

New host and first description of a male *Anchistrotos kojimensis* Do and Ho, 1983 (Copepoda: Cyclopoida: Taeniacanthidae) from Korean waters

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Taeniacanthid copepods *Anchistrotos kojimensis* Do and Ho, 1983 were collected from the branchial cavities of stichaeid fish, *Ernogrammus hexagrammus* (Schlegel) and yellowfin goby, *Acanthogobius flavimanus* (Temminck and Schlegel) in Korean waters. Here, we provide the first description of a male of *Anchistrotos* Do and Ho, 1983. A close comparison of the specimens of *A. kojimensis* collected from Korea with the original description revealed differences in the adult female: (1) the caudal ramus bears seven setae (seta I minute); (2) the maxillule with small knob-like process anteriorly; (3) leg 5 ornamented with patched spinules distally and having row of spinules at base of each spine and distal seta. The first description of the adult male reveals the following features: (1) the distal abdominal somite had rows of spinules anteriorly and near insertion of each caudal ramus; (2) the postantennal process is more elongate than in the female; (3) the basis of maxilliped is with two prosimomedial setae, two longitudinal rows of stout denticles found on posteromedial surface and row of spinules on anteromedial surface; and (4) the second endopodal segment is a strongly curved claw, with a row of stout denticles along a concave margin, two long and one small setae.

Keywords: *Anchistrotos kojimensis*, Copepoda, *Ernogrammus hexagrammus*, fish parasite, Korea

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DOI:10.12651/JSR.2017.6(S).008

INTRODUCTION

Most of the species belonging to the genus *Anchistrotos* Brian, 1906 are parasites that inhabit the gills and body surface of marine teleost fishes and approximately ten species have been described to date (Dojiri and Cressey, 1987; Boxshall and Halsey, 2004; Venmathi Maran *et al.*, 2014; Moon *et al.* 2015). The genus has hitherto been recorded off Plymouth, England, the Mediterranean Sea, the Arabian sea, and the western North Pacific (Do and Ho, 1983; Dojiri and Cressey, 1987; Suh *et al.*, 1992; Venmathi Maran *et al.*, 2014; Moon *et al.*, 2015). Of these, only two species have been recorded from Korea and Japan: *Anchistrotos kojimensis* Do and Ho, 1983 and *A. tongyeongensis* Moon, Lee and Kim, 2015 (Do and Ho, 1983; Suh *et al.*, 1992; Kim, 2014; Moon *et al.*, 2015).

Anchistrotos kojimensis Do and Ho, 1983 was originally described and illustrated from the yellowfin goby, *Acanthogobius flavimanus* (Temminck and Schlegel) in Kojima Bay, Japan (Do and Ho, 1983). Later, *A.*

kojimensis was found in *A. flavimanus* and the javelin goby, *Synechogobius hasta* (Temminck and Schlegel) in Korean waters, but only the adult female was described (Suh *et al.*, 1992; Kim, 2014).

In a recent survey, several specimens of *A. kojimensis* were found in a stichaeid fish, *Ernogrammus hexagrammus* (Schlegel), and yellowfin goby (*A. Flavimanus*) in Korean waters. In this paper, we provide a detailed illustration and description of both male and female specimens of *A. kojimensis*. This is the first description of a male *A. kojimensis*, and in addition is a new host record.

MATERIALS AND METHODS

The hosts *Ernogrammus hexagrammus* ($n=6$) and *Acanthogobius flavimanus* ($n=3$) were collected by line fishing off the southern coast of Korea and 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 dis-

secting 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 and Gooding, 1964). Drawings were made with the aid of a drawing tube mounted on a Nikon Eclipse 80i microscope. After microscopic 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 micrometers unless otherwise indicated. The morphological terminology follows Dojiri and Cressey (1987) and fish names conform to FishBase (Froese and Pauly, 2016). Specimens were deposited in the National Institute of Biological Resources (NIBR), Incheon, Korea.

