

Three Species of the Notodelphyid Copepods (Cyclopoida) Associated with the Solitary Ascidians (Tunicata) in Korea

In-Soon Seo and Kyung-Sook Lee*

(Ecosystem Conservation Division, Ministry of Environment, Kyönggi-Do, 427-760;

*Department of Biological Science, Dankook University, Cheonan 330-714, Republic of Korea)

ABSTRACT

Three notodelphyid copepods, *Doropygus curvipes* Gotto, *Notodelphys agilis villosus* Ooishi and *Bonnierilla curvicaudata* Ooishi are redescribed, based on the specimens taken from the solitary ascidians in Korea. Accordingly, Korean copepods associated with ascidians now includes 11 described species.

Key words: Notodelphyid Copepods, *Doropygus*, *Notodelphys* and *Bonnierilla*, Ascidiains, Korea

INTRODUCTION

Doropygus, *Notodelphys* and *Bonnierilla* are the genera in the notodelphyid copepods and the species of these genera have been known in association with various solitary ascidians (Illg 1958). Seo and Lee (1997) reported two species of the *Doropygus* from Korea. In the present paper, I will report the species of *Notodelphys* and *Bonnierilla* for the first time from Korea. Up to now, the genera *Notodelphys* and *Bonnierilla* have been reported by eight species, respectively in the world (Illg and Dudley, 1961; Stock, 1967).

The ascidians were collected from 10 localities of the East, South and Yellow Sea from January 1986 to June 1998. The ascidian hosts, from which the examined copepods were collected, were collected by SCUBA divers and some were taken from fishing nets or bought from fishing markets. 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. The copepod specimens are deposited in the Department of Biological Science, Dankook University.

DESCRIPTIONS

Family Notodelphyidae Dana, 1853

Genus *Doropygus* Thorell, 1859

***Doropygus curvipes* Gotto, 1975 (Figs. 1-6)**

Doropygus curvipes Gotto, 1975, p. 169, fig. 3.

Material Examined. 20 ♀♀, 4 ♂♂ collected from *Styela clava clava* Herdman, Imwon, 27 Dec. 1986; 5 ♀♀ from *Styela clava clava* Herdman, Taejin, 26 Oct. 1986; 6 ♀♀ from *Pyura vittata* (Stimpson), Ullung Island, 6 Aug. 1987; 6 ♀♀ from *Styela clava clava* Herdman, fish market in Pusan, 23 Apr. 1986; 1 ♀, 6 ♂♂ from *Halocynthia hilgendorfi igaboya* (Oka), fish market in Kangnung, 11 Jan. 1986.

Female. Body (Fig. 1C) compressed, rather elongated. Body length 3.5mm (from tip of cephalosome to end of caudal rami, except terminal setae). Urosome (Fig. 1A) 6-segmented, of which anal somite smallest. Caudal ramus long, with 4 short terminal setae, and 1 proximal and 1 distal tiny setae. Metasome 4-segmented. Last metasomal somite expanded, forming brood pouch. Rostrum long, triangular and ventrally protruded.

Antennule (Fig. 2B) 9-segmented, setal formula: 3(plumose 2), 17 (plumose 4 and spine-like 1), 6 (plumose 1), 5 (plumose 1), 4 (plumose 1), 4 (plumose 1), 2, 3, and 7+1 aesthete.

Antenna (Figs. 1D, E) 3-segmented. First segment with 2 tiny ventrodorsal setae and 1 short dorsodistal seta. Second segment with 1 short dorsodistal seta. Third segment with 2 tiny setae on inner face, 1 terminal clawed hook invested by a light membranous sheath, 3 stiff setae, 2 short setae and a pair of setae on distal part.

Mandible (Fig. 2A) consisting of coxa and rami. Masticatory lamella of coxa with 5 heavy teeth and 2 tiny proximal setae; basis with 1 medial seta. Endopod 2-segmented. First segment with 4 setae; second segment with 8 setae. Exopod unimerous, with 4 long setae and 1 reduced seta. Maxillule (Fig. 2E) with indistinctly bimerous protopodite and unimerous rami. Major endite of coxa with 9 setae. Epipodite with 1 short and 1 long seta. Basipodite with 3 setae. Endopod with 2 long setae. Exopod with 4 setae. Secondary endite with 1 setiform element.

Maxilla (Fig. 2C) consisting of 5 segments. First segment as long as the rest segments combined together, and forming 4 endites. Basal endite with 3 setae. Second endite with 1 seta. Third and fourth endites with 2 setae, respectively. Second segment with 2 long and 1 tiny seta. Third and fourth segments with 1 long seta, respectively. Fifth segment with 1 long and 2 median setae.

Maxilliped (Fig. 1F) indistinctly 2-segmented: first segment with 9 setae forming 2 groups of 4 proximal and 5 distal setae. Second segment with 2 long terminal setae, with hairs on inner margin.

Legs 1-4 (Figs. 3A-D) biramous, with 3-segmented exopod and 2-segmented endopod, but leg 1 with 3-segmented rami, Formula of spines (Roman numerals) and setae (Arabic numerals) as follows:

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

Leg 5 (Fig. 2D) uniramous, 2-segmented: basal segment with 1 outer seta and a row of teeth of 2 groups on distal margin; distal segment with 2 unequal terminal setae, medial surface with 2 rows of denticles. Length of distal segment as long as 3 times of width.

Male. Body (Fig. 4C) typically cyclopoid form, 1.77 mm (from tip of cephalosome to end of caudal rami, except terminal setae), consisting of cephalosome, metasome and urosome. Body covered by short sparse hairs, but urosome with dense hairs. Urosome consists of 6 segments. Second urosomal somite bearing leg 6 on ventral margin.

Antennule (Fig. 5B) 9-segmented, setal formula similar to those of female, but setae short and simple, and fourth, fifth and sixth segments added by 1 aesthete, respectively.

Antenna (Figs. 4E, 5D) 3-segmented. Terminal spine of third segment consisting of clawed hook.

Mandible (Fig. 5A) differs from that of female. Exopod with well-developed 5 setae. Maxillule, maxilla and maxilliped similar as well to those of female. Legs 1-4 similar to those of female, but setae short.

Leg 5 (Fig. 4D) uniramous, 2-segmented: first segment with 1 short outer seta, with 2 groups of denticles on distal margin; second segment with 2 terminal setae, medial surface with 2 rows of denticles.

Leg 6 located on ventral margin of second urosomal somite, trapezoid form, with 2 inner distal setae and 1 outer distal seta. Caudal ramus similar to that of female.

Remarks. Our specimens closely resembles the type specimen in the form of terminal clawed hook of antenna, setation of mandible, maxillule and maxilliped, and legs 1-5. But the Korean specimens of this species are different from the type specimen in the following characteristics: 1) the second segment of antennule of the Korean specimens are less inflated than that of the type specimen; 2) the first segment of antenna in the Korean specimen doesn't have 2 proximal setae, whereas that of the type specimen has 2 proximal setae; 3) the maxilliped of the Korean specimens are bimerous, whereas that of the type specimen is unimerous; 4) the length of basal segment of leg 5 of the Korean specimens are shorter than that of the type specimen; 5) the second segment of maxilla of the Korean specimens have 1 tiny seta, whereas that of the type specimen is absent; 6) the caudal rami of the Korean specimens have 2 setae on the inner face, whereas that of the type specimen has 4 setae.

Genus *Notodelphys* Allman, 1847

***Notodelphys agilis villosus* Ooishi, 1962 (Figs. 7-9)**

Notodelphys agilis villosus Ooishi, 1962, p. 8, figs. 1, 2.

