

# A SIPHONOSTOME COPEPOD ASSOCIATED WITH A VESTIMENTIFERAN FROM THE GALAPAGOS RIFT AND THE EAST PACIFIC RISE<sup>1</sup>

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*Abstract*—*Ceuthoecetes aliger*, new genus, new species, a siphonostome copepod belonging to the new family Dirivultidae Humes and Dojiri (in press) occurs on the tentacular crown of a large vestimentiferan living in warm water near hydrothermal vents on the Galapagos Rift and the East Pacific Rise.

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Two species of copepods are known as associates of Vestimentifera Webb, 1969, a group of tubicolous marine worms placed in the Pogonophora by Webb (1969) but among the Annelida by van der Land and Nørrevang (1977). The clausidiid *Tychidion guyanense* Humes, 1973, is associated with *Lamellibrachia luymesii* van der Land and Nørrevang, 1977, in 500 m off Guyana. *Dirivultus dentaneus* Humes and Dojiri, in press (new family Dirivultidae), occurs on the tentacular crown of *Lamellibrachia barhami* Webb, 1969, in 1125 m, off southern California. This paper includes the description of a third species of copepod, this time from the tentacular crown of a large vestimentiferan from the Galapagos Rift and the East Pacific Rise. The worms from these two areas, tentatively identified as the same species, are presently under study by Dr. Meredith L. Jones, National Museum of Natural History, Smithsonian Institution.

The vestimentiferans, living in warm water near hydrothermal vents on the Galapagos Rift (about 380 km northwest of the Galapagos and 1,000 km west of Ecuador) and the East Pacific Rise (about 250 km south of the tip of Baja California), were collected during dives by the submersible *Alvin*, operated by the Woods Hole Oceanographic Institution (see Corliss *et al.*, 1979).

Three preserved vestimentiferans were washed gently in 70 percent ethyl alcohol, making sure that the alcohol passed freely between the many lamellae on the tentacular crown. The copepods were recovered from the sediment obtained after passing the solution through a fine net (openings about 100  $\mu\text{m}$  square). The first vestimentiferan yielded 34 adults and 17

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copepodids; the second 1 adult and 6 copepodids; and the third 2 adults and 18 copepodids. The total number was 37 adults and 41 copepodids.

The study of the copepods was aided by grant DEB 77 11879 from the National Science Foundation.

All measurements were made on specimens in lactic acid. The figures were drawn with the aid of a camera lucida. The letter after the explanation of each figure refers to the scale at which it was drawn. The abbreviations used are:  $A_1$  = first antenna and MXPd = maxilliped.

*Dirivultidae* Humes and Dojiri, in press

*Ceuthoecetes*, new genus

*Diagnosis*.—Siphonostomatoida, Dirivultidae. Body unmodified. Urosome 5-segmented in female, 6-segmented in male. Caudal ramus with six setae. Rostrum not well defined. First antenna 10-segmented, with aesthete on next to last segment. Prehensile second antenna with minute exopod and 2-segmented endopod with one terminal claw.

Oral cone short. Mandible a long slender blade with serrate tip, lacking palp. First maxilla with small outer lobe. Second maxilla prehensile, second segment merging with long slender claw. Maxilliped prehensile and 4-segmented with terminal claw.

Legs 1–3 with 3-segmented rami. Leg 4 with 3-segmented exopod and 2-segmented endopod. Formula for endopod 0-0; I,1. Legs 1–4 alike in both sexes.

Leg 5 sexually dimorphic, in female placed laterally with four setae on free segment and dorsal seta absent, in male placed ventrally with five setae on free segment and “dorsal” seta present. Leg 6 in female lacking identifiable setae or spines but perhaps represented by two small processes on genital area, in male with two setae on posteroventral flap on genital segment.

Other features as in species described below.

Associated with Vestimentifera.

*Type-species*.—*Ceuthoecetes aliger*, new species.

