

A new species of *Anchistrotos* Brian, 1906 (Copepoda: Cyclopoida: Taeniacanthidae) from the filamentous shrimpgoby *Myersina filifer* (Valenciennes) (Perciformes: Gobiidae) in Korean waters

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Abstract A new species of *Anchistrotos* Brian, 1906 (Copepoda: Cyclopoida: Taeniacanthidae), parasitic in the branchial cavities of the filamentous shrimpgoby *Myersina filifer* (Valenciennes) (Perciformes: Gobiidae) from Korea is described. The new species is most closely related to *A. tangi* Venmathi Maran, Moon & Adday, 2014, but differs from it by the following combination of characters in the adult female: the U-shaped rostrum, the distal margin of the anal somite lacks patches of spinules, the proximal segment of the maxilliped is without seta, and the maxilliped claw is armed with long and small naked setae. This is the tenth species of the genus and a key is provided to distinguish all nominal species.

Introduction

Copepods of the family Taeniacanthidae C. B. Wilson, 1911 (Copepoda: Cyclopoida) are typically parasitic on marine teleost fishes or associated with sea urchins (Boxshall & Halsey, 2004). Within the family c.100 species of 21 genera have been described (Dojiri & Cressey, 1987; Tang, 2011; Tang et al., 2011; Kim & Moon, 2013; Uyeno et al., 2013; Venmathi Maran et al.,

2014, 2015). The largest four genera, i.e. *Anchistrotos* Brian, 1906, *Irodes* C. B. Wilson, 1911, *Metataeniacanthus* Pillai, 1963, *Taeniacanthus* Sumpf, 1871, include 69 nominal species (Dojiri & Cressey, 1987; Tang, 2011; Tang et al., 2011; Kim & Moon, 2013; Venmathi Maran et al., 2014). *Anchistrotos* currently contains nine valid species (Dojiri & Cressey, 1987; Venmathi Maran et al., 2014), which are known to parasitize the gills and body surface of marine teleost fishes although one was found associated with sea weed (Leigh-Sharpe, 1935; Kabata, 1979; Dojiri & Cressey, 1987; Boxshall & Halsey, 2004; Venmathi Maran et al., 2014). This genus of copepod parasites has mostly been reported from British waters, the Mediterranean Sea and the Arabian Sea (Dojiri & Cressey, 1987; Venmathi Maran et al., 2014). To date, only a single species of *Anchistrotos* has been reported in gobiid fishes from Korea and Japan: *Anchistrotos kojimensis* Do & Ho, 1983 (Do & Ho, 1983; Suh et al., 1992).

This study provides a detailed description of *Anchistrotos tongyeongensis* n. sp., based on adult specimens collected from the branchial cavities of filamentous shrimpgoby *Myersina filifer* (Valenciennes) (Perciformes: Gobiidae), caught off Tongyeong, southern Korea.

Materials and methods

The host *Myersina filifer* (n = 4) was collected by line fishing from off the southern coast of Korea and