Material Examined. 6 ♀♀ collected from *Ciona intestinalis* (Linnaeus), Imwon in the East Sea,

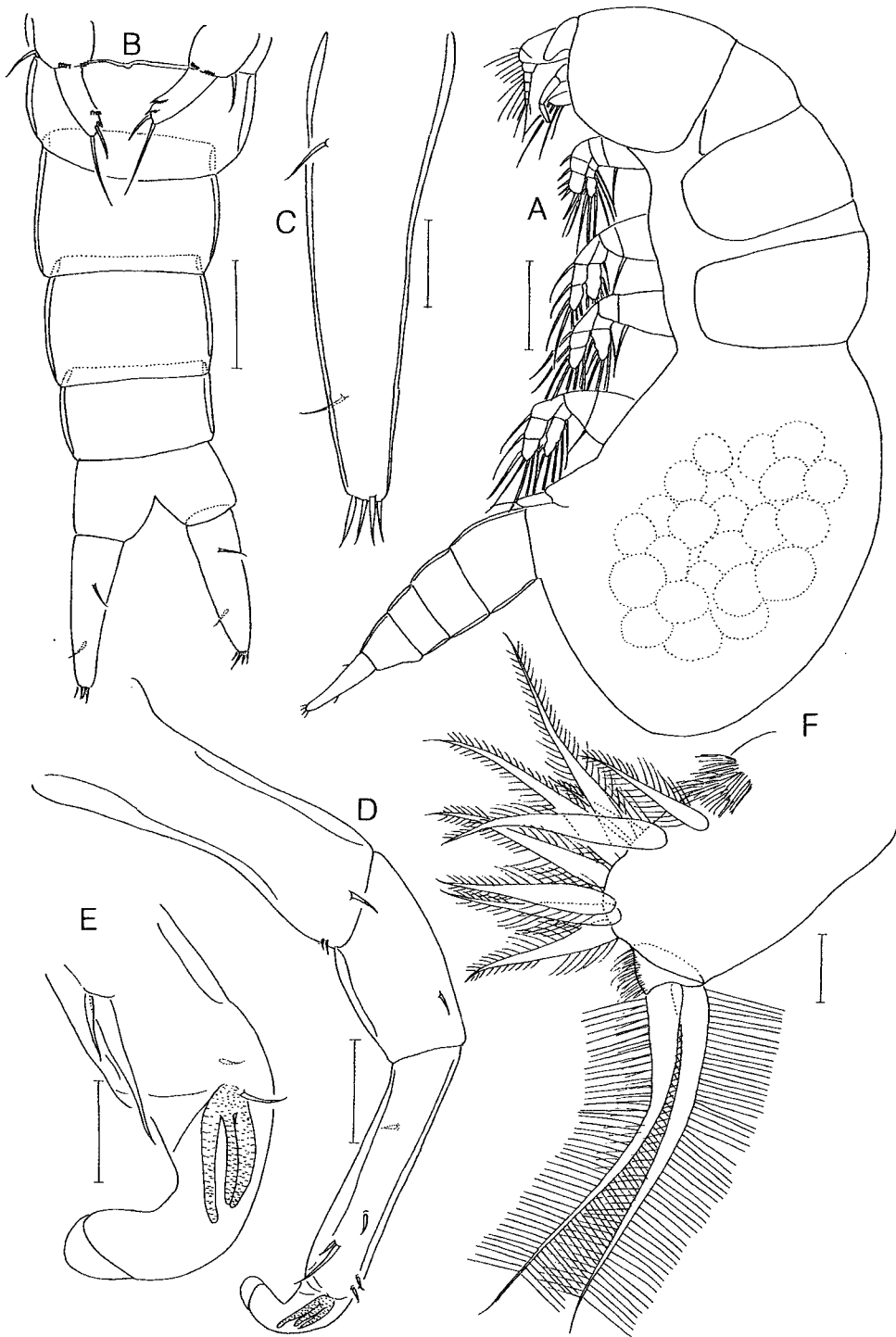


Fig. 1. *Doropygus curvipes* Gotto, 1975, female. A, habitus, lateral; B, urosome, ventral; C, caudal ramus; D, antenna; E, terminal portion of antenna; F, maxilliped. Scales: A, B = 0.3 mm; C = 0.1 mm; D, F = 0.05 mm; E = 0.02 mm.

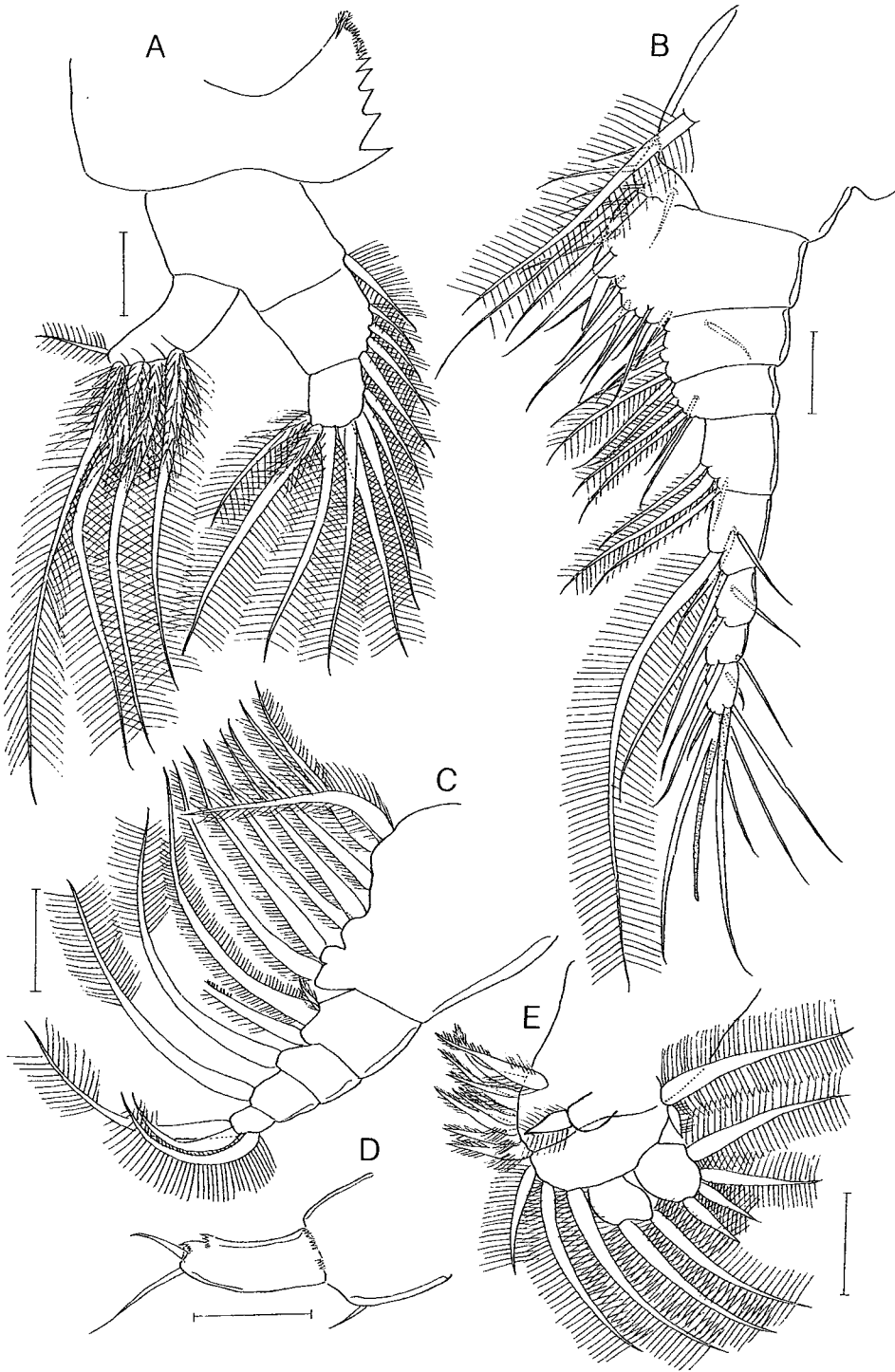


Fig. 2. *Doropygus curvipes* Gotto, 1975, female. A, mandible; B, antennule; C, maxilla; D, leg 5; E, maxillule. Scale: A - E = 0.1 mm.

