Two species of gall-inducing poecilostomatoid copepods on the scleractinian coral, Montipora aequituberculata

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Two species of gall-inducing poecilostomatoid copepods on the scleractinian coral,

Montipora aequituberculata

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Running title: gall forming copepod

ABSTRACT

Two species of the poecilostomatoid copepods, *Allopodion ryukyuensis* Kim and Yamashiro, 2007 and *Haplomolgus montiporae* Humes and Ho, 1968, are recorded from a scleractinian corals *Montipora aequituberculata*. These two species of copepods can elicit defense reactions of their host corals to deposit calcareous barrier by their appendages and are considered as gall-inducing copepods. Both of them are first recorded from *M. aequituberculata* and Taiwan.

Key words: poecilostomatoid, parasitic copepods, scleractinian corals, Taiwan.

INTRODUCTION

Scleractinian corals are frequently associated with copepods and provide greater diversity of copepods with readily available microhabitats and various resources (Humes 1985; Cheng and Dai 2010). In the evolutionary history of copepods and corals, copepods have developed plenty of associated modes with their host corals. Most species of copepods are generally known to live on the surface of corals or inside the gastrovascular cavities of coral polyps (Humes 1985; Cheng and Dai 2009). Only a few species, unlike those general species, inhabit gall structure of corals and were referred to gall-inducing copepods. These copepods might attach to soft tissues of coral hosts and elicit defense reactions of corals to deposit calcareous barrier (gall) by their appendages such as swimming legs (Dojiri 1988). So far, at least four species of poecilostomatoid copepods have been found in the gall structure of scleractinian corals. Dojiri (1988) described the first gallicolous copepod, *Isomolgus desmotes* from *Seriatopora hystrix* in Indonesia. Dojiri and Grygier (1990) reported *Pionomolgus gallicolus* from *Echinopora lamellose* collected in Australia. Recently, *Allopodion ryukyuensis* and *Xenomolgus varius* were recorded from the galls and crypts of *Montipora informis* and *Porites* sp., respectively, in Japan (Kim and Yamashiro 2007).

In this study, two species of gall-inducing poecilostomatoid copepods in association with a scleractinian coral *Montipora aequituberculata* were reported from southern Taiwan. A full description of the two species is given below.

MATERIALS AND METHODS

Fragments of *Montipora aequituberculata* (about 7-9 cm in length and width, Fig 1A) were collected at 5 m depth, Wanlitong (Fig. 2), Ping-tung, in southern Taiwan, isolated in a plastic bag, and transported to the laboratory. The coral fragments were examined under a dissecting microscope, and the copepods were picked by breaking the galls (Fig 1B). Before dissecting, the copepods were cleared in 85% lactic acid for 1 to 2 hrs, and then were dissected on a wooden slide under the microscope (Humes and Gooding, 1964). The removed body parts and appendages were examined under a compound microscope with a series of magnifications up to 1000X. All drawings were made with the aid of a camera lucida.

RESULTS

Order Poecilostomatoida Thorell, 1859

Family Anchimolgidae Humes and Boxshall, 1996

Genus *Allopodion* Humes, 1978

Allopodion ryukyuensis Kim and Yamashiro, 2007

(Figs. 3-5)

Material examined: 10 ♀♀ and 8 ♂♂ collected from galls on the scleractinian coral *Montipora aequituberculata* Bernard, at 5 m depth, Wanlitong (Fig. 2), Ping-tung, in southern Taiwan on 26 December 2005.

Female: Body (Fig. 3 A and B) with total length 0.96 mm (0.90-0.98 mm) and greatest widest 0.40 mm (0.39-0.41 mm), based on 5 specimens. Prosome (Fig. 3 A) greatly swollen, subspherical, much longer and wider than urosome. Genital segment (Fig 3 D) with rounded lateral margins, only a little longer than the width; genital areas located dorsally in anterior one-third of genital segment. Three postgenital segments (Fig. 3 B and E), each with equal length and width. Caudal ramus (fig. 3 E) longer than the width, and bearing 6 setae, all setae naked. Egg sacs not seen.

Antennule (Fig. 3 F) slender, 7-segmented. Armature formula: 4, 13, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete, all setae naked; all setae naked. Antenna (Fig. 3 G) 4-segmented; armature: 1, 1, 3, 1+ I. Mandible (Fig. 3 I) with a slender proximal part; inner margin with two lobes armed with many spinules; flagellum moderately long, with lateral spinules distally; convex outer margin with a large expansion. Maxillule (Fig. 3 H) a single segment with four elements, three distal setae bearing thick setules and a smaller naked seta. Maxilla (Fig. 4 A) 2-segmented; first segment unarmed; second segment bearing a small proximal spinule, a distal lamellate seta with dentiform spinules, and a seta with a row of minute spinules on its inner margin; terminal lash with a row of dentiform spinules. Maxilliped (Fig. 4 B) 3-segmented; first segment unarmed; second segment with two very unequal setae; third segment with a process bearing spinules and two naked setae.

