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## CLAVISODALIS HETEROCENTROTI GEN. ET SP. N., A CYCLOPOID COPEPOD PARASITIC ON AN ECHINOID AT ENIWETOK ATOLL

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**ABSTRACT:** *Clavisodalis heterocentroti* is described from the pencil urchin, *Heterocentrotus trigonarius* (Lamarck), at Eniwetok Atoll in the Marshall Islands. This is the third genus of Taeniacanthidae known to parasitize Echinoidea, the other genera being parasites of fishes.

Most of the genera in the family Taeniacanthidae are parasitic on fishes. Two genera, however, live on Echinoidea. *Echinosocius pectinatus*, *E. dentatus*, and *Echinirus laxatus*, all described by Humes and Cressey (1961), are associates of *Diadema setosum* (Leske) in Madagascar. Gooding (1965) reported that at Singapore *Diadema* harbors two more species of *Echinosocius* and another *Echinirus*, but he did not describe them.

At Eniwetok Atoll in the Marshall Islands the new taeniacanthid described below occurs on the large pencil urchin, *Heterocentrotus trigonarius* (Lamarck). The copepods apparently can attach themselves to the host. At first, when the hosts were rinsed in seawater with about 5% ethyl alcohol, relatively few copepods were obtained. Later, when the hosts were not only rinsed as before but also washed thoroughly with a strong jet of water, a large number of copepods were recovered.

The figures have been prepared with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are: A<sub>1</sub>, first antenna; A<sub>2</sub>, second antenna; MD, mandible; P, paragnath; MX<sub>1</sub>, first maxilla; MX<sub>2</sub>, second maxilla; MXP<sub>1</sub>, maxilliped; and P<sub>1-4</sub>, legs 1 through 4.

### *Clavisodalis* gen. n.

Body elongate, somewhat modified from the usual taeniacanthid type. In female segments of legs 1 and 2 fused with cephalosome and 3 postgenital segments fused with one another and with caudal ramus. In male segment of leg 1 fused with cephalosome and 3 postgenital segments distinctly separated. Caudal ramus with 6 setae. Egg sac with eggs not serially arranged.

Rostrum not developed. First antenna 6-segmented. Second antenna 3-segmented, last segment with 3 terminal claws. Pair of maxillary

hooks present. Labrum with rounded posteroventral margin. Mandible with 2 very unequal terminal elements. Paragnath present. First maxilla with 2 setae and recurved spatulate element. Second maxilla 2-segmented. Maxilliped of female probably 4-segmented, last segment having prominent inner process and fused with the straight clavate claw. Maxilliped of male 4-segmented, the greatly swollen second segment having an inner process which opposes the terminal claw.

Leg 1 with 2-segmented rami, legs 2-4 with 3-segmented rami. Inner seta absent on certain segments of endopod (second segment in leg 2, first and second segments in legs 3 and 4) and of exopod (second segment in leg 4).

Leg 5 with 4 setae on free segment.

Leg 6 in female with 3 setae, in male without armature.

Other features as described below.

Associated with Echinoidea.

*Type and only known species:* *Clavisodalis heterocentroti* sp. n.

Gender masculine.

*Etymology:* The generic name is a combination of the Latin words *clava* = a club and *sodalis* = a companion or associate, alluding both to the shape of the claw in the female maxilliped and to the habitat among the club-shaped spines of the host.

### *Clavisodalis heterocentroti* sp. n.

(Figs. 1-35)

*Type material:* 82 ♀♀, 24 ♂♂, and 28 copepodids, from 32 *Heterocentrotus trigonarius* (Lamarck), on outer edge of reef, northern end of Sand Island, north of Eniwetok Island, Eniwetok Atoll, Marshall Islands, 15 July 1969. Holotype ♀, allotype, and 64 paratypes (50 ♀♀, 14 ♂♂) deposited in the United States National Museum, Washington (Nos.—holotype 126979, allotype 126980, paratypes 126981); 10 paratypes (8 ♀♀, 2 ♂♂) in the Zoölogisch Museum, Amsterdam; remaining paratypes in collection of the author.

*Other specimens* (also from *Heterocentrotus trigonarius*): 13 ♀♀, 2 ♂♂, and 1 copepodid, from 46 hosts, at the type locality, 2 July 1969.

### Female

Body (Figs. 1, 2) elongated and somewhat modified, with rather thin sclerotization throughout. Length (excluding setae on caudal rami) 2.33 mm

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(2.02 to 2.62) and greatest width 0.66 mm (0.56 to 0.74), based on 10 specimens in lactic acid. Pedigerous segments weakly delimited, and segments of legs 1 and 2 fused with cephalosome. A crescentic sclerotized bar joining bases of 2 maxillary hooks. Ratio of length to width of prosome 2.58:1. Ratio of length of prosome to that of urosome 2.22:1.

