Zootaxa 4174 (1): 274–290
http://www.mapress.com/j/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

http://doi.org/10.11646/zootaxa.4174.1.19
http://zoobank.org/urn:lsid:zoobank.org:pub:05CD698B-A523-42C6-96F0-7D97156BA447

Four anchimolgid copepods (Poecilostomatoida: Anchimolgidae) associated with the scleractinian coral *Pavona explanulata* (Lamarck, 1816) in Taiwan

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Abstract

Several species of copepods are known to live in association with the coral genus *Pavona* Lamarck, 1801. In this paper, four poecilostomatoid copepods, including one new genus, two new species, and one species new to Taiwan, are described, *i.e. Alienigena triangula* **gen. et sp. nov.**, *Odontomolgus cognatus* **sp. nov.**, *O. mucosus* Kim, 2006 and *Sociellus subgeminus* **sp. nov.** All species were found together in a single washing of the scleractinian coral *Pavona explanulata* (Lamarck, 1816), collected from shallow water reefs in northern Taiwan. All of them appear closely related to the genera of the *Odontomolgus*-group in the family Anchimolgidae due to the possession of a large process on the convex margin of the mandible. The present report brings the number of copepod species that live in symbiosis with members of the coral genus *Pavona* to 17.

Key words: Poecilostomatoida, symbiotic copepods, scleractinian corals, Taiwan

Introduction

Among the various groups of marine macroinvertebrates, cnidarians have more copepod associates than any other group. In the Indo-Pacific scleractinian corals in particular are one of the most important host groups for symbiotic copepods. They sustain a high diversity of copepods with various resources including microhabitats and foods, and one host coral may frequently support more than one species of copepod (Humes 1985a; 1994a; Cheng & Dai 2010). The coral genus, *Pavona* Lamarck, 1801 is an agariciid coral which is widely distributed throughout the Indo-Pacific (Veron 1986). Between 1962 and 2007, at least ten species of copepods belonging to four genera, *Anchimolgus* Humes & Stock, 1972 (one species), *Odontomolgus* Humes & Stock, 1972 (four species), *Paramolgus* Humes & Stock, 1972 (two species), and *Xarifia* Humes, 1960 (three species), have been reported from members of the genus *Pavona* (Table 1). Recently, Cheng *et al*. (2011) described four new species of xarifiid copepods (*Xarifia capillata*, *Xarifia parva*, *Xarifia pavonae* and *Xarifia taiwanensis*) that were found to be associated with the scleractinian coral, *Pavona explanulata* (Lamarck, 1816) collected from the shallow water reefs off Yenliao in northern Taiwan. Up to the present, a total of 14 species of symbiotic copepods have been recorded living in various degrees of association with *Pavona* corals (Table 1).

In this paper, we add four poecilostomatoid copepods including one new genus, two new species, and one new record from off Taiwan to the list of symbionts of *P. explanulata*. All four species are members of the Anchimolgidae, one of the largest families in the Poecilostomatoida. The family currently comprises approximately 135 species which mainly utilize scleractinian corals as hosts (Boxshall & Halsey 2004; Walter & Boxshall 2014).

Materials and methods

A fragment (approximately 10 cm long and 5 cm wide) from one leaf coral colony of *Pavona explanulata* was

 Accepted by R. Huys: 10 Mar. 2015; published: 11 Oct. 2016

collected by SCUBA diving. The sample was placed in a plastic bag and brought back to the laboratory for examination of copepod parasites. In the lab, the coral together with the seawater was emptied into a bucket to which 95% ethyl alcohol was gradually added to make it approximately a 5% solution, and kept for at least six hours, allowing for the copepods to be expelled from the coral. Then, the water was poured through a fine net (mesh size approximately 100 μm) and the copepods were picked from the sediment using a dissecting microscope. All copepod specimens were subsequently preserved in 70% ethanol. For morphological studies, specimens were cleared in 85% lactic acid for one hour and dissected on a wooden slide using a dissecting microscope (Humes & Gooding 1964). The dissected body parts and appendages were examined under a compound microscope with a series of objectives up to 1000×. All drawings were made with the aid of a drawing tube.

Results

Order Poecilostomatoida Thorell, 1859

Family Anchimolgidae Humes & Boxshall, 1996

Alienigena gen. nov.

Diagnosis. Body elongate and slender. Segmentation of body indistinct. Cephalosome triangular, with prominent posterolateral expansions in dorsal view. Urosome 4-segmented in female and 5-segmented in male. Caudal ramus with six setae. Antennule 7-segmented. Antenna 4-segmented; third segment with three setae; fourth segment tipped with one well developed terminal claw. Mandible weakly bilobate along inner margin and with large process on convex side. Maxillule with four setae. Maxilla 2-segmented; second segment terminating in distal lash. Maxilliped 3-segmented in female; 4-segmented in male. Legs 1–4 biramous with 3-segmented exopods and 1-(leg 4) or 2-segmented endopods (legs 1–3). Leg 5 reduced, represented by three setae. Leg 6 represented by two setae. No sexual dimorphism in legs 1–4.

Type species. *Alienigena triangula* **gen. et sp. nov.** (by original designation).

Etymology. The generic name is derived from the Latin "*Alienigena*", meaning stranger. It refers to the most remarkable and unique features such as the body shape and armature of legs 1–4 in the type species. Gender feminine.

Alienigena triangula gen. et sp. nov.

(Figs 1–3)

Type host. *Pavona explanulata* (Lamarck, 1816) (family Agariciidae).

Location in the host. Inside polyps.

Type locality. Yenliao Bay, northern Taiwan.

Etymology. The specific name *triangula* is an adjective based on the Latin "*triangulus*", meaning triangular, and refers to the triangular form of cephalosome of the new species.

Type material. Nine females and five males obtained from washings of a coral colony collected at five m depth on 12 August 2010. The female holotype (NTUIO-COPE 1), male allotype (NTUIO-COPE 2), and paratypes (NTUIO-COPE s3; five females and three males) are deposited in the Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

Description of female. Body (Fig. 1A–B) elongate. Body length of dissected specimen 0.88 mm (0.74–0.98 mm) and greatest width 0.13 mm (0.11–0.16 mm), based on five specimens. Segmentation of body distinct, but incomplete. Cephalosome (Fig. 1A–B) triangular, with prominent posterolateral expansions in dorsal view and fused to first pedigerous somite (leg 1). Urosome (Fig. 1C) 4-segmented. Genital double-somite (Fig. 1C) fused to fifth pedigerous somite, with genital apertures located dorsally. Abdomen (Fig. 1C) 3-segmented, first somite largest, third (anal) somite with prominent rounded anal operculum. Caudal ramus (Fig. 1C– D) small, armed with six naked setae. Surface of body without setules (Fig. 1 A, B). Egg sacs not observed.

TABLE 1. Poecilostomatoid copepods associated with scleractinian host corals of the genus *Pavona*.

Copepod symbiont	Host coral	Distribution	Reference
Family Anchimolgidae			
Alienigena triangula **gen. et sp. nov.**	*Pavona explanulata* (Lamarck, 1816)	Taiwan	this study
Anchimolgus gracilipes Kim, 2007	*Pavona danai* Milne Edwards & Haime, 1860	Moluccas	Kim (2007)
Odontomolgus actinophorus (Humes & Frost, 1964)	*Pavona angulata* Klunzinger [1]	Madagascar	Humes & Frost (1964)
	Pavona cactus (Forsskål, 1775)	Madagascar	Humes & Frost (1964)
	Pavona danai Milne Edwards & Haime, 1860 and/or *P. angularis* (Klunzinger, 1879)	Madagascar	Humes & Ho (1968)
	Pavona? *venusta* (Dana, 1846) [2]	Madagascar	Humes & Ho (1968)
Odontomolgus cognatus **sp. nov.**	*Pavona explanulata* (Lamarck, 1816)	Taiwan	this study
Odontomolgus mucosus Kim, 2006	*Pavona explanulata* (Lamarck, 1816)	Taiwan	this study
Odontomolgus pavonus Kim, 2007	*Pavona danai* Milne Edwards & Haime, 1860	Moluccas	Kim (2007)
Odontomolgus rhadinus (Humes & Ho, 1967)	*Pavona* sp.	Madagascar	Hunes & Stock (1973)
Paramolgus pavonae Humes, 1994b	*Pavona cactus* (Forsskål, 1775) [3]	New Caledonia	Humes (1994b)
Paramolgus setellus Humes, 1992	*Pavona cactus* (Forsskål, 1775) [3]	New Caledonia	Humes (1994b)
Sociellus subgeminus **sp. nov.**	*Pavona explanulata* (Lamarck, 1816)	Taiwan	this study
Family Xarifiidae			
Xarifia diminuta Humes & Ho, 1967	*Pavona* sp.	Madagascar	Humes (1985b)
Xarifia finitima Humes, 1985	*Pavona cactus* (Forsskål, 1775)	New Caledonia	Humes (1985b)
	Pavona varians Verrill, 1864	Mauritius	Humes (1985b)
Xarifia longipes Humes, 1962	*Pavona angulata* Klunzinger [1]	Madagascar	Humes (1962)
Xarifia capilata Cheng, Ho & Dai, 2011	*Pavona explanulata* (Lamarck, 1816)	Taiwan	Cheng *et al.* (2011)
Xarifia parva Cheng, Ho & Dai, 2011	*Pavona explanulata* (Lamarck, 1816)	Taiwan	Cheng *et al.* (2011)
Xarifia pavonae Cheng, Ho & Dai, 2011	*Pavona explanulata* (Lamarck, 1816)	Taiwan	Cheng *et al.* (2011)
Xarifia taiwanensis Cheng, Ho & Dai, 2011	*Pavona explanulata* (Lamarck, 1816)	Taiwan	Cheng *et al.* (2011)

[1] : This species is not listed in the World Register of Marine Species (www.marinespecies.org/).

