moderately elongated, 71 μ along its outer edge, 40 μ along its inner edge, bearing



FIGS. 18–22. *Lichomolgus dentipes* Thompson and A. Scott, 1903, female: 18, leg 4 and intercoxal plate, anterior (F); 19, endopod of leg 4, anterior (C); 20, leg 5, dorsal (E). Male: 21, body, dorsal (G); 22, urosome, dorsal (D).

distally five small hyaline elements and a single claw 44μ along its greatest axis.

Labrum (fig. 8) with two broad posteroventral lobes. Mandible (fig. 9) with flagellum very reduced, and represented only by a small pointed process. Paragnath (fig. 10) a small hairy lobe. First maxilla



FIGS. 23-28. *Lichomolgus dentipes* Thompson and A. Scott, 1903, male: 23, caudal ramus, dorsal (H); 24, first antenna, dorsal (F); 25, second antenna, posterior (outer) (E); 26, maxilliped, outer (F); 27, endopod of leg 1, anterior (C); 28, leg 5, dorsal (H).

(fig. 11) with two long unequal naked terminal elements and a small subterminal one. Second maxilla (fig. 12) 2-segmented. Maxilliped (fig. 13) 3-segmented, the second segment with two very unequal setae, and the third with two terminal spiniform elements (one lacking a distinct articulation) and a small seta. Area between maxillipeds and first pair of legs (fig. 14) not protuberant.

Legs 1-4 (figs. 15-18) with trimerous rami except for 2-segmented endopod of leg 4. Armature of legs as follows (Roman numerals = spines, Arabic numerals = setae):

P ₁	protopod	0-1	1-0	exp	I-0	I-1	III,I,4
				end	0-1	0-1	I,5
P ₂	protopod	0-1	1-0	exp	I-0	I-1	III,I,5
				end	0-1	0-2	I,II,3
P ₃	protopod	0-1	1-0	exp	I-0	I-1	III,I,5
				end	0-1	0-2	I,II,2
P ₄	protopod	0-1	1-0	exp	I-0	I-1	III,I,5
				end	0-1	II	

Inner seta on coxa of leg 4 very short (6 μ), blunt, and naked. Outer seta on basis of legs 3 and 4 unusually long (up to 90 μ). Terminal spine on last segment of endopod of leg 1 a little longer than the segment, naked, and recurved. Endopod of leg 4 (fig. 19) slender, first segment 22 $\mu \times 9 \mu$, with inner distal seta 33 μ , second segment 47 μ long (including processes) and 7 μ wide at middle, with the two terminal spines 18 μ (outer) and 36 μ (inner). Hairs along outer margin of second segment arranged in two rows.

Leg 5 (fig. 20) with free segment 74 μ long, its proximal area extended obliquely and inwardly to form a very large toothlike process. Oblique length from outer base of segment to tip of process 67 μ . Two terminal naked setae 34 μ and 37 μ . Row of spinules along outer edge of segment.

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

Color in life in transmitted light translucent, eye red, egg sacs light gray.

Male: Body (fig. 21) with prosome less broadened than in the female. Length 0.58 mm (0.56-0.60 mm) and greatest width 0.28 mm (0.26-0.30 mm), based on 10 specimens. Ratio of length to width of prosome 1.27 : 1.

Segment of leg 5 (fig. 22) 21 $\mu \times 81 \mu$. Genital segment rounded in dorsal view, 122 $\mu \times 133 \mu$, with a small constricted area posteriorly. First postgenital segment 15 $\mu \times 46 \mu$, second 14 $\mu \times 41 \mu$. Third and fourth postgenital segments fused, third probably represented by the anterior constricted part, 11 $\mu \times 35 \mu$, and fourth being the much broadened posterior region, 39 $\mu \times 55 \mu$.

Caudal ramus (fig. 23) about as long as wide, 17 $\mu \times 19 \mu$.

Ratio of length of prosome to that of urosome 1.6 : 1.

Rostral area like that of female. First antenna (fig. 24) similar to that of female, but two aesthetes added on second segment, and one on third, so that the 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 inner surface of second segment with a row of spinules and a raised membranous lamella.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those of female. Maxilliped (fig. 26) slender and 4-segmented (assuming that the proximal part of claw represents a fourth segment). Claw $124\ \mu$ long (measured along its axis). Area between maxillipeds and first pair of legs like that in 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. Last segment of endopod of leg 1 bearing two terminal barbed spines, with a slender process between them. Endopod of leg 4 as in female.

Leg 5 (fig. 28) with a slender free segment $27\ \mu \times 6\ \mu$, lacking the large toothlike process seen in the female. Two terminal setae $24\ \mu$ and $22\ \mu$.

Leg 6 (see fig. 22) a posterolateral flap on ventral surface of genital segment bearing two naked setae $17\ \mu$ and $22\ \mu$ long.

Spermatophore not observed.

Color in life like that of female.

Remarks: The brief original description of the female of *L. dentipes* by Thompson and A. Scott (1903, p. 281, pl. XVI, figs. 27-30), based on one female, fits almost exactly the specimens from *Sinularia*. Although it is impossible to compare them with the single Ceylonese female (which no longer exists), the specimens from Madagascar appear to be identical with *L. dentipes*. Probably Thompson and A. Scott's specimen, obtained in washings of dredged invertebrates, actually came from an octocoral, perhaps even *Sinularia*.

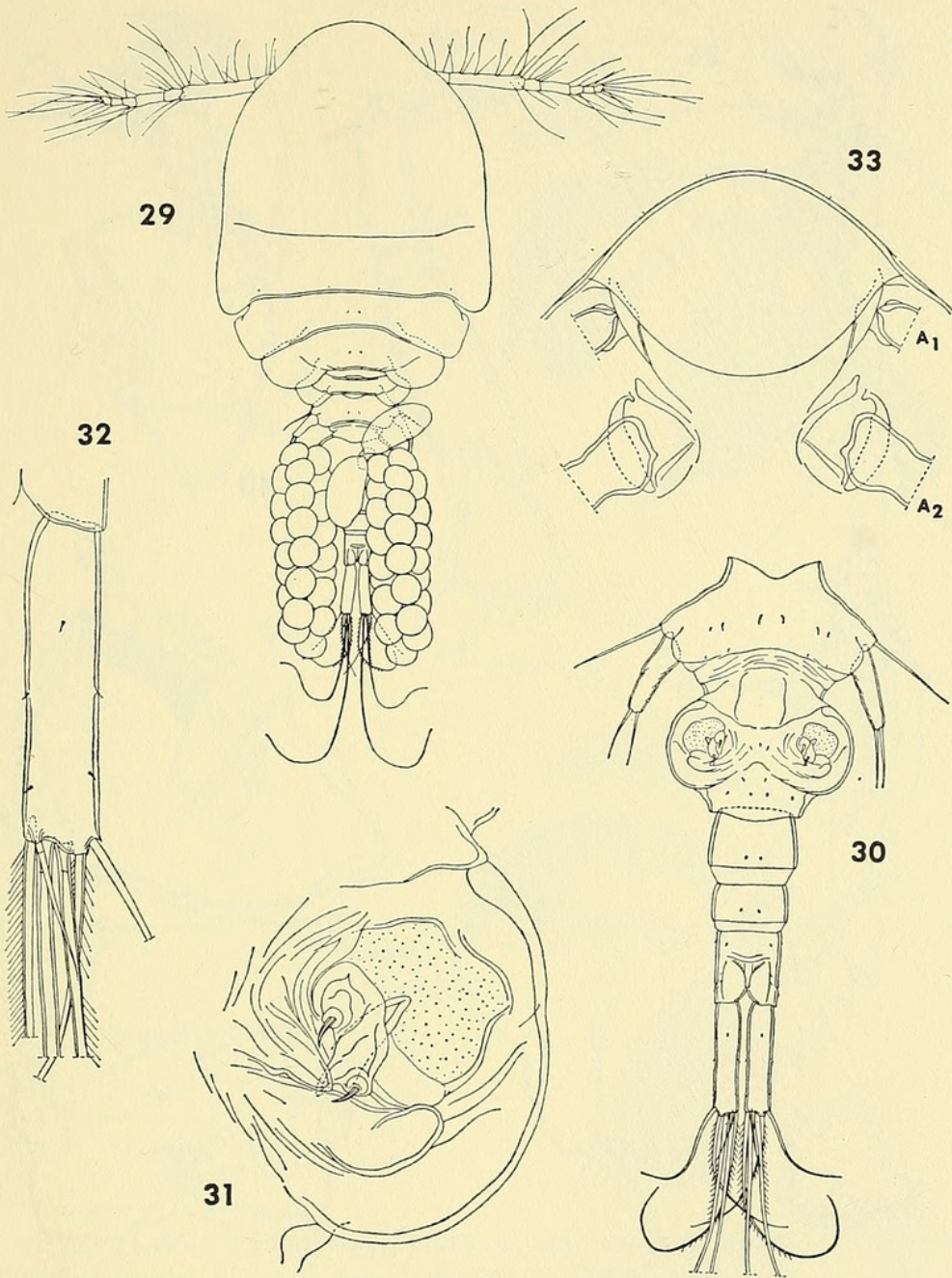
***Lichomolgus cristatus* new species**

Figures 29-50

Type material: 57 ♀♀ and 10 copepodids from one colony of *Sinularia leptocladus* (Ehrenberg), in 1 m, west of Pte. Mahatsinjo, Nosy Bé, Madagascar, collected 2 November 1960. Holotype and 45 paratypes deposited in the United States National Museum and the remaining paratypes in the collection of A. G. Humes.

Female: Body (fig. 29) with moderately broadened prosome, the sides of the cephalosome more or less parallel instead of rounded. Length 1.00 mm (0.95-1.10 mm) and greatest width 0.48 mm (0.45-0.50 mm), based on 10 specimens. Ratio of length to width of prosome 1.37 : 1. Segment of leg 1 separated dorsally from head by a transverse furrow. Epimeral areas of segments of legs 1-4 rounded posteriorly as in figure.

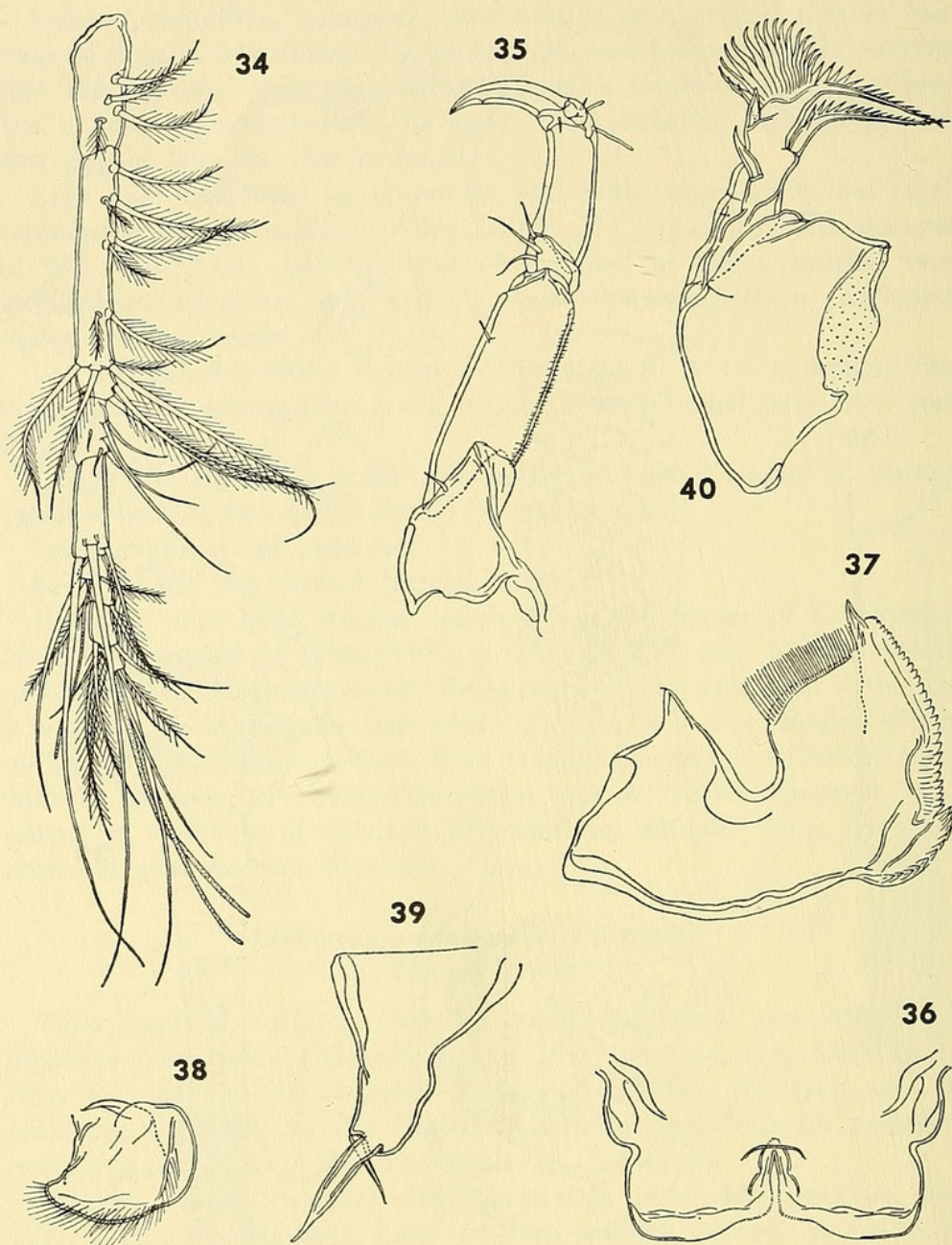
Segment of leg 5 (fig. 30) $96\ \mu \times 166\ \mu$. Ventrally between this segment and genital segment a weak intersegmental sclerite. Genital segment shorter than wide, $94\ \mu \times 146\ \mu$, in dorsal view rounded on either side and constricted posteriorly. Areas of attachment of egg sacs situated dorsally in midregion of segment. Each area (fig. 31) bearing two small naked setae $6\ \mu$ long. Three postgenital segments



FIGS. 29-33. *Lichomolgus cristatus*, new species, female: 29, body, dorsal (A); 30, urosome, dorsal (B); 31, area of attachment of egg sac, dorsal (C); 32, caudal ramus, dorsal (E); 33, rostral area, ventral (B).

$57 \mu \times 70 \mu$, $36 \mu \times 60 \mu$, and $60 \mu \times 50 \mu$, from anterior to posterior.

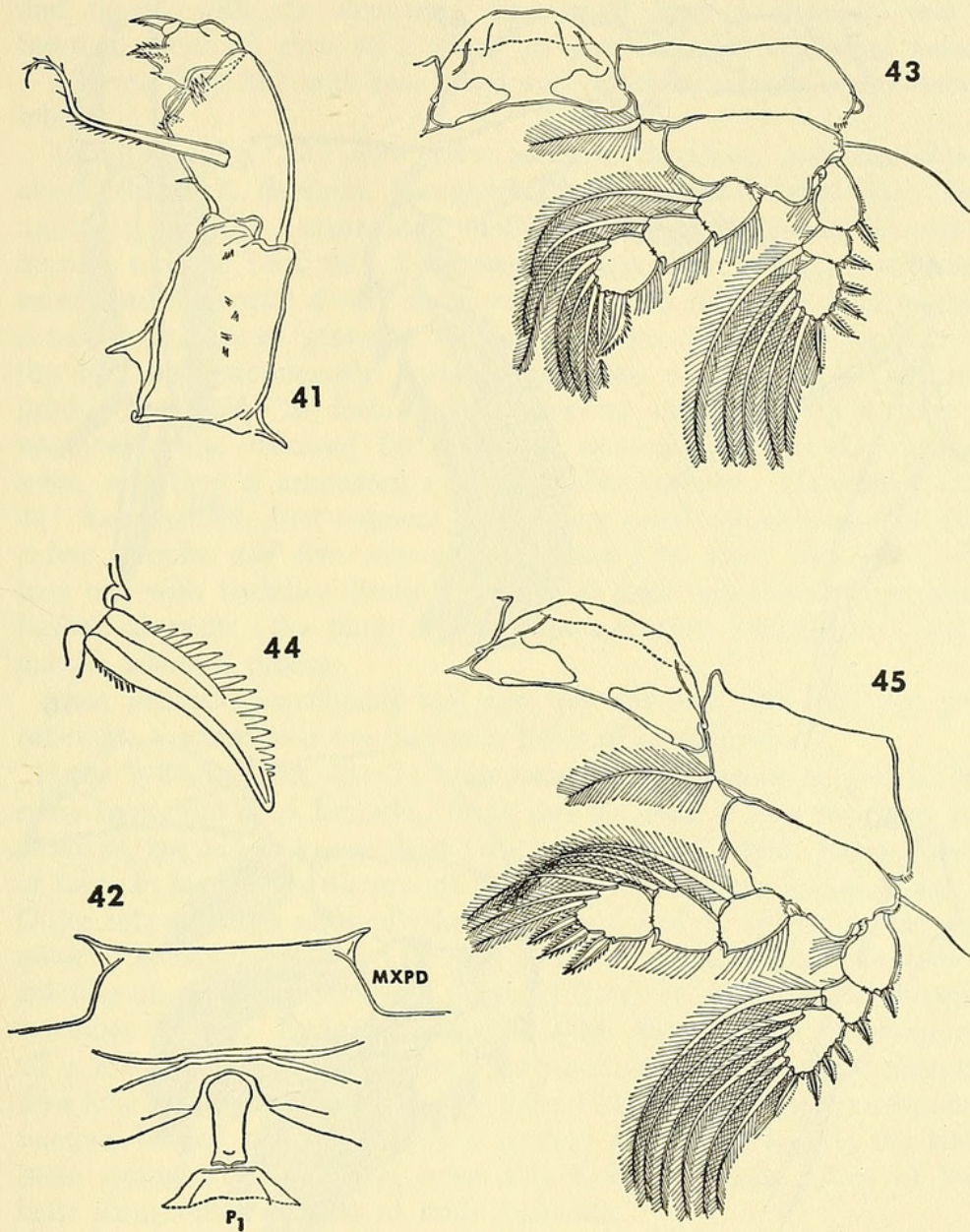
Caudal ramus (fig. 32) about 4.5 times longer than wide, its greatest dimensions being $89 \mu \times 20 \mu$. Outer lateral seta 80μ long and naked, pedicellate dorsal seta 38μ and naked, outermost distal seta 112μ with lateral hairs proximally, innermost distal seta 156μ with hairs along inner margin, and the two long median terminal setae 325μ (outer)



FIGS. 34-40. *Lichomolgus cristatus*, new species, female: 34, first antenna, anteroventral (D); 35, second antenna, posterior (outer) (F); 36, labrum, ventral (E); 37, mandible, posterior (C); 38, paragnath, ventral (C); 39, first maxilla, posterior (C); 40, second maxilla, posterior (E).

with a few spinules on outer margin and $400\ \mu$ (inner) without spinules. A few surficial spinules on ramus.

Dorsal surface of prosome and urosome with very few hairs. Ratio of length of prosome to that of urosome 1.7 : 1.

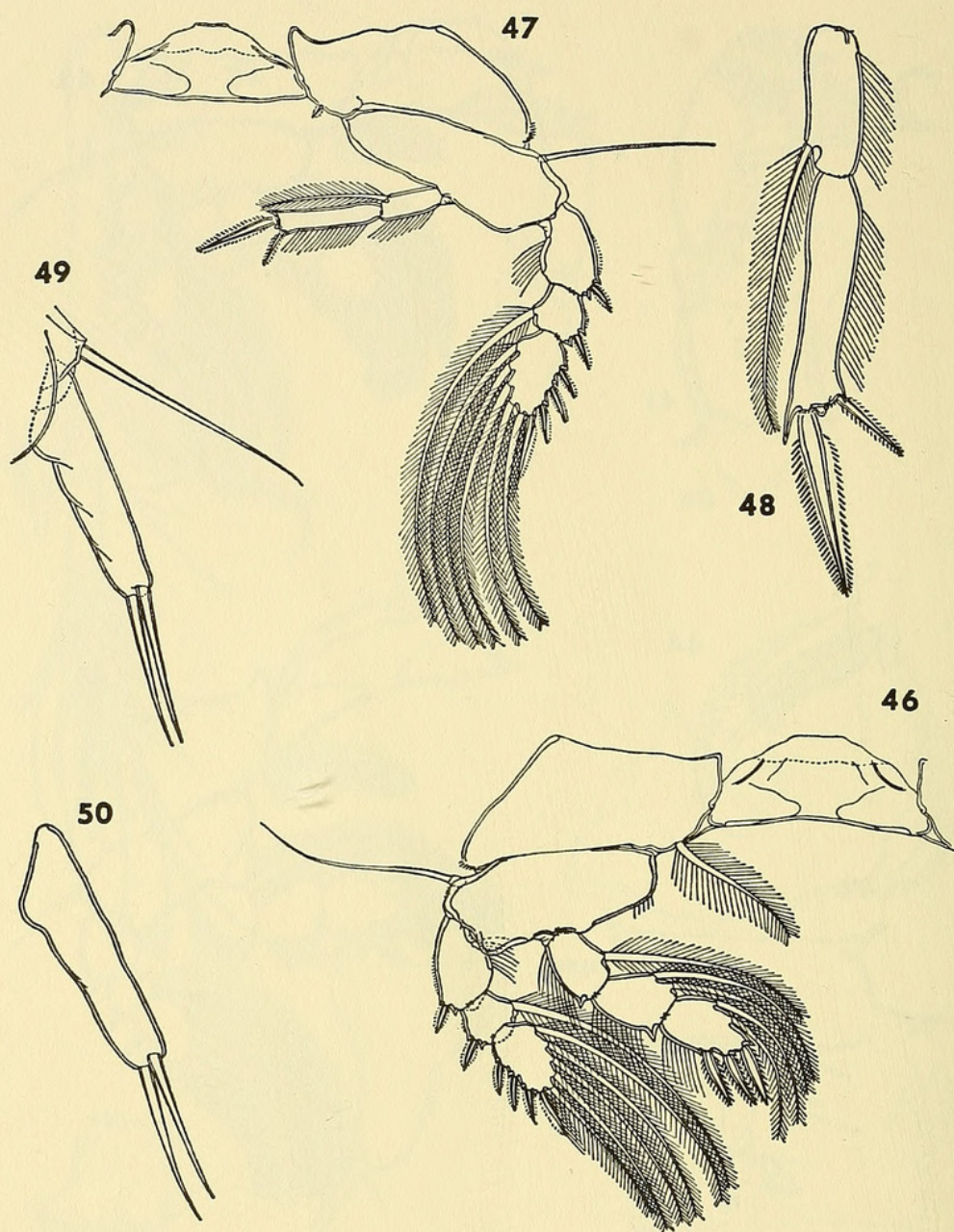


FIGS. 41-45. *Lichomolgus cristatus*, new species, female: 41, maxilliped, posterior (E); 42, area between maxillipeds and first pair of legs, ventral (F); 43, leg 1 and intercoxal plate, anterior (F); 44, spine on last segment of endopod of leg 1, anterior (H); 45, leg 2 and intercoxal plate, anterior (F).