Legs 1 and 2 (Fig. 4 C and D) with trimerous rami. Leg 3 and 4 (Fig. 4 E and F) uniramous, with 3-segmented exopod; armature as follows:

P1	protopod 0-1; 1-0	exp	I-0; I-1, III, I, 4
		end	0-1; 0-1; I, 5
P2	protopod 0-1; 1-0	exp	I-0; I-1, III, I, 5
		end	0-1; 0-2; I, II, 2

P3 protopod 0-1; 1-0 exp I-0; I-1, I, I, 5

end absent

P4 protopod 0-1; 1-0 exp I-0; I-1, I, I, 4

end absent

Leg 5 (Fig. 3 A, B and C) with a broad free segment, slightly arched, its inner surface slightly concave, bearing a patch of minute spinules, and armed with two terminal naked setae. Near free segment have a naked seta.

Leg 6 (Fig. 3 D and fig. 4 G) probably represent by the two setae near attachment of egg sac.

Male: body (Fig. 5 A) without expanded prosome. Length 0.61 mm (0.58-0.62 mm) and greatest width 0.22 mm (0.21-0.23 mm), based on 5 specimens. Urosome (Fig 5 B) 6-segmented; genital segment large, wider than fourth and fifth pedigerous somite, its lateral borders gently rounded in dorsal view; postgenital four segments, the next to the last segment being the longest. Caudal ramus resembling that of female.

Antennule, antenna, maxillule, maxilla and mandible as in female, but antennule with two aesthetes added on 2 segment and one on segment 4 (indicated by arrows in Fig. 3 F). Maxilliped (Fig. 5 C) slender and 4-segmented (assuming that the proximal part of claw represents a fourth segment); first segment longest and unarmed; second segment with two naked setae and rows of spinules on its inner surface; third segment small and unarmed; claw (or 4-segmented) long, slender, and strongly recurved. Proximal part of claw with two unequal setae.

Legs 1-4 segmented and armed as in female. Leg 5 (Fig. 5 A and B) with free segment much smaller than female. Leg 6 (Fig. 5 A and B) a posteroventral flap on genital segment, represented by two naked setae. Spermatophore not observed.

Order Poecilostomatoida Thorell, 1859

Family Lichomolgidae Kossmann, 1877

Genus *Haplomolgus* Humes and Ho, 1968

Haplomolgus montiporae Humes and Ho, 1968

(Figs. 6-8)

Material examined: 2 ♀♀ and 2 ♂♂ collected from galls on the scleractinian coral *Montipora aequituberculata* Bernard, at5 m depth, Wanlitong, Ping-tung, in southern Taiwan on 26 December 2005.

Female: Body (Fig. 6 A) rather slender; dorsal surface of prosome and urosome with a few hairs. Length 0.84 mm (0.78-0.90 mm) and the greatest width 0.33 mm (0.27-0.39 mm), based on 2 specimens. Genital segment (Fig. 6 A) only a little longer than wide and slightly wider in its anterior half than posteriorly; areas of attachment of egg sacs located dorsally, each area bearing two small setae. Three postgenital segments (Fig. 6 A) from anterior to posterior, the middle segment being the longest. Caudal ramus (Fig. 6 B) elongated, bearing 6 setae, all setae naked. Egg sacs not seen.

Antennule (Fig. 6 C) slender, 7-segmented. Armature formula: 4, 13, 6, 3, 4 + 1 aesthete, 2 + 1 aesthete, and 7 + 1 aesthete, all setae naked. Antenna (Fig. 6 D) 4-segmented. Armature: 1, 1, 3, 1+I. Mandible (Fig. 6 F) with an unusually slender proximal part and broadened distal part; distal part with two lobes bearing obtuse spinules, and on its convex side with a large pointed posteriorly directed process followed by a row of small serrations. Maxillule (Fig. 6 E) bearing three setae with spinules and a relatively smaller naked seta. Maxilla (Fig. 6 G) 2-segmented, first segment unarmed; second segment bearing a small proximal spinule, a distal lamellate seta and a seta with a row of minute spinules; terminal lash with a row of dentiform spinules. Maxilliped (Fig. 7 A) 3-segmented; first segment unarmed; second segment with two unequal setae; third segment with a process bearing spinules and two setae (one naked seta and one barbed seta).

