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ORIGINAL PAPER

Two new species of taeniacanthid copepods (Poecilostomatoida) parasitic on marine fishes of Taiwan

Ju-shey Ho · Ching-Long Lin

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Abstract Two new species of copepods (Poecilostomatoida Taeniacanthidae) parasitic on fishes of Taiwan are reported. They are: *Irodes parupenei* n. sp. from *Parupeneus spilurus* (Bleeker) and *P. multifasciatus* (Quoy & Gaimard), and *Taeniacanthus spiniferus* n. sp. from *Acanthocepola limbata* Valenciennes. *I. parupenei* is characteristic in having nine (instead of eight) elements on the terminal segment of leg 2 exopod, a spiniform element (instead of a long, plumose seta) on the medial margin of the proximal segment of leg 4 endopod, and thee spines and one long, naked seta (rather than four short setae) on the slender (rather than spatula-like), terminal segment of leg 5. *T. spiniferus* is distinguished from its 38 congeners in carrying a pair of sharp tines in the ventral area of the rostrum.

Introduction

During our past eight years of survey on the parasitic copepods of marine fishes of Taiwan, 13 species of taeniacanthid copepods were found parasitic on 10 species of bony fishes. In this paper we shall describe two new species belonging to *Irodes* Wilson, 1911 and *Taeniacanthus* Sumpf, 1871, respectively.

Irodes was established by Wilson (1911) to accommodate *Bomolochus gracilis* Heller, 1865. However, due to his inclusion of other species of *Bomolochus* von Nordmann, 1832, which created confusion in the diagnosis of the newly erected genus, Ho (1969) rejected *Irodes*. This decision was followed by Kabata (1979), Balarman (1983) and Pillai (1985). Nevertheless, due to the discovery of four other taeniacanthids that share certain derived character states with *B. gracilis*, Dojiri & Cressey (1987) resurrected the genus *Irodes* and redefined it accordingly. We consider Dojiri & Cressey's (1987) resurrection of *Irodes* to be valid.

Materials and methods

Fishes landed at various fishing ports in Taiwan were purchased and transferred in a icebox to the laboratory of fish disease located on the campus of National Chiayi University. The fishes were examined under a dissection microscope and the copepod parasites were removed, cleaned in saltwater and preserved in 70% ethanol. The preserved specimens were soaked in 85% lactic

J.-s. Ho (✉)
Department of Biological Sciences, California State University, Long Beach, California, 90840-3702, USA
e-mail: jsho@csulb.edu

C.-L. Lin
Department of Aquatic Biosciences, National Chiayi University, Chiayi, 60083, Taiwan

acid overnight prior to dissection in a drop of lactic acid. The hanging drop method, devised by Humes & Gooding (1964), was employed in the examination of the isolated body parts and appendages under the compound microscope. All drawings were made with the aid of a camera lucida.

Irodes parupenei n sp.

Material examined

All parasites found in nostrils of goatfishes landed at Ma-gong Fishing Port in Penhu County, Taiwan: 101 ♀♀ and 18 ♂♂ from 21 *Parupeneus spilurus* (Quoy & Gaimard) collected on 19 March 1998, 1 ♀ and 1 ♂ from same species of fish landed on 7 May 1998, and 6 ♀♀ on 2 *P. multifasciatus* (Bleeker) collected on 19 March 1998.

Type-material: Holotype (USNM 1083909), allotype (USNM 1083910) and 38 paratypes (30 ♀♀ USNM 1083911 and 8 ♂♂ USNM 1083912) are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC; the remaining specimens are in the collection of the junior author.

Etymology: The specific name *parupenei* is taken from the generic name of the host.

Description

Female (Figs. 1A–O, 2A–F)

Body (Fig. 1A) 1.38 (1.32–1.52) mm long, excluding setae on caudal rami. Cephalothorax wider than long, 0.54 (0.52–0.56) × 0.73 (0.70–0.80) mm. Pedigers 2, 3 and 4 well separated and distinctly wider than long. Urosome short, 486 (462–527) μm in length. Genital somite wider than long, 152 (146–162) × 237 (227–259) μm, with area of egg-sac attachment located on posterodorsal corner (Fig. 1B); some specimens carry spermatophore in this area (Fig. 1C). Abdomen 4-segmented, without ornamentation. Caudal ramus (Fig. 1D) longer than wide, 50 × 41 μm, and armed with 4 short and 2 long setae in distal and subterminal regions, in addition to lateral setule in basal region and 4 setules on dorsal surface. Egg-sac (Fig. 1A) longer than body, 1.60 mm, multiseriate.

