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JOURNAL OF CRUSTACEAN BIOLOGY, 11(4): 594–606, 1991

ARRAMA, NEW GENUS (SIPHONOSTOMATOIDA: CALIGIDAE), WITH TWO NEW SPECIES, COPEPODS PARASITIC ON AUSTRALIAN FISHES

Masahiro Dojiri and Roger F. Cressey

ABSTRACT

A new genus, *Arrama*, and two new species, *A. tandani* and *A. cordata*, belonging to the copepod family Caligidae (Siphonostomatoida), are described from the gill filaments of two species of plotosid catfishes, *Cnidoglanis macrocephalus* (Valenciennes) and an undescribed species of *Paraplotosus*, respectively, from Australia. The new genus can be distinguished from confamilial genera by a combination of characters that include (1) the reduced apical armature of the leg 1 exopod, (2) the 2-segmented rami of leg 2, (3) the absence of the ventral apron of leg 3, and (4) the reduction of legs 3 and 4 to setiferous lobes. The two new species are distinguished from each other by the shape of the genital complex, the setae of the caudal ramus, the arrangement of spinules of the canna of the second maxilla, the apical armature of the leg 1 exopod, and the terminal armature of the leg 2 exopod. The morphology of the suckerlike cephalothorax of the members of the Caligidae appears to be an adaptation for attachment to smooth flat surfaces, i.e., external body surfaces, buccal cavity walls, and branchial chamber walls of the hosts. Two genera, *Abasia* and *Hermilius*, have become specialized for living on gill filaments of their hosts by modifications of their cephalothoraces. Although the ventral apron, a structure formed by the expansion of the intercoxal plate and sympod of leg 3, remains intact in these two genera, it may no longer be functional. Members of the new genus, *Arrama*, which also live on gill filaments, lack the ventral apron.

The Plotosidae, commonly known as the eel catfishes, eeltail catfishes, stinging catfishes, coral reef catfishes, and barbel eels, inhabit coastal waters of the Indo-West Pacific region (Burgess, 1989). There are several genera (e.g., *Cnidoglanis, Euristhmus, Neosilurus, Paraplotosus, Plotosus,* and *Tandanus*) included in this family (Nelson, 1984). Although a few species are marine, most are estuarine or fresh-water species (Burgess, 1989). Several species of plotosids are considered edible (Burgess, 1989) and are taken in sufficient numbers to be considered economically important (Nel *et al.*, 1985).

While conducting a revision of marine plotosid catfishes, Ms. Janet R. Gomon, Smithsonian Institution, collected several specimens of parasitic copepods from the gill filaments of the cobbler *Cnidoglanis macrocephalus* (Valenciennes) and an undescribed species of *Paraplotosus*. Although parasitic copepods have been reported previously from plotosids (Table 1), the specimens in the present collection are unique and represent two new species and a new genus of the siphonostomatoid family Caligidae. These new taxa are described below. Additional specimens of the new taxa were collected by the first author during a Short-Term Visitor appointment to the Smithsonian Institution, and by Dr. Alan Williams, Murdoch University, Western Australia.

The copepods were preserved in 70% ethanol, cleared in 85% lactic acid for a period of at least 24 h, and dissected on wooden slides (Humes and Gooding, 1964). Illustrations were drawn with the aid of a drawing tube attached to a Nikon Optiphot, HFX-II. Type specimens have been deposited in the Western Australian Museum, Francis Street, Perth, Western Australia, 6000, Australia.

Order Siphonostomatoida Thorell, 1859
Family Caligidae Burmeister, 1835
Arrama, new genus

Diagnosis.—Siphonostomatoida. Caligiform facies. Cephalothorax, composed of cephalosome fused with first–third pedigerous somites, divided into cephalic, thoracic, and 2 lateral zones. Fourth pedigerous somite forming short neck. Genital complex with ventral egg sac attachment area. Caudal ramus partially fused to abdomen and bearing 4 setae. Frontal plate divided into 2 parts with distinct gap between them. First antenna 2-segmented. Second antenna

Table 1. Host-parasite and locality of collection list for copepods parasitic on Plotosidae.

Host	Parasite (attachment site)	Locality	Authority
Plotosus anguillaris (Bloch)	*Lepeophtheirus plotosi* Barnard (gills)	South Africa	Barnard, 1948
	Lepeophtheirus anguilli Hameed (external surface and gills)	India	Hameed, 1976
	Taeniacanthus anguillaris (Devi and Shyamasundari) (gills)	India	Devi and Shyamasundari, 1980
	Caligus kuwaitensis Kabata and Tareen (external body surface)	Kuwait Bay	Kabata and Tareen, 1984
Plotosus lineatus (Thunberg)	*Irodes remipes* Dojiri and Cressey (throat and gill chamber)	Indo-West Pacific	Dojiri and Cressey, 1987
	Taeniacanthus anguillaris (Devi and Shyamasundari) (throat and gill chamber)	Indo-West Pacific; Red Sea	Dojiri and Cressey, 1987
Cnidoglanis macrocephalus (Valenciennes)	*Irodes remipes* Dojiri and Cressey (throat and gill chamber)	Western Australia	Dojiri and Cressey, 1987
	Arrama tandani, new species (gills)	Western Australia	present paper
Paraplotosus sp.	*Arrama cordata*, new species (gills)	Australia	present paper

3-segmented, prehensile; posteriorly directed spiniform process absent on basal segment. Postantennal process absent.

Mouth tube with protuberant anteroventral surface. Mandible with 12 teeth on medial margin. First maxilla with setiform lobe and dentiform process with setiform tip. Second maxilla with flabellum on brachium and relatively stout calamus and canna. Maxilliped prehensile, comprising corpus, shaft, and claw; shaft and claw partially fused to form subchela. Sternal furca absent.

Legs 1 and 2 biramous. Leg 1 with 2-segmented exopod and greatly reduced endopod. Leg 2 with 2-segmented rami. Ventral apron absent. Legs 3 and 4 reduced to setiferous lobes. Leg 5 represented by single naked seta near egg sac attachment area. Leg 6 apparently absent.

Parasitic on Plotosidae.

Type Species.—*Arrama tandani,* new species, by original designation.

Etymology.—The generic name *Arrama* is an Australian aboriginal word meaning "louse," used as a feminine noun.

Remarks.—The new genus can be distinguished from other genera of the Caligidae by: (1) the reduced armature at the tip of the exopod of leg 1, (2) the 2-segmented rami of leg 2, (3) the absence of the ventral apron of leg 3, and (4) the reduction of legs 3 and 4 to setiferous lobes.

