Korean J Biol Sci 8: 165-186, 2004

New Species of Copepods (Crustacea) Associated with Marine Invertebrates from the Pacific Coast of Panama

Il-Hoi Kim*

Department of Biology, College of Natural Sciences, Kangnung National University, Kangnung 210-702, Korea

Key Words:

Copepoda
Association
New species
Pseudomacrochiron
Acontiophorus
Asterocheres

Five new species of copepods associated with marine invertebrates are described from shallow water of the Pacific coast of Panama. They are *Pseudomacrochiron pocilloporae* n. sp., *Acontiophorus panamensis* n. sp. and *Asterocheres urabensis* n. sp. associated with the scleractinian coral *Pocillopora damicornis* (Linnaeus), *Asterocheres pilosus* n. sp. associated with the echinoid *Eucidaris thouarsii* (Valenciennes), and *Asterocheres walteri* n. sp. associated with the sea star *Oreaster brevispinis*.

Four species of copepods associated with marine invertebrates have been recorded from the Pacific coast of Panama. From this region, *Hemicyclops columnaris* Humes, 1984 and *Euryte verecunda* Humes, 1992 were described by Humes (1984a, 1992) as associates of the scleractinian coral *Porites lobata* Dana. From the bivalves, Humes (1984b) recorded *Pseudomyicola spinosus* (Rafaele and Monticelli) as associate of *Anadara obesa* (Sowerby) and *Ostrincola falcatus* Humes, 1984 as associate of *Mytella guyanensis* (Lamarck) and *Protothaca asperrima* (Sowerby).

In the present report five new species are additionally described from the same region: one species of Cyclopoida and four of Siphonostomatoida. Copepod material examined were all collected by the late Dr. Arthur G. Humes and have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C.

Descriptions of Species

Order Cyclopoida
Family Macrochironidae
Genus *Pseudomacrochiron* Reddiah, 1969

Pseudomacrochiron pocilloporae n. sp.
(Figs. 1-3)

Material examined

3♀♀, 1♂ from the scleractinian coral *Pocillopora damicornis* (Linnaeus), at north side of Uraba Island in the Pacific coast of Panama, in 12 m, 29 October 1981, collected by A. G. Humes. Holotype (♀), allotype (♂, right maxilliped dissected out), and paratype (♀) will be deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C. Dissected paratype (1♀) is kept in the collection of the author.

Female

Body (Fig. 1A) with moderately broad prosome and slender urosome. Length 782 μm. Prosome 500×326 μm, with demarcation between cephalosome and first pedigerous somite by faint dorsal suture line. Urosome (Fig. 1B) 5-segmented. Fifth pedigerous somite 90 μm wide. Genital double-somite 127×81 μm, with moderately expanded anterior part and narrower posterior part; genital areas located at anterior 37% length of somite at area of maximum width in expanded anterior part. Three abdominal somites 24×50, 20×49, and 32×52 μm from anterior to posterior. Anal somite distinctly shorter than wide, with minute spinules on posteroventral margin. Caudal ramus (Fig. 1C) 46×25 μm, ratio (1.84:1), with 6 setae. Outer lateral seta located at 65% length of outer lateral margin. Two median terminal setae with thin membrane along one side.

Rostrum as long as wide, reversed triangle-like (Fig. 1D). Antennule (Fig. 1E) 7-segmented, 271 μm long, with armature formula 4, 13, 6, 3, 4+aesthetasc, 2+aesthetasc, and 7+aesthetasc. All setae smooth. Antenna (Fig. 1F) 4-segmented, with armature formula 1, 1, 2+claw, and 5+2 claws. Second segment with minute spinules on proximal half of inner margin. Claw on third segment 31 μm. Terminal segment 57×23 μm. Claws of terminal segment slender, distinctly annulated in middle, both 76 μm long. Two of 5 setae on terminal segment distinctly longer than other 3 and claws.

Labrum (Fig. 2A) with wide median incision; inner margin of both lobes with row of minute spinules. Mandible (Fig. 2B) with deep proximal notch. Inner

*Tel: 82-33-640-2312, Fax: 82-33-642-6124
E-mail: ihkim@kangnung.ac.kr

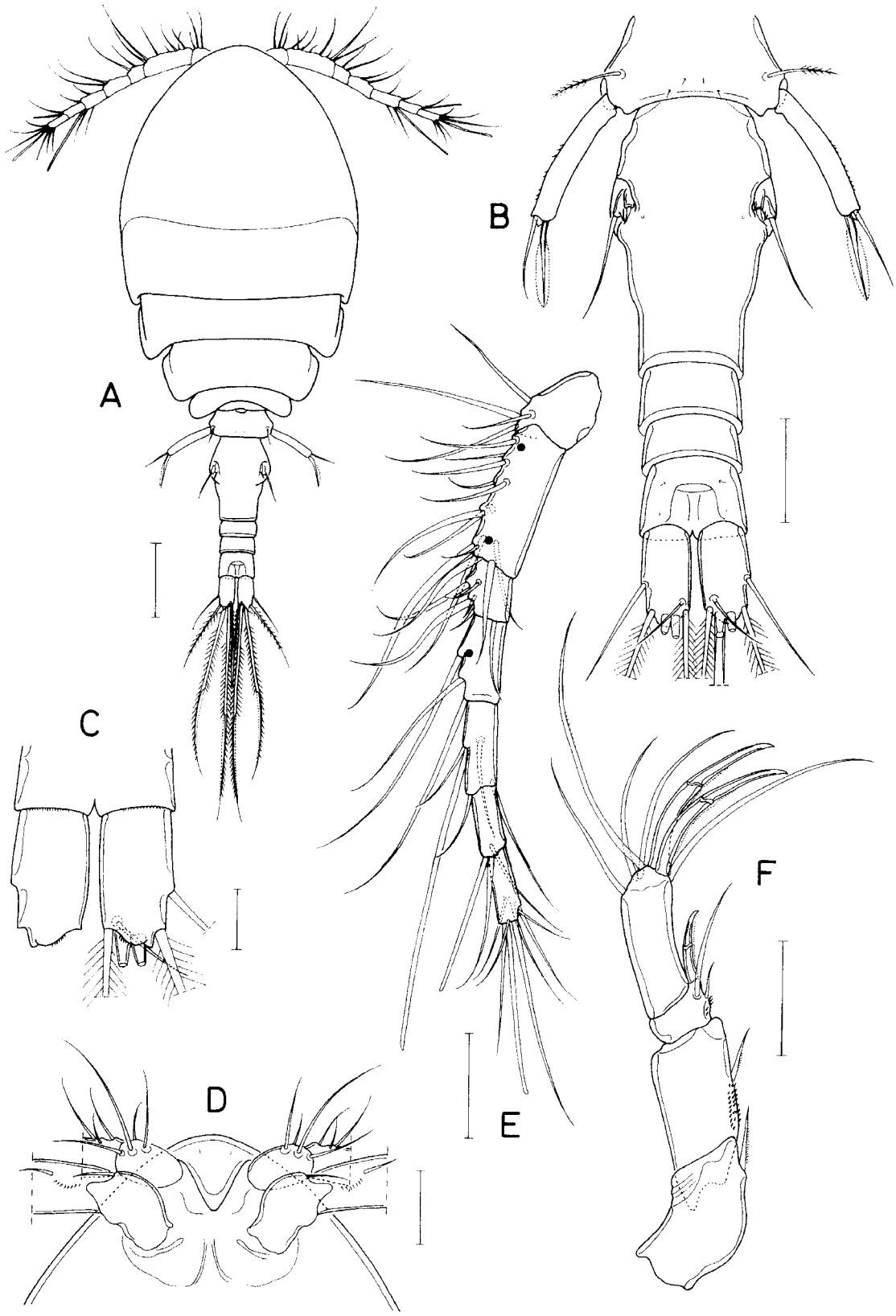

Fig. 1. *Pseudomacrochiron pocilloporae* n. sp., female. A, Habitus, dorsal. B, Urosome, dorsal. C, Caudal rami, ventral. D, Rostral area, ventral. E, Antennule. F, Antenna. Scale bars=100 μm (A), 50 μm (B, D-F), 20 μm (C).

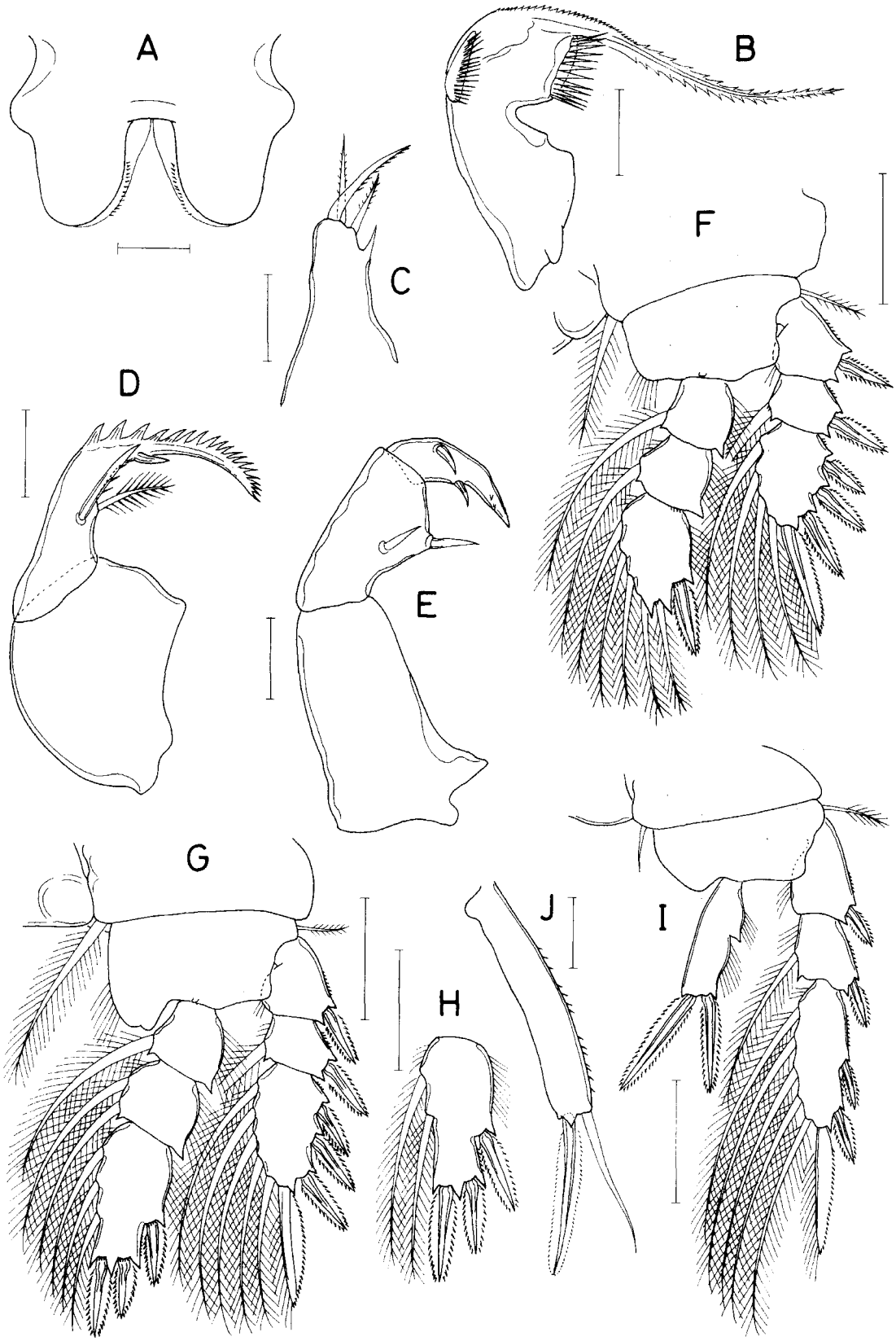

Fig. 2. *Pseudomacrochiron pocilloporae* n. sp., female. A, Labrum. B, Mandible. C, Maxillule. D, Maxilla. E, Maxilliped. F, Leg 1. G, Leg 2. H, Third endopodal segment of leg 3. I, Leg 4. J, Free segment of leg 5. Scale bars=20 μm (A-E, J), and 50 μm (F-I).