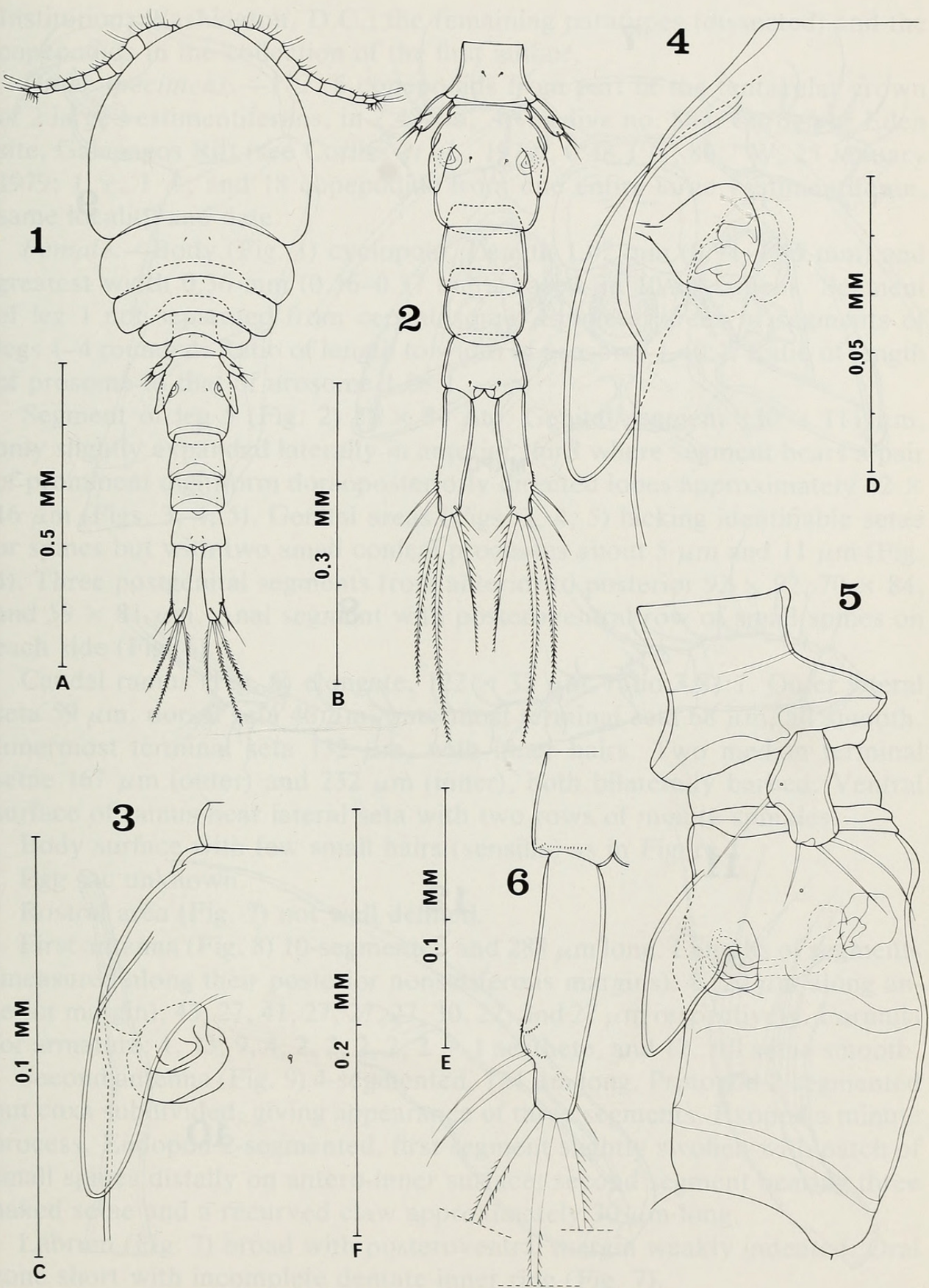
*Etymology*.—The generic name is a combination of *κευθος*, the depths, and *οικητης*, an inhabitant. Gender masculine.