[2] : *Pavona venusta* (Dana, 1846) is currently regarded as a junior synonym of *Pavona cactus* (Forsskål, 1775).

[3] : as *Pavona praetorta* (Dana, 1846).

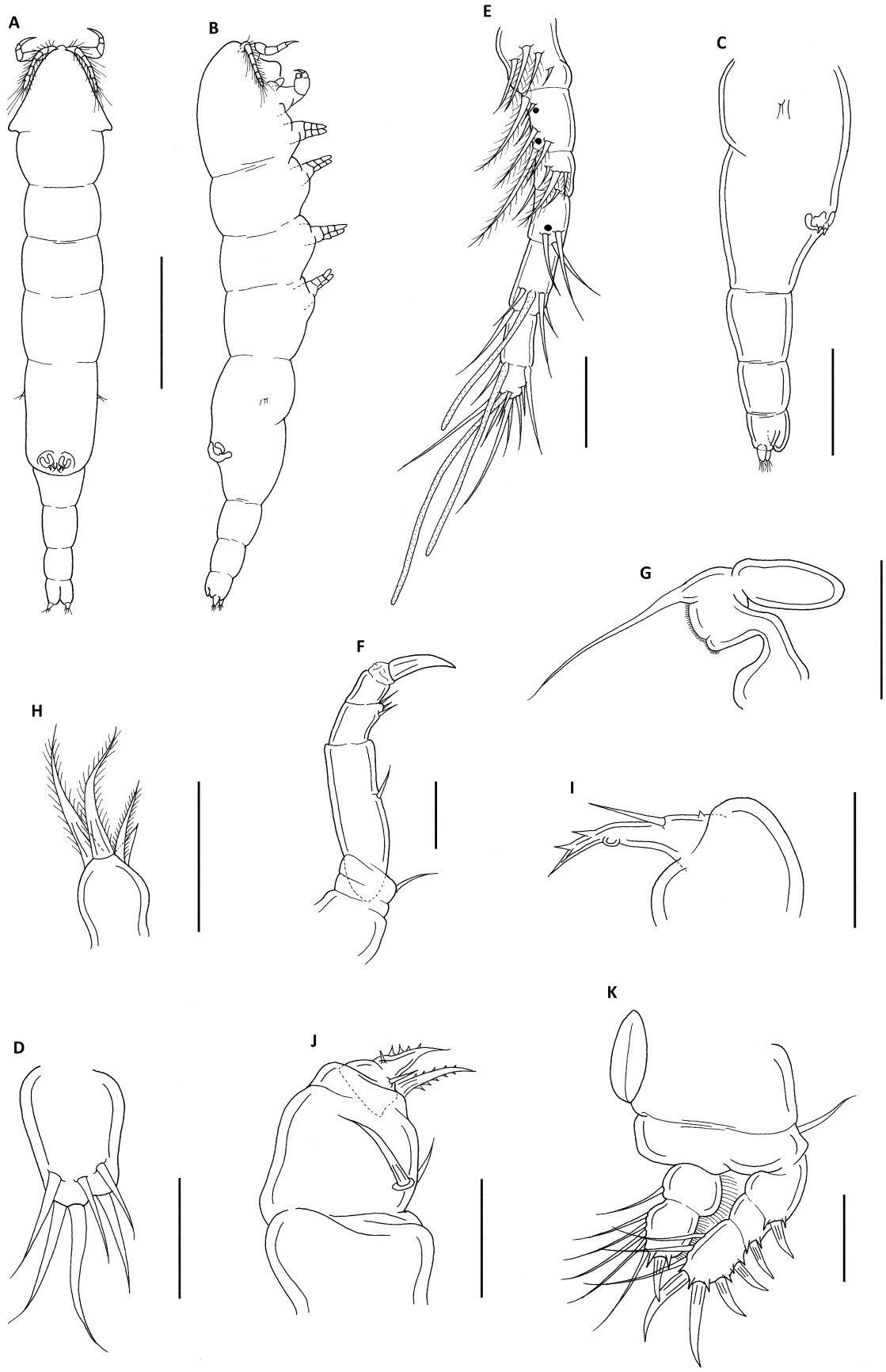

FIGURE 1. *Alienigena triangula* **gen. et sp. nov.** (female). A, habitus, dorsal; B, habitus, lateral; C, urosome; D, caudal ramus; E, antennule; F, antenna; G, mandible; H, maxillule; I, maxilla; J, maxilliped; K, leg 1. Scale bars: A–B = 0.2 mm; C = 0.1 mm; D–K = 0.02 mm.

Antennule (Fig. 1E) 7-segmented; armature: 4, 6, 5, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, 7 + 1 aesthetasc. Antenna (Fig. 1F) 4-segmented; measurements (length × width) of segments 16 × 25 μm, 50 × 15 μm, 14 × 12 μm, 13 × 9 μm, respectively; armature: 1, 1, 3, and 1 terminal claw (63 μm long). Mandible (Fig. 1G) with prominent proximal notch; inner margin weakly bilobate with relatively small spinules; convex side with a large process and slender terminal lash. Maxillule (Fig. 1H) small, tipped with one short, smooth subapical seta and three plumose apical setae. Maxilla (Fig. 1I) 2-segmented, first segment stout and unarmed; second segment small, with distal lash bearing two spinules, one nodular tubercle halfway along concave margin of lash, one spiniform anterior seta, and one small proximal spinule. Maxilliped (Fig. 1J) 3-segmented, syncoxa largest, unarmed; basis with two unequal setae (larger one about 16 μm) along medial margin; endopod small, tipped with one larger pinnate process, one small subapical seta and one bipinnate spine.

Legs 1–4 (Figs. 1K, 2A–C) with 3-segmented exopods and 2-segmented endopods (except for leg 4 endopod being 1-segmented). Armature formula of spines (in Roman numerals) and setae (in Arabic numerals) as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-0	1-0	I-0; I-0; IV+3	0-1; I+5
Leg 2	0-0	1-0	I-0; I-0; IV+3	0-1; III+2
Leg 3	0-0	1-0	I-0; I-0; IV	0-0; I
Leg 4	0-0	1-0	I-0; I-0; III	I

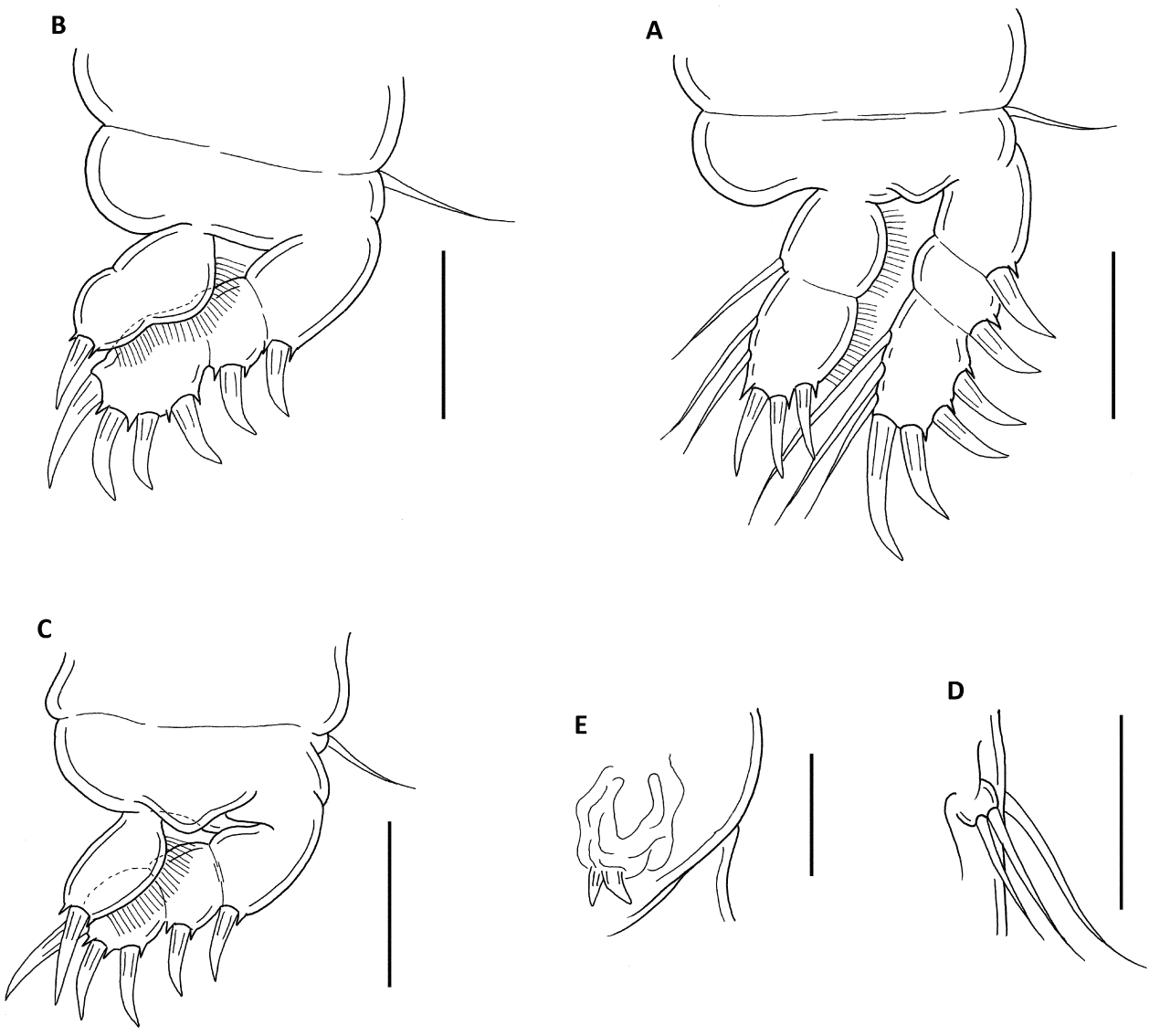

FIGURE 2. *Alienigena triangula* **gen. et sp. nov.** (female). A, leg 2; B, leg 3; C, leg 4; D, leg 5; E, leg 6. Scale bars: A–E = 0.02 mm.