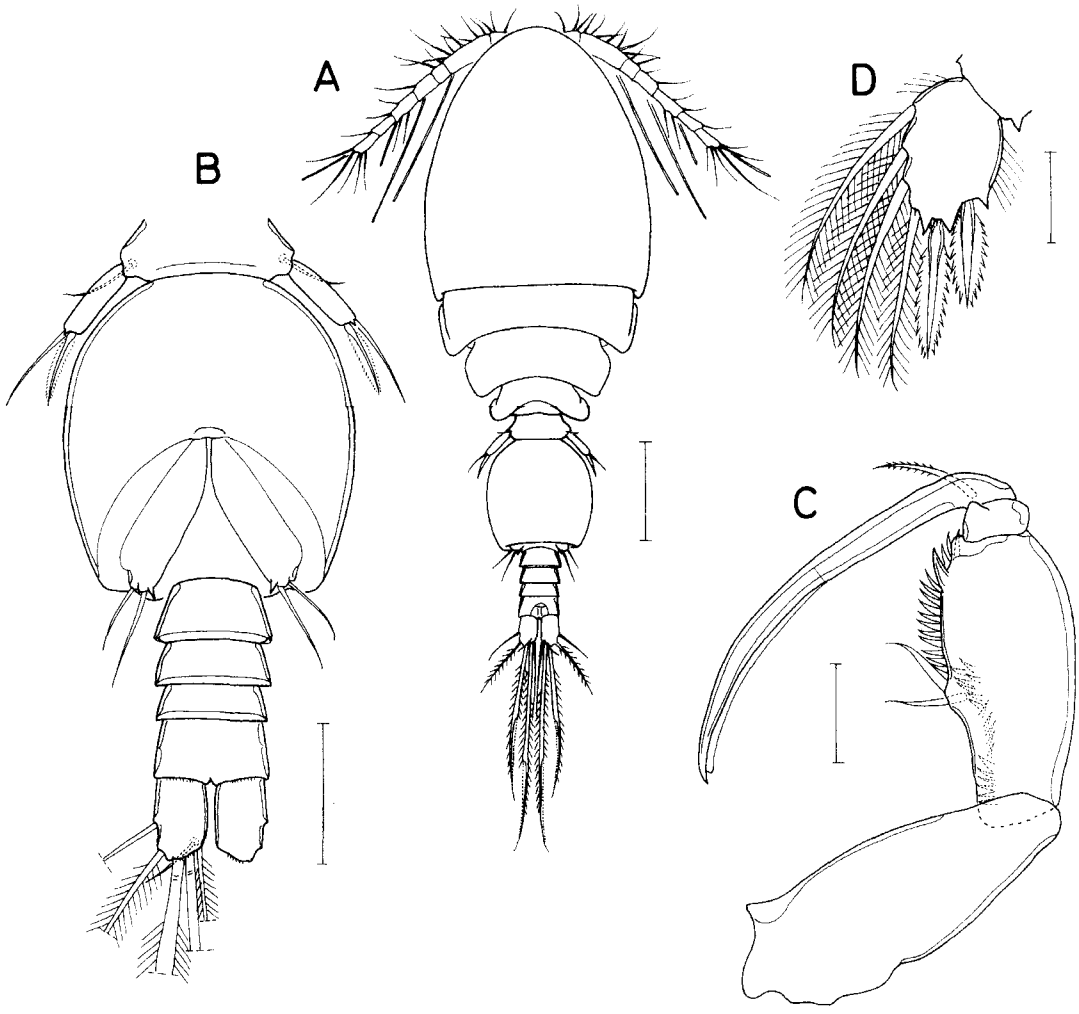

Fig. 3. *Pseudomacrochiron pocilloporae* n. sp., male. A, Habitus, dorsal. B, Urosome, ventral. C, Maxilliped. D, Third endopodal segment of leg 1. Scale bars=100 μm (A), 50 μm (B), and 20 μm (C, D).

margin almost straight, fringed with long spinules. Outer margin with 1 scale-like ornamentation bearing setules along one side. Terminal lash very long, clearly defined from inner margin, with serrate margins. Maxillule (Fig. 2C) with 3 terminal setae and 1 subterminal setiform process. Maxilla (Fig. 2D) with unarmed first segment. Second segment with plumose inner seta and stiff anterior seta; proximal seta absent; lash with crenulated outer margin and 1 spiniform process proximally on inner margin. Maxilliped (Fig. 2E) 3-segmented. First segment longest and unarmed. Second segment with protruded inner margin and 2 identical setae, one of them located at apex of protuberance. Third segment tapering somewhat elongated, with 2 spiniform setae and 2 distal spinules.

Legs 1-4 (Fig. 2F-I) with 3-segmented rami, except for 2-segmented endopod of leg 4. Endopod of leg 4 50×19 μm, with pointed process on outer margin; 2 terminal spines 39 μm (outer) and 50 μm (inner). Armature formula of legs 1-4 as follows:

Leg 1: coxa 0-1; basis 1-0; exopod I-0; I-1; III,I,4; endopod 0-1; 0-1; I,5

Leg 2: coxa 0-1; basis 1-0; exopod I-0; I-1; III,I,5; endopod 0-1; 0-2; I,II,3

Leg 3: coxa 0-1; basis 1-0; exopod I-0; I-1; III,I,5; endopod 0-1; 0-2; I,II,2

Leg 4: coxa 0-1; basis 1-0; exopod I-0; I-1; II,I,5; endopod II

Leg 5 consisting of 1 seta on fifth pedigerous somite and free segment. Free segment (Fig. 2J) elongate, 71×13 μm, ratio 5.46:1, gradually broadened distally, with small proximal inner expansion, spinules on outer margin, and terminally 1 small process, 1 lamellate spine (46 μm) and 1 smooth seta (42 μm). Leg 6 represented by 1 long seta and 2 spinules in genital area (Fig. 1B).

Male

Body (Fig. 3A) similar in general form to that of female. Body length 611 μm. First pedigerous somite completely

fused with cephalosome. Prosome 381×222 μm. Urosome (Fig. 3B) 6-segmented. Fifth pedigerous somite 62 μm wide. Genital somite 108×103 μm and semicircular. Four abdominal somites 21×41, 16×41, 12×39, and 21×40 μm from anterior to posterior. Caudal ramus 29×19 μm, ratio 1.53:1.

Rostrum as in female. Antennule with three additional aesthetascs: 2 on second and 1 on third segments at dots in Fig. 1E. All aesthetascs long, as long as whole antennule. Antenna, Labrum, mandible, maxillule, and maxilla as in female. Maxilliped (Fig. 3C) with unarmed first and third segments. Second segment proximally narrow and distally broader, with one longitudinal row of spinules, 2 similar setae, and 1 distal cusp-like process. Claw weakly curved, with 1 plumous proximal seta.

Leg 1 with third endopodal segment bearing 2 spines and 4 setae (II,4; instead of I, 5 as in female) (Fig. 3D). Legs 2-4 as in female. Free segment of leg 5 much smaller than that of female. Leg 6 represented by 2 setae and 1 spiniform process on genital flap (Fig. 3B).

Etymology

The specific name *pocilloporae* is derived from the generic name of the host *Pocillopora damicornis*.

Remarks

The genus *Pseudomacrochiron* consists of six known species: *P. fusicolum* (T. Scott, 1912), *P. malayense* (Sewell, 1949), *P. ornatum* (Krishnaswamy, 1952), *P. parvum* (A. Scott, 1908), *P. stocki* Reddiah, 1969, and *P. urostenum* Kim, 2000. Most of these species were so vaguely described that they cannot be easily compared with one another. However, some evidences revealed on the original descriptions, mainly in the figures, allow to differentiate *P. pocilloporae* from these species, as follow.

In *P. pocilloporae* the free segment of leg 5 carries terminally one spine and one seta, compared to two setae in *P. fusicolum*, *P. malayense*, and *P. ornatum*.

In *P. pocilloporae* the third endopodal segment of leg 1 is armed with one spine and five setae, compared to two spines and four setae in *P. malayense* and *P. ornatum*.

In *P. pocilloporae* the caudal ramus is less than twice as long as wide, in contrast to more than twice as long in *P. malayense*, *P. ornatum*, *P. stock*, as shown in illustrations by the original describers, and *P. urostenum*.

In *P. pocilloporae* the free segment of female leg 5 is more than five times as long as wide, in contrast to less than five in *P. parvum*, based on the illustration by A. Scott (1909) and *P. urostenum*.

Pseudomacrochiron pocilloporae is the second species known for the relationship with host, following after *P. stocki* which is recorded to be associated with the scypozoan *Dactylometra quinquicirrha* L. Agassiz from the Indian Ocean (Reddiah, 1969).

Order Siphonostomatoida
Family Asterocheridae
Genus *Acontiophorus* Brady, 1880

Acontiophorus panamensis n. sp.
(Figs. 4-6)

Material examined

6♀♀, 2♂♂ from the scleractinian coral *Pocillopora damicornis* (Linnaeus), at north side of Uraba Island in the Pacific coast of Panama, in 12 m, 29 October 1981, collected by A. G. Humes. Holotype (♀), allotype (♂), and paratypes (4♀♀) will be deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C. Dissected paratypes (1♀, 1♂) are kept in the collection of the author.

Female

Body (Fig. 4A) with fusiform prosome and small urosome. Body length 706 μm. Length of prosome 485 μm. Cephalothorax 335×338 μm. Urosome (Fig. 4B) 4-segmented. Fifth pedigerous somite 110 μm wide, wider than genital double-somite, with broad membrane along whole posterodorsal border and distinctly crenate posteroventral margin bearing scattered patches of small spinules (Fig. 4C). Genital double-somite 90×100 μm and anteriorly expanded, with pointed process on posterior side of anterior expansions. Genital double- and first abdominal somites marginated with membrane along posteroventral and posterodorsal borders. First and second abdominal somites 36×58 and 35×56 μm. Caudal ramus 25×27 μm, ratio 1:1.08, with 2 transverse rows of spinules on inner side of dorsal surface, membrane along posteroventral margin, and 6 caudal setae. Smallest inner dorsal seta based on digitiform process. This and outer dorsal setae smooth, other 4 setae plumous. Egg sac not seen.

Rostrum not developed (Fig. 5A). Antennule (Fig. 4D) short, 167 μm long, 13-segmented, with armature formula: 2, 2, 12, 6, 2, 2, 5, 1, 3, 1+aesthetasc, 2, 3, and 7. Setae densely crowded. One proximal seta on second segment enlarged. Antenna (Fig. 4E) with short first segment (coxa). Second segment (basis) 62 μm long with 2 or 3 long setules on inner distal area. Exopod 27×7.3 μm (ratio 3.70:1), armed laterally with 1 seta and terminally with 1 small spinule and 1 long setae. First endopodal segment 29 μm and unarmed. Second segment with 1 proximnal seta bearing 4 long setules, 1 subterminal plumous seta, and terminally 1 minute, 1 smooth and 1 enlarged setae. Enlarged seta 77 μm long.

Siphon long and thin, 420 μm, extending over posterior margin of prosome. Mandible thread-like and as long as siphon. Palp 1-segmented, short (Fig. 5B), terminally with 1 spinule and extremely long plumous seta longer

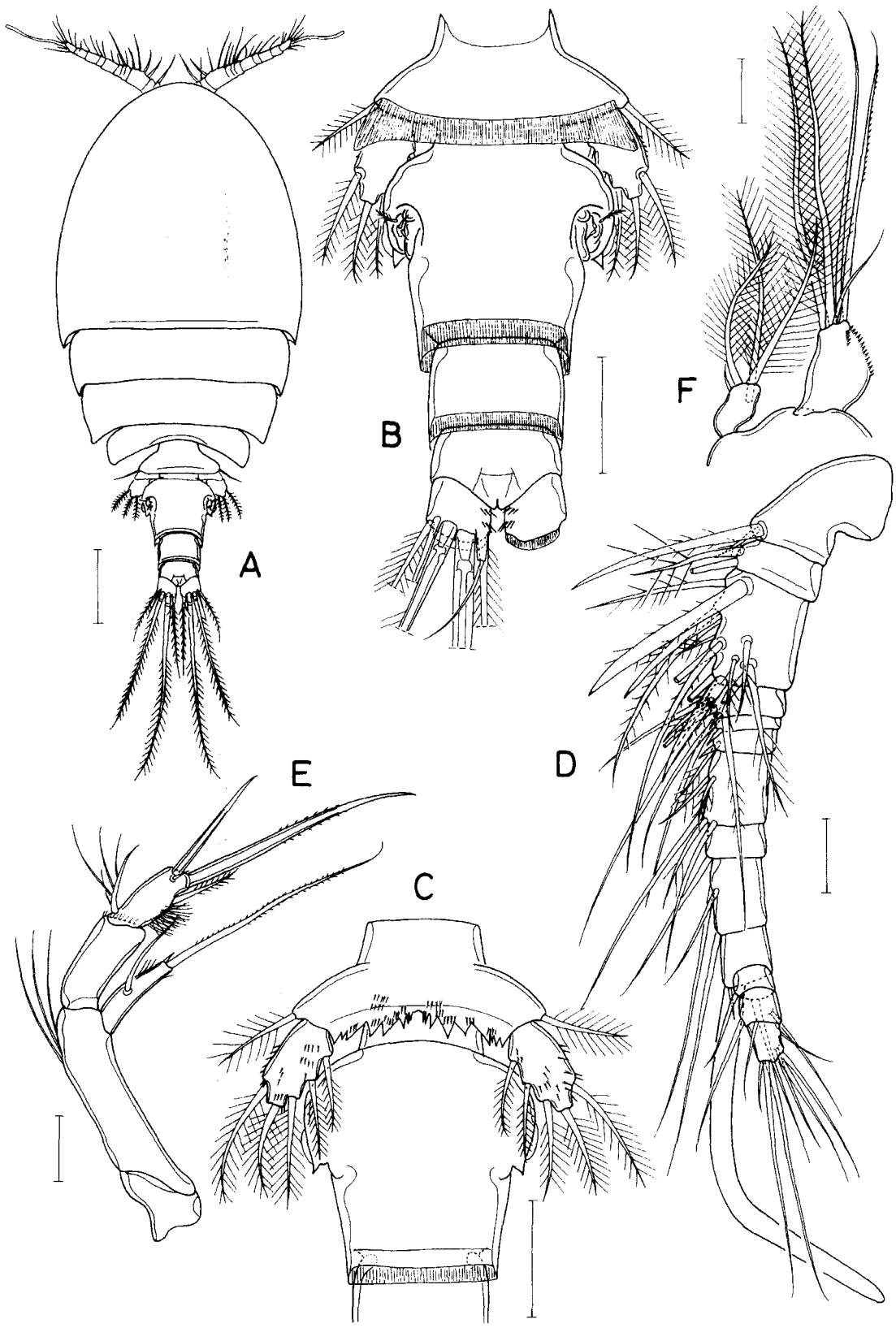

Fig. 4. *Acontiophorus panamensis* n. sp., female. A. Habitus, dorsal. B, Urosome, dorsal. C, Anterior part of urosome, ventral. D, Antennule. E, Antenna. F, Maxillule. Scale bars=100 μm (A), 50 μm (B, C), and 20 μm (D-F).