Rostral area broadly protruded anteriorly (Fig. 1A) but without sclerite on its ventral surface. Antennule (Fig. 1E) 6-segmented; armature formula: 20, 4, 3, 4, 2 + ae and 7 + ae. Antenna (Fig. 1G) 4-segmented; proximal segment (coxobasis) largest, bearing single basal seta; 1st endopodal segment bearing short outer seta; 2nd endopodal segment with 2 pectinate, distal processes (longer with 5–7 rows of spinules plus distal seta, shorter with 3–4 rows of spinules and hyaline seta at mid-length) plus 1 curved, terminal claw; 3rd endopodal segment tipped with 2 curved claws and 4 naked setae (Fig. 1H). Postantennal process (Fig. 1F) slightly curved at tip. Labrum (Fig. 1I) broad, fringed with spinules on posterior margin. Mandible (Fig. 1M) tipped with 2 unequal blades, each bearing several rows of denticles on posterior margin. Paragnath (Fig. 1L) a protruded lobe bearing patches of spinules in basal region. Maxillule (Fig. 1K) a small lobe tipped with 3 (2 naked, 1 unipinnate) short and 2 long, bristled setae. Labium-like sclerite (Fig. 1J) located in posterior region of oral area bearing row of denticles on 2 protuberances on its anterior margin. Maxilla (Fig. 1N) 2-segmented; proximal segment large, bent and unarmed; distal segment tipped with 3 unequal, pinnate spines. Maxilliped (Fig. 1O) 2-segmented; proximal segment (syncoxa) small and inconspicuous; distal segment (basis or corpus) robust, with 3 setae in myxal region and another 3 setae (1 of them very small) in distal region.

Armature on rami of legs 1–4 as follows (Roman and Arabic numerals indicate spines and setae, respectively):

	Coxa	Basis	Exopod	Endopod
Leg 1	0 – 1	1 – 1	1 – 0; 9	0 – 1; 7
Leg 2	0 – 1	1 – 0	I – 0; I– 1; III,I,5	0 – 1; 0 – 2; II,I,3
Leg 3	0 – 1	1 – 0	I – 0; I – 1; II,I,5	0 – 1; 0 – 2; II,I,2
Leg 4	0 – 0	1 – 0	I – 0; I – 1; II,I,5	0 – 1; 0 – 1; I,III

Intercoxal plate of leg 1 (Fig. 2A) with rows of spinules on mid-posterior protuberance. Legs 2 (Fig. 2B), 3 (Fig. 2C) and 4 (Fig. 2D) with row of spinules on postero-lateral margin of intercoxal plate and each spine on their 1st and 2nd expodal segments bearing subterminal flagellum. Proximal

