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Doropygus hoi, a New Species, and Redescription of *Doropygus pinguis* Ooishi, 1962 (Copepoda, Cyclopoida, Notodelphyidae) Associated with Solitary Ascidians in Korea

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Copepoda
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One new copepod species (*Doropygus hoi* n. sp.) is described based on specimens taken from solitary ascidians collected from the East Sea (Sea of Japan) and the South Sea. *Doropygus pinguis* Ooishi, 1962 taken from solitary ascidians, *Styela plicata* (Lesueur) and *Boltenia echinata* (Linnaeus), collected from 8 localities of the South Sea and the East Sea are redescribed.

Doropygus, composed of 29 species, is the largest genus in the notodelphyid copepods and has been found in association with various solitary ascidians (Gotto, 1975; Illg, 1958; Jones, 1974, 1979). The genus is characterized by the 5 metasomites, 6 urosomites, more or less compressed body habitus, greatly reduced terminal setae of caudal rami and curved and tapered rami (Dudley and Illg, 1991). Among species of the genus *Doropygus*, *D. pulex* Thorell, 1859 has been confused with other species of *Doropygus*. Ooishi (1962) reported *Doropygus pulex pinguis* as a new subspecies based on the copepod specimens taken from only *Styela plicata* (Lesueur) collected from the Pacific coast of Japan. Later, Ho (1984) elevated *Doropygus pulex pinguis* Ooishi, 1962 to *D. pinguis* and redescribed it based on the specimens taken from various ascidians (except for *Styela plicata*) collected from the Sea of Japan. Also, he divided *D. pinguis* in two types: "Pacific type" for the Ooishi's (1962) copepod specimens taken from *Styela plicata* (Lesueur) collected from the Pacific coast of Japan, and "Sea of Japan type" for his copepod specimens taken from *Polycarpa cryptocarpa kuroboja* (Oka), *Halocynthia roretzi* (von Darsche), and *H. hilgendorfi ritteri* Oka collected from the Sea of Japan.

In the present study, the authors found that there were two types ("Pacific type" and "Sea of Japan type") of *D. pinguis* in Korea. Ho (1984) considered the minute setule of the exopod of mandible of *D. pulex* as an aberrant growth of a particular specimen. However, we found that the presence of this setule is a distinctive morphological characteristic, because all the Korean specimens (8♀♀, dissected) of "Pacific type" collected from 8 localities of the South Sea and East Sea have a minute setule on the exopod of mandible.

Therefore, we confirm that the two types are good species. In the present paper, we describe *D. hoi* n. sp. for the "Sea of Japan type", and redescribe *D. pinguis* Ooishi, 1962 for the "Pacific type".

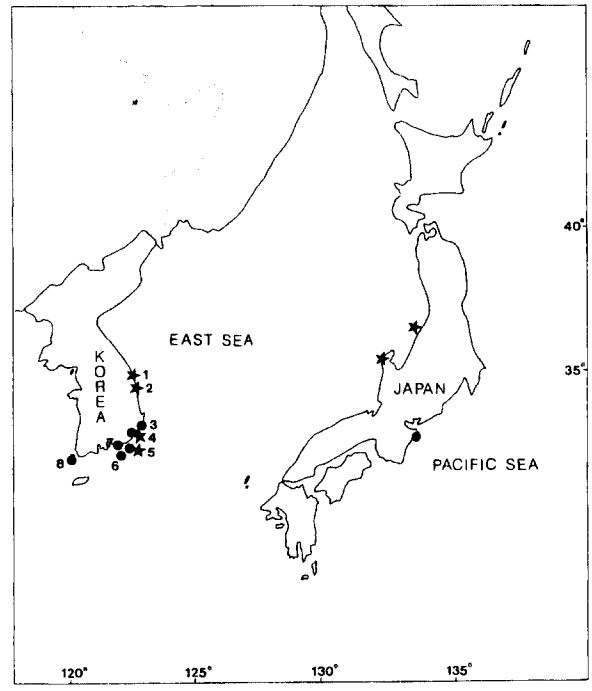

Fig. 1. Sampling localities and Distribution of *D. hoi* n. sp. (★) and *D. pinguis* Ooishi (●) in Korea and Japan. 1. Changho; 2. Imwŏn; 3. Ch'undo in Onsan; 4. Pusan; 5. Kŏjedo; 6. Kaldo; 7, Samch'ŏnp'o; 8. Chindo.

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Fig. 2. *Doropygus hoi* n. sp., female. A, antenna; B, antenna, terminal; C, habitus, lateral; D, rosrtum; E, mandible; F, maxilliped. Scale bars=0.5 mm (B, D), 0.1 mm (A, E, F), and 1 mm (C).

The materials examined in the present study were collected at 13 localities of the East Sea (Sea of Japan) and the South Sea in Korea (Fig. 1) from May 1981 to February 1997. Collected ascidians were preserved in a weak solution of formalin, about 2.5%. The ascidian specimens were cut along the median plane with scissors and then were filtered for copepods with a fine net. Filtered copepods were preserved in 70% ethanol. Copepods were measured and dissected after soaking in lactic acid for at least one day. The illustrations were made with the aid of a drawing tube attached to a microscope.

Results

Family Notodelphyidae Dana, 1853
Genus *Doropygus* Thorell, 1859

Doropygus hoi n. sp.
(Figs. 2-7)