SYSTEMATIC ACCOUNTS

Systematics

Order Cyclopoida Burmeister, 1835 *검물벼룩목*
 Family Taeniacanthidae C. B. Wilson, 1911
띠아가미이과
 Genus *Anchistrotos* Brian, 1906 *이웃띠아가미이속*

Anchistrotos kojimensis Do and Ho, 1983 (Figs. 1-3)

Korean name: Go-ji-ma-tti-a-ga-mi-i
 (고지마띠아가미이)

Anchistrotos kojimensis Do and Ho, 1983, p. 1, figs. 1-19; Dojiri and Cressey, 1987, p. 148; Suh, Shim and Choi, 1992, p. 297, fig. 4; Kim, 2014, p. 166, figs. 102-104.

Material examined. 2 adult females and 2 adult males (1 vial, NIBRIV0000293069) collected from yellowfin goby, *Acanthogobius flavimanus* (Temminck et Schlegel) (Perciformes: Gobiidae) at Gamak Bay (34°74'72" N, 127°65'92" E), southern Korea, 25 September 2009; 1 adult female and 1 adult male (1 vial, NIBRIV0000293070) from *Ernogrammus hexagrammus* at intertidal mudflat in Wando Island (34°35'71" N, 126°73'89" E), 15 March 2013.

Diagnosis of female. Body (Fig. 1A) 1.46 mm long (excluding caudal setae) and 0.47 mm wide. Prosome composed of broad cephalothorax (first pedigerous somite fused with cephalothorax) and progressively narrower second to fourth pedigerous somites. Posterodorsal surface of cephalothorax with dorsal frame, sclerotised structure. Urosome (Fig. 1B) comprised of genital somite and 4 free abdominal somites. Second to fourth

pedigerous somites 462 × 213, 356 × 163 and 237 × 103 μm, respectively. Urosome comprising genital somite and 4 free abdominal somites. Genital somite 191 × 134 μm; genital apertures positioned dorsolaterally near mid-way of somite. Proportional length (%) of first to fourth abdominal somites 29.7 : 24.4 : 15.8 : 30.1 = 100; first to third abdominal somites naked; distal abdominal somite with 2 transverse rows of spinules anteriorly and row of spinules near insertion of each caudal ramus. Caudal ramus (Fig. 1B) weakly tapering, approximately 2.24 times longer (85 μm) than wide (38 μm), bearing 7 setae (seta I minute; arrowed in Fig. 1B); setae II and III with row of minute spinules at base; setae IV ornamented with medial row of bristles and lateral row of spinules; seta V (448 μm) long, with outer row of spinules only. Rostral area (Fig. 1C) wider than long, bears inverted U-shaped, with sclerotized plates. Longest egg sac (Fig. 1A) 648 μm long, eggs arranged in 4 rows.

Antennule (Fig. 1C) 6-segmented, with armature formula: 5, 15, 8, 4, 2 + 1 aesthetasc, 7 + 1 aesthetasc. Antenna (Fig. 1D, E) 3-segmented (second and third endopodal segments fused); composed of coxobasis and 2 endopodal segments; coxobasis with distal seta; proximal 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 seta and several rows of spinules medially; short pectinate process with long seta and row of spinules (Fig. 1E). Postantennal process (Fig. 1F) stout and slightly curved.

Labrum nearly hemispherical, with fine spinules along posterior and lateral margin (not figured). Mandible (Fig. 1G) with broad expansion proximally and 2 large and 1 small, broad, conical spines. Paragnath (Fig. 1H) with basal patch of setules and single row of minute spinules. Maxillule (Fig. 1I) lobate, small knob-like process posteriorly, bears 2 long and 4 short naked setae (one spiniform seta with denticles at tip); longest seta (arrow in Fig. 31) with row of minute spinules at tip. Maxilla (Fig. 1J) 2-segmented; syncoxa with numerous pores; basis armed with spinulate terminal process and 2 subequal elements (spine with unilateral row of spinules; seta naked). Maxilliped (Fig. 2A) 3-segmented; first (basal) segment large, irregularly-shaped, with naked seta; second segment (corpus) with 2 proximal naked setae and distomedial protrusion; terminal segment elongate, curved distally, bearing 2 subequal long (76 μm) and small (59 μm) naked setae, with approximately 19 minute spinules medially to apically and well-developed inner basal protrusion ornamented with hyaline membrane.