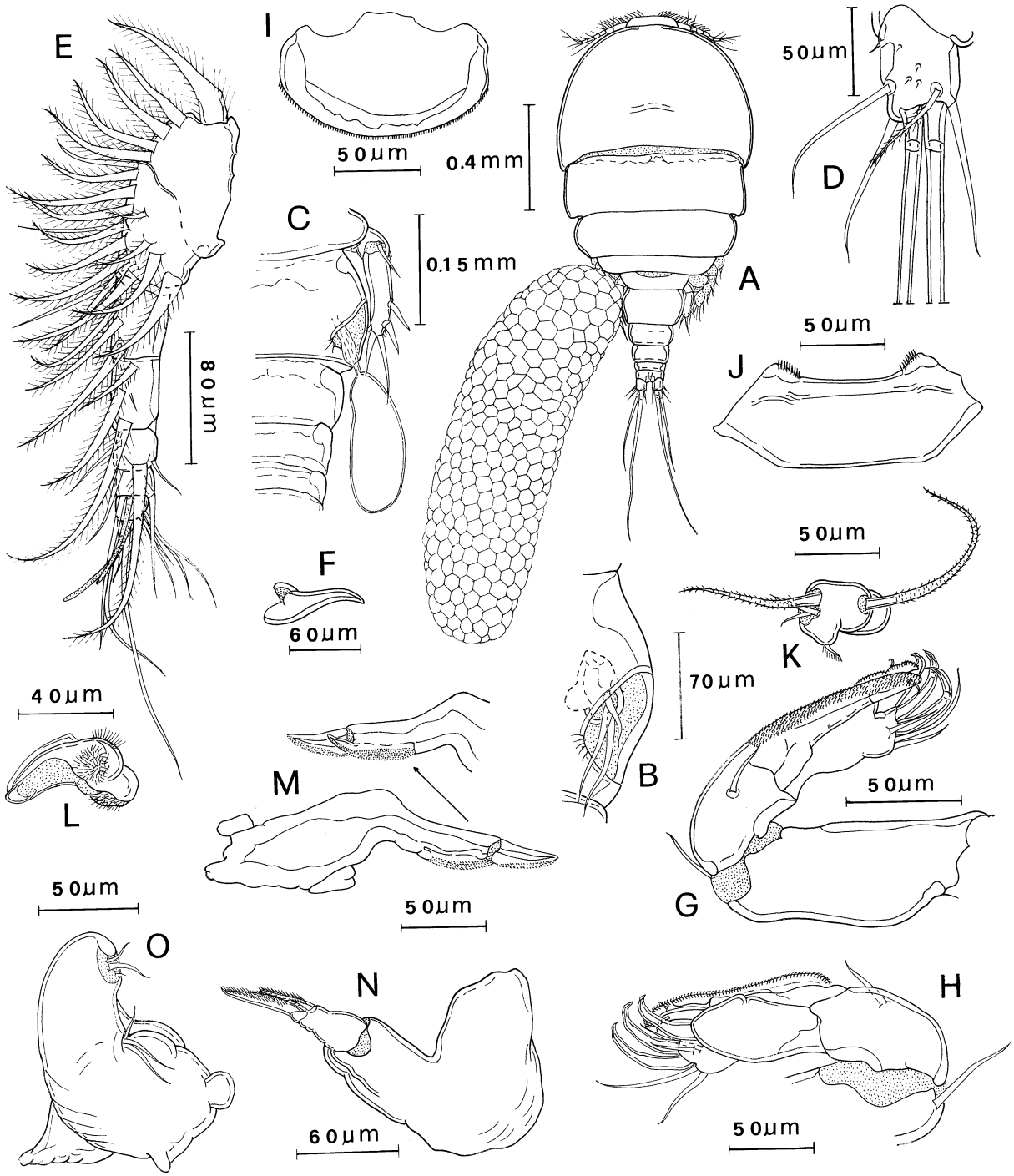

Fig. 1 *Irodes parupenei* n. sp., female. A. habitus, dorsal; B. egg-sac attachment area, dorsal; C. right half of urosome, dorsal; D. caudal ramus, dorsal; E. antennule, ventral; F. postantennal process, ventral; G. antenna, anterior; H. antenna, posterior; I. labrum; J. postoral plate; K. maxillule; L. paragnath; M. mandible; N. maxilla; O. maxilliped