Egg sac (fig. 29) elongated, $380 \mu \times 100 \mu$, reaching beyond caudal rami, with each egg about 50μ in diameter.

Rostral area (fig. 33) with an extremely delicate broadly rounded posteroventral margin.

First antenna (fig. 34) 7-segmented, 342μ in length. Lengths of segments: 55μ (68μ along anterior margin), 130μ , 33μ , 47μ , 25μ ,



FIGS. 46-50. *Lichomolgus cristatus*, new species, female: 46, leg 3 and intercoxal plate, anterior (F); 47, leg 4 and intercoxal plate, anterior (F); 48, endopod of leg 4, anterior (C); 49, leg 5, dorsal (E); 50, free segment of leg 5, dorsal (E).

21 μ , and 18 μ respectively. Formula for armature as in *L. dentipes*. Many setae haired as in figure.

Second antenna (fig. 35) 4-segmented, with last segment moderately elongated, 70 μ along its outer edge, 42 μ along its inner edge, and 19 μ wide at middle. First segment with a small inner seta, second with a similar seta and outer surficial spinules, third with three setae,

and fourth with six elements: five small hyaline elements and a terminal recurved claw $46\ \mu$ along its greatest axis. All setae naked.

Labrum (fig. 36) with two broad and rather truncated posteroventral lobes.

Mandible (fig. 37) with very reduced flagellum and resembling closely that of *L. dentipes*. Paragnath (fig. 38) a small hairy lobe. First maxilla (fig. 39) 1-segmented, with two unequal terminal elements. Second maxilla (fig. 40) 2-segmented, large first segment unarmed, second segment with a very small setule near its proximal outer margin, a naked seta on its posterior surface, an outer distal spine as long as the lash and prominently barbed along one edge, and the segment produced distally to form a lash bearing along its inner edge a proximal spine, followed by a row of unusually long rather hyaline setae, and then a graduated row of smaller spinules. Maxilliped (fig. 41) 3-segmented, first segment with a few small spinules, second with a few spinules and two very unequal setae (the short seta naked, the long one with barbules distally), and third with two terminal spiniform barbed elements (the inner one without a distinct articulation) and a minute setiform process.

Area between maxillipeds and first pair of legs (fig. 42) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 43, 45-47) segmented as in *L. dentipes*, and having same spine and setal formula. Inner seta on coxa of legs 1-3 long and plumose, but in leg 4 very short ($8\ \mu$) and finely barbed. Inner margin of basis in legs 1-3 with row of hairs, but this margin naked in leg 4. Outer seta on basis unusually long in legs 3 and 4. Spine on last segment of endopod of leg 1 (fig. 44) somewhat recurved with prominent spinules on outer margin and a proximal fringe of much smaller spinules on inner margin. Endopod of leg 4 (fig. 48) slender, first segment $25\ \mu \times 9\ \mu$ with its inner distal feathered seta $45\ \mu$, second segment $48\ \mu$ long (including processes) and $8.5\ \mu$ wide at middle, its two terminal unequal barbed spines being $15\ \mu$ (outer) and $34\ \mu$ (inner), the latter more strongly barbed along inner side than outer side. Row of long hairs along outer margins of both segments.

Leg 5 (fig. 49) with elongated free segment, $68\ \mu$ long, $17\ \mu$ wide at the slight proximal inner expansion (fig. 50), $12\ \mu$ wide at midregion. Two terminal naked setae $40\ \mu$ and $42\ \mu$. Naked seta on body near insertion of free segment $60\ \mu$.

Leg 6 probably represented by the two setae near areas of attachment of each egg sac (see fig. 31).

Color in life in transmitted light translucent, eye red, egg sacs gray.

Male: Unknown.

Etymology: The specific name *cristatus*, from Latin = crested, refers to the crest of unusually long setae on the proximal part of the terminal lash of the second maxilla.

Comparison with related species: The crest of long setae on the

terminal lash of the second maxilla sets this species apart from all other known species in the genus. In some respects *L. cristatus* resembles *L. dentipes*, for example, the second antenna, labrum, mandible, maxilliped, and endopod of leg 4.

Since the male of *L. cristatus* is unknown, comparisons with *L. aegyptius* Gurney, 1927, and *L. vagans* Gurney, 1927, of which only males are known, cannot be made directly. In *L. aegyptius*, however, the male has three claws and two setae on the end of the second antenna, the caudal ramus is very short (nearly as broad as long), and the slender mandible has a long flagellum. In *L. vagans* the male has two claws on the second antenna, the caudal ramus is only a little longer than wide, and the formula for the third segment of the exopod of leg 4 is II,I,5. It would appear very unlikely, therefore, that the new species could be the same as either of Gurney's species.

***Lichomolgus adelphus* new species**

Figures 51–66

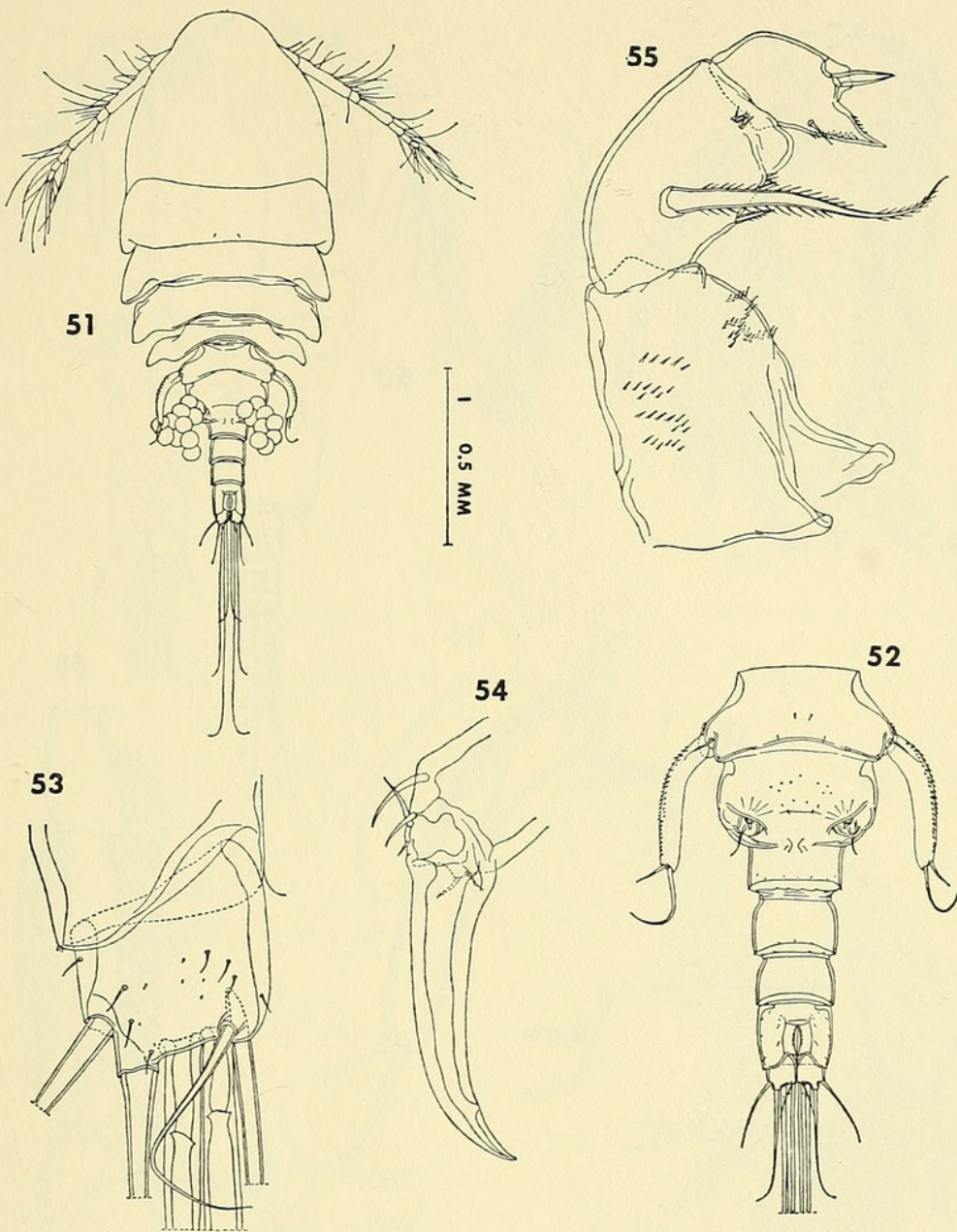
Type material: 51 ♀♀, 34 ♂♂, and 11 copepodids from one colony of *Sinularia whiteleggei* Lüttschwager, in 2 m, Antsamantsara, northwest of Madirokely, Nosy Bé, Madagascar, collected 31 October 1960. Holotype ♀, allotype, and 62 paratypes (37 ♀♀, 25 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

Other material: 5 ♀♀, 11 ♂♂, and 4 copepodids from one colony of *Sinularia pedunculata* Tixier-Durivault, in 3 m, Pte. Ambarionaomby, Nosy Komba, near Nosy Bé, 3 October 1960; and 10 ♀♀, 9 ♂♂, and 4 copepodids from one colony of *Sinularia polydactyla* (Ehrenberg), in 15 m, Tany Kely, a small island south of Nosy Bé, 30 August 1964.

Female: Body (fig. 51) resembling that of *L. squamiger* Humes and Frost, 1964. Length 1.29 mm (1.26–1.37 mm) and greatest width 0.55 mm (0.51–0.59 mm), based on 10 specimens. Ratio of length to width of prosome 1.58 : 1. Epimeral areas of segments of legs 1–4 somewhat more angulate posteriorly than in *L. squamiger*.

Segment of leg 5 (fig. 52) $101 \mu \times 229 \mu$. Ventrally between this segment and genital segment no intersegmental sclerite. Genital segment 153μ long, in dorsal view expanded in anterior part (width 187μ) and constricted with parallel sides posteriorly (width 109μ). Areas of attachment of egg sacs situated dorsolaterally near middle of segment. Each area with two very unequal naked elements, as in *L. squamiger*. Three postgenital segments $73 \mu \times 99 \mu$, $57 \mu \times 91 \mu$, and $78 \mu \times 88 \mu$, from anterior to posterior.

Caudal ramus (fig. 53) about as long as wide, $35 \mu \times 23 \mu$ in greatest dimensions. Outer lateral seta 77μ , pedicellate dorsal seta 50μ , outer most distal seta 121μ , innermost distal seta 300μ , and the two long median terminal setae 470μ (outer) and 685μ (inner), both inserted between slight unornamented dorsal and ventral flaps. All



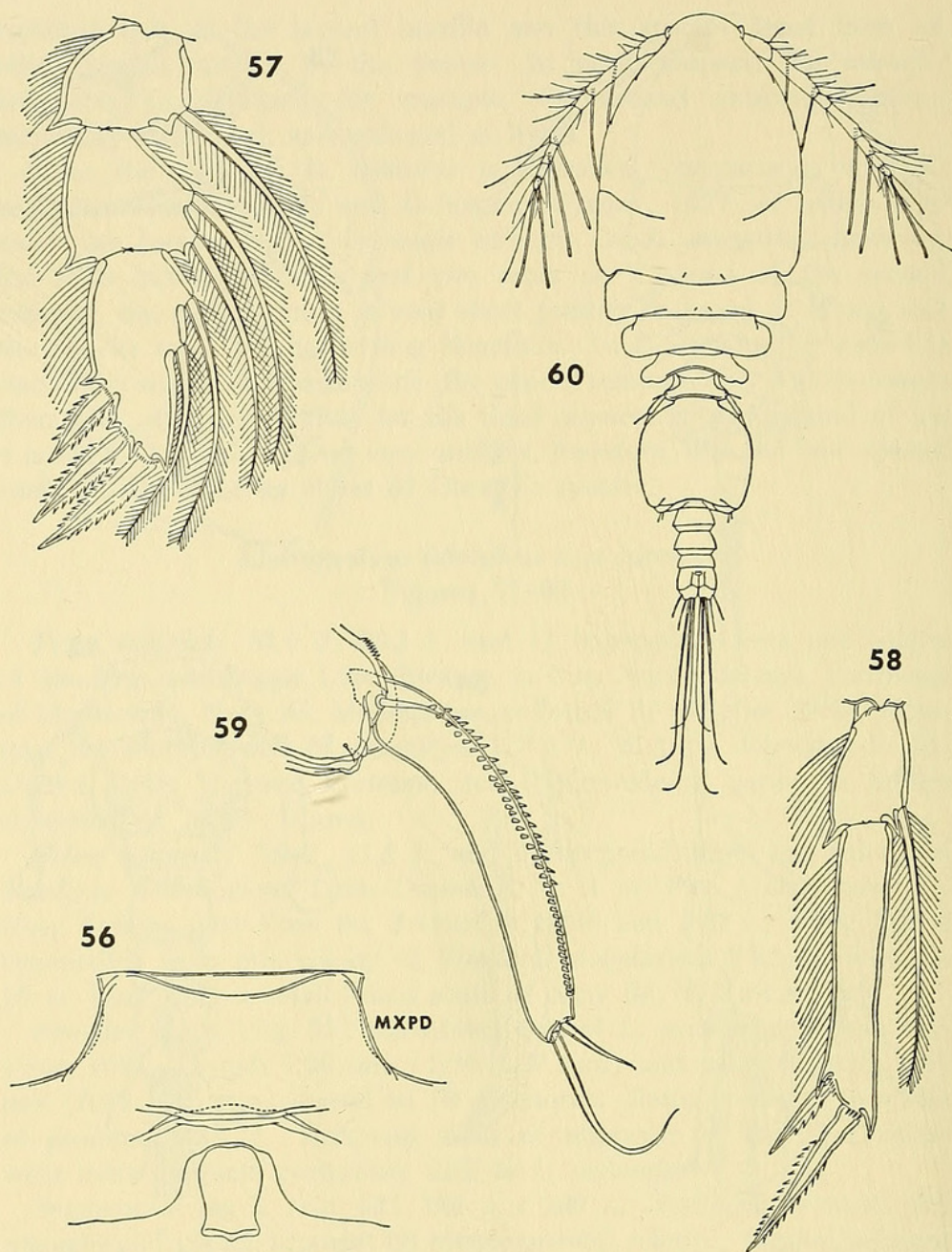
FIGS. 51-55. *Lichomolgus adelphus*, new species, female: 51, body, dorsal (I); 52, urosome, dorsal (G); 53, caudal ramus, dorsal (C); 54, tip of second antenna, anterior (inner) (C); 55, maxilliped, postero-inner (E).

setae naked. A few surficial small setules and refractile points on ramus.

Dorsal surface of prosome and urosome with a few short hairs. Ratio of length of prosome to that of urosome 1.85 : 1.

Form of egg sac unknown, since all ovigerous females collected had broken sacs. Each egg about 52μ in diameter.

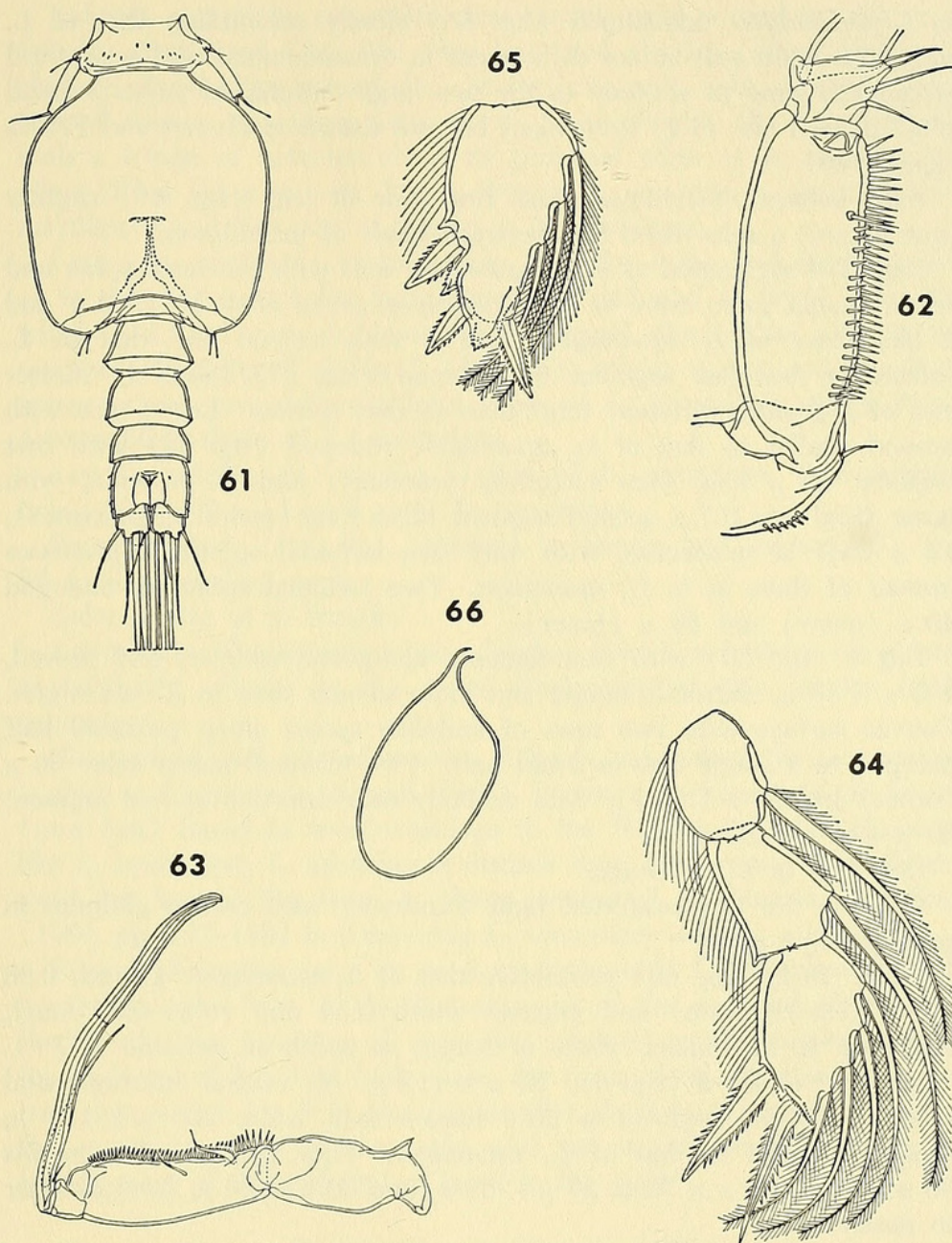
Rostral area as in *L. squamiger*.



FIGS. 56-60. *Lichomolgus adelphus*, new species, female: 56, area between maxillipeds and first pair of legs, ventral (D); 57, endopod of leg 3, anterior (F); 58, endopod of leg 4, anterior (F); 59, leg 5, dorsal (F). Male: 60, body, dorsal (A).

First antenna similar to that of *L. squamiger*. Lengths of segments: $55\ \mu$ ($88\ \mu$ along anterior edge), $143\ \mu$, $44\ \mu$, $104\ \mu$, $47\ \mu$, $36\ \mu$, and $31\ \mu$ respectively. Formula for armature as in *L. squamiger* (and also like *L. dentipes*, given above).

Second antenna resembling that of *L. squamiger*, but inner distal edge of first segment a little more swollen. Fourth segment $104\ \mu$ along



FIGS. 61-66. *Lichomoligus adelphus*, new species, male: 61, urosome, dorsal (B); 62, second segment of second antenna, anterior (inner) (E); 63, maxilliped, outer (B); 64, endopod of leg 1, anterior (E); 65, last segment of endopod of leg 2, anterior (E); 66, spermatophore, empty and attached to female, dorsal (B).

outer side, 66μ along inner side, and 21μ wide; bearing distally six small hyaline elements (as in *L. squamiger*, though only three such elements indicated in Humes and Frost's figure 174) and a terminal claw 52μ long (fig. 54).

