

Two Species of *Makrostromos* gen. nov. (Copepoda: Taeniacanthidae) Parasitic on the Laced Moray (*Gymnothorax favagineus* Bloch and Schneider) in Taiwan

Ju-shey Ho¹ and Ching-Long Lin^{2,*}

¹Department of Biological Sciences, California State University, Long Beach, CA 90840-3702, USA

²Department of Aquatic Sciences, National Chiayi University, Chiayi, Taiwan 600, R.O.C.

(Accepted November 21, 2005)

Ju-shey Ho and Ching-Long Lin (2006) Two species of *Makrostromos* gen. nov. (Copepoda: Taeniacanthidae) parasitic on the laced moray (*Gymnothorax favagineus* Bloch and Schneider) in Taiwan. *Zoological Studies* 45(4): 578-585. Two species of *Makrostromos* gen. nov. (Copepoda: Taeniacanthidae), *M. acuminatus* sp. nov. and *M. hamus* sp. nov., were discovered parasitic on the gill filaments of the laced moray, *Gymnothorax favagineus* Bloch and Schneider, caught and landed at fishing ports in southern Taiwan. The new genus is characterized in having a T-shaped (instead of a Y-shaped) rostral bar, a robust, prehensile maxilla, and a whiplike maxilliped. The 2 new species of *Makrostromos* can be distinguished by the structure of the terminal claw on the maxilla and the armature of the 3rd expopodal segment of leg 4. <http://zoolstud.sinica.edu.tw/Journals/45.4/578.pdf>

Key words: Taeniacanthidae, Copepoda, *Makrostromos*, Taiwan, Marine fish.

Taeniacanthid copepods of the genus *Pseudotaeniacanthus* Yamaguti and Yamasu, 1959 are parasitic specifically on the gill filaments of anguilliform fishes (Dojiri and Cressey, 1987). Our recent examination of moray eels of Taiwan has yielded 5 species of taeniacanthids from the laced moray, *Gymnothorax favagineus* Bloch and Schneider. Based on Dojiri and Cressey's (1987: 6) key to the genera of the Taeniacanthidae, all 5 species from the laced moray of Taiwan are keyed out to *Pseudotaeniacanthus*. However, checking with the diagnosis of the genus provided by Dojiri and Cressey (1987: 200) turned out that two of our 5 species of taeniacanthids cannot be placed in the genus without redefining it. The disparities are seen in the structures of the maxilla, maxilliped, and leg 1.

Two additional genera of taeniacanthids, viz. *Caudacanthus* Tang and Johnson, 2005 and *Biacanthus* Tang and Izawa, 2005, were proposed after publication of Dojiri and Cressey's (1987)

revision of the family. Comparison with the description of the type species provided by Tang and Johnson (2005) for *Caudacanthus* and by Tang and Izawa (2005) for *Biacanthus* has also yielded the same disparities mentioned above for the structures of the maxilla, maxilliped, and leg 1 present in our new taeniacanthids. Thus, a new genus, *Makrostromos*, is created in this paper to accommodate these 2 new forms.

MATERIALS AND METHODS

Moray eels caught and landed at fishing ports in southern Taiwan were purchased and transferred in an icebox to National Chiayi University where the laboratory examination of the copepod parasites was carried out. The gill cavity of the eel was fully exposed by cutting and folding back the operculum. Copepod parasites removed from the host's gill filaments were preserved in 70%

*To whom correspondence and reprint requests should be addressed. Tel: 886-5-2783065. Fax: 886-5-2783065. E-mail: cllin@mail.ncyu.edu.tw

ethanol. They were later cleared in 85% lactic acid for 1-2 h before dissection in a drop of lactic acid on a wooden slide (Humes and Gooding, 1964). The removed parts and appendages were examined under a compound microscope with a series of magnifications of up to 1500x. All drawings were made with the aid of a camera lucida, and measurements were taken after soaking the specimens in lactic acid.

RESULTS

Order Poecilostomatoida Thorell, 1859.

Family Taeniacanthidae Wilson, 1911.

Makrostromos gen. nov.