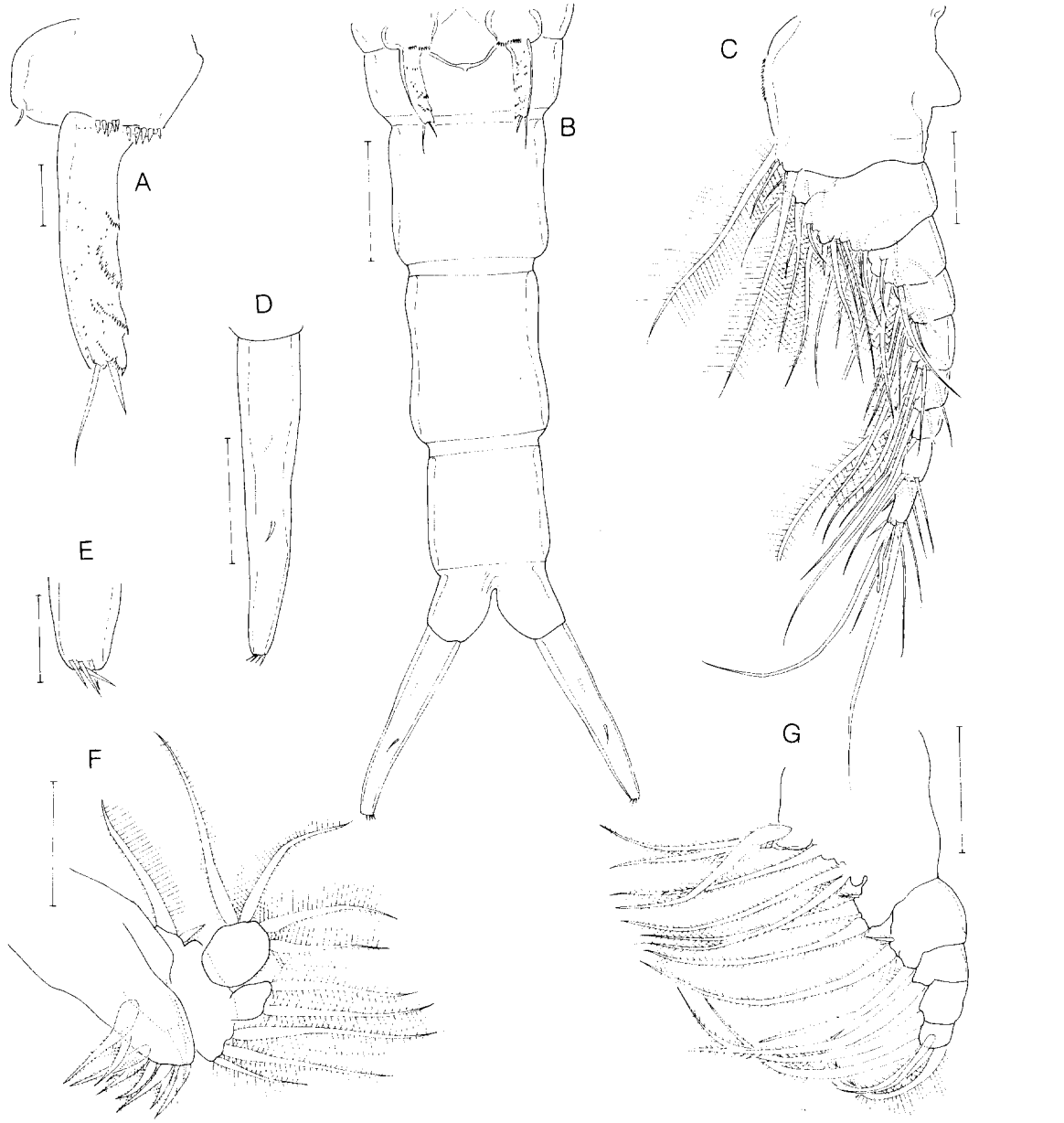

Fig. 3. *Doropygus hoi* n. sp., female. A, leg 5, right; B, urosome, ventral; C, antennule; D, caudal ramus; E, caudal ramus, terminal; F, maxillule; G, maxilla. Scale bars=0.05 mm (A, E), 0.1 mm (C, F, G), 0.2 mm (D), and 0.3 mm (B).

Doropygus pinguis: Ho, 1984 ("Sea of Japan type", p. 24, figs. 1-4)

Material examined: 30 ♀♀, 2 ♂♂ collected from the solitary ascidian, *Halocynthia hilgendorfi ritteri* (Oka), at Changsŭngp'o (approximately 34° 50′ 128° 45′) in Kŏjedo of the South Sea, on 29 Jun. 1987. Holotype (♀), allotype (♂), paratypes (24 ♀♀) will be deposited in the Korea National Museum of Natural History, Seoul. Dissected paratypes (5 ♀♀, 1 ♂) are kept in the collection of the authors; 3 ♀♀, 2 ♂♂ collected from the solitary ascidian, *Halocynthia hilgendorfi igaboya* (Oka), at Kaldo of the South Sea, on 18 July 1982; 3 ♀♀, 2 ♂♂ collected from the solitary ascidian, *Halocynthia hilgendorfi igaboya* (Oka), at Changho of the East Sea (Sea of Japan), on 3 Oct. 1986; 2 ♀♀ collected from the solitary ascidian, *Styela tokiokai* Nishikawa, at Pusan of the South Sea, July 1987; 1 ♀ collected from the solitary ascidian, *Halocynthia hilgendorfi igaboya* (Oka), at Imwŏn in the East Sea (Sea of Japan), on 8 June 1986.

Female: Body (Fig. 2C) rather elongate and laterally compressed. Length 3.0 mm (average 5 specimens, from anterior tip of cephalosome to end of brood pouch). Urosome (Fig. 3B) consists of 6 well-defined

