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NEW LICHOMOLGID COPEPODS (CYCLOPOIDA) FROM ZOANTHID COELENTERATES IN MADAGASCAR

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Résumé

Les auteurs décrivent deux genres nouveaux (Temnomolgus et Indomolgus) et cinq espèces nouvelles des copépodes cyclopoïdes lichomolgides associés aux zoanthides (Palythoa tuberculosa et Palythoa liscia) du nord-ouest de Madagascar: Lichomolgus inaequalis n. sp., Temnomolgus eurynotus n. gen., n. sp., Indomolgus brevisetosus n. gen., n. sp., Indomolgus diversus n. gen. n. sp. et Indomolgus mutatus n. gen., n. sp., Indomolgus panikkari (Gnanamuthu, 1955), une combinaison nouvelle, devient la quatrième espèce du genre Indomolgus.

Although lichomolgid copepods are known to be commonly associated with members of the Actiniaria and the Madreporaria, they have not been reported to our knowledge from the Zoanthidea. The five copepods described below were recovered from two species of the zoanthid genus *Palythoa* in the region of Nosy Bé, Madagascar.

The copepods were collected by the first author in 1963-64 as part of the work of the U.S. Program in Biology of the International Indian Ocean Expedition.

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LICHOMOLGIDAE KOSSMANN 1877 LICHOMOLGUS INAEQUALIS n. sp. Figs. 1-28

Type material. — 17 females from pieces of a colony of the zoanthid *Palythoa tuberculosa* (Esper), in 2 m, at Ambariotelo, a small island between Nosy Bé and Nosy Komba, Madagascar. Collected May 24, 1964. Holotype female and 10 paratypic females deposited in the United States National Museum, Washington.

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4 females and 6 males from *Palythoa liscia* Haddon and Duerden, in 2 m, at Pte. Ambarionaomby, Nosy Komba (a locality only 2 kms distant from Ambariotelo). Collected October 1, 1963. Allotype and 6 paratypes (3 females and 3 males) deposited in the United States National Museum. The remaining paratypes in the collection of A. G. Humes.

Other specimens. — 20 females from *Palythoa tuberculosa*, in 2 m, Ambariotelo, May 23, 1964; 1 female from *Palythoa liscia*, in 2 m, Ambariotelo, September 10, 1964; and 11 females from *Palythoa tuberculosa*, intertidal, Ambariobe, near Ambariotelo, July 6, 1963.

Female. — The body (fig. 1) has a moderately broadened prosome. Its length (not including the setae on the caudal rami) is 0.81 mm (0.72-0.90 mm) and its greatest width (at the level of the posterior part of the head) is 0.43 mm (0.38-0.47 mm), based on 10 specimens. The length of the prosome in relation to its width is about 1.4:1. The segment of leg 1 is separated dorsally and laterally from the head by a distinct furrow. The epimeral areas of the segments of legs 2-4 are rounded.

The segment of leg 5 is slightly produced ventrolaterally on each side under the insertion of the free segment of leg 5 (fig. 2); dorsally this segment bears a transverse line with its two ends turned forward. The genital segment is a little longer than wide, 114μ in length, 104μ in greatest width in the anterior third, and 84μ in width in the posterior third. The areas of attachment of the egg sacs are situated dorsolaterally in the anterior half of the segment, and each area (fig. 3) bears two small setae 8μ in length plus a small spiniform process. The three postgenital segments are 40×63 , 33×56 , and $44 \times 61 \mu$ respectively from anterior to posterior. The anal segment has a row of minute spinules along the outer posteroventral margin on either side.

The caudal ramus (fig. 4), inserted dorsally on the anal segment, is not much elongated, $50 \times 28 \mu$ in greatest dimensions, or 1.8 times longer than wide. The naked outer lateral seta, 68μ long, is inserted at a slight indentation midway on the outer margin. The naked pedicellate dorsal seta is 40μ long. Of the four terminal setae, the outermost is naked and 68μ in length, the innermost is 100μ long with inner hairs, and the remaining two long setae are 213μ (outer) and 370μ (inner) in length, both with the usual basal « peg » and with extremely short lateral spinules on the distal half.

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome have very sparse minute refractile points and setules. The ratio of the length of the prosome to that of the urosome is 2:1.

The egg sac (fig. 1) is moderately elongated (in one female $360 \times 155 \mu$, in another $426 \times 179 \mu$, and contains numerous eggs each about 52μ in diameter.

The rostral area (fig. 5) is fairly well-defined.

The first antenna (fig. 6) is 7-segmented, with the second segment the longest. The lengths of the segments (measured along their posterior non-setiferous margins) are : 30 (66 μ along the anterior margin), 112, 25, 56, 56, 39, and 30 μ respectively. The formula for the armature is 4, 12 (3+2+7), 6, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. All the setae are naked.

The second antenna (fig. 7) is slender and 4-segmented. Each of the first two segments bears a small hyaline naked inner seta, the third segment bears three such setae, and the elongated fourth segment bears two very unequal terminal claws (one 47 μ in length, distinctly unguiform and well-sclerotized, the other less claw-like, slender, somewhat shorter, and weakly sclerotized) plus five small hyaline naked setae near the bases of the claws.

The labrum (fig. 8) has two lobes without ornamentation.

The mandible (fig. 9) bears on its inner basal area a scale-like spinulose sclerotization and a more distal striated flange, and on its outer basal area a row of long, very slender spinules. The greatly attenuated flagellum bears lateral spinules. The paragnath is similar to that of the male (see fig. 23), where it is an elongated lobe bearing a few hairs. The first maxilla (fig. 10) is a single segment bearing four setae, three more or less terminal and one subterminal. The second maxilla

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(fig. 11) is 2-segmented, the stout basal segment unarmed, the slender second segment attenuated to form a long flagellum having along one side a row of spines (large proximally but gradually reduced in size distally) and along the opposite side a few small spinules. On the second segment there is a minute hyaline naked basal seta, distally a larger hyaline naked seta, and still more distally a long flagelliform seta ornamented like the terminal flagellum. The maxilliped (fig. 12) is 3-segmented and slender, the first segment being elongated and unarmed, the second of about the same length with two hyaline naked setae, the third short, bearing two small hyaline naked setae and terminating in a pointed process.

The area between the maxillipeds and the first pair of legs (fig. 13) is not produced ventrally, and a line can be seen connecting the bases of the maxillipeds.

The rami of legs 1-4 (figs. 14, 16, 17, and 18) are 3-segmented except for the endopod of leg 4 which is 2-segmented. The spine and setal formula is as follows (the Roman numerals representing the spines, the Arabic numerals the 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-11-3
Р3	protopod	0-1;	1-0	exp.	I-0;	I-1;	III-I-5
				end.	0-1;	0-2;	I-II-2
P4	protopod	0-1;	1-0	exp.	I-0;	I-1;	II-I-5
		·		end.	0-1;	11	

The inner seta on the coxa is feathered in legs 1-3, but smaller and naked on leg 4. On the last segment of the endopod in legs 1-3 there are conspicuous spinules near the insertions of the terminal armature, as shown for leg 1 in fig. 15. In the endopods of leg 4 there is a slight but readily observable asymmetry in the proportions. The first segment appears to have the same size in both legs, about $31 \times 22 \mu$, though its seta on the right leg is 45μ and on the left leg 41μ in length. The second segment on the right side measures 72μ (the greatest length including the spinous process) $\times 18 \mu$ (the greatest width), with its two terminal spines 40 (inner) and 28μ (outer); on the left side this segment is $78 \times 15 \mu$ and the spines 45 and 26μ . Such asymmetry in proportions was observed in each of the four females dissected.

Leg 5 (fig. 19) has an elongated free segment, 75 μ in greatest length, 31 μ wide at the proximal inner expansion and 19 μ wide in the slender distal portion. The two unequal naked terminal setae are 72 (outer) and 44 μ (inner) in length. The seta on the body near the insertion of the free segment is 39 μ long and feathered.

Leg 6 is represented by the two setae on the area of attachment of the egg sac (see fig. 3). The color in life in transmitted light is slightly opaque, the eye red, the egg sacs opaque gray.

Male. — The body (fig. 20) is a little less broadened than in the female. The length (excluding the setae on the caudal rami) is 0.69 mm (0.65-0.74 mm) and the greatest width is 0.24 mm (0.22-0.26 mm), based on 6 specimens. The ratio of the length of the prosome to its width is 1.7:1.

The genital segment (fig. 21) is about as long as wide, $130 \times 126 \mu$, with its lateral margins in dorsal view only slightly rounded. The four postgenital segments are 33×51 , 23×47 , 21×44 , and $28 \times 46 \mu$ from anterior to posterior. The minute spinules seen in the female on the posterior ventral margin of the anal segment appear to be absent in this sex.

The caudal ramus resembles that of the female.

There are fewer refractile points and setules on the surfaces of the prosome and urosome than in the female. The ratio of the length of the prosome to that of the urosome is 1.44 : 1.

The rostral area is like that of the female.

