

PROCEEDINGS
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CYCLOPOID COPEPODS ASSOCIATED WITH
TRIDACNIDAE (MOLLUSCA, BIVALVIA)
AT ENIWETOK ATOLL¹

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Four species of cyclopoid copepods have been reported from large sea clams of the genus *Tridacna*. Kossmann (1877) described a new genus and species, *Paclabius tumidus*, from the pericardium (Herzbeutel) of a *Tridacna* at Bohol in the Philippine Islands, but this copepod has not been found again. Three new species of the myicolid genus *Anthessius* were described by Humes and Stock (1965) from the Red Sea and Madagascar: *Anthessius solidus* from *Tridacna squamosa* Lamarck, *Anthessius amicalis* from *Tridacna squamosa* and *Tridacna elongata* Lamarck, and *Anthessius alatus* from *Tridacna noae* (Röding) and *Tridacna squamosa*.

At Eniwetok the same three species of *Anthessius* and a new species of *Lichomolgus* occurred in the mantle cavity of various Tridacnidae.

The specimens reported here were collected by the author and Mr. Charles T. Krebs during field work made possible by the support and facilities of the Eniwetok Marine Biological Laboratory at Eniwetok. The study of the copepods has been aided by a grant (GB-8381X) from the National Science Foundation.

All figures have been drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the

¹ SEP Contr. No. 241.

scale at which it was drawn. The abbreviations used are: A_1 = first antenna, A_2 = second antenna, MXPD = maxilliped, and P_1 = leg 1.

FAMILY MYICOLIDAE YAMAGUTI, 1936

The collections of *Anthessius* made at Eniwetok Atoll, Marshall Islands, in 1969, are listed below. Specimens of the three species have been deposited in the National Museum of Natural History, Washington, and in the Zoölogisch Museum, Amsterdam, as indicated.

Anthessius solidus Humes and Stock, 1965

From *Tridacna squamosa* Lamarck: 3 ♀ ♀, 5 ♂ ♂, and 2 copepodids from 1 host, length of shell 30 cm, in a depth of 17 m, in lagoon west of beach between Parry (Elmer) I. and Eniwetok I., 10 July (USNM); 1 ♀, 6 ♂ ♂, and 2 copepodids from 1 host, length 30 cm, in 6 m, west of Eniwetok I., 17 July; 2 ♂ ♂ from 1 host, length 28 cm, west of Eniwetok I., 17 July; 1 ♀, 3 ♂ ♂, and 1 copepodid from 4 hosts, 12.5, 16, 20, and 29 cm long, in 3 m, south of Parry (Elmer) I., 9 July; 1 ♀ from 1 host, length 34 cm, in 6 m, west of Eniwetok I., 17 July; 2 ♀ ♀ from 1 host, length 32 cm, in 6 m, west of Eniwetok I., 16 July; 1 ♂ and 2 copepodids from 1 host, length 34 cm, in 6 m, west of Eniwetok I., 17 July.

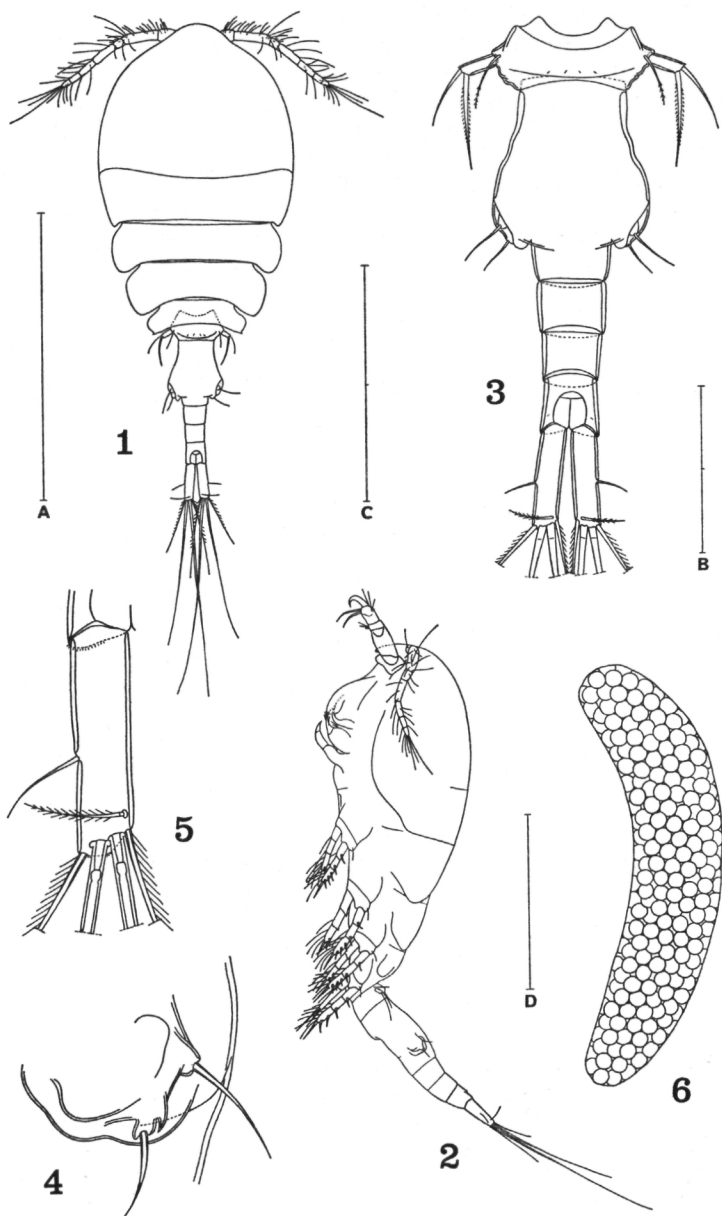
Anthessius amicalis Humes and Stock, 1965