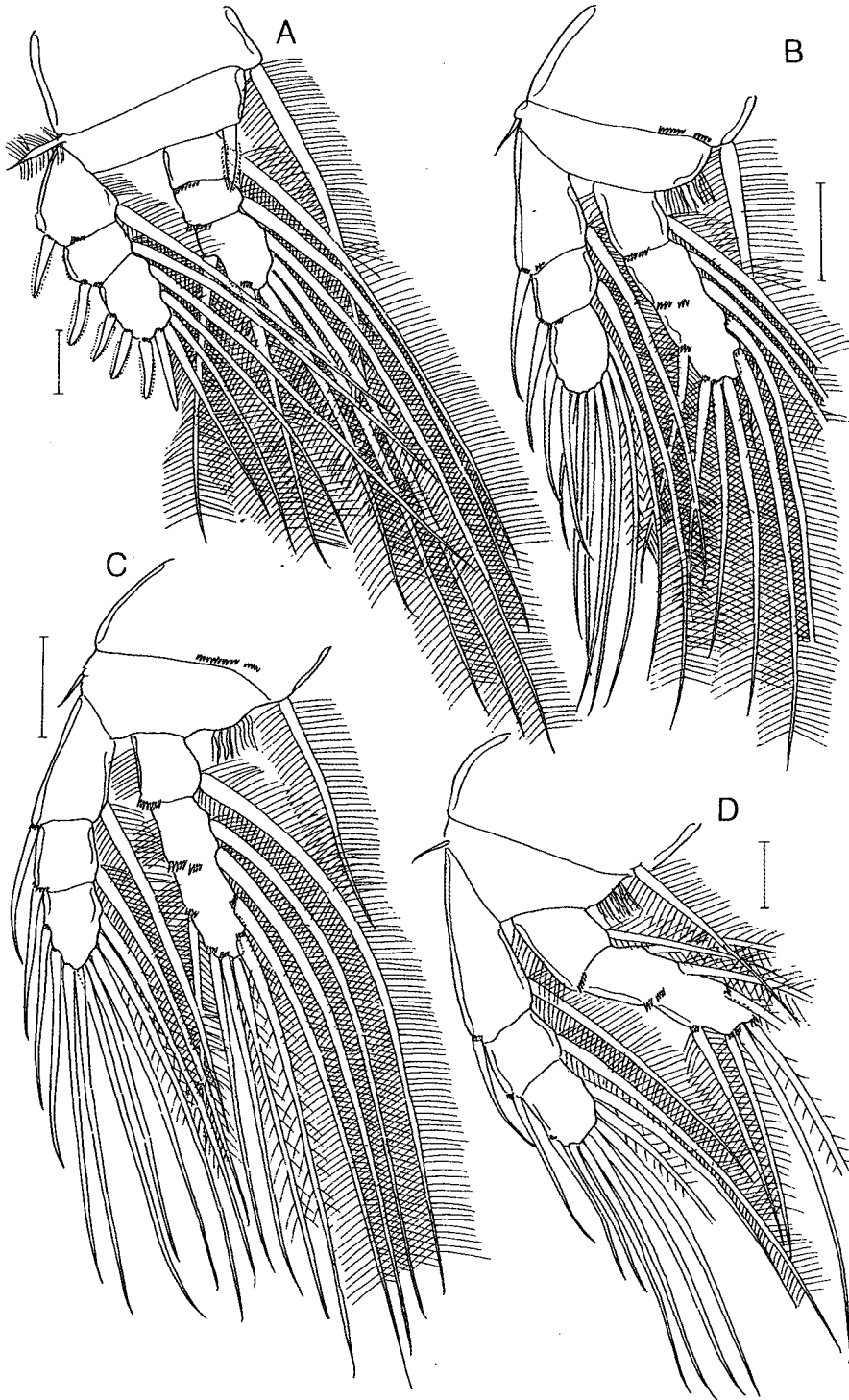


Fig. 3. *Doropygus curvipes* Gotto, 1975, female, A, leg 1; B, leg 3; C, leg 2; D, leg 4. Scales: A, D = 0.1 mm; B, C = 0.2 mm.

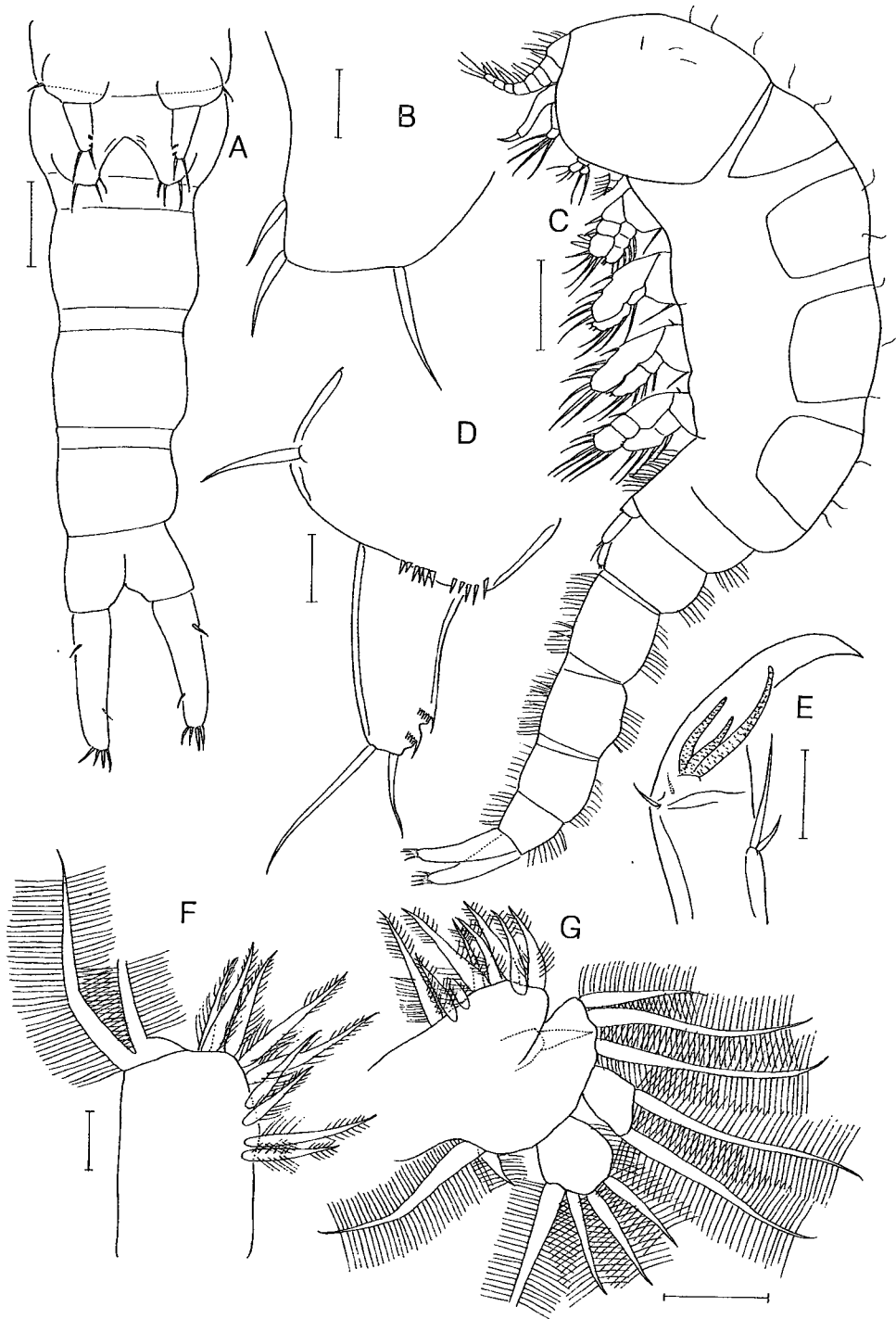


Fig. 4. *Doropygus curvipes* Gotto, 1975, male. A, urosome, ventral; B, leg 6; C, habitus, lateral; D, leg 5; E, terminal portion of antenna; F, maxilliped; G, maxillule. Scales: A = 0.1 mm; B, D - F = 0.02 mm; C = 0.2 mm; G = 0.03 mm.