Leg 1 (Fig. 2B, C) with 3-segmented exopod and 2-segmented endopod; suture incomplete between 2 distal segments of exopod. Legs 2 (Fig. 2D, E), 3 (Fig. 2F), and 4 (Fig. 2G, H) with 3-segmented rami. Inner coxal

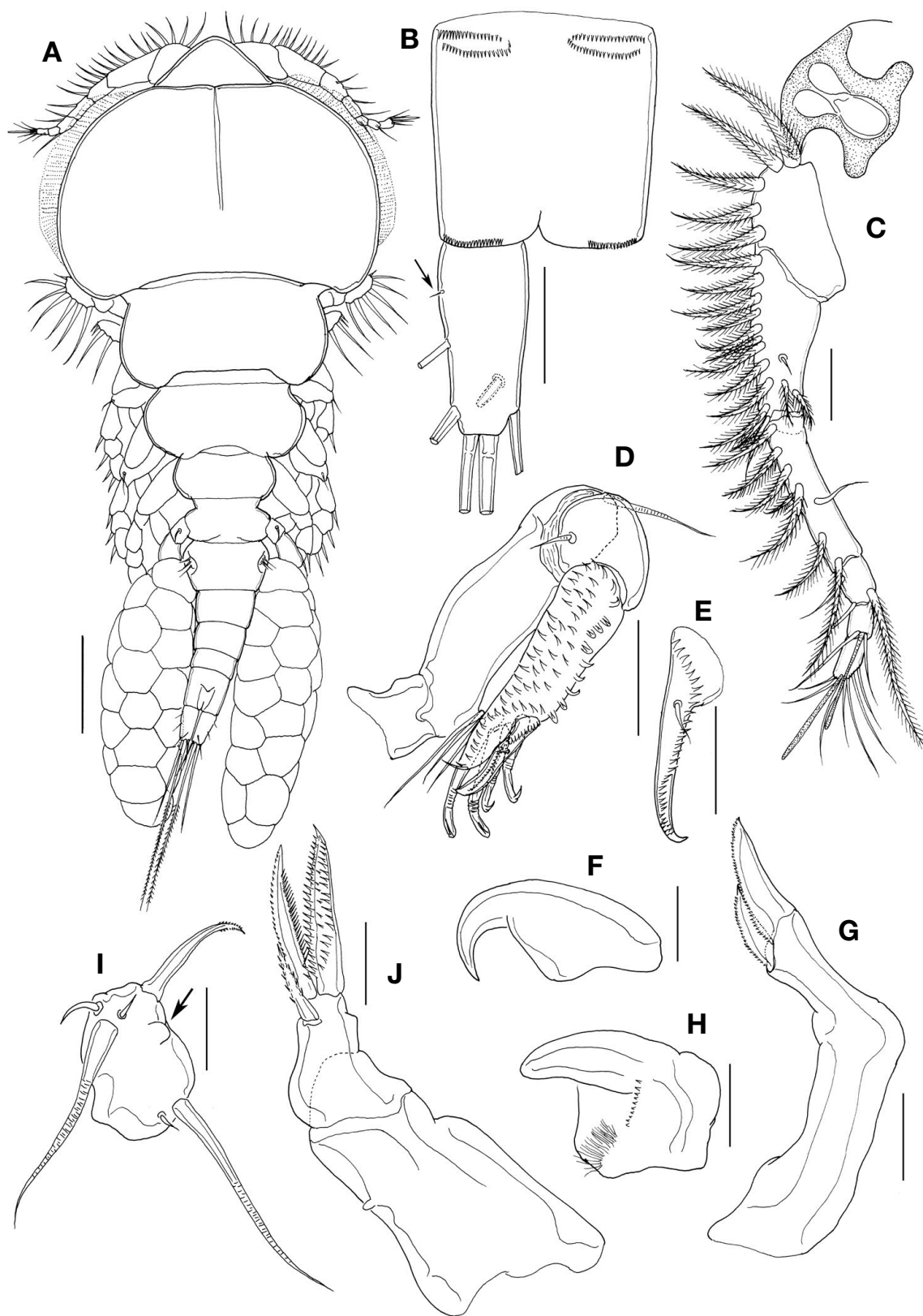


Fig. 1. *Anchistrotos kojimensis* Do and Ho, 1983, female: A, habitus, dorsal; B, anal somite and cardal ramus, ventral (seta I indicated by arrow); C, rostral area and antennules; D, antenna; E, short pectinate process of antenna; F, postantennal process; G, mandible, ventral; H, paragnath; I, maxillule; J, maxilla. Scale bars = 200 μ m (A), 50 μ m (B-D), 25 μ m (E-J).

seta present in legs 1-3, but absent in leg 4.

Armature formula of legs 1-4 as follows (Roman numerals = spines; Arabic numerals = setae):

	Coxa	Basis	Exopod	Endopod
Leg 1	0-1	1-1	I-0; 1-1; 2,1,4	0-1; 6
Leg 2	0-0	1-0	I-0; I-1; II,2,4	0-1; 0-2; II, I, 3
Leg 3	0-0	1-0	I-0; I-1; II,2,4	0-1; 0-2; II, I, 2
Leg 4	0-0	1-0	I-0; I-1; II,2,4	0-1; 0-1; 1,2,1

Leg 1 coxa (Fig. 2B) with long row of setules along outer border and several rows of spinules on anterior surface; basis with distal row of spinules; first exopodal segment with long outer spine (arrowed in Fig. 2C). Legs 2 (Fig. 2D), 3 (Fig. 2E), and 4 (Fig. 2F, G) distal spine on endopodal segments with acute-like at tip. Terminal endopodal segment of leg 4 (Fig. 2F) 1.94 times longer (66 μ m) and wide (34 μ m). Leg 5 (Fig. 2H) well developed, 2-segmented. Protopodal segment armed with 1 dorsolateral pinnate seta and outer patch of minute spinules. Free exopodal segment 1.98 times longer than wide, 107 \times 54 μ m, ornamented with patched spinules distally and having row of spinules at base of each spine and distal seta and armed with 3 spinulate spines and seta.