Segment of leg 5 (Fig. 3) 195 by 217  $\mu$ . Between this segment and genital segment no ventral intersegmental sclerite. Genital segment in dorsal view much wider than long, 187 by 380  $\mu$ , its lateral margins bilobed. Areas of attachment of egg sacs located dorsolaterally in posterior half of segment. Each area (Fig. 4) bearing 2 prominent recurved setae 80  $\mu$  and 90  $\mu$  long, both bilaterally spinulose, and a slender naked seta 17  $\mu$ . In majority of specimens the 2 long setae broken as in Figure 5. Three postgenital segments mostly fused with one another and the third fused with caudal ramus. First segment broader, 120 by 275  $\mu$ , than other two. Second 77 by 176  $\mu$ . Third (anal segment) 39 by 187  $\mu$ , bearing postero-ventrally on each side a crescentic row of small spines.

Caudal ramus (Figs. 6, 7) 104 by 187  $\mu$ , almost wholly fused with anal segment. Outer lateral seta 67  $\mu$ , dorsal seta 100  $\mu$ , and outermost terminal seta 70  $\mu$ , all 3 of them naked. Innermost terminal seta 117  $\mu$  with short spinules. Of the 2 median terminal setae the outer 185  $\mu$  and the inner (with a swollen base) 390  $\mu$ , both with lateral and ventral spinules. A few small spines ventrolaterally near insertion of outermost terminal seta.

Dorsal surface of prosome and urosome bearing few minute hairs (sensilla); ventral surface of urosome lacking such ornamentation.

Egg sac (Fig. 8) in most specimens moderately elongated, 750 by 265  $\mu$ , extending well beyond tip of longest seta on caudal ramus. In a few

cases egg sac much smaller (Fig. 9), 400 by 240  $\mu$ . Each egg about 133  $\mu$  in diameter, but sometimes of irregular shape.

Rostrum not developed (Fig. 10), but rostral area set off by a bicornuate ventral sclerite.

First antenna (Fig. 11) about 280  $\mu$  long and 6-segmented, though articulations between first 3 segments seen only on ventral surface. First 3 segments combined measuring 203  $\mu$  along anterior margin and 117  $\mu$  along posterior margin. Last 3 segments 35, 22, and 21  $\mu$ , respectively, along anterior margin. First 3 segments with 28 setae, most of them hairy as in the figure. Fourth segment with 4 setae, 3 of them naked and 1 lightly feathered. Fifth segment with 2 naked setae and 1 aesthete; sixth segment with 7 naked setae and 1 aesthete. Entire armature thus consisting of 41 setae and 2 aesthetes.

Second antenna (Fig. 12) 3-segmented. First segment bearing an outer distal seta and second a postero-inner seta. Third segment having on its postero-inner surface a greatly elongated patch of minute spinules and an adjacent row of 6 to 8 teeth (Fig. 13). Three terminal claws (Fig. 14) 60, 45, and 72  $\mu$  in length. In addition, 5 setae, 2 of them with a few short barbules.

Maxillary hook (Fig. 15) 130  $\mu$  long, situated laterally to second antenna (Fig. 2).

Labrum (Fig. 16) with rounded spinose posteroventral margin without median indentation.

Mandible (Fig. 17) terminally with a large spine 35  $\mu$  long and pectinate along one edge, and a very small spine only 4  $\mu$ . Paragnath (Fig. 16) a rounded lobe inwardly adjacent to first maxilla and posterior to mandible. First maxilla (Fig. 18) consisting of a single small segment bearing 2 prominent barbed setae and a recurved and somewhat spatulate finely barbed element. Second maxilla (Fig. 19) 2-segmented. Unarmed first segment elongated and appressed to body surface. Second

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FIGURES 1–5. *Clavisodalis heterocentroti* gen. et sp. n., female. 1. Dorsal (A). 2. Lateral (A). 3. Urosome, dorsal (B). 4. Area of attachment of egg sac, dorsal (C). 5. Area of attachment of egg sac, with two setae broken as frequently seen, dorsal (C).