Legs 1-3 (Fig. 7 B, C and D) with trimerous rami. Leg 4 (Fig. 7 E) only with a single (or two) segment in endopod; armature as follows:

P1 protopod 0-1; 1-0	exp	I-0; I-1, III, I, 4
	end	0-1; 0-1; I, 5
P2 protopod 0-1; 1-0	exp	I-0; I-1, III, I, 5
	end	0-1; 0-2; I, II, 3
P3 protopod 0-1; 1-0	exp	I-0; I-1, II, I, 5
	end	0-1; 0-2; II, 2
P4 protopod 0-1; 1-0	exp	I-0; I-1, II, I, 5
	end	0

Leg 5 (Fig. 7 F) with a broad free segment, its inner surface slightly concave, bearing a patch of minute spinules, and armed with two terminal naked setae. Near free segment have a naked seta.

Leg 6 (Fig. 7 G) probably represent by the two setae near attachment of egg sac.

Male: body (Fig. 8 A) slender as in female. Length 0.82 mm (0.80-0.84 mm) and greatest width 0.26 mm (0.25-0.26 mm), based on 2 specimens. Urosome (Fig 8 B) 6-segmented; genital segment only slightly longer than wide, its lateral borders gently rounded in dorsal view; postgenital four segments, the next to the last segment being the longest, as in the female. Caudal ramus resembling that of female.

Antennule, antenna, maxillule, maxilla and mandible like female, but antennule with two aesthetes added on 2 segment and one on segment 4 (indicated by arrows in Fig. 6 C). Maxilliped (Fig. 8 C) slender and 4-segmented; first segment unarmed, second segment with two similar naked setae and rows of spinules on inner margin, third segment small and unarmed, claw (4-segmented) long and slender; proximal part of claw with two unequal setae (the smaller seta naked, the larger with distal spinules).

Legs 1-4 segmented as in female, but in endopod of leg 1(Fig. 8 D) with outermost seta much shorter than female. Leg 5 (Fig. 8A, B) with free segment smaller and narrower than in female. Leg 6 (Fig. 8 A, B) represented by 2 small setae on posteroventral flap on genital segment. Spermatophore not observed.

DISCUSSION

Kim and Yamashiro (2007) originally described *Allopodion ryukyuensis* based on specimens associated with *Montipora informis* in Japan. Our specimens found in the galls of *M. aequituberculata* from Taiwan are well in accord with their original description. However, two minor differences were observed in the specimens from Taiwan and should be noted: (1) the armature in Antenna: 1, 1, 3, 1+I (instead of 1, 1, 2, 1+I), (2) the armature of endopod in leg 2 as 0-1; 0-2; I, II, 2. According to Kim and Yamashiro (2007), the specimens of *A. ryukyuensis* in Japan possess 3 setae in its first segment of endopod of leg 2, while the specimens in Taiwan only have 2 setae. This difference should be considered as an artificial mistake because only 2 setae were observed in the article (see Fig 3 A in Kim and Yamashiro 2007).

Haplomolgus montiporae was previously reported by Humes and Ho (1968) based on specimens from washing the fragments of *Montipora sinensis* and *M. stellata* collected in Madagascar. In spite of a large number of specimens were obtained in Humes and Ho (1968), they did not mention the possibility of gall-inhabiting of this species. Our results showed that this species is found from galls of *M. aequituberculata*, and two minor differences between our specimens and those from Madagascar are observed in: (1) the armature in Antenna: 1, 1, 3, 1+I (instead of 1, 1, 3, I), (2) the setae on endopod of legs 1-4 are much shorter, and (3) the dorsal surface of urosome and the edge of anal operculum lack hairs or minute spinules. We considered that these differences should be either infra-specific variations or artifacts.

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中文摘要

首次在臺灣產癭葉表孔珊瑚蟲癭裡發現的二種杯口水蚤目之寄生橈足類

鄭有容 [1]，戴昌鳳 [1]，張文炳 [2*]

本篇報告描述寄生於臺灣產癭葉表孔珊瑚上發現的二種屬於杯口水蚤目之寄生橈足類，分別為 Kim and Yamashiro (2007) 描述的 *Allopodion ryukyuensis* 與 Humes and Ho (1968) 描述的 *Haplomolgus montiporae*。它們藉由其附屬肢的干擾，誘導珊瑚宿主產生生理抵抗反應，並造成珊瑚骨骼異常增生進而堆積形成蟲癭構造。這二種寄生橈足類均為首次在癭葉表孔珊瑚及臺灣發現的新紀錄種。

關鍵詞： 杯口水蚤，寄生橈足類，癭葉表孔珊瑚，蟲癭，臺灣。

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Figure Legends

Figure 1. Photographs of *Montipora aequituberculata*: A, a colony of *M. aequituberculata* showing several galls each inhabited by *Allopodion ryukyuensis* and *Hoplomolgus montiporae*; B, a closer view of dome-shaped gall. White arrow indicate gall structure. Scale bar: 4 cm in A; 2 cm in B.

Figure 2. Map of Taiwan showing the type locality of *Allopodion ryukyuensis* and *Hoplomolgus montiporae*.