Female: Body cycloform, with 1st pedigerous somite fused to cephalosome; remaining pro-somal somites separated. Abdomen 4 segmented. Caudal ramus with 6 setae as usual. Rostral area with T-shaped rostral bar. Antennule slender and

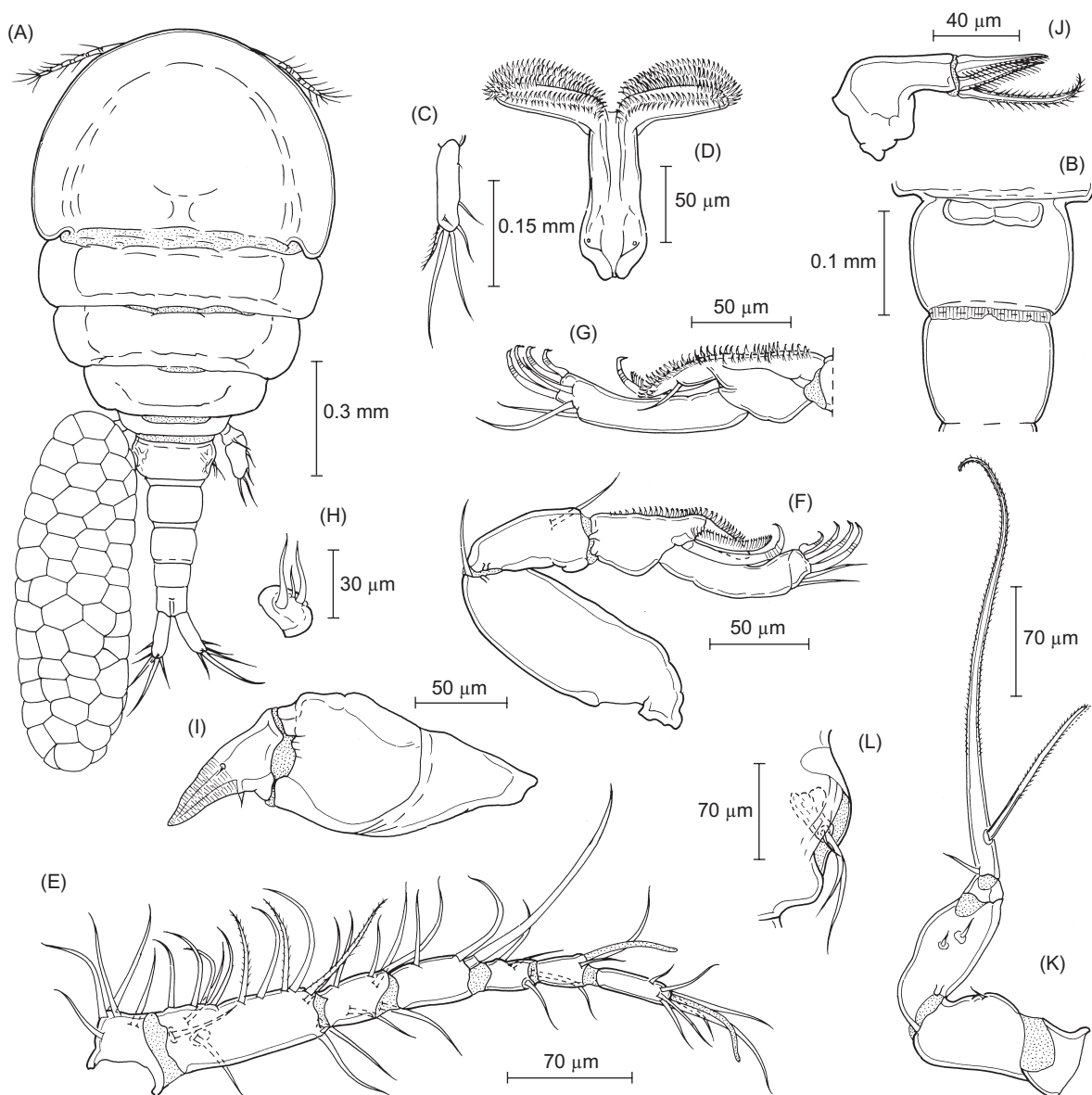


Fig. 1. *Makrostromos acuminatus* gen. nov., sp. nov., female. (A) Habitus, dorsal view; (B) 1st 2 somites of abdomen, ventral view; (C) caudal ramus, dorsal view; (D) rostral bar, ventral view; (E) antennule; (F) antenna, posteroventral view; (G) endopod of antenna, anterodorsal view; (H) maxillule; (I) maxilla; (J) mandible; (K) maxilliped; (L) right side of genital segment, dorsal view.

7 segmented. Antenna 4 segmented; terminal segment tipped with 4 claw-like spines. Post-antennal process absent. Labrum with rounded posteroventral margin. Mandible tipped with 2 spinulate blades and 1 pinnate spiniform seta. Maxillule a small, rounded lobe carrying 3 or 4 setae. Maxilla 2-segmented; terminal segment a robust claw or process. Maxilliped 4-segmented; terminal segment drawn out into a long, pinnate, whiplike process. Legs 1-4 biramous with 3-segmented rami. Endopod of leg 1 not lamelliform. Leg 5 2-segmented. Leg 6 represented by 3 setae attached to genital operculum.