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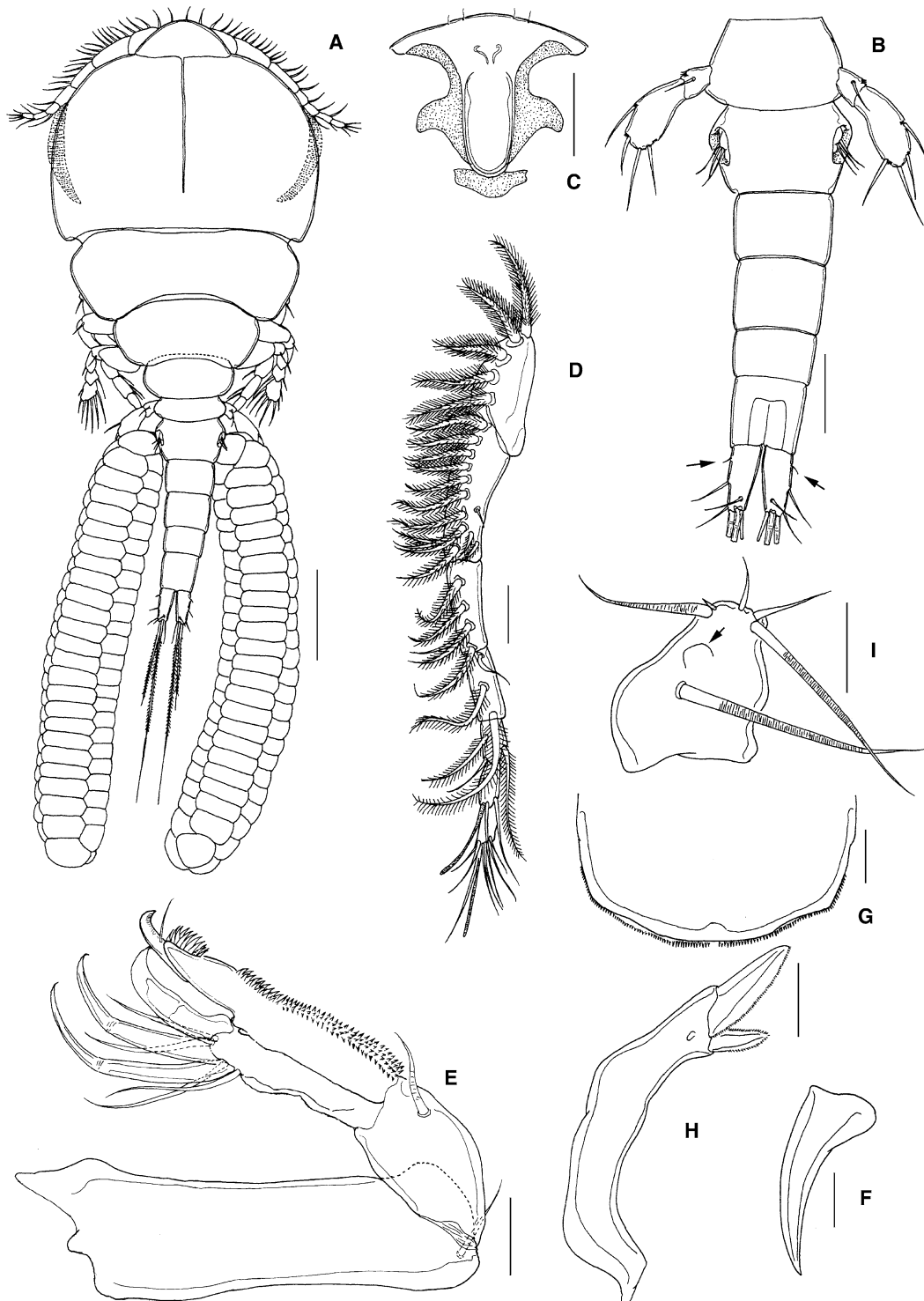


Fig. 1 *Anchistrotos tongyeongensis* n. sp., female, paratype. A, Habitus, dorsal view; B, Urosome, dorsal view (seta I indicated by arrows); C, Rostral area, ventral view; D, Antennules, ventral view; E, Antenna, dorsal view; F, Postantennal process, dorsal view; G, Labrum, ventral view; H, Mandible, ventral view; I, Maxillule, ventral view. Scale-bars: A, 200 μ m; B, 100 μ m; C, D, F, G, 50 μ m; E, H, I, 25 μ m

immediately fixed and preserved in 95% ethanol. The parasitic copepods were carefully removed from the branchial cavities of the host using fine forceps and observed under a dissecting microscope. Copepod specimens were preserved in 70% ethanol and subsequently cleared in a drop of 80% lactic acid prior to examination using an Olympus BX51 differential phase contrast microscope. Examination was carried out using the wooden slide method (Humes & Gooding, 1964). Drawings were made with the aid of a drawing tube mounted on a Nikon Eclipse 80i microscope. After microscopical examination, the dissected appendages were mounted on a slide in lactophenol mounting medium and were sealed with transparent nail varnish. In the descriptions, body length was measured using a micrometer from the anterior margin of the cephalothorax to the posterior margin of the caudal rami excluding setae on caudal rami. All measurements are in micrometres unless otherwise indicated. The morphological terminology follows Dojiri & Cressey (1987) and fish names conform to FishBase (Froese & Pauly, 2015). Type-specimens were deposited in the National Institute of Biological Resources (NIBR), Incheon, Korea.

Family Taeniacanthidae C. B. Wilson, 1911
Genus *Anchistrotos* Brian, 1906

***Anchistrotos tongyeongensis* n. sp.**

Type-host: *Myersina filifer* (Valenciennes) (Perciformes: Gobiidae).

Type-locality: Off Tongyeong (34°76'39"N, 128°42'09"E), southern Korea.