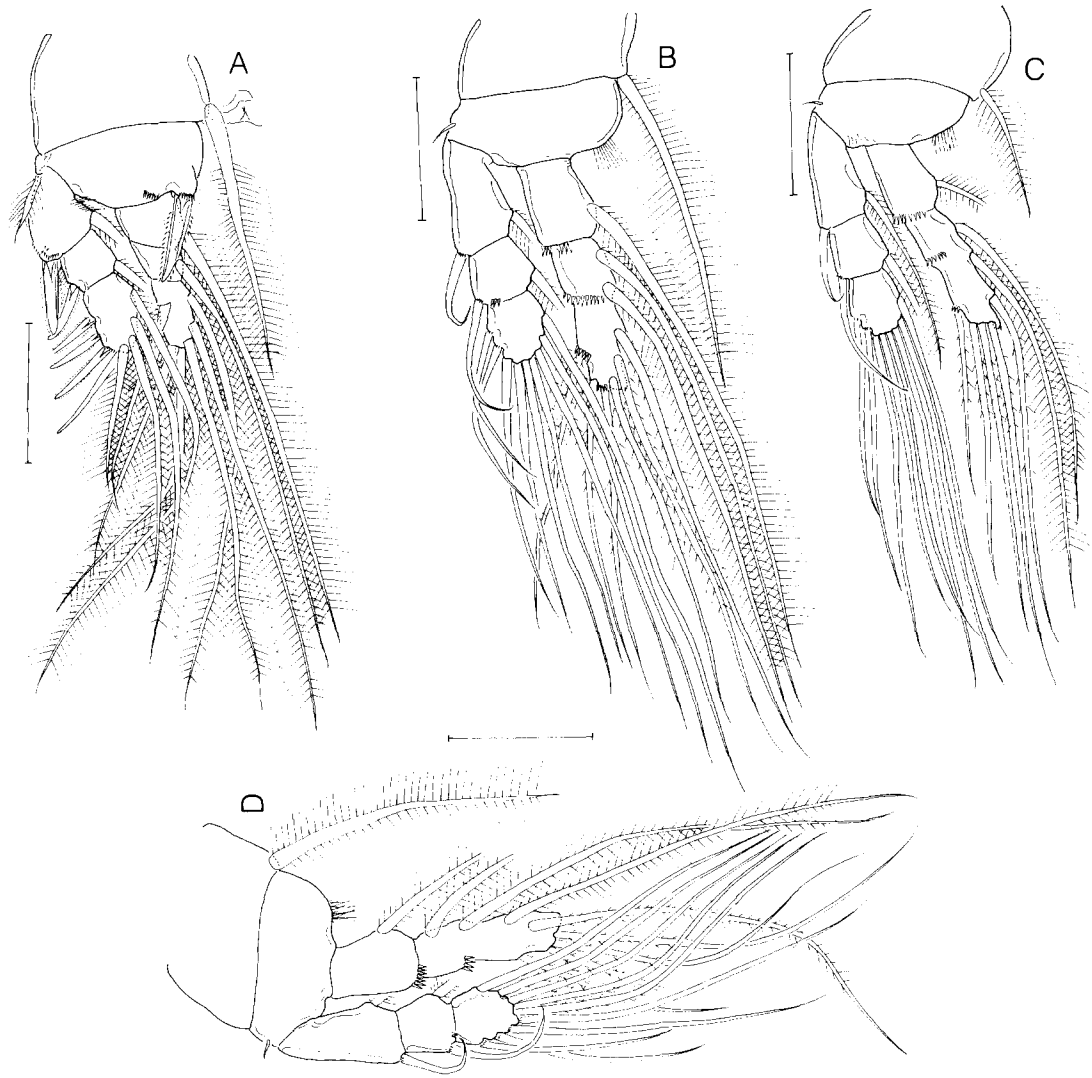

Fig. 4. *Doropygus hoi* n. sp., female. A, leg 1; B, leg 2; C, leg 4; D, leg 3. Scale bars=0.2 mm.

somites, of which anal somite smallest. Some specimens with a small auxilliary brood sac protruding from ventral surface of brood pouch just posterior to attachment of urosome. Caudal ramus (Fig. 3D) slender and long, terminally with 4 short setae, and with 1 proximal seta on ventral surface and 1 distal seta on dorsal one. Rostrum (Fig. 2D) U-shaped. Brood pouch consists of large gibbous form and occupies only the last metasome (=fourth pedigerous somite).

Antennule (Fig. 3C) slender, 9-segmented. Armature formula 3 (2 plumose), 17 (4 plumose, 1 spine-like), 6 (1 plumose), 5 (2 plumose), 4 (2 plumose), 4 (1 plumose), 2, 3, and 7+1 aesthetasc. Setation well-developed.

Antenna (Fig. 2A and 2B) 3-segmented. Amature formula 2+1, 1, and 10+1 claw.

Labrum consists of 1 posteroventral lobe.

Mandible (Fig. 2E) with 5 heavy distal teeth, a row of denticles and 2 proximal setules on masticatory lamella of coxa. Basis with 1 medial seta. Endopod 2-segmented: first segment with 4 setae, second one with 8 setae. Exopod with 5 long well-developed setae.

Maxillule (Fig. 3F) with indistinct bimerous protopodite and unimerous rami. Major endite of coxa with 9 medial setae; epipodite with 1 short and 1 long seta; basipodite with 3 setae; distal endite with 1 broad, blade-like seta. Exopod with 4 long setae. Endopod with 2 long setae.

Maxilla (Fig. 3G) consists of 5 segments. First segment as long as the remaining segments combined together, and forming 4 endites: basal endite with 3 setae; second one with 1 seta; third one with 2 setae and fourth one with 2 setae and 1 proximal setule. Second segment with 2 setae and 1 proximal setule. Third and fourth segments with 1 long seta, respectively. Fifth segment small, and with 4 terminal setae.