Male: Body cycloform as in female.

Appendages similar to those of female except maxilliped with robust corpus bearing prominent myxal process and terminal segment transformed into stubby claw. Leg 6 represented by a single seta at tip of genital ridge.

Type species: *Makrostromos acuminatus* sp. nov.

Etymology: The generic name is a combination of *makros* ("long" in Greek) and *stromos* ("spread or laid out" in Greek) alluding to the possession of a long terminal whiplike process on the maxilliped and a rostral bar with its arms spread out to form a T-shaped structure.

Remarks: While the male of this new genus

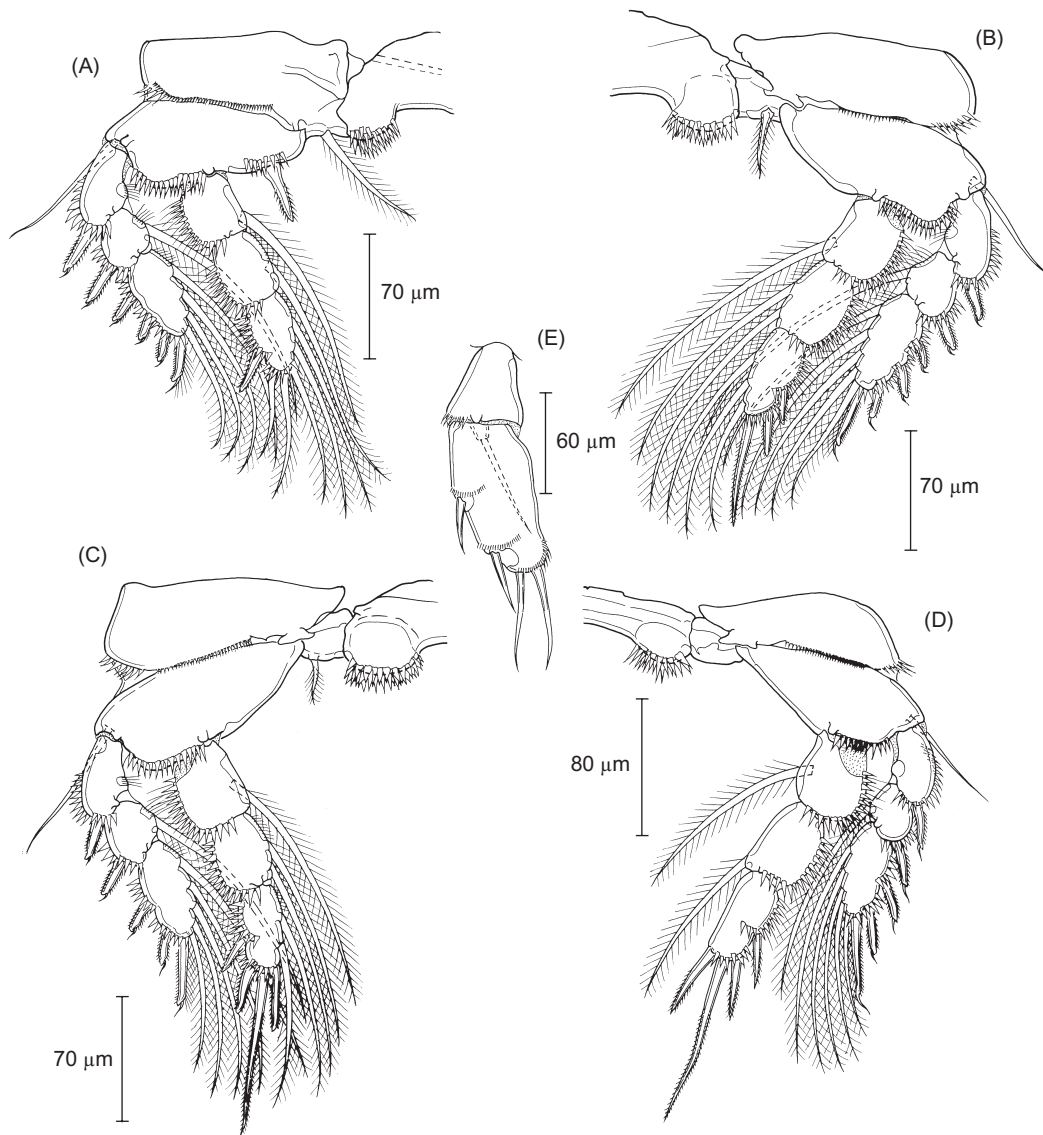


Fig. 2. *Makrostromos acuminatus* gen. nov., sp. nov., female. (A) Leg 1, anterior view; (B) leg 2, anterior view; (C) leg 3, anterior view; (D) leg 4, anterior view; (E) leg 5, anterior view.