From *Tridacna squamosa*: 21 ♀ ♀, 29 ♂ ♂, and 2 copepodids from 1 host, length 30 cm, in 17 m, in lagoon west of beach between Parry (Elmer) I. and Eniwetok I., 10 July (USNM); 14 ♀ ♀, 33 ♂ ♂, and 5 copepodids from 1 host, length 30 cm, in 6 m, west of Eniwetok I., 17 July (ZMA); 3 ♀ ♀, 13 ♂ ♂, and 4 copepodids from 1 host, length 28 cm, in 6 m, west of Eniwetok I., 17 July; 3 ♀ ♀, 20 ♂ ♂, and 3 copepodids from 4 hosts, 12.5, 16, 20, and 29 cm long, in 3 m, south of Parry (Elmer) I., 9 July; 8 ♀ ♀, 11 ♂ ♂, and 1 copepodid from 1 host, length 34 cm, in 6 m, west of Eniwetok I., 17 July; 1 ♀ and 2 ♂ ♂ from 1 host, length 32 cm, in 6 m, west of Eniwetok I., 16 July; 4 ♀ ♀, 5 ♂ ♂, and 1 copepodid from 1 host, in 3 m, western end of Bogen (Rex) I., 23 June; 4 ♀ ♀, 1 ♂, and 3 copepodids from 1 host, length 34 cm, in 6 m, west of Eniwetok I., 17 July.

From *Hippopus hippopus* (Linnaeus): 1 ♀ from 1 host, length 27.5 cm, in 1 m, Runit (Yvonne) I., 19 July.

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FIGS. 1-6. *Lichomolgus tridacnae* new species, female: 1, dorsal (A); 2, lateral (A); 3, urosome, dorsal (B); 4, area of attachment of egg sac, lateral (C); 5, caudal ramus, dorsal (D); 6, egg sac, dorsal (A). Scale A = 1.0 mm, B = 0.2 mm, C = 0.1 mm, and D = 0.1 mm.



Anthessius alatus Humes and Stock, 1965

From *Tridacna squamosa*: 1 ♀, 2 ♂ ♂, and 3 copepodids from 4 hosts, 12.5, 16, 20, and 29 cm long, in 3 m, south of Parry (Elmer) I., 9 July (ZMA); 2 ♂ ♂ from 1 host, length 30 cm, in 6 m, west of Eniwetok I., 17 July; 2 ♀ ♀ and 4 ♂ ♂ from 1 host, length 28 cm, in 6 m, west of Eniwetok I., 17 July (USNM); 2 ♂ ♂ from 1 host, length 34 cm, in 6 m, west of Eniwetok I., 17 July; 1 ♂ from 1 host, length 32 cm, in 6 m, west of Eniwetok I., 16 July; 2 ♀ ♀, 1 ♂, and 2 copepodids from 1 host, in 3 m, western end of Bogen (Rex) I., 23 June; 1 ♀ and 1 copepodid from 3 hosts, each 10 cm long, in 3 m, north of Sand I., near Eniwetok I., 8 July.