Attachment site: Branchial cavity.

Type-material: Holotype adult female (NIBRIV0000293099) and allotype adult male undissected in 80% ethanol (NIBRIV0000293100); two paratype adult females dissected and mounted on 2 glass slides (NIBRIV0000293106, NIBRIV0000293112).

Etymology: The specific name *tongyeongensis* refers to the type-locality Tongyeong-si, Korea.

Description (Figs. 1–3)

Adult female [Based on three specimens.] Body (Fig. 1A) 1.57–1.65 (1.62) mm long (excluding caudal

setae), 0.69–0.75 (0.72) mm wide. Prosome composed of broad cephalothorax (first pedigerous somite fused with cephalosome) and progressively narrower second to fourth pedigerous somites. Posterodorsal surface of cephalothorax with dorsal frame, sclerotised structure (Fig. 1A). Urosome (Fig. 1B) comprising genital somite and 4 free abdominal somites. Second to fourth pedigerous somites 596 × 241, 382 × 173 and 235 × 106, respectively. Genital somite (Fig. 1B) 1.52 times wider than long, 184 × 121; genital apertures positioned dorsolaterally near middle of somite. Proportional length (%) of abdominal somites 26.2 : 26.7 : 19.3 : 27.8% = 100; abdominal somites lacking ornamentation. Caudal ramus 2.28 times longer than wide, 93 × 41, bearing 7 setae (seta I smallest located anteroventrally); setae II and III with row of minute spinules at base; setae IV and V ornamented with medial row of bristles and lateral row of spinules. Rostral area (Fig. 1C) with U-shaped rostrum, bearing 3 sclerotised plates. Longest egg-sac (Fig. 1A) 1.12 mm long; eggs arranged in 4 rows.

Antennule (Fig. 1D) 7-segmented, armature formula: 5, 15, 5, 3, 4, 2+1 aesthetasc, and 7 + 1 aesthetasc. Antenna (Fig. 1E) composed of coxobasis and 2 endopodal segments; coxobasis with distal seta; first endopodal segment with inner seta; second endopodal segment bears 2 unequal pectinate processes, 3 claw-like spines and 4 unequal setae; large pectinate process with multiple rows of spinules (usual seta not observed, possibly broken off); small pectinate process with row of spinules and minute seta. Postantennal process (Fig. 1F) elongate, evenly curved distally. Labrum (Fig. 1G) with row of tiny spinules along posterior margin. Mandible (Fig. 1H) armed with two apical blades; both blades spinulate along inner margin. Paragnath (Fig. 2A) strongly curved with medial patch of hairs. Maxillule (Fig. 1I) lobate, small knob-like process anteriorly (arrowed in Fig. 1I), bearing 3 long and 3 short naked setae. Maxilla (Fig. 2B) 2-segmented; syncoxa unarmed; basis armed with 2 long spinulate spines and 1 short spinulate spine. Maxilliped (Fig. 2C) 3-segmented; first segment with 1 distal unarmed seta; second segment (corpus) with 2 proximal naked setae and distomedial protrusion; distal segment elongate, curved distally, bearing long (76) and small (10) naked setae, with approximately 10 minute spinules