Figure 3. *Allopodion ryukyuensis*, female: A, dorsal; B, lateral; C, fifth pedigerous; D, genital double somites; E , abdomen and caudal ramus, dorsal; F, antennule, with dot indicating position of aesthete in male; G, antenna, inner; H, maxillule, posterior; I, mandible, posterior. Scale bar: 0.2 mm in A and B; 0.1 mm in E; 0.05 mm in C, D; 0.04 mm in F and G; 0.02 mm in H and I.

Figure 4. *Allopodion ryukyuensis*, female: A, Maxilla, anterior; B, maxilliped, anterior;

C, leg 1; D, leg 2; E, leg 3; F, leg 4; G, leg 6. Scale bar: 0.02 mm in A; 0.04 mm in B, C, D, E, F, and G.

Figure 5. *Allopodion ryukyuensis*, male: A, dorsal; B, urosome, dorsal; C, maxilliped, inner. Scale bar: 0.2 mm in A ; 0.1 mm in B; 0.04 mm in C.

Figure 6. *Hoplomolgus montiporae,* female: A, dorsal; B, caudal ramus, dorsal; C, antennule, with dot indicating position of aesthete in male; D, antenna, inner; E, maxillule, posterior; F, mandible, posterior; G, maxilla, posterior. Scale bar: 0.2 mm in A; 0.04 mm in B, C, and D; 0.02 mm in E, F, and G.

Figure 7. *Hoplomolgus montiporae*, female: A, maxilliped, anterior; B, leg 1 and intercoxal plate; C, leg 2; D, leg 3; E, leg 4; F, leg 5; G, leg 6. Scale bar: 0.02 mm in A; 0.04 mm in B, C, D, E, F, and G.

Figure 8. *Hoplomolgus montiporae,* male: A, dorsal; B, urosome, dorsal; C, maxilliped, inner; D, endopod of leg 1. Scale bar: 0.2 mm in A ; 0.1 mm in B and C; 0.04 mm in D .

Figure 1.