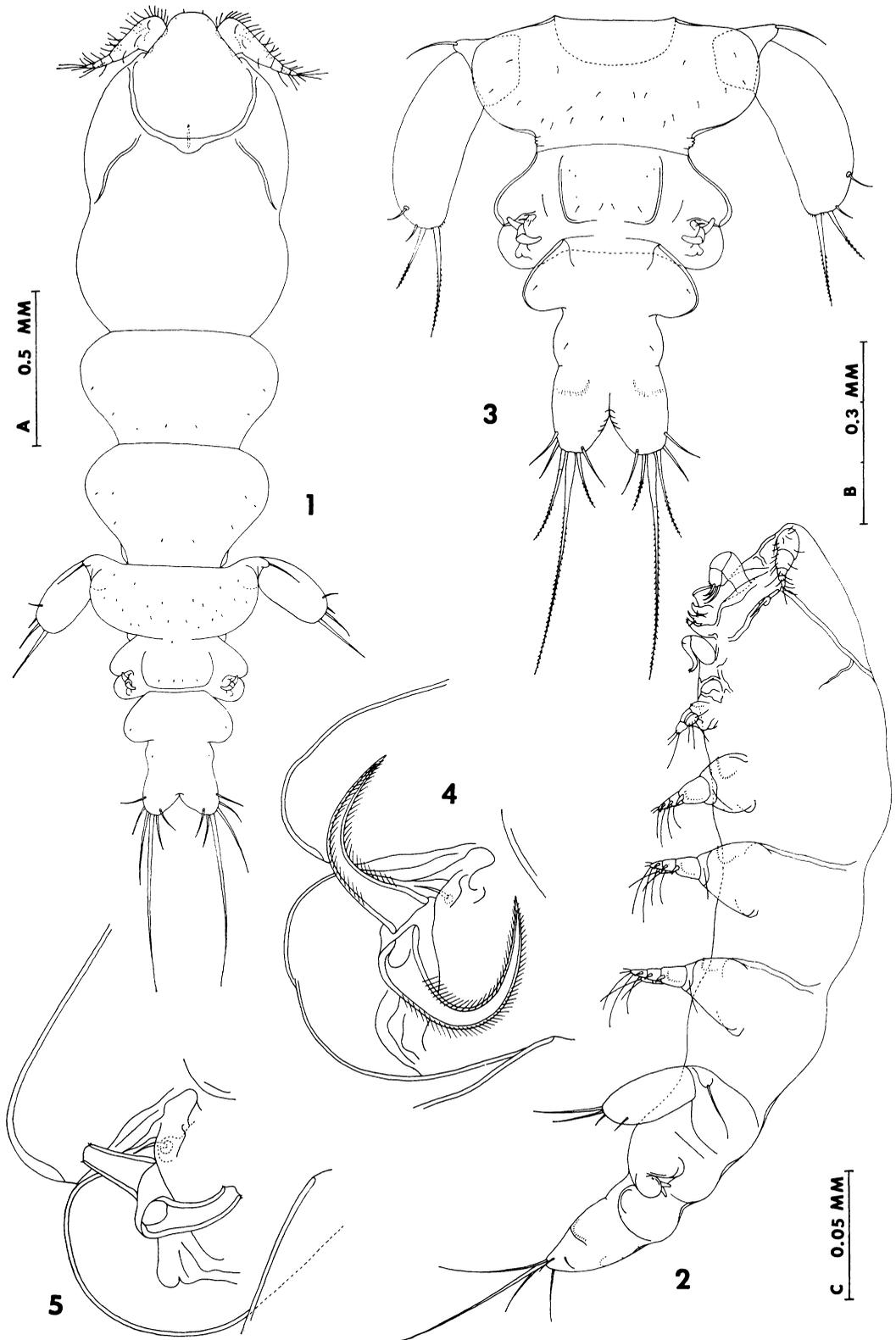
FIGURES 6–14. *Clavisodalis heterocentroti*, female. 6. Caudal ramus, ventral (D). 7. Caudal ramus, dorsal (D). 8. Egg sac, as seen in most specimens, dorsal (B). 9. Egg sac, as seen in a few specimens, inner (B). 10. Rostral area, ventral (D). 11. First antenna, dorsal (E). 12. Second antenna, antero-outer (C). 13. Third segment of second antenna, postero-inner (F). 14. Tip of second antenna to show shape of claws, outer (F).