*Ceuthoecetes aliger*, new species

Figs. 1–28

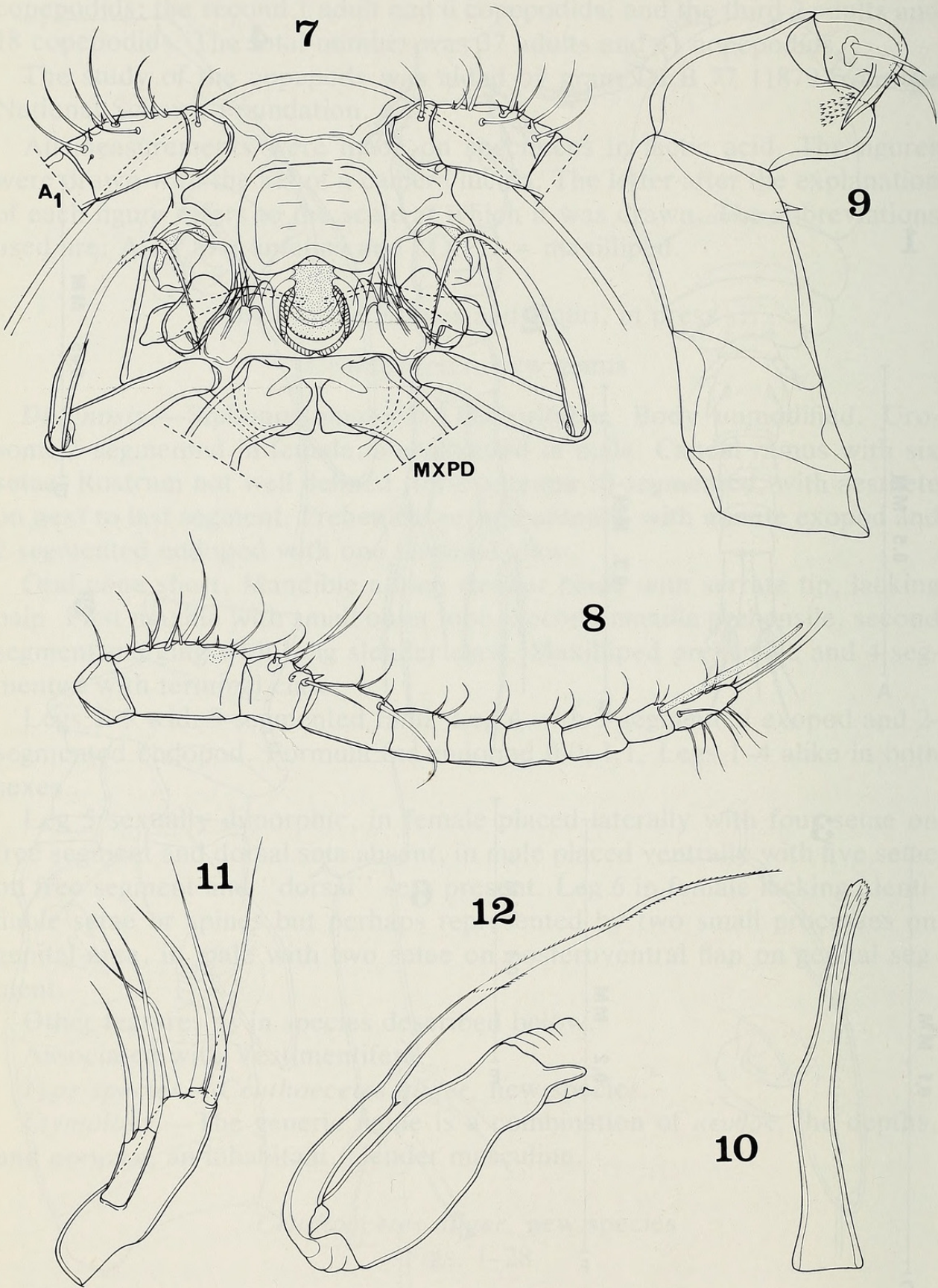
*Type-material*.—8 ♀♀, 26 ♂♂, and 17 copepodids from one large vestimentiferan in 2,595 m, *Alvin* dive no. 915, East Pacific Rise, 20°51'N, 109°4.9'W, 22 April 1979. Holotype ♀, allotype, and 25 paratypes (4 ♀♀, 21 ♂♂) deposited in the National Museum of Natural History, Smithsonian





Figs. 1–6. *Ceuthoecetes aliger*, female: 1, Dorsal (A); 2, Urosome, dorsal (B); 3, Genital area, dorsal (C); 4, Genital area, ventral (D); 5, Segment of leg 5 and genital segment, lateral (E); 6, Caudal ramus, ventral (F).





Figs. 7-12. *Ceuthoecetes aliger*, female: 7, Oral area, ventral (F); 8, First antenna, ventral (F); 9, Second antenna, antero-inner (D); 10, Mandible, posterior (D); 11, First maxilla, posterolateral (C); 12, Second maxilla, posterior (C).



Institution, Washington, D.C.; the remaining paratypes (dissected) and the copepodids in the collection of the first author.

*Other specimens.*—1 ♀, 6 copepodids from part of the tentacular crown of 2 large vestimentiferans, in 2,482 m, *Alvin* dive no. 884, Garden of Eden site, Galapagos Rift (see Corliss *et al.*, 1979), 0°48.1'N, 86°7'W, 25 January 1979; 1 ♀, 1 ♂, and 18 copepodids from one entire large vestimentiferan, same locality and date.

*Female.*—Body (Fig. 1) cyclopoid. Length 1.02 mm (0.94–1.15 mm) and greatest width 0.36 mm (0.36–0.37 mm), based on 10 specimens. Segment of leg 1 not separated from cephalosome. Epimeral areas of segments of legs 1–4 rounded. Ratio of length to width of prosome 1.40:1. Ratio of length of prosome to that of urosome 1.08:1.