From *Tridacna maxima* (Röding): 1 ♂ from 1 host, length 20 cm, in 2 m, western side of reef on northern end of Muti (David) I., 29 June; 1 ♂ from 2 hosts, both 10 cm long, in 3 m, southern end of Parry (Elmer) I., 5 July; 1 ♀ and 1 ♂ from 2 hosts, 11.5 and 13.5 long, in 3 m, Runit (Yvonne) I., 12 July; 1 ♀ and 1 ♂ from 1 host, length 18.5 cm, in 5 m, west of Eniwetok I., 16 July.

From *Tridacna gigas* (Linnaeus): 14 ♂ ♂ from 1 host, length 41 cm, in 3 m, west of Eniwetok I., 11 July.

New hosts are: *Hippopus hippopus* for *Anthessius amicalis* and *Tridacna maxima* and *Tridacna gigas* for *Anthessius alatus*. [A single male *Anthessius amicalis* was recovered from a spondylid bivalve, *Spondylus varius* Sowerby, in 18 m, in the lagoon west of the beach between Parry (Elmer) I. and Eniwetok I., 10 July. This record is regarded as accidental, since all other *A. amicalis* have been found in Tridacnidae.]

FAMILY LICHOMOLGIDAE KOSSMANN, 1877

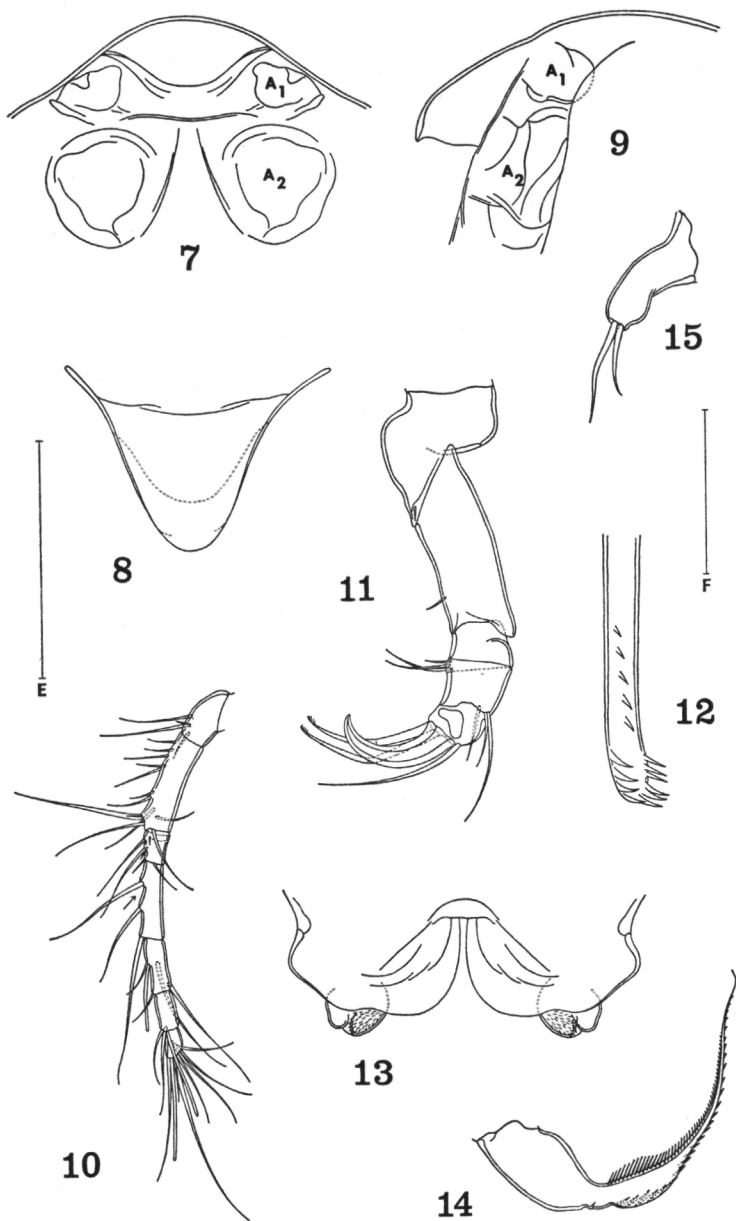
Lichomolgus tridacnae new species

Figures 1-32

Type material: 10 ♀ ♀, 11 ♂ ♂, and 2 copepodids from 1 *Tridacna gigas* (Linnaeus), length 41 cm, in 3 m, west of Eniwetok I., Eniwetok Atoll, Marshall Islands, 11 July 1969. Holotype ♀, allotype, and 14 paratypes (6 ♀ ♀, 8 ♂ ♂) deposited in the National Museum of Natural His-