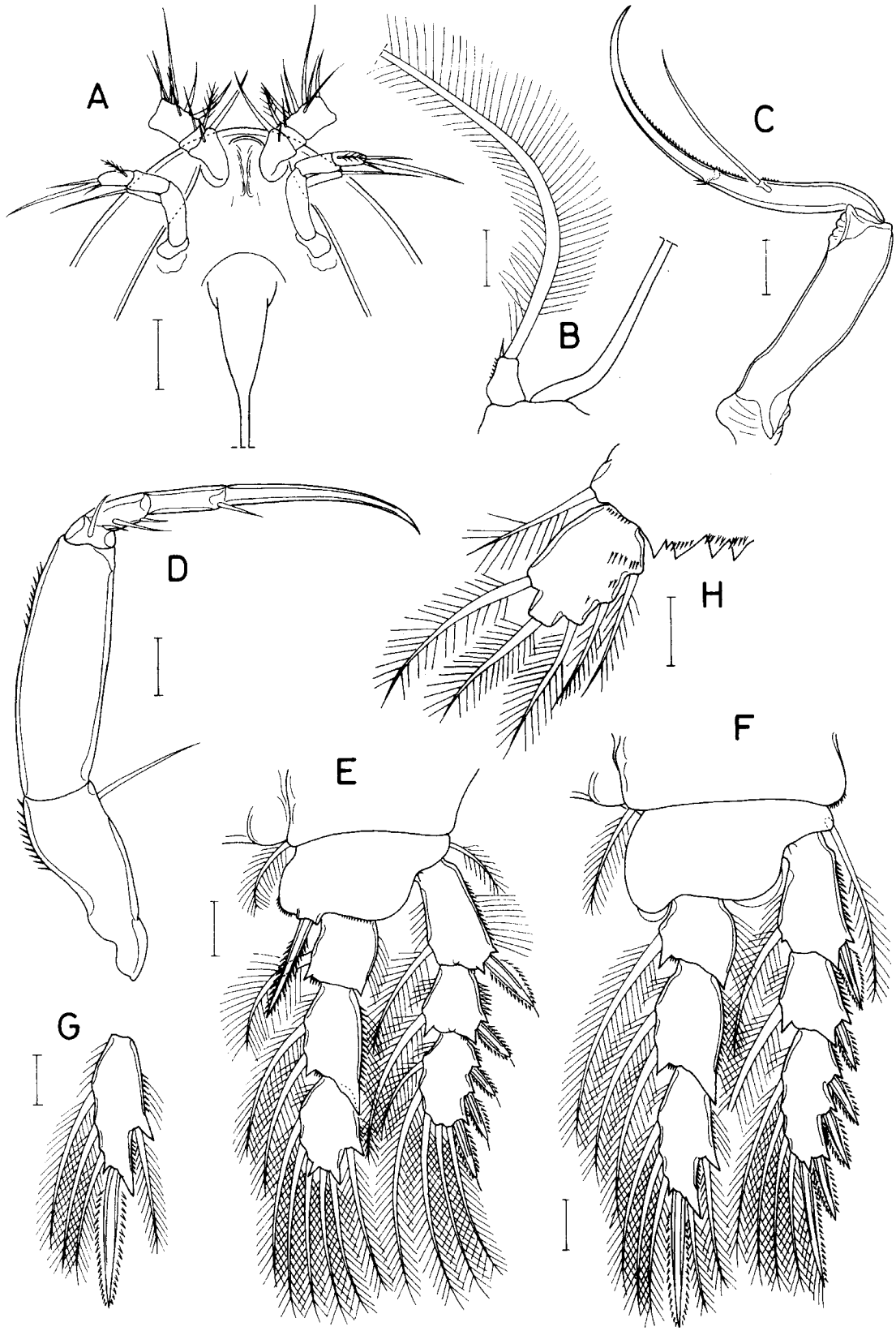

Fig. 5. *Acontiophorus panamensis* n. sp., female. A, Rostral area, ventral. B, Mandible. C, Maxilla. D, Maxilliped. E, Leg 1. F, Leg 2. G, Third endopodal segment of leg 3. H, Leg 5, ventral. Scale bars=50 μm (A), and 20 μm (B-H).

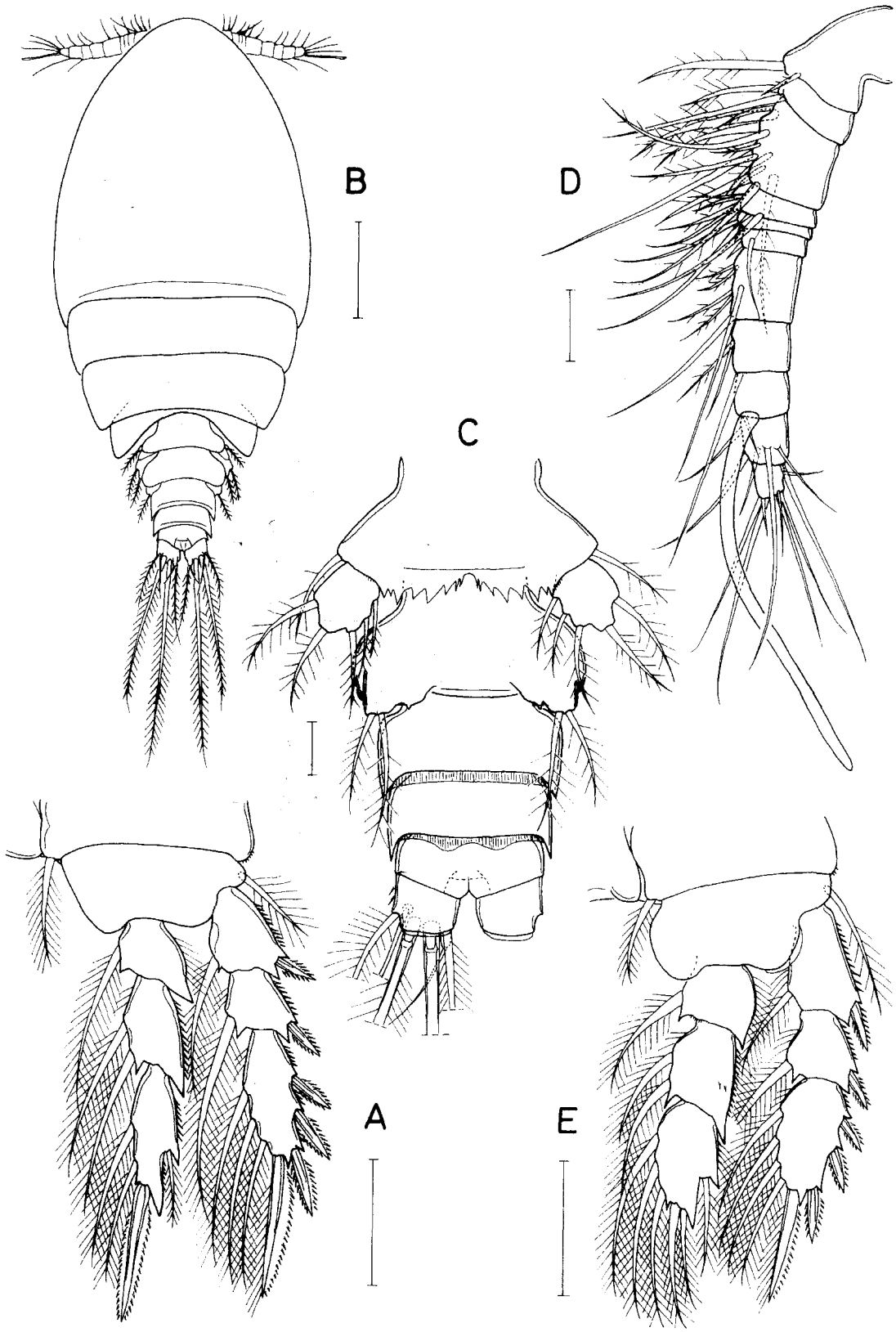

Fig. 6. *Acontiophorus panamensis* n. sp. Female: A, Leg 4. Male: B, Habitus, dorsal. C, Urosome, ventral. D, Antennule. E, Leg 2. Scale bars=50 μm (A, E), 100 μm (B), and 20 μm (C, D).

than half length of siphon. Maxillule (Fig. 4F) with 3 plumous setae and 1 small smooth seta. Inner lobe expanded in middle, terminally with 4 large and 1 small setae. Maxilla (Fig. 5C) with unarmed proximal segment of 133 μm long. Distal segment with 1 long seta. Terminal claw slender, strongly curved distally, fused with segment, leaving rudimentary demarcation. Maxilliped (Fig. 5D) 5-segmented. First segment with 1 long inner distal seta and outer spinules. Second segment unarmed, with outer distal spinules. Third and fourth segment each armed with 2 setae. Fifth segment with 1 seta. Claw distally curved.

Legs 1-4 (Figs. 5E-G, 6A) with 3-segmented rami. Armature formula as follows:

Leg 1: coxa 0-1; basis 1-I exp. I-1; I-1; II,I,5;
enp. 0-1; 0-2; 1,2,3
Leg 2: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4;
enp. 0-1; 0-2; 1,1+I,3
Leg 3: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4;
enp. 0-1; 0-2; 1,I,3
Leg 4: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,3;
enp. 0-1; 0-2; 1,I,2

Inner spine on basis of leg 1 40 μm. Outer seta on basis of leg 2 large, but that of leg 3 small.

Leg 5 (Fig. 5H) represented by setae on fifth pedigerous somite and free segment. Free segment 38×25 μm (ratio 1.52:1) with 5 plumous setae. Leg 6 represented by 1 small plumous seta and 2 minute spiniform setae in genital area (Fig. 4B).

Male

Body (Fig. 6B) similar to that of female. Length 561 μm. Length of prosome 408 μm. Cephalothorax 289×269 μm. Urosome (Fig. 6B) 5-segmented. Fifth pedigerous somite 96 μm wide. Genital somite 37 μm long at midline and 86 μm wide. Three abdominal somites from anterior to posterior 26×69, 22×61, and 26×56 μm. Caudal ramus 23×26 μm, ratio 1:1.13.

Rostrum like that of female. Antennule (Fig. 6D) 11-segmented, 146 μm long. Armature formula: 2, 2, 12, 6(?), 3, 2, 6, 3, 1+aesthetasc, 6, and 7. Antenna and mouthparts resembling those of female.

Leg 2 (Fig. 6E) with third segment of endopod armed with 6 setae (formula 1,2,3). Leg 1, legs 3-5 armed as in female. Leg 6 represented by posteroventral flap on genital somite bearing 2 subequal plumous setae (Fig. 6C).

Etymology

The specific name *panamensis* is derived from Panama where the type locality is located in.