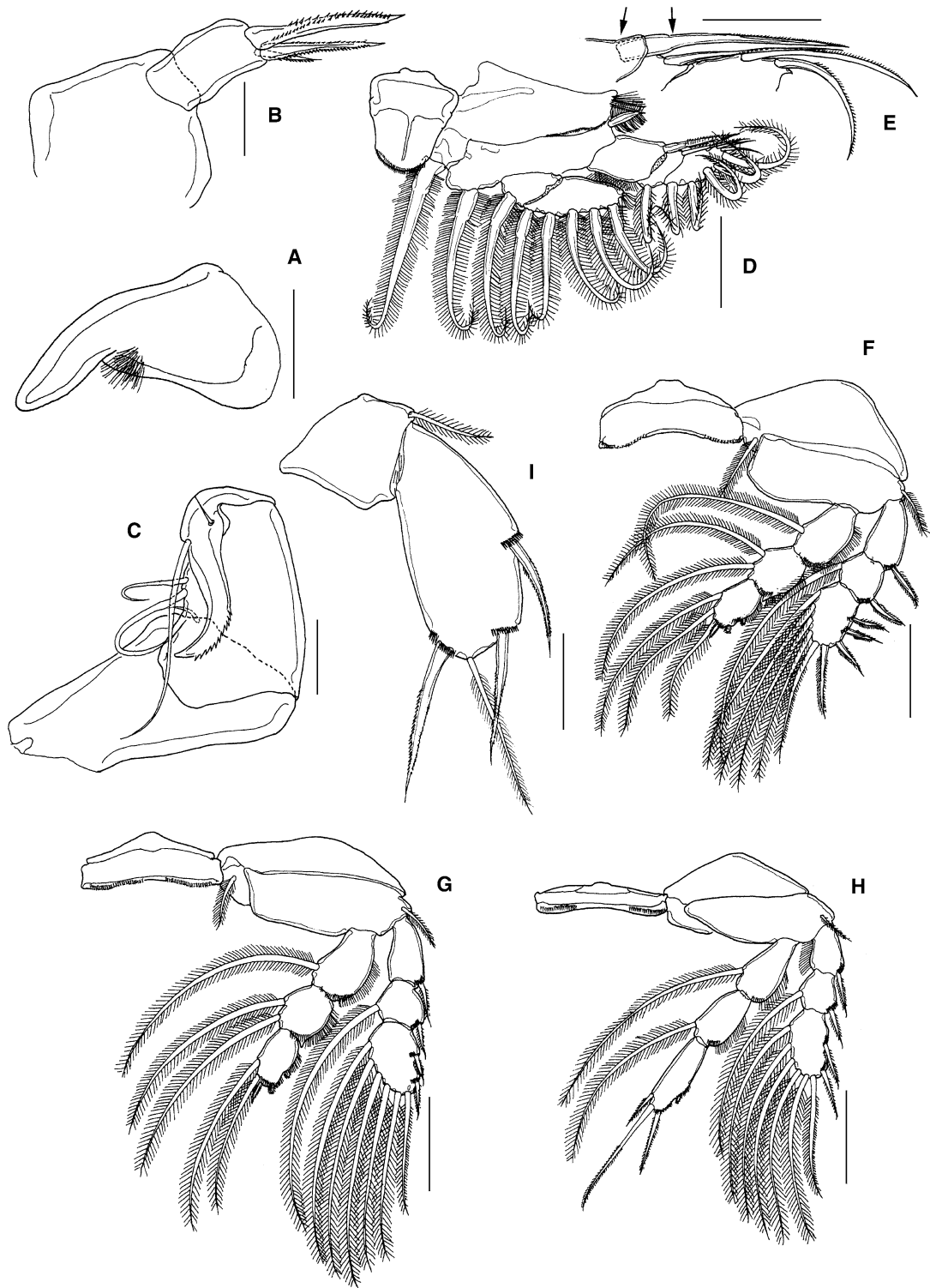


Fig. 2 *Anchistrotos tongyeongensis* n. sp., female, paratype. A, Paragnath, ventral view; B, Maxilla, ventral view; C, Maxilliped, ventral view; D, Leg 1, ventral view; E, Tip of exopodal segments of leg 1; F, Leg 2, ventral view; G, Leg 3, ventral view; H, Leg 4, ventral view; I, Leg 5, ventral view. Scale-bars: A, B, 25 µm; E, I, 50 µm; C, D, F–H, 100 µm

subapically on convex margin and well-developed inner basal protrusion ornamented with hyaline membrane.

Legs 2–4 (Fig. 2F–H) with trimerous rami; leg 1 (Fig. 1D, E) with trimerous exopod and bimerous endopod. Armature on rami of legs 1–4 as follows (Roman numerals, spines; Arabic numerals, setae).

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-1	I-0; I-1; 7 (5, II)	0-1; 6
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; IV

Leg 1 (Fig. 2D, E) lamelliform, coxa, basis and rami flattened. Intercoxal sclerite subtriangular, ornamented with fine spinules along posterior margin. Coxa with patch of long setules on outer margin; coxa and basis ornamented with rows of minute spinules. Outer margin of second endopodal segment with patch of setules. Outer margin of first exopodal segment with long spine (arrowed in Fig. 2E). Leg 2 (Fig. 2F) intercoxal sclerite broad triangular, ornamented with rows of spinules along posterior margin. Coxa and basis without spinules on anterior surface. Leg 2 exopodal spine spinulate along outer margin, each spinule with accessory distal flagellum. Leg 2 endopodal segment with row of spinules along lateral margin;