The first antenna (fig. 22) resembles that of the female except for the addition of two aesthetes

on segment 2 and one aesthete on segment 4, creating the formula 4, 12 and 2 aesthetes (3+1) aesthete, 2, 7+1 aesthete), 6, 3+1 aesthete, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete.

The second antenna, labrum, mandible, paragnath (fig. 23), first maxilla, and second maxilla are like those in the female.

The maxilliped (fig. 24) is 4-segmented and slender. The basal segment is unarmed, the second segment bears two naked setae and rows of spinules arranged as in the figure, the third segment is very short and unarmed, and the fourth segment, forming part of the claw, bears two setae, one short and naked, the other longer with short hairs along one edge. The gently recurved slender claw is 109 μ in greatest length (measured along its axis and not along its curvature), and shows a suggestion of division midway along its length. On the tip of the claw there is a rather prominent lamella.

The area between the bases of the maxillipeds and the first pair of legs resembles that of the female.

Legs 1-4 resemble those of the female, except that the last segment of the endopod of leg 1 (fig. 25) has the formula I-I-4 instead of I-5 as in the female, the outermost of the setae here being replaced by a spine. The endopods of the fourth legs show asymmetry as in the female, though somewhat less pronounced. In one male the second segment of the endopod (fig. 26) measured on the right side $46 \times 15 \mu$, with the two spines 39 and 32 μ , on the left side $50 \times 15 \mu$, with the spines 40 and 29 μ .

Leg 5 (fig. 27) has an elongated free segment, $23 \times 8 \mu$, without a basal expansion. The two terminal setae, separated by a spinous process, are 39 and 17μ in length, the longer one naked, the shorter one with a slight lamella.

Leg 6 (fig. 28) consists of a posterolateral flap on the ventral surface of the genital segment. It is armed with two naked setae 33 and 20 μ in length arising near a small spiniform process.

Spermatophores were not observed.

The color in life in transmitted light resembles that of the female.

[The specific name *inaequalis* (Latin = unequally matched, asymmetrical) refers to the unequal size of the terminal claws of the second antenna and to the differences in proportions of the two endopods of the fourth leg.]

Relationship to the host. — *Lichomolgus inaequalis* apparently lives chiefly on the outer surface of the zoanthid colony. This species was recovered in washings of the entire masses of the colony. Later, after the zoanthid had been broken up into small fragments, the washings contained very few of these copepods.

Comparison with other species. — Having the combination of II-I-5 for the third segment of the exopod of leg 4, with the caudal ramus moderately elongated (not subquadrate or very long) and possessing two claws on the second antenna, *Lichomolgus inaequalis* appears to be near L. furcillatus Thorell, 1860, and L. spinulifer Humes and Frost, 1964. It differs from these two species, however, in readily observable characters. L. furcillatus is larger (the female 1.30 mm in length, according to Sars, 1917), one of the three elements on the third segment of the second antenna is a strong spine, and the free segment of leg 5 in the female lacks a basal expansion but instead has a notch in the middle of the outer edge. L. spinulifer is also larger, the two terminal claws on the second antenna are subequal, the caudal ramus is 3.3:1, and there is a row of spinules instead of hairs along the outer side of the second segment of the endopod of leg 4.

TEMNOMOLGUS n. gen.

Prosome broad and swollen. Segment of leg 1 separated dorsally and laterally from the head by a furrow. Urosome relatively short, 4-segmented in the female and 5-segmented in the male (though in both sexes the last two segments are clearly separated only on the dorsal side). First antenna 7-segmented. Second antenna 4-segmented with two terminal claws. Mouthparts lichomolgid. Legs 1 and 2 with 3-segmented rami. Leg 3 represented only by two setae. Leg 4 absent. Leg 5 rudimentary, without a free segment and comprising three setae.

Other features as in the species described below.

Living in zoanthids.

Type and only known species : Temnomolgus eurynotus n. sp. (The generic name is a combin ation of $\tau \leq \mu \nu \in \nu = t_0$ amputate, referring to the reduced leg 3 and the missing leg 4, and $\mu \circ \lambda \gamma \circ \zeta = a$ sack made of leather.)

Gender masculine.

TEMNOMOLGUS EURYNOTUS n. sp. Figs. 29-55

Type material. — 147 females, 143 males, and 15 copepodids from a piece (area about 0.25 square meter and thickness 1 cm) of the colonial zoanthid *Palythoa tuberculosa* (Esper), growing on dead coral in 2 m, at Ambariotelo, a small island between Nosy Bé and Nosy Komba, Madagascar. (This is the same zoanthid colony from which *Lichomolgus inaequalis* was recovered). Collected May 24, 1964. Holotype female, allotype, and 185 paratypes (91 females and 94 males) deposited in the United States National Museum, Washington; 35 paratypes (20 females and 15 males) in the Zoölogisch Museum, Amsterdam; and the remaining paratypes in the collection of A. G. Humes.

Other specimens. — 37 females, 40 males, and 39 copepodids from *Palythoa tuberculosa*, in 2 m, Ambariotelo, September 10, 1964.

Female. — The form of the body (figs. 29, 30, and 31) is rather different from that in many lichomolgid genera. The length (excluding the setae on the caudal rami) is 1.18 mm (1.03-1.32 mm) and the greatest width, near the junction of the cephalosome and the first pedigerous segment, is 0.82 mm (0.74-0.90 mm), based on 10 specimens. The prosome is broad and swollen, the proportions of length to width to thickness being about 1.2:1.5:1.0. The segment of leg 1 is separated dorsally and laterally from the head by a furrow. The epimeral areas of the metasomal segments are more or less rounded. The segment corresponding to leg 4 has a distinct narrow tergal area (390 μ in width) but is not clearly defined ventrally.

The segment of leg 5 (fig. 32) is a little broader (414 μ) than the preceding segment. The setae of the fifth legs arise dorsally. The genital segment is wider than long, being broadest in its anterior half and tapering posteriorly. Its greatest width is 314 μ and its length 185 μ . The areas of attachment of the egg sacs are dorsal and anterior in position, with each area showing two small spines about 7 μ in length (fig. 33). There are three postgenital segments, but the last two are clearly separated only dorsally. In a ventral view these two segments appear as a single segment (compare fig. 30). The first postgenital segment is 101 μ long ×190 μ wide; the second 50 × 159 μ , and the third 85 × 159 μ , making an overall length of 135 μ . The last segment has an anal operculum and at the insertion of each caudal ramus is slightly truncated.

The caudal ramus (fig. 34), which is inserted a little ventrally on the anal segment, is hyaline, somewhat subelliptical in outline, measuring $55 \times 28 \mu$ in greatest dimensions, or two times longer than wide. On the border of the distal half of the ramus there are five hyaline naked setae, the outermost being a little set apart and corresponding to the usual outer lateral seta of lichomolgids. The naked dorsal pedicellate seta is a little more slender than the others. There are refractile areas bearing minute hyaline setules on both dorsal and ventral surfaces of the ramus. There are no spinules on the anal segment near the insertion of the ramus nor are there any on the distal end of the ramus.

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome bear

numerous refractile points with minute setules. The ratio of the length of the prosome to that of the urosome is about 1.8 : 1. In lateral view (fig. 30) the body is arcuate, making it difficult to achieve a complete dorsal view of the animal.

The egg sacs are small and spherical (fig. 35), about $280 \,\mu$ in diameter, and contain a relatively small number of eggs each with a diameter of about $100 \,\mu$.

The rostral region (fig. 36) in ventral view is well-defined, forming a rather narrow linguiform area between the bases of the antennae.

The first antenna (fig. 37) is 7-segmented, the second segment being longer than any of the others. The lengths of the segments (measured along their posterior non-setiferous margins) are : 28 (94 μ along the anterior margin), 93, 44, 40, 39, 22, and 14 μ respectively. The first segment bears 3 setae, the second 13 setae (in groups of 5+2+6), the third 4 setae, the fourth 5 setae, the fifth 3 setae and 1 aesthete, the sixth 2 setae and 1 aesthete, and the seventh 7 setae and 1 aesthete. The formula thus is 3,13 (5+2+6), 4,5,3+1 aesthete, 2+1 aesthete, and 7+1 aesthete. The entire first antenna is hyaline and lightly sclerotized. All the setae are naked and hyaline with delicate annulations.

The second antenna (fig. 38) is 4-segmented, and rather short and robust. Each of the broad first two segments bears a small naked seta. The third segment is less broad and bears three naked setae. The fourth segment is longer than the third and bears four small hyaline setae and two well-sclerotized recurved subequal terminal claws (see fig. 39).

The labrum (fig. 40) has two widely diverging lobes without ornamentation.