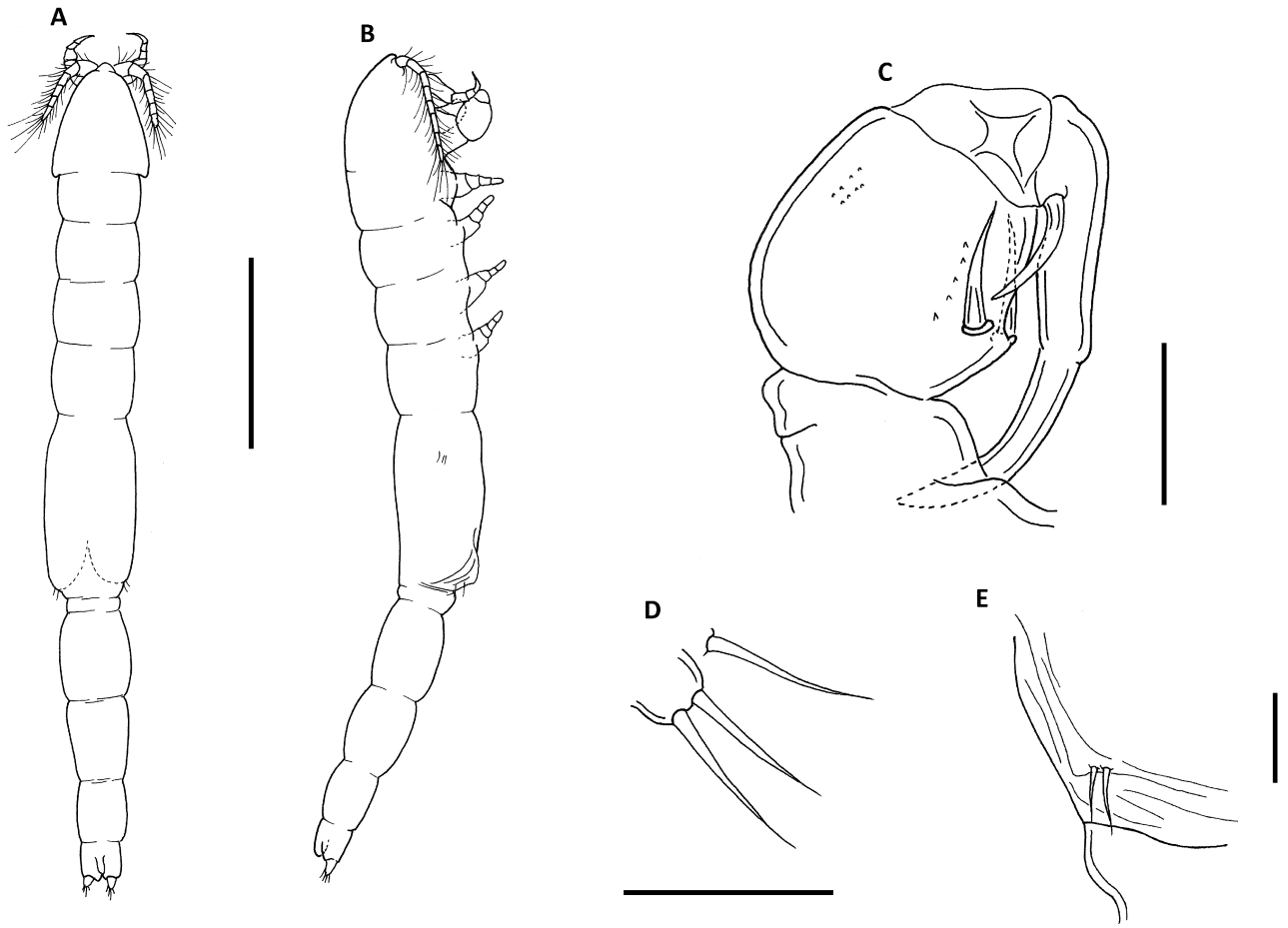

FIGURE 3. *Alienigena triangula* **gen. et sp. nov.** (male). A, habitus, dorsal; B, habitus, lateral; C, maxilliped; D, leg 5; E, leg 6. Scale bars: A–B = 0.2 mm; C–E = 0.02 mm.

Leg 5 (Fig. 2D) reduced to two terminal setae and one adjacent dorsal (= outer basal) seta.

Leg 6 (Fig. 1E) represented by two small setae arising from operculum closing off genital aperture.

Description of male. Body (Fig. 3A–B) as in female but much more slender. Surface of body smooth. Body length of dissected specimen 0.87 mm (0.80–0.90 mm) and greatest width 0.10 mm (0.09-0.12 mm), based on five specimens. Urosome 5-segmented. Abdomen (Fig. 3A–B) 4-segmented, anal somite with rounded operculum as in female. Caudal ramus as in female, but much smaller.

Antennule, antenna, mandible, maxillule, and maxilla as in female except for antennule with three additional long aesthetascs (positions indicated by dots in Fig. 1E). Maxilliped (Fig. 3C) consisting of three segments and terminal claw; first (syncoxa) and third (endopod) segment unarmed; second segment (basis) broadest, with two equal setae along medial margin and longitudinal rows of small spinules as indicated in Fig, 3C; terminal claw with one seta near the base.

Legs 1–4 as in female, without sexual dimorphism. Leg 5 (Fig. 3A, B, D) a small free segment with two setae and one adjacent dorsal (= outer basal) seta as in female.

Leg 6 (Fig. 3B, E) represented by two small setae on posteroventral operculum on genital somite.

Remarks. Members of the family Anchimolgidae are characterized by the derived form of the mandible, exhibiting a bilobed inner margin, and by the possession of a single terminal claw on the distal segment of the antenna (Humes & Boxshall 1996; Boxshall & Halsey 2004). Based on these two characters, *Alienigena triangula* **gen. et sp. nov.** is here placed in the Anchimolgidae. Humes & Boxshall (1996) classified the 24 anchimolgid genera known at that time in five distinct generic groups characterized by the segmentation of the antenna and by the form and ornamentation of the armature of the maxilla, *i.e. Amarda*-group, *Anchimolgus*-group, *Andrianellus*-group, *Odontomolgus*-group and *Schedomolgus*-group. The *Odontomolgus*-group currently consists of four genera, *Allopodion* Humes, 1978, *Haplomolgus* Humes & Ho, 1968, *Odontomolgus*, and *Kawanolus* Humes, 1978, all of

which have a large process along the convex margin of the mandible (Boxshall & Halsey 2004). The presence of a similarly large process along the convex margin of the mandible in *Alienigena* **gen. nov.** indicates a close relationship to the genera of the *Odontomolgus*-group. However, the elongate body shape of *A. triangula* **gen. et sp. nov.** is radically divergent from that in the other genera of this generic grouping and the armature formulae of legs 1–4 also seems to be unique among the currently known genera of the Anchimogidae. Hence, a new genus is proposed herein to accommodate this new form.

Genus *Odontomolgus* Humes & Stock, 1972

Odontomolgus cognatus sp. nov.

(Figs 4–6)

Type host. *Pavona explanulata* (Lamarck, 1816) (family Agariciidae).

Location in host. Surface of colony.

Type locality. Yenliao Bay, Taiwan.

Etymology. The specific name is derived from the Latin "*cognatus*", meaning relative, and refers to the close relationship of this new species to its congener, *Odontomolgus actinophorus* (Humes & Frost, 1964).

Type material. Three females and two males obtained from washings of a coral colony collected at five m depth on 12 August 2010. The female holotype (NTUIO-COPE 3), male allotype (NTUIO-COPE 4), and paratypes (NTUIO-COPE s5; one female and one male) are deposited in the Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

Description of female. Body (Fig. 4A–B) relatively broad. Body length of dissected specimen 1.70 mm (1.69–1.72 mm) and greatest width 0.62 mm (0.61–0.62 mm), based on three specimens. Cephalosome partially delimited from first pedigerous somite by dorsal suture line (Fig. 4A–B). Urosome (Fig. 4 A–C) 5-segmented. Genital double-somite (Fig. 4C) with transverse suture dorsally but fused laterally and ventrally; anterior half with lateral expansions in dorsal view. Genital apertures (Fig. 4A–C) located dorsally in first third of double-somite. Three postgenital somites unornamented and equal in length. Caudal ramus (Fig. 4C–D) 185 × 55μm, with six naked setae. Surface of body with small setules (Fig. 4A). Egg sacs not observed.

Antennule (Fig. 4E) 7-segmented; armature: 4, 13, 6, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, 7 + 1 aesthetasc; all setae naked. Antenna (Fig. 4F) 4-segmented; armature: 1, 1, 3, I; measurements (length × width) of segments 78 × 63 μm, 156 × 63 μm, 63 × 34 μm, 47 × 25 μm, respectively; terminal claw 63 μm long and slightly curved. Mandible (Fig. 4G) with prominent proximal notch; inner margin distinctly bilobate; convex side with a digitate process; terminal lash slender, with spinules on both sides. Maxillule (Fig. 4H) armed with three plumose apical setae. Maxilla (Fig. 4I) 2-segmented, first segment unarmed; second segment terminating in distal lash bearing setules; with one nodular tubercle near base of lash, one inner seta transformed to globular tubercle covered with minute setules, one spiniform anterior seta, and one small proximal seta. Maxilliped (Fig. 4J) 3-segmented, syncoxa unarmed; basis with two unequal setae (larger one about 21μm) along medial margin; small endopodal segment with one relatively large spiniform process, one small subapical inner seta, and one bipinnate spine.