Remarks

The segmentation of antennule in *Acontiophorus* is variable depending on species, therefore, provides with valuable taxonomic character. *Acontiophorus panamensis* n. sp. is closely related to *A. tynani* Eiselt, 1965 from the Atlantic. Both species share the 13-segmented female antennule, the same armature formula of legs 1-4, and the short caudal rami. Although *Acontiophorus tynani* was incompletely described, it can be distinguished from *A. panamensis* by the larger body size (1 mm, compared to 706 μm in *A. panamensis*) and by the first segment of female leg 5 which is well delimited from the fifth pedigerous somite, with a developed inner flap, according to the illustration of Eiselt (1965).

Genus *Asterocheres* Boeck, 1859

Asterocheres pilosus n. sp.
(Figs. 7-9)

Material examined

10 ♀♀, 9♂♂ from 2 individuals of the pencil urchin *Eucidaris thouarsii* (Valenciennes), in 12 m, north side of Uraba Island in the Pacific coast of Panama, 29 October 1981, collected by A. G. Humes. Holotype (♀), allotype (♂), and paratypes (8♀♀, 7♂♂) will be deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C. Dissected paratypes (1 ♀, 1 ♂) are retained in the collection of the author.

Female

Body (Fig. 7A) small, with broad prosome and small urosome. Body length 479 μm (458-500 μm), based on 10 specimens. Prosome 315 μm long. Cephalothorax 200×256 μm. Urosome (Fig. 7B) 4-segmented. Fifth pedigerous somite 74 μm wide, with dorsolateral process. Genital double-somite 67×67 μm, as long as wide, gradually narrowed posteriorly, with setules on lateral margins posterior to genital areas. Genital areas located dorsolaterally. First abdominal somite 29×43 μm. Anal somite 26×40 μm, with scales on outer lateral margins. Caudal ramus 16×18 μm, ratio 1:1.13, based on greatest demensions, with 6 setae. Egg sac not seen.

Rostrum not developed (Fig. 7C). Antennule (Fig. 7D) 152 μm long, 19-segmented, with armature formula: 2, 2, 2, 2, 2; 2, 2, 2, 7, 2; 2, 2, 2, 2, 2; 2, 2, 2+1 aesthetasc, and 13. All setae smooth except for plumous one of two setae on first segment. First segment with setules on anterior margin. Antenna (Fig. 7E) with short first segment (coxa). Second segment (basis) gradually expanded distally. Exopod 9×3 μm, with 1 lateral and 2 terminal setae. First endopodal segment with setules on distal outer margin. Short second segment with 1 inner distal seta. Third segment distally with 1 inner seta and 1 small outer seta. Terminal claw 35 μm, slender and slightly curved.

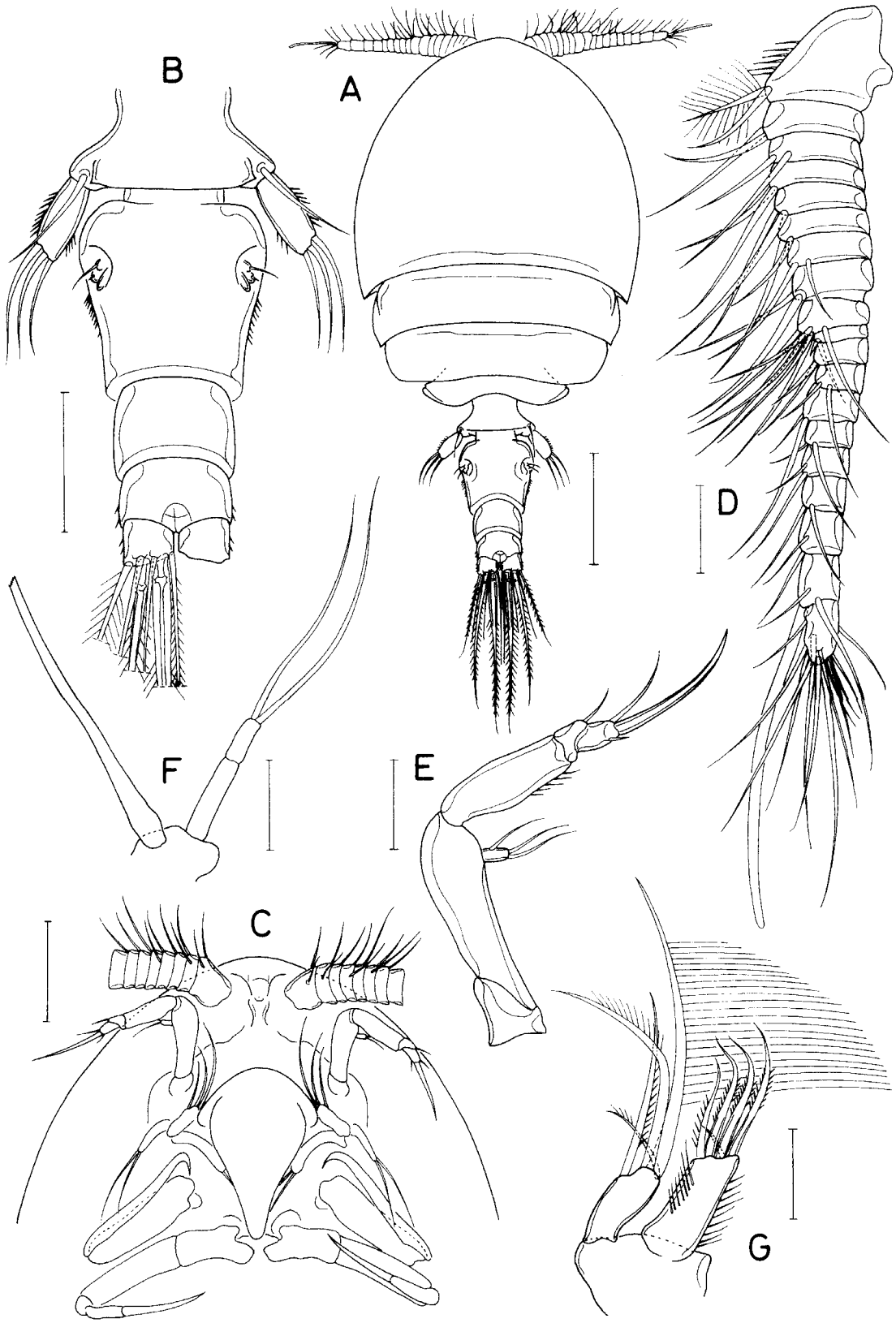

Fig. 7. *Asterocheres pilosus* n. sp., female. A, Habitus, dorsal. B, Urosome, dorsal. C, Anterior part of cephalothorax, ventral. D, Antennule. E, Antenna. F, Mandible. G, Maxillule. Scale bars=100 mm (A), 50 μm (B, C), and 20 μm (D-G).

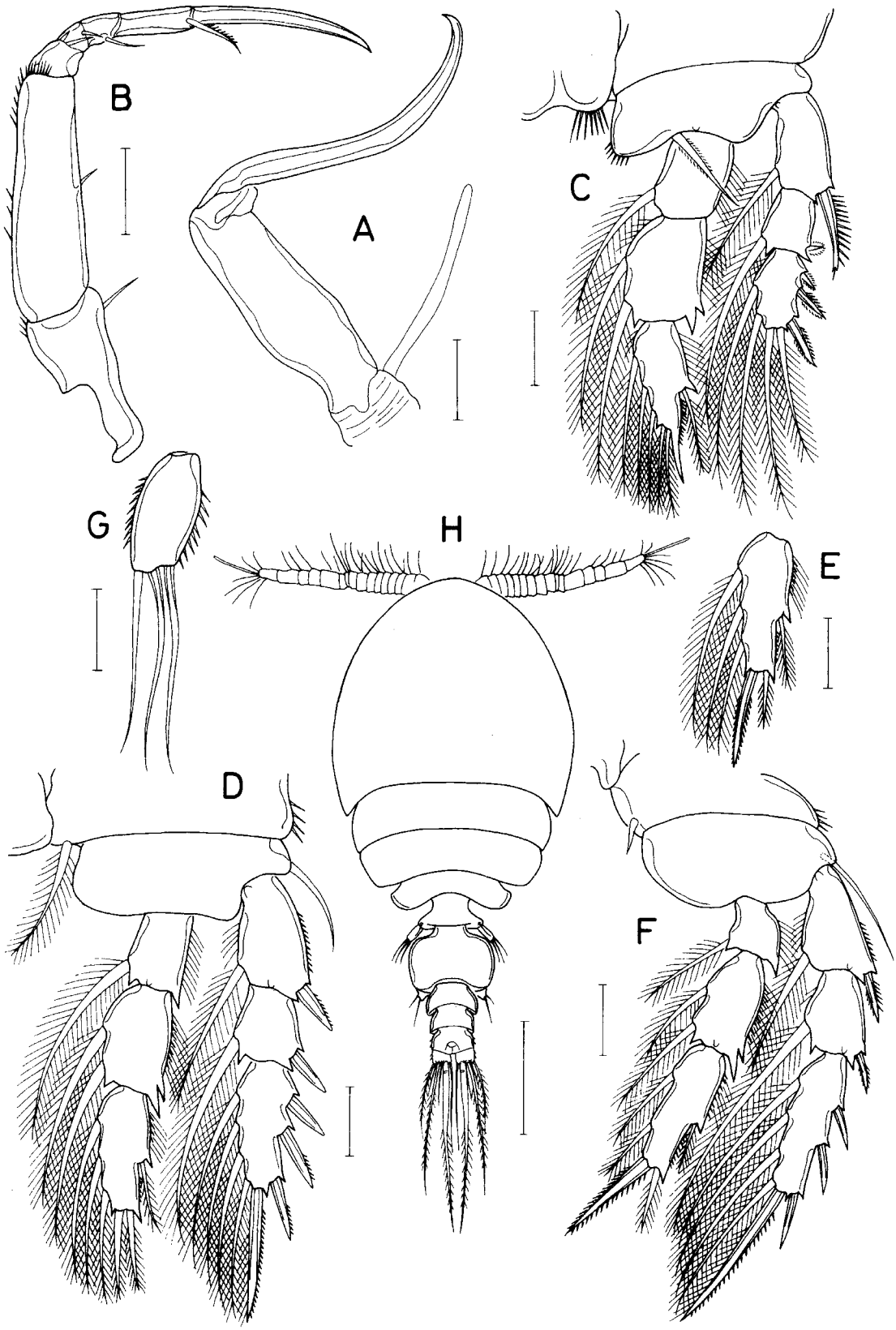

Fig. 8. *Asterocheres pilosus* n. sp. Female: A, Maxilla. B, Maxilliped. C, Leg 1. D, Leg 2. E, Third endopodal segment of leg 3. F, Leg 4. G, Free segment of leg 5. Male: H, Habitus, dorsal. Scale bars=20 μm (A-G), and 100 μm (H).

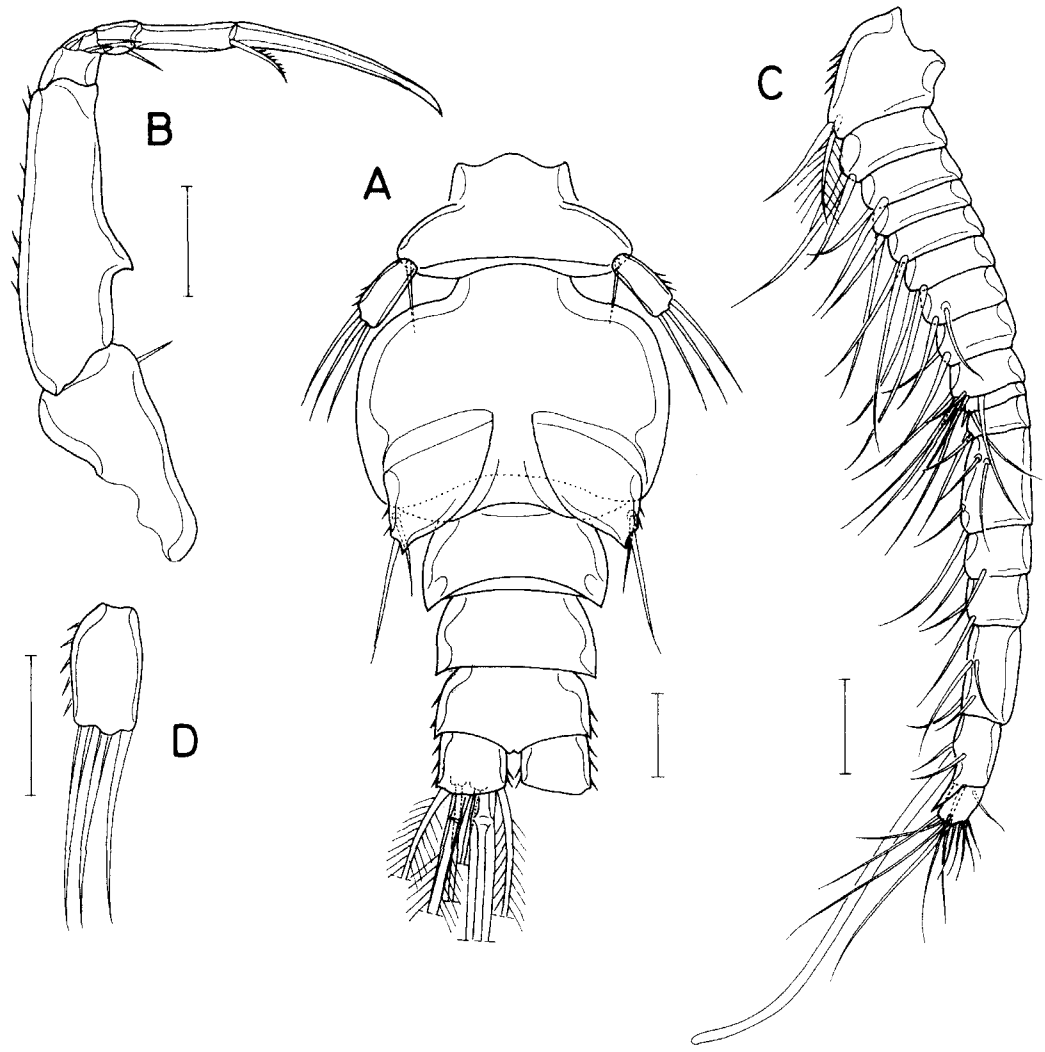

Fig. 9. *Asterocheres pilosus* n. sp., male. A, Urosome, ventral. B, Maxilliped. C, Antennule. D, Free segment of leg 5. Scale bar=20 μm.