Segment of leg 5 (Fig. 2)  $59 \times 84 \mu\text{m}$ . Genital segment  $130 \times 111 \mu\text{m}$ , only slightly expanded laterally in anterior third where segment bears a pair of prominent digitiform dorsoposteriorly directed lobes approximately  $62 \times 16 \mu\text{m}$  (Figs. 3, 4, 5). Genital areas (Figs. 3, 4, 5) lacking identifiable setae or spines but with two small conical processes about  $5 \mu\text{m}$  and  $11 \mu\text{m}$  (Fig. 4). Three postgenital segments from anterior to posterior  $92 \times 92$ ,  $70 \times 84$ , and  $59 \times 81 \mu\text{m}$ . Anal segment with posteroventral row of small spines on each side (Fig. 6).

Caudal ramus (Fig. 6) elongate,  $122 \times 32 \mu\text{m}$ , ratio 3.81:1. Outer lateral seta  $59 \mu\text{m}$ , dorsal seta  $46 \mu\text{m}$ , outermost terminal seta  $68 \mu\text{m}$ , all smooth. Innermost terminal seta  $132 \mu\text{m}$ , with inner hairs. Two median terminal setae  $167 \mu\text{m}$  (outer) and  $232 \mu\text{m}$  (inner), both bilaterally barbed. Ventral surface of ramus near lateral seta with two rows of minute spinules.

Body surface with few small hairs (sensilla) as in Figure 1.

Egg sac unknown.

Rostral area (Fig. 7) not well defined.

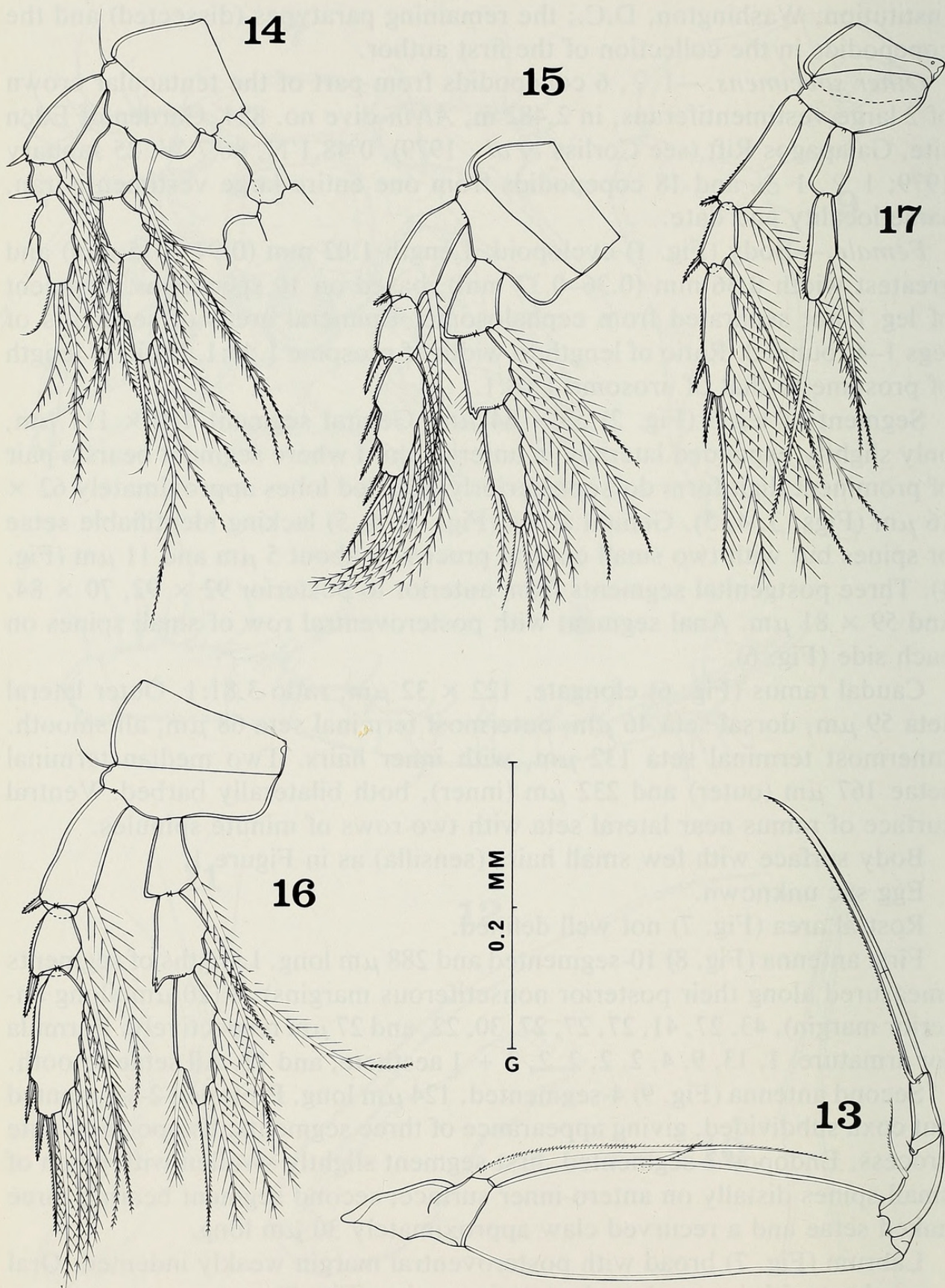
First antenna (Fig. 8) 10-segmented and  $288 \mu\text{m}$  long. Lengths of segments (measured along their posterior nonsetiferous margins): 8 ( $20 \mu\text{m}$  along anterior margin), 43, 27, 41, 27, 27, 27, 30, 22, and  $27 \mu\text{m}$  respectively. Formula for armature: 1, 13, 9, 4, 2, 2, 2, 2, 2 + 1 aesthete, and 12. All setae smooth.