Legs 1–4 (Fig. 5A–D) with 3-segmented exopods and endopods (except for leg 4 endopod being 2-segmented). Armature formula of spines (in Roman numerals) and setae (in Arabic numerals) as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-0	I-0; I-1; IV+4	0-1; 0-1; I+5
Leg 2	0-1	1-0	I-0; I-1; IV+5	0-1; 0-2; III+3
Leg 3	0-1	1-0	I-0; I-1; IV+5	0-1; 0-2; III+2
Leg 4	0-1	1-0	I-0; I-1; IV+5	0-1; II

Leg 5 (Fig. 5E) 190 × 75 μm, consisting of an unornamented free segment bearing two unequal apical setae and a small adjacent dorsal (= outer basal) seta.

Leg 6 (Fig. 4C) represented by two small setae arising from operculum closing off genital aperture.

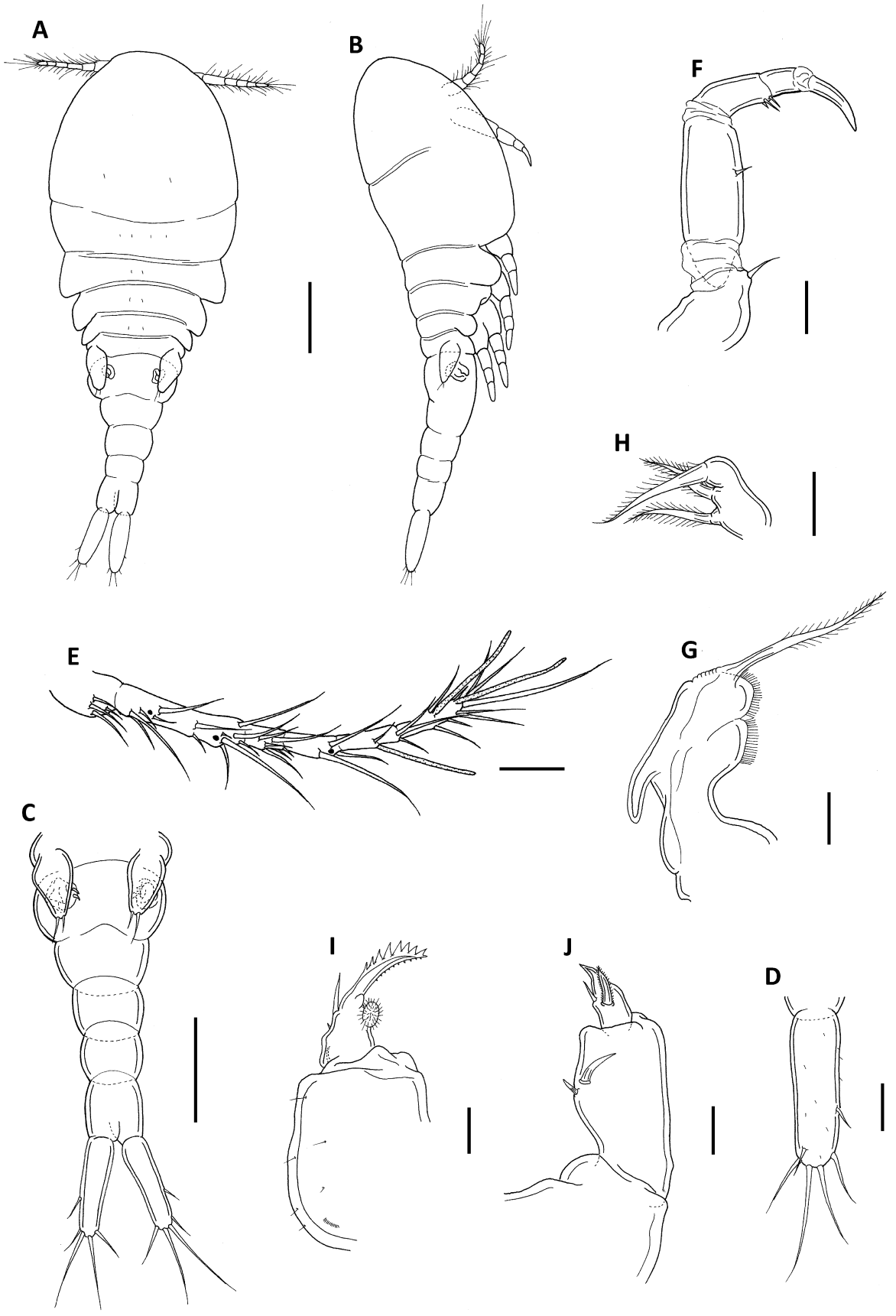

FIGURE 4. *Odontomolgus cognatus* **sp. nov.** (female). A, habitus, dorsal; B, habitus, lateral; C, urosome; D, caudal ramus; E, antennule; F, antenna; G, mandible; H, maxillule; I, maxilla; J, maxilliped. Scale bars: A–C = 0.2 mm; D–F = 0.05 mm; G–J = 0.02 mm.

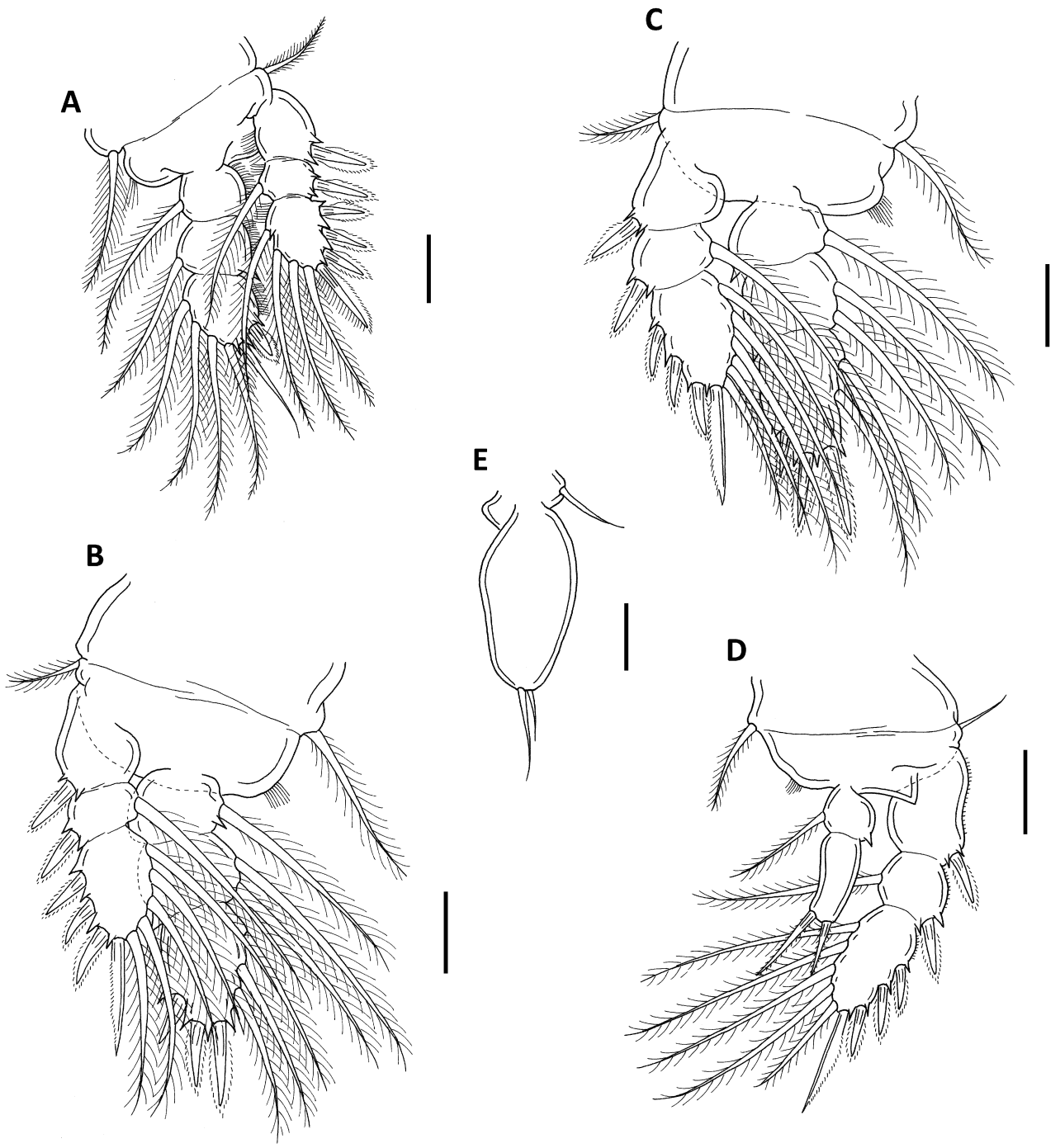

FIGURE 5. *Odontomolgus cognatus* **sp. nov.** (female). A, leg 1; B, leg 2; C, leg 3; D, leg 4; E, leg 5. Scale bars: A–E = 0.05 mm.

Description of male. Body (Fig 6A–B) resembling that of female. Body length 1.61 mm (1.54–1.68 mm) and greatest width 0.51 mm (0.48–0.54 mm), based on two specimens. Urosome (Fig. 6A) 6-segmented. Caudal ramus as in female.

Antennule, antenna, mandible, maxillule, and maxilla as in female, except for antennule with three additional long aesthetascs (positions indicated by dots in Fig. 4E) and antenna with additional spinules on medial surface of basis (Fig. 6B). Maxilliped (Fig. 6C) consisting of three segments and terminal claw; syncoxa broadest, unarmed; basis with two unequal inner setae and longitudinal rows of small spinules as figured; endopodal segment very short and unarmed; terminal claw evenly curved, with two unequal setae at its base.