Leg 6 (not figured) vestigial, represented by opercular plate armed with 3 naked setae at genital opening.

Diagnosis of male. Body 0.69 mm long (excluding caudal setae). Urosome (Fig. 3B) comprised of fifth pedigerous somite, genital somite and 3 free abdominal somites. Genital somite (Fig. 3B) 88 \times 92 μ m; genital apertures positioned dorsolaterally near midway of somite. Proportional length (%) of first to third abdominal somites 33.6 : 23.9 : 42.5 = 100; first and second abdominal somites naked; distal abdominal somite with transverse rows of stout spinules near insertion of each caudal ramus. Caudal ramus (Fig. 3B) 2.15 times longer (43 μ m) than wide (20 μ m), bearing similar elements as in female. Postantennal process (Fig. 3C) more elongate than in female. Maxilliped (Fig. 3D) 4-segmented; syncoxa irregularly-shaped, bearing seta; basis robust, armed with 2 proximomedial setae, 2 longitudinal rows of stout denticles on posteromedial surface and row of spinules on anteromedial surface; first endopodal segment small, unarmed; second endopodal segment forming strongly curved claw, with row of stout denticles along concave margin, 2 long setae and 1 small seta. 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 somite.

Distribution. *Anchistrotos kojimensis* has been reported from Japan (Do and Ho, 1983) and Korea (Suh *et al.*, 1992; Kim, 2014; this study).

Hosts. *Anchistrotos kojimensis* are parasites of *Acanthogobius flavimanus* (Temminck and Schlegel), *Synochogobius hasta* (Temminck and Schlegel), and *Ernogrammus hexagrammus* (Schlegel).