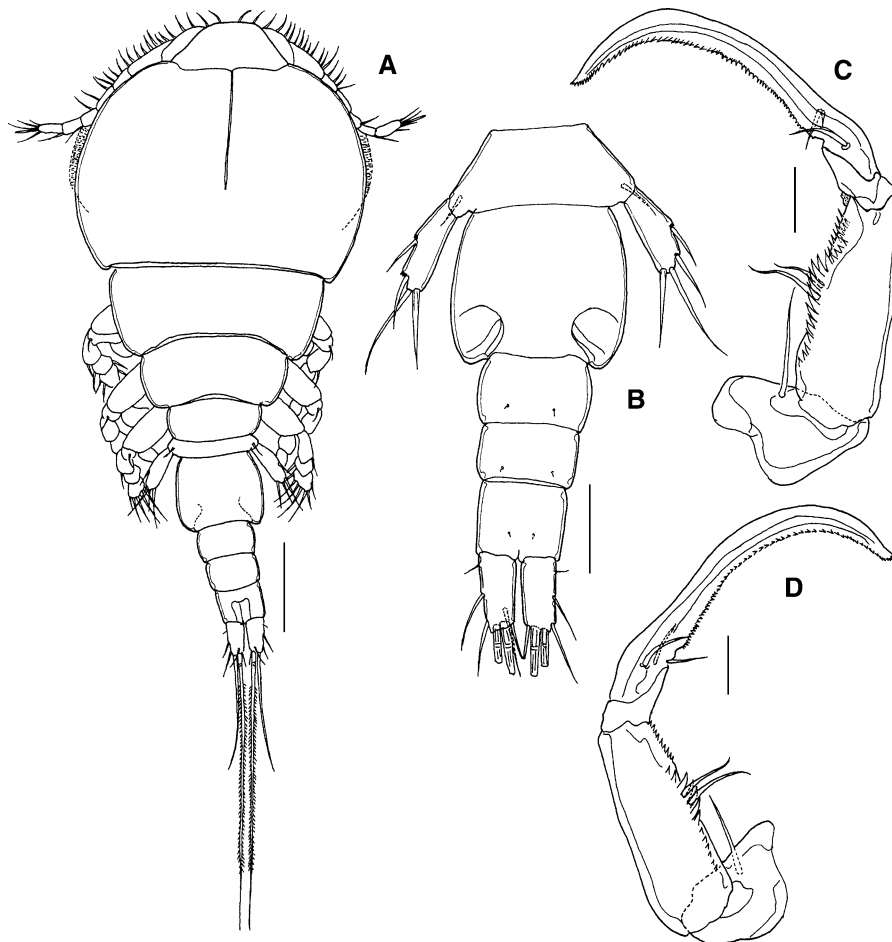


Fig. 3 *Anchistrotos tongyeongensis* n. sp., male, paratype. A, Habitus, dorsal view; B, Urosome, ventral view; C, Maxilliped, ventral view; D, Maxilliped, dorsal view. Scale-bars: A, 100 µm; B, 50 µm; C, D, 25 µm

Table 1 Morphological differences among the nominal species of *Anchistratos*

Species/ Character	Rostral area	Row of spinules on the ventral surface of anal somite	Antennule segments	Two pairs of spiniform processes on the rostral area	Seta on the proximal segment of maxilliped	Tip of terminal segment of maxilliped	Spiniform process on claw of maxilliped	Setal formula on the distal exopodal segment of leg 2	Reference
<i>Anchistratos caligiformis</i> (Gurney, 1927)	protuberant	– ^a	–	present	absent	serrated	absent	III, I, 5	Kabata (1979)
<i>Anchistratos gobii</i> Brian, 1906	ventromedian sclerotised part	–	7	absent	absent	naked	present	III, I, 5	Dojiri & Cressey (1987)
<i>Anchistratos kojimensis</i> Do & Ho, 1983	pair of horizontally directed blunt processes	present	6	absent	absent	serrated	absent	II, I, 5	Do & Ho (1983)
<i>Anchistratos laqueus</i> Leigh-Sharpe, 1935	ventromedian sclerotised part	–	7	absent	absent	serrated	absent	II, I, 5	Dojiri & Cressey (1987)
<i>Anchistratos lucipetus</i> Holmes, 1985	–	absent	6	absent	absent	naked	absent	II, I, 5	Dojiri & Cressey (1987)
<i>Anchistratos onosi</i> (T. Scott, 1902)	–	absent	7	absent	present	naked	absent	III, I, 5	Kabata (1979)
<i>Anchistratos tangi</i> Venmathi Maran, Moon & Adday, 2014	distinct, with sclerotised part	present	7	absent	present	serrated	absent	III, I, 5	Venmathi Maran et al. (2014)
<i>Anchistratos tongyeongensis</i> n. sp.	U-shaped rostrum and 3 sclerotised plates	absent	7	absent	absent	serrated	absent	III, I, 5	This study
<i>Anchistratos wilsoni</i> (A. Scott, 1929)	–	–	7	absent	absent	naked	absent	III, I, 5	Kabata (1979)
<i>Anchistratos zeugopteri</i> (T. Scott, 1902)	–	–	6	absent	Absent	pectinate row of spinules	absent	II, I, 5	Kabata (1979)