does not show very prominent differences from that of *Pseudotaeniacanthus*, the female bears several distinctive differences. The female *Makrostromos* can be easily distinguished from those of *Pseudotaeniacanthus* by the structure of the rostral bar (T-shaped instead of Y-shaped), the bearing of a mandible with 3 (instead of 2) terminal elements, a maxilla with a blunt process or a strong, bent hook at the tip, a long, whiplike process at the tip of the maxilliped, and a normal endopod on leg 1 (not transformed into a lamellate structure).

***Makrostromos acuminatus* sp. nov.**

(Figs. 1-3)

Material examined: 62 ♀♀, 12 ♂♂, and 2 larvae recovered from gill filaments of 4 laced morays, *Gymnothorax favagineus*, landed at Dong-Gang Fishing Port on 27 Dec. 2003. Holotype (USNM 1082985), allotype (USNM 1082986), and 36 paratypes (30 ♀♀ in USNM 1082987; 6 ♂♂ in USNM 1082988) deposited in the National Museum of Natural History, Smithsonian Institution, Washington DC.

Female: Body (Fig. 1A) 1.59 (1.54-1.71) mm long, excluding setae on caudal rami. Cephalothorax wider than long, 0.54 (0.50-0.60) x 0.74 (0.70-0.80) mm, with a broadly rounded anterior margin. Urosome short, less than 1/2 of total body length, 541 (502-583) μm . Genital somite wider than long, 92 (89-105) x 194 (158-211) μm , with an area of egg sac attachment (Fig. 1L) visible in dorsal view of habitus. Abdomen (Fig. 1A) 4-segmented; posterior margin of 1st somite fringed with a hyaline membrane on ventral side (Fig. 1B); anal somite without ornamentation. Caudal ramus (Fig. 1C) distinctly longer than wide, 115 (105-130) x 37 (32-41) μm , and armed with 1 prominent, lateral setule in proximal region in addition to the usual 4 short and 2 long setae in distal region. Egg sac (Fig. 1A) shorter than body, 92 mm long, and carrying multi-seriate eggs.

Rostral bar (Fig. 1D) T-shaped, armed with rows of hooklets on both arms. Antennule (Fig. 1E) 7-segmented; armature formula: 5, 15, 6, 3, 4, 2+1 aesthete, and 7+1 aesthete. Antenna (Fig. 1F) 4-segmented; proximal segment (coxobasis) bearing a single terminal seta; 1st endopodal segment bearing long outer seta; 2nd endopodal seg-