Labrum, mandible, paragnath, first maxilla, and second maxilla as

in *L. squamiger*. Maxilliped (fig. 55) closely resembling that of *L. squamiger* with only minor differences in ornamentation and with third segment bearing in addition to the two large terminal elements a small seta (present also in *L. squamiger*, but not shown in Humes and Frost's figure 180).

Area between maxillipeds and first pair of legs (fig. 56) slightly protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 segmented as in *L. squamiger* and with the same spine and setal formula (also same as in *L. dentipes*, given above). Legs 1 and 2 like those of *L. squamiger*. Leg 3 with exopod like that of *L. squamiger*, but last segment of endopod (fig. 57) relatively shorter and of a slightly different form than in that species. Leg 4 also with exopod similar to that of *L. squamiger*; endopod (fig. 58) with first segment $47\ \mu$ long (not including processes) and $30\ \mu$ wide, with inner distal seta $107\ \mu$, second segment $125\ \mu$ long (including processes), $19\ \mu$ wide at midregion, with only two terminal spiniform processes instead of three as in *L. squamiger*. Two terminal spines of endopod $40\ \mu$ (outer) and $69\ \mu$ (inner).

Leg 5 (fig. 59) with free segment elongated, slender, and bowed, $195\ \mu \times 26\ \mu$, distinctly longer and more slender than in *L. squamiger*. Convex surface with two rows of scalelike spines along proximal half merging to a single row in distal half. Two terminal naked setae $36\ \mu$ (outer) and $73\ \mu$ (inner). Seta on body near insertion of free segment $39\ \mu$ and naked.

Leg 6 as in *L. squamiger*.

Color in life in transmitted light translucent, with orange globules in prosome, eye red.

Male: Body (fig. 60) resembling that of *L. squamiger*. Length 0.98 mm (0.95-0.99 mm) and greatest width 0.34 mm (0.33-0.35 mm), based on 10 specimens. Ratio of length to width of prosome 1.77 : 1.

Segment of leg 5 (fig. 61) $52\ \mu \times 112\ \mu$. No ventral intersegmental sclerite. Genital segment a little longer than wide, $200\ \mu \times 185\ \mu$, similar in form to that of *L. squamiger*. Four postgenital segments $36\ \mu \times 71\ \mu$, $39\ \mu \times 70\ \mu$, $27\ \mu \times 62\ \mu$, and $36\ \mu \times 60\ \mu$, from anterior to posterior.

Caudal ramus similar to that of female, but a little wider than long, $22\ \mu \times 26\ \mu$.

Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 1.58 : 1.

Rostral area as in *L. squamiger*, with two lateral anterior processes more prominent than in female, as in that species.

First antenna like that of *L. squamiger*, with same formula for armature (also same as for *L. dentipes*, given above). Second antenna as in *L. squamiger*, but lacking the obtuse spines seen in that species and having two rows of slender spines along inner surface of second segment (fig. 62).

Labrum, mandible, paragnath, first maxilla, and second maxilla as in female. Maxilliped (fig. 63) very long and slender (about 600 μ including claw when extended). Second segment with a single inner row of spines; two inner setae as in *L. squamiger*, the proximal one with a fringe of spinules along its proximal edge as in that species. Claw 297 μ along its axis, longer than in *L. squamiger*. Area between maxillipeds and first pair of legs as in *L. squamiger*.

Legs 1-4 segmented as in female, and the spine and setal formula as in that sex except for last segment of endopod of leg 1 (fig. 64) which is I,I,4 (as in *L. squamiger*). Sexual dimorphism also in last segment of endopod of leg 2 (fig. 65), where spines and spiniform processes are very different from those of *L. squamiger*. Legs 3 and 4 resembling those of *L. squamiger*.

Leg 5 (see fig. 61) similar to that of *L. squamiger*, free segment being 50 $\mu \times 9 \mu$. Leg 6 as in *L. squamiger*.

Spermatophore (fig. 66), attached to female and empty, 151 $\mu \times 86 \mu$, not including neck.

Color in life as in female.

Etymology: The specific name *adelphus*, from Greek ἀδελφός = sisterly or brotherly, alludes to the close relationship of this species to *L. squamiger*.

Comparison with related species: Like *L. squamiger*, the new species is close to *L. spinipes* (Sewell, 1949), known only from a single female (now lost) found in weed-washings in the Nicobar Islands. However, like *L. squamiger*, *L. adelphus* is distinct from *L. spinipes*. The distinctions are largely the same as those mentioned by Humes and Frost (1964, pp. 147-148) in comparing *L. squamiger* with *L. spinipes*.

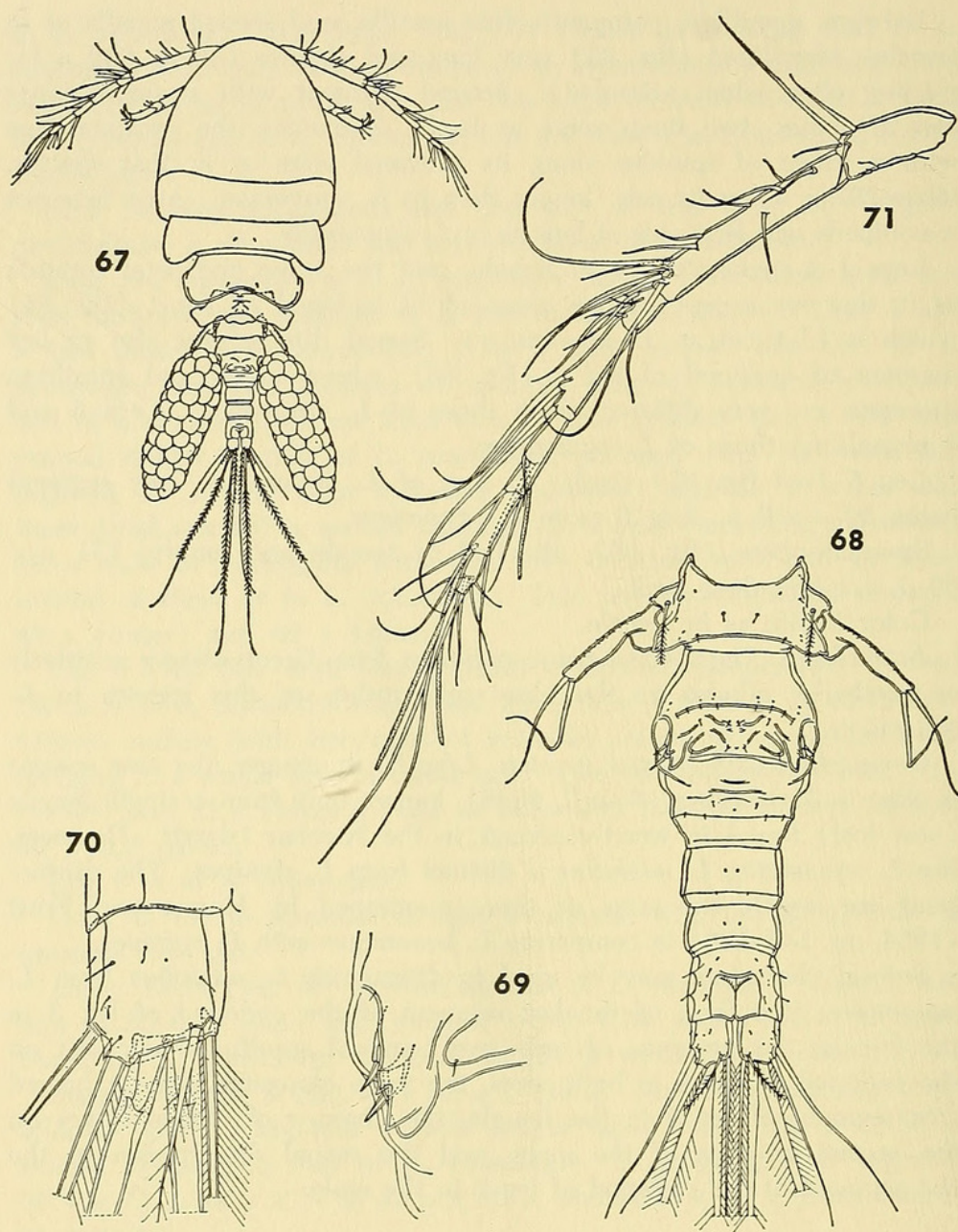
Several characters may be used to distinguish *L. adelphus* from *L. squamiger*: the form of the last segment of the endopod of leg 3 in the female, the presence of only two terminal spiniform processes on the endopod of leg 4 in both sexes, the more elongated slender bowed free segment of leg 5 in the female, the absence of obtuse spines on the second antenna of the male, and the sexual dimorphism in the last segment of the endopod of leg 2 in the male.

Lichomolgus foxi Gurney, 1927

Figures 67-88

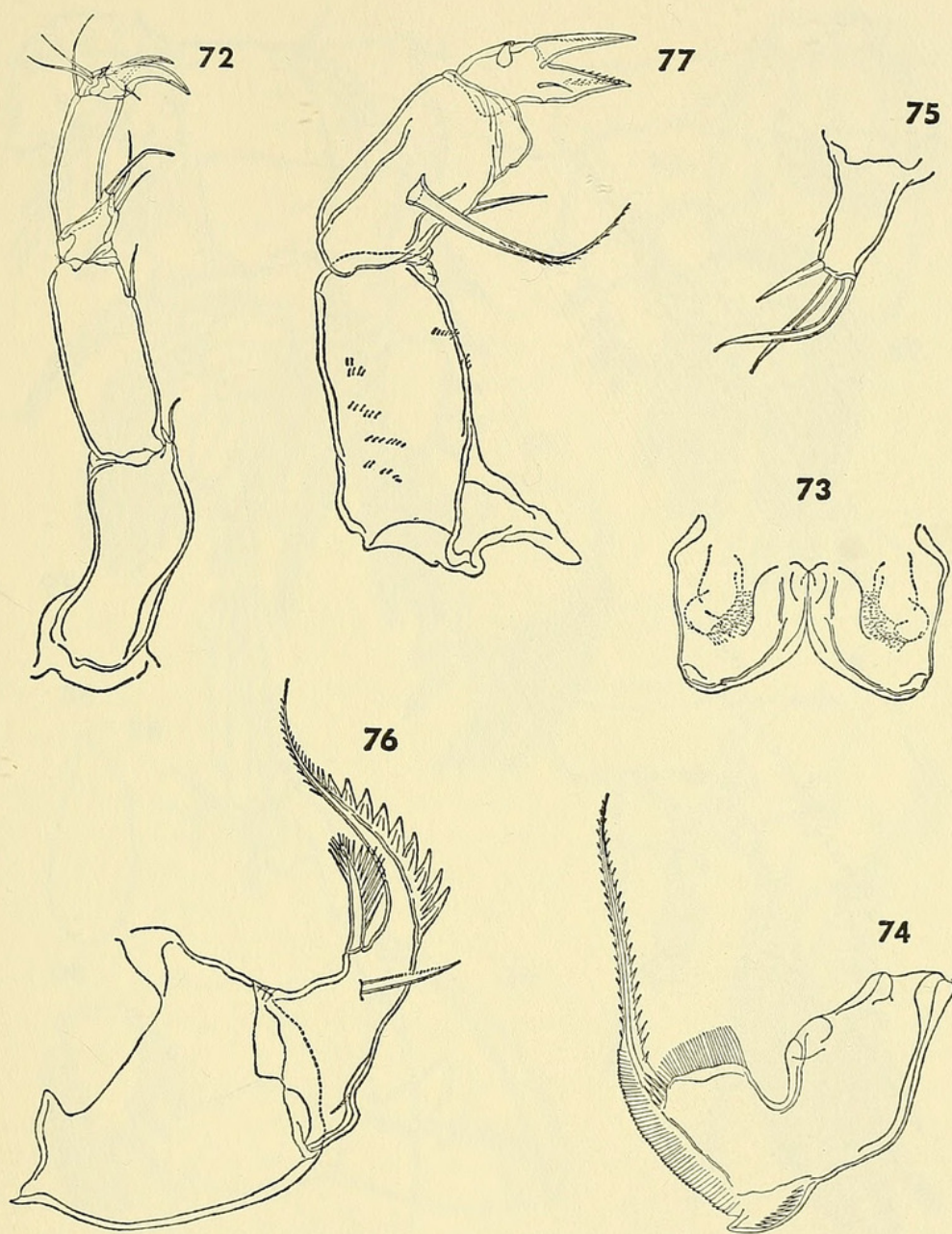
Gurney described this species on the basis of one female taken at Port Taufiq in the Suez Canal. This specimen was supposed to have been deposited in the British Museum (Natural History), but upon examination of the vial in the museum's collection labeled "*Lichomolgus foxi* n. sp." we have found only a fragment of an unknown lichomolgid and a specimen of *Corycaeus*. Thus the type specimen appears to have been misplaced or lost. The male has been unknown until now.

In Madagascar the first author collected specimens referable to *L. foxi* as follows: 196 ♀ ♀, 212 ♂ ♂, and 74 copepodids from several colonies



FIGS. 67-71. *Lichomolgus foxi* Gurney, 1927, female: 67, body, dorsal (I); 68, urosome, dorsal (B); 69, area of attachment of egg sac, dorsal (E); 70, caudal ramus, dorsal (E); 71, first antenna, dorsal (B).

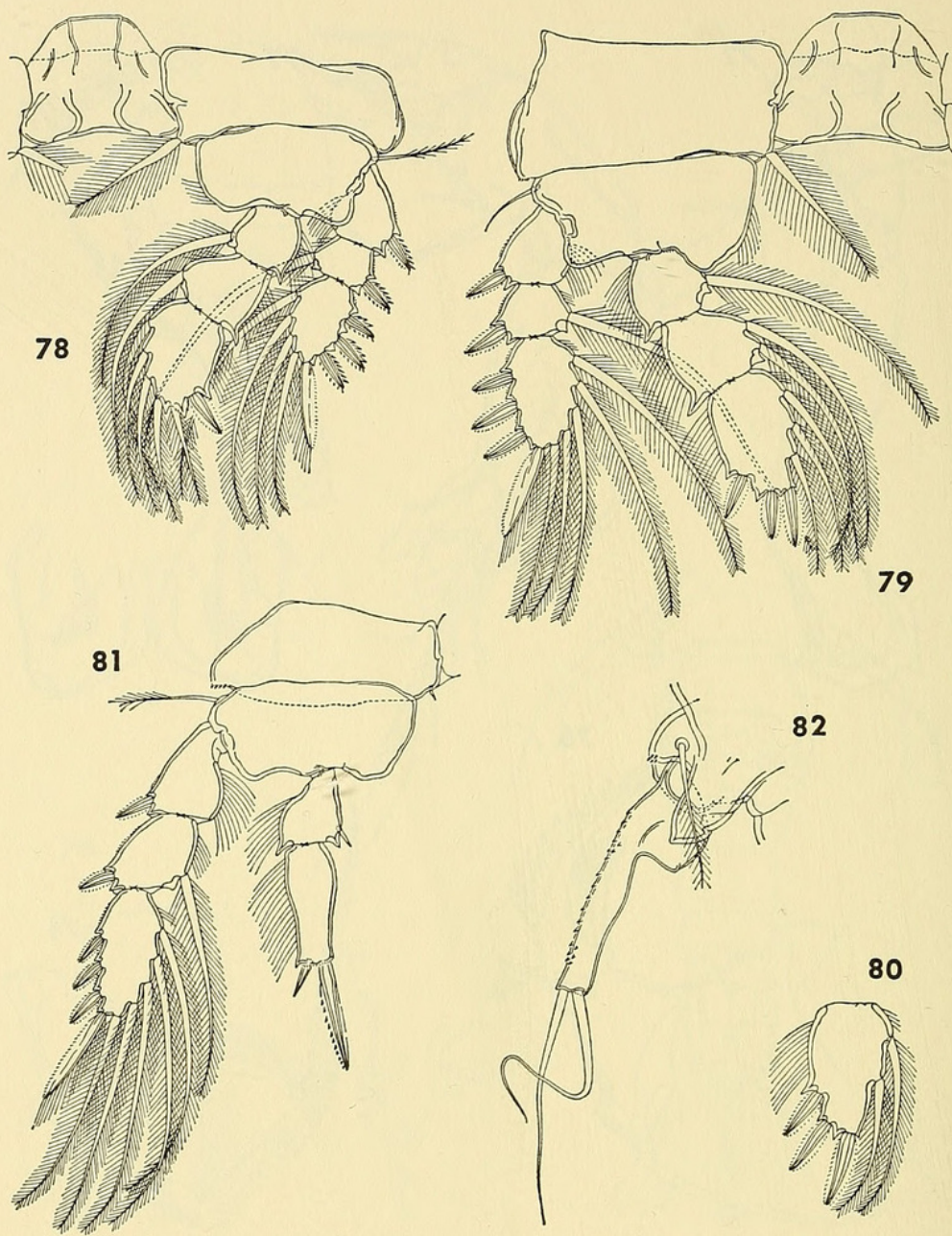
of *Cladiella krempfi* Hickson, in 1 m, west of Pte. de Tafondro, Nosy Bé, 5 December 1963 (specimens deposited in the United States National Museum, the Zoölogisch Museum, Amsterdam, and the British Museum (Natural History)); 25 ♀♀, 19 ♂♂, and 7 copepodids from one colony of *Cladiella laciniosa* (Tixier-Durivault), in 1 m, Nosy Kisimany, a small island 27 km southwest of Nosy Bé near the mainland of Madagascar, 4 October 1960 (specimens in the U.S.N.M.); and 20 ♀♀



FIGS. 72-77. *Lichomolgus foxi*, Gurney, 1927, female: 72, second antenna, anterior (inner) (D); 73, labrum, with paragnaths in dashed lines, ventral (F); 74, mandible, posterior (E); 75, first maxilla, anterior (E); 76, second maxilla, posterior (E); 77, maxilliped, posterior (E).

and 9♂♂ from one colony of *Cladiella pachyclados* (Klunzinger), in 1 m, Ambariotelo, a small island almost between Nosy Bé and Nosy Komba, 15 May 1964 (specimens in the U.S.N.M.).

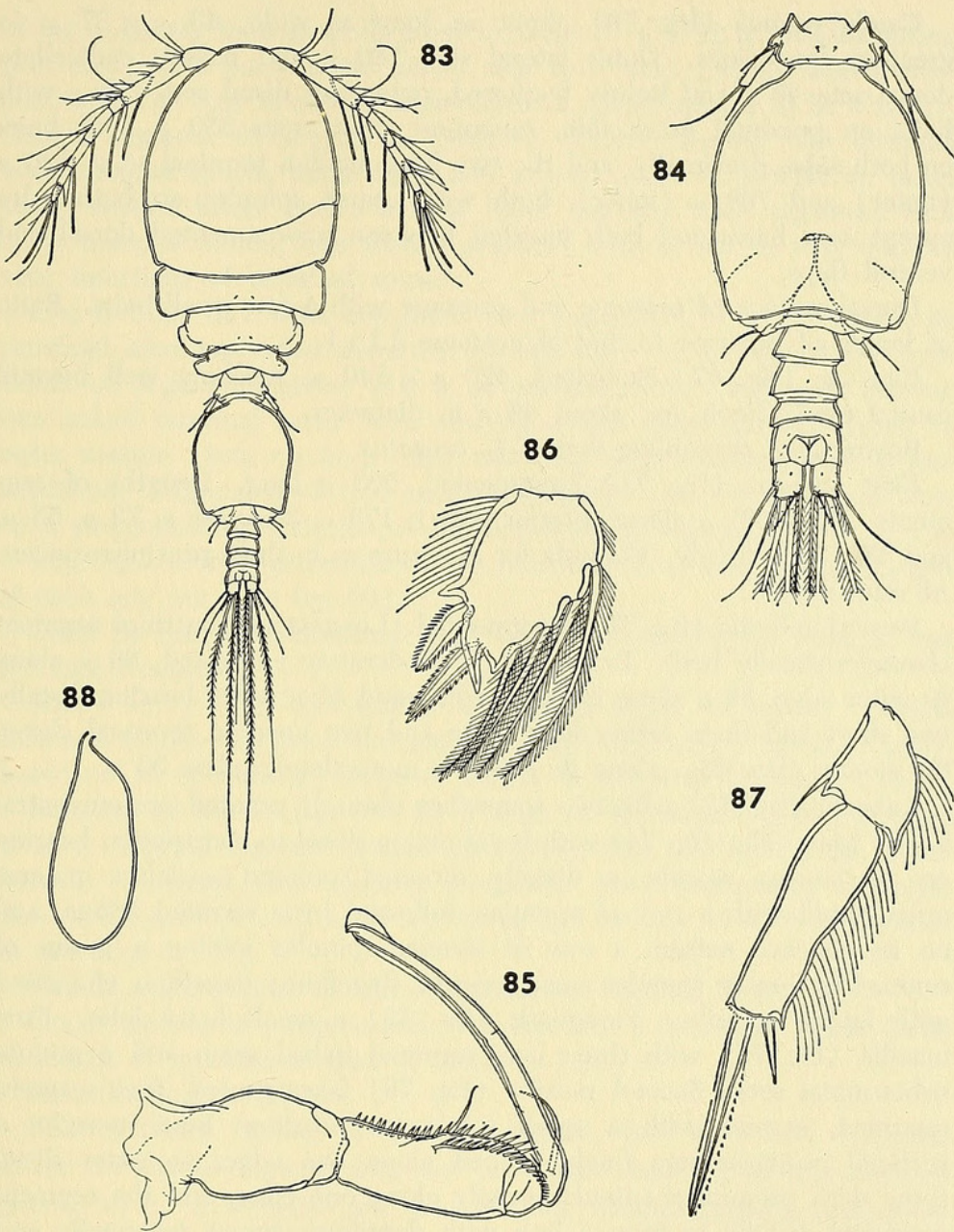
Female: Body (fig. 67) with slender prosome. Length 1.16 mm (1.04-1.27 mm) and greatest width 0.51 mm (0.49-0.54 mm), based on 10 specimens. Ratio of length to width of prosome 1.57 : 1. Segment



FIGS. 78–82. *Lichomolgus foxi* Gurney, 1927, female: 78, leg 1 and intercoxal plate, anterior (D); 79, leg 2 and intercoxal plate, anterior (D); 80, last segment of endopod of leg 3, anterior (D); 81, leg 4, anterior (D); 82, leg 5, dorsal (F).

of leg 1 separated dorsally and laterally from head by a transverse furrow. Epimeral areas of segments of legs 1–4 as in figure.