Legs 1–4 as in female except for leg 1 (Fig. 6D); third endopodal segment of leg 1 armed with two spines and four setae instead of one spine and five setae in female.

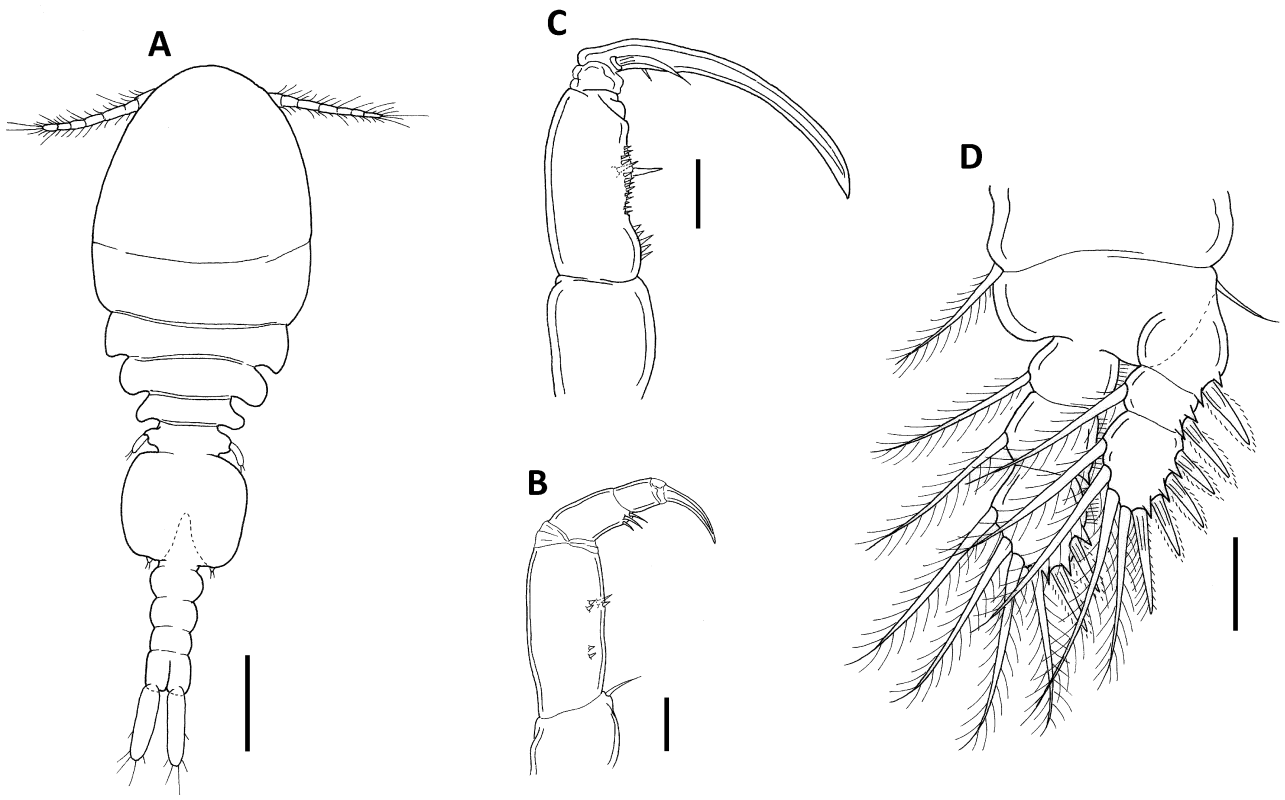

FIGURE 6. *Odontomolgus cognatus* **sp. nov.** (male). A, habitus, dorsal; B, antenna; C, maxilliped; D, leg 1. Scale bars: A = 0.2 mm; B–D = 0.05 mm.

Leg 5 (Fig. 6A) a small free segment with two setae and one adjacent dorsal (= outer basal) seta as in female.

Leg 6 (Fig. 6A) represented by two small setae on posteroventral operculum on genital somite.

Remarks. *Odontomolgus* is one of the most speciose genera in the Anchimolgidae, currently accommodating 17 valid species (Walter & Boxshall 2014). Kim (2006) pointed out that the transformation of the inner seta on the second segment of the maxilla into a hairy globule or a mucus-like structure is not a diagnostic feature of the genus *Odontomolgus* since it is only displayed by three other species so far: *O. actinophorus*, *O. mucosus* Kim, 2006 and *O. unioviger* Kim, 2006. *Odontomolgus cognatus* **sp. nov.** can be readily distinguished from these three congeners by the larger body size (1.70 mm) and the armature of the third exopodal segment of leg 4 being IV+5 instead of III+5. The remaining dissimilarities among these species are summarized in Table 2.

TABLE 2. Differences between *Odontomolgus actinophorus*, *O. cognatus*, *O. mucosus* (Taiwan), *O. mucosus* (Moluccas) and *O. unioviger*.

	O. actinophorus	*O. cognatus*	*O. mucosus* (Taiwan)	*O. mucosus* (Moluccas)	*O. unioviger*
Body size ♀ (mm)	1.42	1.70	1	0.91	0.82
Length × width of caudal ramus (μm)	139 × 40	185 × 55	87 × 25	96 × 22	67 × 32
Shape of the genital double-somite	rounded	rounded	rounded	rounded	quadrangular
Spinules on leg 5 exopod	present	absent	present	absent	present
Length × width of leg 5 exopod (μm)	141 × 67	190 × 75	65 × 13	76 × 13	58 × 17
Armature of maxillule	3 plumose setae	3 plumose setae	1 naked and 3 plumose setae	4 naked setae	1 naked and 3 plumose setae
Armature of third exopodal segment of leg 4	III+5	IV+5	III+5	III+5	III+5
Armature of caudal ramus	plumose setae	naked setae	plumose setae	plumose setae	plumose setae

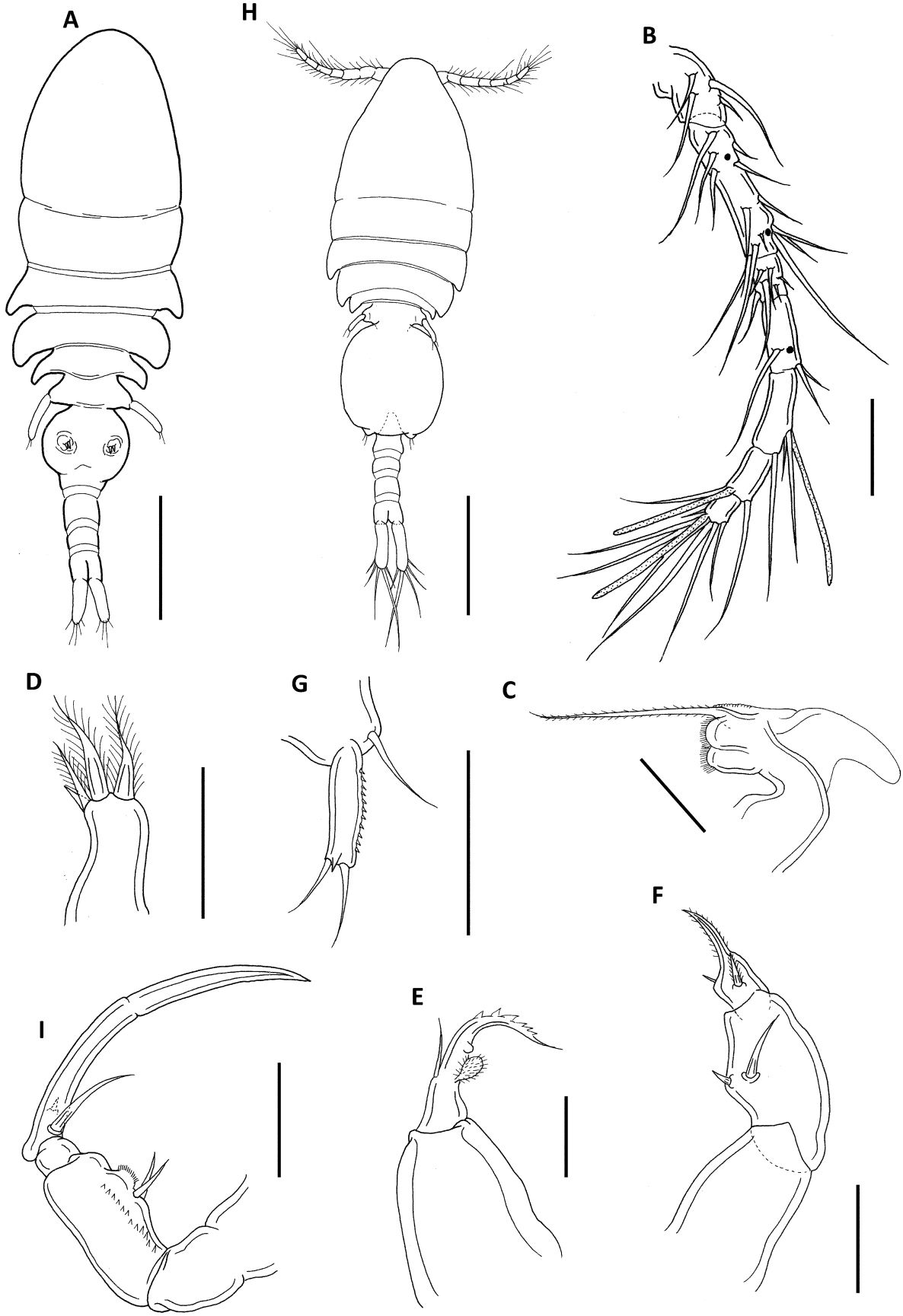

FIGURE 7. *Odontomolgus mucosus* Kim, 2006 (female: A–G; male: H–I). A, habitus, dorsal; B, antennule; C, mandible; D, maxillule; E, maxilla; F, maxilliped; G, leg 5; H, habitus, dorsal; I, male, maxilliped. Scale bars: A, H = 0.2 mm; B = 0.04 mm; C–F = 0.02 mm; G, I = 0.05 mm.