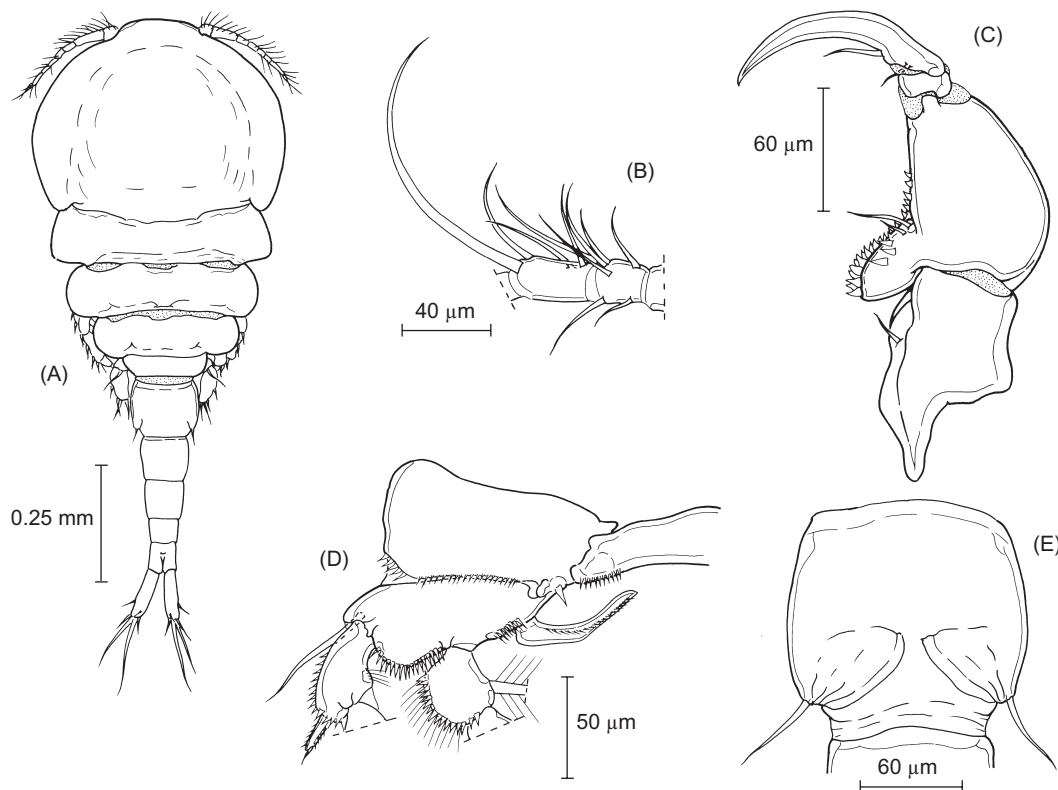


Fig. 3. *Makrostromos acuminatus* gen. nov., sp. nov., male. (A) Habitus, dorsal view; (B) 3rd and 4th somites of antennule; (C) maxilliped; (D) protopod and 1st segment of both rami of leg 1, anterior view; (E) genital segment, ventral view.

ment with 2 pectinate, distal processes and 1 curved, terminal claw, row of denticles on medial margin of this segment extending into one of 2 terminal processes; 3rd endopodal segment tipped with 4 curved claws and 3 setae (Fig. 1G). Mandible (Fig. 1J) tipped with 2 bladelike processes bearing spinules on posterior margin and 1 spiniform seta with spinules on both sides. Maxillule (Fig. 1H) a small lobe tipped with 3 short setae. Maxilla (Fig. 1I) 2-segmented; proximal segment large but unarmed; distal segment a large, bluntly pointed process with 1 basal and 1 outer, short, spiniform seta. Maxilliped (Fig. 1K) 4-segmented; syncoxa longest, bearing small, medial seta; basis (= corpus) spindle-shaped, carrying 2 tiny, medial setae; 1st endopodal segment smallest and unarmed; distal (2nd endopodal) segment prolonged into a whiplike process bearing 1 short,

naked seta and 1 long spiniform, pinnate seta in basal region.

Armature on rami of legs 1-4 as follows (Roman numerals indicating spines and Arabic numerals setae).

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

Intercoxal plate of leg 1 (Fig. 2A) with cluster of spines at posterolateral protrusion, row of spines/spinules on coxa, 2 rows of spines on basis, and row of spines on outer margin of all segments of both rami. Ornamentations on legs 2 (Fig. 2B), 3 (Fig. 2C), and 4 (Fig. 2D) generally as