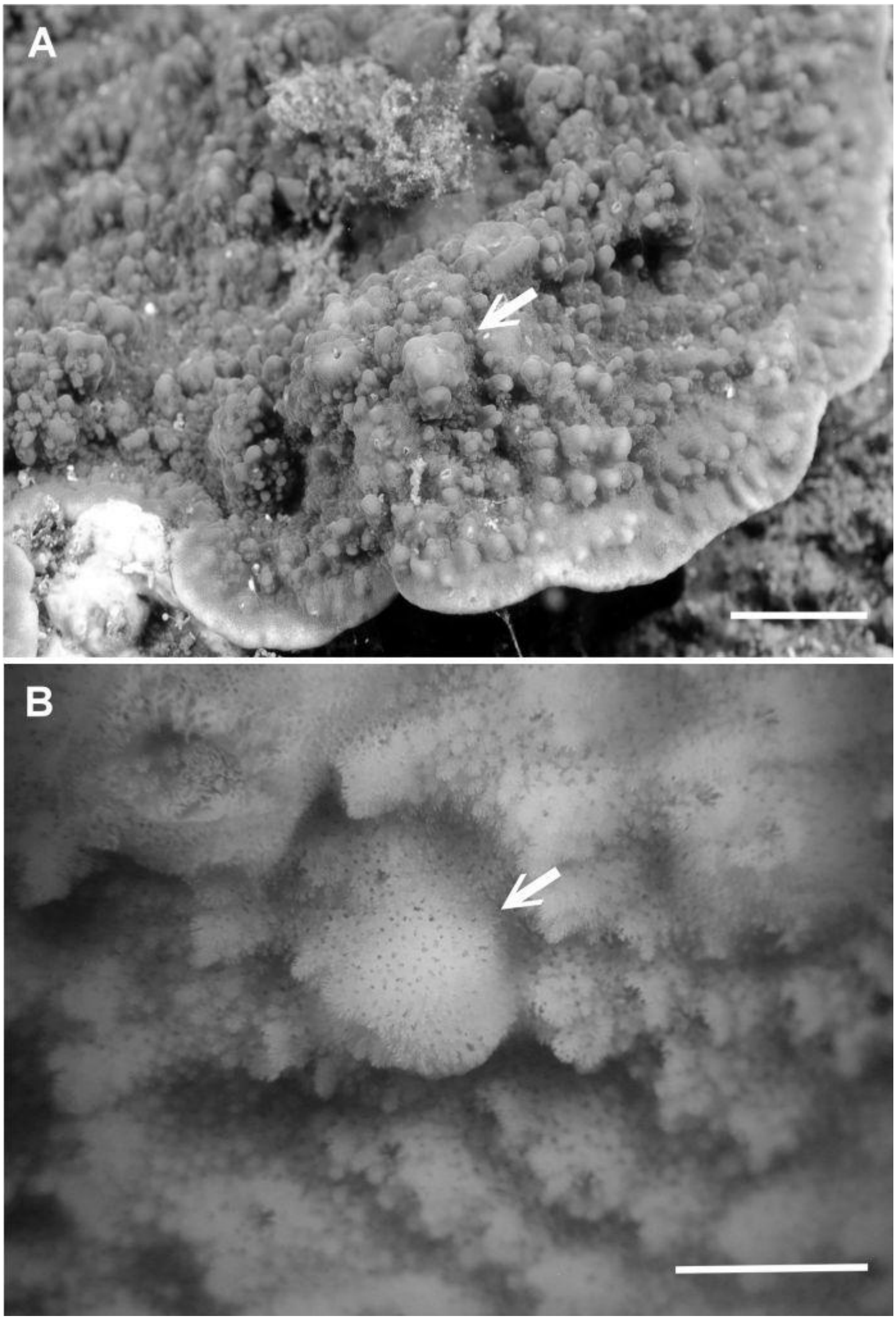
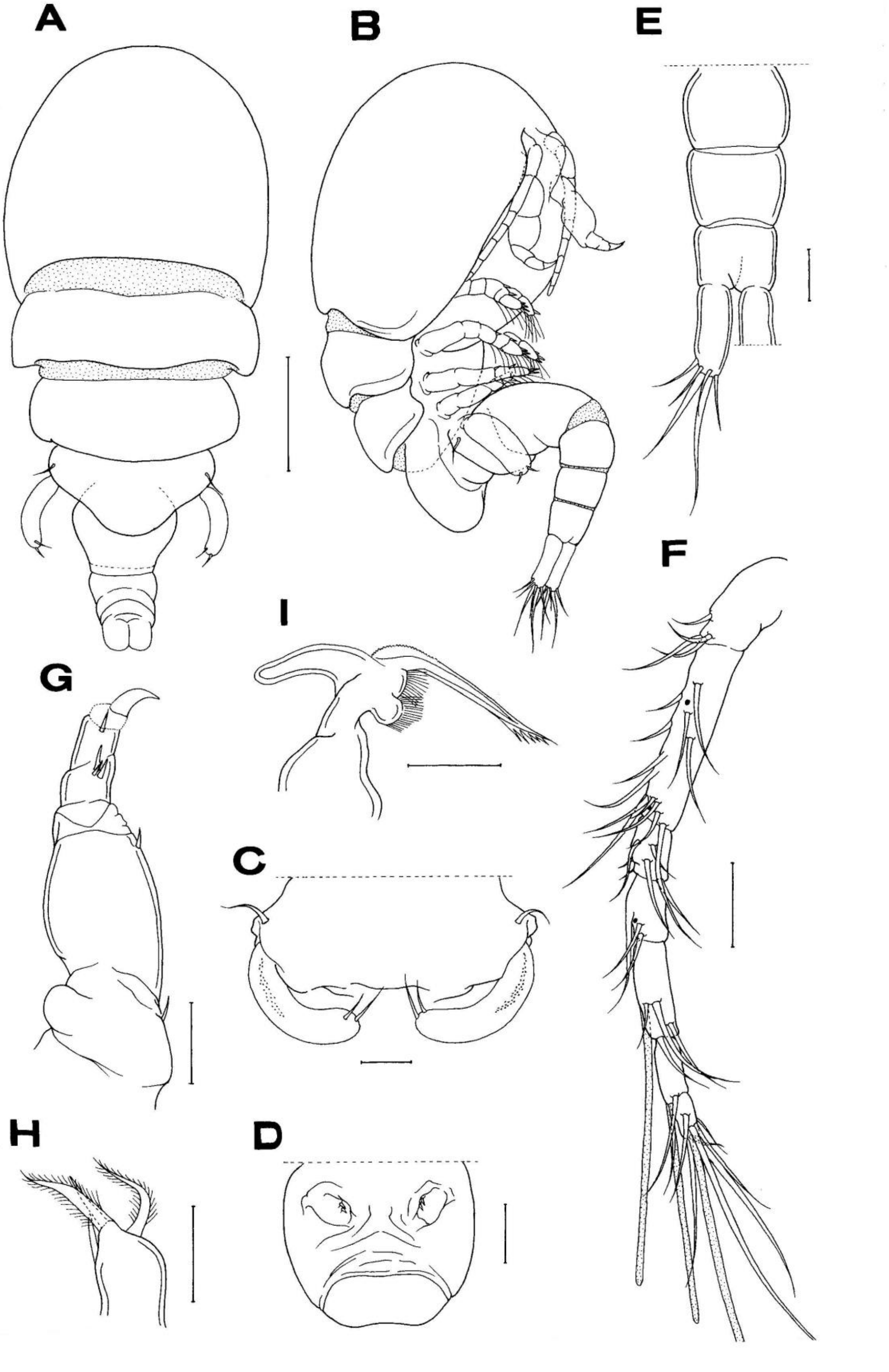


Figure 2.