The mandible (fig. 41) consists of a basal region (its inner edge with a scale bearing a row of slender setules and its expanded outer edge with a row of hair-like setules and another similar scale) and a distal flagellum basally with an inner striated fringe and distally with bilaterally disposed spinules. The paragnath (fig. 42) is an elongated lobe with groups of hairs; in ventral view it is seen lying under the lobe of the labrum (see fig. 40). The first maxilla (fig. 43) consists of a single segment with two unequal apical setae, one stout, 21μ in length, with a well-sclerotized proximal half, the other slender, 10μ long. The second maxilla (fig. 44) is 2-segmented. The large basal segment is unornamented. The slender arcuate distal segment terminates in a spiniform flagellum provided first with a row of 5-6 sclerotized teeth along its medial margin and then more distally with bilaterally disposed spinules. On this segment there is proximally a small unilaterally barbed seta and distally a large spine bearing two rows of prominent spinules. The maxilliped (fig. 45) is 3-segmented, the first segment the largest and unarmed, the second smaller and bearing two small inner setae, and the third the smallest, bearing two minute hyaline spinules and terminating in two processes, one well-sclerotized and slightly obtuse, the other hyaline and pointed.

The area between the maxillipeds and the first pair of legs (fig. 46) is not produced ventrally. There seems to be no connecting line between the bases of the maxillipeds.

The first two pairs of legs (figs. 47 and 48) have 3-segmented rami. The third leg is rudimentary. The fourth leg is entirely absent. The spine and setal formula is as follows (the Roman numerals indicating the spines, the Arabic numerals the setae) :

P 1	protopod	0-0;	1-0	exp.	I-0;	I-1;	III-I-4
				end.	0-1;	0-1;	I-I-4
P 2	protopod	0-0;	1-0	exp.	I-0;	0-1;	II-I-4
				end.	0-1;	0-1;	I-11-2
РЗ					2		
P 4	absent						

The coxae of legs 1 and 2 are unarmed. The basis of both of these legs has an outer seta but otherwise is unornamented. The spines on the rami are naked and recurved; the setae are relatively short, naked, and show sclerotized bases, giving the appearance of a « joint ». On the second segment of the exopod of leg 2 the outer spine is absent, an unusual condition in lichomolgid copepods. Leg 3 (fig. 49) consists only of a small sclerotization bearing two unequal naked setae, the outer one 31 μ , the inner one 21 μ in length. No trace could be found of a fourth leg.

Leg 5 (see fig. 32) is rudimentary and consists only of three naked setae, two closely approximated (28μ and 12μ in length) and probably corresponding to the setae found on the free segment in other lichomolgids, and one more distant (28μ long) corresponding to the seta on the body adjacent to the free segment.

Leg 6 may be represented by the two small spines in the area of attachment of the egg sac (see fig. 33).

The color in life in transmitted light is somewhat opaque, with fine red speckling over the rostral region, the eye dark red, the ovary dark gray, the intestine light brown, the egg sacs dark greenish gray.

Male. — The form of the body (fig. 50) resembles that of the female, but the proportions of the prosome and urosome are somewhat different. The length (not including the setae on the caudal rami) is 1.21 mm (1.07-1.35 mm) and the greatest width near the junction of the cephalosome and the segment of leg 1 is 0.60 mm (0.54-0.66 mm), based on 10 specimens. The prosome is broad and inflated as in the female, the ratio of length to width being about 1.1:1. The epimeral areas of the metasomal segments are rounded as in the female. The tergal area of the segment of leg 4 is rather narrow.

The segment of leg 5 (fig. 51) is a little wider than the following segment and bears dorsolaterally the rudimentary fifth legs. The genital segment is much wider than long, $150 \times 328 \mu$. There are four postgenital segments, but as in the female the last two segments are separated only on the dorsal side. These segments are 135×177 , 117×151 , 62×124 , and $78 \times 121 \mu$ respectively.

The caudal ramus resembles that of the female but is a little larger, measuring about $62 \times 38 \,\mu$.

The surfaces of the prosome and urosome bear refractile points as in the female. The ratio of the length of the prosome to that of the urosome is about 1.1:1.

The rostral area is like that of the female.

The first antenna resembles that of the female, with the same armature except for the replacement by an aesthete of one seta in the first group on segment 2 and of one seta on segment 4. The formula thus is : 3, 12+1 aesthete (4+1 aesthete, 2, 6), 4, 4+1 aesthete, 3+1 aesthete, 2+1 aesthete, and 7+1 aesthete.

The second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla resemble those of the female.

The maxilliped (fig. 52) is 4-segmented. The first segment is the largest and unarmed; the second is smaller, with two inner setae and a small patch of spinules on its posterior surface; the third is very small and unarmed; and the fourth is elongated, forming part of the claw, and bearing two unequal setae. The claw proper is delimited from the fourth segment by interruptions in the sclerotization. The functional claw (including the fourth segment and the recurved tip) is 66 μ in length (measured along its axis and not along its curvature).

The area between the maxillipeds and the first pair of legs (fig. 53) is not produced ventrally, and shows only indistinct lines between the bases of the maxillipeds.

The first two pairs of legs (figs. 54 and 55) have 3-segmented rami, the third leg is rudimentary, and the fourth leg is absent, all as in the female. The spine and setal formula is the same as in the female. In legs 1 and 2 the spines on the exopods sometimes show minute subterminal flagella; the setae are longer than in the female, feathered, and do not show the basal « joints ». Leg 3 is like that in the opposite sex. No evidence of leg 4 could be found.

Leg 5 (see fig. 51) resembles that of the female, with the two adjacent setae 42 and 26 μ in length and the more distant seta 39 μ long.

Leg 6 (see fig. 51) consists of a posterolateral flap on the ventral surface of the genital segment, bearing two naked setae 44 and 39 μ in length.

Spermatophores were not observed.

The color in life in transmitted light is somewhat opaque, the eye red.

(The specific name is from $\dot{\epsilon}$ upúv $\omega\tau\sigma\zeta$ = broad-backed, alluding to the form of the prosome.)

Relationship to the host. — *Temnomolgus eurynotus* appears to live in the polyps of the zoanthids. When the pieces of the zoanthid colonies were washed intact in alcoholized sea water, no copepods were recovered. When, however, the zoanthid colonies were broken into small pieces and then washed, large numbers of the copepods were found in the sediment. The living copepods recovered in this way are unable to swim, suggesting that of necessity they inhabit protected places such as the gastrovascular cavities of the polyps.

Systematic position of the new genus. — Temnomolgus belongs to the large family Lichomolgidae, in which some 25 apparently valid genera have already been placed. These genera show in varying degrees a reduction of legs 1-4. Several genera have 3-segmented rami on all four legs (for example, Herrmannella, Modiolicola, and Paranthessius). Others have 3-segmented rami except for the endopod of leg 4 which is 2-segmented (for example, Lichomolgus and Stellicola). Still others have 3-segmented rami but the endopod of leg 4 is reduced to a single segment (for example, Kelleria, Octopicola, and Pseudanthessius). (In Scambicornus the reduction occurs only in the male, where the endopods of legs 1 and 2 are 2-segmented). In Heteranthessius the reduction is carried further, and, while the other rami are 3-segmented, the endopod of leg 4 is represented only by a small mucronate knob (Bocquet, Stock, and Bénard, 1959). The genus Meomicola shows the most extreme reduction known in the family until now. Here the endopod of leg 3 is absent and the ramus of leg 4 is reduced to a single segment (Stock, Humes, and Gooding, 1964). Temnomolgus exhibits still more dramatic reduction, having lost leg 4 entirely and leg 3 being reduced to a small sclerotization bearing two setae.

Most of the known lichomolgid genera have a free segment on leg 5. In some, however, the free segment is absent and the leg is represented only by two or three setae (for example, *Heleranthessius*, *Meomicola*, *Pseudanthessius*, and *Urocopia*). *Temnomolgus* shows a similar reduction of leg 5 to a condition of having only three setae.

As pointed out by Stock, Humes, and Gooding (1964, p. 56), the number of body segments in the Lichomolgidae is generally constant, there being five urosomal segments in the female and six in the male. In certain species of *Pseudanthessius*, however, this number is reduced, as in *P. deficiens* Stock, Humes, and Gooding, 1964, and in *P. dubius* Sars, 1918, where there are four segments in the urosome of the female and five in the male. *Temnomolgus* shows a condition intermediate between these, having five urosomal segments in the female and six in the male, but in both sexes the last two segments incompletely separated. In *Meomicola* the urosome has three segments in the female and four in the male.

Sexual dimorphism among the appendages of the Lichomolgidae occurs in several genera. In *Temnomolgus* it is seen not only in the first antennae and maxillipeds, but also in legs 1 and 2, where, although the segmentation and spine and setal formula is similar in both sexes, the nature of the setae is markedly different (short, naked, and « jointed » in the female, but longer, feathered, and entire in the male).

The absence of an outer spine on the second segment of the exopod of leg 2 in both sexes of *Temnomolgus* is unusual among lichomolgid copepods. This spine may be absent, however, in certain other cyclopoids, such as species of *Ergasilus*.

Temnomolgus does not seem to be very close to any other genus in the family, although in the reduction of legs 3 and 4, in the rudimentary condition of leg 5, and in the tendency toward reduction in the number of urosomal segments it approaches *Pseudanthessius*, *Meomicola*, and *Heteranthessius*.