Segment of leg 5 (fig. 68) $80 \mu \times 143 \mu$. Between this segment and genital segment a short ventral intersegmental sclerite. Genital segment $156 \mu \times 135 \mu$, only a little longer than wide, and not greatly expanded laterally in dorsal view. Areas of attachment of egg sacs located



FIGS. 83-88. *Lichomolgus foxi* Gurney, 1927, male: 83, body, dorsal (A); 84, urosome, dorsal (B); 85, maxilliped, outer (D); 86, last segment of endopod of leg 1, anterior (E); 87, endopod of leg 4, anterior (E); 88, spermatophore, empty and attached to female, dorsal (G).

dorsolaterally in middle of segment. Each area (fig. 69) bearing two small naked setae $10\ \mu$ and $12\ \mu$ long, partially covered in dorsal view by sclerotized processes. Region between two areas of attachment with sclerotized lines and setules as indicated in figure. Three postgenital segments $52\ \mu \times 86\ \mu$, $36\ \mu \times 78\ \mu$, and $52\ \mu \times 78\ \mu$, from anterior to posterior.

Caudal ramus (fig. 70) about as long as wide, $43\ \mu \times 37\ \mu$ in greatest dimensions. Outer lateral seta $180\ \mu$ and naked, pedicellate dorsal seta $46\ \mu$ and lightly feathered, outermost distal seta $195\ \mu$ with hairs on proximal inner side, innermost distal seta $350\ \mu$ with hairs on both sides proximally, and the two long median terminal setae $600\ \mu$ (outer) and $790\ \mu$ (inner), both with coarse spinules on both sides except near bases and both inserted between unornamented dorsal and ventral flaps.

Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 2.1 : 1.

Egg sac (fig. 67) elongated, $420\ \mu \times 140\ \mu$, reaching well beyond caudal rami. Each egg about $46\ \mu$ in diameter.

Rostral area resembling that of *L. cristatus*.

First antenna (fig. 71) 7-segmented, $563\ \mu$ long. Lengths of segments: $55\ \mu$ ($91\ \mu$ along anterior edge), $179\ \mu$, $36\ \mu$, $91\ \mu$, $73\ \mu$, $55\ \mu$, and $38\ \mu$ respectively. Formula for armature as in three previous species. All setae naked.

Second antenna (fig. 72) 4-segmented. Longest seta on third segment characteristically bent. Last segment moderately elongated, $88\ \mu$ along its outer edge, $59\ \mu$ along its inner edge, and $23\ \mu$ wide, bearing distally two short and three rather long setae and two unequal terminal claws, the stouter claw $46\ \mu$ along its axis, the more slender claw $33\ \mu$.

Labrum (fig. 73) with two somewhat obtusely pointed posteroventral lobes. Mandible (fig. 74) with basal region distal to constriction bearing on its convex margin a distally directed pointed scalelike process ornamented with a row of spinules, followed by a serrated fringe, and on its concave margin a row of slender spinules joining a group of somewhat stouter spinules near base of flagellum; flagellum elongated with lateral spinules. Paragnath (fig. 73) a small hairy lobe. First maxilla (fig. 75) with three long terminal naked setae and a minute subterminal seta. Second maxilla (fig. 76) 2-segmented, first segment unarmed, second with a small setule on proximal inner margin, a surficial posterior seta finely barbed along one edge, an outer distal spine with prominent spinules mostly along one edge, and the segment produced distally to form a lash with dentiform spines proximally and fine bilateral spinulation distally. Maxilliped (fig. 77) 3-segmented, armed as in *L. dentipes*, though details of form and ornamentation somewhat different.

Area between maxillipeds and first pair of legs similar to that in *L. cristatus*, but slightly protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 78-81) segmented as in three previous species and with same spine and setal formula. Inner seta on coxa of legs 1-3 long and plumose, but in leg 4 very short ($8\ \mu$) and naked. Inner margin of basis with row of hairs in legs 1-3, but naked in leg 4. Outer spines of exopod of leg 1 with strong spinules along proximal edges. Endopod

of leg 4 shorter than exopod. First segment $37 \mu \times 32 \mu$ (not including processes) with inner distal naked seta very short (11μ) and turned anteriorly (so that in casual examination it might appear to be absent). Second segment $65 \mu \times 26 \mu$ (greatest width) bearing two terminal very unequal spines, outer 23μ and naked, inner 61μ with an outer finely barbed fringe and a narrow inner lamella. Both segments with outer margins haired, and second segment with a row of fine spinules near insertions of terminal spines.

Leg 5 (fig. 82) with elongated free segment, 101μ in length, its proximal area expanded inwardly (width here 33μ) but distal two-thirds of segment slender (15μ at widest point). Segment bearing two naked terminal setae 94μ and 99μ and short spinules along its outer margin. Seta on body near insertion of free segment 45μ and feathered. Expansion of free segment partially covered in dorsal view by a posterolateral extension of dorsum of body segment.

Leg 6 probably represented by the two setae near areas of attachment of each egg sac (see fig. 69).

Color in life in transmitted light translucent to slightly opaque, eye red, egg sacs gray.

Male: Body (fig. 83) similar in general shape to female. Length 0.93 mm ($0.88\text{--}0.96 \text{ mm}$) and greatest width 0.32 mm ($0.31\text{--}0.33 \text{ mm}$), based on 10 specimens. Ratio of length to width of prosome $1.66 : 1$.

Segment of leg 5 (fig. 84) $42 \mu \times 91 \mu$. No ventral intersegmental sclerite. Genital segment longer than wide, $211 \mu \times 172 \mu$, its lateral borders in dorsal view slightly irregular. Four postgenital segments $32 \mu \times 57 \mu$, $28 \mu \times 56 \mu$, $20 \mu \times 56 \mu$, and $29 \mu \times 56 \mu$, from anterior to posterior.

Caudal ramus similar to that of female, but smaller, $26 \mu \times 24 \mu$.

Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome $1.46 : 1$.

Rostral area as in female.

First antenna similar to that of female, but with two aesthetes added on second segment and one on fourth segment, so that formula is same as for *L. dentipes* and *L. adelphus*. Second antenna resembling that of female, but with small spinules added on inner surface of first, second, and fourth segments.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those of female. Maxilliped (fig. 85) resembling in general form and armature that of *L. dentipes*. Claw 185μ along its axis (including terminal lamella).

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

Legs 1-4 segmented as in female, and spine and setal formula as in that sex except for last segment of endopod of leg 1 (fig. 86) which is I,I,4. No sexual dimorphism in legs 2 or 3. Endopod of leg 4 (fig. 87) closely resembling that of female.

Leg 5 (see fig. 84) with slender free segment $41 \mu \times 8 \mu$, without

a proximal expansion. Outer margin with fewer spinules than in female. Two terminal naked setae $31\ \mu$ (inner) and $63\ \mu$ (outer).

Leg 6 (see fig. 84) a posterolateral flap on ventral surface of genital segment bearing two naked setae $30\ \mu$ and $39\ \mu$ long.

Spermatophore (fig. 88), attached to female and empty, elongated, $220\ \mu \times 90\ \mu$ (not including neck).

Color in life as in female.

Remarks: As nearly as can be determined, the specimens from *Cladiella* in Madagascar represent the species described by Gurney (1927) as *L. foxi*. In Gurney's description, based upon a single female, several significant points of similarity with the Madagascan specimens may be noted: the body shape and size, the proportional lengths of the segments of the first antenna, the bent seta on the third segment and the two unequal claws on the last segment of the second antenna, the strong spinules on the proximal edges of the outer spines of the exopod of leg 1, and the form of the caudal ramus.

There are two rather perplexing apparent differences. Gurney stated that the first segment of the endopod of leg 4 had no seta, but added that "it may have been broken off." In his figure 113E he showed two small spiniform processes at the region where the seta would normally be. In the Madagascan females the very small seta at this point is often directed anteriorly and could easily be overlooked when the leg is examined on a slide in flat view. We think it probable that one of Gurney's spiniform processes may represent this seta, since it would be very unusual in *Lichomolgus* for two spiniform processes to be present here. The length of the second segment of the endopod in leg 4 is relatively shorter and the two terminal spines are less unequal in Gurney's figure than in the Madagascan females. However, such small differences may be attributable to the technique of drawing.

Leg 5 as shown in Gurney's figure 113G in general resembles that in the Madagascan specimens, but shows an inner proximal expansion of somewhat different form, the terminal setae are relatively shorter, and the outer margin is said to be hairy. The form of the expansion in his figure does not appear to be significantly different from that in the Madagascan females, since the variation could be introduced by the angle at which the leg was drawn. The terminal setae in the Madagascan females are very delicate distally and those shown in Gurney's figure may not represent their entire length. The "hairy" nature of the outer margin may simply be an interpretation of the rather small spinules seen here in the Madagascan material.

Admittedly we are interpreting these features in relation to what we know of the females from Madagascar, but in the absence of types or other specimens we have come to the conclusion that the apparent differences in the endopod of leg 4 and in leg 5 are probably not significant, and that our specimens from *Cladiella* actually represent *L. foxi*.

Lichomolgus hetaericus new species

Figures 89–106

Type material: 74 ♀♀, 18 ♂♂, and 1 copepodid from one colony of *Cladiella pachyclados* (Klunzinger), in 1 m, Ambariotelo, a small island almost between Nosy Komba and Nosy Bé, Madagascar, collected 15 May 1964. Holotype ♀, allotype, and 62 paratypes (50 ♀♀, 12 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

Other material: 9 ♀♀ from several colonies of *Cladiella krempfi* Hickson, in 1 m, west of Pte. de Tafondro, Nosy Bé, 5 December 1963.

Female: Body (fig. 89) with moderately broadened prosome. Length 0.84 mm (0.78–0.89 mm) and greatest width 0.42 mm (0.40–0.45 mm), based on 10 specimens. Ratio of length to width of prosome 1.27 : 1. Segment of leg 1 separated dorsally and laterally from head by a transverse furrow. Epimeral areas of segments of legs 1–4 as in figure.

Segment of leg 5 (fig. 90) $62 \mu \times 109 \mu$. No ventral intersegmental sclerite. Genital segment (fig. 90) about as long as wide, $107 \mu \times 112 \mu$, in dorsal view moderately expanded laterally. Areas of attachment of egg sacs situated laterally near middle of segment. Each area (fig. 91) bearing two small naked spiniform setae 6μ and 4.5μ long, and partly covered dorsally by a flap of dorsum of genital segment. Three postgenital segments $34 \mu \times 62 \mu$, $26 \mu \times 60 \mu$, and $29 \mu \times 57 \mu$, from anterior to posterior.

Caudal ramus (fig. 92) nearly quadrate, $22 \mu \times 23 \mu$ in greatest dimensions. Outer lateral seta 133μ and naked, dorsal pedicellate seta 80μ and apparently naked, outermost distal seta 79μ and naked, innermost distal seta 143μ and haired proximally, and the two long median terminal setae 395μ (outer) and 495μ (inner), both with lateral spinules except near bases and inserted between dorsal and ventral unornamented flaps.

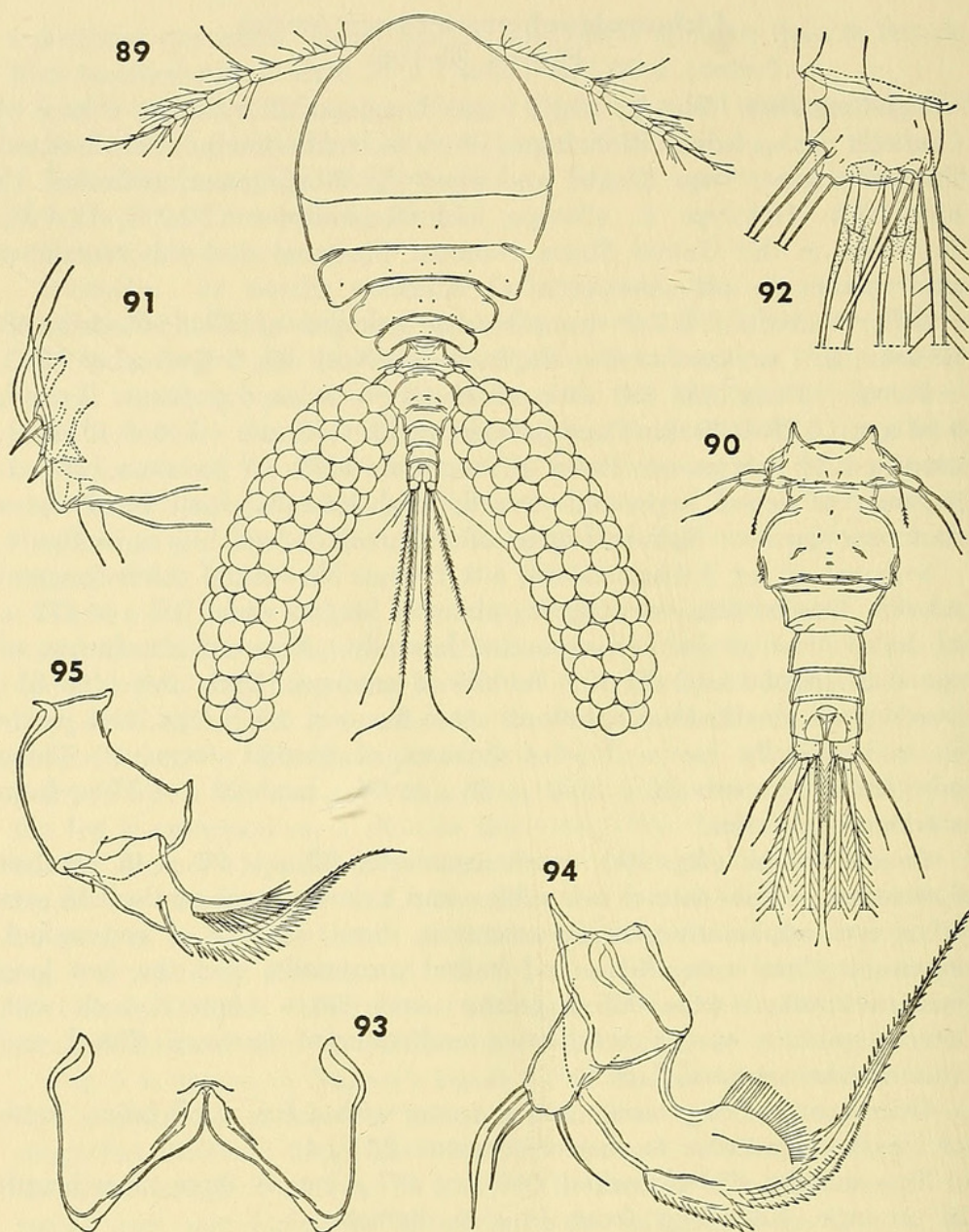
Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 2.15 : 1.

Egg sac (fig. 89) elongated, $660 \mu \times 187 \mu$, nearly three times length of urosome. Each egg about 49μ in diameter.

Rostral area as in *L. cristatus*.

First antenna similar to that of *L. foxi*. Lengths of segments: 34μ (68μ along anterior margin), 151μ , 26μ , 65μ , 47μ , 32μ , and 29μ respectively. All setae naked. Second antenna also resembling that of *L. foxi*, with seta on third segment bent as in that species. Last segment 75μ along outer side, 47μ along inner side, and 17μ wide at middle. Stouter claw 36μ , more slender claw 29μ .

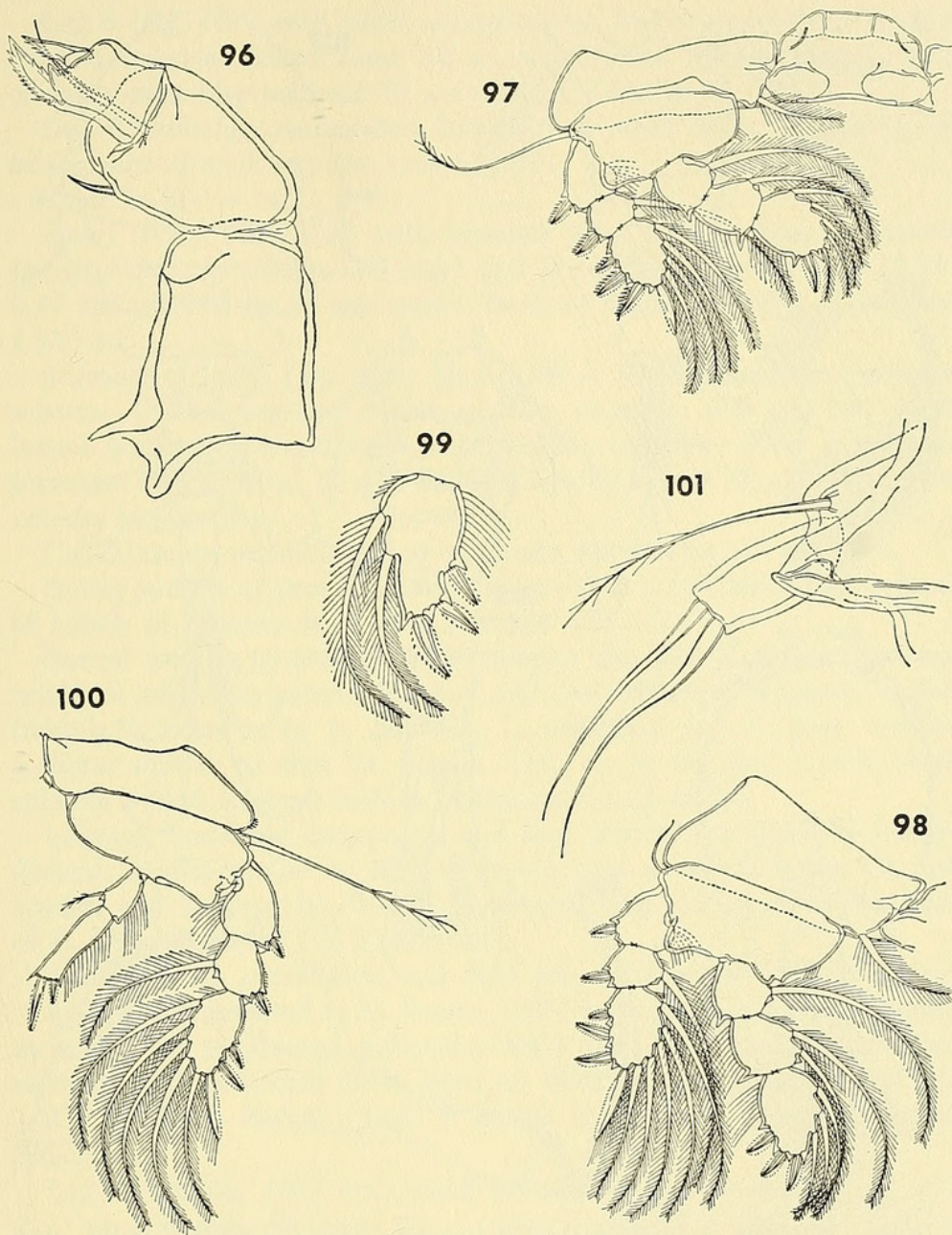
Labrum (fig. 93) with two rather pointed posteroventral lobes. Mandible (fig. 94) resembling that of *L. foxi*, but distal end of scalelike process on convex margin of basal region ornamented with spinules. Paragnath and first maxilla (fig. 94) similar to those in *L. foxi*. Second maxilla (fig. 95) resembling that of *L. foxi*, but proximal



FIGS. 89-95. *Lichomolgus hetaericus*, new species, female: 89, body, dorsal (A); 90, urosome, dorsal (B); 91, area of attachment of egg sac, dorsal (C); 92, caudal ramus, dorsal (C); 93, labrum, ventral (E); 94, mandible and first maxilla, posterior (C); 95, second maxilla, posterior (E).