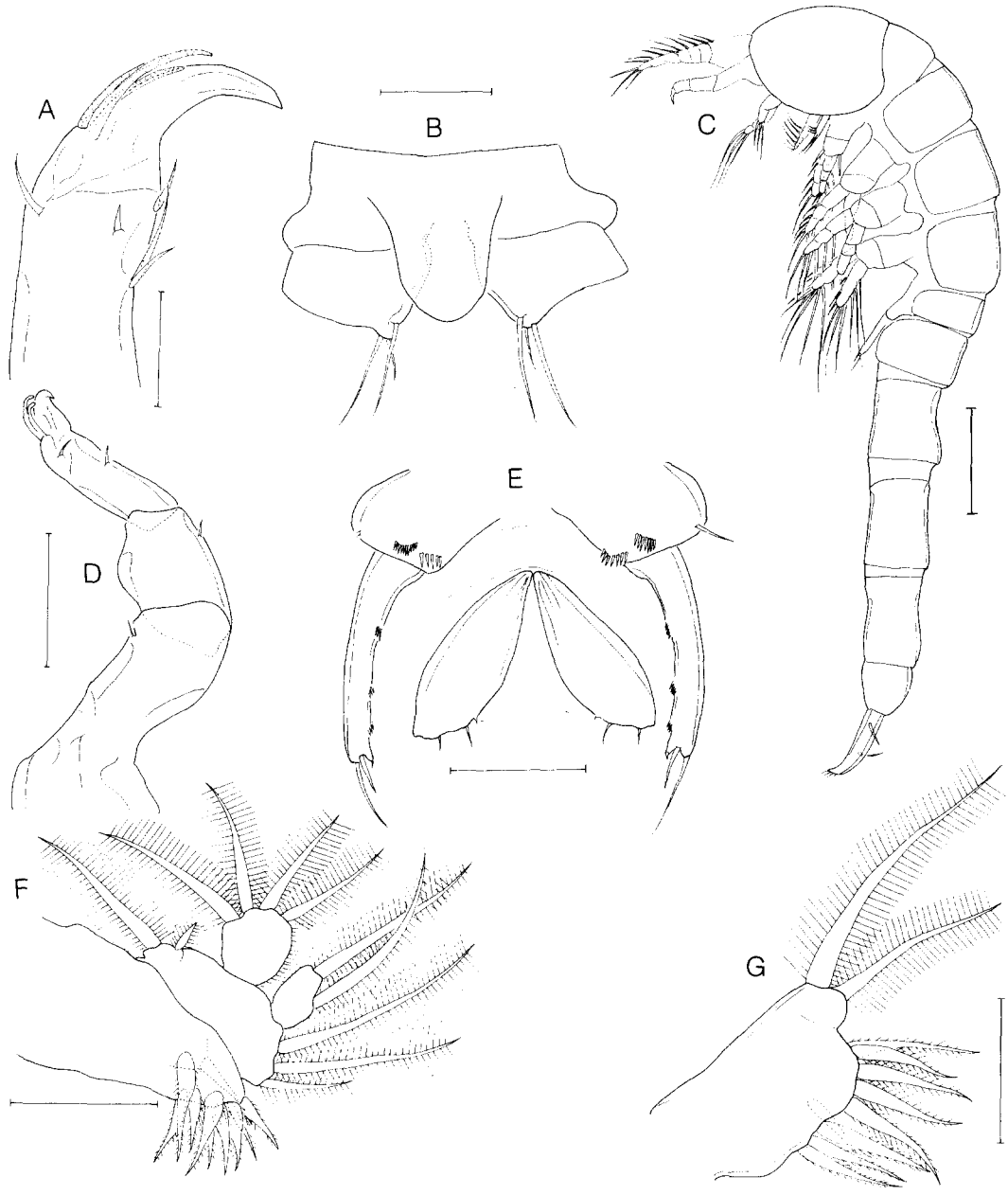

Fig. 5. *Doropygus hoi* n. sp., male. A, antenna, terminal; B, rostrum; C, habitus, lateral; D, antenna; E, leg 5 and leg 6, ventral; F, maxillule; G, Sde bars=0.03 mm (A), 0.05 mm (D, F, G), 0.1 mm (B, E), and 0.3 mm (C).

Maxilliped (Fig. 2F) 2-segmented, with hairs on proximal portion. First segment with 9 setae forming 2 groups of 4 proximal and 5 distal setae. Second segment with 2 long apical setae.

Leg 1 (Fig. 4A) with 3-segmented rami. Leg 2 (Fig. 4B), leg 3 (Fig. 4D), and leg 4 (Fig. 4C) with 3-segmented exopod and 2-segmented endopod, respectively. These legs armed as follows (Roman numerals indicating spines, and Arabic numerals, setae):

Leg 1 coxa 0-1; basis 1-I; exp. I-1; I-1; IV, 4
enp. 0-1; 0-1; 6
Leg 2 coxa 0-1; basis 1-0; exp. 1-1; 1-1; 9
enp. 0-1; 8
Leg 3 coxa 0-1; basis 1-0; exp. 1-1; 1-1; 9
enp. 0-1; 8
Leg 4 coxa 0-1; basis 1-0; exp. 1-1; 1-1; 8
enp. 0-1; 7

Rami of legs 1-4 slender, with well-developed long setae.

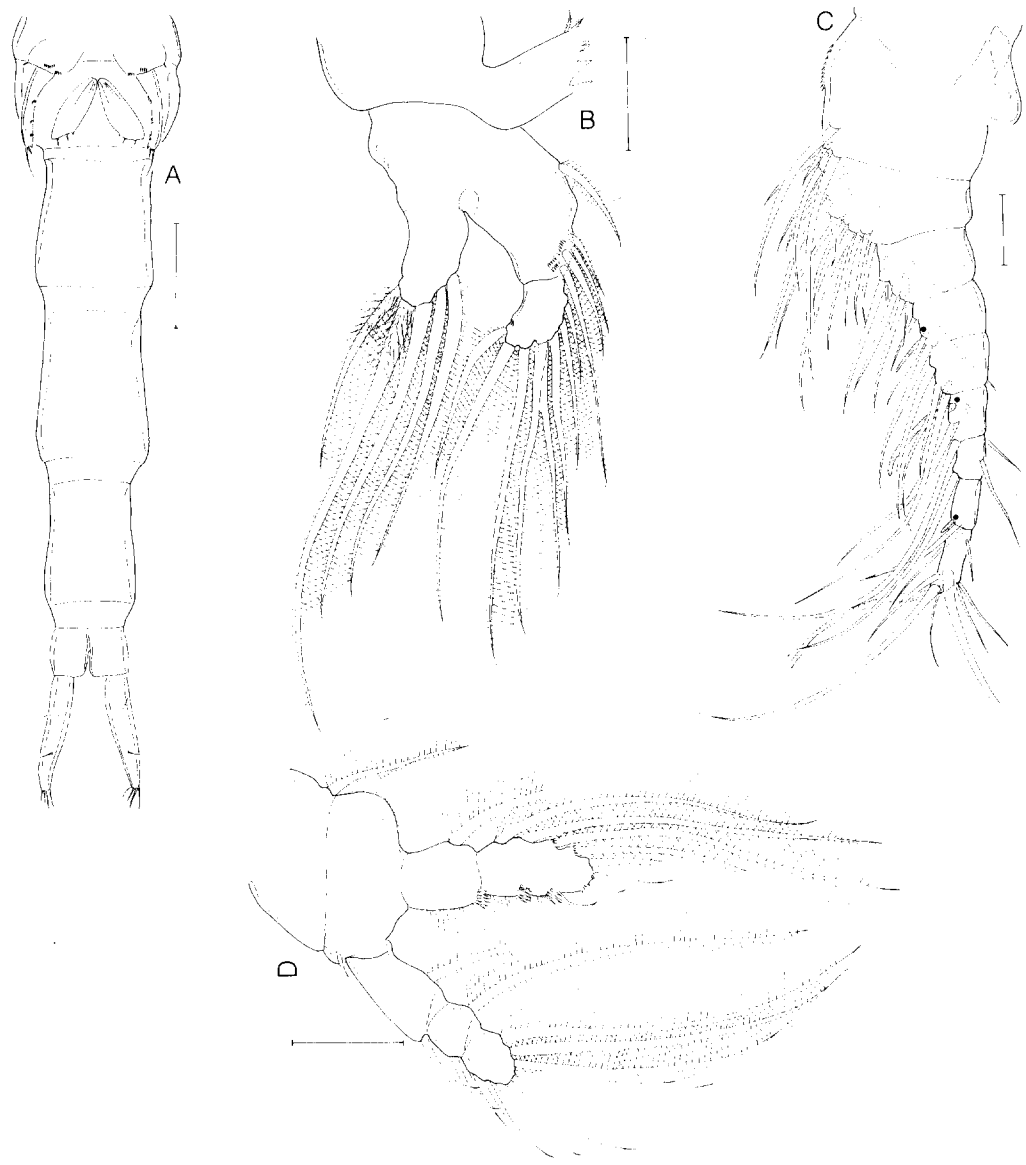

Fig. 6. *Doropygus hoi* n. sp., male. A, urosome, ventral; B, mandible; C, antennule; D, leg 3. Scale bars=0.05 mm (B, C), 0.1 mm (D), and 0.2 mm (A).