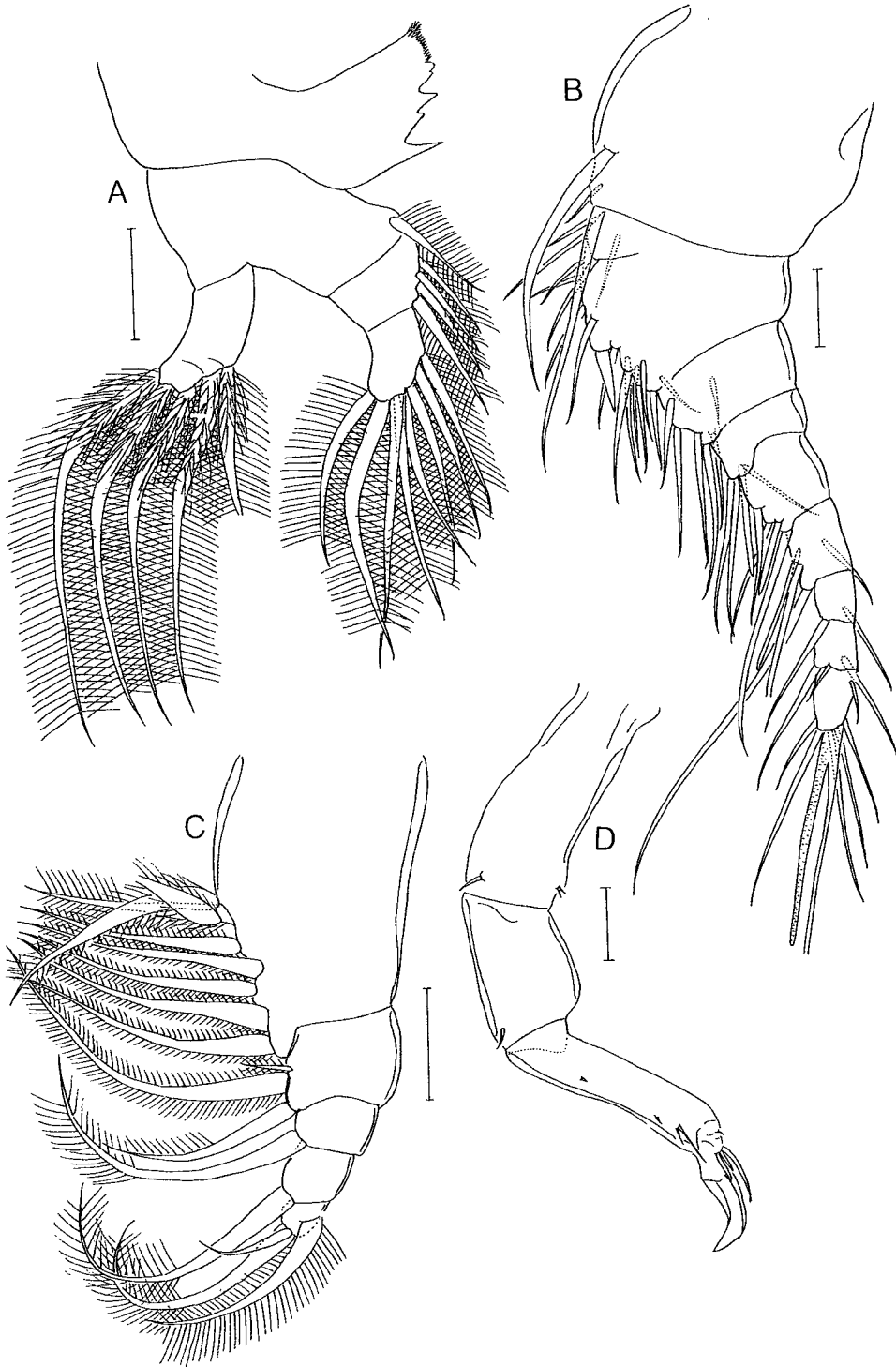


Fig. 5. *Doropygus curvipes* Gotto, 1975, male. A, mandible, B, antennule; C, maxilla; D, antenna. Scales: A, C, D = 0.03 mm; B = 0.05 mm.