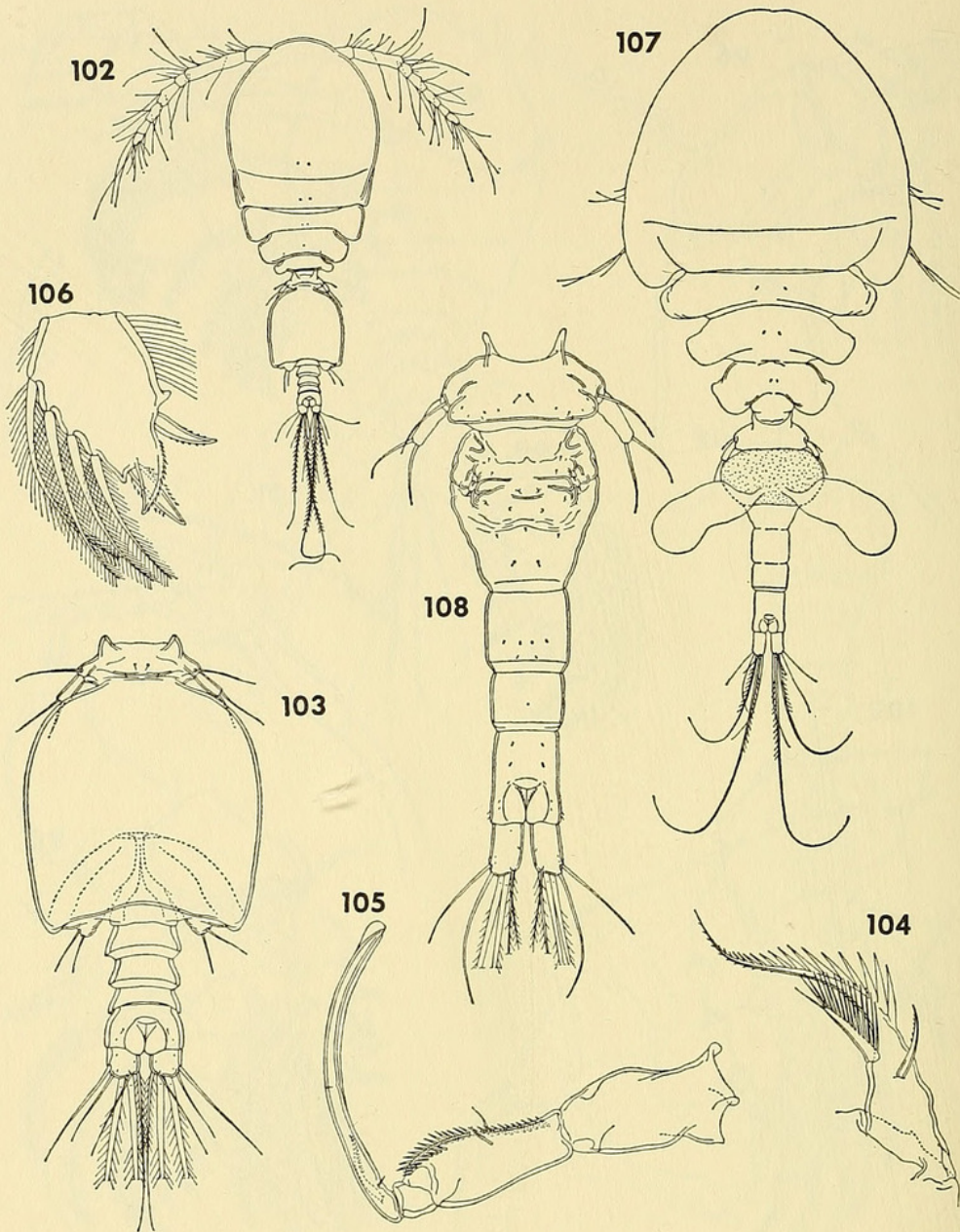
spines on lash more slender. Maxilliped (fig. 96) similar to that of *L. foxi*, but first segment without ornamentation, long seta on second segment relatively shorter, and a spiniform process between two large terminal elements.

Area between maxillipeds and first pair of legs not protuberant and similar to that in *L. cristatus*.



FIGS. 96-101. *Lichomolgus hetaericus*, new species, female: 96, maxilliped, anterior (C); 97, leg 1 and intercoxal plate, anterior (F); 98, leg 2, anterior (F); 99, last segment of endopod of leg 3, anterior (E); 100, leg 4, anterior (F); 101, leg 5, dorsal (C).

Legs 1-4 (figs. 97-100) segmented as in four previous species, with same spine and setal formula except for last segment of exopod of leg 4 which is II,I,5. Inner seta on coxa long and plumose in legs 1-3, but extremely minute ($3\ \mu$) and naked in leg 4. Outer seta on basis long ($70\ \mu$) in legs 1, 3, and 4. Inner margin of basis in leg 4 naked. Proximal outer spine on third segment of exopod in legs 1-3 distinctly



FIGS. 102-108. *Lichomolgus hetaericus*, new species, male: 102, body, dorsal (A); 103, urosome, dorsal (D); 104, second maxilla, posterior (C); 105, maxilliped, outer (F); 106, last segment of endopod of leg 1, anterior (C). *Lichomolgus insolens*, new species, female: 107, body, dorsal (A); 108, urosome, dorsal (B).

shorter than distal spines. Endopod of leg 4 (fig. 100) rather slender, shorter than exopod. First segment $22 \mu \times 12 \mu$, with its inner distal seta 20μ and very lightly feathered. Second segment $44 \mu \times 11 \mu$ (including processes and width taken at widest point), two terminal fringed spines 11μ (outer) and 23μ (inner). Hairs along outer margins of both segments and minute spinules near insertions of terminal spines.

Leg 5 (fig. 101) with small unornamented free segment $27 \mu \times 12 \mu$, its two terminal naked setae 46μ (outer) and 55μ (inner). Seta on body near free segment 50μ and lightly feathered.

Leg 6 probably represented by the two small setae near areas of attachment of each egg sac (see fig. 91).

Color in life as in *L. foxi*.

Male: Body (fig. 102) with prosome more slender than in female. Length 0.62 mm (0.59–0.66 mm) and greatest width 0.25 mm (0.24–0.27 mm), based on 10 specimens. Ratio of length to width of prosome 1.53 : 1.

Segment of leg 5 (fig. 103) $26 \mu \times 65 \mu$. No ventral intersegmental sclerite. Genital segment about as long as wide, $139 \mu \times 130 \mu$, its lateral borders in dorsal view only slightly rounded. Four postgenital segments $18 \mu \times 41 \mu$, $17 \mu \times 40 \mu$, $13 \mu \times 40 \mu$, and $19 \mu \times 43 \mu$, from anterior to posterior.

Caudal ramus resembling that of female, but smaller, $19 \mu \times 18 \mu$.

Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 1.62 : 1.

Rostral area as in female. First antenna like that of female, but two aesthetes added on second segment and one on fourth segment, so that formula is same as in *L. dentipes*, *L. adelphus*, and *L. foxi*. Second antenna similar to that of female, but, as in *L. foxi*, a few small spinules added on inner surface of segments 1, 2, and 4.

Labrum, mandible, paragnath, and first maxilla like those of female. Second maxilla similar to that of female but proximal spines on lash coarser and longer (fig. 104). Maxilliped (fig. 105) resembling that of *L. foxi*, but claw (122μ) shorter.

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

Legs 1–4 segmented as in female, with same spine and setal formula, except for last segment of endopod of leg 1 (fig. 106) which has arrangement of I,I,4. Proximal outer spine on third segment of exopod in legs 1–3 short as in female. Legs 2 and 3 as in female, without sexual dimorphism.

Leg 5 (see fig. 103) with small unornamented free segment $17 \mu \times 7 \mu$, its two terminal setae 28μ (outer) and 20μ (inner). Seta on body near free segment 33μ . All setae naked.

Leg 6 (see fig. 103) a posterolateral flap on ventral surface of genital segment bearing two naked setae 24μ and 26μ long.

Spermatophore not observed.

Color in life like that of female.

Etymology: The specific name *hetaericus*, from Greek *ἑταιρικός* = comradely or sociable, alludes to the occurrence of this species along with *L. foxi* on the same colonies of octocorals.

Comparison with related species: *L. hetaericus* may be distinguished from all other known species of *Lichomolgus* by the combination of the following characters: the nearly quadrate caudal ramus, the second

antenna with two short terminal claws, the mandible with a relatively long flagellum and without a strong tooth on its basal part, leg 1 showing sexual dimorphism (I,I,4) in the male, legs 1–3 with the proximal outer spine on the third segment of the exopod reduced, the formula for the third segment of the exopod of leg 4 as II,I,5, and the free segment of leg 5 in the female with a length to width ratio of 2.3 : 1 and lacking a proximal expansion or surficial ornamentation.

Two species of *Lichomolgus* described from southeastern India by Ummerkutty (1962) might at first glance be confused with *L. hetaericus*, but differ from the new species in significant details. In *L. brevifurcatus* Ummerkutty, 1962, the female is 1.6 mm in length and the male 1.5 mm; the genital segment of the female is "barrel-like and does not become narrowed in the posterior half"; and the proximal outer spine on the third segment of the exopod in the swimming legs is not reduced. In *L. indicus* Ummerkutty, 1962, the female is 1.05 mm and the male 1.00 mm; there are only two postgenital segments in the female and three in the male; there is no sexual dimorphism in leg 1; and the endopod of leg 4 differs from that of *L. hetaericus* in details of shape and armature. *L. indicus* shows a reduction (as in the new species) of the proximal outer spine on the third segment of the exopod of leg 1 (Ummerkutty's Pl. XII, fig. 9) and leg 2 (his Pl. XIII, fig. 2).

***Lichomolgus insolens* new species**

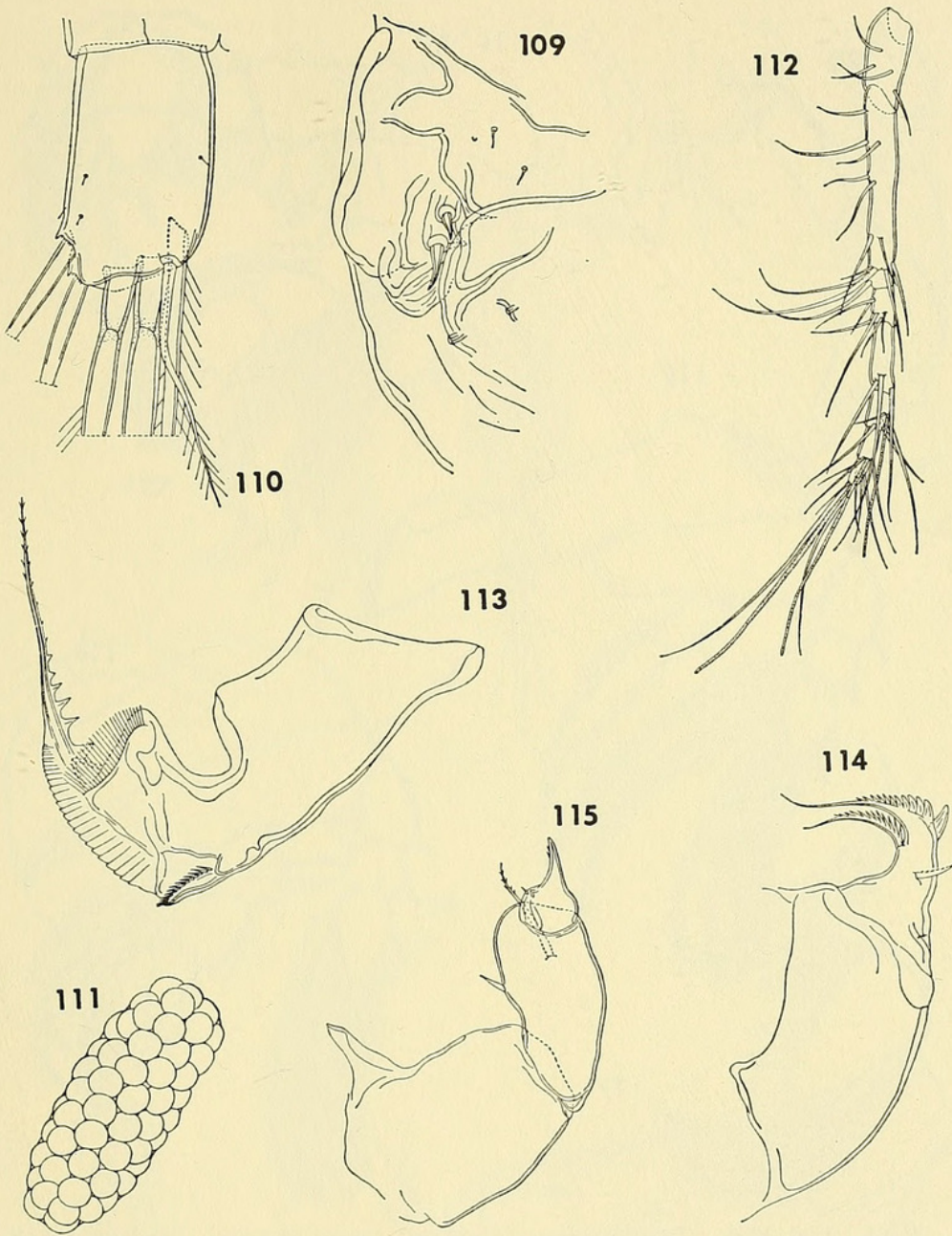
Figures 107–127

Type material: 18 ♀ ♀, 16 ♂ ♂, and 17 copepodids from one colony of *Lobophytum crassum* Marenzeller, in 1 m, opposite Ambariotsimarama, a small island on the southern coast of Nosy Bé, Madagascar, collected 12 June 1964. Holotype ♀, allotype, and 23 paratypes (12 ♀ ♀, 11 ♂ ♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

Other material (from *Lobophytum crassum*): 16 ♀ ♀, 15 ♂ ♂, and 4 copepodids, from one colony, in 10 cm, Ambafaho, Nosy Bé, 25 September 1964; and 12 ♀ ♀, 16 ♂ ♂, and 6 copepodids, from one colony, in 1 m, Nosy N'Tangam, near Nosy Bé, 5 September 1963.

Female: Body (fig. 107) rather weakly sclerotized and with broadened prosome. Anterior border of head with a minute median notch. Length 1.11 mm (1.06–1.19 mm) and greatest width 0.52 mm (0.48–0.58 mm), based on 10 specimens. Ratio of length to width of prosome 1.40 : 1. Segment of leg 1 separated from head by a weak dorsal furrow. Epimeral areas of segments of swimming legs formed as in figure.

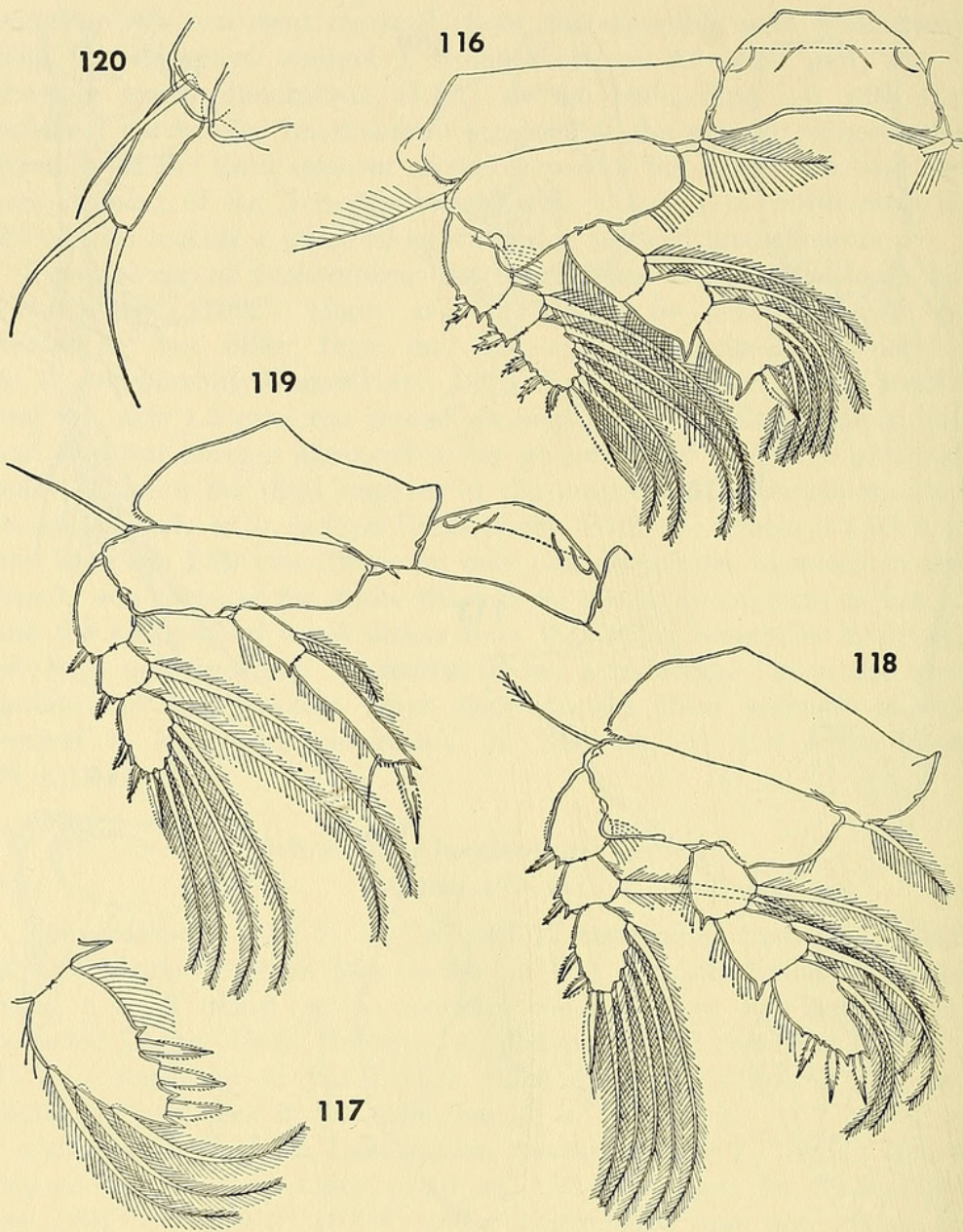
Segment of leg 5 (fig. 108) $78 \mu \times 138 \mu$. Between this segment and genital segment a weak intersegmental sclerite ventrally. Genital segment (fig. 108) longer than wide, $153 \mu \times 121 \mu$, broadest in its anterior half and tapering gradually posteriorly. Areas of attachment



FIGS. 109–115. *Lichomolgus insolens*, new species, female: 109, area of attachment of egg sac, dorsal (F); 110, caudal ramus, dorsal (C); 111, egg sac, ventral (A); 112, first antenna, dorsal (B); 113, mandible, posterior (C); 114, second maxilla, posterior (E); 115, maxilliped, anterior (E).

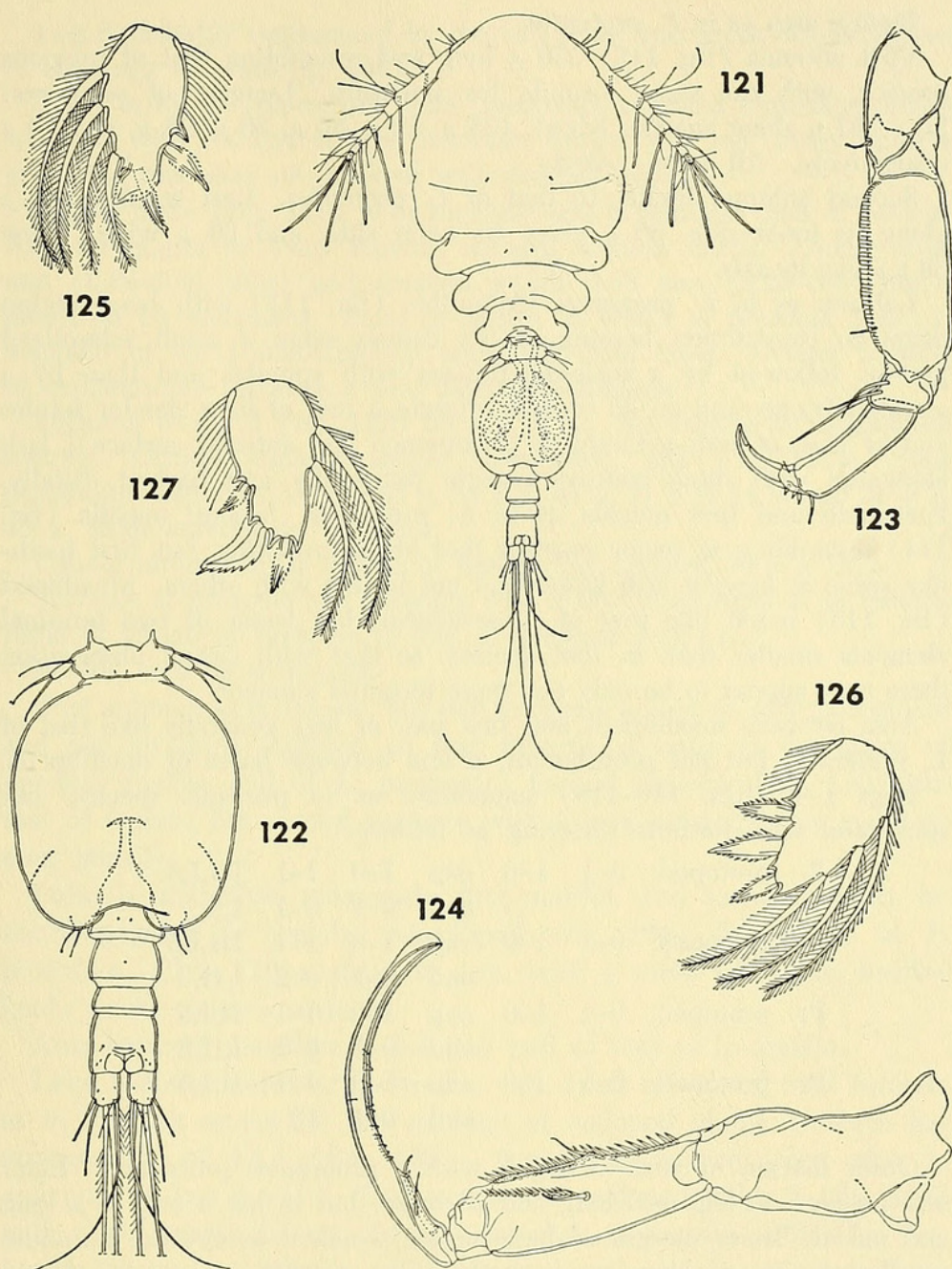
of egg sacs situated dorsolaterally at level of junction of anterior two thirds of segment. Each area (fig. 109) with two small spiniform naked setae $5\ \mu$ and $8\ \mu$ in length. Three postgenital segments $68\ \mu \times 70\ \mu$, $47\ \mu \times 62\ \mu$, and $74\ \mu \times 55\ \mu$, from anterior to posterior.