Arrama bears a superficial resemblance to the caligid genus *Abasia* Wilson, 1908, parasitic on lizardfishes (Synodontidae), and *Hermilius* Heller, 1865, parasitic on the gill filaments of marine catfishes (Ariidae). The cephalothorax of all three genera is folded, with the lateral zones directed ventrally, resulting in a midventral longitudinal groove in which the gill filament of the host lies.

Although *Abasia* exhibits a progressive reduction in leg 3 from a 3-segmented exopod and 2-segmented endopod (*A. pseudorostris* Wilson, 1908) to a 1-segmented exopod with endopod absent (*A. inflata* Cressey and Cressey, 1979) (see Cressey and Cressey, 1979), all species of this caligid genus, as well as species of *Hermilius,* possess a distinct ventral apron, a structure absent in the new genus.

Both new species of this new genus were collected from the gill filaments of plotosid fishes from Australia.

Arrama tandani, new species
Figs. 1–4

Material Examined.—1 ♀ holotype (WAM 1-91), 1 allotype (WAM 2-91), 10 paratypes (1 intact ♀ and 1 ♀ dissected on slide; 5 intact ♂♂ and 2 ♂♂ dissected on slides; and 1 immature ♀ (WAM 3-91) from gill filaments of *Cnidoglanis macrocephalus* (WAM P11948-58) collected at Swan River, Preston Point, Australia, by R.J. Slack on 18 January 1965; 1 ♀ paratype (WAM 4-91) from *Cnidoglanis macrocephalus* collected from Swan River, Cockburn Sound, Perth, Western Australia, by Dr. Alan Williams, Murdoch University.

Female.—Body as in Fig. 1A, B. Total length 3.06 mm (2.93–3.19 mm) and width at widest points 1.48 mm (1.33–1.65 mm), based on 3 specimens. Cephalothorax (Fig. 1A) much wider than long, 0.79 mm (0.73–0.90 mm) × 1.48 mm (1.33–1.65 mm); tips of first antennae well within lateral margins of cephalothorax; posterior sinuses absent; lateral zone expanded into aliform structure, curved ventrad and forming midventral longitudinal groove encompassing gill filament of host; tips of lateral zone extending slightly beyond posterior margin of thoracic zone; thoracic zone demarcated anteriorly by partial suture and approximately one-fourth length of cephalic zone. Fourth pedigerous somite (Fig. 1C) short neck, not well defined; this somite and genital complex forming trunk, combined measuring 2.00 mm (1.95–2.10 mm) × 0.97 mm (0.87–1.14 mm); trunk greatly constricted and narrower at posterior end near junction with abdomen. Abdomen (Fig. 1D) small, wider than long, 0.14 mm (0.11–0.19 mm) × 0.23 mm (0.18–0.31 mm). Caudal ramus (Fig. 1E) fused to abdomen, bearing 1 naked and 3 pinnate setae. Egg sac attachment area (Fig. 1D) at ventrolateral corner.

Frontal plate (Fig. 1A, C) in 2 sections with distinct gap between halves; reduced striated marginal membrane at anterior end; 2 oval pits located in center of anterior margin of cephalothorax, and directly posteromedial to frontal plate. First antenna (Fig. 1F) 2-segmented; first segment relatively slender with 15 pilose setae; second segment cylindrical and bearing 1 subapical seta and 12 setae + 1 aesthete (2 posterior setae sharing common base) at tip. Second antenna (Fig. 2A) 3-segmented; first segment unarmed, relatively small, and without posteriorly directed spiniform process; second segment, longest of 3 segments, naked; terminal segment curved claw with 2 setae and small pit bearing 2 minute, hyaline digitiform elements. Postantennal process absent.

Mouth tube (Fig. 2B) longer than wide, 217 × 192 μm, and protuberant at anteroventral surface; intrabuccal stylet dorsal to frons labri. Mandible (Fig. 2C) of 4 parts (possibly representing segments); third and fourth parts almost completely fused; terminal portion with lateral hyaline membrane and 12 medial teeth. First maxilla (Fig. 2D) composed of 2 parts: setiferous lobe bearing 2 small naked setae and 1 large pinnate seta, and dentiform structure with pinnate setiform tip. Second maxilla (Fig. 2E, F) brachiform; first segment (lacertus) relatively stout; flabellum, located at distal third of second segment (brachium), striated membrane with serrated margin; calamus shorter than canna and equipped with 3 rows of serrated membranes; canna blunt and ornamented with numerous spinules (some grouped in patches, others along margin). Maxilliped (Figs. 2G, 3A) with first segment stout; shaft and claw (tip broken off in specimen illustrated) with incomplete suture near 2 small naked setae. Sternal furca absent.

Leg 1 (Fig. 3B) biramous, greatly reduced in size (see Fig. 1C); intercoxal plate not sclerotized and very inconspicuous; sympod with distal lateral seta. Exopod (Fig. 3B) indistinctly 2-segmented, with constricted area dividing exopod into 2 segments; terminal segment with lateral spine, 4 terminal spines, and 1 terminal seta; truncate process (opening to duct ?) on ventral surface at tip of exopod (Fig. 3C). Endopod (Fig. 3B) small lobe with 2 minute papillae; oval process adjacent to origin of endopod. Leg 2 (Fig. 3D, E) biramous; intercoxal plate with striated membrane on posterior margin; coxa with lateral membrane, medial setule, and medial pinnate seta; basis with lateral seta and medial setule. Exopod 2-segmented; first segment with striated marginal membrane, 1 unilaterally barbed spine with row of spinules at base, and 1 pinnate seta (shown in Fig. 3D, but broken off in Fig. 3E) and row of setules (hairs) on medial margin; terminal segment with 2 barbed lateral spines and 1