Leg 5 (Fig. 3A) uniramous, slender, and 2-segmented. Basal segment wider than long, with a row of 2 groups of teeth on distal margin and 1 outer small seta. Terminal segment with 2 unequal apical setae and medial surface with 4 rows of spinules.

Male: Body (Fig. 5C) typically cyclopoid form, slender. Length 2.9 mm (from anterior tip of cephalosome to end of caudal ramus, except for setae). Urosome (Fig. 6A) consists 6 somites. Caudal ramus similar to that of female but terminal setae rather longer. Rostrum (Fig. 5B) as in female.

Antennule (Fig. 6C) similar to that of femal, but added by aesthetascs (at positions indicated by dots in Fig. 6C) and setation rather shorter.

Antenna (Fig. 5D) similar to that of female but third segment without 1 distal plumose seta.

Mandible, maxillule, maxilla, and maxilliped as in female.

Legs 1-4 (Fig. 6D, 7A, 7B and 7C) lateral and apical setae of endopods distinctly shorter than those of female.

Leg 5 (Fig. 5E) with distal segment longer than that of female, length of distal somite 6 times as long as width. Leg 6 (Fig. 5E) represented by a flap on genital somite, and bearing 3 tiny setae.

Etymology: The specific name is from Dr. Ju-Shey Ho, Department of Biology, California State University. He

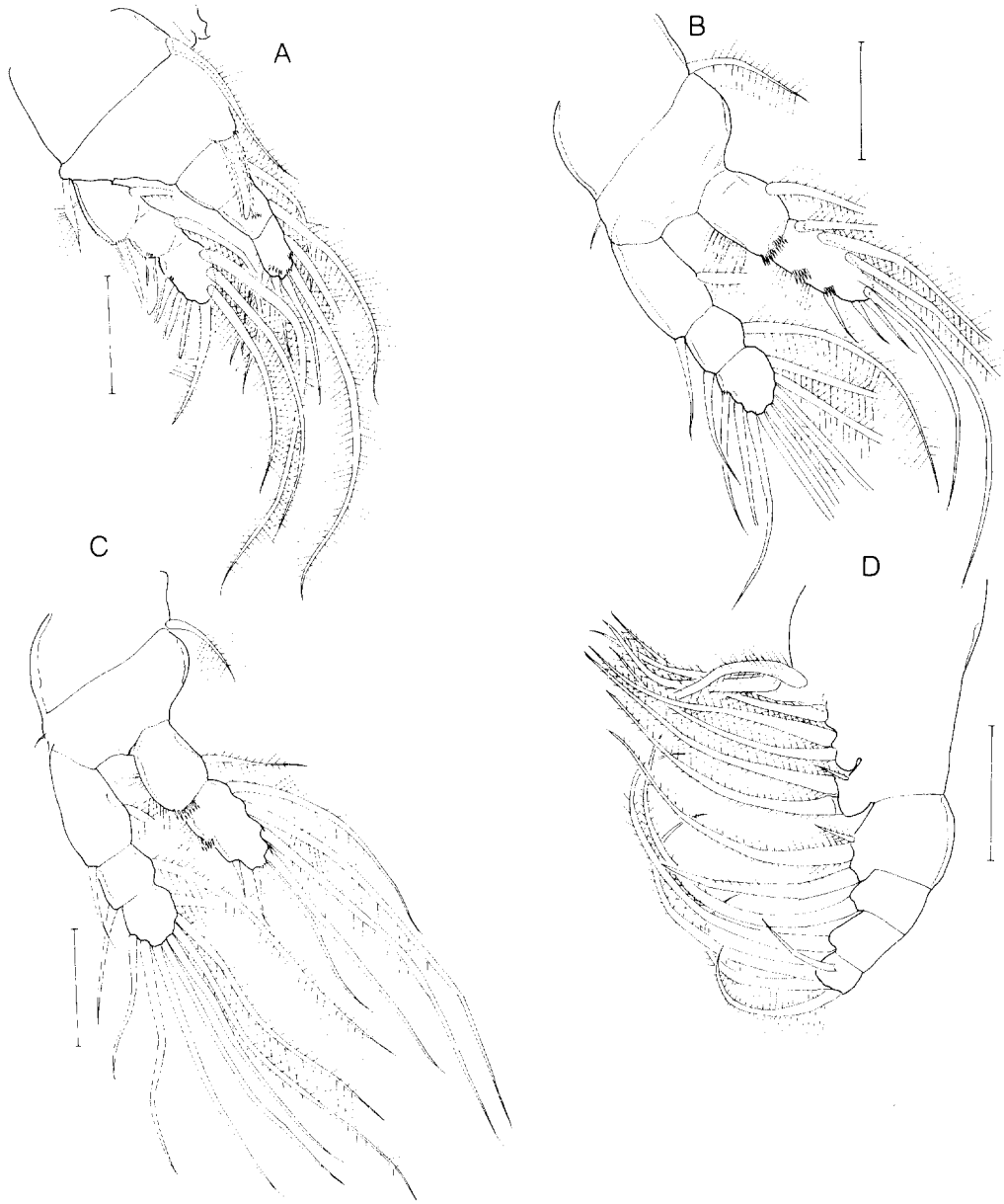

Fig. 7. *Doropygus hoi* n. sp., male. A, leg 1; B, leg 2; C, leg 4; D, maxilla. Scale bars=0.05 mm (D) and 0.1 mm (A-C).

rocognized first this species.