Caudal ramus (fig. 110) nearly twice as long as wide, $43\ \mu \times 23\ \mu$



FIGS. 116-120. *Lichomolgus insolens*, new species, female: 116, leg 1 and intercoxal plate, anterior (F); 117, last segment of endopod of leg 2, anterior (E); 118, leg 3, anterior (F); 119, leg 4 and intercoxal plate, anterior (F); 120, leg 5, dorsal (E).

in greatest dimensions. Outer lateral seta $70\ \mu$ and naked, dorsal pedicellate seta $38\ \mu$ and lightly feathered, outermost distal seta $104\ \mu$ and naked, innermost distal seta $203\ \mu$ and haired proximally, and the two long median terminal setae $290\ \mu$ (outer) with a few outer spinules and $430\ \mu$ (inner) with a few inner spinules, both inserted between the usual dorsal (unornamented) and ventral (with a short row of spinules) flaps.



FIGS. 121-127. *Lichomolgus insolens*, new species, male: 121, body, dorsal (A); 122, urosome, dorsal (B); 123, second antenna, posterior (outer) (F); 124, maxilliped, outer (F); 125, last segment of endopod of leg 1, anterior (E); 126, last segment of endopod of leg 2, anterior (E); 127, last segment of endopod of leg 3, anterior (E).

Dorsal surface of prosome and urosome with a few hairs. Ratio of length of prosome to that of urosome 1.64 : 1.

Egg sac (fig. 111) elongated, $462 \mu \times 176 \mu$, reaching well beyond ends of caudal rami. Each egg about 47μ in diameter.

Rostral area as in *L. protentus*.

First antenna (fig. 112) 350 μ long and resembling that of previous species, with the same formula for armature. Lengths of segments: 50 μ (57 μ along anterior edge), 135 μ , 32 μ , 50 μ , 30 μ , 28 μ , and 19 μ respectively. All setae naked.

Second antenna similar to that of *L. protentus*. Last segment 48 μ along its inner side, 66 μ along its outer side, and 20 μ wide. Claw 39 μ along its axis.

Labrum as in *L. protentus*. Mandible (fig. 113) with basal region distal to constriction bearing on its convex edge a small sclerotized process followed by a scalelike process with spinules and then by a serrated fringe, and on its concave margin a row of long slender setules and at base of lash a toothlike prominence (on anterior surface); lash elongated with spiny concave margin proximally and barbed distally. Paragnath and first maxilla as in *L. protentus*. Second maxilla (fig. 114) resembling in major respects that of *L. protentus*, but first toothlike spine at base of lash larger and not in line with others. Maxilliped (fig. 115) much like that of *L. protentus*, but lesser of two terminal elements smaller than in that species, so that with casual observation there may appear to be only one large terminal element.

Area between maxillipeds and first pair of legs generally like that of *L. protentus*, but not protuberant; a line between bases of maxillipeds.

Legs 1-4 (figs. 116-119) segmented as in previous species, but spine and setal formula differing as follows:

P ₁	protopod	0-1	1-0	exp	I-0	I-1	III,I,4
				end	0-1	0-1	I,5
P ₂	protopod	0-1	1-0	exp	I-0	I-1	III,I,5
				end	0-1	0-2	I,II,3
P ₃	protopod	0-1	1-0	exp	I-0	I-1	II,I,5
				end	0-1	0-2	I,II,2
P ₄	protopod	0-1	1-0	exp	I-0	I-1	II,I,5
				end	0-1	1,I	

Outer margin of coxa of leg 1 with a prominent protrusion. Inner seta on coxa in legs 1-3 long and plumose, but in leg 4 only 6 μ long and naked. Inner margin of basis of leg 4 naked except for a minute sensillum. Outer spines on exopod of leg 1 with coarse spinulation as in *L. protentus*. Third segment of exopod of leg 3 with only two outer spines (fig. 118) as in leg 4. Endopod of leg 4 (fig. 119) slender and a little longer than exopod. First segment 32 $\mu \times 13 \mu$, with inner distal plumose seta 44 μ . Second segment 68 $\mu \times 13 \mu$ (including terminal processes), bearing distally an outer naked seta 25 μ and an inner fringed spine 35 μ , and resembling the endopod of *L. protentus*.

Leg 5 (fig. 120) with unornamented free segment about 3.6 times longer than wide, 43 $\mu \times 12 \mu$, with width at very slight inner proximal expansion 14 μ ; bearing two terminal naked setae 40 μ (outer) and 53 μ (inner). Seta on body near free segment 50 μ and naked.

Leg 6 probably represented by the two setae near areas of attachment of each egg sac (see fig. 109).

Color in life in transmitted light translucent, prosome sometimes finely speckled with reddish orange, intestine brown, eye red, ovary opaque gray, egg sacs gray or speckled with reddish orange.

Male: Body (fig. 121) with prosome less broadened than in female. Anterior border of head smooth, without median notch. Length 0.89 mm (0.84–0.91 mm) and greatest width 0.33 mm (0.29–0.34 mm), based on 10 specimens. Ratio of length to width of prosome 1.49 : 1. Segment of leg 1 incompletely separated from head. Lateral borders of cephalosome showing a few slight indentations.

Segment of leg 5 (fig. 122) $38 \mu \times 74 \mu$. No ventral intersegmental sclerite. Genital segment longer than wide, $192 \mu \times 164 \mu$. Four postgenital segments $31 \mu \times 48 \mu$, $31 \mu \times 47 \mu$, $21 \mu \times 44 \mu$, and $36 \mu \times 45 \mu$, from anterior to posterior.

Caudal ramus similar to that of female, but smaller, $30 \mu \times 19 \mu$.

Surfaces of prosome and urosome with a few small hairs as in female. Ratio of length of prosome to that of urosome 1.46 : 1.

Rostral area as in female.

First antenna as in female, but two aesthetes added on second segment and one on third segment, so that formula is same as for males of previous species and of *L. protentus*. Second antenna (fig. 123) like that of female, but second segment with a long striated inner membranous lamella.

Labrum, mandible, paragnath, first maxilla, and second maxilla resembling those of female. Maxilliped (fig. 124) slender, as in *L. protentus*. Claw 126μ along its axis, with a series of obtuse hyaline knobs on its concave surface.

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

Legs 1–4 segmented as in female, with same spine and setal formula as in that sex except for last segment of endopod of leg 1 which has arrangement of I,1,4 (fig. 125). Sexual dimorphism seen also in endopods of legs 2 and 3. Last segment of endopod of leg 2 (fig. 126) with three spines shorter and broader than in female, with first two having coarser spinulation. (In female lengths of these spines from proximal to distal are 18μ , 17μ , and 17μ ; in male 13μ , 14μ , and 12μ). Last segment of endopod of leg 3 (fig. 127) with middle spine modified (compare with fig. 118). Endopod of leg 4 as in female.

Leg 5 (see fig. 122) with small unornamented free segment, $20 \mu \times 7 \mu$, without a proximal expansion. Two terminal naked setae 28μ and 31μ , and naked seta on body near free segment 35μ .

Leg 6 (see fig. 122) a posterolateral flap on ventral surface of genital segment bearing two naked setae about 23μ long.

Spermatophore (see fig. 107), attached to female, elongated and somewhat irregular, $177 \mu \times 86 \mu$ (not including neck).

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

Etymology: The specific name *insolens*, from Latin = contrary to custom, refers to the unusual formula of II,I,5 for the last segment of the exopod of leg 3 in this species.

Comparison with related species: *L. insolens* appears to be closely related to *L. protentus*, a species associated with *Sarcophyton* in Madagascar. In both there are striking similarities in the mandible, the maxilliped of the female, the nature of the outer spines on the exopod of leg 1, and the armature of the endopod of leg 4. The new species differs from *L. protentus*, however, in several important features: its smaller size, the proportions of the genital segment in the female, details of the mouthparts, the presence of only two outer spines on the last segment of the exopod of leg 3, the unornamented leg 5 in the female, the membranous lamella on the second segment of the second antenna in the male, and the series of hyaline knobs on the claw of the maxilliped of the male.

Like *L. protentus*, *L. insolens* seems to approach *L. robustus* Thompson and A. Scott, 1903, described from one female found in washings of dredged invertebrates in Ceylon. However, in *L. robustus* the formula for the last segment of the exopod of leg 4 is III,I,5, and the two terminal elements on the endopod of this leg appear to be different (T. and S., Pl. XVI, fig. 20).

Although interspecific variation in the number of outer spines on the last segment of the exopod of leg 4 occurs in *Lichomolgus* (the formula for the segment being either III,I,5 or II,I,5), it is unusual that the corresponding segment of leg 3 should show a reduction from III,I,5 to II,I,5, as is the case in the new species. Another species, *L. curtiramus* Bocquet and Stock, 1962, shows a similar armature on the third segment of leg 3.

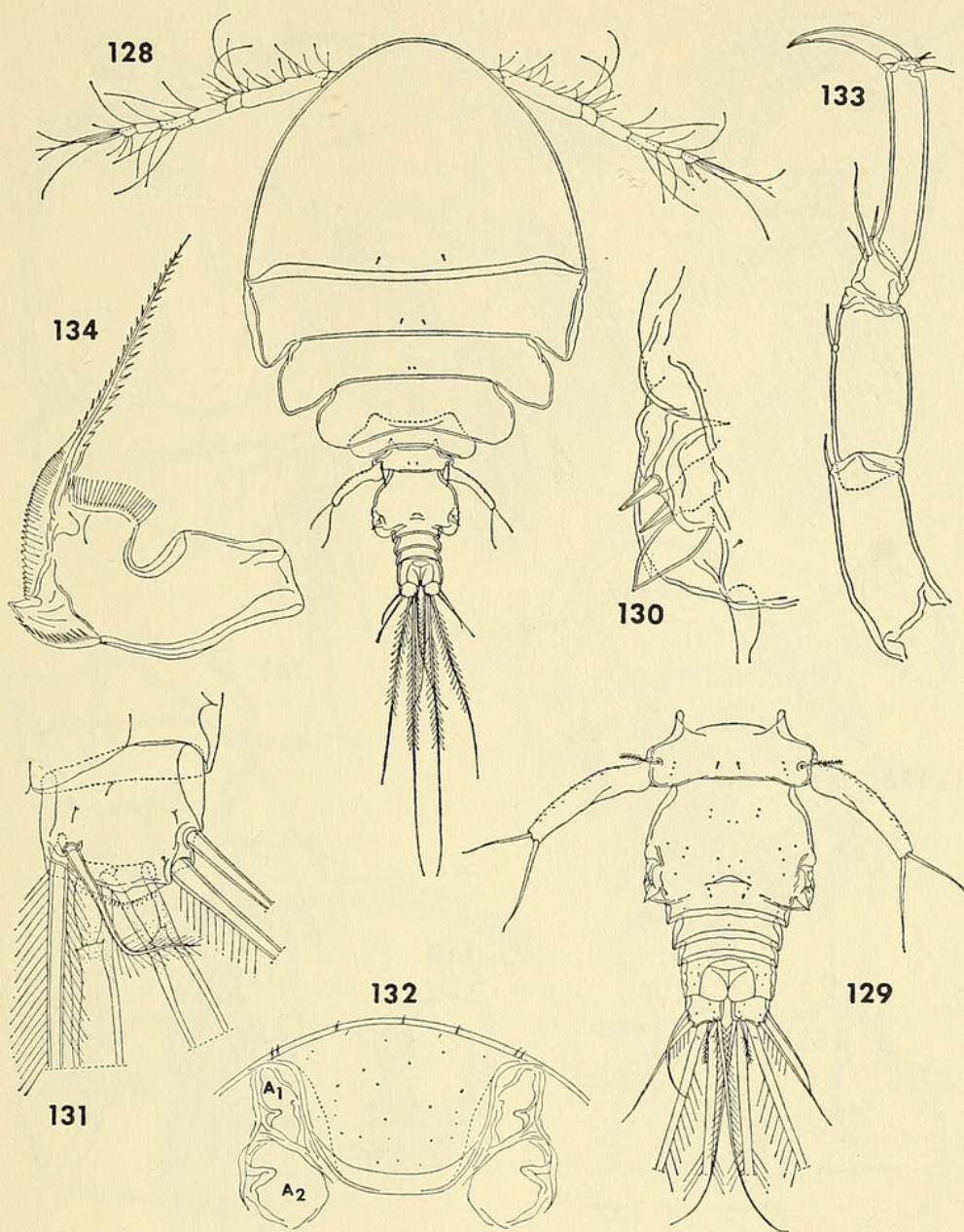
***Lichomolgus spathophorus* new species**

Figures 128–147

Type material: 13 ♀♀ and 17 ♂♂ from two colonies of *Sarcophyton glaucum* (Quoy and Gaimard), in 0.5 m, Tany Kely, a small island south of Nosy Bé, Madagascar, collected 23 June 1963. Holotype ♀, allotype, and 18 paratypes (7 ♀♀, 11 ♂♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

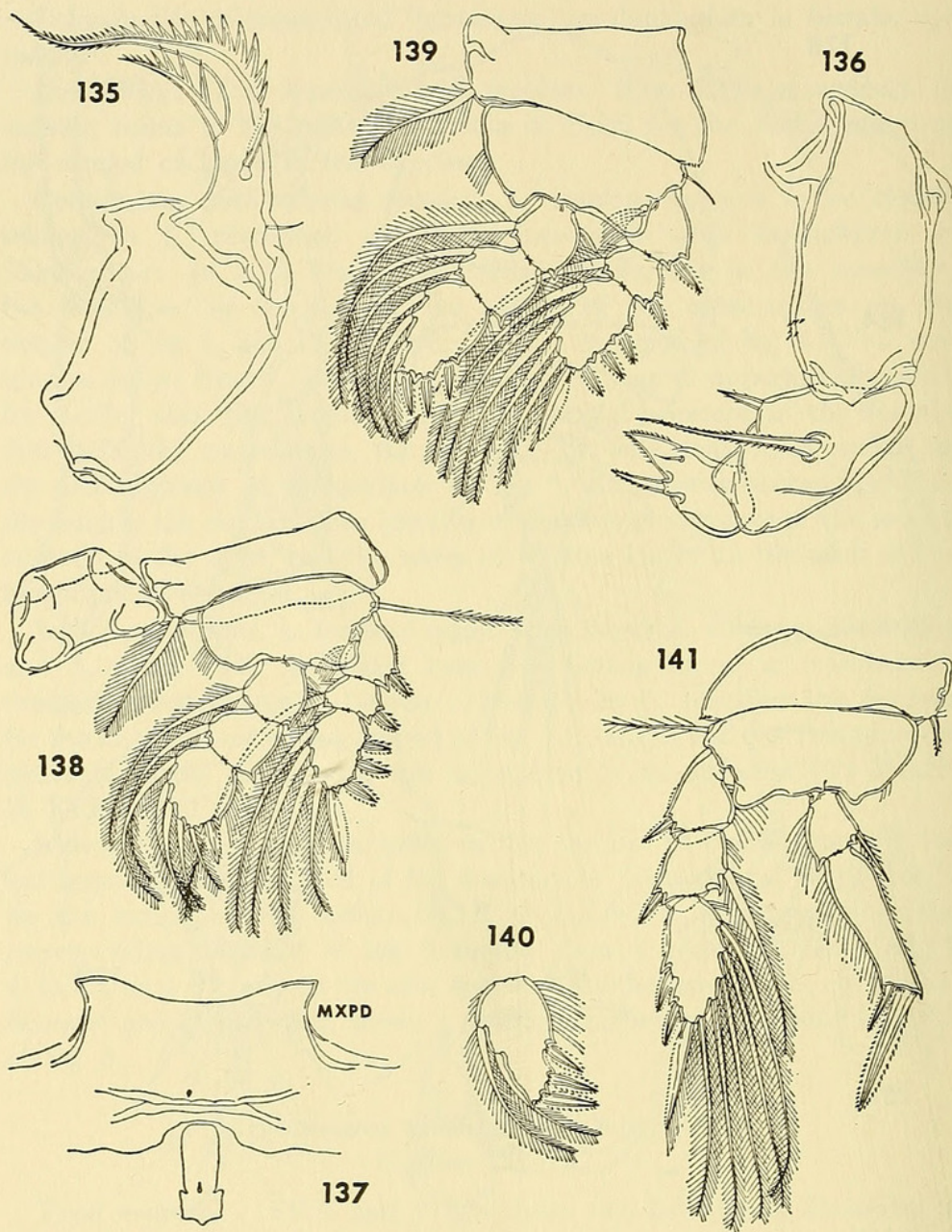
Female: Body (fig. 128) with expanded prosome. Length 0.98 mm (0.95–1.04 mm) and greatest width 0.59 mm (0.57–0.61 mm), based on 10 specimens. Ratio of length to width of prosome 1.17 : 1. Segment of leg 1 distinctly separated from head. Epimeral areas of segments of legs 1–4 as in figure.

Segment of leg 5 (fig. 129) $60 \mu \times 146 \mu$. Between this segment and genital segment a short ventral intersegmental sclerite. Genital



FIGS. 128–134. *Lichomolgus spathophorus*, new species, female: 128, body, dorsal (A); 129, urosome, dorsal (B); 130, area of attachment of egg sac, dorsal (C); 131, caudal ramus, dorsal (C); 132, rostral area, ventral (B); 133, second antenna, posterior (outer) (D); 134, mandible, posterior (E).

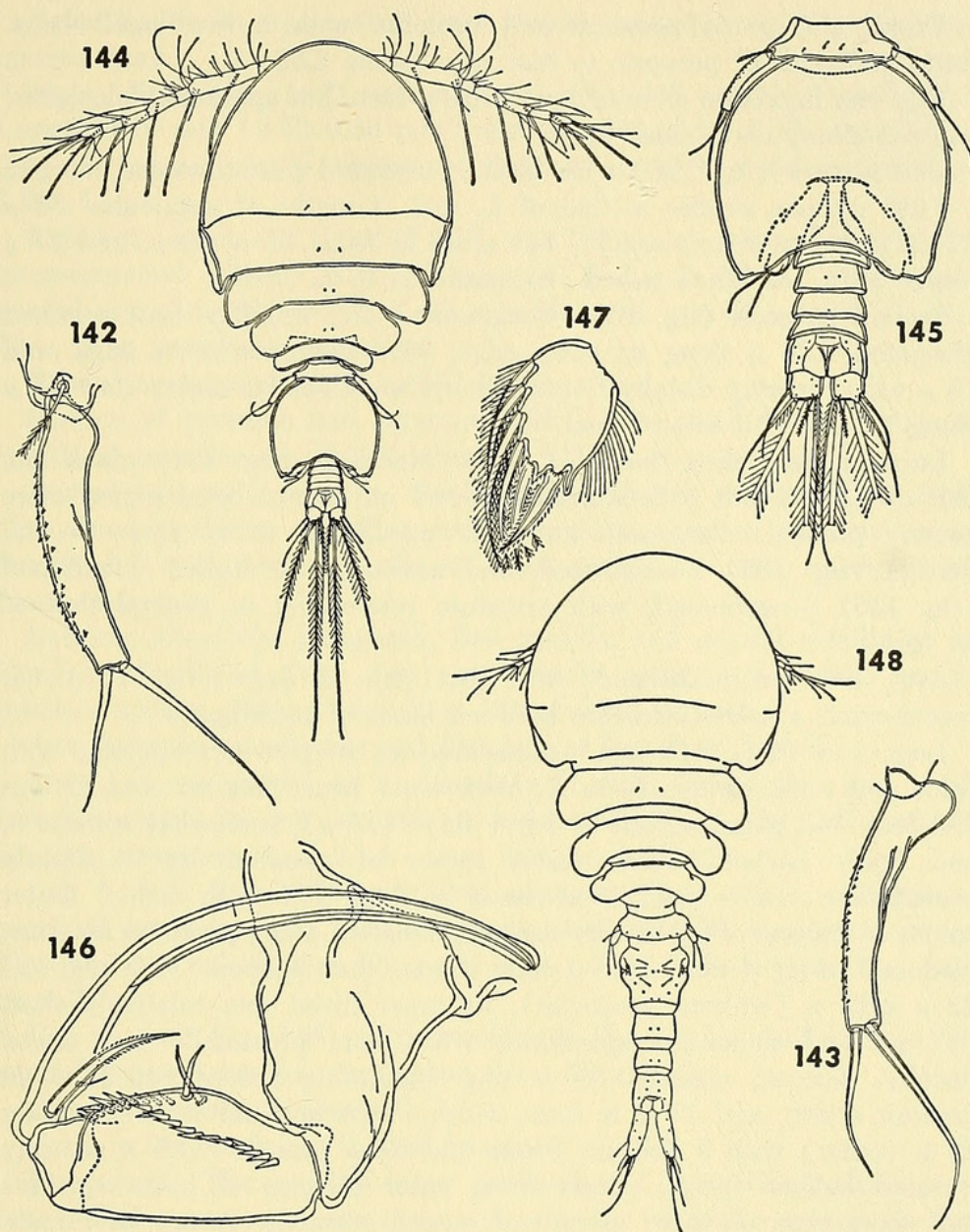
segment (fig. 129) $117 \mu \times 140 \mu$, wider than long, a little broadened in its anterior four-fifths in dorsal view, but abruptly narrowed in its posterior fifth. Areas of attachment of egg sacs located almost laterally in posterior half of segment. Each area (fig. 130) with two naked spiniform setae 10μ and 8μ long and a large pointed bladellike process.