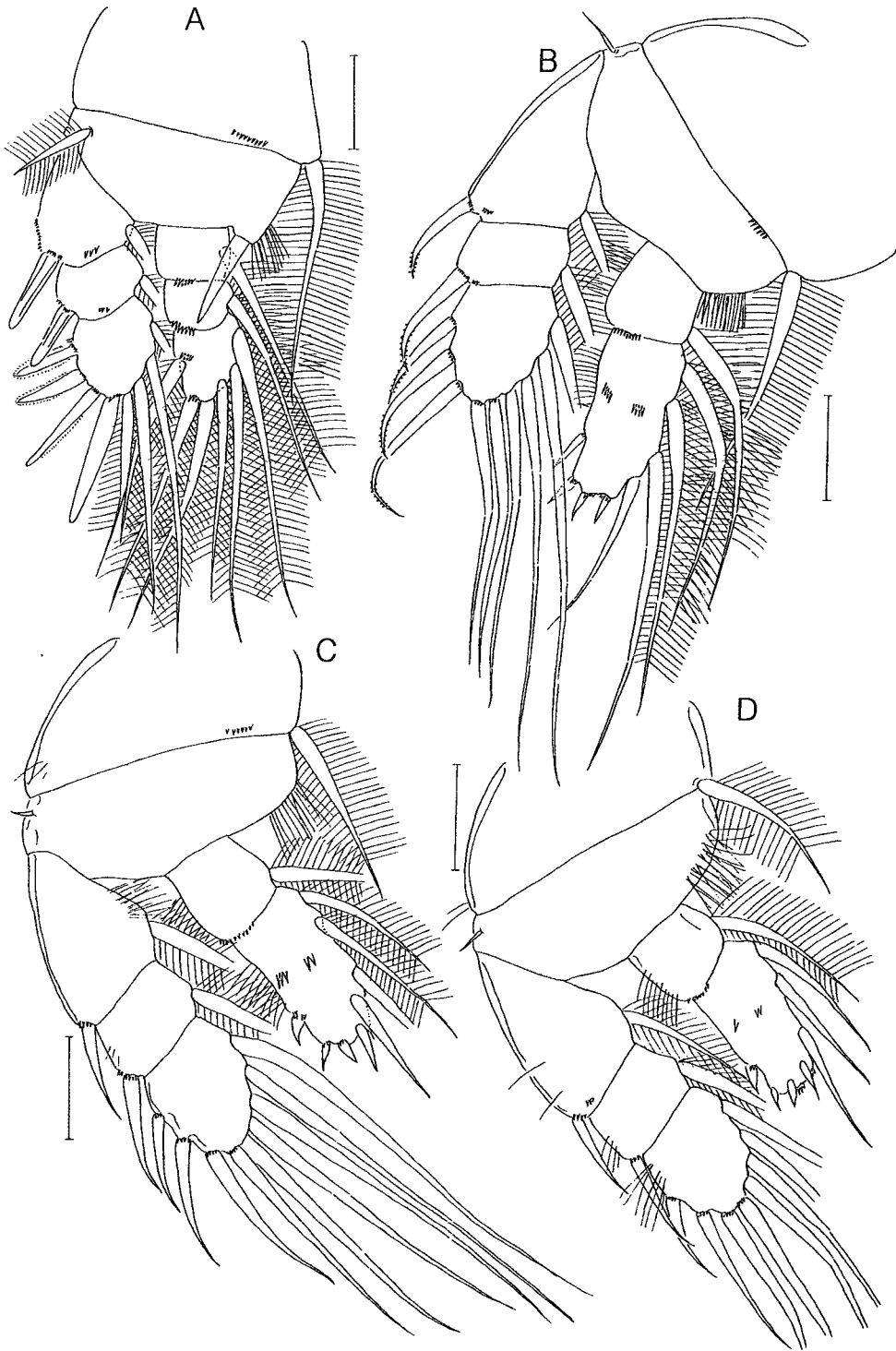


Fig. 6. *Doropygus curvipes* Gotto, 1975, male. A, leg 1; B, leg 2; C, leg 3; D, leg 4. Scale: A - D = 0.05 mm.

27 Dec. 1986.

Female. Body (Fig. 7C) 3.9 mm long (from tip of cephalosome to end of caudal rami, except terminal setae). Body depressed, consisting of cephalosome, 4-segmented metasome and 5-segmented urosome. Last metasomal somite inflated to form brood pouch. Genital apparatus located on near posterior ventral margin of first urosomal somite.

Antennule (Fig. 7A) 13-segmented, these segments gradually narrowing toward terminal end. Simple and plumose setae and aesthete mixed. Setal formula: 3, 16, 6, 4+1 aesthete, 4, 2, 2, 1+1 aesthete, 1, 1, 2, 2+1 aesthete, 7+1 aesthete.

Antenna (Figs. 7B, D) 3-segmented, proportional lengths of segments 1.7: 1: 1.4. Third segment narrow, about 4 times as long as wide, with 1 stout clawed hook. First segment with proximal spicules on inner face and with 1 long and 1 short distodorsal plumose seta and 1 short distoventral plumose seta on corner of outer margin. Second segment with 1 subdistal plumose seta on inner margin. Third segment with 2 isolated setae on inner face and with 3 subdistal setae, with terminally 3 stiff blunt setae, and with 3 rows of spinules on outer margin.

Mandible (Fig. 8A) consists of 2-segmented protopodite, 2-segmented endopod and unimerous exopod. Masticatory lamella of coxa with 4 sharp distal teeth, 3 blunt teeth, 2 proximal tiny setae. Basis with 1 seta on subdistal portion of inner margin and scattered spicules on distal margin. First segment of endopod with 4 setae on inner margin; second segment with 10 setae on inner and terminal margins. Exopod long, with scattered spicules on inner margin, with 5 long setae on median and distal margins, and distal seta of these longest.

Maxillule (Fig. 7G) consists of 2-segmented protopodite and unimerous rami. Epipodite with 1 long seta and 1 short setule on distal margin. Major endite enlarged, with 9 subequal setae on median margin, secondary endite with 1 setiform seta. Basis with 3 graded setae on outer margin. Endopod with 4 graded setae on outer margin. Exopod with 7 graded setae on inner and distal margins.

Maxilla (Fig. 7F) 5-segmented. First segment strongly enlarged, with 4 setiferous endites: first endite with 3 long setae and 1 tiny setule; second one with 1 long seta; third one with 2 long setae; fourth one with 2 long setae and 1 short seta. Second segment with 2 long setae and 1 falciform process. Third and fourth segments small, each with 1 long seta. Fifth segment smallest, with 1 proximal seta and 3 terminal setae.

Maxilliped (Fig. 7E) 3-segmented. First segment longer than remaining segments combined together, with hairs on outer margin, and with 9 setae forming 2 groups of 5 distal group and 4 proximal group. Second segment with hairs on inner margin. Third segment with 2 denticulated setae on inner margin, and 2 terminal setae and 1 denticulated distal seta.

Swimming legs 1-4 (Figs. 8E, 9A-C) consisting of 2-segmented protopodite and 3-segmented rami. Exopod of leg 1 longer than endopod, but exopod of legs 2-4 shorter than endopod. Leg 1 with 1 long seta on distal corner of coxa. Basis with 1 long seta on inner margin and 1 denticulated stout spine on medio-distal corner margin. Setae of coxa of legs 2-4 weakly developed than that those of leg 1.

Formula of spines (Roman numerals) and setae (Arabic numerals) as follows:

Leg 1 prp 0-1; 1-1 exp I-1; I-1; IV-4
enp 0-1; 0-1; 6

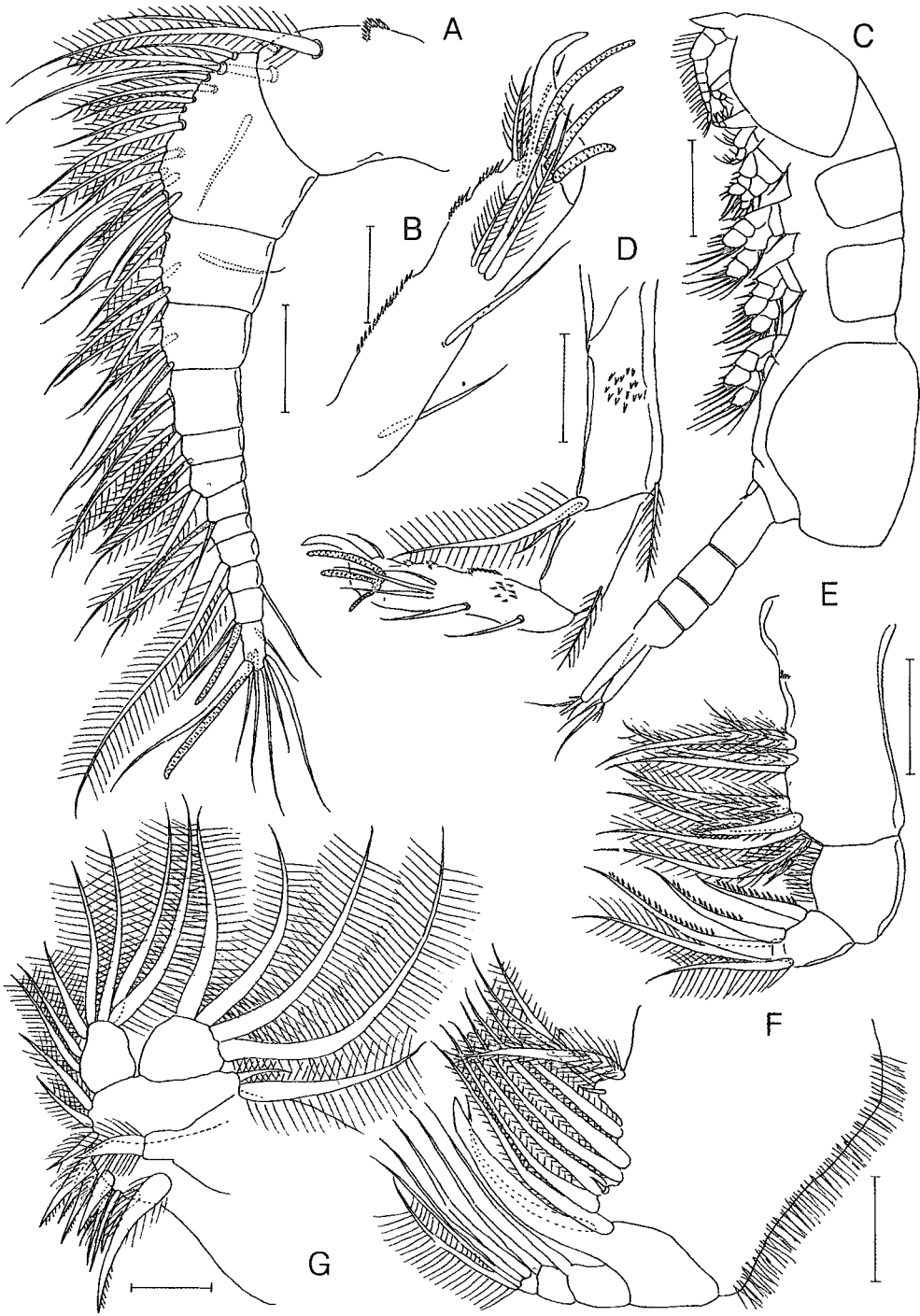


Fig. 7. *Notodelphys agilis villosus* Ooishi, 1962, female. A, antennule; B, terminal portion of antenna; C, habitus, lateral; D, antenna; E, maxilliped; F, maxilla; G, maxillule. Scales: A, D - F = 0.2 mm; B = 0.1 mm; C = 0.5 mm; G = 0.05 mm.

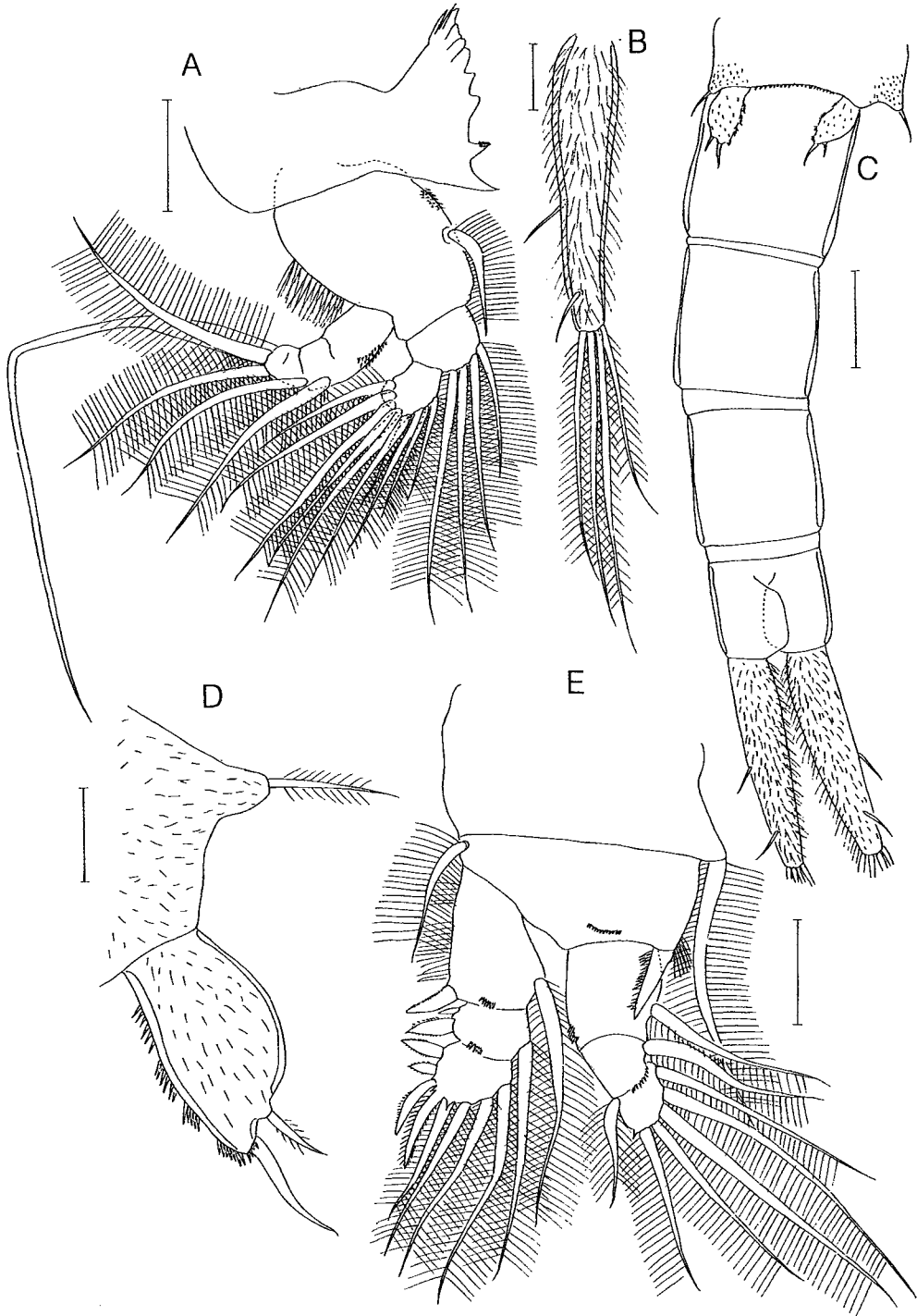


Fig. 8. *Notodelphys agilis villosus* Ooishi, 1962, female. A, mandible; B, caudal ramus; C, urosome, ventral; D, leg 5; E, leg 1. Scales: A, C, E = 0.2 mm; B, D = 0.1 mm.