Second antenna (Fig. 9) 4-segmented,  $124 \mu\text{m}$  long. Protopod 2-segmented but coxa subdivided, giving appearance of three segments. Exopod a minute process. Endopod 2-segmented, first segment slightly swollen with patch of small spines distally on antero-inner surface; second segment bearing three naked setae and a recurved claw approximately  $30 \mu\text{m}$  long.

Labrum (Fig. 7) broad with posteroventral margin weakly indented. Oral cone short with incomplete dentate inner ring (Fig. 7).

Mandible (Fig. 10) a long slender blade  $65 \mu\text{m}$  with finely serrate tip. Paragnath not seen. First maxilla (Fig. 11) with small outer lobe having three setae, large inner lobe with four setae, all setae smooth. Second max-





Figs. 13–17. *Ceuthoecetes aliger*, female: 13, Maxilliped, posterior (F); 14, Leg 1 and intercoxal plate, anterior (G); 15, Leg 2, anterior (G); 16, Leg 3, anterior (G); 17, Leg 4, anterior (G).



illa (Fig. 12) with elongate first segment  $78 \times 25 \mu\text{m}$  including proximal blunt spinelike process. Second segment merging with long slender claw, forming functional claw  $157 \mu\text{m}$  long provided distally with small spinules. Maxilliped (Fig. 13) 4-segmented. First segment small with long spinulose inner seta. Second segment elongate,  $189 \times 54 \mu\text{m}$ , with short inner seta. Third segment  $51 \mu\text{m}$  long with two very unequal setae. Fourth segment  $27 \mu\text{m}$ , with one seta and two minute spinules. Claw nearly straight,  $135 \mu\text{m}$ , obscurely subdivided and bearing short spinules along inner side.

Ventral area between maxillipeds and first pair of legs without special sclerotization.

Legs 1–4 (Figs. 14, 15, 16, 17) biramous, with all rami 3-segmented except for 2-segmented endopod of leg 4. Formula for armature as follows (Roman numerals indicating spines, Arabic numerals representing setae):

$P_1$	coxa	0–0	basis	1–1	exp	I–1;	I–1;	II,I,4
					enp	0–1;	0–2;	1,2,3
$P_2$	coxa	0–0	basis	1–0	exp	I–1;	I–1;	III,I,4
					enp	0–1;	0–2;	1,2,3
$P_3$	coxa	0–0	basis	1–0	exp	I–1;	I–1;	II,I,5
					enp	0–1;	0–2;	1,1,3
$P_4$	coxa	0–0	basis	1–0	exp	I–1;	I–1;	II,I,4
					enp	0–0;	I,1	

Leg 1 (Fig. 14) with intercoxal plate bearing pair of processes on ventral margin. Basis with smooth inner seta  $43 \mu\text{m}$  long. Outer spines on exopod weak and setiform. Proximal five inner setae on endopod with short spinules near tips instead of long hairs. Outer margin of first endopod segment smooth (as in legs 2–4 also). Leg 2 (Fig. 15) and leg 3 (Fig. 16) with bifurcate distal outer process on second endopod segment and with several setae showing short distal spinules as in leg 1. Leg 4 (Fig. 17) with exopod  $216 \mu\text{m}$ . Endopod with smooth unarmed first segment  $49 \times 21 \mu\text{m}$ ; second segment  $76 \times 21 \mu\text{m}$ , with terminal barbed spine  $146 \mu\text{m}$  and inner seta  $151 \mu\text{m}$ , segment with small spinules along outer margin.