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FIG. 7-15. *Lichomolgus tridacnae* new species, female: 7, rostrum, ventral (as seen in entire animal) (E); 8, rostrum, anteroventral (as seen in a dissection) (E); 9, rostrum, lateral (E); 10, first antenna (with the arrow indicating the position of an aesthete added in the male), dorsal (B); 11, second antenna, anterior (inner) (E); 12, tip of geniculate seta on last segment of second antenna, anterior (F); 13, labrum and paragnaths, ventral (C); 14, mandible, anterior (C); 15, first maxilla, anterior (C). Scale E = 0.2 mm and F = 0.02 mm.



tory, Washington; the remaining paratypes (dissected) and the copepods in the collection of the author.

Other specimens: All from Eniwetok Atoll in 1969.

From *Tridacna gigas*: 4 ♀ ♀, 4 ♂ ♂, and 1 copepodid from 1 host, length 30 cm, in 3 m, west of Eniwetok I., 20 July.

From *Tridacna squamosa* Lamarck: 1 copepodid from 1 host, in 3 m, western end of Bogen (Rex) I., 23 June; 12 ♀ ♀ and 8 ♂ ♂ from 4 hosts, 12.5, 16, 20, and 29 cm long, in 3 m, south of Parry (Elmer) I., 9 July (USNM); 11 ♀ ♀ and 2 ♂ ♂ from 1 host, length 30 cm, in 17 m, in lagoon west of beach between Parry (Elmer) I. and Eniwetok I., 10 July (ZMA); 1 ♀ from 1 host, length 32 cm, in 6 m, west of Eniwetok I., 16 July; 4 ♀ ♀ and 1 ♂ from 1 host, length 34 cm, in 6 m, west of Eniwetok I., 17 July; 1 ♀ from 1 host, length 34 cm, in 6 m, west of Eniwetok I., 17 July; 6 ♀ ♀ and 4 copepodids from 1 host, length 30 cm, in 6 m, west of Eniwetok I., 17 July; 3 ♀ ♀ and 2 ♂ ♂ from 1 host, length 28 cm, in 6 m, west of Eniwetok I., 17 July.

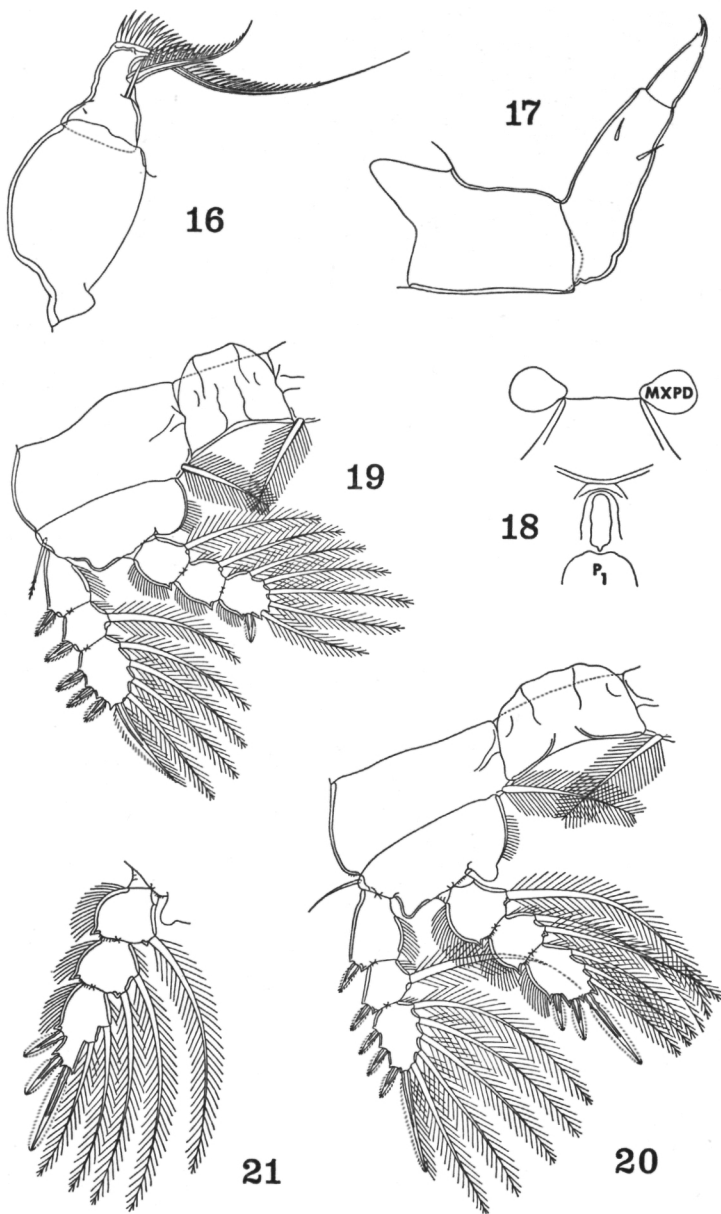
Female: The body (Figs. 1 and 2) is moderately slender. The length, not including the setae on the caudal rami, is 1.79 mm (1.62–1.86 mm) and the greatest width 0.70 mm (0.67–0.74 mm), based on 10 specimens in lactic acid. The segment of leg 1 is separated from the head dorsally by a transverse furrow. The epimeral areas of the segments of legs 1–4 are as indicated in Figure 1. The ratio of the length to the width of the prosome is 1.56:1. The ratio of the length of the prosome to that of the urosome is 1.72:1.