Attachment site. Branchial cavity wall and gill filaments.

Remarks. *Anchistrotos* has the following major features which provide a key for females within this genus: presence or absence on the ventral surface of anal somite, the shape of rostral area, the antennule segments, the ornamentation of maxilliped and leg 2 (Moon *et al.*, 2015). To date, *Anchistrotos kojimensis* has only been found in Japan (Do and Ho, 1983) and Korea (Suh *et al.*, 1992; Kim, 2015). Previously, the male had not been observed in either country. Hence, the reported male in this study is the first for this species.

The specimens examined in this study conform to the description and illustration provided by Do and Ho (1983). However, our specimens differ from Japanese specimens in the caudal ramus bears seven setae (seta I minute), the maxillule with small knob-like process anteriorly, and the leg 5 ornamented with patched spinules distally and row of spinules at base of each spine and armed with 3 spinulate spines and distal seta of our specimens.

The characteristic features of the adult female are: (1) the rostral area with a pair of horizontally directed blunt process; (2) the caudal ramus bears 7 setae; (3) the presence of two transverse rows of spinules ventrolaterally of anal somite; (4) the tip of antenna with 2 unequal pectinate processes, 3 claw-like spines and 4 unequal setae, large pectinate process with several rows of spinules, and small pectinate process with blunt seta; (5) the presence of basal patch of setules and single row of spinules on the anterior surface of paragnath; (6) the maxillule with small knob-like process anteriorly, bears 2 long and 4 short naked seta; (7) the maxilliped with 2 subequal setae and a comparatively short terminal claw; (8) the setal formula on the distal exopodal segment of leg 2 with II, I, 5; (9) the presence of row of setules on the endopodal segments of legs 2 to 4; and (10) the second segment of leg 5 with distal seta and armed with 3 spinulate spines and having row of spinules at base of each spine and distal seta.

The complete description of male is also provided in this study. This is only the fifth species of the genus with a male description after *A. onosi* (T. Scott, 1902), *A. zeugopteri* (T. Scott, 1902), *A. lucipetus* Holmes, 1985 and *A. tongyeongensis* Moon, Lee and Kim, 2015. The prominent features of the adult male are: (1) the morphological characters of cephalothorax similar to that of female but more slender; (2) the prosome 4-segmented and urosome comprised of fifth pedigerous somite, genital somite and 3 free abdominal somites; (3) the second