Doropygus pinguis Ooishi, 1962
(Figs. 8-10)

Doropygus pulex pinguis Ooishi, 1962 (p. 16. figs. 5, 6)
Doropygus pinguis: Ho, 1984 ("Pacific type", p. 24)

Material examined: 5♀♀ collected from the solitary ascidian, *Styela plicata* (Lesueur), at fish market in Pusan of the South Sea, on 26, May 1981; 2♀♀ collected from the solitary ascidian, *Styela plicata,* at Samch'ŏnp'o of the South Sea, on 27 Dec. 1986; 3♀♀ collected from the solitary ascidian, *Styela plicata* at Kŏjedo of the South Sea, on 29 June 1987; 3♀♀ collected from the solitary ascidian, *Styela plicata* at Tadaep'o of the South Sea, on 25 Nov. 1991; 2♀♀ collected from the solitary ascidian, *Styela plicata,* at Jŏpdo in Chindo Island of the South Sea, on 23 June 1994; 1♀ collected from the solitary ascidian, *Styela plicata,* on Oyster bed at Jŏpdo in Chindo Island of the South Sea on 6 Nov. 1994; 1♀ collected from the solitary ascidian, *Boltenia echinata(Linnaeus)*, in Esudo Island of the South Sea on 25 July 1995; 1♀ collected from the solitary ascidian, *Styela plicata,* at Ch'undo Island in Onsan of the East Sea on 1 Feb. 1997.

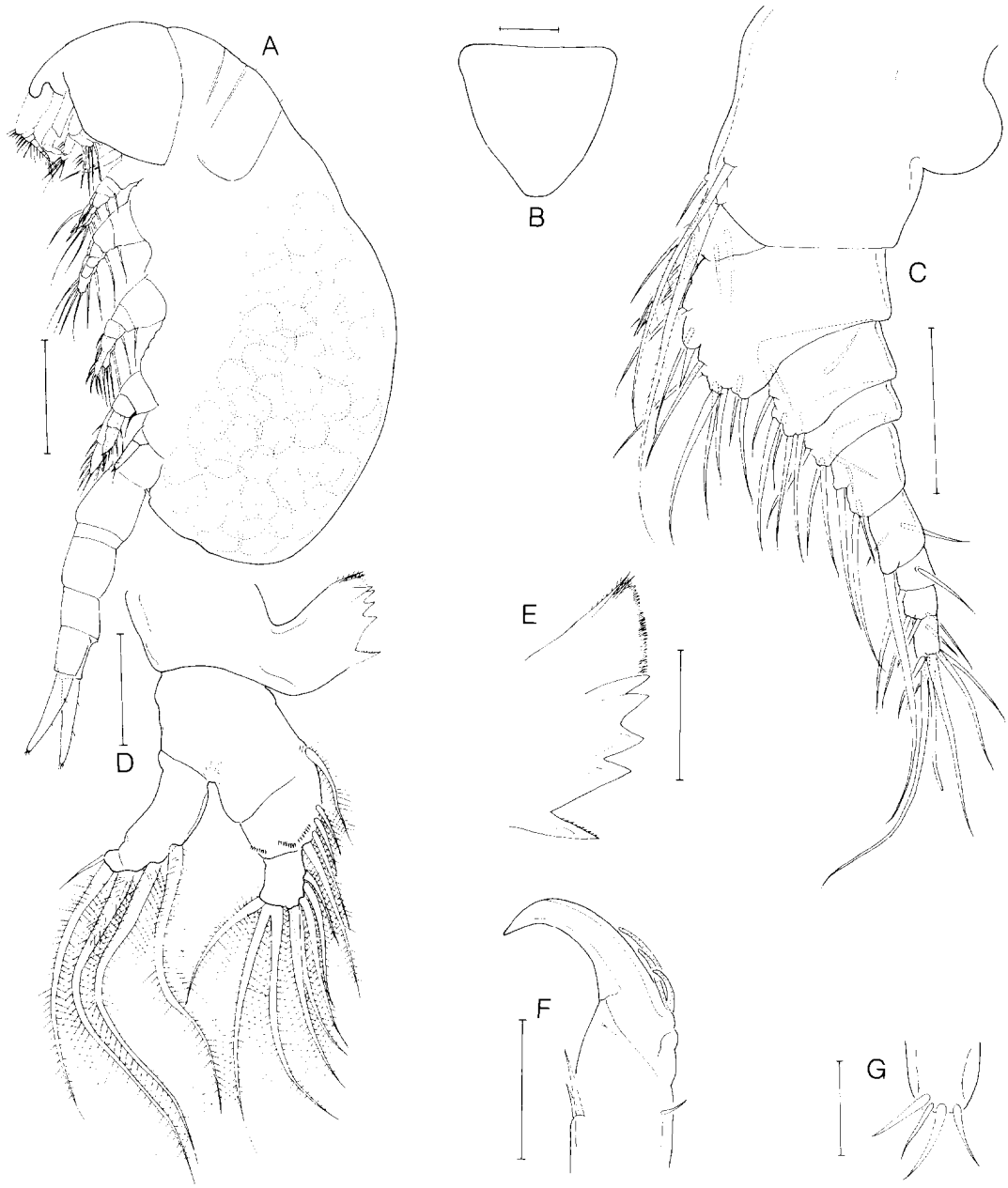

Fig. 8. *Doropygus pulex pinguis* Ooishi, female. A, habitus, lateral; B, rostrum; C, antennule; D, mandible; E, mandible, masticatory lamella; F, antenna, terminal; G, caudal ramus, terminal. Scale bars=0.05 mm (B, C, E-G), 0.1 mm (D), and 0.5 mm (A).

Female: Body (Fig. 8A) rather stubby, laterally compressed. Length 2.0 mm (average of 8 specimens, from anterior tip of cephalosome to end of brood pouch). Urosome (Fig. 9B) consists of 6 well-defined somites, of which anal somite smallest. Caudal ramus ender, terminally with 4 short setae, and with 1 proximal seta on ventral surface and 1 distal seta on dorsal one. Rostrum (Fig. 8B) triangular, protruding antero-ventrally. Brood pouch occupies from third to last metasomites.

Antennule (Fig. 8C) short, 9-segmented. Amature formula 3 (2 plumose), 17 (1 spine-like), 6, 4, 4, 3, 2, 3, 7+1 aesthetasc.

Antenna (Fig. 9A) 3-segmented. Amature formula 2+1, 1, 8+1 claw.