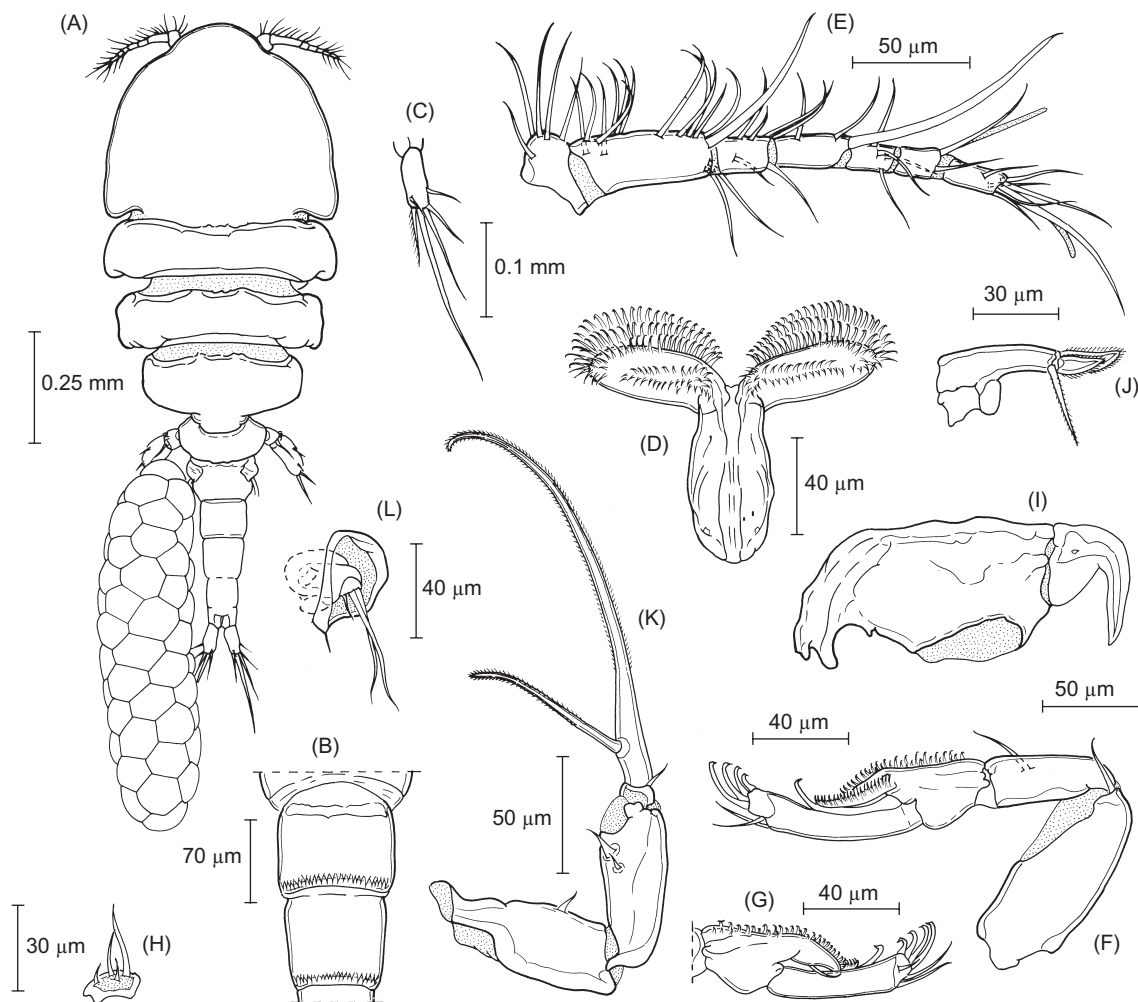


Fig. 4. *Makrostromos hamus* gen. nov., sp. nov., female. (A) Habitus, dorsal view; (B) proximal 2 somites of abdomen, ventral view; (C) caudal ramus, dorsal view; (D) rostral bar, ventral view; (E) antennule; (F) antenna, posteroventral view; (G) endopod of antenna, anterodorsal view; (H) maxillule; (I) maxilla; (J) mandible; (K) maxilliped; (L) egg sac attachment area, dorsal view.

in leg 1. Leg 5 (Fig. 2E) 2-segmented; proximal segment short, but armed with a long, outer seta and a row of spinules at base; distal segment twice as long as wide and armed with 4 spiniform setae; row of spinules at base of each seta. Leg 6 (Fig. 1L) represented by 2 long and 1 short setae on genital operculum located in a pit for attachment of egg sac.

Male: Body (Fig. 3A) 1.19 (1.12-1.24) mm long, excluding setae on caudal rami. Cephalothorax wider than long, 0.39 (0.38-0.42) x 0.49 (0.48-0.52) mm. Urosome 496 (462-510) μm

long, shorter than prosome and occupying 42% of body length. Genital somite wider than long, 118 (109-130) x 140 (130-146) μm , with 2 genital ridges (Fig. 3E) on ventral side. Abdomen 4-segmented (Fig. 3A). Caudal ramus (Fig. 3A) longer than wide, 100 (97-105) x 24 (24-24) μm , and armed as in female. Antennule 7-segmented as in female, but 1 seta added to armature on 3rd and 4th segments (Fig. 3B). Thus, armature of formula on antennule changed to 5, 15, 7, 4, 4, 2+1 aesthete, and 7+1 aesthete. Maxilliped (Fig. 3C) 4-segmented; proximal segment (syncoxa) armed