INDOMOLGUS n. gen.

Body elongated, the prosome not much widened. Segment of leg 1 separated partially or completely from the head by a furrow. Urosome 5-segmented in the female, 6-segmented in the

male. Caudal ramus with relatively short setae. First antenna 7-segmented, with short setae. Second antenna 4-segmented with two sometimes unequal terminal claws. Mouthparts lichomolgid. Legs 1-4 with 3-segmented rami except for leg 4 which has a 2-segmented endopod. Armature of the legs somewhat variable. Last segment of the endopod of leg 4 with the formula 11-2, I-3, or II-3. Free segment of leg 5 relatively small and provided with two terminal setae.

Living in actiniarians and zoanthids.

Type species : Indomolgus breviselosus n. sp. (The generic name is derived from $I\nu\delta\delta\varsigma =$ Indian, alluding to the occurrence of this genus in the Indian Ocean, and $\mu o\lambda\gamma\delta\varsigma =$ a sac made of leather).

Gender masculine.

INDOMOLGUS PANIKKARI (Gnanamuthu, 1955), new combination

Lichomolgus panikkari Gnanamuthu, 1955, from the brackish water sea anemone Phylocoeteopsis ramunni Panikkar in Madras, India, conforms to the generic diagnosis of Indomolgus and should be transferred to that genus. Although the original description of I. panikkari antedates the descriptions of the three new species from Madagascar, I. panikkari has not been selected as the type species (on the basis of Recommendation 69B(6) of the International Code of Zoological Nomenclature). Certain discrepancies seem to exist between the spine and setal formula of legs 1-4 given in th text (p. 152) and the armature shown in text-fig. 1b, c, d, and e. (The legends for text-figs. 1 and 2 are reversed). We have been unable to obtain type or other specimens of I. panikkari for study (1).

INDOMOLGUS BREVISETOSUS n. sp. Figs. 56-85

Type material. — 49 females, 21 males, and 16 copepodids from the colonial zoanthid *Palythoa tuberculosa* (Esper) (the same colony from which *Lichomolgus inaequalis* and *Temnomolgus eurynolus* were taken), in 2 m, at Ambariotelo, a small island between Nosy Bé and Nosy Komba, Madagascar. Collected May 24, 1964. Holotype female, allotype, and 42 paratypes (30 females and 12 males) deposited in the United States National Museum, Washington, and the remaining paratypes in the collection of A. G. Humes.

Other specimens. — 39 females, 31 males, and 11 copepodids from *Palythoa liscia* Haddon and Duerden, in 2 m, Ambariotelo, September 10, 1964; 1 female and 1 copepodid from *Palythoa liscia*, *tuberculosa*, in 2 m, Ambariotelo, September 10, 1964; 2 females and 1 male from *Palythoa liscia*, in 2 m, Ambato Rano, an islet between Nosy Komba and Ankify, October 20, 1964; 7 females, 8 males, and 5 copepodids from *Palythoa liscia*, in 2 m, Pte. Ambarionaomby, Nosy Komba, October 1, 1963; and 4 females and 5 males from *Palythoa liscia*, in 2 m, Tany Kely, near Nosy Bé, October 3, 1963.

Female. — The body (figs. 56 and 57) is elongated, with the prosome not unusually expanded. The length (not including the setae on the caudal rami) is 2.02 mm (1.83-2.20 mm) and the greatest width, near the junction of the cephalosome and the first pedigerous segment, is 0.69 mm (0.63-0.75 mm), based on 10 specimens. The ratio of the length of the prosome to its width is 1.6 : 1. The segment of leg 1 is separated from the head by a furrow which, though readily visible laterally, is indistinct dorsally. The epimeral areas of the metasomal segments are rounded in dorsal view, those of the fourth pedigerous segment being more acutely so.

⁽¹⁾ The type specimens of L. *panikkari* are not in the collections of the Zoological Survey of India. Personal inquiry indicates that no specimens of this species are now in Dr. Gnanamuthu's collection (letter from Dr. K. Reddiah, April 3, 1965).

The segment of leg 5 (fig. 58) is a little broader (526 μ) than the preceding segment. The fifth legs arise slightly dorsally. The genital segment is only a little longer than wide (336 × 325 μ), with its lateral margins in dorsal view smooth and only gently expanded. The areas of attachment of the egg sacs lie dorsally and far anteriorly, and each area (fig. 59) bears two small spines, each about 10 μ in length and with an extremely minute lateral tooth. The three postgenital segments are 143×221 , 86×180 , and $156 \times 188 \mu$ respectively. The anal segment shows an anal operculum and is slightly truncated at the insertion of each caudal ramus.

The caudal ramus (fig. 60), inserted a little dorsally in the anal segment, is elongated, $218 \times 81 \mu$ in greatest dimensions, or 2.7 times longer than wide. It bears six short naked setae, each about 57 μ in length. One of these is inserted about midway on the outer margin, one is located subterminally on the inner margin, and the remaining four are more or less terminal. One of these setae certainly represents the usual dorsal seta, but since all the setae are inserted marginally this could not be identified with certainty. Both dorsal and ventral surfaces of the ramus bear scattered minute setules. There are no spinules terminally on the ramus nor are there any on the anal segment near its insertion.

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome bear relatively few refractile points with minute hyaline setules. The ratio of the length of the prosome to that of the urosome is about 1.19:1.

The egg sacs are moderately elongated (fig. 61), $672 \times 300 \ \mu$, and contain numerous eggs, each about 112 μ in diameter.

The rostral area (fig. 62) is poorly defined.

The first antenna (fig. 63) is 7-segmented, with the second segment by far the longest. The lengths of the segments (measured along their posterior non-setiferous margins) are: 25 (62 μ along the anterior margin), 95, 23, 31, 33, 15, and 17 μ respectively. The formula for the armature is: 4, 11 (3 and 1 minute setule+2+6), 6 (+2 minute setules), 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. (One female showed on one first antenna 7 setae instead of 6 in the distal group on segment 2). All the setae are naked and relatively short.

The second antenna (fig. 64) is 4-segmented. Each of the rather large first two segments bears a slender naked inner seta. The small third segment bears three similar inner setae. The fourth segment is elongated and bears seven elements : subterminally three slender naked setae and a larger seta unilaterally with spinules, terminally a small naked setule and two nearly equal claws 39 and 34 μ in length. Both claws are smooth except for a slight knob-like projection at the break in the sclerotization along the convex margin (fig. 65).

The labrum (fig. 66) has two widely diverging lobes devoid of ornamentation.

The mandible (fig. 67) shows on the inner basal region a sclerotization suggesting a scale and a broad hyaline lamella bearing a distal marginal row of minute spinules, and on the outer basal area a row of rather stout spinules. The distal flagellum is short, not finely attenuated, and has serrated margins. The paragnath (fig. 68) is a small lobe bearing two groups of hairs. The first maxilla (fig. 69) is a single segment with three subequal naked terminal setae. The second maxilla (fig. 70) is 2-segmented, the large basal segment bearing a few minute setules, the distal segment terminating in a spiniform flagellum armed on one side with a row of teeth which gradually become more slender distally. On the second segment there is a small outer basal sclerotized knob, a naked seta on the posterior surface, and more distally an inner seta unilaterally with a row of spinules. The maxilliped (fig. 71) is 3-segmented. The first segment is large and unarmed; the second is smaller and flattened in posterior view (fig. 72), bearing two small hyaline naked setae; and the third is the smallest, terminating in a pointed, rather weakly sclerotized process, and bearing two unequal hyaline naked setae.

The area between the maxillipeds and the first pair of legs (fig. 62) shows a balloon-like expansion just behind the level of the maxillipeds. This is prominent in lateral view (fig.73).

The rami of legs 1-4 (figs. 74, 76, 77, and 78) are 3-segmented except for the endopod of leg 4

which is 2-segmented. The spine and setal formula is as follows (the Roman numerals indicating the spines and the Arabic numerals the setae) :

P 1	protopod	0-1;	1-0	exp.	I-0;	I-1;	III-I-4
				end.	0-1;	0-1;	I-I-4
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-3	

The distalmost spine on the third segment of the exopod in all four legs has a subterminal process as shown for leg 1 in fig. 75. The setae on these legs are not as finely attenuated as in many other species of lichomolgids. The first segment of the endopod of leg 4 measures $36 \times 51 \mu$, the second $95 \times 55 \mu$. The row of hairs along the outer margin of the second segment is interrupted, perhaps indicating the dual nature of this segment. On this segment the two spines are 30 and 37 μ in length and the setae 51, 63, and 80 μ , from outer to inner.

Leg 5 (fig. 79) has a relatively small free segment, $63 \times 32 \mu$, two times longer than wide, bearing two naked unequal terminal setae 16 and 36 μ in length and a few small hyaline setules on dorsal and ventral surfaces. The naked seta arising from the body near the free segment is 31μ in length.

Leg 6 is probably represented by the two minute spines on the area of attachment of the egg sac (see fig. 59).