Figure 3.



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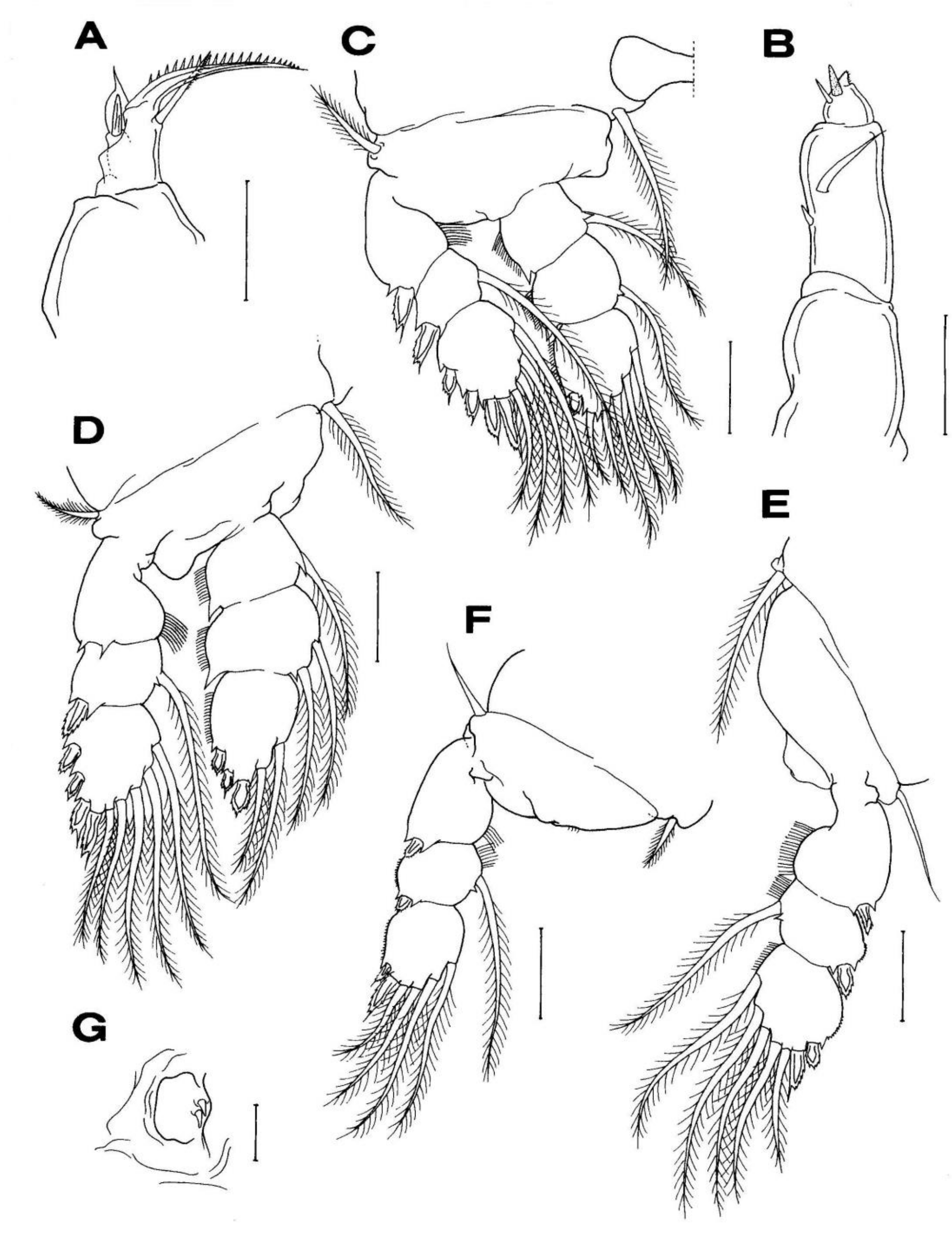