The segment of leg 5 (Fig. 3) is $81 \times 205 \mu$. Between this segment and the genital segment there is no ventral intersegmental sclerite. The genital segment is a little longer than wide, $234 \times 216 \mu$, broadest in its posterior half, with its posterior sixth abruptly constricted. The genital areas are located laterally on the expanded part of the segment. Each area (Fig. 4) bears two naked setae 29μ and 44μ with a small spiniform process between them. The three postgenital segments are $73 \times 96 \mu$, $70 \times 78 \mu$, and $73 \times 75 \mu$ from anterior to posterior. The anal segment bears on each side a posteroventral row of very small spinules.

The caudal ramus (Fig. 5) is elongated, $140 \times 35 \mu$ in greatest dimensions, the ratio being 4:1. The outer lateral seta is 57μ and naked, the dorsal seta 65μ and haired, the outermost terminal seta 195μ with outer spinules, the innermost terminal seta 239μ with inner spinules, and the two long median terminal setae 560μ (outer) and 770μ (inner), both

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FIGS. 16–21. *Lichomolgus tridacnae* new species, female: 16, second maxilla, posterior (C); 17, maxilliped, inner (C); 18, area between maxillipeds and first pair of legs, ventral (B); 19, leg 1 and intercoxal plate, anterior (E); 20, leg 2 and intercoxal plate, anterior (E); 21, endopod of leg 3, anterior (E).



naked and both inserted dorsally to a small ventral flap with minute spinules.

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome have very few hairs (sensilla).

The large egg sac (Fig. 6) is elongated, $500 \times 100 \mu$, reaches well beyond the tips of the ramal setae, and contains many small eggs about 62μ in diameter.

The rostrum in a ventral view of the whole animal appears as a broad lobe (Fig. 7), but in a dissected specimen it is subtriangular and linguiform (Fig. 8). In lateral view it projects noticeably (Fig. 9).

The first antenna (Fig. 10) is seven segmented and 455μ long. The lengths of the segments (measured along their posterior nonsetiferous margins) are: 22 (72μ along its anterior margin), 112, 35, 91, 68, 44, and 33μ respectively. The formula for the armature is 4, 13, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. All the setae are naked.

The second antenna (Fig. 11) is four segmented, with the fourth segment 85μ along its outer edge, 48μ along its inner edge, and 52μ wide, bearing distally a recurved claw 99μ along its axis and five setae, two of them geniculate and provided apically with spinules as in Figure 12. The first and second segments bear a small seta. The third segment carries three setae.

The labrum (Fig. 13) has two broad posteroventral lobes. The mandible (Fig. 14) has a long slender blade armed with spines along one side and with slender spinules along the other. The paragnath (Fig. 13) is a small lobe with fine spinules. The first maxilla (Fig. 15) has two setae. The second maxilla (Fig. 16) has an unarmed first segment. Its second segment carries a minute setule on its proximal postero-outer surface, a surficial posterior naked seta, and an inner distal spine with unilateral spinules, and terminates in a long slender lash borne nearly at a right angle to the two segments and having graduated spinules along the outer edge. The maxilliped (Fig. 17) is three segmented, the first segment unarmed, the second with two small naked setae, and the third terminating in a recurved clawlike process near the base of which there is a minute thorn.