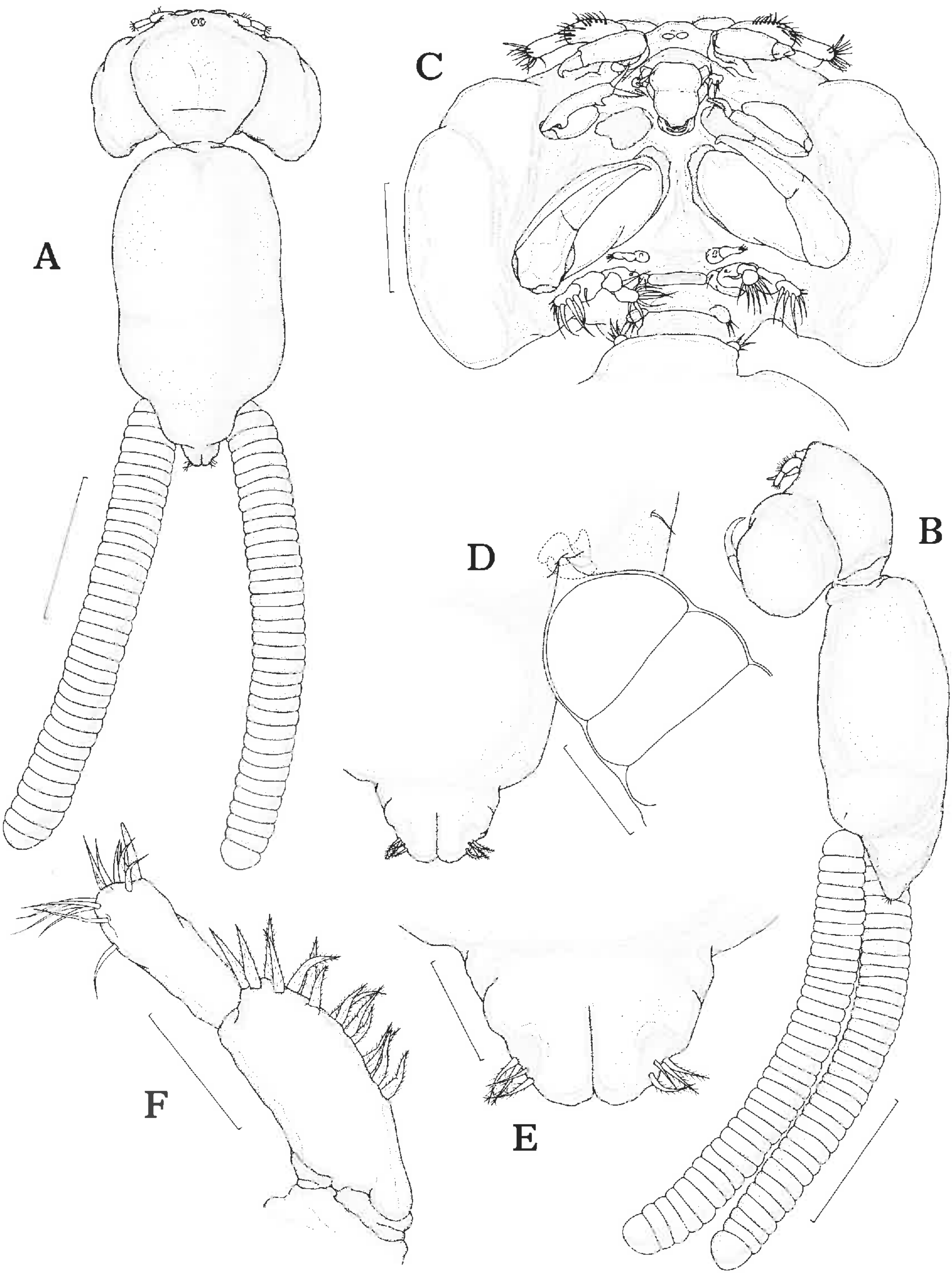

Fig. 1. *Arrama tandani,* new genus, new species, female: A, habitus, dorsal; B, habitus, lateral; C, cephalothorax, ventral; D, posterior portion of urosome with egg sac, ventral; E, anal segment, ventral; F, first antenna, ventral. Scale: 1.0 mm in A, B; 0.3 mm in C; 0.2 mm in D; 0.1 mm in E, F.

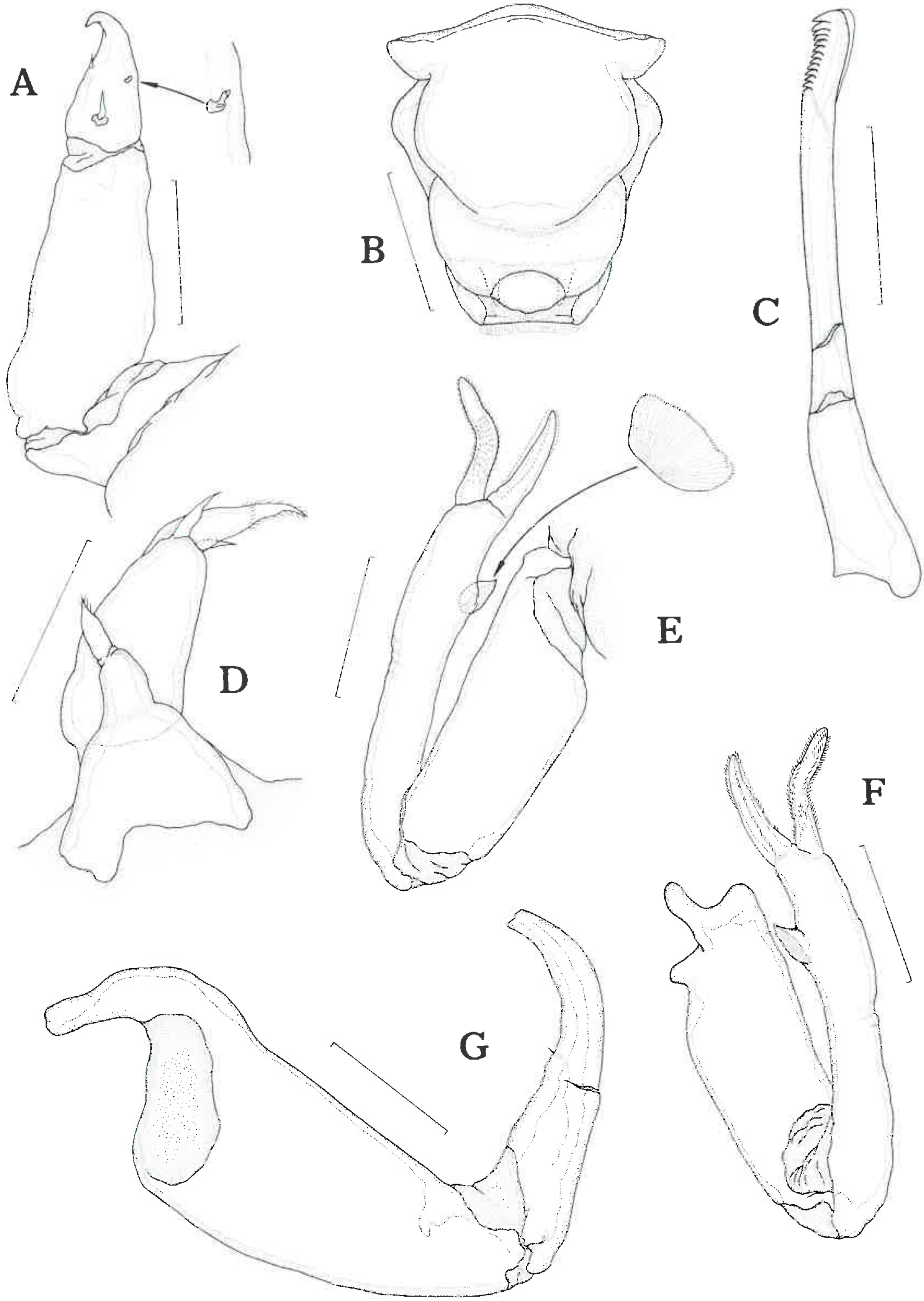

Fig. 2. *Arrama tandani*, new genus, new species, female: A, second antenna, ventral; B, mouth tube, ventral; C, mandible, ventral; D, first maxilla, posterior; E, second maxilla, ventral; F, second maxilla, dorsal; G, maxilliped, dorsal. Scale: 0.1 mm in A, B, E–G; 0.05 mm in C, D.