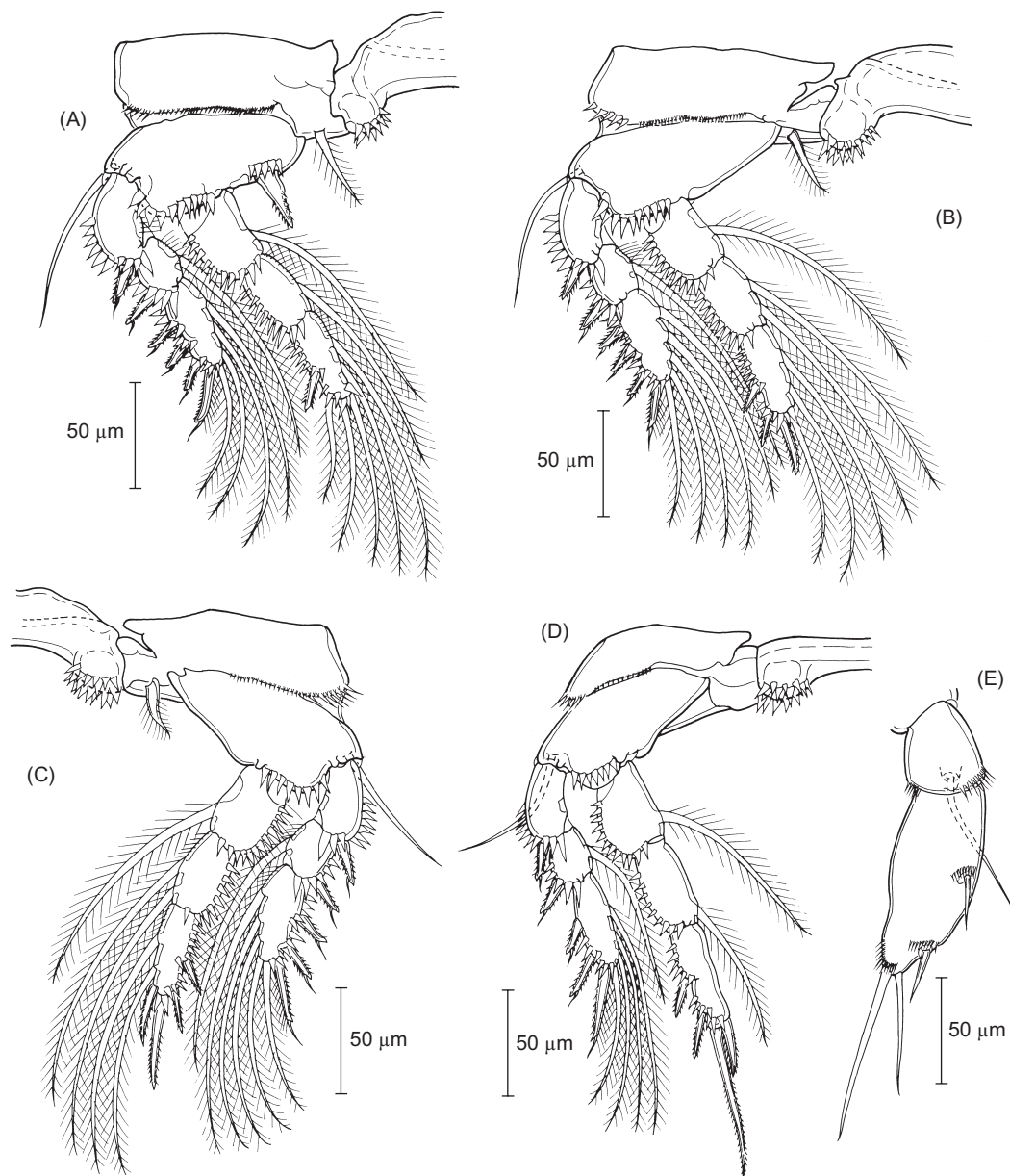


Fig. 5. *Makrostromos hamus* gen. nov., sp. nov., female. (A) Leg 1, anterior view; (B) leg 2, anterior view; (C) leg 3, anterior view; (D) leg 4, anterior view; (E) leg 5, anterior view.

with a medial seta; 2nd segment (basis or corpus) largest, armed with a large myxal process bearing 2 setae, row of denticles on medial margin of this segment extending up to myxal process; 3rd segment (1st endopodal segment) smallest and unarmed; terminal endopodal segment a curved claw with 2 basal setae. Medial coxal seta on leg 1 reduced and medial spine on basis deformed (Fig. 3D). Leg 6 (Fig. 3E) represented by a long, naked seta on genital ridge.

Etymology: The specific name *acuminatus* means "pointed" in Latin. It alludes to possession in the present new species of an unusual maxilla armed with a large, bluntly pointed process (Fig. 1I).

Remarks: Of the 5 species of taeniacanthids found on the gill filaments of the 4 laced moray landed at Dong-Gang Fishing Port, this species was the most common parasite comprising 63.3% (76/120) of the collection.

***Makrostromos hamus* sp. nov.**

(Figs. 4, 5)

Material examined: 24 ♀♀ recovered from gill filaments of 4 laced morays, *G. favagineus*, landed at Dong-Gang Fishing Port on 27 Dec. 2003. Holotype (USNM 1082989) and 10 paratypes (USNM 1082990) deposited in the National Museum of Natural History, Smithsonian Institution, Washington DC.