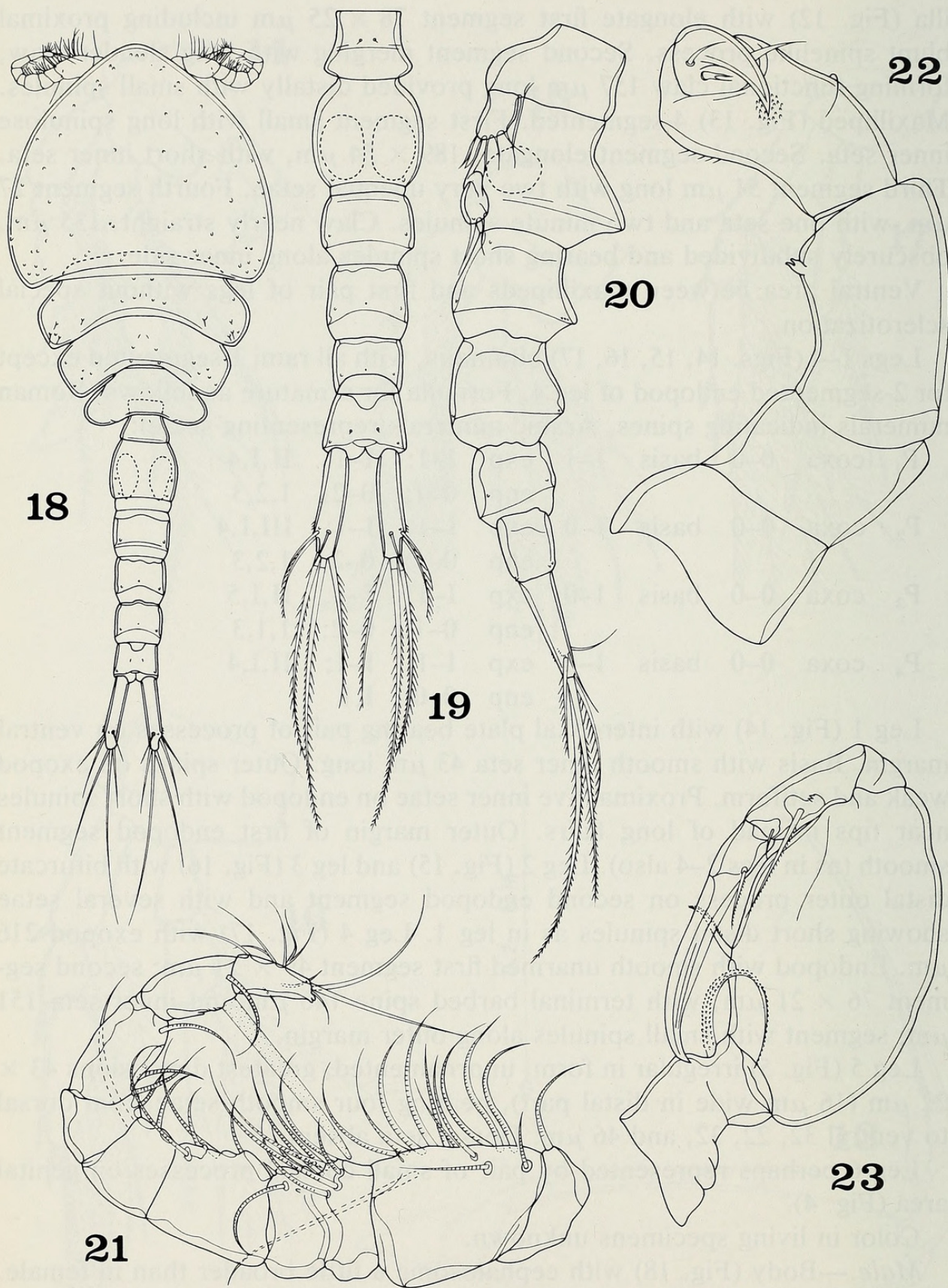
Leg 5 (Fig. 5) irregular in form, unornamented, greatest dimensions  $43 \times 22 \mu\text{m}$  ( $16 \mu\text{m}$  wide in distal part), bearing four smooth setae from dorsal to ventral 32, 22, 32, and  $46 \mu\text{m}$ . Dorsal seta absent.

Leg 6 perhaps represented by pair of small conical processes on genital area (Fig. 4).

Color in living specimens unknown.