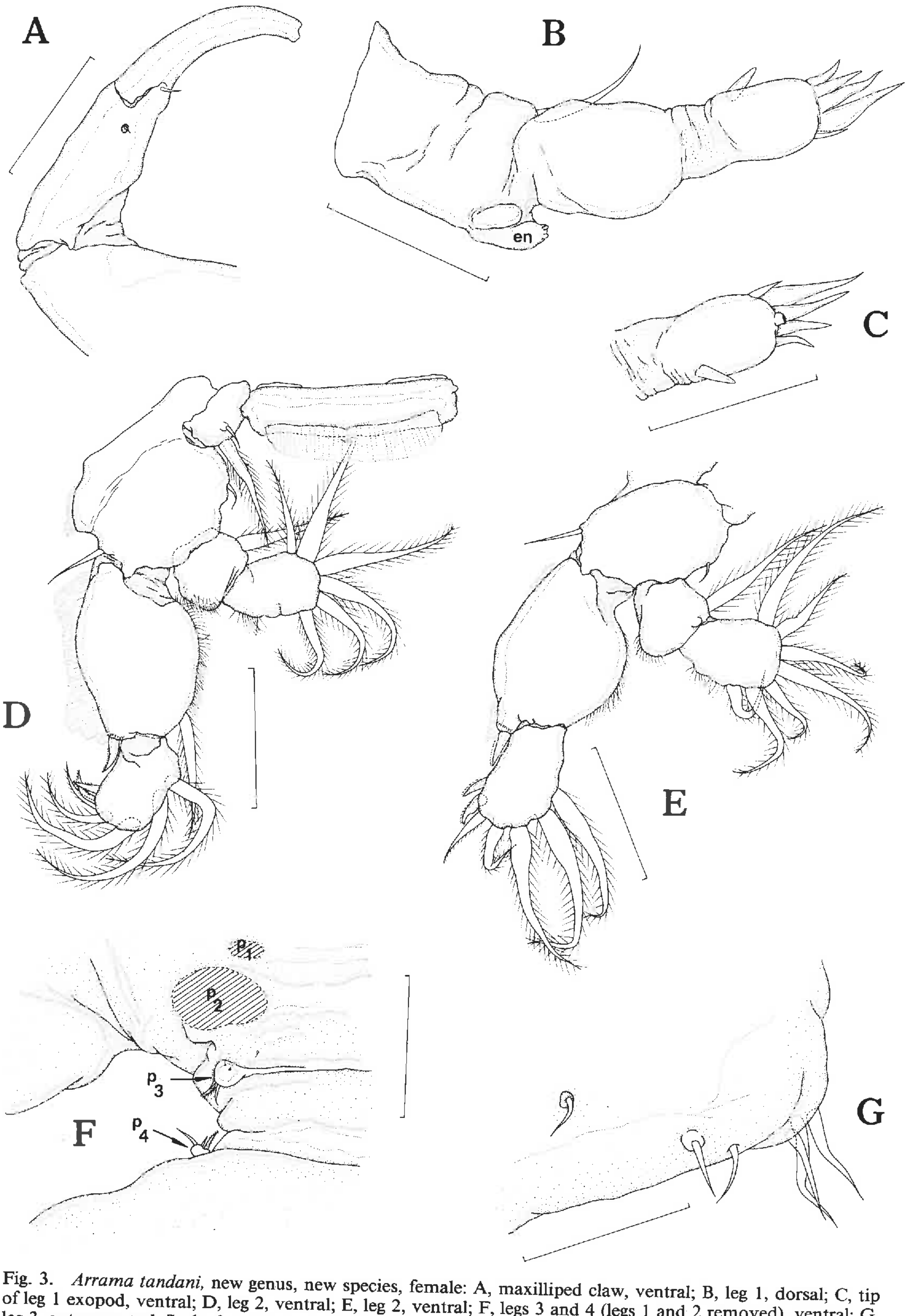

Fig. 3. *Arrama tandani,* new genus, new species, female: A, maxilliped claw, ventral; B, leg 1, dorsal; C, tip of leg 1 exopod, ventral; D, leg 2, ventral; E, leg 2, ventral; F, legs 3 and 4 (legs 1 and 2 removed), ventral; G, leg 3, anteroventral. Scale: 0.1 mm in A, D, E; 0.05 mm in B, C, G; 0.2 mm in F. Symbols: en = endopod; p1–p4 = legs 1–4.