^a No data available

second endopodal segment protruded slightly distolaterally and with row of setules along outer corner; spines on distal segment spinulate along outer margin and bearing short spines at tip. Intercoxal sclerite of legs 3 (Fig. 2G) and 4 (Fig. 2H) wider than long, spinulate along posterior margin. Coxa and basis of legs 3 (Fig. 2G) and 4 (Fig. 2H) similar to those of leg 2. Second endopodal segments of legs 3 and 4 each with spinules along outer margin. Distal endopodal segment of leg 4 3.14 times longer than wide, 91×29 .

Leg 5 (Fig. 2I) well developed, 2-segmented. Protopodal segment armed with dorsolateral pinnate seta. Free exopodal segment 2.04 times longer than wide, 127×62 , ornamented with patch of spinules on posterior margin and row of spinules at base of each spine and armed with 3 spinulate spines and seta. Leg 6 (Fig. 1B) vestigial, represented by opercular plate armed with 3 naked setae at genital opening.

Adult male [Based on one specimen.] Body (Fig. 3A) similar to that of female but more slender. Body length 0.71 mm (excluding caudal setae). Cephalothorax 225×319 . Urosome (Fig. 3B) comprised of fifth pedigerous somite, genital somite and 3 free abdominal somites. Fifth pedigerous somite 45×103 . Genital double-somite (Fig. 3B) wider than long, 96×89 . Abdominal somites 3, 38×63 , 32×56 and 48×41 , respectively. Anal somite unornamented (Fig. 3B). Caudal ramus 2.03 times longer than wide, 43×21 , setation as in female.

Maxilliped (Fig. 3C, D) 4-segmented; syncoxa with short, distomedial seta; basis elongate, armed with 2 proximal setae and 2 inner longitudinal rows of spinules (spinules on anterior surface shorter than on medial surface); first endopodal segment short, unarmed; second endopodal segment forming long curved claw, bearing seta on posterior surface, 2 setae on anterior surface and rows of denticles along concave margin. Setal formula and ornamentation of legs 1–5 same as in female. Leg 6 (not figured) vestigial, represented by unarmed opercular plate on posteroventral surface of genital double-somite.

Remarks

The diagnostic features of *Anchistrotos tongyeongensis* n. sp. are: the rostral area, anal somite and maxilliped, and setal formula on the distal exopodal segment of leg 2. The new species is morphologically

similar to *A. laqueus* Leigh-Sharpe, 1935, but can be easily recognised by its four diagnostic features in the adult female: the rostrum is U-shaped (*vs* not U-shaped in *A. laqueus*); the distal segment of the maxilliped bears 1 long and 1 whip-like seta (*vs* two equal, long setae in *A. laqueus*); the setal formula of the distal exopodal segment of leg 2 is III, I, 5 (*vs* II, I, 5 in *A. laqueus*); and the distal endopodal segment of leg 4 is 3 times longer than wide (*vs* less than 3 times in *A. laqueus*) (Leigh-Sharpe, 1935).

Anchistrotos tongyeongensis n. sp. closely resembles *A. tangi*, but differs in the following features in the adult female: the absence of a row of spinules on the anal somite (*vs* spinule row present in *A. tangi*); the distal segment of maxilliped bears 2 unequal (long and short) naked setae (*vs* two long naked setae in *A. tangi*); and the distal seta on the distal endopodal segment is approximately 2 times longer than the inner seta (*vs* 4 times longer in *A. tangi*) (Venmathi Maran et al., 2014).