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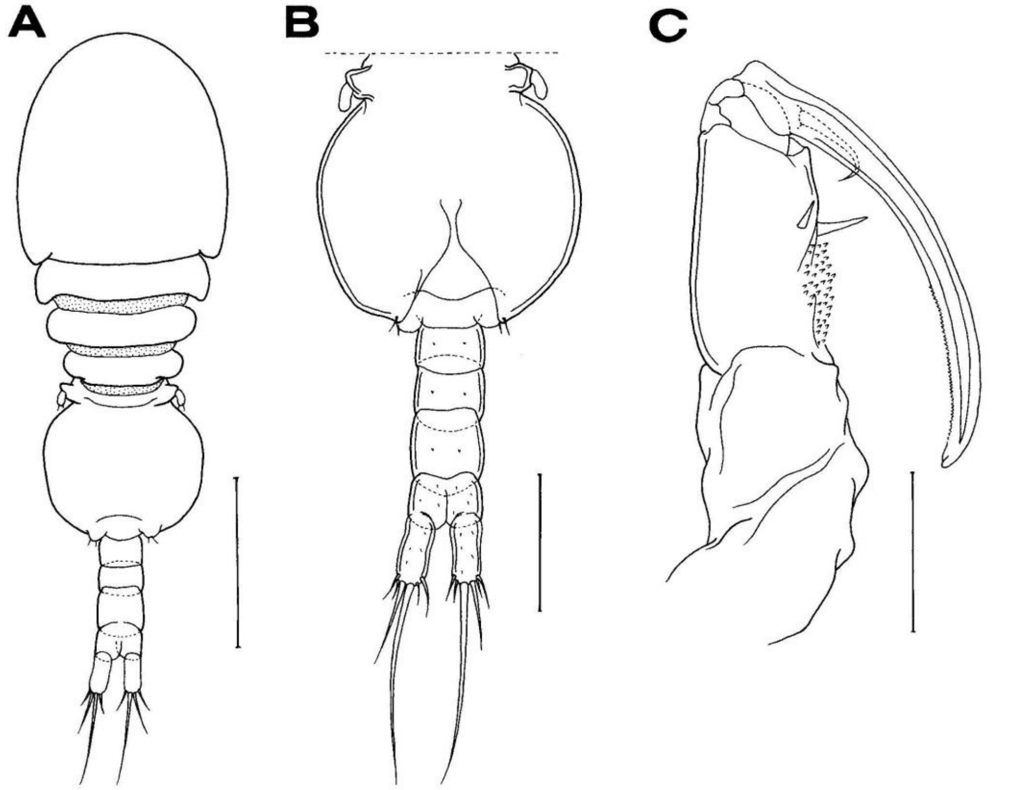

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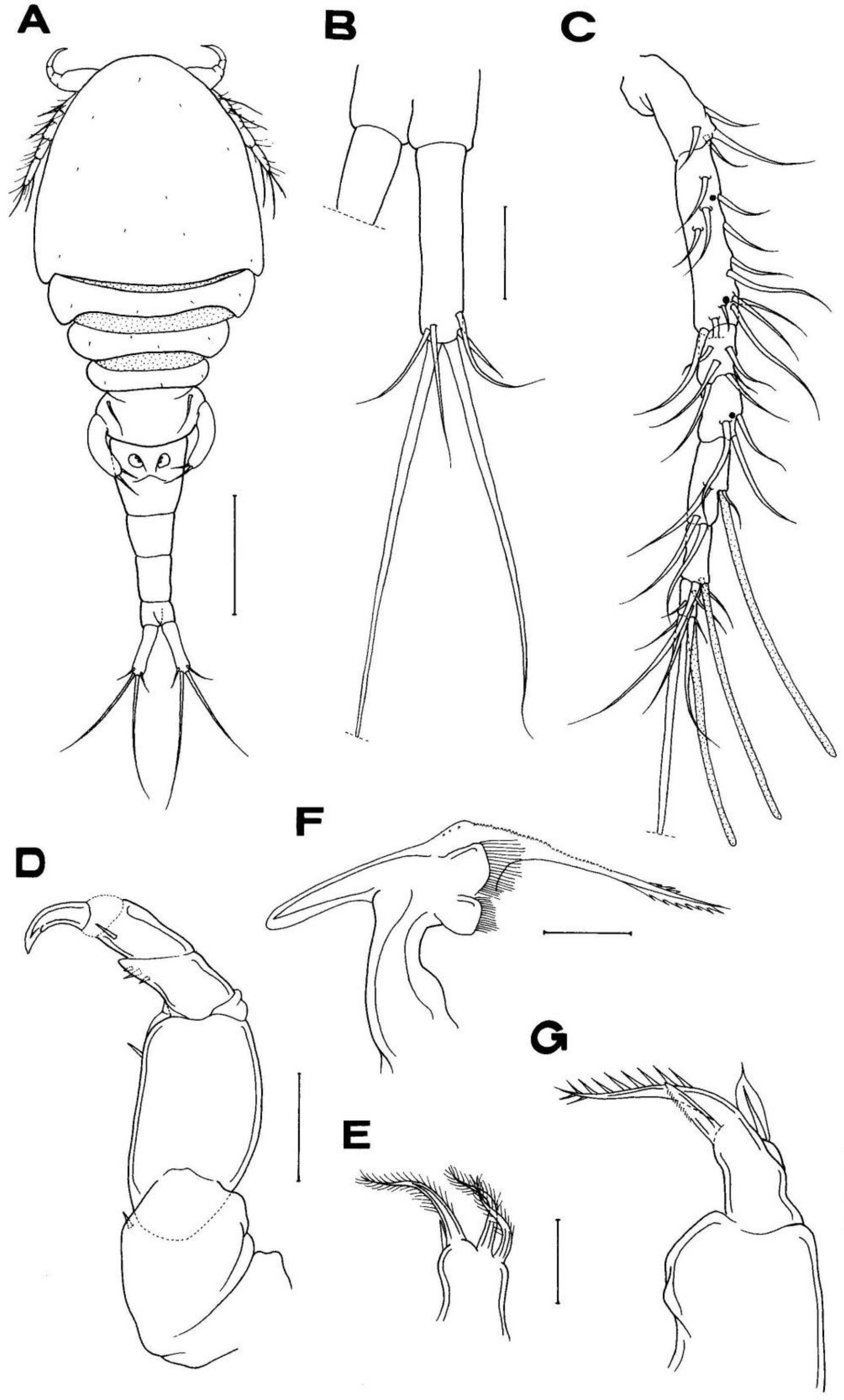