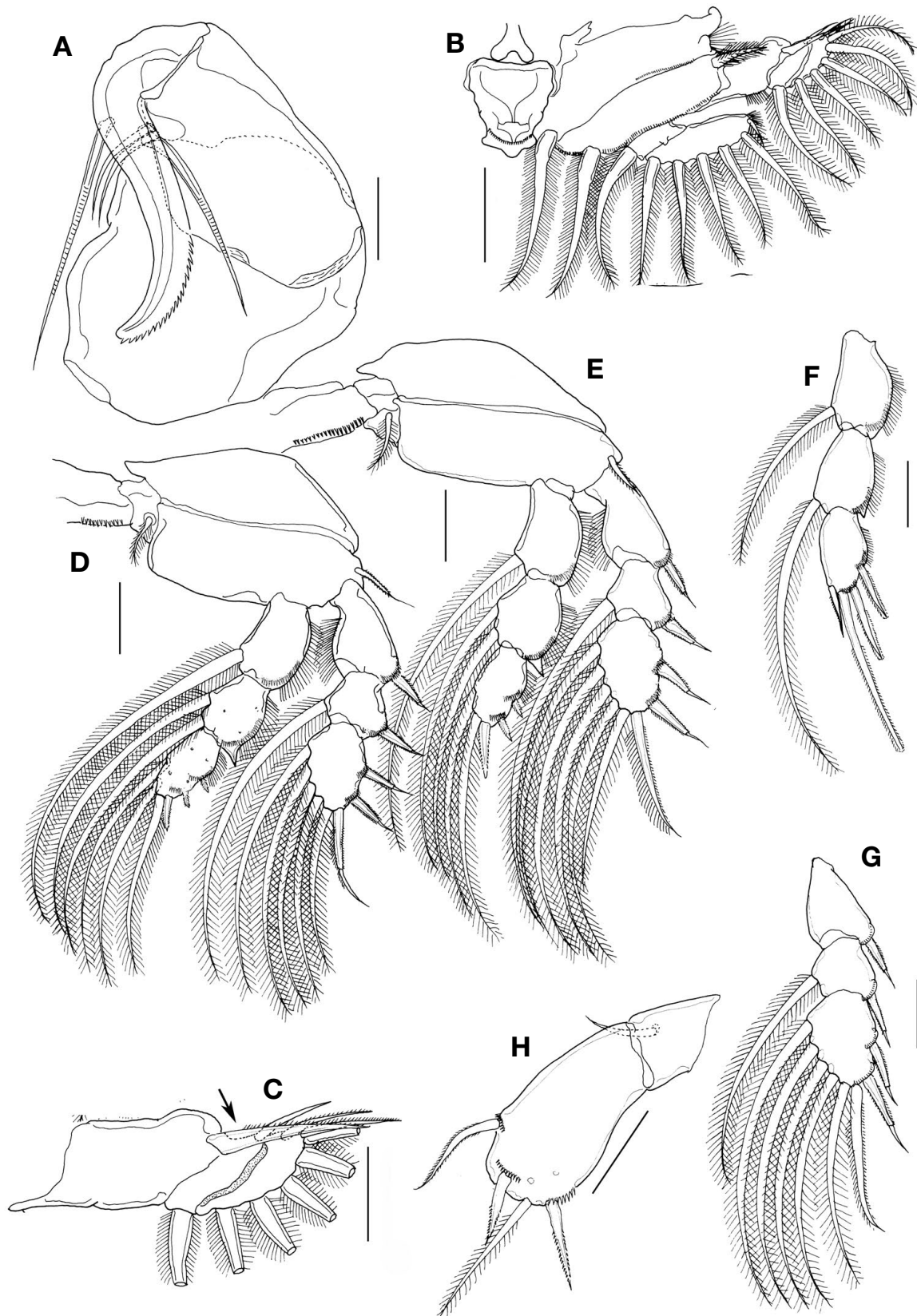


Fig. 2. *Anchistrotos kojimensis* Do and Ho, 1983, female: A, maxilliped; B, leg 1; C, exopodal segment of leg 1; D, leg 2; E, leg 3; F, endopodal segment of leg 4; G, exopodal segment of leg 4; H, leg 5. Scale bars = 50 μm (A, B, D-H), 25 μm (C).