The new species differs from *A. kojimensis* in the following features of the adult female: the absence of row of spinules on the proximal and distal margins of anal somite (*vs* spinules present in *A. kojimensis*); the distal exopodal segment of leg 2 has an armature formula III, I, 5 (*vs* II, I, 5 in *A. kojimensis*); and the distal endopodal segment of leg 4 can be more than 3 times longer than wide (*vs* less than 3 times in *A. kojimensis*) (Do & Ho, 1983). The adult male of *A. tongyeongensis* n. sp. can be easily differentiated from *A. lucipetus* Holmes, 1985, *A. onosi* (T. Scott, 1902) and *A. zeugopteri* (T. Scott, 1902) by having large spinules on the basis of maxilliped and small denticles along the concave margin of maxillipedal claw.

Discussion

The genus *Anchistrotos* now consists of ten nominal species, including the new species described herein: *A. caligiformis* (Gurney, 1927), *A. gobii* Brian, 1906, *A. kojimensis*, *A. laqueus*, *A. lucipetus*, *A. onosi*, *A. tongyeongensis* n. sp., *A. tangi*, *A. wilsoni* (A. Scott, 1929) and *A. zeugopteri* (T. Scott, 1902). It is evident that *Anchistrotos* may not exhibit a high degree of host-specificity as it has been reported from six host families (Clupeidae, Gobiidae, Lotidae, Rajidae, Scopthalmidae and Serranidae) representing five

orders (Clupeiformes, Gadiformes, Perciformes, Rajiformes and Pleuronectiformes) (see Table 1, Venmathi Maran et al., 2014; this study). Two species of *Anchistrotos* are now reported from Asian waters: *A. kojimensis* from off Japan and Korea (Do & Ho, 1983; Suh et al., 1992) and *A. tongyeongensis* n. sp. from off Korea (present study).

Anchistrotos shares many of the characteristics of *Taeniacanthus* Sumpf, 1981, but differs in features of the maxilliped claw, which has two long whip-like setae extending to or beyond distal limit of the claw and in the segmentation of leg 1 (Dojiri & Cressey, 1987). According to Venmathi Maran et al. (2014) the structure of the rostral area, maxilliped, leg 2 and leg 5 of the adult female are of great significance in the taxonomy of *Anchistrotos* spp. These characters were utilised in the keys to species of *Anchistrotos* by Dojiri & Cressey (1987) and Venmathi Maran et al. (2014), and in a phylogenetic analysis by Tang (2006). In addition, we suggest that the antennule segmentation, the shape of the maxilliped claw, the relative length of two setae on the maxilliped claw, the setal formula of the distal exopodal segment of leg 2 and the length/width ratio of the distal exopodal segment of leg 4 should also be carefully considered as diagnostic features for the identification of *Anchistrotos* spp. The principal differences between *A. tongyeongensis* n. sp. and its congeners are summarised in Table 1. To facilitate the identification of all nominal species, a simple key is provided based on the morphology of adult females.

Key to the females of the genus *Anchistrotos*

- 1a Maxilliped claw reduced to short spiniform process bearing 2 setae near its base (1 modified seta extremely long and whip-like) *A. gobii* Brian, 1906
- 1b Maxilliped claw not reduced 2
- 2a Distal half of maxilliped claw setiform (flexible) *A. laqueus* Leigh-Sharpe, 1935
- 2b Entire maxilliped claw rigid 3
- 3a Setal formula of the distal exopodal segment of leg 2: II, I, 5 4
- 3b Setal formula of the distal exopodal segment of leg 2: III, I, 5 6

- 4a Inner margin (convex) of maxilliped claw serrated *A. kojimensis* Do & Ho, 1983
- 4b Inner margin (convex) of maxilliped claw not serrated 5
- 5a Maxilliped longer seta approximately twice length of claw *A. lucipetus* Holmes, 1985
- 5b Maxilliped tapering and almost straight *A. zeugopteri* (T. Scott, 1902)
- 6a Two pairs of spiniform processes present on posteroventral surface of the rostral area *A. caligiformis* (Gurney, 1927)
- 6b Posteroventral surface of rostral area lacking pairs of spiniform processes 7
- 7a Proximal segment of maxilliped with seta 8
- 7b Proximal segment of maxilliped without seta 9
- 8a Row of spinules present anteroventrally on anal somite; longest outer seta approximately equal in length to maxilliped claw *A. tangi* Venmathi Maran, Moon & Adday, 2014
- 8b Anal somite lacking anteroventral rows of spinules; longest outer seta approximately 1.5 times length of maxilliped claw *A. onosi* (T. Scott, 1902)
- 9a Outer seta longer than inner seta on distal segment of maxilliped *A. wilsoni* (A. Scott, 1929)
- 9b Outer seta shorter than inner seta on distal segment of maxilliped *A. tongyeongensis* n. sp.