***Odontomolgus mucosus* Kim, 2006**
(Fig. 7)

New host. *Pavona explanulata* (Lamarck, 1816) (family Agariciidae).

Locality in host. Surface of colony.

Locality. Off Yenliao, Taiwan.

Material examined. Seven females and two males obtained from washings of a coral colony collected at five m depth on 12 August 2010.

Remarks. Kim (2006) recently described two new species, *O. mucosus* and *O. unioviger*, based on specimens associated with the scleractinian coral, *Gardineroseris planulata* (Dana, 1846) collected in the Moluccas. The differences between these species include (1) the shape of the genital double-somite of the female, (2) the size of the caudal ramus, and (3) the size of the free segment (exopod) of leg 5 in the female. The body form of the female and male specimens collected from the coral *P. explanulata* in Taiwanese coastal waters are similar to those of the two species collected from the Moluccas (Fig. 7A, H). A similar concordance can also be observed in the antennule (Fig. 7B), mandible (Fig. 7C), maxilla (Fig. 7E), and maxilliped (Fig. 7F). However, slight differences were noted between the Taiwanese and the Moluccan material, particularly in body size, the ornamentation of the maxillulary setae and leg 5 exopod, and in the dimensions of the caudal ramus and leg 5 (Table 2). Such minute dissimilarities probably reflect local variation in geographically separated populations rather than providing evidence for specific distinctiveness. Pending analysis of molecular sequence data the Taiwanese and Moluccan specimens are considered conspecific despite the different coral hosts they utilize.

Genus *Sociellus* Humes, 1992

***Sociellus subgeminus* sp. nov.**
(Figs 8–10)

Type host. *Pavona explanulata* (Lamarck, 1816) (family Agariciidae).

Location in host. Surface of colony.

Type locality. Yenliao Bay, northern Taiwan.

Etymology. The specific name "*subgeminus*" refers to the similarity between body shape of this new species and its congener, *Sociellus geminus* Kim, 2006.

Type material. Eighteen females and eight males obtained from washings of a coral colony collected at five m depth on 12 August 2010. The female holotype (NTUIO-COPE 7), male allotype (NTUIO-COPE 8), and paratypes (NTUIO-COPE s9; 15 females and five males) are deposited in the Institute of Oceanography, National Taiwan University, Taipei, Taiwan.

Description of female. Body (Fig. 8A–B) elongate and slender. Length 0.94 mm (0.92–0.96 mm) and greatest width 0.23 mm (0.19–0.24 mm), based on five specimens. Cephalosome delimited from first pedigerous somite by dorsal furrow. Cephalosome 273 × 233 μm, long than wide. Measurements (length × width) of first to fifth pedigerous somites 75 × 206 μm, 64 × 187 μm, 56 × 193 μm, 54 × 163 μm, and 50 × 150 μm, respectively. Urosome (Fig. 8C) 5-segmented. Genital double-somite in dorsal view 130 × 160 μm. Genital apertures located dorsally near middle of double-somite. Three postgenital somites 56 × 100 μm, 62 × 78 μm, and 50 × 68 μm, respectively. Anal operculum projecting posteriorly (Fig. 8B). Caudal ramus (Fig. 8D) 50 × 18μm, with six naked setae and several minute spinules. Surface of body with small setules (Fig. 8C). Egg sacs not observed.

Antennule (Fig. 8E) 7-segmented; armature: 3, 10, 6, 3, 4 + 1 aesthetasc, 2 + 1 aesthetasc, 7 + 1 aesthetasc; all setae naked. Antenna (Fig. 8F) 4-segmented; armature formula 1, 1, 1, I.

Mandible (Fig. 8G) with prominent proximal notch; inner margin distinctly bilobate; convex side with strongly tapering process; terminal lash slender with spinules. Maxillule (Fig. 8H) with two plumose apical setae, one plumose subapical seta, and one minute spiniform element laterally. Maxilla (Fig. 8I) 2-segmented, first segment unarmed; second segment with lash showing three small serrations along convex margin, one small spiniform element, one relatively large anterior seta, and one plumose inner sea. Maxilliped (Fig. 8J) 3-segmented, syncoxa unarmed; basis with two setae along medial margin; small endopodal segment with one large spiniform process bearing spinules along outer side, one spine and one minute subapical seta.

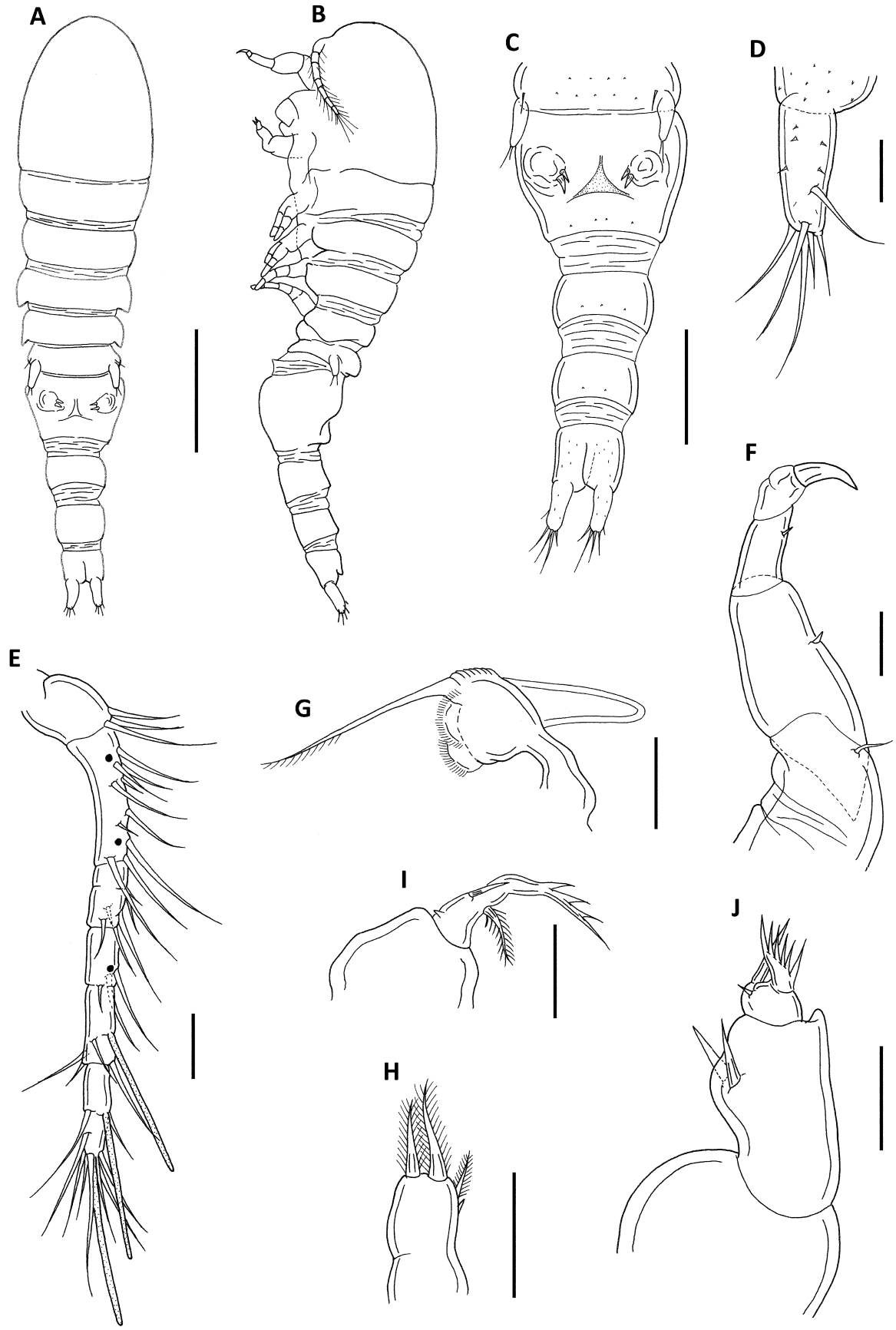

FIGURE 8. *Sociellus subgeminus* **sp. nov.** (female). A, habitus, dorsal; B, habitus, lateral; C, urosome; D, caudal ramus; E, antennule; F, antenna G, mandible; H, maxillule; I, maxilla; J, maxilliped. Scale bars: A–B = 0.2 mm; C = 0.1 mm; D–J = 0.02 mm.