The color in life in transmitted light is opaque, with the eye red and the egg sacs dark greenish gray. The posterior borders and the epimera of the pedigerous segments, the genital segment, and the caudal rami are tinged with pale amber.

Male. — The form of the body (fig. 80) resembles that of the female. The length (excluding the setae on the caudal rami) is 2.20 mm (2.04-2.36 mm) and the greatest width is 0.68 mm (0.63-0.72 mm), based on 10 specimens. The ratio of the length of the prosome to its width is 1.57 : 1.

The genital segment (fig. 81) is broad with rounded margins in dorsal view, wider than long, $403 \times 482 \mu$. The four postgenital segments are 138×195 , 122×169 , 70×151 , and $153 \times 164 \mu$ respectively.

The caudal ramus resembles that of the female, but is a little longer and more slender, $234 \times 64 \mu$.

The surfaces of the prosome and urosome, as in the female, bear refractile points with minute setules. The ratio of the length of the prosome to that of the urosome is about 1:1.

The rostral area is like that of the female.

The first antenna (fig. 82) resembles that of the female but two aesthetes are added on segment 2 and one on segment 4, making the formula as follows: 4, 11+2 aesthetes (3 and 1 minute setule plus 1 aesthete+2+6 and 1 aesthete), 6,3+1 aesthete, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete.

The second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla are like those in the female.

The maxilliped (fig. 83) is 4-segmented. The large first segment bears on its distal inner area a pointed sclerotized knob and a low ridge. The second segment bears two naked inner setae, a postero-inner row of small spines, and two small sclerotized ridges. The small third segment is unarmed. The fourth segment forms part of the claw and bears two basal naked setae. The slightly recurved claw is 318 μ in length (measured along its axis and not along its curvature). It shows a slight indication of division about midway along its length and has a small terminal lamella.

The area between the maxillipeds and the first pair of legs resembles that in the female.

Legs 1-4 are similar to those of the female, except that on legs 1-3 the outer process adjacent to the distalmost spine on the endopods is relatively longer (fig. 84).

Leg 5 (fig. 85) resembles that of the female, but the free segment is relatively much smaller, $31 \times 19 \mu$, with the two terminal naked setae relatively longer, 33 and 22 μ respectively. The seta arising from the body near the base of the free segment is 31μ long.

Leg 6 (fig. 81) consists of a posterolateral flap on the ventral surface of the genital segment, bearing an inner rounded protuberance and two outer small naked setae 17 and 13 μ long respectively.

Spermatophores were not observed.

The color in life in transmitted light resembles that of the female, though the pale amber color on the genital segment and the caudal rami appears to be a little more intense.

[The specific name breviselosus (Latin, brevis =short, and setosus =full of setae) alludes to the relatively short setae in this species on the first antennae and on the caudal rami].

Relationship to the host. — Like *Temnomolgus eurynotus*, these copepods apparently inhabit the gastrovascular cavities of the polyps. They were recovered only from washings of zoanthid colonies which had been broken into small pieces, never from washings of intact colonies. When removed from the host, the copepods are unable to swim.

Comparison with related species. — Indomolgus brevisetosus may be readily distinguished from the following two new species by the armature of the second segment of the endopod of leg 4. It differs in several ways from *I. panikkari* (Gnanamuthu), being smaller [the females of *I. panikkari* have a length of 2.9 mm (2.7-3.1 mm) and the males 2.7 mm (2.4-2.8 mm), the size ranges in both sexes in these two species not overlapping], and having a caudal ramus only a little longer than the anal segment (whereas in *I. panikkari* it is longer than the last two postgenital segments together). The spine and setal formula for legs 1-4 in *I. panikkari* is apparently somewhat different from that in *I. breviselosus*, but the discrepancies between Gnanamuthu's description and figures make a comparison uncertain. The armature of the second segment of the endopod of leg 4 resembles that of *I. breviselosus*.

INDOMOLGUS DIVERSUS n. sp. Figs. 86-114

Type material. — 165 females, 56 males, and 40 copepodids washed from the colonial zoanthid *Palythoa tuberculosa* (Esper) (the same colony from which *Lichomolgus inaequalis*, *Temnomolgus eurynotus*, and *Indomolgus breviselosus* were recovered), in 2 m, at Ambariotelo, a small island between Nosy Bé and Nosy Komba, Madagascar. Collected May 24, 1964. Holotype female, allotype, and 144 paratypes (110 females and 34 males) deposited in the United States National Museum, Washington ; 30 paratypes (20 females and 10 males) in the Zoölogisch Museum, Amsterdam ; and the remaining paratypes in the collection of A. G. Humes.

Other specimens. — 2 females, 5 males, and 3 copepodids from *Palythoa tuberculosa*, in 2 m, Ambariotelo, May 23, 1964; 13 females, 21 males, and 3 copepodids from *Palythoa liscia*, in 1 m, Ambariotrimaramara, off Ampombilava, Nosy Bé, June 12, 1964; 58 females, 13 males, and 15 copepodids from *Palythoa liscia*, in 2 m, Ambariotelo, September 10, 1964; 35 females, 13 males, and 19 copepodids from *Palythoa tuberculosa*, in 2 m, Ambariotelo, September 10, 1964; 44 females 15 males, and 5 copepodids from *Palythoa liscia*, in 2 m, Ambariotelo, September 10, 1964; 44 females 15 males, and 5 copepodids from *Palythoa liscia*, in 2 m, Ambato Rano, an islet between Nosy Komba and Ankify, October 20, 1964; 2 females from *Palythoa liscia*, in 2 m, Pte. Ambarionaomby, Nosy Komba, October 1, 1963; and 4 females, 2 males, and 3 copepodids from *Palythoa liscia*, in 2 m, Tany Kely, near Nosy Bé, October 3, 1963. **Female.** — The body (figs. 86 and 87) is elongated, with the prosome not greatly broadened. The length (not including the setae on the caudal rami) is 1.43 mm (1.36-1.49 mm) and the greatest width, just in front of the junction between the cephalosome and the segment of leg 1, is 0.53 mm (0.50-0.55 mm), based on 10 specimens. The ratio of the length of the prosome to its width is about 1.8:1. The segment of leg 1 is separated dorsally and laterally from the head by a distinct furrow. The segments of legs 3 and 4 are often expanded in length (as shown in the figures) but in some specimens they are short. The rounded epimeral areas of the metasomal segments are less prominent than in the preceding species.

The segment of leg 5 (fig. 88) is narrower $(240 \ \mu)$ than either the fourth pedigerous segment or the genital segment. The free segment of leg 5 is inserted slightly ventrally. The genital segment is wider than long $(220 \times 250 \ \mu)$, with the areas of attachment of the egg sacs protruding laterally in the anterior half of the segment. Each such area (fig. 89) bears two small spines about 6 μ in length. The three postgenital segments are 91×159 , 60×140 , and $96 \times 140 \ \mu$ respectively. The anal segment shows an anal operculum, and bears posteriorly near the insertion of each caudal ramus a dorsolateral row of minute spinules.

The caudal ramus (fig. 90), inserted dorsally on the anal segment, is moderately elongated and held in a widely diverging position. The length along the inner margin is 74 μ , along the outer margin 79 μ , and its greatest width is 41 μ . The ramus is broadest near its base and tapers distally. Taking the greatest dimensions, the ratio of length to width is about 1.9 : 1. The outer lateral seta (33 μ in length) is inserted about midway on the margin. The pedicellate dorsal seta is 27 μ long. Of the four terminal setae, the outermost and innermost are short, 35 and 38 μ respectively; the remaining two setae are longer but very unequal, the outer 67 μ and indistinctly « pegged », the inner 168 μ and showing the usual sclerotization or « peg ». All the setae are naked. A minute setule is borne on the dorsal surface of the ramus.

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome are very sparsely provided with minute hyaline setules. The ratio of the length of the prosome to that of the urosome is about 1.85 : 1.

The egg sacs are moderately elongated (fig. 91), $548 \times 235 \mu$, and each contains a relatively small number of eggs about 78 μ in diameter.

The rostral area (fig. 92) is well-defined, forming a tongue-shaped region between the bases of the first antennae.

The first antenna (fig. 93) is 7-segmented, with the second segment the longest. The lengths of the segments (measured along their posterior non-setiferous margins) are : 15 (40 μ along the anterior margin), 77, 24, 45, 39, 25, and 27 μ respectively. The formula for the armature is 3, 12 (4+2+6), 6, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. On the dorsal surface of segment 1 there is a row of minute spinules. In one female an aesthete was present on segment 4 on both antennae in addition to the three setae. All the setae are naked. The posteriormost distal seta of segment 3 often appears to arise on the extreme basal part of segment 4, but this seta is considered here to belong to segment 3.

The second antenna (fig. 94) is slender and 4-segmented. The armature consists of the same number of elements as in the preceding species. The first and second segments have a single inner seta, the third three inner setae, and the fourth seven elements, — five small setae and two gently recurved claws, 69 and 63 μ in length respectively. All the setae are naked.

The labrum (fig. 95) has two lobes without conspicuous ornamentation.