FIGS. 135-141. *Lichomolgus spathophorus*, new species, female: 135, second maxilla, posterior (E); 136, maxilliped, posterior (E); 137, area between maxillipeds and first pair of legs, ventral (D); 138, leg 1 and intercoxal plate, anterior (D); 139, leg 2, anterior (D); 140, last segment of endopod of leg 3, anterior (D); 141, leg 4, anterior (D).

Three postgenital segments $26 \mu \times 89 \mu$, $21 \mu \times 83 \mu$, and $31 \mu \times 78 \mu$, from anterior to posterior.

Caudal ramus (fig. 131) quadrate, $30 \mu \times 30 \mu$ in greatest dimensions. Outer lateral seta 44μ and naked, pedicellate dorsal seta 45μ and feathered, outermost distal seta 104μ with proximal inner spinules,



FIGS. 142–148. *Lichomolgus spathophorus*, new species, female: 142, leg 5, dorsal (F); 143, leg 5, dorsal (F). Male: 144, body, dorsal (A); 145, urosome, dorsal (B); 146, maxilliped, inner (E); 147, last segment of endopod of leg 1, anterior (E). *Lichomolgus incisus*, new species, female: 148, body, dorsal (A).

innermost distal seta $180\ \mu$ with spinules along both sides proximally, and the two long median terminal setae $375\ \mu$ (outer) with spinules on inner midregion only or along both sides and $500\ \mu$ (inner) with spinules along both sides proximally. Both terminal setae inserted between dorsal (unornamented) and ventral (with a marginal row of spinules) flaps.

Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 2.58 : 1.

Egg sacs broken in all ovigerous females seen, but apparently elongated and containing many small eggs.

Rostral area (fig. 132) with broadly rounded posteroventral margin.

First antenna similar to that of *L. foxi*. Lengths of segments: 35 μ (71 μ along anterior margin), 143 μ , 23 μ , 64 μ , 55 μ , 39 μ , and 27 μ respectively. All setae naked. Armature as in *L. foxi*.

Second antenna (fig. 133) 4-segmented and slender. Last segment elongated, 122 μ along its outer edge, 94 μ along its inner edge, and 18 μ wide, bearing distally five small hyaline elements and a claw 58 μ along its axis. All setae naked.

Labrum resembling that of *L. foxi*. Mandible (fig. 134) much like that of *L. foxi*, but with scalelike process on convex basal region more acutely pointed. Paragnath and first maxilla as in *L. foxi*. Second maxilla (fig. 135) 2-segmented, and armed as in figure. Maxilliped (fig. 136) 3-segmented, with armature resembling in general that of *L. foxi*.

Area between maxillipeds and first pair of legs (fig. 137) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 138-141) segmented as in previous species, with spine and setal formula as in *L. hetaericus*. Inner seta on coxa of legs 1-3 long and plumose, but in leg 4 short (18 μ), somewhat spiniform, and finely barbed. Inner distal corner of coxa of leg 1 slightly protuberant. Inner margin of basis of legs 1-4 with hairs. Outer spines on exopod of leg 1 with coarse spinulation along proximal margins. Endopod of leg 4 (fig. 141) a little shorter than exopod. First segment 33 $\mu \times 25 \mu$ (without processes), its inner distal seta relatively short (37 μ) and somewhat spiniform, with hairs proximally but naked distally. Second segment 85 μ long (including processes), 23 μ in greatest width, and 17 μ in least width. Two unequal terminal spines 26 μ (outer) with a delicate fringe and 54 μ (inner) with a coarsely serrated hyaline fringe. Hairs along outer margins of both segments and short hairs on inner margin of second segment. A row of minute spinules near insertions of terminal spines.

Leg 5 (fig. 142) with elongated free segment, 122 $\mu \times 20 \mu$, having a slight proximal inner expansion, where width is 22 μ . Outer convex surface with numerous small spines. Two naked terminal setae 57 μ (outer) and 81 μ (inner). Plumose seta on body near free segment 38 μ . Apparent variation in size of proximal expansion, some females showing free segment of leg 5 as in fig. 143, where dimensions of segment are 112 $\mu \times 16 \mu$, and width at expansion 27 μ . Other females showing expansion intermediate in size between those in figs. 142 and 143.

Leg 6 probably represented by the two setae near areas of attachment of each egg sac (see fig. 130).

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

Male: Body (fig. 144) with prosome expanded nearly as in female. Length 0.79 mm (0.72–0.86 mm) and greatest width 0.39 mm (0.33–0.44 mm), based on 10 specimens. Ratio of length to width of prosome 1.26 : 1.

Segment of leg 5 (fig. 145) $33 \mu \times 105 \mu$. A very short ventral intersegmental sclerite. Genital segment $174 \mu \times 187 \mu$. Four post-genital segments $22 \mu \times 60 \mu$, $22 \mu \times 64 \mu$, $18 \mu \times 64 \mu$, and $29 \mu \times 66 \mu$, from anterior to posterior.

Caudal ramus as in female, $25 \mu \times 24 \mu$.

Surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 2.0 : 1.

Rostral area as in female. First antenna similar to that of *L. foxi*, with three aesthetes added as in that species. Second antenna as in female, but with small spinules on inner surfaces of first, second, and fourth segments.

Labrum, mandible, paragnath, first maxilla, and second maxilla as in female. Maxilliped (fig. 146) moderately stout and armed as in previous species, with a long claw 151μ along its axis.

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

Legs 1–4 segmented as in female and with same spine and setal formula, except for last segment of endopod of leg 1 (fig. 147) which has the arrangement of I,I,4. Legs 2–4 as in female.

Leg 5 (see fig. 145) with free segment $62 \mu \times 8 \mu$, without a proximal expansion, and with extremely small spinules on outer surface. Two terminal naked setae 58μ and 33μ . Seta on body near free segment 33μ .

Leg 6 (see fig. 145) a posterolateral flap on ventral surface of genital segment bearing two naked setae 50μ long.

Spermatophore not observed.

Color in life similar to that of female.

Etymology: The specific name *spathophorus*, from Greek *σπάθη* = a broad blade and *φορέω* = to carry, refers to the bladelike process on the area of attachment of each egg sac.

Comparison with related species: *L. spathophorus* may be distinguished from all but two species of *Lichomolgus* on the basis of a combination of three features: the single short claw on the second antenna, the formula of II,I,5 for the third segment of the exopod of leg 4, and the short quadrangle caudal ramus. The remaining two species have other characters that show them to be distinct from *L. spathophorus*. *L. anomalus* A. Scott, 1909, differs in having the endopod of leg 1 in the male geniculate between the second and third segments, the third segment being elongated (about 3 : 1 in A. Scott's Pl. LXVII, fig. 14). *L. elegans* Thompson and A. Scott, 1903, of which the male is unknown, is larger (female 1.5 mm), has a less expanded prosome,

and the genital segment has different proportions and shape than in the new species.

***Lichomolgus incisus* new species**

Figures 148–167

Type material: 24 ♀ ♀, 10 ♂ ♂, and 3 copepodids from one colony of *Sarcophyton ehrenbergi* Marenzeller, in 0.5 m, Andilana, Nosy Bé, collected 9 August 1963. Holotype ♀, allotype, and 24 paratypes (19 ♀ ♀, 5 ♂ ♂) deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

Female: Body (fig. 148) with expanded and relatively short cephalosome, its anterior border broadly rounded in dorsal view. Length 1.03 mm (0.90–1.08 mm) and greatest width 0.42 mm (0.40–0.43 mm), based on 10 specimens. Ratio of length to width of prosome 1.41 : 1. Segment of leg 1 separated from head by an incomplete dorsal transverse furrow. Epimeral areas of legs 1–4 rounded.

Segment of leg 5 (fig. 149) $52 \mu \times 117 \mu$. Between this segment and genital segment a short ventral intersegmental sclerite. Genital segment (fig. 149) only a little wider than long, $114 \mu \times 121 \mu$. Areas of attachment of egg sacs situated dorsolaterally in anterior half of segment. Each area (fig. 150) bearing two minute naked setae about 4μ long. Three postgenital segments $52 \mu \times 68 \mu$, $44 \mu \times 63 \mu$, and $56 \mu \times 61 \mu$, from anterior to posterior.

Caudal ramus (fig. 151) elongated, 77μ long, 24μ wide near base, and 19μ wide distally. Setae relatively short. Outer lateral seta 35μ , dorsal pedicellate seta 28μ , outermost distal seta 33μ , innermost distal seta 82μ , and the two long median terminal setae 105μ (outer) and 150μ (inner), both inserted between unornamented dorsal and ventral flaps. All setae naked.

Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 1.42 : 1.

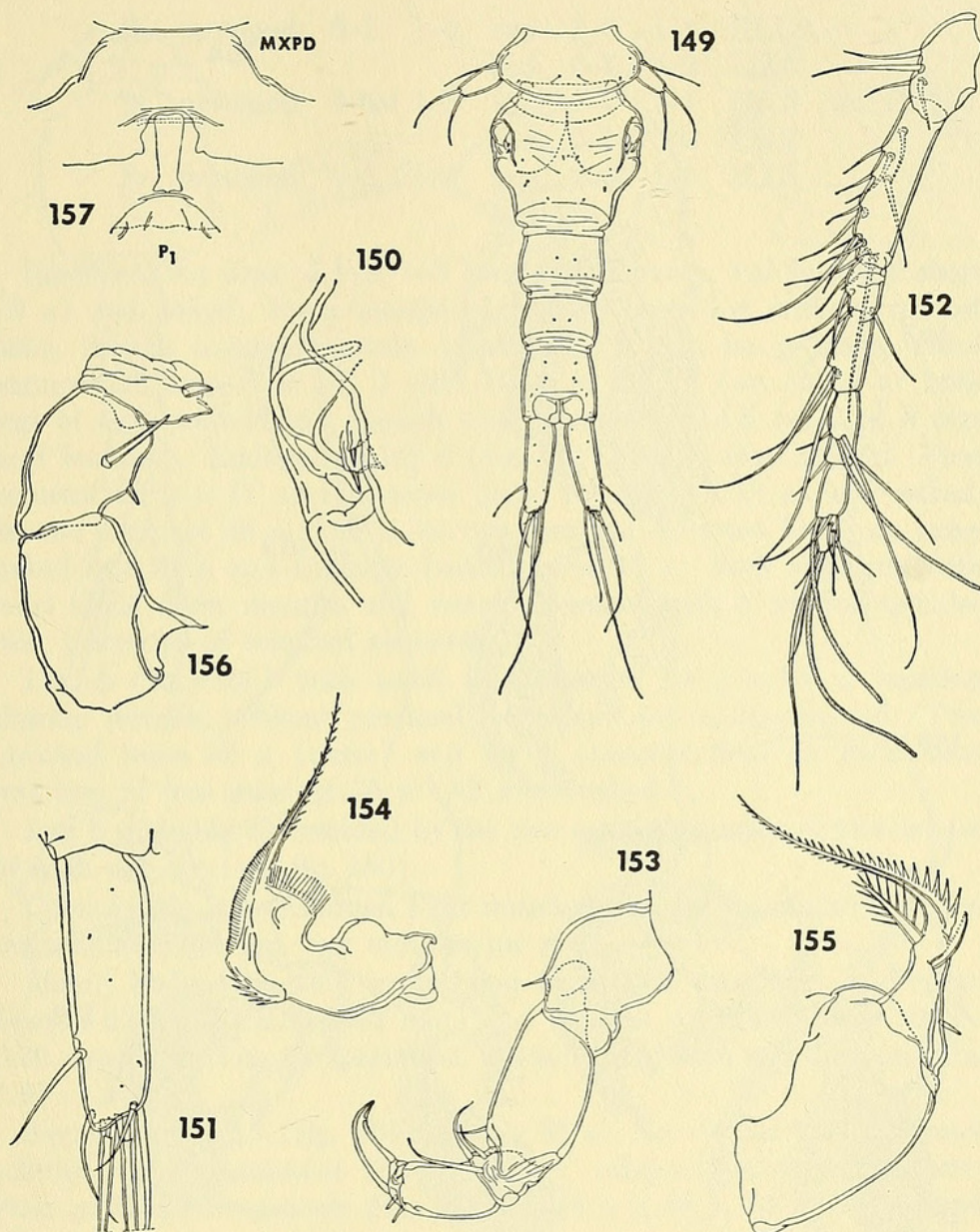
Egg sac in one ovigerous female elongated, $450 \mu \times 175 \mu$, reaching just beyond ends of caudal rami and containing many eggs about 52μ in diameter.

Rostral area as in *L. cristatus*.

First antenna (fig. 152) 7-segmented, but relatively short (232μ). Armature as in all previous species. Lengths of segments: 25μ (41μ along anterior margin), 61μ , 21μ , 31μ , 30μ , 21μ , and 17μ respectively. All setae naked.

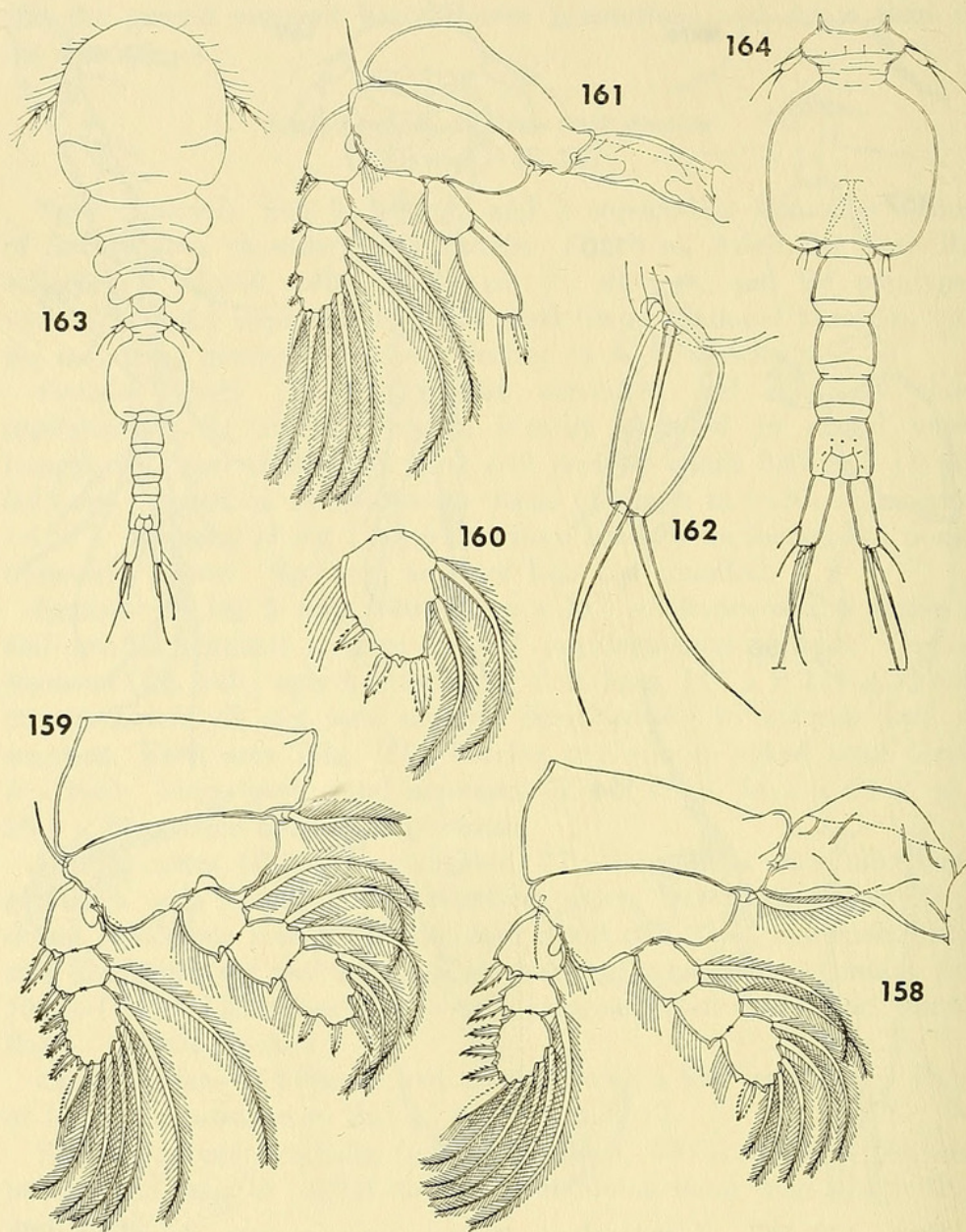
Second antenna (fig. 153) 4-segmented. Last segment relatively short, 46μ along its outer edge, 31μ along its inner edge, and 19μ wide, bearing distally four small hyaline elements and a terminal claw 33μ along its axis. All setae naked.

Labrum as in *L. foxi*. Mandible (fig. 154) resembling that of *L. spathophorus*, but scalelike process on convex side of basal region not pointed distally. Paragnath and first maxilla as in *L. protentus*. Second



FIGS. 149-157. *Lichomolgus incisus*, new species, female: 149, urosome, dorsal (B); 150, area of attachment of egg sac, dorsal (C); 151, caudal ramus, dorsal (E); 152, first antenna, ventral (F); 153, second antenna, posterior (outer) (F); 154, mandible, posterior (E); 155, second maxilla, posterior (E); 156, maxilliped, posterior (E); 157, area between maxillipeds and first pair of legs, ventral (D).

maxilla (fig. 155) resembling that of *L. spathophorus*. Maxilliped (fig. 156) 3-segmented. Second segment with two unequal naked setae, the longer seta only about four times the length of the other. Third segment with the usual two terminal spiniform elements (one without an articulation) and a small subterminal seta; outer side of segment swollen and membranous.



FIGS. 158-164. *Lichomolgus incisus*, new species, female: 158, leg 1 and intercoxal plate, anterior (F); 159, leg 2, anterior (F); 160, last segment of endopod of leg 3, anterior (E); 161, leg 4 and intercoxal plate, anterior (F); 162, leg 5, dorsal (C). Male: 163, body, dorsal (A); 164, urosome, dorsal (B).

Area between maxillipeds and first pair of legs (fig. 157) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1-4 (figs. 158-161) segmented as in previous species, with spine and setal formula as follows:

P ₁	protopod	0-1	1-0	exp	I-0	I-1	III,I,4
				end	0-1	0-1	I,5

P ₂	protopod	0-1	1-0	exp	I-0	I-1	III,I,5
				end	0-1	0-2	I,II,3
P ₃	protopod	0-1	1-0	exp	I-0	I-1	II,I,5 (or III,I,5)
				end	0-1	0-2	I,II,2
P ₄	protopod	0-1	1-0	exp	I-0	I-1	II,I,5
				end	0-1	1,I	

Inner seta on coxa of legs 1-3 long and plumose, but in leg 4 short ($5\ \mu$) and naked. Inner margin of basis of legs 1-4 without row of hairs, though a minute setule (sensillum ?) may be present. Third segment of exopod of leg 3 with II,I,5 or III,I,5 (on either or both legs of same individual), though most frequently II,I,5 (in 7 of 8 legs in 4 females). Endopod of leg 4 (fig. 161) shorter than exopod. First segment $25\ \mu \times 17\ \mu$, with inner distal seta short ($19\ \mu$) and naked. Second segment $39\ \mu \times 17\ \mu$, its two terminal elements being an outer naked seta $29\ \mu$ and an inner barbed spine $18\ \mu$. Both segments with hairs along outer margins and second segment with a row of spinules near insertions of terminal elements.

Leg 5 (fig. 162) with small free segment $34\ \mu \times 15\ \mu$, tapering slightly distally, without proximal expansion and unornamented. Two terminal setae $38\ \mu$ (outer) and $42\ \mu$ (inner). Seta on body near insertion of free segment $36\ \mu$. All setae naked.

Leg 6 probably represented by the two setae near areas of attachment of each egg sac (see fig. 150).

Color in life in transmitted light translucent except for slightly opaque cephalosome, eye red, egg sacs opaque gray.

Male: Body (fig. 163) resembling in general form that of female. Length 0.90 mm (0.86-0.92 mm) and greatest width 0.29 mm (0.29-0.30 mm), based on 10 specimens. Ratio of length to width of prosome 1.69 : 1.

Segment of leg 5 (fig. 164) $44\ \mu \times 88\ \mu$. No ventral intersegmental sclerite. Genital segment $156\ \mu \times 146\ \mu$, subquadrate in dorsal view. Four postgenital segments $44\ \mu \times 55\ \mu$, $44\ \mu \times 49\ \mu$, $34\ \mu \times 47\ \mu$, and $49\ \mu \times 49\ \mu$, from anterior to posterior.