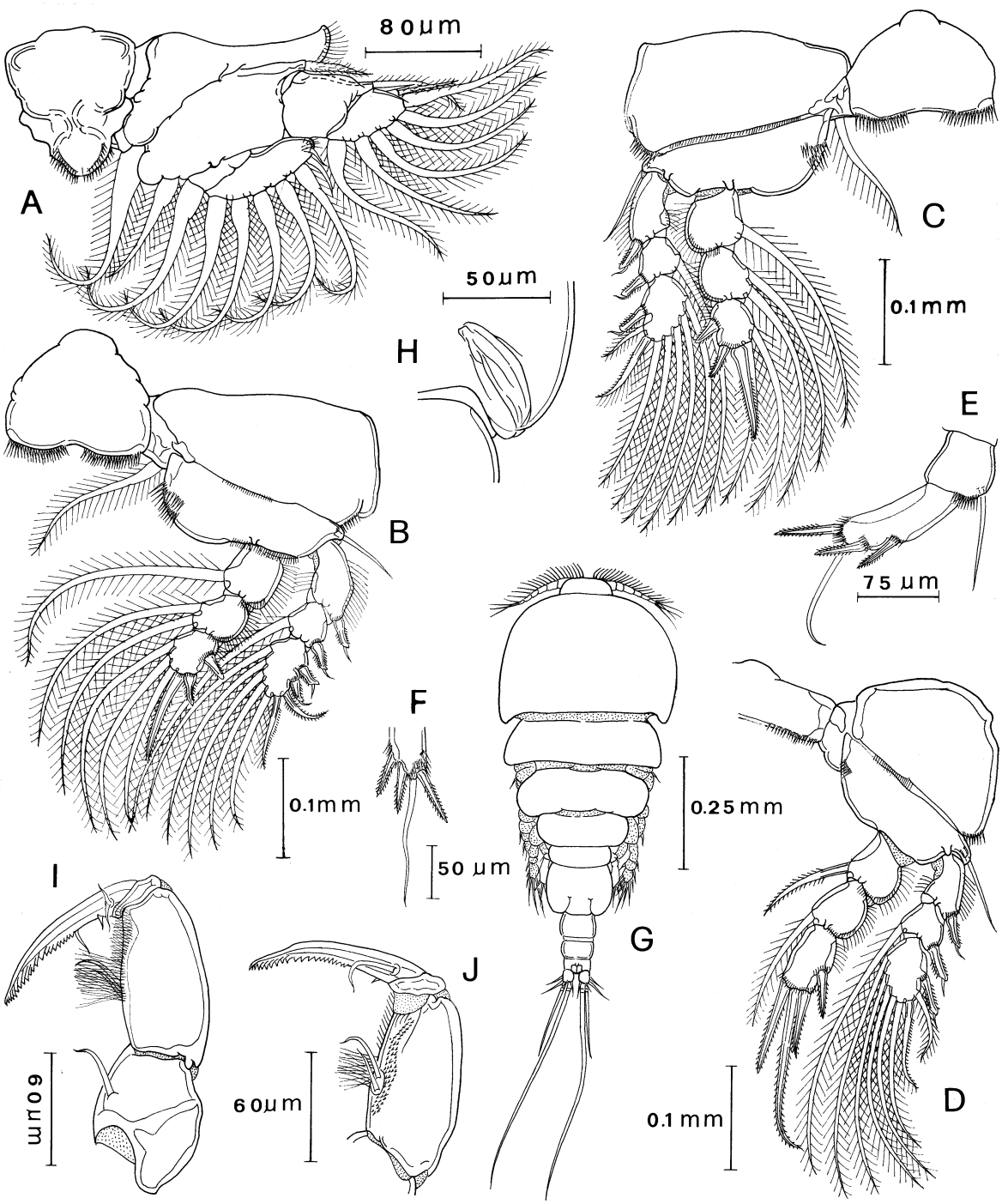

Fig. 2 *Irodes parupenei* n. sp. Female: A. leg 1, anterior; B. leg 2, anterior; C. leg 3, anterior; D. leg 4, anterior; E. leg 5, ventral; F. tip of leg 5. Male: G. habitus, dorsal; H. posterolateral corner of genital somite, ventral; I. maxilliped, anterior; J. middle and distal parts of maxilliped, posterior