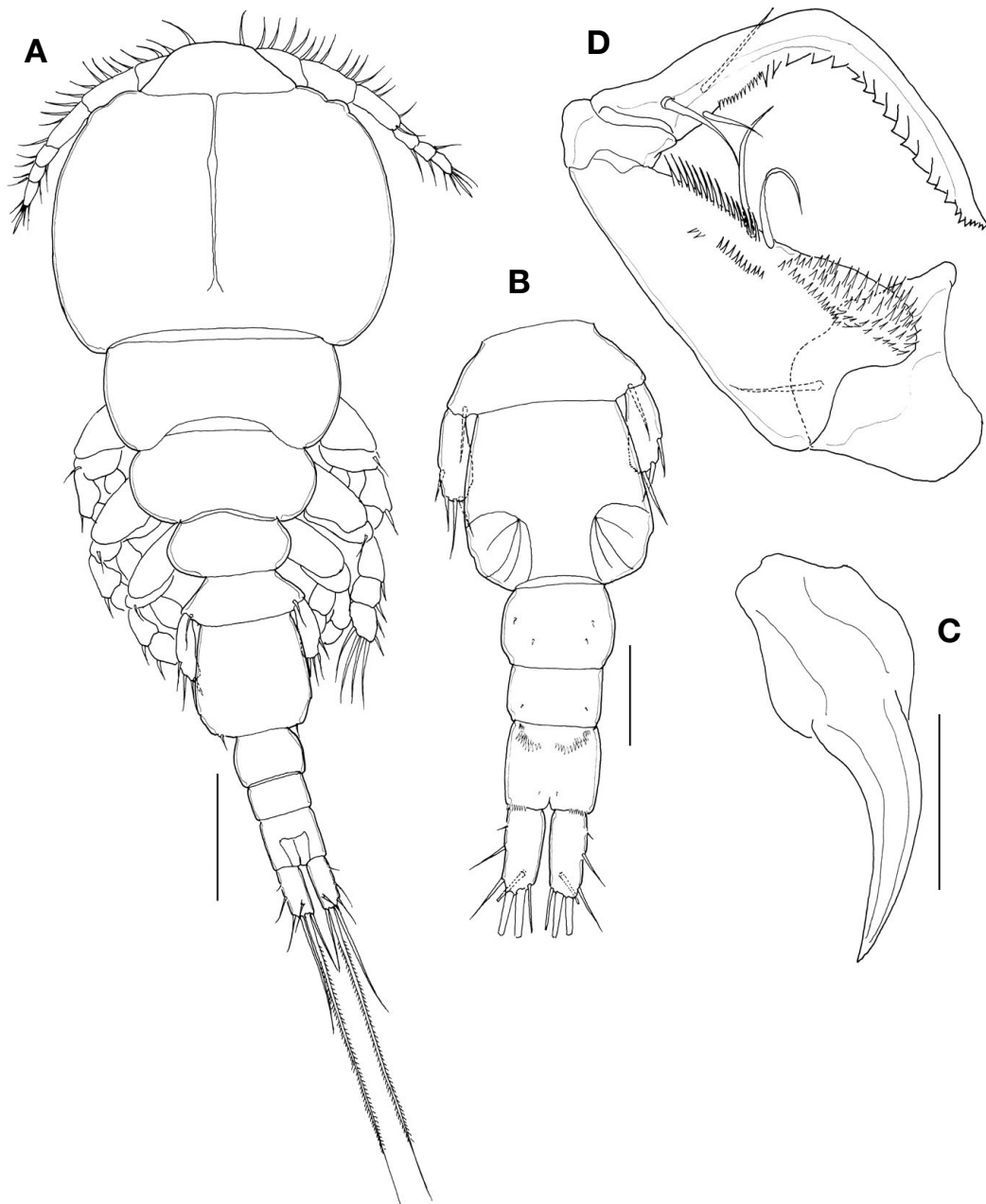


Fig. 3. *Anchistrotos kojimensis* Do and Ho, 1983, male: A, habitus, dorsal; B, urosome, ventral; C, postantennal process; D, maxilliped. Scale bars = A = 100 μm (A), 50 μm (B), 25 μm (C, D).

endopodal segment of maxilliped forming a long curved claw, bearing 2 inner posterior setae and 1 inner ventral seta; (4) the distal segment of maxilliped with basal tooth and row of blunt denticles along concave margin; and (5) the presence of rows of stout spinules ventrolaterally of anal somite.

The genus *Anchistrotos* is host specific to marine gobiid (Gobiidae) and lotid (Lotidae) fishes (Kabata, 1979; Dojiri and Cressey, 1987; Venmathi Maran *et al.*, 2014; Moon *et al.*, 2015; this study). Hitherto, this taeniaca-

nid was host specific to gobiid fish, since it was already reported from *A. flavimanus* and *S. hasta* (Do and Ho, 1983; Suh *et al.*, 1992; Kim, 2014). In this study, we identified a new host of *A. kojimensis*, the stichaeid fish, *E. hexagrammus*.

ACKNOWLEDGEMENTS

The authors extend their appreciation to Ms. Jung-Ah Lee for her great help in capturing the present speci-

mens. This research was supported by a grant from the National Institute of Fisheries Science (NIFS) of the Republic of Korea (R2017025).

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Submitted: July 11, 2017
Revised: November 6, 2017
Accepted: November 7, 2017