Oral cone short, 80 μm long, strongly tapering, reaching insertions of maxillipeds (Fig. 7C). Mandible (Fig. 7F) 69 μm, terminally with fine teeth. Palp 2-segmented. Second segment about half as long as first, terminally with 2 subequal, large, smooth setae. Maxillule (Fig. 7G) with 4 setae (one of them smaller) on smaller outer lobe of 19 μm long; largest innermost seta with characteristically long hairs on inner margin. Inner lobe 27 μm long, with setule on both sides and terminally 5 short setae (one of them minute). Maxilla (Fig. 8A) with basal segment bearing long proximal aesthetasc. Distal claw slender and smooth. Maxilliped (Fig. 8B) 5-segmented. First segment with 1 inner distal seta and spinules near outer distal corner. Largest second segment with several minute spinules on outer margin and 1 seta in middle of straight inner margin. Third segment with 2 distal setae. Fourth segment divided by tansverse line into proximal and distal parts each bearing 1 seta. Fifth segment with 1 terminal seta. Terminal claw smooth.

Legs 1-4 (Figs. 8C-F) with 3-segmented rami. Armature formula as follows:

Leg 1: coxa 0-0; basis 1-1 exp. I-1; I-1; III,4; enp. 0-1; 0-2; 1,2,3
Leg 2: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,2,3
Leg 3: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,1+I,3
Leg 4: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,1+I,2

Leg 1 with spinules on intercoxal plate and on inner distal corner of basis; distal process of third endopod segment remarkably produced; inner coxal seta apparently lacking; outer distal corner of second endopodal segment bifurcate as in legs 2-4; outer spine of first exopodal segment extending over posterior border of second segment, with spinules along outer margin and small terminal flagellum. Inner coxal seta of leg 4 small.

Leg 5 with free segment (Fig. 8G) 31×16 μm, with

spinules on lateral margins and 3 smooth terminal setae of subequal sizes. Leg 6 represented by 1 small seta and 1 minute spinule in genital area (Fig. 7B).

Male

Body (Fig. 8H) narrower than that of female. Length 413 μm (392-435 μm) based on 9 specimens. Cepahlothorax 183×213 μm. Urosome (Fig. 9A) 5-segmented. Fifth pedigerous somite 57 μm wide. Genital somite 54 μm long along axis and 77 μm wide. Three abdominal somites from anterior to posterior 19×45, 18×38, and 19×38 μm. First 2 abdominal somites with angular posterolateral corners. Caudal ramus 15×17 μm, ratio 1:1.13.

Rostrum like that of female. Antennule (Fig. 9C) 17-segmented and 176 μm long. Armature formula: 2, 2, 2, 2, 2; 2, 2, 2, 7, 2; 2, 4, 2, 2, 4; 3+1 aesthetasc, and 11. Penultimate segment with distinct anterodistal process. Antenna, oral cone, mandible, maxillule like those of female. Maxilliped (Fig. 9B) resembling that of female but sexually dimorphic in having conical process on inner margin of second segment.

Legs 1-4 as in female. Leg 5 with free segment 18×10 μm, its 3 terminal setae identical in size (Fig. 9D). Leg 6 represented by posteroventral flap on genital somite bearing 2 unequal setae (Fig. 9A).

Etymology

The specific name *pilosus*, a Latin meaning "hairy", alludes to the long hairs on inner seta on the outer lobe of maxillule.

Remarks

Asterocheres is the largest genus within the Asterocheridae. Johnsson (1998) included 52 species in a key to species of this genus, not including *A dysideae* Humes, 1996, *A. eniwetakensis* Humes, 1997, *A. flustrae* Ivanenko & Smurov, 1997, and *A. serrulatus* (Humes, 1996). Later, he added two new species, *A. aplysinus* and *A. spongus*, to this genus (Johnsson, 2002). Therefore, the genus *Asterochres* comprises 58 nominal species, including many incompletely described species.

Species of *Asterocheres* having at least one of the following features which are not observable in *A. pilosus* are excluded from a comparison with *A. pilosus*: (1) the female antennule is 20 or more segmented; (2) the mandibular palp is 1-segmented; (3) the caudal ramus is distinctly longer than wide.

The following species included in a comparison can be distinguished from *A. pilosus* by their following features: by the 18-segmented antennule in *A. stimulans* Giesbrecht, 1897 and *A. micheli* (Gurney, 1927); by the elongate of slender free segment of female leg 5, with the ratio of the length to width 3:1 or more in *A. abrohensis* Johnsson, 1988 (the ratio being 3.19:1), *A. crenulatus* Johnsson, 1998 (5.86:1), *A. dysideae* Humes, 1996 (3.42:1), *A. spinopaulus* Johnsson, 1998 (6.4:1), and *A. halichondriae* Stock, 1966 (about 3:1, based on the illustration of the author); by the long siphon in *A. siphonatus* where the siphon extends over leg 4; and by the broad genital double-somite which is wider than long in the three incompletely known species *A. canui* Giesbrecht, 1897, *A. simulans* (Scott, 1898) and *A. ventricosus* (Brian, 1927).

The small body size of *A. pilosus* is remarkable, because only four known species in the genus are recorded to approach this body size (less than 500 μm in length): *A. bulbosus* Malt, 1991 (length 0.5 mm); *A. halichondriae* Stock, 1966 (499 μm); *A. hongkongensis* Malt, 1991 (0.5 mm); and *A. ovalis* Sewell, 1949 (450 μm in the male; the female is unknown). These species are not related to and readily distinguishable from *A. pilosus*.

In addition to the small body size, *A. pilosus* displays as the diagnostic traits that one of the two setae on the first segment of the antennule is plumous, and the innermost seta on the outer lobe of the maxillule bears long hairs. A combination of these three features may serve to differentiate *A. pilosus* from other congeners.

Asterocheres walteri n. sp.
(Figs. 10-12)

Material examined

23♀♀, 46♂♂ and copepodids I-V from 4 individuals of the sea star *Oreaster brevispinis*, in 4 m, Saboga Island in the Pacific coast of Panama, 14 November 1981, collected by A. G. Humes. Holotype (♀), allotype (♂), and paratypes (20♀♀, 43♂♂).

Female

Body (Fig. 10A) with broad and dorsoventrally flat prosome. Length 833 μm (820-840 μm), based on 10 specimens. Prosome 563 μm long. Cephalothorax 375×471 μm. Urosome (Fig. 10B) 4-segmented. Fifth pedigerous somite 141 μm wide, with scales on lateral margins. Genital double-somite 112×126 μm, wider than long, with strongly tapering posterior half and stiff setules on lateral margins posterior to genital areas. First abdominal somite 41×69 μm. Anal somite 46×67 μm. These 2 abdominal somites with scales on lateral margins. Caudal ramus 33×31 μm, ratio 1.06:1, with scales on outer margin, 2 transverse rows of fine spinules on median side, fine spinules on posterior margin, and 6 setae. Egg sac (Fig. 10C) 242×179 μm, containing less than 10 eggs.

Rostrum not discernible (Fig. 10D). Antennule (Fig.

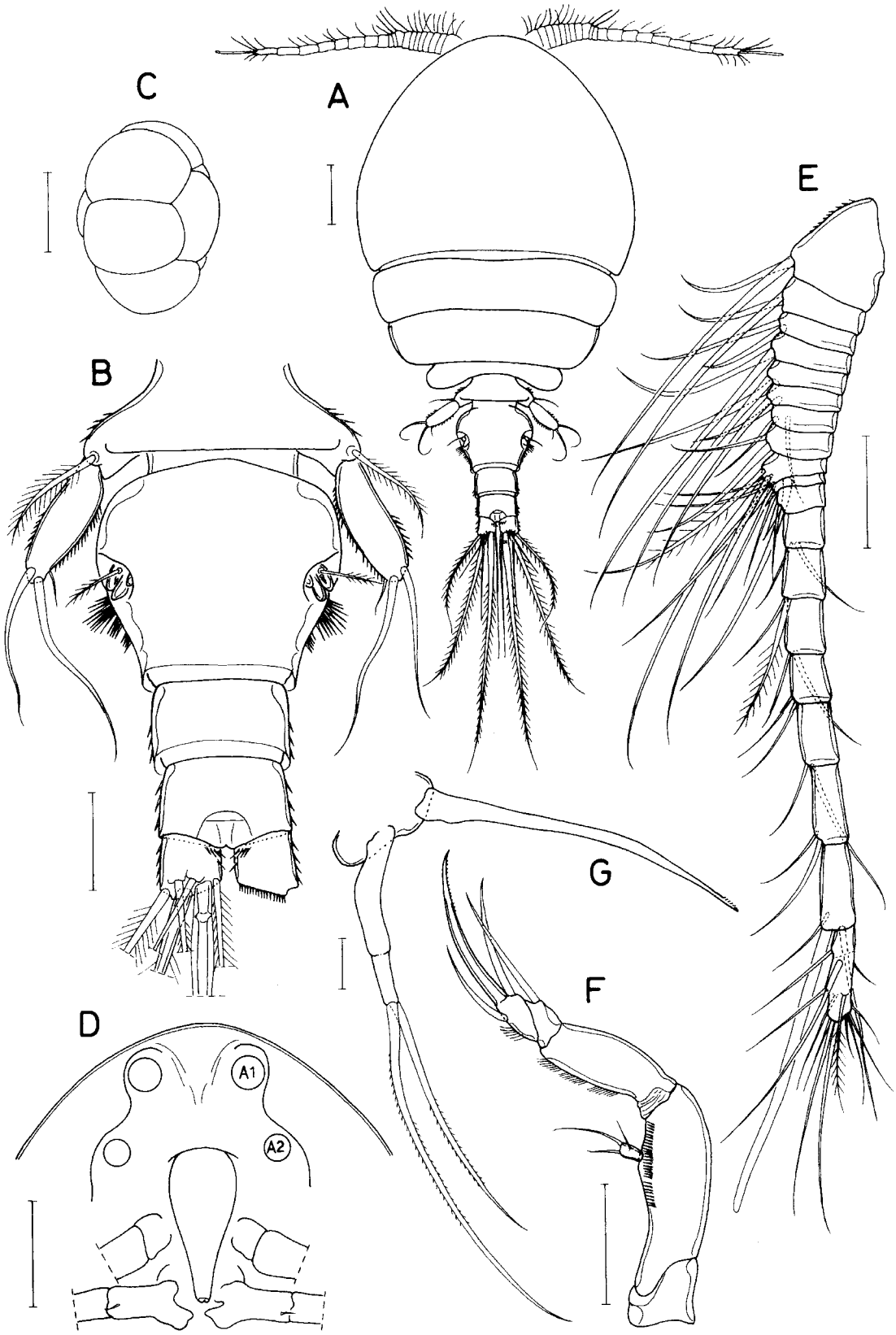

Fig. 10. *Asterocheres walteri* n. sp., female. A, Habitus, dorsal. B, Urosome, dorsal. C, Egg sac. D, Anterior part of cephalothorax. E, Antennule. F, Antenna. G, Mandible. Scale bars=100 μm (A, C, D), 50 μm (B, E, F), and 20 μm (G).