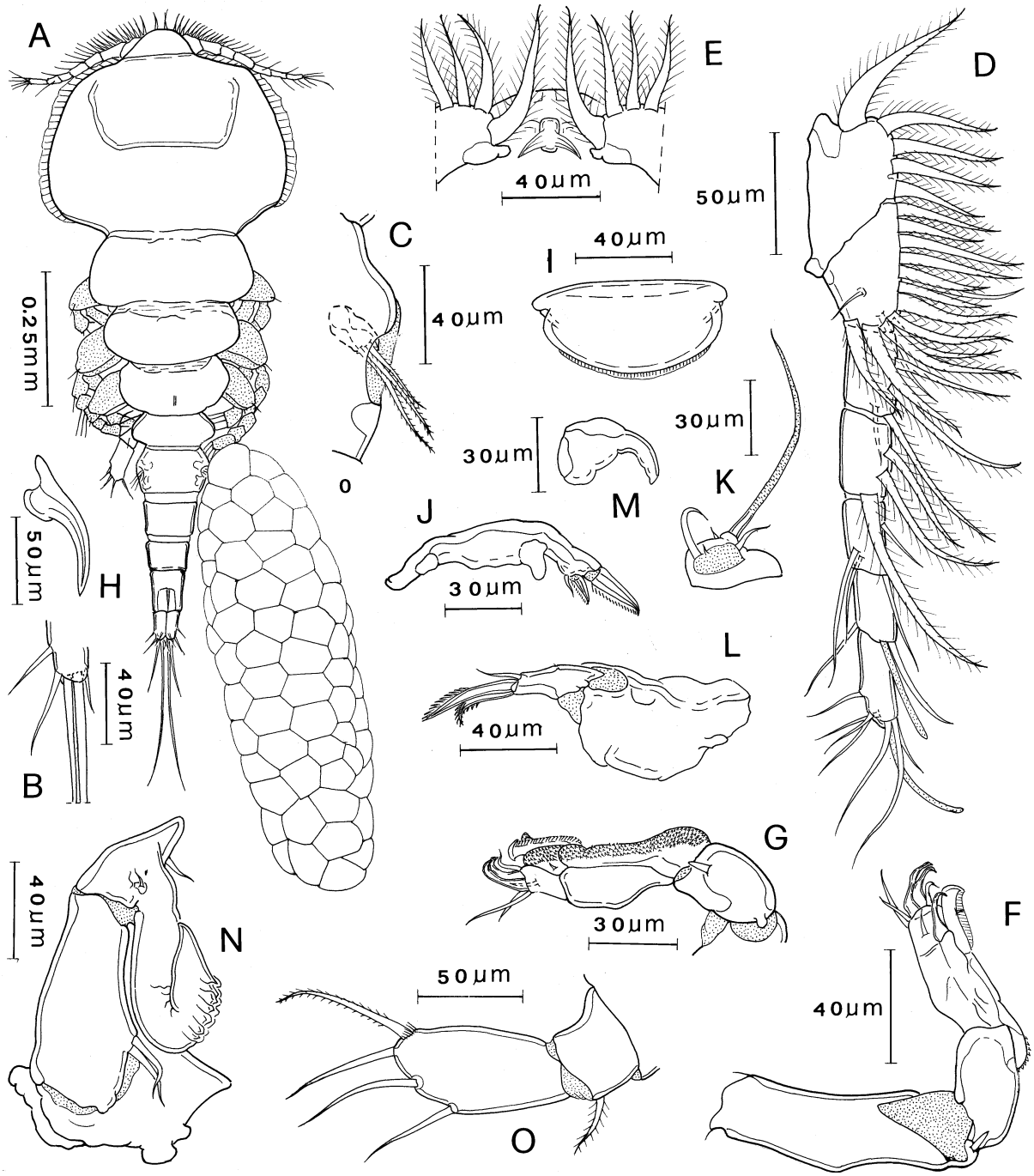

Fig. 3 *Taeniacanthus spiniferus* n. sp., female. A. habitus, dorsal; B. tip of caudal ramus, ventral; C. egg-sac attachment area, dorsal; D. antennule, ventral; E. rostral area, ventral; F. antenna, posterior; G. middle and distal segments of antenna, anterior; H. postantennal process, ventral; I. labrum, ventral; J. mandible; K. maxillule; L. maxilla; M. paragnath; N. maxilliped; O. leg 5

2 spines on 3rd exopodal segment of leg 2 and proximal spine on 3rd exopodal segment of legs 3 and 4 also bearing subterminal flagellum. Leg 5 (Fig. 2E) 2-segmented; proximal segment subsquare and wider than distal segment, armed with long, outer seta; distal segment slender, nearly 3

times as long as wide, and carrying 3 pinnate spines and 1 long, naked seta (Fig. 2F); both segments with spinules at bases of spines and setae. Leg 6 represented by 3 long, naked setae on genital operculum, located in pit for attachment of egg-sac (Fig. 1B).