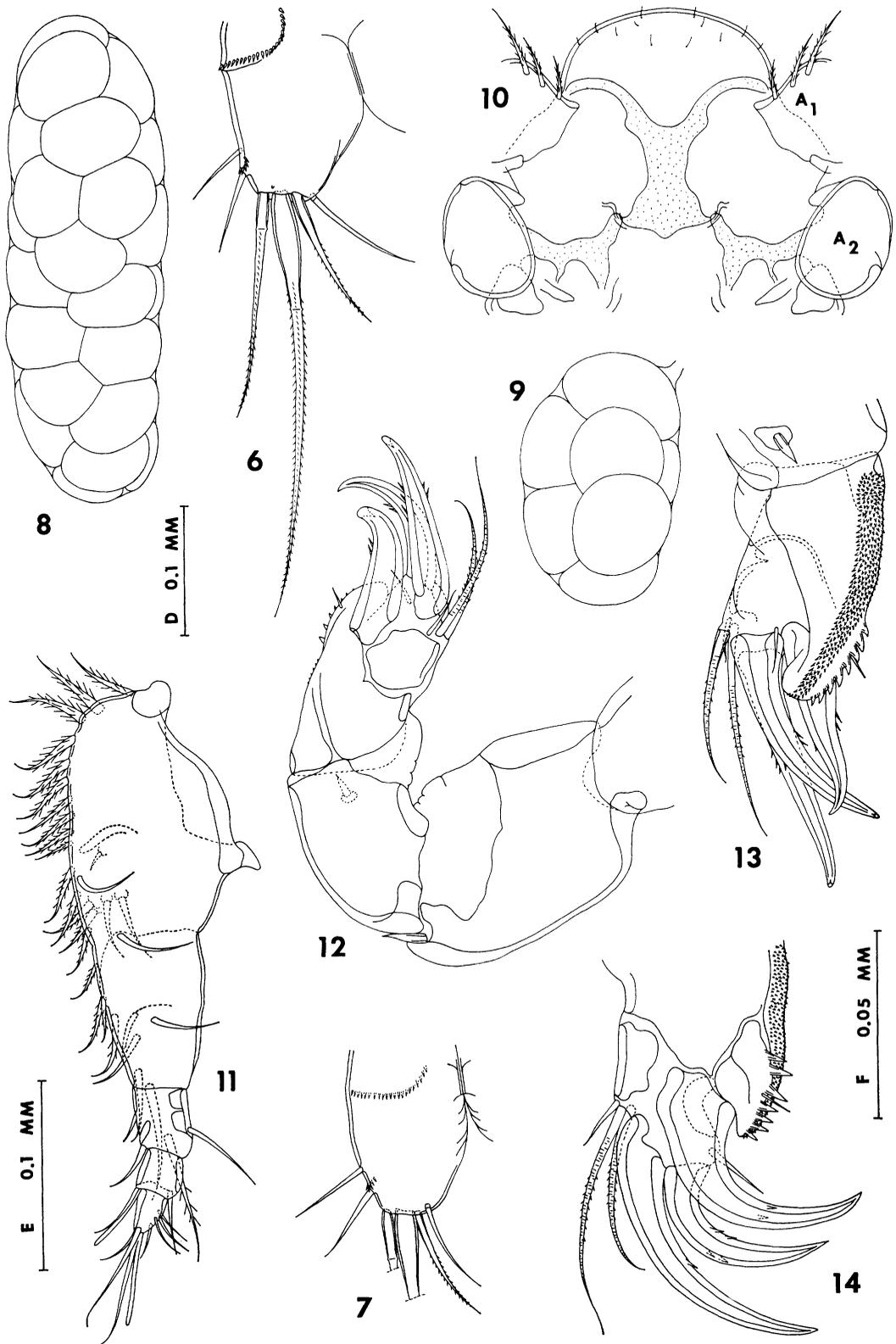
FIGURES 15–23. *Clavisodalis heterocentroti*, female. 15. Maxillary hook, ventral (C). 16. Labrum and postoral area, ventral (E). 17. Mandible, antero-inner (F). 18. First maxilla, posterior (F). 19. Second maxilla, anterior (C). 20. Maxilliped, ventral (C). 21. Tip of claw of maxilliped, ventral (F). 22. Median region from maxillipeds to leg 4, ventral (B). 23. Leg 1 and intercoxal plate, anterior (D).