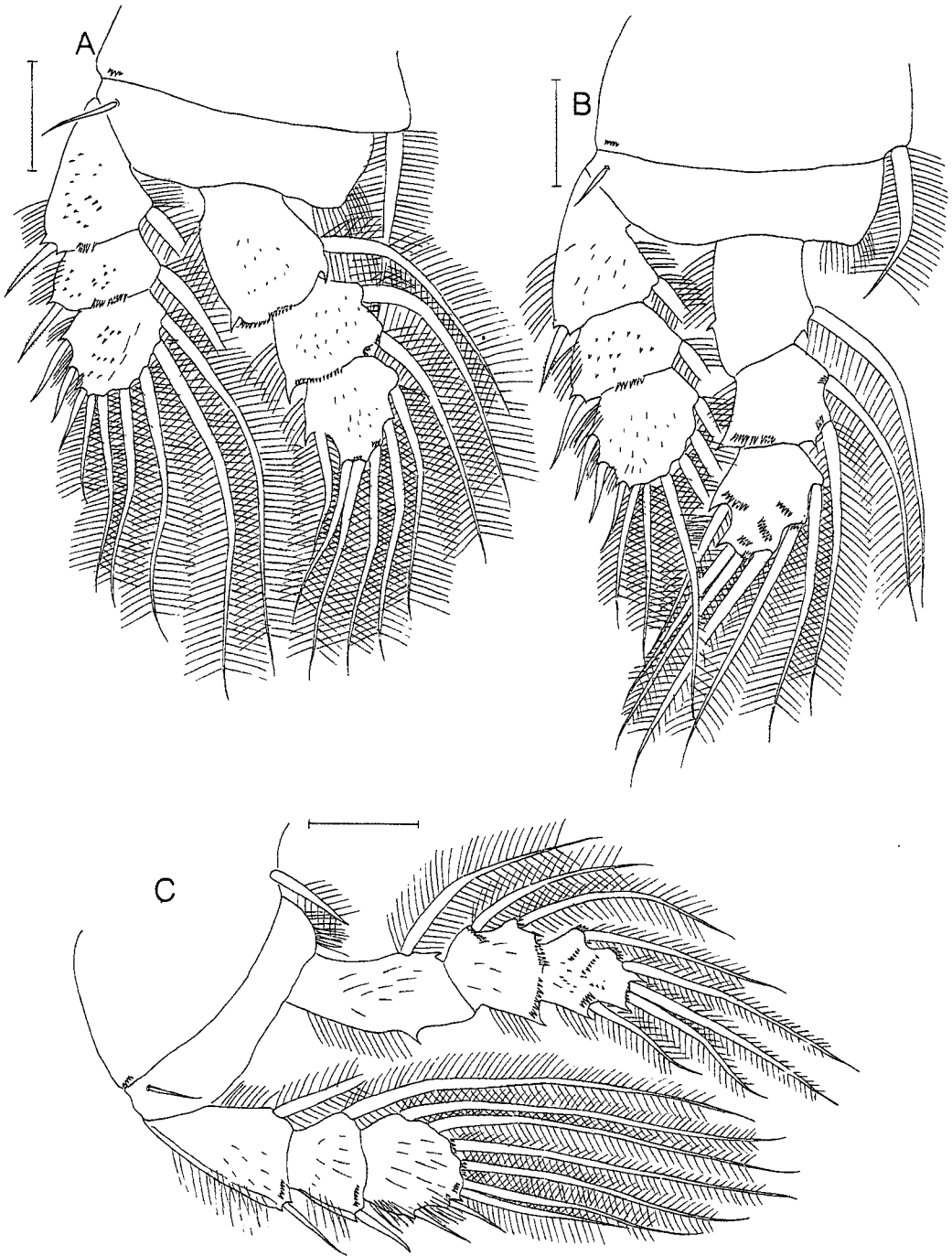


Fig. 9. *Notodelphys agilis villosus* Ooishi, 1962, female. A, leg 2; B, leg 3; C, leg 4. Scale: A - C = 0.2 mm.

Leg 2 prp 0-1; 1-0 exp I-1; I-1; III-6
 enp 0-1; 0-2; 6

Leg 3 prp 0-1; 1-0 exp I-1; I-1; III-6
 enp 0-1; 0-2; 6

Leg 4 prp 0-1; 1-0 exp I-1; I-1; II-6
 enp 0-1; 0-2; 5

Leg 5 (Fig. 8D) uniramous and 2-segmented. Basal segment broad, produced at lateral corner into a short digitiform process, tipped by 1 short slender plumose seta and spinules scattered on inner face. Second segment ovate, with 4 groups of denticles on inner margin, and 1 terminal spine and 1 short subterminal seta.

Caudal ramus (Fig. 8B) about 5 times as long as wide, with hairs on inner face, inner and outer margins. Length longer than 2 times of anal segment, and with 4 terminal setae. Two central setae of these longer than others. Middle surface of outer margin with 1 short seta and 1 subterminal seta on outer margin.

Male. Unknown.

Remarks. The present species is similar to *N. agilis* Thorell in the characteristics of the length of caudal ramus and the site of its lateral seta. But the present species is different from *N. agilis* in having the caudal rami ciliated on both sides and having fine marginal denticles on the two segments of the fifth leg. We agree that Ooishi ranked this species to subspecies of *N. agilis*.

Genus *Bonnierilla* Canu, 1891

***Bonnierilla curvicaudata* Ooishi, 1963 (Figs. 10-15)**

Bonnierilla curvicaudata Ooishi, 1963, p. 377, figs. 1-4.

Material Examined. 2 ♀♀, 9 ♂♂ collected from *Halocynthia roretzi* (von Drasche), fish market in Pusan, 3 Nov. 1986; 12 ♀♀, 4 ♂♂ from *Halocynthia roretzi* (von Drasche) fish market in Seogwipo 1 Nov. 1986; 10 ♀♀ from *Halocynthia roretzi* (von Drasche), fish market in Pusan, 14 Mar. 1993; 7 ♀♀ from *Halocynthia roretzi* (von Drasche), Taecheon, 27 Feb. 1993; 7 ♀♀ from *Halocynthia roretzi* (von Drasche), Pusan, 20 June. 1993; 5 ♀♀ from *Halocynthia roretzi* (von Drasche), Sokcho, 25 June. 1993; 7 ♀♀ from *Halocynthia roretzi* (von Drasche), Bijindo, Island, in the South Sea, 24 June. 1998.

Female. Yellowish brown. Body (Fig. 10A) compressed, body length 2.9mm (from tip of cephalosome to end of caudal rami). Anterior margin of cephalosome blunted, laterally flaring epimera and fused posteriorly with metasome. Rostrum consists of semicircular lobe. Dorsal margin of metasome much inflated. Metasome indistinctively 4-segmented, with four pairs of legs. Brood pouch occupies entire metasome. Urosome 5-segmented. Genital aperture located on anterior margin of second urosomal somite. Caudal ramus about 2 times as long as anal segment.

Antennule (Fig. 10B) 8-segmented. Setal formula: 3, 17 (spine 1), 9+1 aesthete, 5+1 aesthete, 1, 2, 2+1 aesthete, 7+1 aesthete.

Antenna (Fig. 10C) 3-segmented. Proportional lengths of segments from basal to apical as 1.4: 1: 2.5. First segment with 2 setules on inner distal corner. Second segment with 1 short seta on outer distal margin. Third segment with a group of 3 minute setae on distal quarter of inner margin, 1 proximal seta on inner margin, with 1 terminal clawed hook, 3 stiff terminal setae and 2 distal