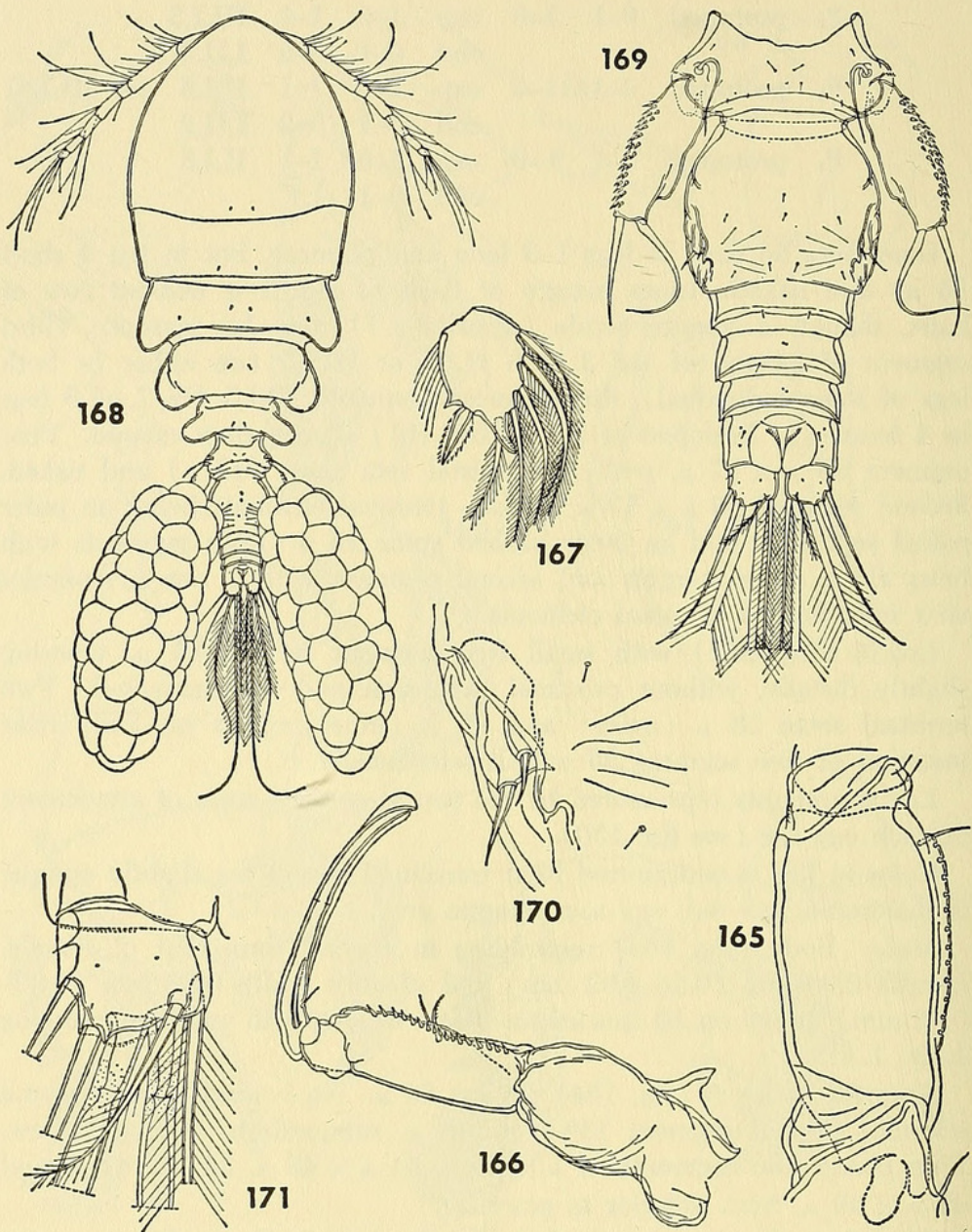
Caudal ramus as in female, but slightly shorter, $68\ \mu \times 19\ \mu$.

Surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 1.12 : 1.

Rostral area as in female. First antenna similar to that of female but three aesthetes added, so that formula is same as for males of previous species. Second antenna resembling that of female but second segment (fig. 165) bearing a notched lamella along inner surface.

Labrum, mandible, paragnath, first maxilla, and second maxilla like those of female. Maxilliped (fig. 166) with only one row of spines along inner surface of second segment; claw relatively short, $115\ \mu$ along its axis (including terminal lamella), and not strongly recurved.

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



FIGS. 165-171. *Lichomolgus incisus*, new species, male: 165, second segment of second antenna, posterior (outer) (C); 166, maxilliped, inner (F); 167, last segment of endopod of leg 1, anterior (E). *Lichomolgus singularipes*, new species, female: 168, body, dorsal (A); 169, urosome, dorsal (D); 170, area of attachment of egg sac, dorsal (C); 171, caudal ramus, dorsal (C).

Legs 1-4 segmented as in female and with same spine and setal formula. Sexual dimorphism showing in last segment of endopod of leg 1 (fig. 167), where terminal spiniform process is much longer than in female. Last segment of endopods of legs 2 and 3 also with longer terminal processes than in female.

Leg 5 (see fig. 164) with free segment $24 \mu \times 8 \mu$, unornamented, its two terminal setae 25μ and 35μ . Seta on body near free segment 25μ . All setae naked.

Leg 6 (see fig. 164) a posterolateral flap on ventral surface of genital segment bearing two naked setae 22μ and 24μ .

Spermatophore not observed.

Color in life similar to that of female, but cephalosome more translucent.

Etymology: The specific name *incisus*, from Latin = cut into or notched, alludes to the notched lamella on the second segment of the second antenna of the male.

Comparison with related species: Two features of *L. incisus* may be used as recognition characters,—the swollen and membranous outer side of the last segment of the maxilliped in the female and the notched lamella along the inner surface of the second segment of the second antenna of the male. These occur in no other known species of *Lichomolgus*.

The new species has several features which suggest a relationship to *L. insolens*. Both species have a reduction in the number of outer spines on the third segment of the exopod of leg 3, the terminal armature of the endopod of leg 4 consisting of a spine and a seta, and a lamella or membrane along the inner surface of the second segment of the second antenna of the male.

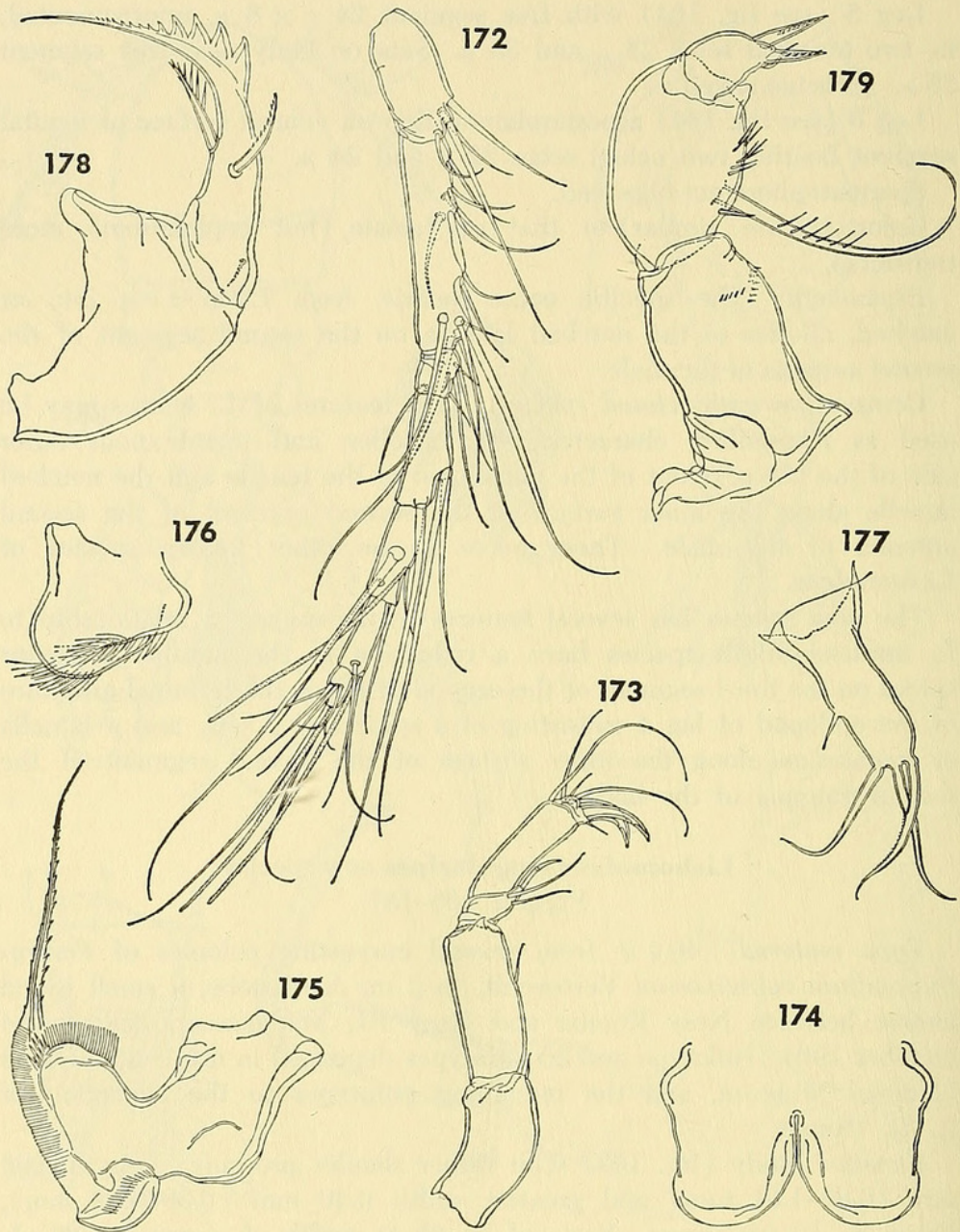
***Lichomolgus singularipes* new species**

Figures 168–187

Type material: 40 ♀♀ from several encrusting colonies of *Parerythropodium rubiginosum* Verseveldt, in 2 m, Ambariobe, a small island almost between Nosy Komba and Nosy Bé, Madagascar, collected 4 October 1964. Holotype and 30 paratypes deposited in the United States National Museum, and the remaining paratypes in the collection of A. G. Humes.

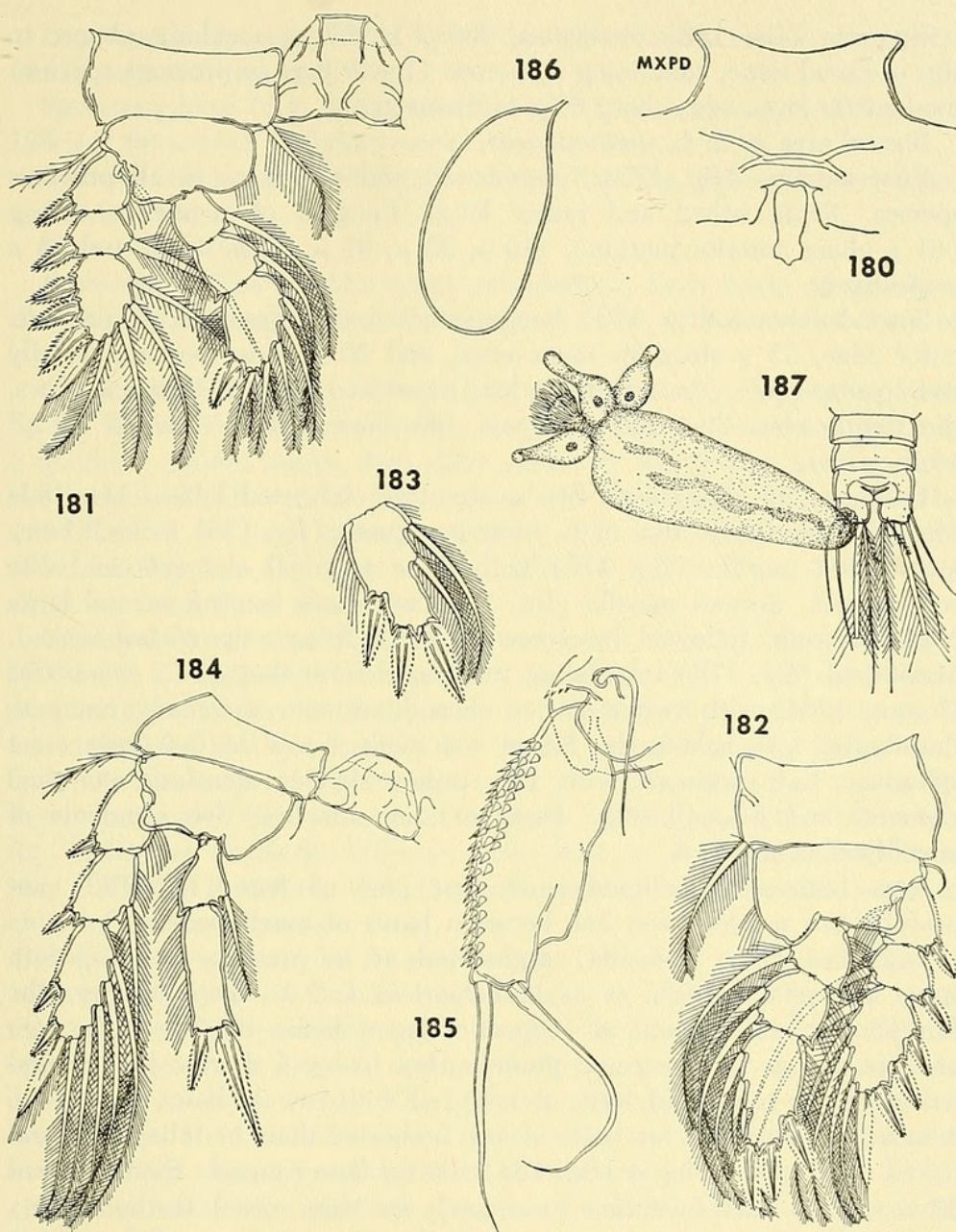
Female: Body (fig. 168) with rather slender prosome. Length 0.95 mm (0.88–1.01 mm) and greatest width 0.40 mm (0.39–0.42 mm), based on 10 specimens. Ratio of length to width of prosome 1.86 : 1. Segment of leg 1 separated from head by a dorsal transverse furrow. Epimeral areas of segments of legs 1–4 rounded.

Segment of leg 5 (fig. 169) $57 \mu \times 120 \mu$. Between this segment and genital segment a very short ventral intersegmental sclerite. Genital segment a little longer than wide, $120 \mu \times 107 \mu$, in dorsal view not greatly expanded, with its posterior eighth set off by transverse dorsal ridges and at first glance suggesting a postgenital segment. Areas of attachment of egg sacs situated dorsolaterally just posterior to middle of segment. Each area (fig. 170) with two spiniform naked setae 11μ and 17μ long. Three postgenital segments $26 \mu \times 68 \mu$, $21 \mu \times 63 \mu$, and $29 \mu \times 61 \mu$, from anterior to posterior.



FIGS. 172-179. *Lichomolgus singularipes*, new species, female: 172, first antenna, ventral (D); 173, second antenna, posterior (outer) (D); 174, labrum, ventral (F); 175, mandible, posterior (E); 176, paragnath, posterior (C); 177, first maxilla, posterior (E); 178, second maxilla, posterior (E); 179, maxilliped, anterior (E).

Caudal ramus (fig. 171) quadrate, $24 \mu \times 25 \mu$ in greatest dimensions. Outer lateral seta 83μ and naked, dorsal pedicellate seta 40μ and feathered, outermost distal seta 95μ and naked, innermost distal seta 161μ with proximal spinules, and the two long median terminal setae 275μ (outer) and 360μ (inner) with strong spinules except near tips,



FIGS. 180-187. *Lichomolgus singularipes*, new species, female: 180, area between maxillipeds and first pair of legs, ventral (D); 181, leg 1 and intercoxal plate, anterior (D); 182, leg 2, anterior (D); 183, last segment of endopod of leg 3, anterior (D); 184, leg 4 and intercoxal plate, anterior (D); 185, leg 5, dorsal (E); 186, spermatophore, empty and attached to female, dorsal (D); 187, *Ophryodendron* sp., attached to caudal ramus, dorsal (B).

both inserted between dorsal (unornamented) and ventral (with a marginal row of very small spinules) flaps.

Dorsal surface of prosome and urosome with a few small hairs. Ratio of length of prosome to that of urosome 2.62 : 1.

Egg sac (fig. 168) elongated, $500\ \mu \times 200\ \mu$, reaching almost to tips of ramal setae, containing numerous (fewer than in previous species) moderately large eggs about $60\ \mu$ in diameter.

Rostral area as in *L. spathophorus*.

First antenna (fig. 172) 7-segmented and armed as in all previous species. Setae naked and rather long. Lengths of segments: $33\ \mu$ ($61\ \mu$ along anterior margin), $115\ \mu$, $22\ \mu$, $61\ \mu$, $51\ \mu$, $40\ \mu$, and $23\ \mu$ respectively.

Second antenna (fig. 173) 4-segmented. Last segment $80\ \mu$ along its outer edge, $53\ \mu$ along its inner edge, and $20\ \mu$ wide, bearing distally five hyaline setae (three of them long) and two unequal terminal claws, the stouter claw $36\ \mu$ along its axis, the more slender claw $43\ \mu$. All setae naked.

Labrum (fig. 174) with two moderately elongated lobes. Mandible (fig. 175) similar to that of *L. foxi*. Paragnath (fig. 176) a small hairy lobe. First maxilla (fig. 177) with three terminal elements and one subterminal. Second maxilla (fig. 178) with lash bearing several large proximal teeth, followed by a row of small spines; tip of lash naked. Maxilliped (fig. 179) resembling in general form that of *L. commodus* Humes, 1964, with two setae on second segment extremely unequal, the shorter seta naked, the longer one with a row of 6–9 long erect spinules. Last segment with two rather slender spiniform terminal elements and a small seta. Ornamentation on first two segments of maxilliped as in figure.

Area between maxillipeds and first pair of legs (fig. 180) not protuberant; a sclerotized line between bases of maxillipeds.

Legs 1–4 (figs. 181–184) segmented as in previous species, with spine and setal formula as in *L. hetaericus* and *L. spathophorus* (the formula for last segment of exopod of leg 4 being II,I,5). Inner seta on coxa of legs 1–3 long and plumose, but in leg 4 shorter ($23\ \mu$) and naked. Inner margin of basis of legs 1–3 with row of hairs, but in leg 4 naked. Outer seta on basis of leg 2 shorter than in other legs and naked. Endopod of leg 4 (fig. 184) shorter than exopod. First segment $33\ \mu \times 26\ \mu$ (not including processes), its inner distal feathered seta $50\ \mu$. Second segment $70\ \mu \times 21\ \mu$ (length including processes and width taken at middle), its two unequal terminal barbed spines $32\ \mu$ (outer) and $67\ \mu$ (inner). Both segments with hairs along outer margins and second segment with a row of spinules near insertions of terminal spines.

Leg 5 (fig. 185) with rather broad free segment, $81\ \mu \times 34\ \mu$ in greatest dimensions, its outer surface with scalelike spines and its inner margin abruptly expanded a short distance from distal end of segment, the contour of margin from this point to base of segment being irregular as in figure. Two terminal naked setae $68\ \mu$ (outer) and $82\ \mu$ (inner). Seta on body near insertion of free segment $44\ \mu$ and naked. A row of small spines near this seta.

Leg 6 probably represented by the two setae near areas of attachment of each egg sac (see fig. 170).

Spermatophore (fig. 186), attached to female and empty, elongated, $125 \mu \times 60 \mu$ (not including neck).

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

Male: Unknown.

Etymology: The specific name *singularipes*; from Latin *singularis* = remarkable, extraordinary, and *pes* = foot, refers to the unusual form of leg 5.

Comparison with related species: *L. singularipes* may be distinguished by the form of leg 5 from all other species in the genus having similarly a quadrate caudal ramus, two short claws on the second antenna, and the formula II,I,5 on the last segment of the exopod of leg 4. The maxilliped of the new species resembles that of *L. commodus* Humes, 1964, but leg 5 in the latter is very different (ratio about 4 : 1 with a slight proximal inner expansion).

L. singularipes cannot be directly compared with *L. vagans* Gurney, 1927, and *L. aegyptius* Gurney, 1927, of which only males are known. In *L. vagans* the length of the male is 1.07 mm, the second antenna is unusually long and slender, and the caudal ramus is a little longer than wide. In the male of *L. aegyptius* the second antenna has terminally three claws and two setae and the form of the mandible (Gurney's fig. 112D) is distinctly different from that in *L. singularipes*. It is very unlikely, therefore, that the new species could be the same as either of Gurney's species.

Epibiotic protozoan on L. singularipes: Thirteen of the 40 females collected (33 per cent) had large suctorians, identified by Dr. John O. Corliss as *Ophryodendron* sp., attached to the caudal ramus. These epibionts were not specially stained, but observed only incidentally in dissections in lactic acid. The greatest dimensions of the specimen drawn (fig. 187), which shows three buds, were $275 \mu \times 78 \mu$, the length being almost one-third that of the copepod.

The suctorians were attached always to the dorsal surface of the caudal rami, and there was never more than one on each ramus. They were distributed on the 13 females as follows: 8 copepods had one on the right caudal ramus, 4 copepods had one on the left ramus, and one copepod had two suctorians, one on each ramus.

Since only female copepods were collected, it is not known whether male copepods also bear these suctorians.

Lichomolgus squamiger Humes and Frost, 1964

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

New host record: From *Sinularia whiteleggei* Lüttschwager: 36 ♀ ♀, 24 ♂ ♂, and 19 copepodids from one colony, in 2 m, Pte. Lokobe, Nosy Bé, 16 August 1960.

Two minor additions should be made to the original description by Humes and Frost. In their figure 174 of the second antenna of the female, there are six small hyaline elements near the terminal claw, and in their figure 180 of the maxilliped of the female there is a small seta on the last segment in addition to the two terminal elements. These features have been verified by studying a paratype of *L. squamiger*.

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