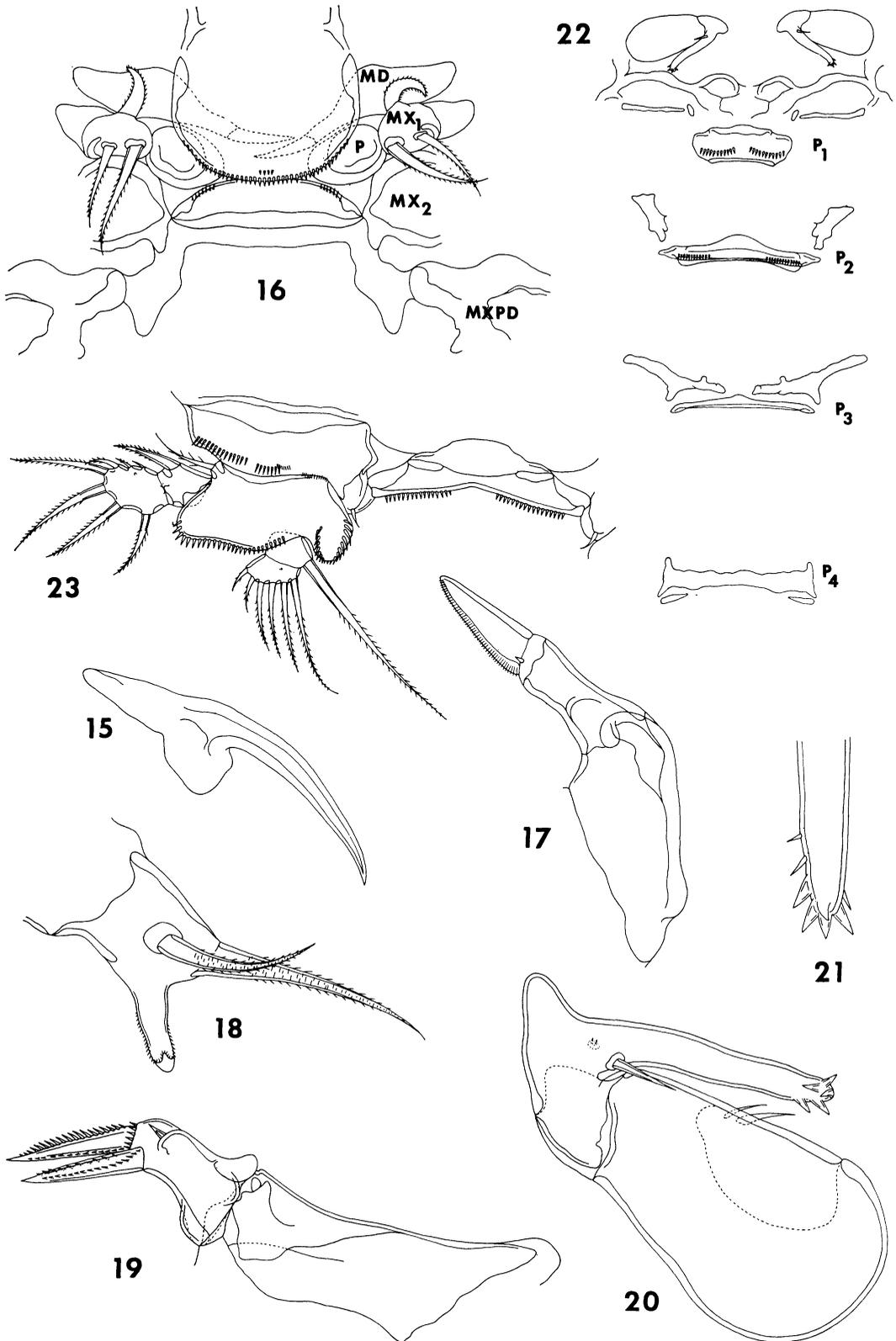
FIGURES 24–28. *Clavisodalis heterocentroti*, female. 24. Leg 2 and intercoxal plate, anterior (D). 25. Abnormal right exopod of leg 2, anterior (E). 26. Leg 3, anterior (D). 27. Leg 4, anterior (D). 28. Leg 5, dorsal and slightly lateral (G).