The mandible (fig. 96) bears on its inner basal region a spinulose scale, a hyaline lamella forming a pointed process and more distally a striated flange, and on its outer basal area three spines (two close together, the other more distant) and an interrupted row of very slender spinules. The distal flagellum is long and attenuated, with spinulose margins. The paragnath (fig. 97) is an elongated smooth lobe. The first maxilla (fig. 98) is a single segment bearing three terminal setae 55, 58, and 15 μ in length. The second maxilla (fig. 99) is 2-segmented, the large basal segment being unarmed, the second segment attenuated to form a distal flagellum armed with 4-5 stout teeth on

its medial margin beyond which its margins are spinulose. The second segment bears a small outer basal hyaline seta (5μ in length), a larger seta with two lateral spinules, and more distally a still longer seta with four prominent spinules along the medial margin. The maxilliped (fig. 100) is slender and 3-segmented, with the same armature as in the previous species, though the terminal process is recurved and more acutely pointed.

The area between the maxillipeds and the first pair of legs shows only a very slightly raised area just behind the level of the maxillipeds. A line connects the bases of the maxillipeds.

The rami of legs 1-4 (figs. 101, 102, 103, and 104) are segmented as in I. breviselosus. The spine and setal formula is as follows (the Roman numerals indicating the spines, the Arabic numerals the setae) :

P 1	protopod	0-1;	1-0	exp.	I-0;	I-1;	III -I -4
				end.	0-1;	0-1;	I-I-4
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-I-2
P 4	protopod	0-1;	1-0	exp.	I-0;	I-1;	III -I -4
				end.	0-1;	11-2	

The hairs on the inner margin of the basis of leg 1 appear to be absent, though they are present on legs 2-4. The second segment of the endopod of leg 4 measures $72 \times 37 \mu$. The outer row of hairs on this segment is interrupted, and at the break there may be in some specimens a minute spinous process. The two spines are 35 and 80 μ and the two setae 90 and 92 μ in length respectively from outer to inner. The setation on this segment seems to be somewhat plastic. One female showed the formula II-3 on both fourth legs (fig. 105). In another the innermost seta on one leg was haired evenly throughout instead of being proximally with long hairs and distally with short spinules as in fig. 104.

Leg 5 (fig. 106) has a slender elongated free segment, $46 \times 12 \mu$ in greatest dimensions, about 4 times longer than wide. It bears two terminal naked setae 57 and 40 μ in length. Along the distal half of its outer margin there are extremely minute spinules. The naked seta arising from the body near the base of the free segment is 36 μ in length. In one female one of the fifth legs showed a short seta (12 μ long) on the ventral surface of the free segment near the insertions of the two terminal setae.

Leg 6 is probably represented by the two small spines on the area of attachment of the egg sac (see fig. 89).

The color in life in transmitted light is opaque to translucid, with the eye red, the egg sacs opaque gray, and with a few minute reddish granules lateral and posterior to the maxillipeds and small reddish areas on the inner sides of the bases of legs 1-4.

Male. — The body (fig. 107) has the same general form as in the female. The length (without the setae on the caudal rami) is 1.21 mm (1.15-1.26 mm) and the greatest width is 0.39 mm (0.37-0.40 mm), based on 10 specimens. The ratio of the length of the prosome to its width is 1.8:1.

The genital segment (fig. 108) is only slightly longer than wide, $246 \times 235 \mu$, with gently rounded margins in dorsal view. The four postgenital segments are 63×110 , 60×107 , 44×99 , and $63 \times 100 \mu$ respectively. The anal segment bears small spinules on its ventral posterior border.

The caudal ramus is very similar to that of the female, its greatest dimensions being $68 \times 33 \mu$.

The surfaces of the prosome and urosome are very sparsely provided with minute setules as in the female. The ratio of the length of the prosome to that of the urosome is about 1.35 : 1.

The rostral region resembles that of the female.

The first antenna (fig. 109) resembles that of the female, but, as in *Indomolgus breviselosus*, two aesthetes are added on segment 2 and one on segment 4, creating the formula 3, 12+2 aesthe-

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tes (4 and 1 aesthete+2+6 and 1 aesthete), 6,3+1 aesthete, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. The aesthetes are long and slender, with one edge more sclerotized than the other.

The second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla are like those of the female.

The maxilliped (fig. 110) is 4-segmented. The basal segment is unarmed; the slender second segment bears the usual two setae, both naked, and a row of short spinules; the third segment is small and unarmed; and the fourth segment forms part of the claw and bears two setae, one on the anterior surface minute, the other on the posterior surface large and with spinulose margins. The slightly recurved claw is 121 μ in length (measured along its axis and not along its curvature) and shows a slight indication of division about midway on its length. There is a minute terminal lamella.

The area between the maxillipeds and the first pair of legs (fig. 111) resembles that of the female.

Legs 1-4 are like those of the female.

Leg 5 (fig. 112) has a much shorter free segment than in the female, measuring $25 \times 10 \mu$, with the two subqual terminal setae relatively longer, 33 and 31 μ in length. The seta on the body near the base of the segment is 35 μ long.

Leg 6 (figs. 108 and 113) consists of a posterolateral flap on the ventral surface of the genital segment. It is armed with two naked setae 29 and 35 μ in length, medial to which there is a small marginal spinous process. The surface of the flap is ornamented with spinules as indicated in the figures.

The spermatophore (fig. 114) attached to the female, is elongated, $255 \times 114 \mu$, not including the neck of 13 μ .

The color in life resembles that of the female, though the body is perhaps a little more translucid.

[The specific name *diversus* (Latin = turned from one another, diverging) refers to the divergent position of the caudal rami.]

Relationship to the host. — Just as in *Temnomolgus eurynotus* and *Indomolgus brevisetosus*, these copepods were not found in washings of the intact masses of the zoanthid colonies, but only after these masses had been thoroughly broken up. This indicates that *I. diversus* also inhabits the gastrovascular cavities of the polyps. All three species of copepods may occur in the same colony of zoanthid (as in the case of the type material from Ambariotelo in May, 1964, and in a second collection from Ambariotelo in September, 1964).

Comparison with related species. — *I. diversus* differs from both *I. panikkari* and *I. breviselosus* in being much smaller, the female only 1.43 mm in length instead of 2.9 and 2.02 mm for the other two species respectively. The caudal ramus in *I. diversus* is shorter than the anal segment, whereas in *I. panikkari* and *I. breviselosus* it is longer. The spine and setal formula for legs 3 and 4 in this species is also somewhat different from that in either *I. panikkari* or *I. breviselosus*. The armature of the second segment of the endopod of leg 4 is II-2. instead of II-3 as in *I. panikkari* and *I. breviselosus*, or I-3 as in the following species.

INDOMOLGUS MUTATUS n. sp. Figs. 115-143

Type material. — 21 females, 19 males, and 11 copepodids from the zoanthid *Palylhoa* tuberculosa (Esper), growing on dead coral exposed at low tide at Antafianambitry, Nosy Bé, Madagascar. Collected September 8, 1964. Holotype female, allotype, and 31 paratypes (16 females and 15 males) deposited in the United States National Museum, Washington; the remaining paratypes in the collection of A. G. Humes.

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Female. — The body (figs. 115 and 116) resembles in general form the two species of *Indomolgus* described above. The length (without the setae on the caudal rami) is 2.59 mm (2.24-2.95 mm) and the greatest width in the cephalosome is 0.92 mm (0.77-1.07 mm), based on 10 specimens. The ratio of the length of the prosome to its width is 1.68 : 1. The segment of leg 1 is separated from the head by a weak suture. The epimera of the metasomal segments are rounded or slightly angular as indicated in the figure.

The segment of leg 5 (fig. 117) is nearly as wide as the genital segment, $168 \times 414 \mu$, and the fifth legs are borne a little ventrally. The genital segment is expanded in the midregion at the level of the attachment of the egg sacs; its greatest dimensions are $392 \times 437 \mu$, being a little wider than long. The area of attachment of each egg sac is situated dorsolaterally and bears two small setae 13 μ in length (fig. 118). The three postgenital segments are 180×336 , 135×302 , and $247 \times 302 \mu$ respectively from anterior to posterior. (The boundaries between the genital and the postgenital segments are weak and difficult to distinguish; hence the measurement of their lengths may be less exact than in other species). The anal segment shows an anal operculum.

The caudal ramus (fig. 119), inserted terminally, is elongated and held in a rather diverging position. The ramus is widest at its base and tapers gradually distally. Its greatest length is 161 μ , and its width at the level of the outer lateral seta is 58 μ . These dimensions give a ratio of length to width of about 2.8 : 1. The outer lateral seta is inserted midway on the margin. The dorsal seta is shorter than the four terminal setae. All the setae are relatively short (the longest only 33 μ in length), hyaline, and naked. The two median terminal setae show a weak « peg » near the base.

The dorsal surface of the prosome and the dorsal and ventral surfaces of the urosome appear to be devoid of refractile points or setules. The ratio of the length of the prosome to that of the urosome is 1.33:1.