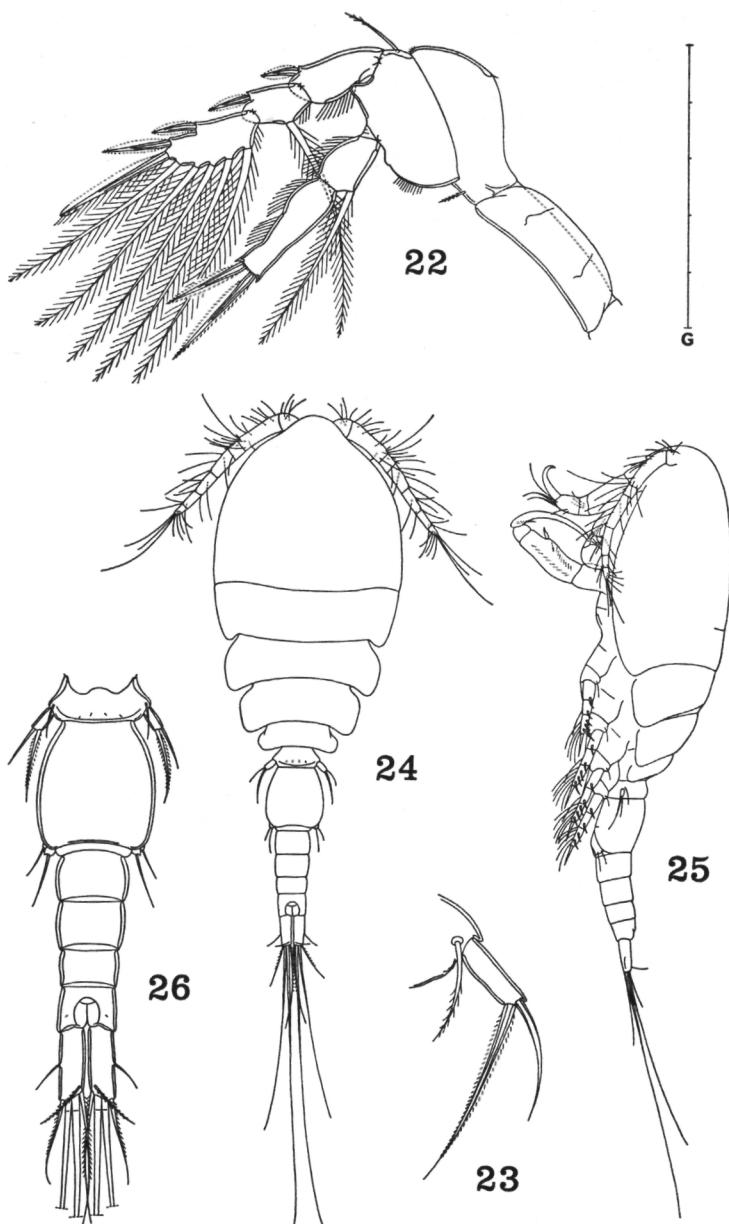
The area between the maxillipeds and the first pair of legs (Fig. 18) is only slightly protuberant (Fig. 2); a weakly sclerotized line connects the bases of the maxillipeds.

Legs 1-4 (Figs. 19, 20, 21, 22) have trimerous rami except for the endopod of leg 4 which is two segmented. The armature is as follows (the Roman numerals indicating spines, the Arabic numerals setae):

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FIGS. 22-23. *Lichomolgus tridacnae* new species, female: 22, leg 4 and intercoxal plate, anterior (E); 23, leg 5, dorsal (D).

FIGS. 24-26. *Lichomolgus tridacnae* new species, male: 24, dorsal (G); 25, lateral (G); 26, urosome, dorsal (E). Scale G = 0.5 mm.