Female: Body (Fig. 4A) 1.22 (1.10-1.34) mm long, excluding setae on caudal rami. Cephalothorax wider than long, 0.40 (0.38-0.42) x 0.47 (0.44-0.52) mm, with a broadly protruded rostral area. Urosome short, less than 1/2 of total body length, 391 (340-429) µm. Genital somite wider than long, 85 (81-89) x 134 (122-146) µm, with an area for egg sac attachment (Fig. 4L) visible in dorsal view of habitus. Abdomen (Fig. 4A) 4-segmented; posterior margin of 1st 2 somites fringed with a row of denticles on ventral side (Fig. 4B); anal somite without ornamentation. Caudal ramus (Fig. 4C) longer than wide, 61 (57-65) x 24 (24-24) µm, and armed with the usual 4 short and 2 long setae in distal region. Egg sac (Fig. 4A) shorter than body, 84 mm long, and carrying multi-seriate eggs.

Rostral bar (Fig. 4D) T-shaped, with 5 rows of hooklets on both arms. Antennule (Fig. 4E), antenna (Figs. 4F, G), and maxilliped (Fig. 4K) constructed as those in *M. acuminatus* sp. nov. Mandible (Fig. 4J) tipped with 2 blades fringed with

spinules all around and 1 long, pinnate, spiniform seta. Maxillule (Fig. 4H) a small lobe tipped with 2 short and 2 long setae. Maxilla (Fig. 4I) 2-segmented; proximal segment large but unarmed; distal segment a robust, strongly bent claw with a tiny basal seta.

Armature and ornamentation on rami of legs 1 (Fig. 5A), 2 (Fig. 5B), 3 (Fig. 5C), and 5 (Fig. 5E) as those in *M. acuminatus* sp. nov. Leg 4 (Fig. 5D) differing from that of *M. acuminatus* sp. nov. in having 4 (vs. 5) setae on terminal segment of exopod. Leg 6 (Fig. 4L) represented by 2 long and 1 short setae on genital operculum located in a pit for attachment of egg sac.

Male: Unknown.

Etymology: The specific name *hamus* means "hook" in Latin. It alludes to the transformation of the terminal segment of the maxilla into a large hook (Fig. 4I).

Remarks: The present new species can be easily separated from *M. acuminatus* sp. nov. by the general form of the body, the terminal hook on the maxilla, and a formula of II,I,4 (instead of II,I,5) on the distal segment of the leg 4 exopod.

It is interesting to point out that convergent evolution of the maxilla developed between the species of *Makrostromos* gen. nov. and those of *Telson* Pearse, 1952. In both *T. elongatus* Pearse, 1952 and *T. nicholsi* Causey, 1960 the maxilla is constructed in the same plan like that of *M. hamus* sp. nov.: a 2-segmented, robust appendage tipped with a huge, bent claw. Since this strong, prehensile appendage is the major attachment organ for species of *Telson* (Ho, 1967), it is also likely used for the same function in species of *Makrostromos* gen. nov.

Acknowledgments: We would like to thank Dr. Shin-Hong Cheng of the Biotechnology Division of the Taiwan Fisheries Research Institute for his kindness in making the necessary arrangements for us to purchase the fish landed at Dong-Gang Fishing Port. Appreciation is also due to You-Rong Cheng, Yuh-Yin Chiang, Mei-Jun Shi, I-chia Ho, Su-chen Hwang, and Meng-Dah Yü of National Chiayi Univ. for their assistance in transportation and examination of fishes. The field and laboratory work of this project was made possible through grants (NSC92-2311-B-415-001) from the National Science Council of Taiwan to CLL. Completion of this work was aided by another grant from the Paramitas Foundation to Jsh.

REFERENCES

- Dojiri M, RF Cressey. 1987. Revision of the Taeniacanthidae (Copepoda: Poecilostomatoida) parasitic on fishes and sea urchins. *Smithson. Contr. Zool.* **447**: 1-250.
- Ho JS. 1967. Cyclopoid copepods of the genus *Telson* parasitic on uranoscopid fishes in the Gulf of Mexico. *J. Parasitol.* **53**: 852-858.
- Humes AG, RU Gooding. 1964. A method for studying the external anatomy of copepods. *Crustaceana* **6**: 238-240.
- Tang D, K Izawa. 2005. *Biacanthus pleuronichthydis* (Yamaguti, 1939) gen. n., comb. n. (Copepoda: Taeniacanthidae), and ectoparasite of flatfishes from Japanese waters. *Zootaxa* **1071**: 47-60.
- Tang D, MD Johnston. 2005. *Caudacanthus*, a new genus for *Caudacanthus narcini* (Pillai 1963) comb. nov. (Poecilostomatoida: Taeniacanthidae), a parasitic copepod of batoid fishes (Chondrichthyes: Elasmobranchii) from the Indo-West Pacific. *Zool. Stud.* **44**: 337-346.