Mandible (Fig. 8D) with 5 heavy teeth, of which first tooth serrated, and a row of denticles and 2 tiny setules on proximal portion. Basis with 1 medial seta.

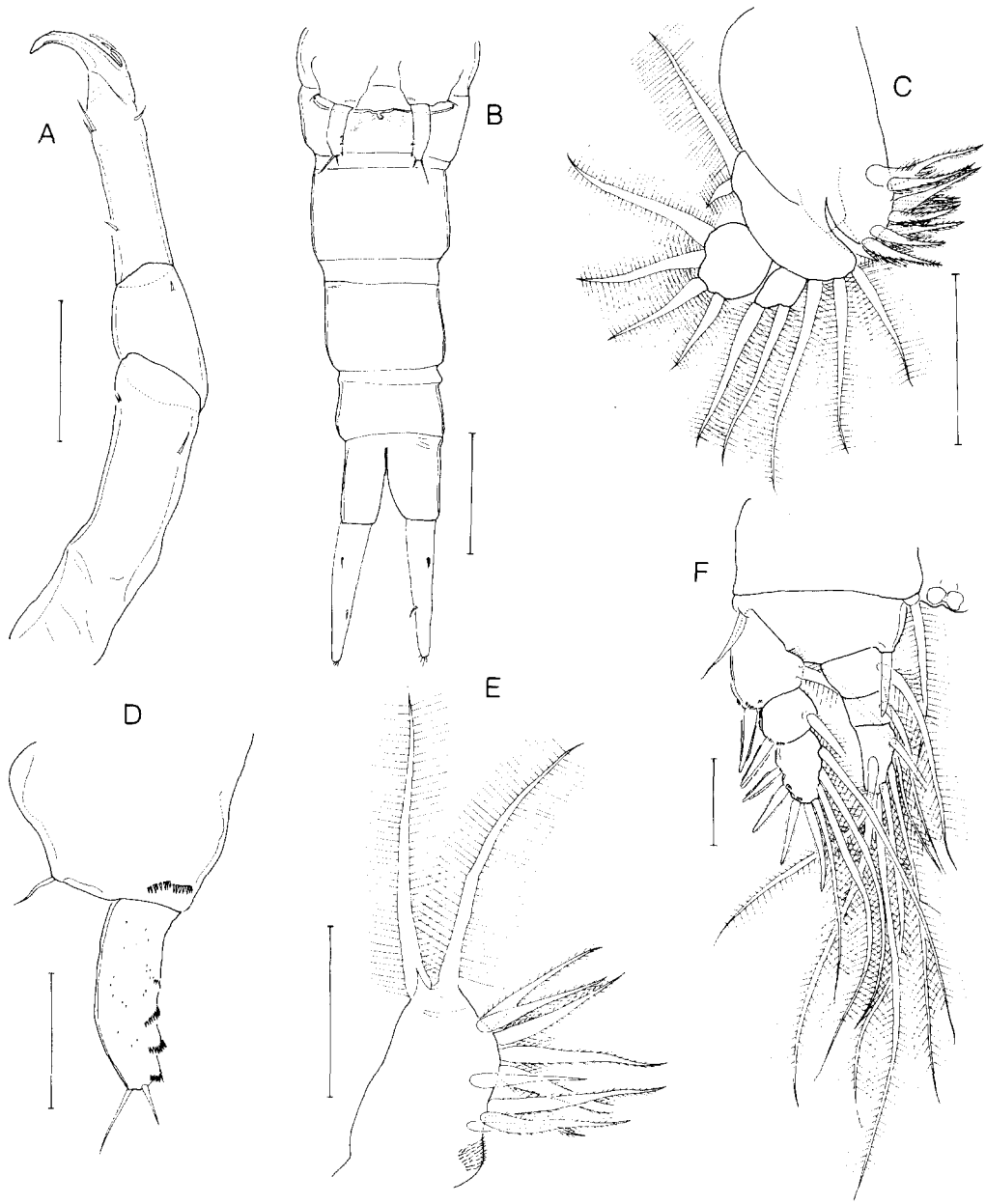

Fig. 9. *Doropygus pulex pinguis* Ooishi, female. A, antenna; B, urosome, ventral; C, maxillule; D, leg 5, right; E, maxilliped; F, leg 1. Scale bars=0.1 mm (A, C-F) and 0.3 mm (B).

Endopod 2-segmented: first segment with 4 setae, second one with 8 setae. Exopod with 4 long well-developed setae and 1 minute seta.

Maxillule (Fig. 9C) and maxilliped (Fig. 9E) similar to those of *D. hoi* n. sp. but exopod of maxillule with 4 setae, of which distal 2 setae sorter than that of *D. hoi* n. sp.

Maxilla (Fig. 10D) similar to that of *D. hoi* n. sp. except for fifth segment with 3 setae.

Legs 1-4 (Fig. 9F, 10A, 10B and 10C) similar to those of *D. hoi* n. sp. but exopods wider than those of *D. hoi* n. sp. and setation of exopods of legs 2-4 shorter than those of *D. hoi* n. sp.

Leg 1	coxa 0-1; basis 1-I;	exp. I-1; I-1; IV, 4
		enp. 0-1; 0-1; 6
Leg 2	coxa 0-1; basis 1-0;	exp. 1-1; 1-1; 9
		enp. 0-1; 8
Leg 3	coxa 0-1; basis 1-0;	exp. 1-1; 1-1; 9
		enp. 0-1; 8
Leg 4	coxa 0-1; basis 1-0;	exp. 1-1; 1-1; 8
		enp. 0-1; 7