Figure 7.

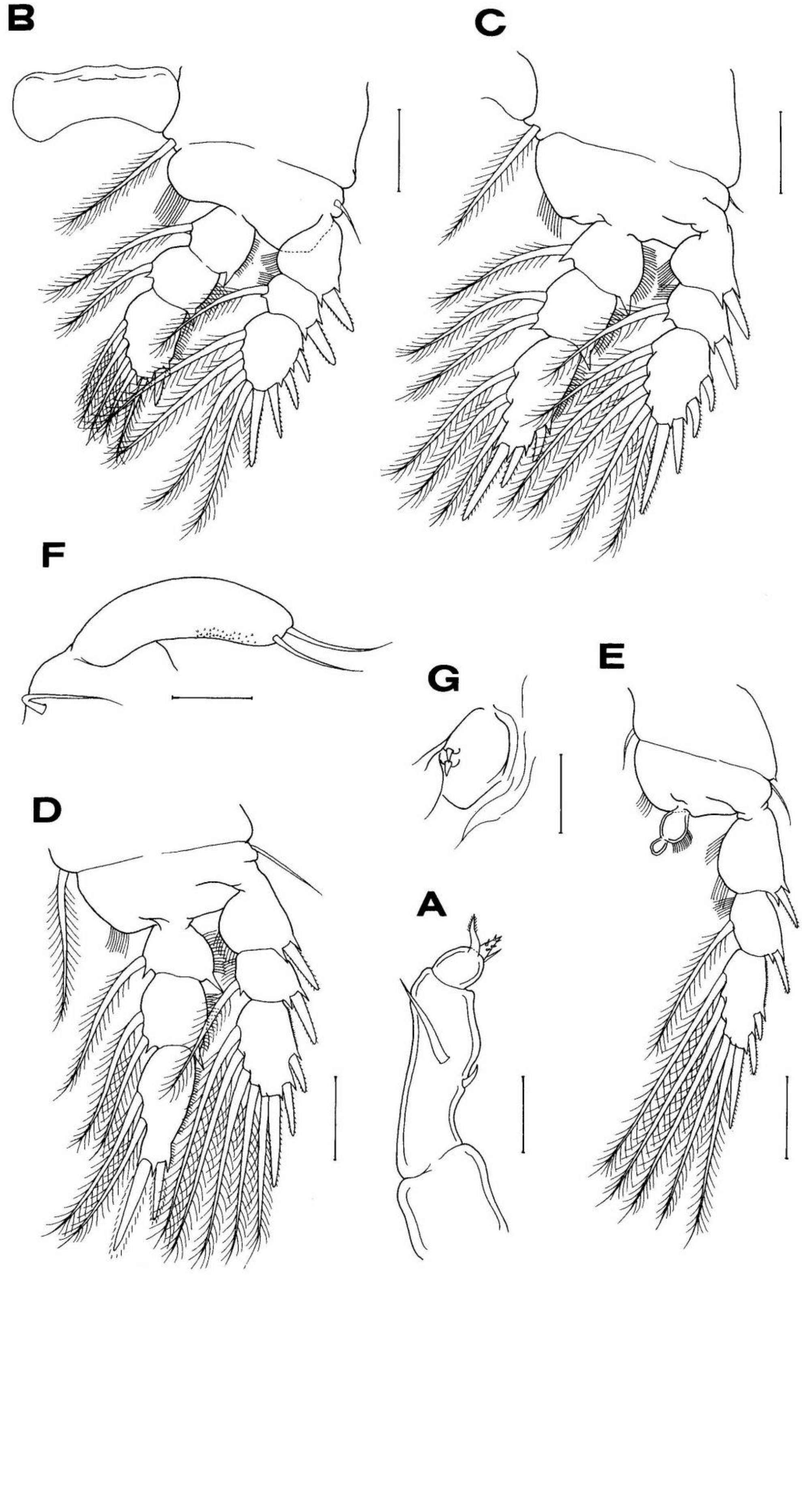

Figure 8.