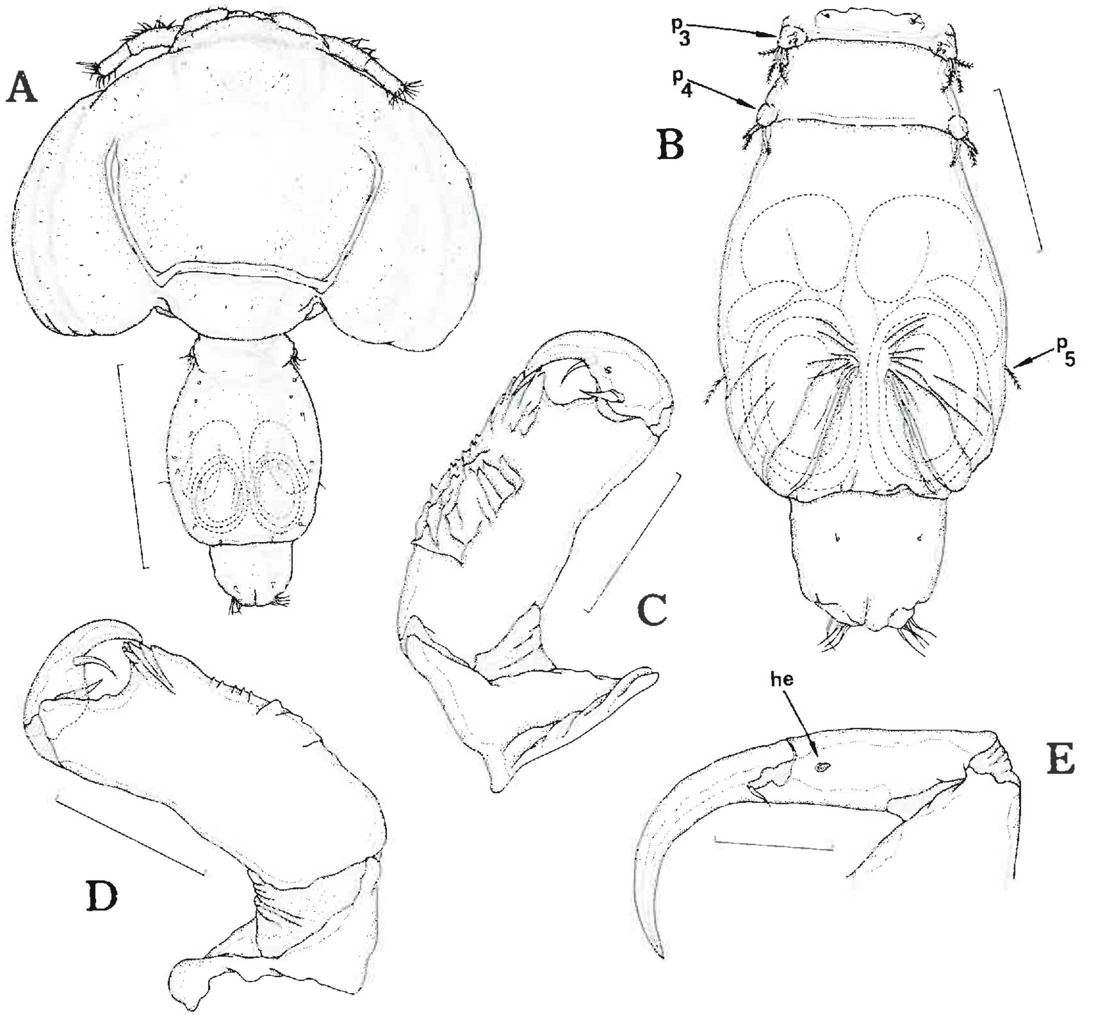

Fig. 4. *Arrama tandani,* new genus, new species, male: A, habitus, dorsal; B, urosome, ventral; C, second antenna, ventral; D, second antenna, dorsal; E, maxilliped claw, ventral. Scale: 0.5 mm in A; 0.2 mm in B; 0.1 mm in C, D. Symbols: p3–p5 = legs 3–5; he = hyaline element.

semipinnate and 4 pinnate setae. Endopod 2-segmented; first segment (with relatively straight lateral margin in Fig. 3D, but protuberant margin in Fig. 3E) bearing lateral setules and medial pinnate seta; second segment (Fig. 3D) with lateral patch of hairs and 6 pinnate setae (7 in Fig. 3E). Leg 3 (Fig. 3F, G) setiferous lobe bearing 3 setae and 3 or 4 relatively large setules; ventral apron absent. Leg 4 (Fig. 3F) also setiferous lobe with 1 seta and 2 spines. Leg 5 (Fig. 1D) represented by single naked seta near egg sac attachment area.

Male.—Body as in Fig. 4A. Total length 1.31 mm (1.23–1.41 mm). Cephalothorax about one-half total length, wider than long, 0.58 mm (0.51–0.65 mm) × 0.83 mm (0.76–0.93 mm), and similar in shape to that of female. Trunk subovoid in outline, 0.40 mm (0.35–0.42 mm) × 0.28 mm (0.25–0.32 mm). Abdomen slightly wider than long, quadrangular, and 0.11 mm (0.09–0.12 mm) × 0.15 mm (0.14–0.19 mm). Caudal ramus (Fig. 4B) partially fused to abdomen, and bearing 4 naked setae.

All appendages as in female except those described below. First antenna as in female except 17 pilose setae on first segment. Second antenna (Fig. 4C, D) sexually dimorphic; second segment with corrugated inner (medial) margin; claw with slightly different shape than that of female (cf. Fig. 4C with Fig. 2A). Claw of maxilliped (Fig. 4E) more slender than in female.

Etymology.—The specific name *tandani* is used as a latinized masculine genitive noun of the Australian aboriginal word for catfish, "tandan."

Remarks.—Only one species of parasitic copepod, *Irodes remipes* Dojiri and Cressey, 1987, has been described from *Cnidoglanis macrocephalus* previous to the discovery of *Arrama tandani.* This species of the Taeniacanthidae was collected from the same lot of specimens from Swan river as *Arrama tandani,* and also from Rottnest Island, both in Western Australia (Dojiri and Cressey, 1987).

The type species of *Arrama* can be distinguished from all other copepod genera by the characters stated in its generic diagnosis, as well as those listed in the "Remarks" section for the genus. It can be separated from its congener, *Arrama cordata,* new species, described below, by the characters listed in Table 2.

Arrama cordata, new species
Figs. 5, 6

Material Examined.—1 ♀ holotype (WAM 5–91; some appendages dissected on slide) from gill filaments of *Paraplotosus* sp. from Australia, 3 April 1969, collected from host by Janet R. Gomon.

Female.—Body (Fig. 5A–C) very stout and composed of 2 distinct parts, cephalothorax and trunk. Total length 2.01 mm based on 1 specimen. Cephalothorax (Fig. 5A, C) much wider than long, 0.61 × 0.96 mm; lateral zones folded ventrad as in preceding species. Fourth pedigerous somite forming short neck 0.07 × 0.28 mm. Genital complex expanded with lateral alae, combined with abdomen forming heart-shaped trunk. Abdomen (anal segment) (Fig. 5D) slightly wider than long 0.18 × 0.21 mm. Caudal ramus (Fig. 5D), slightly retracted into posterior margin of abdomen, bearing 3 large pinnate setae and 1 small naked seta. Egg sac attachment area (Fig. 5C) ventral.

Frontal plate (Fig. 5C) similar to that of preceding species. First antenna (Fig. 5E) 2-segmented; first segment with 14 pilose setae (possibly 15 with 1 seta broken off in specimen figured); second segment bearing 1 subapical seta and 12 setae + 1 aesthete (2 posterior setae sharing common base) at tip. Second antenna (Fig. 5F) similar to that of *A. tandani.* Postantennal process absent.