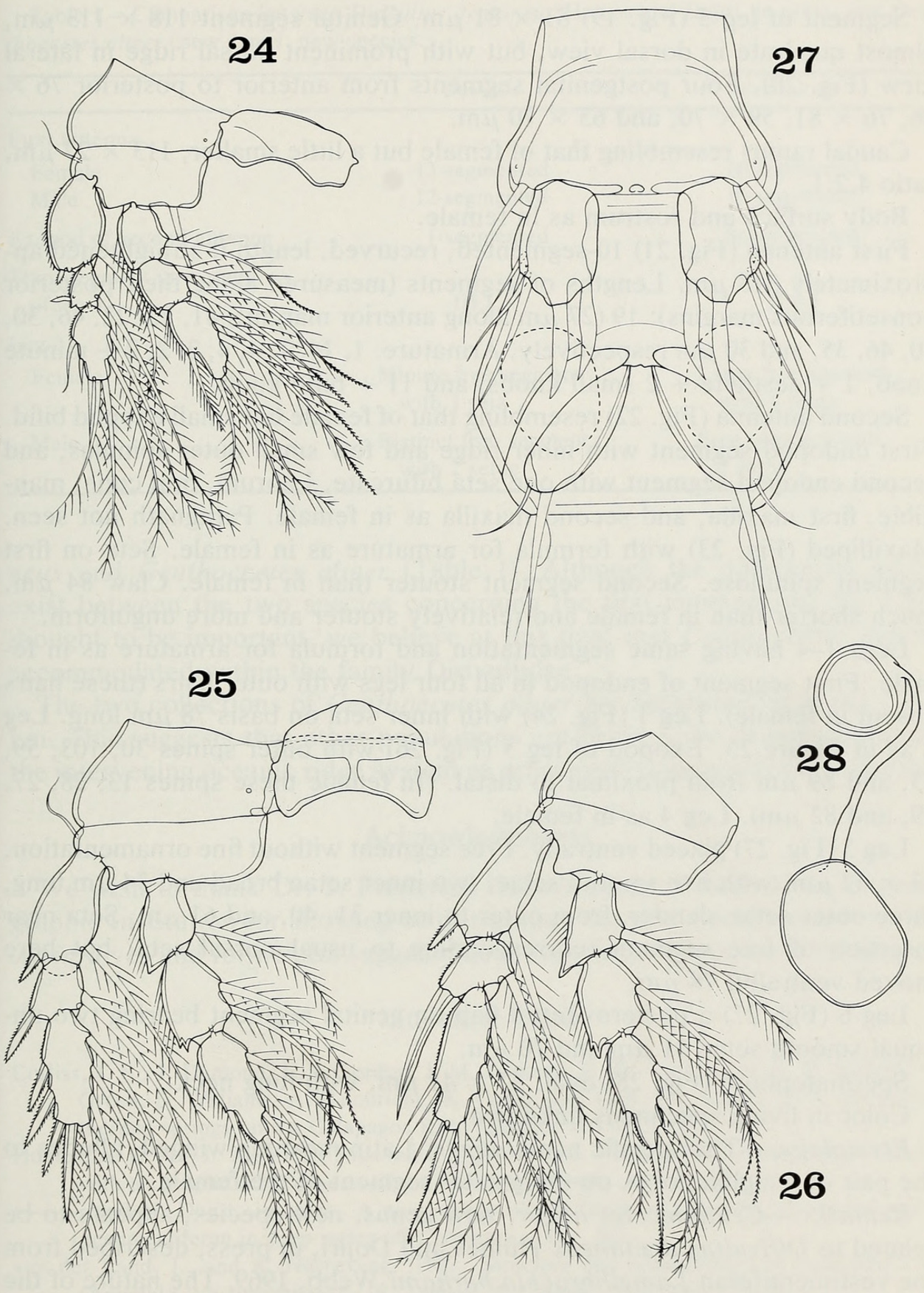
*Male*.—Body (Fig. 18) with cephalosome a little broader than in female. Length (excluding setae on caudal rami) 1.14 mm (1.03–1.29 mm) and greatest width 0.42 mm (0.37–0.45 mm), based on 10 specimens. Ratio of length to width of prosome 1.39:1. Ratio of length of prosome to that of urosome 1.31:1.





Figs. 18–23. *Ceuthoecetes aliger*, male: 18, Dorsal (A); 19, Urosome, dorsal (B); 20, Urosome, lateral (B); 21, First antenna, ventral (E); 22, Second antenna, antero-outer (D); 23, Maxilliped, posterior (F).





Figs. 24–28. *Ceuthoecetes aliger*, male: 24, Leg 1 and intercoxal plate, anterior (G); 25, Leg 2 and intercoxal plate, anterior (G); 26, Leg 3, anterior (G); 27, Legs 5 and 6, ventral (E); 28, Spermatophore, as attached to genital area of female (E).