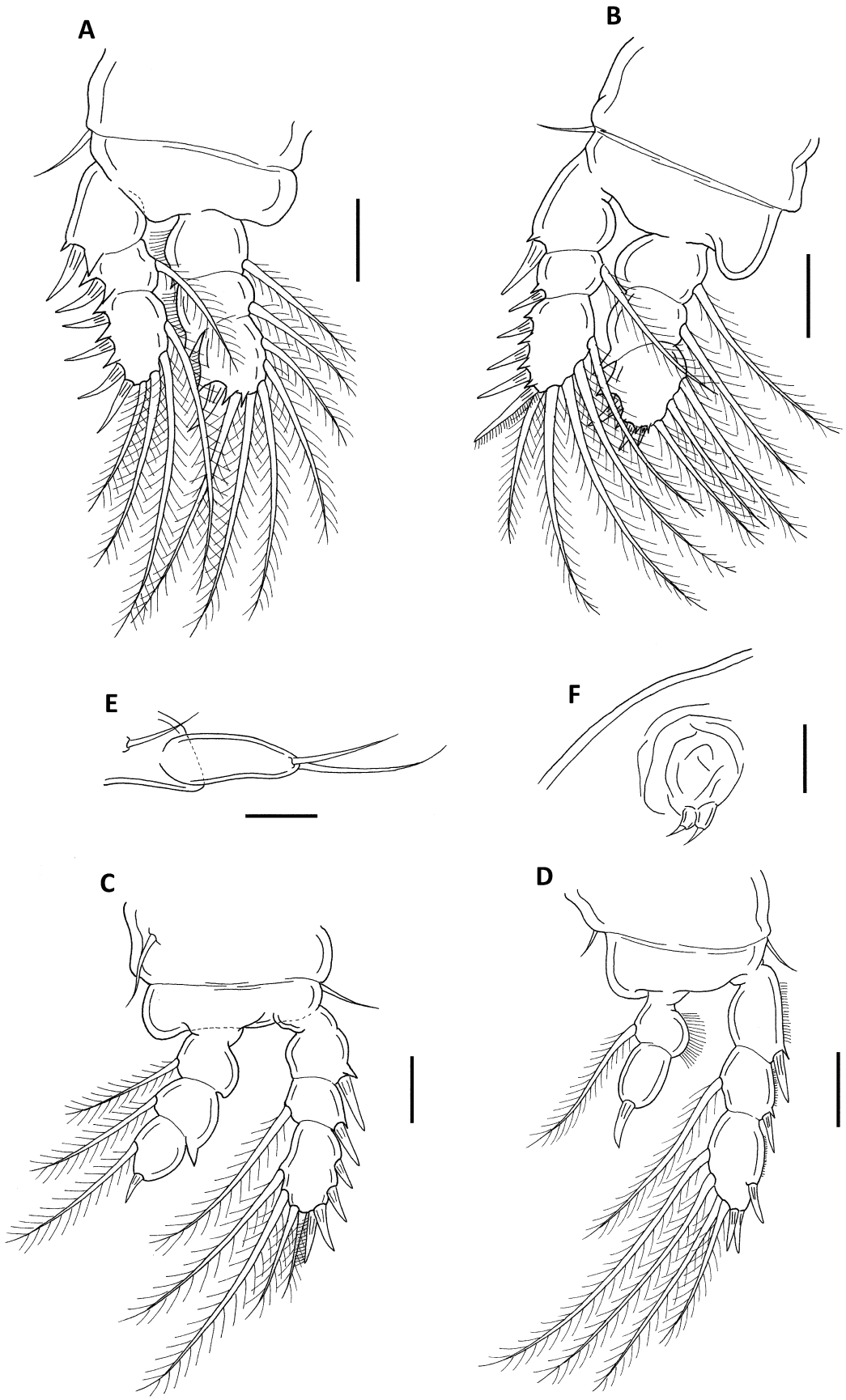

FIGURE 9. *Sociellus subgeminus* **sp. nov.** (female). A, leg 1; B, leg 2; C, leg 3; D, leg 4; E, leg 5; F, leg 6. Scale bars: A–F = 0.02 mm.

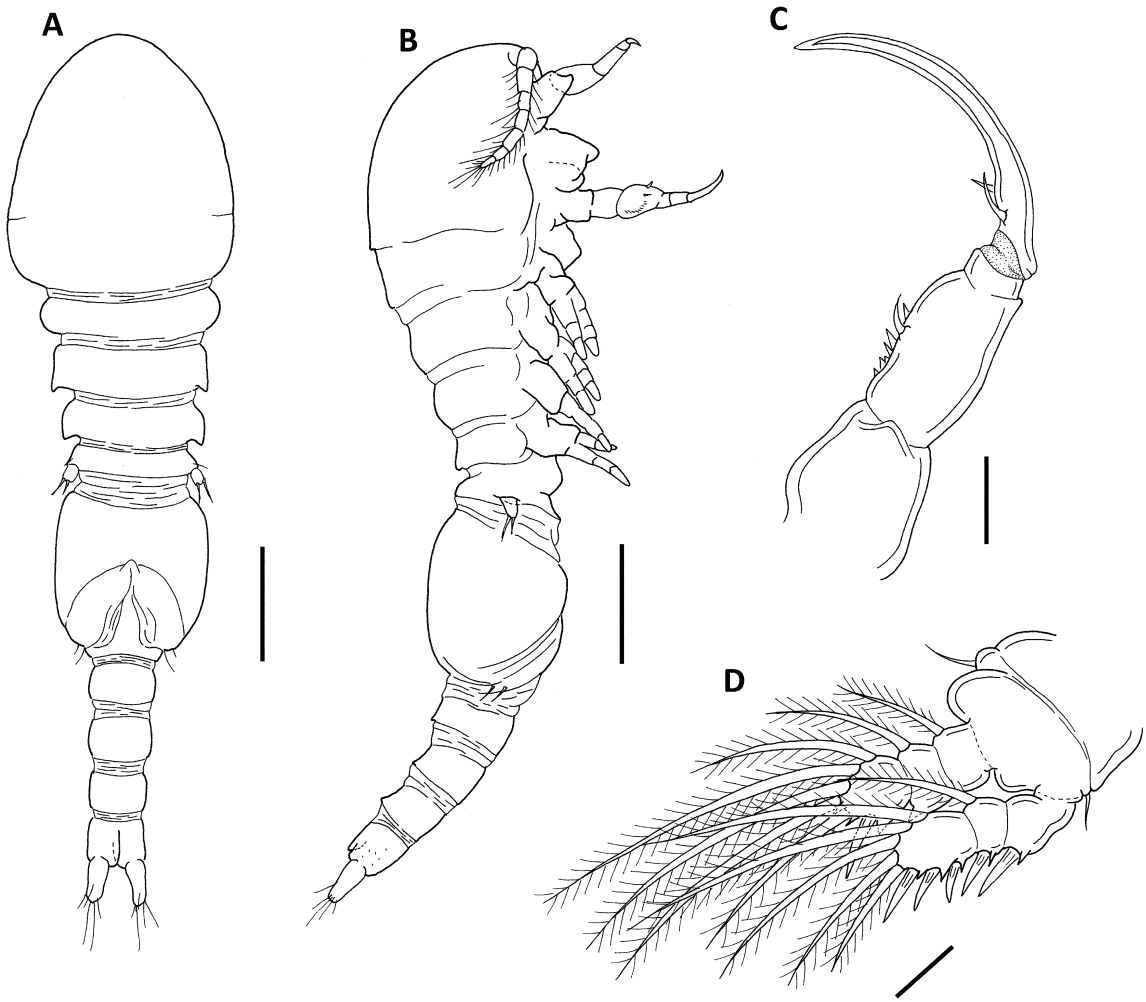

FIGURE 10. *Sociellus subgeminus* **sp. nov.** (male). A, habitus, dorsal; B, habitus, lateral; C, maxilliped; D, leg 1. Scale bars: A–B = 0.1 mm; C–D = 0.02 mm.

Legs 1–4 (Fig. 9A–D) with 3-segmented exopods and endopods (except for leg 4 endopod being 2-segmented). Legs 1–2 lacking inner coxal seta. Formula of spines (in Roman numerals) and setae (in Arabic numerals) as follows:

	Coxa	Basis	Exopod	Endopod
Leg 1	0-0	1-0	I-0; I-1; IV+4	0-1; 0-1; I+5
Leg 2	0-0	1-0	I-0; I-1; IV+5	0-1; 0-1; III+3
Leg 3	0-1	1-0	I-0; I-1; IV+4	0-1; 0-1; I+1
Leg 4	0-1	1-0	I-0; I-1; III+4	0-1; I

Leg 5 (Fig. 9E) with unornamented free segment, bearing two apical setae and small adjacent dorsal (= outer basal) seta.

Leg 6 (Fig. 9F) represented by two small setae arising from operculum closing off genital aperture.

Description of male. Body (Fig. 10A–B) elongate, slender, similar in shape to that of female. Length 0.74 mm (0.71–0.79 mm) and greatest width 0.19 mm (0.18-0.19 mm), based on five specimens. Caudal ramus as in female.

Antennule, antenna, mandible, maxillule and maxilla as in female except for antennule with three additional long aesthetascs (positions indicated by dots in Fig. 8E). Maxilliped (Fig. 10C) 4-segmented, syncoxa broadest, unarmed; basis with two unequal setae and spinules near medial margin; first endopodal segment very short and unarmed; second endopodal segment represented by large claw, bearing two setae at its base.

Legs 1–4 as in female except for leg 1 (Fig. 10D); third exopodal segment of leg 1 armed with three spines and five setae instead of four spines and four setae in female.

Leg 5 (Fig. 10A–B) small free segment (exopod) with two setae and one adjacent dorsal (= outer basal) seta as in female.

Leg 6 (Fig. 10A–B) represented by two small setae on posteroventral operculum on genital somite.

Remarks. The genus *Sociellus* currently contains only two species: *Sociellus torus* Humes, 1992 from the Great Barier Reef, northeastern Australia and *Sociellus geminus* from the Moluccas. Both species utilize the scleractinian host *Gardineroseris planulata* (Humes 1992; Kim 2006). *Sociellus subgeminus* **sp. nov.** differs from its two congeners by the differences summarized in Table 3.

TABLE 3. Differences between *Sociellus subgeminus* **sp. nov.** and its congeners *S. torus* Humes, 1992 and *S. geminus* Kim, 2006.