None of the females found had egg sacs attached, but one detached egg sac (fig. 120) is elongated and arcuate, measuring $1150 \times 730 \mu$, with each of the numerous eggs about 94 μ in diameter. (It is possible that this egg sac may not be complete).

The rostral area (fig. 121) is well-defined.

The first antenna (fig. 122) is 7-segmented, with the second segment the longest. The lengths of the segments (measured along their posterior non-setiferous margins) are : 51 (105 μ along the anterior edge) 106, 54, 69, 79, 52, and 41 μ . The formula for the armature is 4, 13 (5+8), 6, 3, 4+1 aesthete, 2+1 aesthete, and 7+1 aesthete. All the setae are naked and relatively short. The entire appendage is weakly sclerotized.

The second antenna (fig. 123) is 4-segmented and rather slender. The armature of the first three segments resembles that of the two species of *Indomolgus* described above, though one of the three setae on segment 3 is stouter and more sclerotized than the other two. The two terminal claws are slender and weak, one $39 \,\mu$, the other $34 \,\mu$ in length; only three small hyaline setae near the bases of the claws could be identified. All the setae are naked.

The labrum (fig. 124) has a ventrally protruding longitudinal ridge in front of the two unornamented rounded lobes.

The mandible (fig. 125) has on its inner basal area a long sclerotization bearing a row of graduated spinules distal to which there is a striated flange, and on its outer basal region a row of hairs. The distal flagellum is rather short, with very small lateral spinules. The paragnath (figs. 126 and 124) is a rather large lobe with hairs. Between the paragnaths there is a ventral protuberance as shown in fig. 124. The first maxilla (fig. 127) is a single segment bearing three long terminal setae and one short subterminal seta. The second maxilla (fig. 128) is 2-segmented, the large basal segment unarmed, the second segment attenuated to form a moderately long distal flagellum provided with seven teeth along one side. This segment bears a hyaline naked seta on its posterior surface and more distally a prominent seta with a row of spinules along its medial margin. The 3-segmented maxilliped (fig. 129) resembles that of I. diversus.

The area between the maxillipeds and the first pair of legs (fig. 130) is only slightly protuberant. There is a faint line between the bases of the maxillipeds. The rami of legs 1-4 (figs. 131, 132, 133, and 135) are segmented as in the above species of *Indomolgus*. The spine and setal formula is as follows (the Roman numerals indicating the spines, the Arabic numerals the setae) :

-0 exp.	I-0;	I-1;	IV-4
end.	0-1;	0-1;	I-5
-0 exp.	I-0;	I-1;	IV-5
end.	0-1;	0-2;	III-3
-0 exp.	I-0;	I-1;	IV-5
end.	0-1;	0-2;	I-3
-0 exp.	I-0;	I-1;	I-1-I-5
end.	0-1;	I-3	
-	0 exp. end. 0 exp. end. 0 exp. end. 0 exp. end.	0 exp. I-0; end. 0-1; 0 exp. I-0; end. 0-1; 0 exp. I-0; end. 0-1; 0 exp. I-0; end. 0-1;	$\begin{array}{cccccccccccccccccccccccccccccccccccc$

The outer seta on the basis of all four legs is short and naked. The inner coxal seta on leg 4 is shorter than those on the other legs and is naked. On the exopods of legs 1-3 the proximal outer spines tend to be less ornamented with spinules than the distal ones. In leg 1 the distalmost spine on the last segment of the exopod may have hairs instead of spinules along part or all of its inner margin. The distal outer angle of the second segment of the endopod of leg 1 is distinctly bifurcated, instead of being a single spiniform process as in legs 2 and 3. On the third segment of one endopod of leg 3 in one female the formula I-2 was seen (fig. 134), the other endopod being I-3 which is the usual condition. The armature of the last segment of the exopod of leg 4 is unusual, the middle spine of the outer row of three being here transformed to a short slender naked seta. In one female the second segment of this ramus lacked the outer spine and was only weakly separated from the third segment. The second segment of the endopod measures $88 \times 41 \mu$ in greatest dimensions (including the spiniform process) ; its spine is 45μ in length and the setae beginning with the outermost 80, 77, and 70 μ . There may be very slight variation in the form and armature of this segment as shown in fig. 136 (the left endopod of the same female from which fig. 135 was drawn).

Leg 5 (figs. 137 and 138) is small, its « free » segment not clearly separated from the body and forming a rounded lobe about 55 μ long. The two distal naked setae are 22 and 37 μ in length. The naked seta arising from the body near the lobe is 35 μ in length.

Leg 6 is represented by the two small setae near the attachment of the egg sac (see fig. 118).

The color in life in transmitted light is opaque, the eye dark red, the egg sacs gray.

Male. — The body (fig. 139) resembles in general form that of the female. The length (excluding the setae on the caudal rami) is 1.35 mm (1.16-1.54 mm) and the greatest width is 0.45 mm (0.40-0.51 mm), based on 10 specimens. The ratio of the length of the prosome to its width is 1.6:1.

The genital segment (fig. 140) is a little wider than long, $246 \times 269 \mu$, with slightly rounded lateral margins in dorsal view. The four postgenital segments are from anterior to posterior 83×172 , 62×161 , 44×158 , and $112 \times 155 \mu$ (the length of the last segment taken along its margin).

The caudal ramus resembles that of the female, though its distal part may be a little less tapered than in that sex.

The surfaces of the prosome and urosome appear to lack ornamentation, as in the female. The ratio of the length of the prosome to that of the urosome is about 1.34 : 1.

The rostral area, first antenna (with no aesthetes added), second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla resemble those of the female.

The maxilliped (fig. 141) is 4-segmented, slender, and elongated. The first segment is long and unarmed; the second is not quite as long and bears the usual two setae and a row of spinules; the third is very short and unarmed; and the fourth, forming part of the claw, bears two very unequal setae. All the setae are naked. The slender claw, 130 μ in length (measured along its axis and not along its curvature), is rather strongly recurved beyond the proximal indentation and terminates in a sharp point without a lamella. A distinct line of division may be seen about midway on the claw, presumably indicating the distal limit of the fourth segment.

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

Legs 1-4 are like those in the female. One male had the formula 0-1; 0-2; 1-5 for both endopods of leg 1, an extra seta having been added on the second segment.

Leg 5 (fig. 142) resembles in general form that of the female, but is smaller, the lobe being about 20 μ in length, the two terminal setae 11 and 24 μ , and the seta on the body near the lobe 22 μ in length.

Leg 6 (fig. 143) consists of the usual posterolateral flap on the ventral surface of the genital segment. It bears two hyaline naked setae 28 and 24μ in length and a minute spiniform process.

Spermatophores were not observed.

The color in life in transmitted light resembles that of the female.

[The specific name *mutatus* (Latin = altered, changed) alludes to the transformation of the usual spine to a seta on the third segment of the exopod of leg 4].

Relationship to the host. — No copepods were recovered in washings until the zoanthid had been thoroughly broken into small fragments. This indicates that *I. mutatus*, like *I. brevisetosus* and *I. diversus*, inhabits the gastrovascular cavity of the polyps. *I. mutatus* was collected only once, and on that occasion it was the only copepod present.

Comparison with related species. — Indomolgus mutatus may be distinguished from the other three members of the genus by the spine and setal formula of the last segment of both rami of leg 4, where its exopod is I-1-I-5 and its endopod is I-3. In addition, I. mutatus may be readily separated from I. brevisetosus by the size and form of leg 5, the shape of the genital segment, and the form and position of the caudal rami. It is unlike I. diversus in having a more elongated urosome, in the size and form of leg 5, and in having very short setae on the caudal rami. It has several features which distinguish it from I. panikkari, notably, the size of the male (1.35 mm against 2.7 mm for the Indian species), the size and form of leg 5, and the nature of the caudal rami.

REMARKS ON THE GENUS INDOMOLGUS

The establishment of a new genus to receive the three new species from Madagascar and I. panikkari (Gnanamuthu) from India brings together four species which form a group different from other lichomolgids in several major respects. Among the notable features of this genus are the elongated body form, the two claws on the 4-segmented second antenna, and the armature of the second segment of the endopod of leg 4. This endopod may have the following typical and variant arrangement of spines and setae on the last segment :

	lypical	variant
I. panikkari	II-3	
I. brevisetosus	II-3	none observed
I. diversus	II-2	II-3
I. mutatus	I-3	1-2

It has become customary to assign great importance to the segmentation and armature of the endopod of leg 4 in defining lichomolgid genera. In those genera with a 2-segmented endopod the terminal segment may bear only a single element as in *Monomolgus*, two as in *Lichomolgus*, or three as in *Stellicola*. Such armature appears to be fixed throughout the species in those genera, with little or no individual variation. In the four species of *Indomolgus*, however, the armature consists of 4 or 5 elements, of three types : II-3, II-2, or I-3. Considering only this armature, one

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might be tempted to recognize the species having the three types as belonging to separate genera. However, a comparison of the other appendages and the body form in the four species demonstrates their close relationship. Furthermore, it would be unwise to make generic distinctions based only on the armature of the endopod of leg 4 when this armature shows a certain amount of variation within a species. Thus it seems best to regard *Indomolgus* as having on the second segment of the endopod of leg 4 a typical armature of II-3, II-2, I-3.