Segment of leg 5 (Fig. 19)  $81 \times 81 \mu\text{m}$ . Genital segment  $118 \times 113 \mu\text{m}$ , almost quadrate in dorsal view, but with prominent dorsal ridge in lateral view (Fig. 20). Four postgenital segments from anterior to posterior  $76 \times 86$ ,  $76 \times 81$ ,  $59 \times 70$ , and  $65 \times 70 \mu\text{m}$ .

Caudal ramus resembling that of female but a little smaller,  $113 \times 27 \mu\text{m}$ , ratio 4.2:1.

Body surface and rostrum as in female.

First antenna (Fig. 21) 10-segmented, recurved, length if straightened approximately  $318 \mu\text{m}$ . Lengths of segments (measured along their posterior nonsetiferous margins): 19 ( $27 \mu\text{m}$  along anterior margin), 41, 22, 22, 46, 30, 30, 46, 35, and  $30 \mu\text{m}$  respectively. Armature: 1, 14, 7, 4, 4, 2, 2, 2 + minute knob, 1 + aesthete + 2 small knobs, and 11 + bifid knob.

Second antenna (Fig. 22) resembling that of female but small exopod bifid. First endopod segment with inner ridge and few small outer spinules, and second endopod segment with one seta bifurcate. Labrum, oral cone, mandible, first maxilla, and second maxilla as in female. Paragnath not seen. Maxilliped (Fig. 23) with formula for armature as in female. Seta on first segment spinulose. Second segment stouter than in female. Claw  $84 \mu\text{m}$ , much shorter than in female and relatively stouter and more unguiform.

Legs 1–4 having same segmentation and formula for armature as in female. First segment of endopod in all four legs with outer hairs (these hairs absent in female). Leg 1 (Fig. 24) with inner seta on basis  $78 \mu\text{m}$  long. Leg 2 as in Figure 25. Exopod of leg 3 (Fig. 26) with outer spines 30, 103, 59, 65, and  $89 \mu\text{m}$  from proximal to distal. (In female these spines 13, 28, 27, 29, and  $82 \mu\text{m}$ ). Leg 4 as in female.

Leg 5 (Fig. 27) placed ventrally. Free segment without fine ornamentation,  $43 \times 32 \mu\text{m}$ , with five smooth setae, two inner setae broad and  $34 \mu\text{m}$  long, three outer setae slender, from outer to inner 31, 40, and  $61 \mu\text{m}$ . Seta near insertion of free segment (corresponding to usual dorsal seta, but here moved ventrally)  $78 \mu\text{m}$ .

Leg 6 (Fig. 27) a posteroventral flap on genital segment bearing two unequal smooth setae  $51 \mu\text{m}$  and  $70 \mu\text{m}$ .

Spermatophore (Fig. 28) oval,  $57 \times 41 \mu\text{m}$ , with long neck.

Color in living specimens unknown.

*Etymology*.—The specific name *aliger*, Latin meaning winged, alludes to the pair of winglike lobes on the genital segment of the female.

*Remarks*.—*Ceuthoecetes aliger*, new genus, new species, appears to be related to *Dirivultus dentaneus* Humes and Dojiri, in press, described from the vestimentiferan *Lamellibrachia barhami* Webb, 1969. The nature of the first maxilla, the prehensile character of the second maxilla, and the segmentation and armature of legs 1–4 provide evidence for this affinity. Furthermore, the general appearance of the mandible, a very conservative appendage, reflects this presumed relationship.

There are, however, fundamental differences between *Dirivultus denta-*



Table 1.—Comparison between *Dirivultus dentaneus* Humes and Dojiri, in press, and *Ceuthoecetes aliger*, new genus, new species.

	<i>Dirivultus</i>	<i>Ceuthoecetes</i>
First antenna		
Female	13-segmented	10-segmented
Male	12-segmented	10-segmented
Exopod of second antenna	1-segmented	Small process
Third segment of exopod of leg 3	III,I,5	II,I,5
Leg 5		
Female	Minute free segment with 1 seta	Large free segment with 4 setae
Male	Distinct free segment with 2 setae	Free segment with 5 setae

*neus* and *Ceuthoecetes aliger* (Table 1). Although the differences which exist between the two species concerning the first antenna and leg 5 are thought to be important, we believe at this time that *Ceuthoecetes* can be accommodated within the family Dirivultidae.

The two collections of *Ceuthoecetes aliger* are separated by about 3,700 km. This suggests that other populations are likely to be discovered along the intervening oceanic ridge system as other vent communities are studied.

Acknowledgments

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