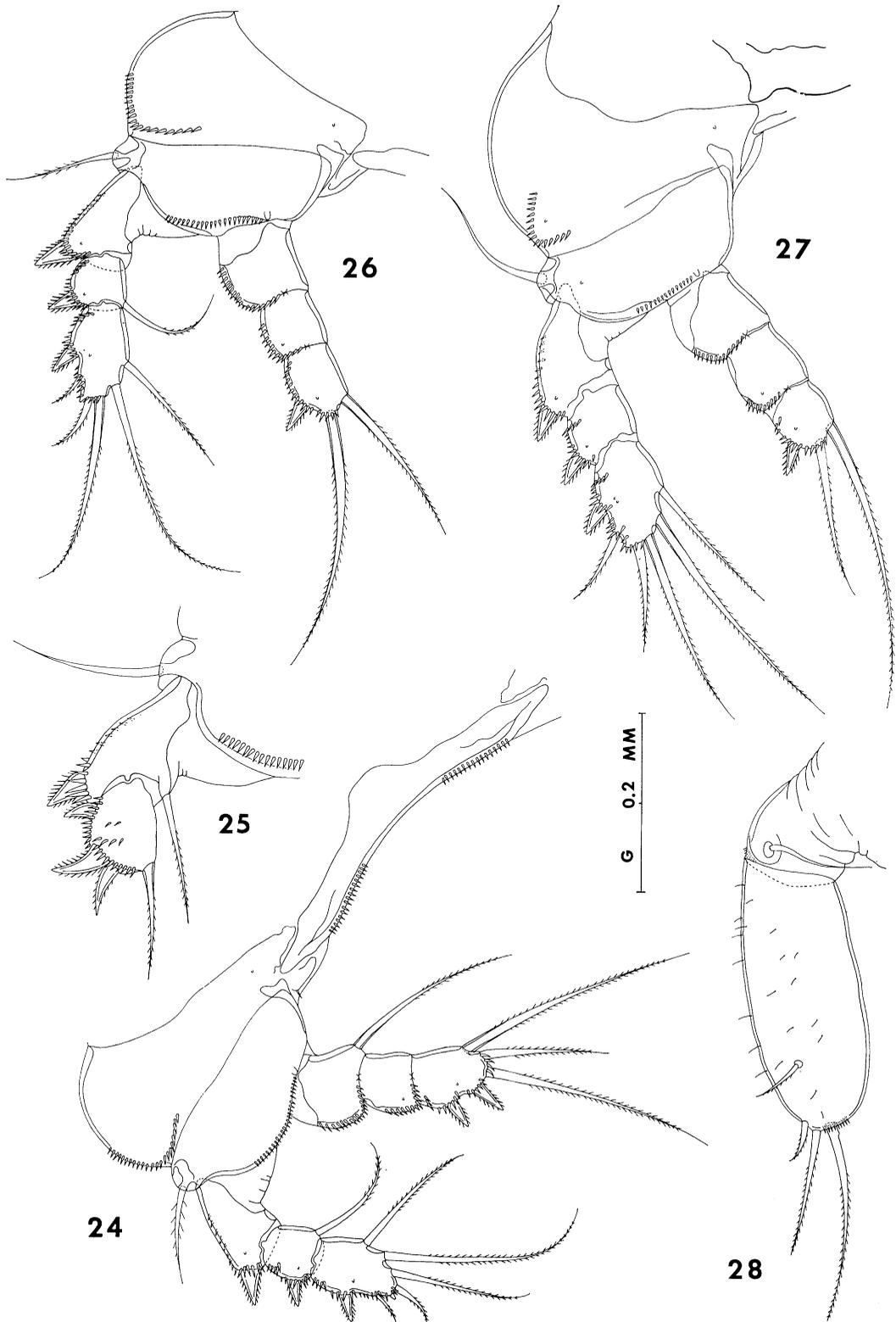
FIGURES 29–35. *Clavisodalis heterocentroti*, male. 29. Dorsal (A). 30. Lateral (A). 31. Urosome, dorsal (G). 32. Maxilliped, posterior (D). 33. Region between maxillipeds and first pair of legs, ventral (G). 34. Leg 6, ventral (C). 35. Spermatophore, dorsal (E).

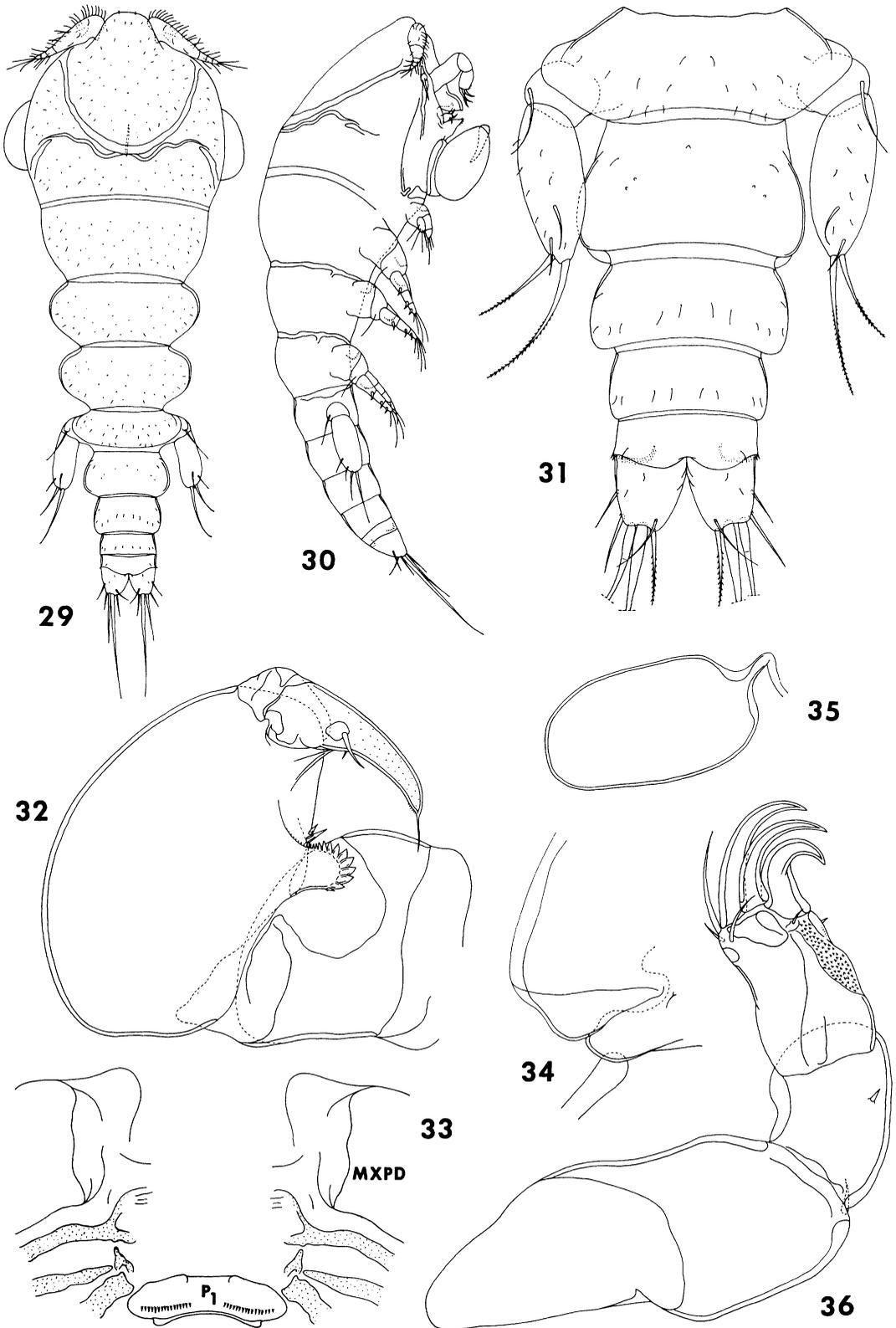
FIGURE 36. *Echinirus laxatus* Humes and Cressey, 1961, female. Second antenna, postero-inner (C).