List of zoanthid hosts and their copepods at Nosy Bé

Palythoa tuberculosa:

Lichomolgus inaequalis; Temnomolgus eurynolus; Indomolgus breviselosus; Indomolgus diversus; Indomolgus mutatus.

Palythoa liscia:

Lichomolgus inaequalis; Indomolgus brevisetosus; Indomolgus diversus.

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EXPLANATION OF THE FIGURES

All the 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 the figure was drawn.

Fig. 1-12. - Lichomolgus inaequalis n. sp., female

1. - Body, dorsal (A)

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- 2. Urosome, dorsal (B)
- 3. Area of attachment of egg sac, dorsal (C)
- 4. Caudal ramus, dorsal (D)
- 5. Rostral area, ventral (B)
- 6. First antenna, dorsal (E)

- 7. Second antenna, posterior (E)
- 8. Labrum, ventral (D)
- 9. Mandible, ventral (D)
- 10. --- First maxilla, ventral (D)
- 11. Second maxilla, ventral (D)
- 12. Maxilliped, posterior (D).



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Fig. 13-19. - Lichomolgus inaequalis n. sp., female (continued)

13. - Area between maxillipeds and first pair of legs, ventral (E)

14. — Leg 1, anterior (E)

- 15. Tip of endopod of leg 1, anterior (C)
- 16. Leg 2, anterior (E)
- 17. Leg 3, anterior (E)
- 18. Leg 4, anterior E)
- 19. Leg 5, dorsal (F).

Fig. 20-21. - Lichomolgus inaequalis n. sp., male

20. - Body, dorsal (G)

21. - Urosome, dorsal (B).

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Fig. 22-28. - Lichomolgus inaequalis n. sp., male (continued)

- 22. First antenna, dorsal (E)
- 23. Paragnath, ventral (C)
- 24. Maxilliped, inner (F)
- 25. Last segment of endopod of leg 1, anterior (D)
- 26. Endopod of leg 4, anterior (F)
- 27. --- Leg 5, ventral (H)
- 28. Leg 6, ventral (F).

Fig. 29-33. -- Temnomolgus eurynolus n. gen., n. sp., female

- 29. Body, dorsal (A)
- 30. Body, lateral (A)
- 31. Body, ventral (A)
- 32. Urosome, dorsal (I)
- 33. Area of attachment of egg sac, dorsal (F).



Fig. 34-47. -- Temnomolgus eurynotus n. gen., n. sp., female (continued)

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34. — Caudal ramus, dorsal (D)

35. — Egg sac, dorsal (A)

36. — Rostral area, ventral (B)

37. — First antenna, dorsal (B)

38. - Second antenna, anterior and ventral (B)

39. — Claw of second antenna (D)

40. — Labrum with paragnaths, ventral (E)

41. — Mandible, ventral (D)

42. — Paragnath, ventral (D)

43. — First maxilla, ventral (D)

44. — Second maxilla, ventral (D)

45. — Maxilliped, anterior (F)

46. — Area between maxillipeds and first pair of legs, ventral (B)

47. — Leg 1, anterior (E)

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Fig. 48-49. — Temnomolgus eurynoius n. gen., n. sp., female (continued)

48. — Leg 2, anterior (E) 49. — Leg 3, ventral (D).

Fig. 50-55. — Temnomolgus eurynotus n. gen., n. sp., male

- 50. Body, dorsal (A)
- 51. Urosome, ventral (G)
- 52. Maxilliped, posterior and ventral (F)
- 53. Area between maxillipeds and first pair of legs, ventral (B)
- 54. Leg 1, anterior (B)
- 55. Leg 2, anterior (B).

Fig. 56-57. — Indomolgus brevisetosus n. gen., n. sp., female

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56. — Body, dorsal (A) 57. — Body, lateral (A).



Fig. 58-70. — Indomolgus brevisetosus n. gen., n. sp., female (continued)

58. — Urosome, dorsal (G)

59. — Area of attachment of egg sac, dorsal (F)

60. — Caudal ramus, ventral (E)

61. — Egg sac, lateral (A)

62. — Midregion of cephalosome, ventral (I)

63. — First antenna, ventral (E)

64. — Second antenna, anterior (E)

65. — Claw on second antenna (H)

66. — Labrum, ventral (E)

67. — Mandible, ventral (F)

68. — Paragnath, ventral (D)

69. — First maxilla, ventral (D)

70. — Second maxilla, anterior (F).



Fig. 71-79. — Indomolgus breviselosus n. gen., n. sp., female (continued)

- 71. Maxilliped, anterior and dorsal (F)
- 72. Segments 2 and 3 of maxilliped, posterior and ventral (D)
- 73. Mouthparts and postoral protuberance, lateral (B)
- 74. Leg 1, anterior (B)
- 75. Distalmost spine on third segment of exopod of leg 1 (H)
- 76. Leg 2, anterior (B)
- 77. Leg 3, anterior (B)
- 78. Leg 4, anterior (B)
- 79. Leg 5, dorsal (F).





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Fig. 80-85. — Indomolgus breviselosus n. gen., n. sp., male

- 80. Body, dorsal (A)
- 81. Urosome, ventral (G)
- 82. First antenna, dorsal (E)
- 83. Maxilliped, posterior and inner (B)
- 84. Terminal spine and adjacent outer process on last segment of endopod of leg 1, anterior $\langle D \rangle$
- 85. Leg 5, dorsal (F).

Fig. 86-88. — Indomolgus diversus n. gen., n. sp., female

- 86. Body, dorsal (A)
- 87. Body, lateral (A)
- 88. Urosome, dorsal (I).

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Fig. 89-101. — Indomolgus diversus n. gen., n. sp., female (continued)

- 89. Area of attachment of egg sac, dorsal (F)
- 90. Caudal ramus, dorsal (F)
- 91. Egg sac, lateral (A)

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- 92. Rostral area, ventral (E)
- 93. First antenna, dorsal (E)
- 94. Second antenna, inner and posterior (E)
- 95. Labrum, ventral (E)
- 96. Mandible, anterior (D)
- 97. Paragnath, ventral (D)
- 98. First maxilla, ventral (D)
- 99. Second maxilla, anterior (D)
- 100. Maxilliped, posterior (F)
- 101. Leg 1, anterior (E)

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Fig. 102-106. — Indomolgus diversus n. gen., n. sp., female (continued)

- 102. Leg 2. anterior (E).
- 103. Leg 3, anterior (E)
- 104. Leg 4, anterior (E)
- 105. Abnormal endopod of leg 4, anterior (E)
- 106. Leg 5, dorsal (D).

Fig. 107-110. - Indomolgus diversus n. gen., n. sp., male

- 107. Body, dorsal (A)
- 108. Urosome, ventral (I)
- 109. First antenna, anterior (E)
- 110. Maxilliped, posterior (F).

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Fig. 111-114. - Indomolgus diversus n. gen., n. sp., male (continued)

111. — Area between maxillipeds and first pair of legs, ventral (E)

112. — Leg 5, lateral (D)

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113. — Leg 6, ventrolateral (D)

114. — Spermatophore attached to female (I).

Fig. 115-122. - Indomolgus mutatus n. gen., n. sp., female

- 115. Body, dorsal (J)
- 116. Body, lateral (J)
- 117. Urosome, dorsal (A)
- 118. Area of attachment of egg sac, dorsal (F)

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- 119. --- Caudal ramus, dorsal (E)
- 120. Egg sac (J)
- 121. Rostral area, ventral (I)
- 122. First antenna, ventral (I).



Fig. 123-132. - Indomolgus mutatus n. gen., n. sp., female (continued)

- 123. Second antenna, anterior (B)
- 124. Labrum, paragnaths, and associated oral area, ventral (E)
- 125. Mandible, anterior (F)
- 126. Paragnath, ventral (D)
- 127. First maxilla, anterior (D)
- 128. Second maxilla, posterior (E)
- 129. Maxilliped, anterior and dorsal (E)
- 130. Area between maxillipeds and first pair of legs, ventral (I)
- 131. Leg 1, anterior (B)
- 132. Leg 2, anterior (B).

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Fig. 133-138. — Indomolgus mutatus n. gen., n. sp., female (continued)

- 133. Leg 3, anterior (B)
- 134. Abnormal last segment of endopod of leg 3, anterior (B)
- 135. Leg 4, anterior (B)
- 136. Endopod of same leg 4, but opposite side of body, anterior (B)
- 137. Leg 5, dorsal (F)
- 138. Leg 5, ventral (F)

Fig. 139-143. — Indomolgus mutatus n. gen., n. sp., male

- 139. Body, dorsal (A)
- 140. Urosome, dorsal (I)
- 141. Maxilliped, posterior (E)
- 142. Leg 5, ventral (D)
- 143. Leg 6, ventral (F).



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