Male (Fig. 2G–J)
Body (Fig. 2G) 0.85 (0.82–0.88) mm long, excluding setae on caudal rami. Cephalothorax wider than long, 299 (292–308) × 398 (373–413) μm, with broadly protruded rostrum and slightly protruded postero-lateral corners. First pediger completely fused to cephalosome, but remaining pedigers on prosome distinctly separated from each other and becoming narrower and smaller posteriorly. Urosome 318 (299–332) μm long, shorter than prosome and occupying 37% of body length. Genital somite (Fig. 2G) slightly wider than long, 122 (113–130) × 153 (146–162) um, with prominent postero-lateral lobe; its ventro-lateral ridge (Fig. 2H) without armature or ornamentation. Abdomen 3-segmented (Fig. 2G), without ornamentation. Caudal ramus longer than wide, 32 × 24 μm, and armed with 4 short and 2 long setae.

Maxilliped (Fig. 2I) 4-segmented; proximal segment (syncoxa) armed with medial seta; 2nd segment (basis or corpus) with 2 myxal setae and rows of denticles and setules on medial surface; 3rd segment (1st endopodal segment) smallest and unarmed; terminal endopodal segment a long, slightly curved claw with serrations on medial margin and 4 setae in basal region, 1 on medial margin, 2 on anterior side (Fig. 2I) and 1 on posterior side (Fig. 2J).

Remarks

In using the key to the species of *Irodes* provided by Ho, Kim, & Sey (1999), the specimens from Taiwan were keyed out to *I. upenei* (Yamaguti, 1954). However, a close comparison of our specimens with the redescription of *I. upenei* given by Dojiri & Cressey (1987) showed that they are not conspecific. The new species differs from *I. upenei* by having in the female: (1) no sclerite on the ventral surface of the rostrum; (2) nine (instead of eight) elements on the terminal segment of the leg 2 exopod; (3) a spiniform element (instead of a long, plumose seta) on the medial margin of the proximal segment of the leg 4 endopod; (4) the terminal segment of leg 5 slender (rather than spatulate) and armed with three spines and one long, naked seta (rather than four short setae); and (5) a large, multiseriate egg-sac longer than the body length. The male of the new species also differs in lacking ornamentation on the ventral surface of the anal somite and in the fine structures on the corpus and terminal claw of the maxilliped. Additional differences are found in the number of rows of spinules on large pectinate process of the antenna and the mandibular blades, and the fine details of the exopodal spines of legs 2 to 4.

***Taeniacanthus spiniferus* n. sp.**

Material examined
All parasites found on gills of *Acanthocepola limbata* Valenciennes: 33 ♀♀ on 21 hosts landed at Dong-gang Fishing Port in Ping-dong County, Taiwan on 29 July 2003, and 13 ♀♀ on 8 hosts landed at Dah-hsi Fishing Port in I-lan County on 5 July 2004.
Type-material: Holotype (USNM 1083913) and 20 paratypes (USNM 1083914) are deposited in the National Museum of Natural History, Smithsonian Institution, Washington, DC; the remaining specimens are in the collection of the junior author.
Etymology: The specific name *spiniferus* is a combination of the Latin words *spina* (= thorn, spine) and *ferre* (= to carry or bear). It is treated as an adjective and alludes to the possession of a pair of tines on the ventral surface of the rostral area.