Mouth tube similar to that of congener, but measuring 226 × 167 μm. Mandible (Fig. 6A) 4-segmented with suture separating third and fourth segments slightly more distinct than in congener. First maxilla (Fig. 6B) with few pinnae on setae, and setiform tip of dentiform process naked. Second maxilla (Fig. 6C) with rows of spinules on both calamus and canna. Maxilliped (Fig. 6D) with stout corpus; subchela (Fig. 6E) not as slender as in congener, and bearing 1 seta and 1 minute digitiform element in small pit.

Leg 1 (Fig. 6F) similar to that of congener except tip of exopod with 3 spines and 3 setae (4 spines and 1 seta in congener); 2 short rows of spinules at bases of outermost and middle spine. Tip of exopod of leg 2 (Fig. 6G) with 2 spines and 6 pinnate setae. Legs 3 and 4 very similar to those of preceding species (see Fig. 3F); in former, lobe bearing 3 setae and few setules; in latter, lobe with 1 pinnate seta and at least 1 spine, possibly 2. Leg 5 (Fig. 5C) represented by 1 naked seta lateral to egg sac attachment area.

Etymology.—The specific name *cordata* is a Latin adjective meaning heart-shaped, alluding to the shape of the genital complex.

Remarks.—*Arrama cordata,* new species, is the first species of parasitic copepod reported from *Paraplotosus.* The host is an undescribed species of this genus.

This parasitic species is the second one known in the new genus, which is reported only from Australian plotosids. It can easily be distinguished from the type species, *A. tandani,* by the heart-shaped genital complex and several other characters (Table 2).

Discussion

Several morphologic characters help to distinguish *Arrama* from confamilial genera. These characters represent degeneration (i.e., reduction in number of setae, or loss of a morphologic structure; both are considered apomorphic compared to an appropriate outgroup such as *Dissonus*), a relatively unmodified character (plesiomorphic feature), or unusual characters previously described for only a few caligid genera.

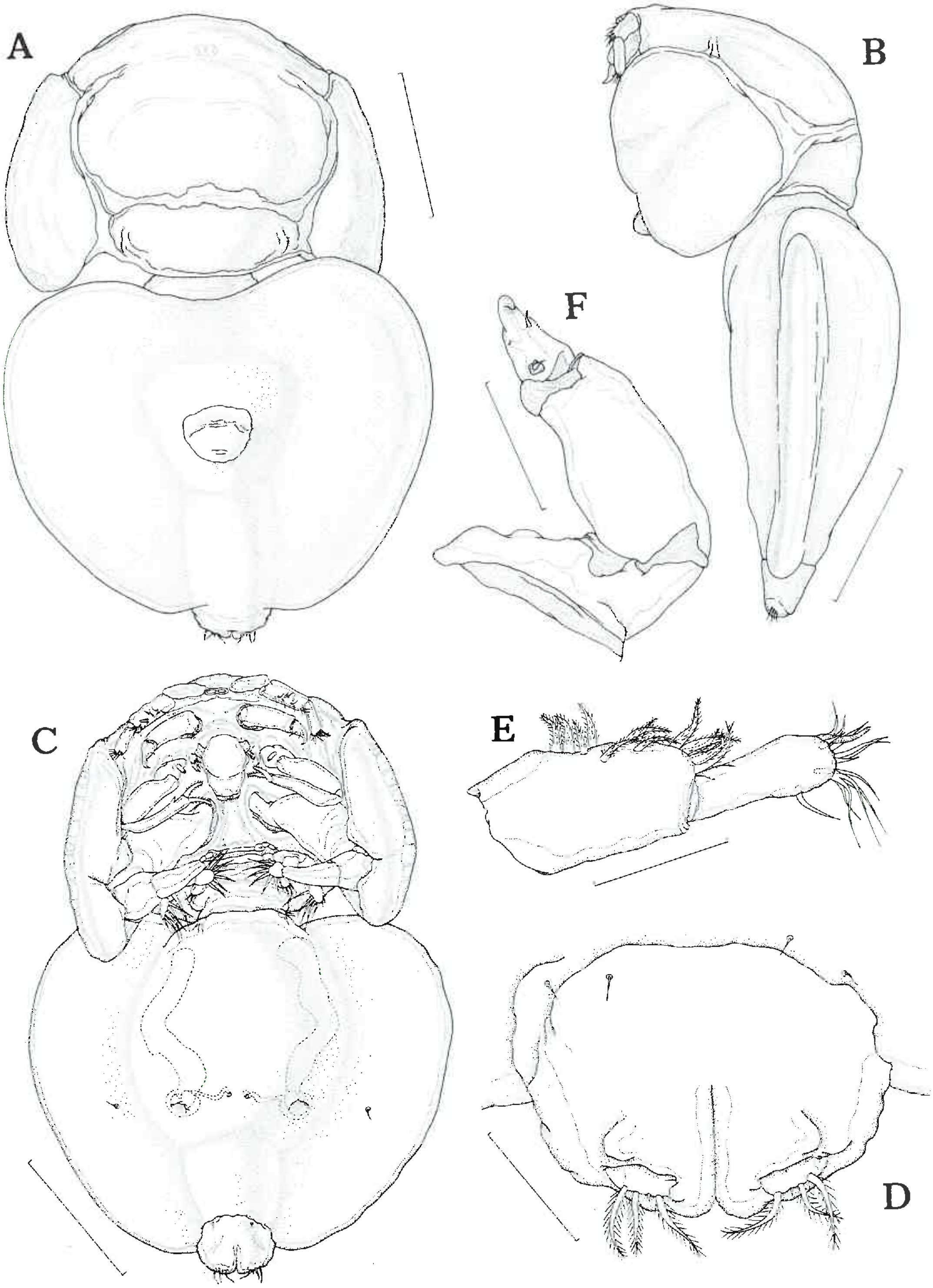

Fig. 5. *Arrama cordata*, new species, female: A, habitus, dorsal; B, habitus, lateral; C, habitus, ventral; D, anal segment and caudal rami, ventral; E, first antenna, ventral; F, second antenna, ventral. Scale: 0.5 mm in A–C; 0.1 mm in D–F.