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Conflict of interest The authors declare that they have no conflict of interest.

Compliance with ethical standards All applicable institutional, national and international guidelines for the care and use of animals were followed.

References

Boxshall, G. A., & Halsey, S. H. (2004). *An introduction to copepod diversity*. London: The Ray Society, 966 pp.

- Do, T. T., & Ho, J.-S. (1983). *Anchistrotos kojimensis* sp. nov. (Copepoda: Taeniacanthidae) parasitic on *Acanthogobius flavimanus* (Pisces: Teleostei) in Kojima Bay, Japan. *Fish Pathology*, 18, 1–5.
- Dojiri, M., & Cressey, R. F. (1987). Revision of the Taeniacanthidae (Copepoda: Poecilostomatoida) parasitic on fishes and sea urchins. *Smithsonian Contributions to Zoology*, 447, 1–250.
- Froese, R., & Pauly, D. (Eds) (2015). FishBase. World Wide Web electronic publication. Available from <http://www.fishbase.org/> (Accessed 16 March 2015).
- Humes, A. G., & Gooding, R. U. (1964). A method for studying the external anatomy of copepods. *Crustaceana*, 6, 238–240.
- Kabata, Z. (1979). *Parasitic Copepoda of British fishes*. London: The Ray Society, 468 pp.
- Kim, I.-H., & Moon, S. Y. (2013). Ten new species of parasitic cyclopoid copepods (Crustacea) belonging to the families Bomolochidae, Philichthyidae, and Taeniacanthidae from marine fishes in Korea. *Ocean Science Journal*, 48, 361–398.
- Leigh-Sharp, W. H. (1935). *Anchistrotos laqueus* n. sp. a parasitic copepod of *Serranus cabrilla*. *Parasitology*, 27, 266–269.
- Suh, H. L., Shim, J. D., & Choi, S. D. (1992). Four species of Copepoda (Poecilostomatoida) parasitic on marine fishes of Korea. *Bulletin of the Korean Fisheries Society*, 25, 291–300.
- Tang, D. (2006). Phylogeny of the copepod family Taeniacanthidae. Proceedings of the 11th International Congress of Parasitology, Glasgow, UK, 6–11 August 2006, Medimond, Bologna, pp. 621–625.
- Tang, D. (2011). A new species of *Taeniacanthus* (Copepoda: Taeniacanthidae) parasitic on two pufferfish species, *Marilyna meraukensis* and *M. darwinii* (Teleostei: Tetraodontidae), from Australia. *Folia Parasitologica*, 58, 233–239.
- Tang, D., Uyeno, D., & Nagasawa, K. (2011). Species of *Taeniacanthus* Sumpf, 1871 (Crustacea: Copepoda: Taeniacanthidae) parasitic on boxfishes (Tetraodontiformes: Aracanidae and Ostraciidae) from the Indo-West Pacific region, with descriptions of two new species. *Systematic Parasitology*, 80, 141–157.
- Uyeno, D., Tang, D., & Nagasawa, K. (2013). *Saging cebuana*, a new genus and species of taeniacanthid copepod (Cyclopoida) parasitic on a filefish (Actinopterygii: Monacanthidae) collected from Cebu Island, the Philippines. *Raffles Bulletin of Zoology*, 61, 515–523.
- Venmathi Maran, B. A., Moon, S. Y., & Adday, T. K. (2014). A new species of *Anchistrotos* (Copepoda: Taeniacanthidae) from hilsa shad, *Tenualosa ilisha* (Actinopterygii: Clupeidae), off Iraq. *Folia Parasitologica*, 61, 479–484.
- Venmathi Maran, B. A., Moon, S. Y., T. K. Adday., & Tang, D. (2015). *Cepolacanthus kimi*, a new genus and species of copepod (Cyclopoida: Taeniacanthidae) parasitic on Bandfish *Acanthocephala abbreviata* (Valenciennes, 1835) (Actinopterygii: Cepolidae) caught off the Iraqi coast. *Zootaxa* (in press).