Description

Female (Figs. 3A–O, 4A–D)
Body (Fig. 3A) 1.109 (0.948–1.264) mm long, excluding setae on caudal rami. Cephalothorax wider than long, 388 (327–462) × 442 (381–518) μm; lateral margin fringed with narrow hyaline membrane. Three free somites in metasome well separated and decreasing in size posteriorly. Urosome moderately long, *c.*37% of body length. Genital double-somite (Fig. 3A) wider than long,

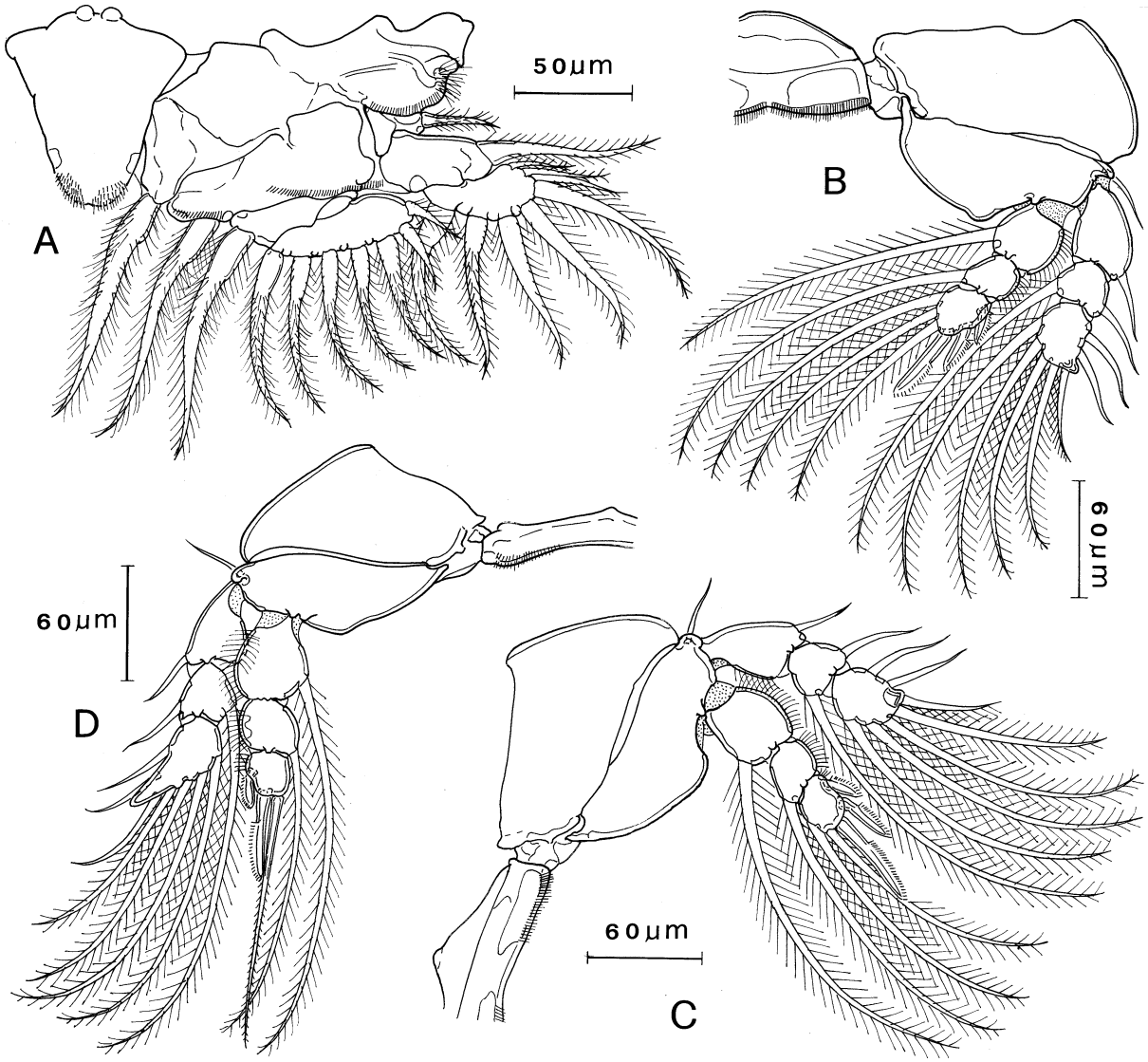

Fig. 4 *Taeniacanthus spiniferus* n. sp., female. A. leg 1, anterior; B. leg 2, anterior; C. leg 3, anterior; D. leg 4, anterior

88 (81–93) × 132 (113–146) µm, protruded outward in middle region. Abdomen (Fig. 3A) 3-segmented; first 2 somites wider than long; anal segment longer than wide. Caudal ramus longer than wide, 56 (44–58) × 22 (19–24) µm, armed with 4 short and 2 long setae (in Fig. 3B one short dorsal seta not shown). Egg-sac (Fig. 3A) large, shorter than body, 860 µm in length.