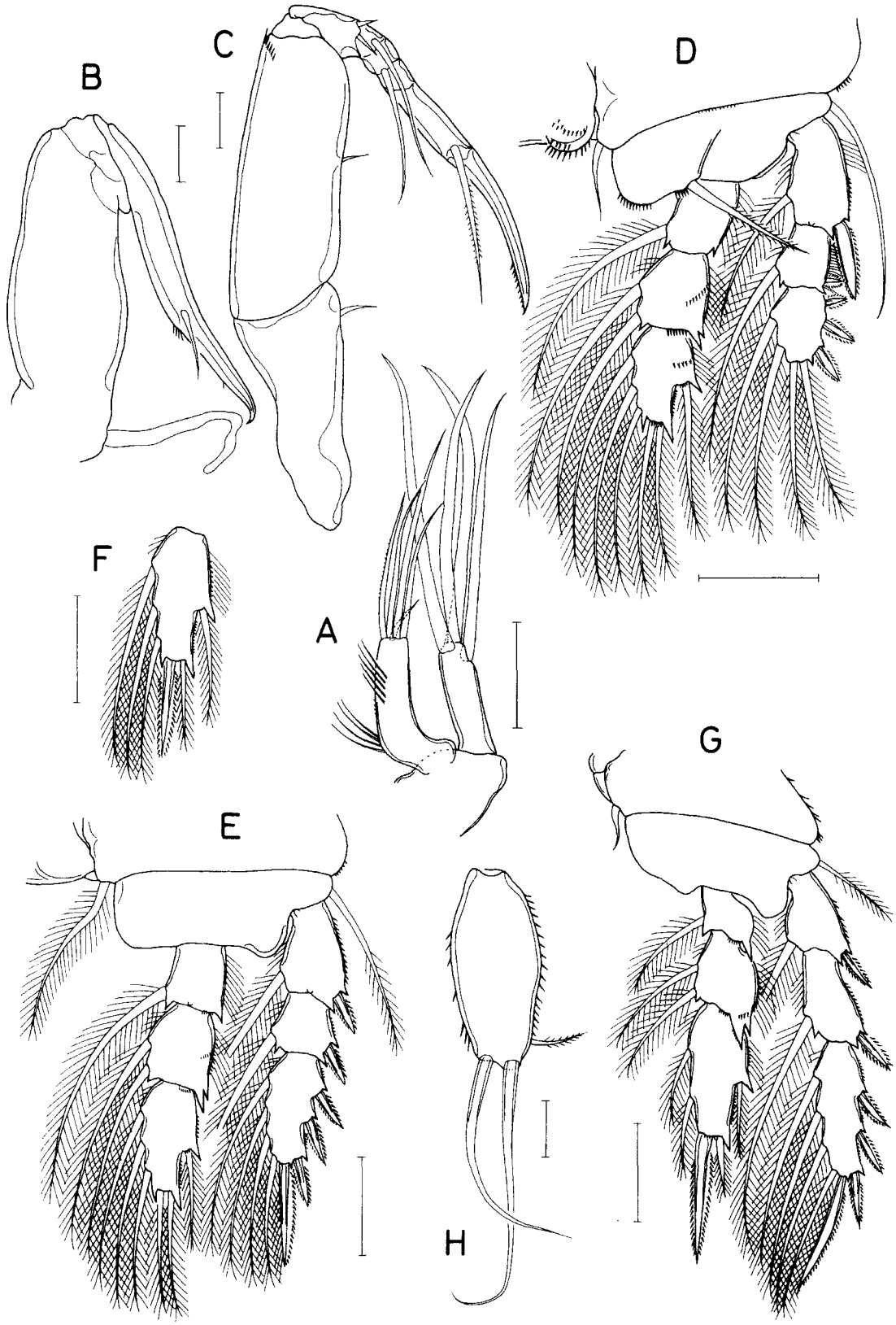

Fig. 11. *Asterocheres walteri* n. sp., female. A, Maxillule. B, Maxilla. C, Maxilliped. D, Leg 1. E, Leg 2. F, Third endopodal segment of leg 3. G, Leg 4. H, Free segment of leg 5. Scale bars=50 μm (A, D-G), and 20 μm (B, C, H).

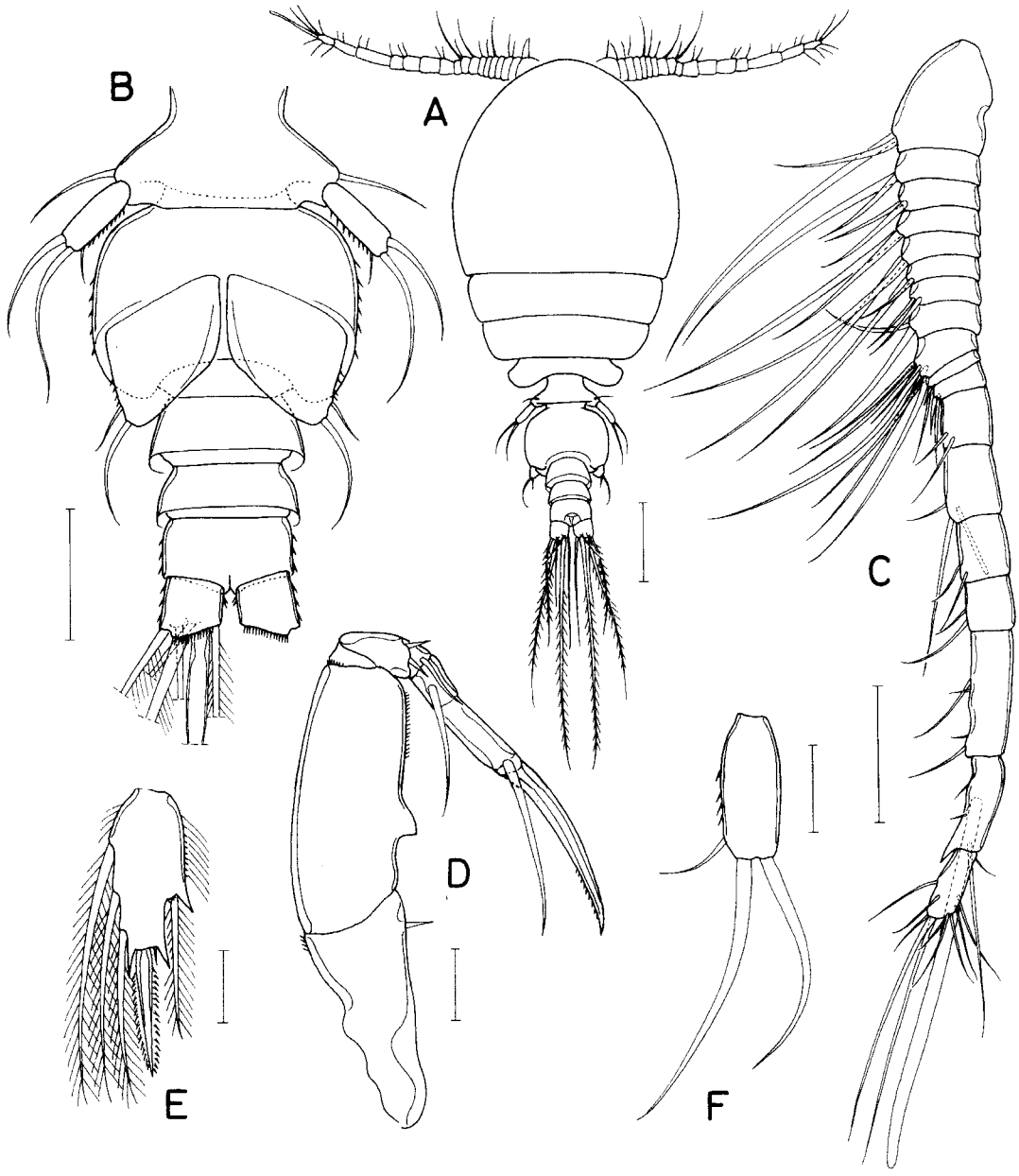

Fig. 12. *Asterocheres walteri* n. sp., male. A, Habitus, dorsal. B, Urosome, ventral. C, Antennule. D, Maxilliped. E, Third endopodal segment of leg 3. F, Free segment of leg 5. Scale bars=100 μm (A), 50 μm (B, C), and 20 μm (D-F).

10E) 19-segmented, 368 μm long, with armature formula: 2, 2, 2, 2, 2; 2, 2, 2, 7, 2; 2, 2, 2, 2, 2; 2, 2, 2+1 aesthetasc, and 13. Some setae on proximal segments elongated. One plumous seta on 9th, 13th, and terminal segments. Antenna (Fig. 10F) with short coxa. Basis 72 μm long, with minute spinules on outer side. Exopod 10×5 μm, with 1 lateral and 2 terminal setae. First endopodal segment 55 μm, with fine setules on outer side. Short second segment with 1 long inner seta. Third segment distally with 2 long setae. Claw 68 μm long.

Siphon 153 μm long, extending to insertions of maxillipeds (Fig. 10D). Mandible (Fig. 10G) slender, 134 μm, with fine teeth distally. Palp indistinctly 2-segmented, each segment 50 μm (proximal segment) and 20 μm (distal), terminally with 2 long unequal setae. Both setae extending over tip of mandible. Maxillule (Fig. 11A) with inner lobe 54 μm, having 4 large, smooth setae of subequal sizes. Outer lobe 69 μm long, slightly larger than inner lobe, with long setules laterally and 5 terminal setae, one of which minute; all setae smaller than those of inner lobe. Maxilla (Fig. 11B) with 1 aesthetasc on proximity of stocky proximal segment. Distal claw with 1

seta near middle. Maxilliped (Fig. 11C) 5-segmented. First segment with 1 small inner distal seta. Second segment with 1 seta on inner margin. Third segment with 2 distal setae. Fourth segment divided by tansverse line into proximal and distal parts each bearing 1 long seta. Fifth segment with 1 terminal seta. Claw weakly curved.

Legs 1-4 (Figs. 11D-G) with 3-segmented rami. Armature formula as follows:

Leg 1: coxa 0-1; basis 1-1 exp. I-1; I-1; III,4; enp. 0-1; 0-2; 1,2,3
Leg 2: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,2,3
Leg 3: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,1I,3
Leg 4: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,1I,2

Leg 1 with smooth inner coxal seta. Inner distal corner of basis with minute spinules. Inner distal seta on basis elongate. Outer seta on basis long and smooth. Outer spine on exopod distinctly longer than second exopodal segment and thick, with spinulated margins. Inner coxal seta of leg 4 small and smooth.

Leg 5 with nearly elliptical free segment (Fig. 11H) 71×32 μm, ratio 2.22:1, with spinules on margins, and 1 small subterminal and 2 larger terminal setae, longest one of them 100 μm long.

Leg 6 represented by 1 small plumous seta and 1 minute spinule in genital area (Fig. 10B).

Male

Body (Fig. 12A) similar to that of female. Length 611 μm (595-630 μm), based on 10 specimens. Urosome (Fig. 12B) 5-segmented. Fifth pedigerous somite 86 μm wide. Genital somite 71 μm long at midline and 102 μm wide. Three abdominal somites from anterior to posterior 26×58, 20×54, and 29×50 μm. Caudal ramus 24×23 μm, ratio 1.04:1.

Rostrum like that of female. Antennule (Fig. 12C) 18-segmented. Armature formula: 2, 2, 2, 2, 2; 2, 2, 2, 8, 2; 2, 2, 2+1 aesthetasc, 2, 2; 4, 3+1 aesthetasc, and 11. Anterodistal corner of penultimate segment produced, beak-like. Antenna, siphon, mandible, maxillule like those of female. Maxilliped (Fig. 12D) resembling that of female but sexually dimorphic in having conical process on inner margin of second segment.

Third endopodal segment of leg 3 (Fig. 12D) with armature formula 1,I,3; outer distal seta greatly reduced and negligible. Legs 1, 2, and 4 as in female. Leg 5 with free segment (Fig. 12F) 33×13 μm, ratio 2.54:1, nearly quadrangular. Leg 6 represented by posteroventral flap on genital somite bearing 2 setae (Fig. 12B).

Etymology

This species is named for Mr. T. Chad Walter, National Museum of Natural History, Smithsonian Institution, who made the author possible to study the copepod collection of Dr. Arthur G. Humes.

Remarks

Species of *Asterocheres* having at least one of the following features which are not concerned with *A. walteri* are excluded in a comparison with *A. walteri*: (1) the antennule is 20 or more segmented; (2) the mandibular palp is 1-segmented; (3) the free segment of female leg 5 reveals the ratio of the length to width 3:1 or more; (4) the caudal ramus is more than 1.5 times as long as wide.

The remaining species not concerned with the above criteria may be differentiated from *A. walteri* by the following ways.

In *Asterocheres canui* Giesbrecht, 1897, *A, renaudi* Canu, 1891 and *A. ventricosus* (Brian, 1927), all of which are incompletely known species, the free segment of female leg 5 bears only two setae.