P ₁	coxa	0-1	basis	1-0	exp	I-0;	I-1;	III,I,4
					enp	0-1;	0-1;	I,5
P ₂	coxa	0-1	basis	1-0	exp	I-0;	I-1;	III,I,5
					enp	0-1;	0-2;	I,II,3
P ₃	coxa	0-1	basis	1-0	exp	I-0;	I-1;	III,I,5
					enp	0-1;	0-2;	I,II,2
P ₄	coxa	0-1	basis	1-0	exp	I-0;	I-1;	II,I,5
					enp	0-1;	II	

The inner coxal seta on legs 1-3 is long and plumose, but on leg 4 is short (22 μ) and finely barbed. The inner margin of the basis in all four legs bears a row of hairs. The outer spines on the exopod of leg 1 are fringed with stronger lateral spinules than in the succeeding legs. The exopod of leg 4 is 205 μ long. The first segment of the endopod is 52 \times 41 μ , with its inner distal plumose seta 122 μ . The second segment is 105 μ long including the terminal processes, 32 μ in greatest width, and 18 μ in least width, with its outer margin irregular. The two terminal fringed spines are 72 μ (outer) and 100 μ (inner). Both segments have hairs along the outer margin, those on the second segment in two groups.

Leg 5 (Fig. 23) has a small unornamented free segment 41 \times 15 μ bearing two terminal elements, one a slender naked seta 72 μ , the other a stouter fringed seta 112 μ . The seta on the body near the insertion of the free segment is 50 μ and haired.

Leg 6 is represented by the two setae on the genital area (Fig. 4).

Living specimens in transmitted light are translucent, the eye red, the egg sacs opaque gray.

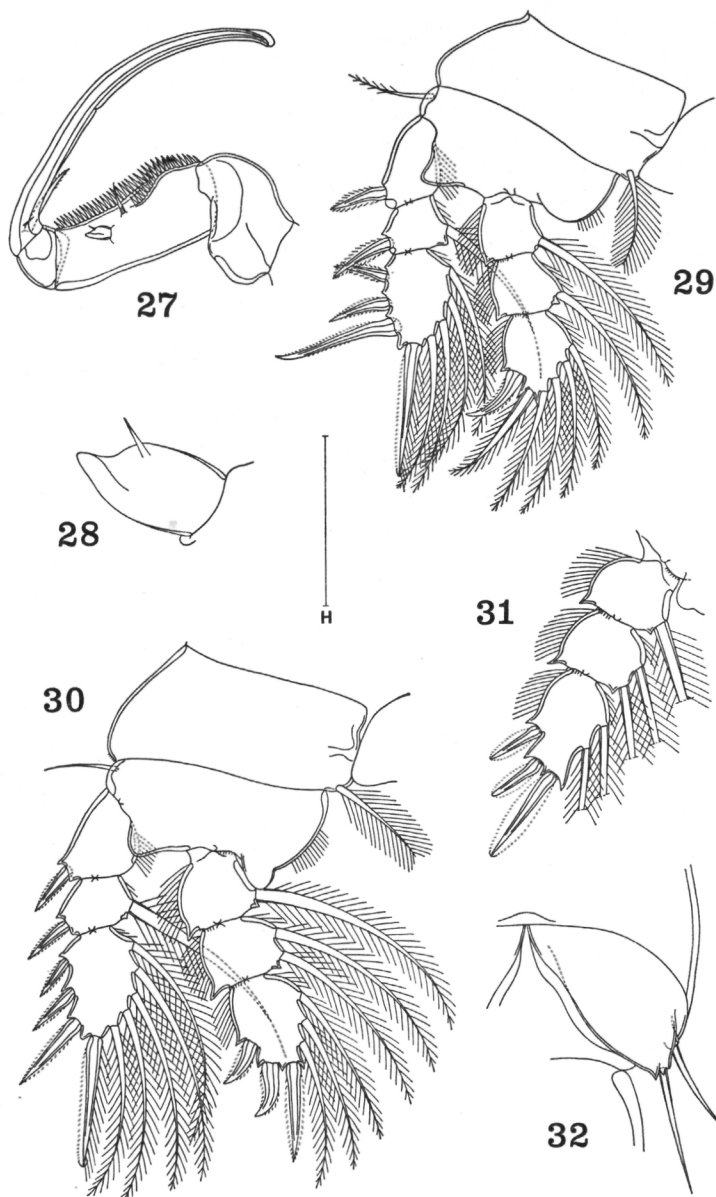
Male: The body (Figs. 24 and 25) resembles in general form that of the female. The length, without the ramal setae, is 0.89 mm (0.84-0.94 mm) and the greatest width 0.31 mm (0.28-0.33 mm), based on 10 specimens in lactic acid. The ratio of the length to the width of the prosome is 1.77:1. The ratio of the length of the prosome to that of the urosome is 1.66:1.