	S. geminus	*S. torus*	*S. subgeminus* **sp. nov.**
Body size (mm)	0.97	0.75–0.82	0.92–0.96
Armature of second segment of antenna	3 setae	3 setae	1 seta
Armature of maxillule	4 setae	2 setae	4 setae
Armature of first endopodal segment of leg 1	0-0	0-0	0-1
Armature of third endopodal segment of leg 1	I+2 or I+3	I+2	I+5
Armature of third exopodal segment of leg 2	IV+4	IV+4	IV+5
Armature of first endopodal segment of leg 2	0-0	0-0	0-1
Armature of second endopodal segment of leg 2	0-2	0-2	0-1
Armature of third exopodal segment of leg 3	IV+2	IV+1	IV+4
Leg 3 endopod	3-segmented	2-segmented	3-segmented
Armature of third exopodal segment of leg 4	III+3 or IV+3	III+2	III+4
Leg 4 endopod	2-segmented	1-segmented	2-segmented

Humes & Boxshall (1996) placed *Sociellus* in the Rhynchomolgidae, presumably because the type species *S. torus* displayed a mandible with a linear inner margin (*cf.* Humes 1992: Fig. 10). Kim (2006) proposed that the genus *Sociellus* should be placed in the family Anchimolgidae since the second species of the genus, *S. geminus*, exhibits the typical anchimolgid type of mandible with a distinctly bilobate inner margin, suggesting that Humes' (1992) description is inaccurate. The position of *Sociellus* in the Anchimolgidae is further corroborated by the mandibular morphology of *S. subgeminus* **sp. nov.** The presence of a large process on the convex margin of the mandible in all three members of *Sociellus* suggests that the genus is closely related to the genera of the *Odontomolgus*-group.

Acknowledgements

We are especially grateful to Dr Ju-shey Ho for his guidance in identifying the copepods. We are also grateful to Ming-Hsien Tsai and Chi-Hsiang Chin at the National Taiwan University, for their assistance with collecting coral samples in the field. This study was partially supported by a grant from the National Science Council, Taiwan (NSC 98-2611-M-002 -001 -MY3) and the Ministry of Science and Technology, Taiwan (Most 103-2811-B-002-146).

References

Boxshall, G.A. & Halsey, S.H. (2004) *An Introduction to Copepod Diversity.* The Ray Society, London, xv + 966 pp.

Cheng, Y.-R. & Dai, C.-F. (2010) Endosymbiotic copepods may feed on zooxanthellae from their coral host, *Pocillopora damicronis*. *Coral Reefs*, 29, 13–18. http://dx.doi.org/10.1007/s00338-009-0559-8

Cheng, Y.-R., Ho, J.-S. & Dai, C.-F. (2011) Four new xarifiid copepods (Poecilostomatoida) associated with the scleractinian coral, *Pavona explanulata* (Lamarck), from Taiwan. *Systematic Parasitology*, 79, 227–240. http://dx.doi.org/10.1007/s11230-011-9305-z

Dana, J.D. (1846–1849) *United States Exploring Expedition during the years 1838-1842. Vol. 7. Zoophytes.* Lea and Blanchard,

Philadelphia, 740 pp., 61 plates. [pp. 1–120, 709–720 (1846); 121–708, 721–740 (1848); atlas plates 1–61(1849)]
Forsskål, P. (1775) *Descriptiones animalium avium, amphibiorum, piscium, insectorum, vermium; quæ in itinere orientali observavit Petrus Forsskål. Post mortem auctoris edidit Carsten Niebuhr. Adjuncta est materia medica Kahirina atque tabula maris rubri geographica.* Möller, Hauniæ, 20 + XXXIV [= 1–34] + 164 pp., 1 map.
http://dx.doi.org/10.5962/bhl.title.2154
Humes, A.G. (1960) New copepods from madreporarian corals. *Kieler Meeresforschungen*, 16, 229–235, plates 1–4.
Humes, A.G. (1962) Eight new species of *Xarifia* (Copepoda, Cyclopoida), parasites of corals in Madagascar. *Bulletin of the Museum of Comparative Zoology, Harvard University*, 128, 37–63, plates 1–13.
Humes, A.G. (1978) Lichomolgid copepods (Cyclopoida) associated with the coral genus *Montipora* in the Moluccas. *Publications of the Seto marine biological Laboratory*, 24, 387–407.
Humes, A.G. (1985a) Cnidarians and copepods: a success story. *Transactions of the American microscopical Society*, 104, 313–320.
Humes, A.G. (1985b) A review of the Xarifiidae (Copepoda, Poecilostomatoida), parasites of scleractinian corals in the Indo-Pacific. *Bulletin of marine Science*, 36, 467–632.
Humes, A.G. (1992) Copepoda associated with the coral *Gardineroseris planulata* (Dana) on the Great Barrier Reef, northeastern Australia. *Hydrobiologia*, 234, 41–57.
http://dx.doi.org/10.1007/BF00010778
Humes, A.G. (1994a) How many copepods? *In*: Ferrari, F.D. & Bradley, B.P. (Eds.), Ecology and Morphology of Copepods. *Proceedings of the Fifth International Conference on Copepoda*, Baltimore, June 6–13, 1993, Hydrobiologia, 292/293, 1–7.
http://dx.doi.org/10.1007/BF00229916
Humes, A.G. (1994b) Two new species of *Paramolgus* (Copepoda: Poecilostomatoida: Lichomolgidae) associated with the scleractinian Pavona in New Caledonia with a key to females of *Paramolgus*. *Beaufortia*, 44, 1–9.
Humes, A.G. & Boxshall, G.A. (1996) A revision of the lichomolgoid complex (Copepoda: Poecilostomatoida), with the recognition of six new families. *Journal of natural History*, 30, 175–227.
http://dx.doi.org/10.1080/00222939600771131
Humes, A.G. & Frost, B.W. (1964) New lichomolgid copepods (Cyclopoida) associated with alcyonarians and madreporarians in Madagascar. *Cahiers de l'Office de la Recherche scientifique et technique Outre-Mer (ORSTOM)*, Série océanographie 6 (Série Nosy-Bé II), 131–212.
Humes, A.G. & Gooding, R.U. (1964) A method for studying the external anatomy of copepods. *Crustaceana*, 6, 238–240.
http://dx.doi.org/10.1163/156854064x00650
Humes, A.G. & Ho, J.-S. (1967) New cyclopoid copepods associated with the coral *Psammocora contigua* (Esper) in Madagascar. *Proceedings of the United States National Museum*, 122, 1–32.
Humes, A.G. & Ho, J.-S. (1968) Lichomolgid copepods (Cyclopoida) associated with corals in Madagascar. *Bulletin of the Museum of Comparative Zoology, Harvard Univeristy*, 136 (10), 353–413.
Humes, A.G. & Stock, J.H. (1972) Preliminary notes on a revision of the Lichomolgidae, cyclopoid copepods mainly associated with marine invertebrates. *Bulletin Zoölogisch Museum, Universiteit van Amsterdam*, 2 (12), 121–133.
Humes, A.G. & Stock, J.H. (1973) A revision of the family Lichomolgidae Kossman, 1877, cyclopoid copepods mainly associated with marine invertebrates. *Smithsonian Contributions to Zoology*, 127, i–v, 1–368.
Kim, I.-H. (2006) Copepoda (Poecilostomatoida: Anchimolgidae) associated with the scleractinian coral *Gardineroseris planulata* (Dana) from the Moluccas. *Korean Journal of systematic Zoology*, 22, 63–78.
Kim, I.-H. (2007) Copepods (Crustacea) associated with marine invertebrates from the Moluccas. *Korean Journal of systematic Zoology*, Special Issue 6, 1–126.
Klunzinger, C.B. (1879) *Die Korallenthiere des Rothen Meeres, 2. Theil: Die Steinkorallen. Erster Abschnitt: Die Madreporaceen und Oculinaceen.* Gutmann, Berlin, 88 pp, 10 plates.
Lamarck, J.-B. de (1801) *Système des Animaux sans Vertèbres, ou Tableau général des Classes, des Orders et des Genres de ces Animaux; présentant leurs Caractères essentiels et leur Distribution, d'après la Considération de leurs Rapports naturels et de leur Organisation, et suivant l'Arrangement établi dans les Galeries du Muséum d'Hist. Naturelle, parmi leurs Dépouilles conservées; précédé du Discours d'Ouverture du Cours de Zoologie, donné dans le Muséum National d'Histoire Naturelle l'An 8 de la République.* Published by the author, and Déterville, Paris, viii + 432 pp., 8 plates.
Lamarck, J.-B. de (1816) *Histoire naturelle des Animaux sans Vertèbres, présentant les Caractères généraux et particuliers de ces Animaux, leur Distribution, leurs Classes, leurs Familles, leurs Genres, et la Citation des principales Espèces qui s'y rapportent; précédée d'une Introduction offrant la Détermination des Caractères essentiels de l'Animal, sa Distinction du Végétal et des autres Corps naturels, enfin, l'Exposition des Principes fondamentaux de la Zoologie. Tome 2.* Verdière, Paris, 568 pp.
Milne Edwards, H. & Haime. J. (1860) *Histoire naturelle des Coralliaires ou Polypes proprement dits. Tome 3.* Librairie Encyclopédique de Roret, Paris, 560 pp.
Thorell, T. (1859) Bidrag till Kännedomen om Krustaceer, som lefva i arter af Slägtet *Ascidia* L. *Kongliga Svenska Vetenskaps-Akademiens Handlingar, Ny Följd*, 3 (8), 1–84, plates I–XV.
Veron, J.E.N. (1986) *Corals of Australia and the Indo-Pacific*. Angus and Robertson Publishers, Sydney, NSW, 644 pp.
Verrill, A.E. (1864) List of the polyps and corals sent by the Museum of Comparative Zoology to other institutions in exchange, with annotations. *Bulletin of the Museum of Comparative Zoology*, 1, 29–60.
Walter, T.C. & Boxshall, G.A. (Eds.) (2014) Poecilostomatoida. *In*: Walter, T.C. & Boxshall, G.A. (Eds.), *World of Copepods Database*. Accessed through World Register of Marine Species. Available from: http://www.marinespecies.org/copepoda/aphia.php?p=taxdetails&id=1103 (accessed 15 October 2014)