In *Asterocheres stimulans* Giesbrecht, 1897 and *A. micheli* (Gurney, 1927) the female antennule is 18-segmented.

In *Asterocheres sphonatus* Giesbrecht, 1897 the siphon is long, extending over leg 4.

In *Asterocheres complexus* Stock, 1960 and *A. ellisi* Hamond, 1968 the exopod of antenna bears only one (in *A. ellisi*) or two (in *A. complexus*) setae.

In *Asterocheres rotundus* Malt, 1991 the aesthetasc of antennule is inserted on the antepenultimate segment.

In *Asterocheres simulans* (Scott, 1898) the body is distinctly larger than that of *A. walteri* (1.10 mm in the female, and 720 μm in the male).

In *Asterocheres abyssi* (Hansen, 1923), an incompletely known species based only on a male, the male antennule is 17-segmented (18-segmented in *A. walteri*) and the male body is 0.88 mm long, a length distinctly longer than that of male *A. wateri*.

Asterocheres urabensis n. sp. (Figs. 13-15)

Material examined

45 ♀♀, 23 ♂♂ from the scleractinian coral *Pocillopora damicornis* (L.) in 12-17 m, north side of Uraba Island in the Pacific coast of Panama, collected by A. G. Humes. Holotype (♀), allotype (♂), and paratypes (42 ♀♀, 20 ♂♂) have been deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D. C. Dissected paratypes (2 ♀♀, 2 ♂♂) are retained in the collection of the author.

Female

Body (Fig. 13A) with moderately broad prosome. Length

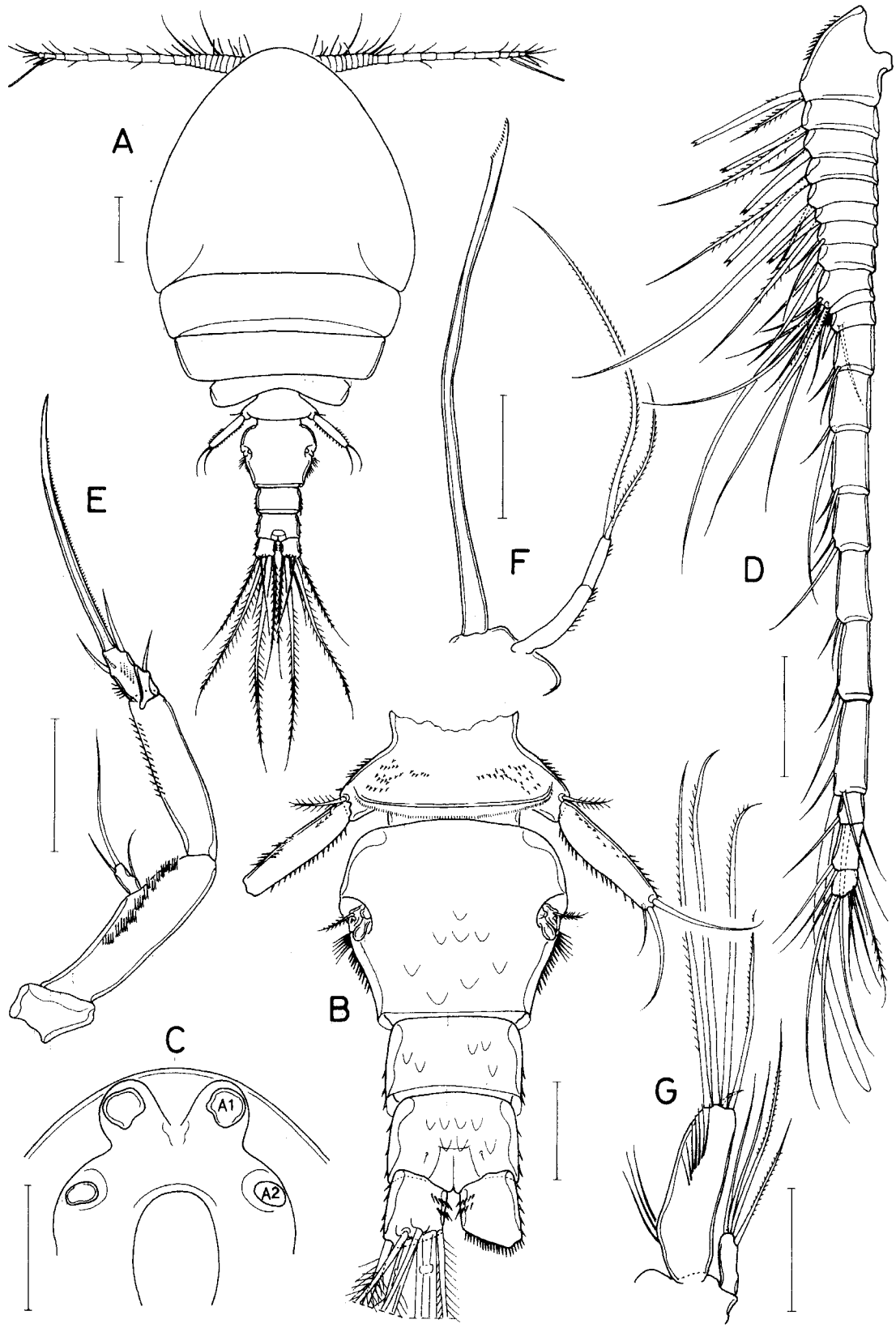

Fig. 13. *Asterocheres urabensis* n. sp., female. A, Habitus, dorsal. B, Urosome, dorsal. C, Rostral area, ventral. D, Antennule. E, Antenna. F, Mandible. G, Maxillule. Scale bars=100 μm (A, C), and 50 μm (B, D-G).

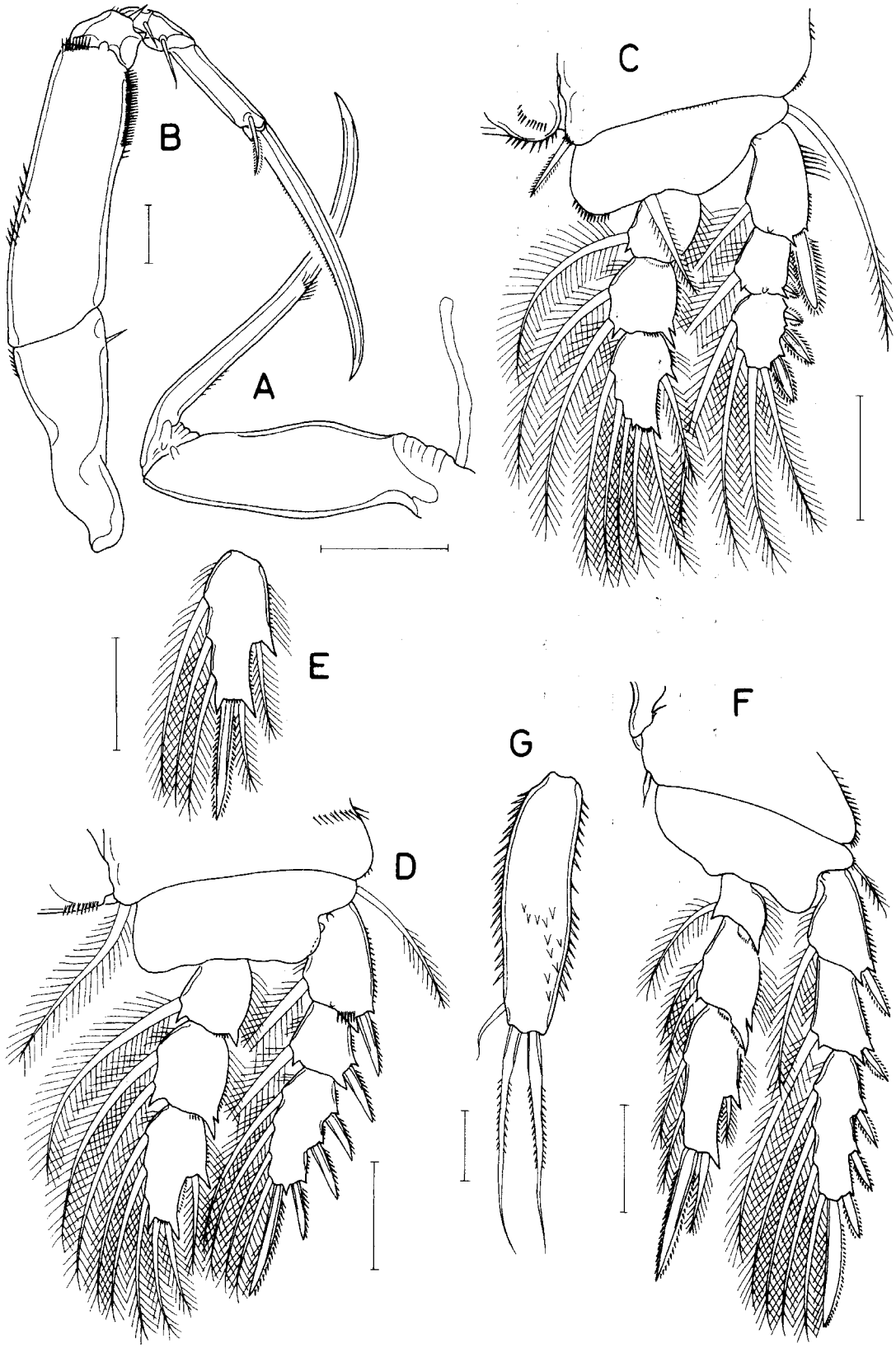

Fig. 14. *Asterocheres urabensis* n. sp., female. A. Maxilla. B, Maxilliped. C, Leg 1. D, Leg 2. E, Third endopodal segment of leg 3. F, Leg 4. G, Free segment of leg 5. Scale bars=50 μm (A, C-F), and 20 μm (B, G).

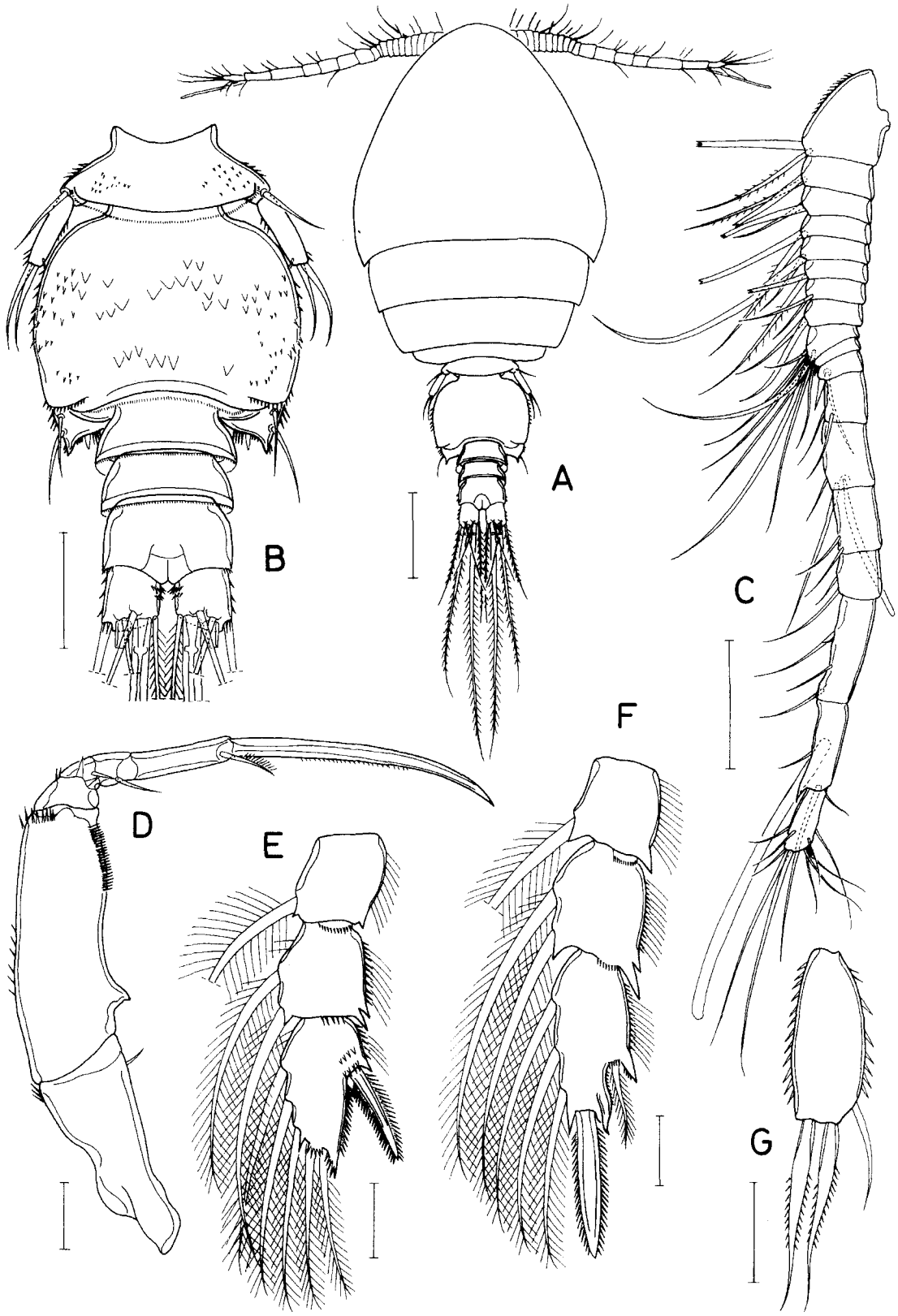

Fig. 15. *Asterocheres urabensis* n. sp., male. A, Habitus, dorsal. B, Urosome, dorsal. C, Antennule. D, Maxilliped. E, Endopod of leg 1. F, Endopod of leg 3. G, Free segment of leg 5. Scale bars=100 μm (A), 50 μm (B, C), and 20 μm (D-G).