The segment of leg 5 (Fig. 26) is 31 \times 81 μ . There is no ventral intersegmental sclerite. The genital segment is 104 \times 94 μ , only slightly expanded laterally. The four postgenital segments are 39 \times 56 μ , 39 \times 52 μ , 31 \times 45 μ , and 36 \times 47 μ from anterior to posterior.

The caudal ramus resembles that of the female but is shorter, 60 \times 21 μ , with the ratio being about 3:1.

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FIGS. 27-32. *Lichomolgus tridacnae* new species, male: 27, maxilliped, antero-inner (D); 28, modified seta on second segment of maxilliped, antero-inner (F); 29, leg 1, anterior (C); 30, leg 2, anterior (C); 31, endopod of leg 3, anterior (C); 32, leg 6, ventral (H). Scale H = 0.05 mm.



The body surface is very lightly ornamented as in the female.

The rostrum is like that of the female.

The first antenna resembles that of the female, but an aesthete is added on the fourth segment (at a point indicated by the arrow in Figure 10), so that the formula is 4, 13, 6, 3 + 1 aesthete, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete. The second antenna is similar to that of the female, but the third segment has four setae (three long and one short) instead of three as in that sex.

The labrum, mandible, paragnath, first maxilla, and second maxilla are like those of the female. The maxilliped (Fig. 27) is four segmented (assuming that the proximal part of the claw represents a fourth segment). The first and third segments are unarmed; the second segment bears two setae, one of them highly modified (hyaline and flattened) as in Figure 28, and two rows of spines. The claw is $195\ \mu$ along its axis including the small terminal lamella, shows on the concave edge a weak interruption in the narrow lamella, and bears proximally two very unequal elements.

The area between the maxillipeds and the first pair of legs is like that of the female.

Legs 1-4 are segmented as in the female, with the same spine and setal formula as in that sex. In leg 1 (Fig. 29) the outer exopod spines are longer than in the female, the distal one much longer than the proximal four; the last endopod segment shows slight sexual dimorphism in that the spine is stouter and more heavily sclerotized and the seta adjacent to it is stout and almost spinelike. In leg 2 (Fig. 30) the distalmost outer exopod spine is longer than the preceding spines and on the last endopod segment the outer spine and the outer terminal spine are recurved and more strongly sclerotized. Leg 3 is much like that of the female, but the proportions of the last endopod segment are different (Fig. 31). Leg 4 is similar to that of the female.

Leg 5 resembles that of the female, but the free segment is smaller, $21 \times 9\ \mu$.

Leg 6 (Fig. 32) consists of a posteroventral flap on the ventral surface of the genital segment bearing two naked setae $32\ \mu$ and $24\ \mu$.

Etymology: The specific name is the genitive form of the generic name of the host.

Useful diagnostic features of *Lichomolgus tridacnae* in the female are the shape of the genital segment and in the male the modified seta on the second segment of the maxilliped. In both sexes the peculiar spinulose tips of the two geniculate setae on the last second antennal segment are distinctive.

Comparison with related species: There are seven species of *Lichomolgus* which live in the mantle cavity of bivalve mollusks and which, like the new species, have a mandible with a slender base merging gradually into a long slender attenuated pectinate lash. Two of these, *L. leptodermatus* Gooding, 1957, and *L. elegantulus* Stock, 1960, have more than one claw on the second antenna. The remaining five, *L. arcanus* Humes and Cressey, 1958, *L. asaphidis* Humes, 1959, *L. charmarum*

Humes, 1968, *L. inflatus* Tanaka, 1961, and *L. spondyli* Yamaguti, 1936, have a single claw on the second antenna as in the new species, but in these the genital segment in the female is widest anterior to the middle and the genital openings are located at the middle of the segment rather than posterior to it.

Three species of *Lichomolgus* have a similar mandible, but their true hosts are uncertain. They differ from *L. tridacnae* as follows: both *L. ieversi* Thompson and A. Scott, 1903, and *L. indicus* Ummerkutty, 1962, have two second antennal claws, and *L. minor* A. Scott, 1902, has no claws but instead five setae on the second antenna. The remaining species of *Lichomolgus* which have a slender attenuated mandible inhabit ascidians or cephalopods and all have more than one claw on the second antenna.

Note on occurrence in hosts: In each of four *Tridacna squamosa* all four species of copepods occurred together (*A. solidus*, *A. amicalis*, *A. alatus*, and *L. tridacnae*). Since these copepods were recovered in washings of the entire mantle cavity, their exact microhabitats (if such exist) are unknown.

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