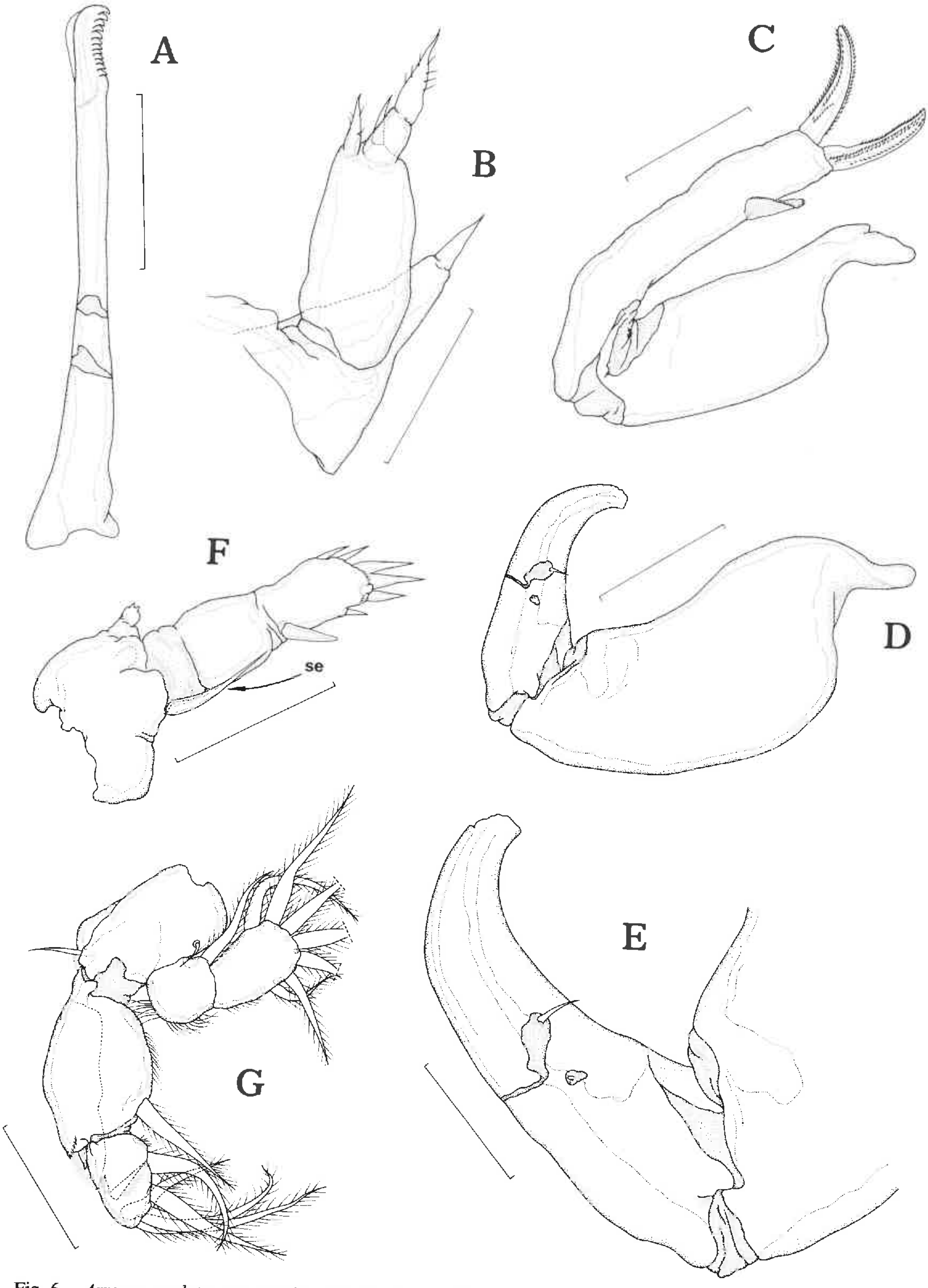

Fig. 6. *Arrama cordata,* new species, female: A, mandible, ventral; B, first maxilla, anterior; C, first maxilla, dorsal; D, maxilliped, ventral; E, maxilliped claw, ventral; F, leg 1, ventral; G, leg 2, ventral. Scale: 0.05 mm in A, B, F; 0.1 mm in C, E, G; 0.2 mm in D. Symbol: se = seta.

Table 2. Comparison of selected morphologic characters of two new species of *Arrama*, new genus. Roman numerals indicate spines and Arabic numerals represent setae.

Characters	*A. tandani*, new species	*A. cordata*, new species
Cephalothorax length/width ratio	0.53:1	0.64:1
Shape of genital complex	subrectangular	heart-shaped
Setae of caudal ramus	4 similar-sized setae	3 similar-sized setae and 1 minute seta
Spinules of canna (MX2)	arranged in patches	arranged in rows
Terminal exopodal segment of leg 1	V + 1	IV + 3
Rows of spinules at base of terminal exopodal spines of leg 1	absent	present
Armature of terminal exopodal segment of leg 2	II,5	II,6

A reduction in the number of setae occurs on the caudal ramus. Both species of the new genus bear only four setae on the caudal ramus, a characteristic shared only with one other caligid genus, *Belizia* Cressey, 1990. Although four genera (i.e., *Anuretes, Kabataella, Mappates,* and *Pseudanuretes*) have five caudal setae, the majority of caligid genera possess six, which most likely represents the plesiomorphic condition in the entire order Siphonostomatoida. The new genus also has one of the smallest number of setae on the first segment of the first antenna, with only 14 or 15 setae. *Abasia* is similar with 15–19, but the predominant condition appears to be 27.

The exopodal armature of leg 1 is also reduced in number in *Arrama*. The outer proximal exopodal spine, which is slightly displaced distally, is present and represents the outer distal spine of the first exopodal segment as in other caligid genera. However, the terminal exopodal segment shows a reduced number of elements (setae/spines). Typically, in relatively unmodified siphonostomes such as *Dirivultus* Humes and Dojiri, 1980, the terminal exopodal segment of leg 1 exhibits the armature formula III, 4 (three spines and four setae) (Humes and Dojiri, 1980: 146, fig. 2f). This armature is also found in the majority of caligids in which there are three clawlike spines at the tip, one pinnate seta on the inner distal corner of the segment, and three large pinnate setae on the inner margin (Dojiri, 1979: 254, fig. 2c, e). *Arrama cordata* bears only six elements (three spines and three setae); one seta is missing from the plesiomorphic condition of seven. The armature is further reduced to five (four spines and one seta) in *A. tandani*. This reduction in the leg 1 armature is not unique to this genus. Other caligids have exopodal armature reduced to six (i.e., *Abasia pseudorostris* Wilson, 1908), five (i.e., *Abasia tripartita* [Shiino, 1955], *Caligus afurcatus* Wilson, 1913, and *C. alaihi* Lewis, 1968), and four (i.e., *Apogonia stocki* Cressey and Cressey, 1990, *Caligus ariicolus* Wilson, 1928, *C. bocki* Heegaard, 1943, *C. enormis* Wilson, 1913, *C. epinepheli* Yamaguti, 1936, *C. fugu* Yamaguti and Yamasu, 1959, *C. haemulonis* Krøyer, 1863, *C. lagocephali* Pillai, 1961, *C. microdontus* Heegaard, 1964, *C. mirabilis* Leigh-Sharpe, 1934, *C. paxillifer* Yamaguti, 1954, *C. productus* Dana, 1952, *C. sciaenae* Gnanamuthu, 1947, and *Kabataella indica* Prabha and Pillai, 1983). In *Caligus* and *Pseudanuretes*, a reduction in the size of the three pinnate setae on the inner margin of the terminal exopodal segment has occurred. Since the missing elements in the leg 1 armature of *Apogonia, Caligus,* and *Kabataella* also belong to this pinnate setal group, the missing setae in the two species of *Arrama* are most likely the inner pinnate setae. However, a conclusion on the homology of the spines and setae of this appendage is postponed until a developmental study is conducted on *Arrama*.