Rostral area broadly protruded anteriorly (Fig. 3A), armed with widely diverged pair of sharp tines on ventral surface (Fig. 3E). Antennule (Fig. 3D) 7-segmented; armature formula: 5, 15, 4, 3, 4, 2 + ae and 7 + ae. Antenna (Fig. 3F) 4-segmented; proximal segment (coxobasis) bears single distal seta; 1st endopodal segment bears short outer seta (Fig. 3G); 2nd endopodal segment with 1 curved terminal claw, 1 short pectinate process bearing 1 small naked seta at about mid-length, and 1 long spinulose processe with 3–5 rows of spinules, 1 distal seta and 1 curved terminal claw; 3rd endopodal segment tipped with 3 curved claws and 3 naked setae (Fig. 3G). Postantennal process (Fig. 3H) strongly curved. Labrum (Fig. 3I) a semi-circular plate fringed with row of spinules on posterior margin. Mandible (Fig. 3J) tipped with 1 seta and

2 unequal, naked blades bearing serrations along posterior margin. Paragnath (Fig. 3M) a bent lobe lacking ornamentation. Maxillule (Fig. 3K) a small lobe tipped with 5 unequal setae. Maxilla (Fig. 3L) 2-segmented; proximal segment large, but unarmed; distal segment tipped with 2 pinnate spines in addition to short, subterminal seta. Maxilliped (Fig. 3N) 3-segmented; proximal segment (syncoxa) amorphous and unarmed; middle segment (basis or corpus) subrectangular, armed with 2 medial setae; distal (endopodal) segment a large, curved, blunt claw with conical, basal projection carrying tiny seta, another tiny seta at base of claw and 7 or 8 transverse ridges along distal portion of claw.

Armature on rami of legs 1–4 as follows (Roman and Arabic numerals indicate spines and setae, respectively):

	Coxa	Basis	Exopod	Endopod
Leg 1	0 – 1	1 – 1	1 – 0; 8	0 – 1; 7
Leg 2	0 – 0	1 – 0	I – 0; I – 1; II,I,4	0 – 1; 0 – 1; II,I,3
Leg 3	0 – 0	1 – 0	I – 0; I – 1; II,I,4	0 – 1; 0 – 1; II,I,2
Leg 4	0 – 0	1 – 0	I – 0; I – 1; II,I,4	0 – 1; 0 – 1; I,II

Intercoxal plate of leg 1 (Fig. 4A) subtriangular, with 2 patches of spinules on protruded posterior margin. Legs 2 (Fig. 4B), 3 (Fig. 4C) and 4 (Fig. 4D) fringed with row of setules on posterolateral margin of intercoxal plate; terminal segment of exopod of leg 4 with medial protuberance on distal corner (Fig. 4D). Leg 5 (Fig. 3O) 2-segmented; proximal segment armed with 1 outer seta; distal segment bears 4 subequal setae and patch of spinules at base of innermost seta. Leg 6 represented by 3 long, pinnate setae on genital operculum, located in pit for attachment of egg-sac (Fig. 3C).

Male
Unknown

Remarks

The new species bears the closest resemblance to *Taeniacanthus acanthocepolae* Yamaguti, 1939 and, in particular, the ''female variant'' of *T. acanthocepolae* reported by Dojiri & Cressey (1987). The two species are alike in their general body form, fine structure of the maxillule, maxilla, maxilliped and the four pairs of thoracopods. However, the new species is readily distinguished from *T. acanthocepolae* and its remaining congeners by the possession of a pair of rostral tines (Fig. 3E) on the ventral surface of the rostral area. While this kind of armature is known in many species of bomolochids, it is rare in taeniacanthids. So far as we are aware, *Pseudotaeniacanthus congeri* Yamaguti & Yamasu, 1959 is the only taeniacanthid that bears a pair of fang-like tines in the rostral area.

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