segment much shorter, with a slight proximal inner swelling, and armed with 2 subequal terminal spines having lateral spinules and with a small naked subterminal spine. Maxilliped (Fig. 20) probably derived from a 4-segmented condition. First segment, however, not clearly identifiable. Second segment very large and bearing 2 naked setae. Small third segment not distinctly set off from claw. Fourth segment probably represented by proximal part of claw; this suggested by fact that some specimens show a very weak division about midway on the claw. Claw itself clavate rather than unguiform; with proximally a prominent inner protuberance, a small hyaline dorsal area with 2 or 3 minute processes (spinules?), and a ventral seta. Terminally claw bearing 4 to 8 short spines (Fig. 21), resembling a mace.

Ventral area between maxillipeds and first pair of legs with well-developed sclerites (Fig. 22). No line connecting bases of maxillipeds.

Leg 1 (Fig. 23) with 2-segmented rami; legs 2-4 (Figs. 24, 26, 27) with 3-segmented rami. Armature as follows (with designation as spines or setae not indicated because of difficulty of differentiation):

$P_1$	coxa	0-1	basis	1-0	exp	1-0;	7
				enp	0-1;	6	
$P_2$	coxa	0-1	basis	1-0	exp	1-0;	1-1; 6
				enp	0-1;	0-0;	5
$P_3$	coxa	0-0	basis	1-0	exp	1-0;	1-1; 6
				enp	0-0;	0-0;	3
				[rarely	0-1;	0-0;	3]
$P_4$	coxa	0-0	basis	1-0	exp	1-0;	1-0; 6
				enp	0-0;	0-0;	3
				[rarely	0-1;	0-0;	3]

Intercostal plates of legs 1-4 (Fig. 22) showing a gradual reduction posteriorly, that of leg 3 lacking the 2 rows of spines seen on those of legs 1 and 2, and that of leg 4 reduced to 2 small unornamented sclerites. With reduction of intercostal plates 2 sclerites anterior to leg increasing in size and finally in leg 4 coalescing medially to form a broad sclerite which apparently substitutes for the vestigial intercostal plate.

Inner coxal seta of leg 1 small and naked, that of leg 2 still smaller, and this seta lacking in legs 3 and 4. Inner margin of basis in leg 1 somewhat expanded and bearing a crescentic row of spines; in legs 2-4 this margin unexpanded and smooth. Basis of leg 1 expanded between 2 rami, but such an expansion absent in legs 2-4. Last segment of exopod of legs 2-4 bearing terminally a small blunt process in addition to spinules. An abnormal right exopod of leg 2 shown in Figure 25. Legs 1 and 2 showing a constant armature in all 9 females closely studied. Eight of these females showing a fixed armature for legs 3 and 4, but the ninth having in right endopod of leg 3 the formula 0-1; 0-0; 3, and in both endopods of leg 4 the formula 0-1; 0-0; 3.