792 μm (700-835 μm), based on 10 specimens. Urosome (Fig. 13B) 4-segmented. Fifth pedigerous somite 119 μm wide, with spinules on dorsal surface and lateral margins, narrow membrane along posterodorsal margin. Genital double-somite 105×117 μm, wider than long, with gradually narrowed posterior half, transparent scales on dorsal surface, fine setules on posterior half of lateral margins. Genital areas located dorsolaterally in middle of genital double-somite. First abdominal somite 38×69 μm. Anal somite 41×67 μm, with fine spinules along posteroventral margin.

Caudal ramus 36×30 μm, ratio 1.20:1, with 2 transverse rows of fine spinules on median side, fine spinules on posteroventral margin, scales on outer margin, and 6 setae.

Rostrum very weakly developed (Fig. 13C). Antennule (Fig. 13D) 360 μm long, 21-segmented, with armature formula: 2, 2, 2, 2, 2; 2, 2, 2, 7, 2; 2, 2, 2, 2, 2; 2, 2, 2+1 aesthetasc, 2, 4, and 7. Several setae on proximal segments bifurcate at tip. Aesthatasc inserted on 18th segment. Several seta on proximal segment serrate with small spinules. First segment with minute spinules (or setules) on anterior margin. Antenna (Fig. 13E) with short coxa. Basis 75 μm long, with comb-like patches of minute spinules on side. Exopod 12×6 μm, with 1 lateral and 2 terminal setae. First endopodal segment 65 μm, with fine spinules on outer side. Short second segment with 1 inner seta. Third segment distally with 1 minute and 2 small setae. Claw 102 μm long and slender, with minute spinules along whole concave margin.

Siphon 230 μm long, extending to insertions of leg 1. Mandible (Fig. 13F) slender, with fine teeth distally. Palp 2-segmented, each segment 40 μm (proximal segment) and 21 μm (distal), terminally with 2 unequal setae, larger one more than twice as long as shorter one, extending to tip of mandible when stretched. Maxillule (Fig. 13G) with inner lobe 24 μm, having 4 subequal setae. Outer lobe 70 μm long, distinctly larger than inner lobe, with long setules laterally and 5 terminal setae, one of latters minute, and longest seta 147 μm. Maxilla (Fig. 14A) with 1 aesthetasc on proximity of proximal segment. Distal claw slender and longer than proximal segment. Maxilliped (Fig. 14B) 5-segmented. First segment with 1 small inner distal seta and several minute spinules on outer distal area. Second segment without seta, but with spinules on outer margin and distal border, and 1 row of minute spinules on distal part of inner margin. Third segment with 2 distal setae. Fourth segment divided by tansverse line into proximal and distal parts, each bearing 1 seta. Fifth segment with 1 terminal seta. Claw slightly curved distally.

Legs 1-4 (Figs. 14C-F) with 3-segmented rami. Armature formula as follows:

Leg 1: coxa 0-1; basis 1-1 exp. I-1; I-1; III,4; enp. 0-1; 0-2; 1,2,3
Leg 2: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,2,3
Leg 3: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,1I,3
Leg 4: coxa 0-1; basis 1-0 exp. I-1; I-1; III,I,4; enp. 0-1; 0-2; 1,1I,2

Leg 1 with spiniform inner coxal seta. Inner distal corner of basis with minute spinules. Outer spine on exopod distinctly longer than second exopodal segment and thick, with spinulated margins. Outer seta on second exopodal segment reduced in size. Inner coxal seta of leg 4 small and spiniform.

Leg 5 with nearly quadrangular free segment (Fig. 14G) 73×20 μm, ratio 3.65:1, with many spinules on surface, and 1 small subterminal and 2 larger terminal setae, longest one them 64 μm long.

Leg 6 represented by 1 small plumous seta and 1 minute spinule in genital area (Fig. 13B).

Male

Body (Fig. 15A) similar to that of female. Length 600 μm (535-625 μm), based on 10 specimens. Urosome (Fig. 15B) 5-segmented. Fifth pedigerous somite 91 μm wide. Genital somite 76 μm long at midline and 116 μm wide. Three abdominal somites from anterior to posterior 26×62, 19×57, and 37×56 μm. Caudal ramus 26×24 μm, ratio 1.08:1.

Rostrum like that of female. Antennule (Fig. 15C) 18-segmented, 285 μm long. Armature formula: 2, 2, 2, 2, 2; 2, 2, 2, 7, 2; 2, 2, 2+aesthetasc, 2, 2; 4, 2+aesthetasc, and 11. Anterodistal corner of penultimate segment produced, beak-like. Antenna, siphon, mandible, maxillule like those of female. Maxilliped (Fig. 15D) resembling that of female but sexually dimorphic in having conical process on inner margin of second segment.

Leg 1 with enlarged outer spine on third endopodal segment (Fig. 15E). Leg 3 sexually dimorphic in having armature formula 1,I,3 and transformed inner distal process on third endopodal segment (Fig. 15F).

Leg 5 with free segment (Fig. 15G) 35×15 μm, ratio 2.33:1; terminal setae 38 μm. Leg 6 represented by posteroventral flap on genital somite bearing 2 setae and distal process (Fig. 15B).

Etymology

The specific name *urabensis* is derived from the type locality "Uraba" Island.

Remarks

According to Ivanenko and Smurov (1997), the following eight valid species of *Asterocheres* have 21-segmented female antennule, as in *A. urabensis* n. sp.: *A. bulbosus* Malt, 1991; *A. flustrae* Ivanenko and Smurov, 1997; *A. jeanyeatmanae* Yeatman, 1970; *A. minutus* (Claus, 1889); *A. reginae* Boxshall and Huys, 1994; *A. suberitis*

Giesbrecht, 1899; *A. tenuicornis* Brady (1910); *A. violaceus* (Claus, 1889). Although the female antennule of *Asterocheres aestheticus* Ho, 1984 which was described originally as having 19 segments (Ho, 1984) has been interpreted by Ivanenko and Smurov (1997) as 21-segmented state, based on the illustration of Ho, I confirmed from the Korean material of the same species that this species actually has a 20-segmented female antennule. Johnsson (1998) recorded *A. lunatus* as new species having 21-segmented antennule. Therefore, there are nine species in *Asterocheres* having 21-segmented female antennule.

Asterocheres urabensis is distinguished from the above nine species by the following features possessed by these congeners:

In *Asterocheres bulbosus* the caudal ramus wider than long (0.6 times as long as wide), the free segment of female leg 5 is about twice as long as wide, and the siphon is short, reaching not to the insertions of maxillipeds (Malt, 1991).

In *Asterocheres flustrae* the free segment of female leg 5 is about 2.6 times as long as wide, based on Fig. 7E of Ivanenko and Smurov (1997), and the body is larger (950 μm in the female, and 790 μm in the male) than that of *A. urabensis.*

In *Asterocheres jeayeatmanae* the third endopodal segment of leg 3 is armed with one spine and five setae (formula 1,1+I,3), and the free segment of female leg 5 is armed with only two setae (Yeatman, 1970).

In *Asterocheres lunatus* the third endopodal segment of leg 3 is armed with six setae (formula 1,2,3), the epimera of cepahlothorax and second pedigerous somite expended and pointed posteriorly, and leg 1 carries no inner element on basis (Johnsson, 1998).

In *Asterocheres minutus* and *A. violaceus* the free segment of female leg 5 is short, less than twice as long as wide, according to Bocquet and Stock (1963).

In *Asterocheres reginae* the body is larger (970 μm in the female and 870 μm in the male) than that of *A. urabensis*, the epimera of cephalothorax is developed, expanded posterolaterally, and the free segment of leg 5 is much more slender in both sexes than that of *A. urabensis* (Boxshall and Huys, 1994).

In *Asterocheres suberitis* the madibular palp is 1-segmented and one of its terminal setae much reduced, and the free segment of female leg 5 is hardly longer than twice its width (Giesbrecht, 1899).

In *Asterocheres tenuicornis* the body is larger (1.10 mm in the female, and 780 μm in the male) than that of *A. urabensis*, and the caudal ramus of the female is elongate, more than four times as long as wide, based on the illustration of Eiselt (1965).

Acknowledgements

I am indebted to Mr. T. C. Walter, a copepodologist in the National Museum of Natural History, Smithsonian Institution, who made the author possible to study copepod material studied. This study was supported by a grant from the Korea Science and Engineering Foundation (R05-2004-000-10302-0).

References

Bocquet C and Stock JH (1963) Copépodes parasites d'invertébrés des côtes de France. XV. Le problème systématique d'*Asterocheres violaceus* (Claus) et d'*Asterocheres minutus* (Claus). *Koninkl Nederl Adad Wetenschappen Amsterdam, Ser* C 66: 37-52.

Boxshall GA and Huys R (1994) *Asterocheres reginae*, a new species of parasitic copepod (Siphonostomatoida: Asterocheridae) from a sponge in Belize. *Syst Parasitol* 27: 19-33.

Eiselt J (1965) Revision und neubeschreibungen weiterer siphonostomer Cyclopoiden (Copepoda, Crust.) aus der Antarktis. *Sber Öst Akad Wiss, Mat-nat Kl* 174: 151-169.

Giesbrecht W (1899) Die Asterocheriden des Golfes von Neapel und angrenzenden Meeresabschnitte. *Fauna Flora Golfes Neapel Angren Meer* 25: 1-217.

Ho J-S (1984) Copepoda associated with sponges, cnidarians, and tunicates of the Sea of Japan. *Rep Sado Mar Biol Stat Niigata Univ* 14: 23-61.

Humes AG (1984a) *Hemicyclops columnaris* sp. n. (Copepoda, Poecilostomatoida, Clausidiidae) associated with a coral in Panama (Pacific side). *Zool Sci* 13: 33-39.

Humes AG (1984b) *Ostrincola* and *Pseudomyicola* (Crustacea: Copepoda: Poecilostomatoida) associated with marine bivalve mollusks on the Pacific coast of Panama. *Proc Biol Soc Wash* 97: 589-600.

Humes AG (1992) *Euryte verecunda*, new species (Copepoda: Cyclopoida) associated with the coral *Porites lobata* on the Pacific coast of Panama. *Proc Biol Soc Wash* 105: 268-274.

Ivanenko VN and Smurov AV (1997) *Asterocheres flustrae* n. sp. (Copepoda: Siphonostomatoida: Asterocheridae) associated with *Flustra foliacea* L. (Bryozoa) from the White Sea. *Syst Parasitol* 38: 111-130.

Johnsson R (1998) Six new species of the genus Asterocheres (Copepoda; Siphonostomatoida) associated with sponges in Brazil. *Nauplius* 6: 61-99.

Johnsson R (2002) Asterocherids (Copepoda: Siphonostomatoida) associated with invertebrates from California reefs: Abrolhos (Brazil). *Hydrobiologia* 470: 247-266.

Malt S (1991) The copepod inhabitants of sponges and algae from Hong Kong. *Bull Br Mus Nat Hist (Zool)* 57: 167-183.

Reddiah K (1969) Pseudomacrochiron stocki n. g., n. sp., a cyclopoid copepod associated with a medusa. *Crustaceana* 16: 43-50.

Scott A (1909) The Copepoda of the Siboga Expedition. Pt I. Free-swimming, littoral and semi-parasitic Copepoda. *Siboga Expedition* 29A: 1-323.

Stock JH (1966) Cyclopoida siphonostoma from Mauritius (Crustacea, Copepoda). *Beaufortia* 13: 145-194.

Yeatman HC (1970) Copepods from Chesapeake Bay sponges including *Asterocheres jeanyeatmnae* n. sp. *Trans Amer Microsc Soc* 89: 27-38.

[Received July 12, 2004; accepted September 2, 2004]