Leg 5 (Fig. 9D) uniramous and 2-segmented. Basal

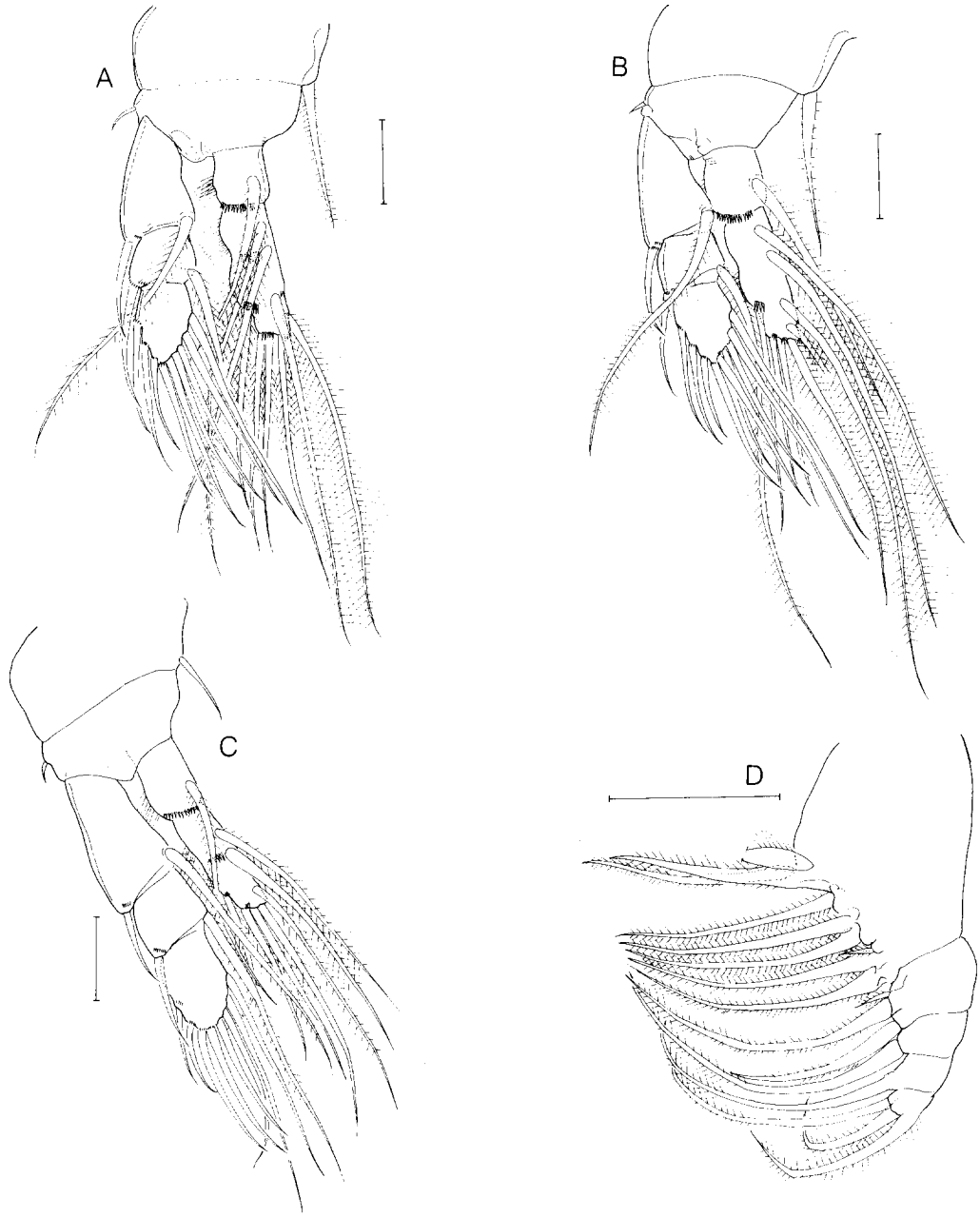

Fig. 10. *Doropygus pulex pinguis* Ooishi, female. A, leg 2; B, leg 3; C, leg 4; D, maxilla. Scale bars=0.1 mm.

segment longer than wide, with 2 rows of teeth on distal margin and 1 outer small seta. Distal segment with 2 unequal apical setae and 4 rows of spinules on medial surface.

Male: Unknown.

Discussion

The authors observed copepod specimens within many ascidian collections deposited at the Department of Biological Science of the Ewha Womans University, Seoul, Korea. Among these diverse host ascidians, especially Solitary ascidian, *Styela Plicata* (Lesueur) was colleted at 10 localities of the South Sea and the East Sea from 1981 to 1997. Copepod specimens were found in 8 of these samples. They were identified to *Doropygus pinguis* Ooishi. In Korea, *D. pinguis* was found exclusively in *Styela plicata* (Lesueur). Also in *Boltenia echinata* (Linnaeus) 1 female was found. Other

Table 1. Distinguishing features between *Doropygus hoi* n. sp. and *D. pinguis* Ooishi.

Characters	*D. hoi* n. sp.	*D. pinguis*
-Prosome length	3.0 mm (N=5)	2.0 mm (N=8)
-Setation of antennule	well-developed	weak
-Distal denticle of masticatory lamella of mandible	smooth	serrate
-Setae on mandibular exopod	5 long	4 long + 1 minute
-Setae on fifth segment of maxilla	4	3
-Width of rami of legs 1-4	slender	wide
-Rostrum	U-shaped	triangular
-Area of Egg pouch	last metasomite	third to last metasomites
-Hosts	*Halocynthia hilgendorfi igaboya, H. hilg. ritteri and Styela tokiokai*	*Styela plicata*, and *Boltenia echinata*

species of *Doropygus*, like *D. pulex*, have been found in diverse host ascidians and show morphological variations depending on the host species (Illg and Dudley, 1961). In contrast, we found that *D. pinguis* is relatively species-specific in the host ascidian, *Styela plicata,* and *D. hoi* n. sp. is not found in *Styela plicata.*

D. pinguis Ooishi and *D. hoi* n. sp. have features in common such as the compressed body form, caudal rami bearing reduced setae, and the armature formula of legs 1-4. However, *D. hoi* n. sp. is easily distinguished from *D. pinguis* in having 5 well-developed setae on the exopod of mandible (*D. pinguis* having one minute seta and 4 well-developed exopodal setae), 4 setae on fifth segment of maxilla (3 setae in the *D. pinguis*), slender exopod of legs 1-4 (wider in *D. pinguis*), brood pouch occupying only the last metasomite (from the third to the last metasomites in *D. pinguis*), and slender body (stubby in *D. pinguis*). Thus, by several morphological differences and host ascidians dependency we Can distinguish *D. hoi* n. sp. from *D. pinguis* (Table 1).

Acknowledgements

The authors are grateful to Dr. Boon-Jo Rho, who provided us with her ascidian collections collected from Korea. Her superb collections, including *Styela plicata* collected from various localities, helped us determine that *D. pinguis* is species-specific in the host ascidian, *Styela plicata.* The authors also thank Dr. Il-Hoi who provided us with copepod specimens, papers, and valuable comments on the manuscript

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