Leg 5 (Fig. 28) having an elongated free segment 308 by 130  $\mu$  held laterally to body in specimens in alcohol. Dorsolateral subterminal seta 55

$\mu$  and 3 terminal setae 42, 143, and 200  $\mu$ , respectively, all 4 setae barbed. Seta on body near free segment 120  $\mu$  and naked, with a dorsal row of spinules near its insertion. Free segment ornamented terminally with similar row of spinules, and with scattered hairs on its dorsal surface.

Leg 6 represented by 3 setae near attachment of each egg sac (Fig. 4).

Color in life in transmitted light reddish, intestine dark reddish brown, eye red, egg sacs grayish brown.

### Male

Body (Figs. 29, 30) with rather different shape from female, prosome having greatest width more anteriorly and tapering posteriorly. Length 1.70 mm (1.54 to 1.92 mm) and greatest width 0.64 mm (0.56 to 0.70 mm), based on 10 specimens in lactic acid. Segment of leg 1 fused with cephalosome, but that of leg 2 clearly delimited. Ratio of length to width of prosome 1.94:1. Ratio of length of prosome to that of urosome 2.16:1.

Segment of leg 5 (Fig. 31) 130 by 385  $\mu$ . Between this segment and genital segment no ventral sclerite. Genital segment 156 by 257  $\mu$  in dorsal view, with only slightly expanded edges. Three postgenital segments 99 by 222  $\mu$ , 73 by 179  $\mu$ , and 39 by 164  $\mu$  from anterior to posterior.

Caudal ramus 78 by 156  $\mu$  and set off from anal segment by a weakly developed suture. Armature like that of female.

Surfaces of body ornamented with small hairs and refractile points, latter more numerous than in female.

Rostral area, first antenna, second antenna, labrum, mandible, paragnath, first maxilla, and second maxilla like those of female. Maxilliped (Fig. 32) 4-segmented, assuming that proximal part of claw represents a fourth segment. Unarmed first segment closely applied to body. Second segment large and swollen, with an inner digitiform lobe whose margin carries a row of spines, and with 2 unequal naked inner setae. Unarmed third segment small and not clearly distinguishable from base of claw. Claw about 135  $\mu$  long, bearing 2 very unequal proximal naked setae, having finely punctate distal surface, and terminating in a slender filament 24  $\mu$  long, near whose base there is a short row of minute spinules.

Ventral area between maxillipeds and first pair of legs (Fig. 33) with sclerotized areas rather different from those of female.

Legs 1-4 like those of female, with same segmentation and armature. Legs 1-3 showing a constant armature in all 7 males closely studied. Five of these males showing a fixed armature in leg 4, but one having in left endopod of leg 4 the formula 0-1; 0-0; 3, and another with same formula on both endopods of this leg.

Leg 5 similar to that of female, but smaller, 180 by 70  $\mu$ .

Leg 6 (Fig. 34) consisting of a small unarmed posteroventral flap on genital segment.

Spermatophore (Fig. 35), attached to female, 117 by 62  $\mu$ , not including neck.

Color as in female.

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

#### Comparison of *Clavisodalis* with related genera

Two features of *Clavisodalis* distinguish it from other taeniacanthid genera. These are (1) the absence of an inner seta on the first two segments of the 3-segmented endopod of leg 4, and (2) the long straight claw, clavate rather than unguiform, on the maxilliped of the female. All other genera with 3-segmented endopods in leg 4 have an inner seta on the first two segments. In all genera where there is a claw on the maxilliped of the female the form of the claw is recurved and unguiform.

*Clavisodalis* appears to be related to *Echinirus* Humes and Cressey, 1961. Notable features common to those two genera are: the habitat on echinoids, the general form of the body, the 6-segmented first antenna, the two terminal elements on the mandible being extremely unequal, the second segment of the male maxilliped swollen with a large inner process which opposes the claw, the head appendages not creating an attachment disk as in *Echinosocius* Humes and Cressey, 1961, and no sexual dimorphism in legs 1–4.

The major differences between these two genera are: the maxilliped of the female present and with a clavate claw in *Clavisodalis*, absent in *Echinirus*; the first maxilla with two setae and a process in *Clavisodalis*, with three setae and a process in *Echinirus*; and differ-

ences in the armature of legs 1–4, especially the absence in *Clavisodalis* of an inner seta on the first and second endopod segments of legs 3 and 4, on the second endopod segment of leg 2, and on the second exopod segment of leg 4.

In the original description of *Echinirus laxatus* Humes and Cressey, 1961, the second antenna was said to be 4-segmented. A re-examination of this appendage based on newly collected (1967) specimens from *Diadema setosum* at the type locality in Madagascar shows (Fig. 36) that in reality there are three segments and that the arrangement of the armature is like that of *Clavisodalis*.

#### ACKNOWLEDGMENTS

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I am indebted to Mr. F. Julian Fell for the identification of the host echinoid.

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