Although *Arrama* exhibits many characters that are considered apomorphic (e.g., the shape of the cephalothorax, the shape of the genital complex, the reduced number of setae discussed above, and the loss of the ventral apron of leg 3 discussed below), one feature stands out as a plesiomorphic character. This is the first maxilla, which consists of two parts, representing a biramous condition. Lewis (1969) suggested that the sympod of an originally biramous first maxilla may have been suppressed, resulting in a separation of the dentiform structure (one ramus) and a setiferous lobe (second ramus). In most caligids, the dentiform structure is a curved triangular process, somewhat removed from a setiferous papilla. However, in genera such as *Abasia, Dartevellia,* and *Arrama,* the setiferous papilla is a distinct lobe bearing three setae. The dentiform process, a remnant of a setiferous ramus, in *Arrama* is tipped with a pinnate setiform element. These two structures represent an originally biramous appendage as suggested by Lewis (1969).

Two very interesting, but little known, structures are found in the two new species of *Arrama*: the oval pits in the center of the anterior margin of the cephalothorax and the truncate process at the tip of the exopod of leg 1. The oval pits, called the "median sucker" by Wilson (1905), are most likely homologous with those reported for species of *Caligus, Lepeophtheirus,* and *Abasia.* Scanning electron micrographs have been taken of these organs, which consist of an area of numerous closely packed microvilli. It has been suggested that this organ may have a chemosensory function to aid the parasite in host location (Kabata, 1981). Unfortunately, the oval pits of the two species of *Arrama* were not examined for microvilli before deposition in the Western Australian Museum.

The homology and function of the truncate process located among the terminal armature of the leg 1 exopod is unknown. The truncate process is found in both new species of *Arrama.* As such, it does not appear to be a broken spine, but may be homologous with the hyaline balloonlike process described in a similar location in *Paralebion, Parapetalus, Synestius,* and *Tuxophorus* by Dojiri (1983) and the minute papilla figured in *Alebion, Caligodes, Caritus, Gloiopotes, Mappates,* and *Midias* by Dojiri (1983), in *Lepeophtheirus* by Dojiri (1979), and in *Trebius* by Deets and Dojiri (1989). The hyaline process and papilla have been observed to be associated with a duct (?) which runs the length of the terminal exopodal segment of leg 1 (Dojiri, 1983: 631, fig. 107c). Unfortunately, the duct could not be traced further to find its origin. Further studies may help elucidate the homology and function of this enigmatic structure.

The most distinguishing features of the new genus are the folding of the cephalothorax and the absence of the ventral apron of leg 3. Apparently, the predilection of the two species of *Arrama* for the gill filaments has helped to determine the morphology of the cephalothorax. Because of the significance of these morphologic adaptations, they are discussed in more detail below.

Many caligid genera exhibit a dorsoventrally flat, suction-cuplike dorsal shield. These genera, as expected, live on the external body surfaces, buccal cavity walls, and branchial cavity walls of their hosts. These attachment sites are all smooth surfaces that provide excellent substrates for the suction-cuplike cephalothorax to produce a tight seal. The shape and function of the cephalothorax appears to have evolved in response to the caligids' predilection for this type of attachment surface. Smooth surfaces, which are the predominant substrate among members of the Caligidae, may represent the plesiomorphic attachment sites.

In members of the Caligidae, except *Arrama,* the posterior margin of the cephalothorax is completely closed off by the enlargement of the intercoxal plate and sympod of leg 3 to form a broad structure referred to as the ventral apron, thus improving its suction capability (Kabata, 1979). Transparent marginal membranes rim the anterior margins of the frontal plate and lateral margins of the cephalothorax and help seal off the concavity beneath the dorsal shield (Kabata, 1979).

Species of some caligid genera (i.e., *Abasia, Hermilius, Kabataella* Prabha and Pillai, 1983, and the new genus *Arrama*), however, have become adapted to a more sedentary existence on the gill filaments and in the nasal cavities of their hosts. The cephalothorax in *Abasia, Hermilius,* and *Arrama* is folded longitudinally so that the lateral areas are bent ventrally. This alteration of the cephalothorax results in a median longitudinal groove which envelopes laterally the gill filament of the host. This morphological similarity, however, may be homoplasious, a result of convergent evolution. The secondary invasion of the branchial cavity from the external body surface of their hosts most likely placed similar selective pressures on the three genera. Each responded in a similar manner to the specialized habitat. Regardless of the possible homoplasy, the shape of the cephalothoraces of these genera and the corrugated surface of the gill filament does not suit a suction-cup-like attachment. Presumably, the ventral aprons in both *Abasia* and *Hermilius*, although present, have lost their function. The ventral apron in *Kabataella*, which lives in the nasal cavities of its host, is reduced in size, and most likely has lost its function also. Apparently, the most derived state is exhibited by *Arrama*, which lacks the ventral apron. It is the only genus within the Caligidae in which the apron is absent.

Acknowledgements

We thank Janet R. Gomon, Smithsonian Institution, for providing us with the specimens of the new taxa, and Dr. Alan Williams, Murdoch University, Western Australia, for sending us an additional specimen of *Arrama tandani*. The first author (MD) gratefully acknowledges the Smithsonian Institution for a Short-Term Visitor's Appointment to the National Museum of Natural History during which this study was conducted. Special thanks are extended to Deborah Horn-Bostel for her explanation on the techniques of stippling the whole-mount views of the copepods, to Gregory B. Deets for his valuable comments on the discussion section, to Dr. Ju-Shey Ho (California State University, Long Beach) and Dr. Z. Kabata (Pacific Biological Station, Nanaimo) for critically reviewing various drafts of this manuscript, and to Paula Rothman and Patricia Nutter, Smithsonian Institution, for their help during this study.

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Received: 4 February 1991.
Accepted: 26 April 1991.

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