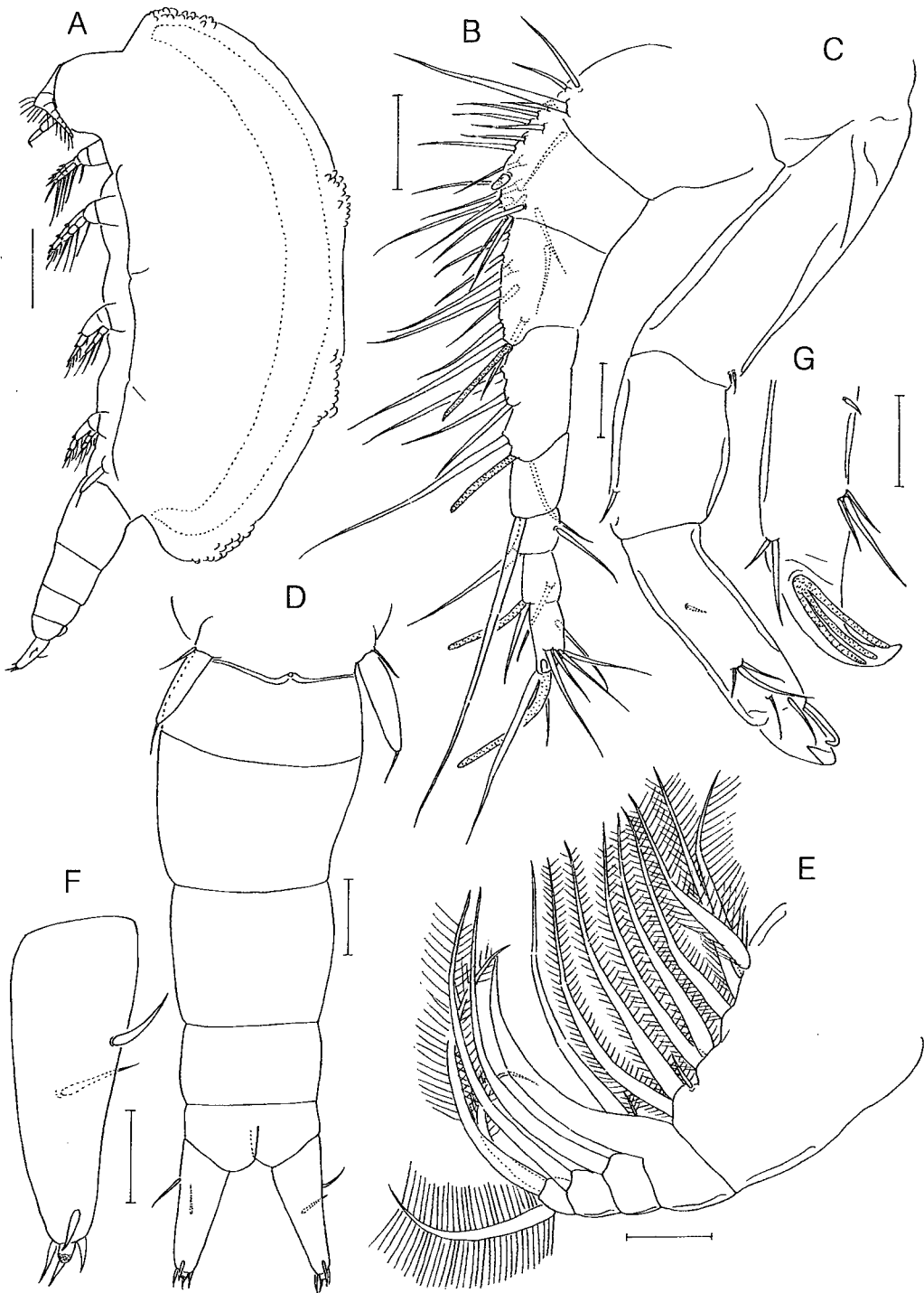


Fig. 10. *Bonnierilla curvicaudata* Ooishi, 1963, female. A, habitus, lateral; B, antennule; C, antenna; D, urosome, ventral; E, maxilla, F, caudal ramus; G, terminal portion of antenna. Scales: A = 0.3 mm; B, D = 0.1 mm; C, E, G = 0.03 mm; F = 0.05 mm.

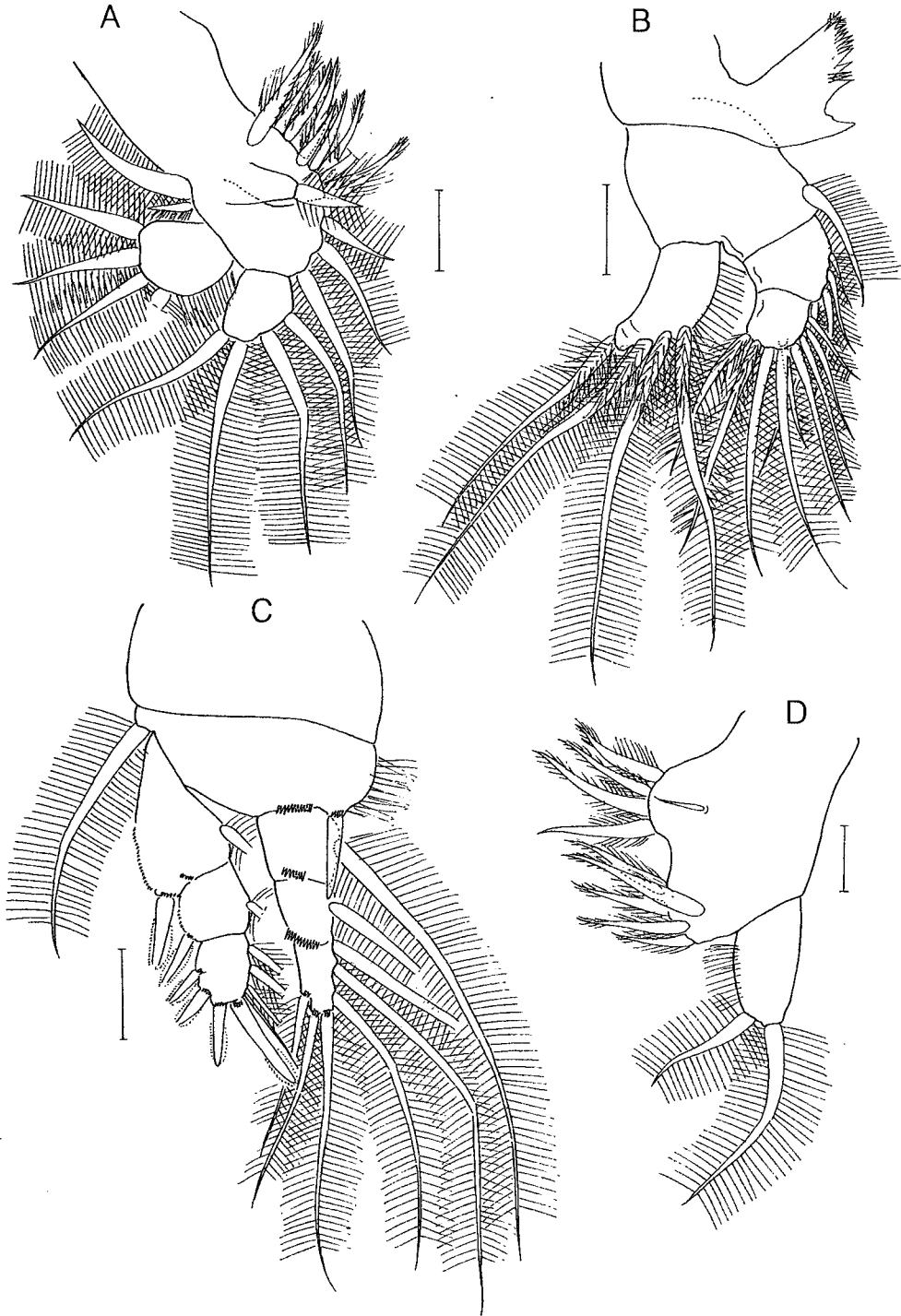


Fig. 11. *Bonnierilla curvicaudata* Ooishi, 1963, female. A, maxillule; B, mandible; C, leg 1; D, maxilliped. Scales: A = 0.03mm; B, C = 0.05 mm; D = 0.02 mm.

setae.

Mandible (Fig. 11B) consists of 2-segmented protopodite, 2-segmented endopod and 1-segmented exopod. Masticatory lamella of coxa with 3 heavy teeth, a row tiny teeth and 2 proximal setules, with 2 tiny setules between second tooth and third one. Basis with 1 distal seta on inner margin. Endopod 2-segmented: first segment with 4 setae on inner margin; second segment with 10 setae on apical and inner margins. Exopod elongate, inner margin with hairs, with 5 setae on inner and distal margins.

Maxillule (Fig. 11A) with 2-segmented protopodite and unimerous rami. Major endite of coxa with 9 setae on medial margin. Second endite with 1 setiform element. Epipodite with 1 long stout seta and 1 short seta. Basis with 3 setae on distal margin. Endopod with 4 long apical and distal setae. Exopod with 4 apical setae and hairs on inner margin. Maxilla (Fig. 10E) 5-segmented. Basal segment with 4 setiferous endites: first endite with 3 long setae; second one with 1 long seta; third one with 2 long seta; fourth one with 2 long setae and 1 tiny setule. Second segment with 1 long seta, 1 long spine and 1 tiny setule. Third and fourth segments with 1 long seta, respectively. Fifth segment with 3 long setae.

Maxilliped (Fig. 11D) 2-segmented. First segment with 10 setae forming 2 groups of 5 distal and 5 proximal groups including 1 tiny seta. Second segment with 2 distal setae and hairs on inner margin. Four pairs of swimming legs (Figs. 11C, 12A-C) consisting of distinctly 3-segmented rami. Exopod of legs 1-4 longer than endopod. Inner face of rami of legs 2-4 ornamented. Formula of spines (Roman numerals) and setae (Arabic numerals) as follows:

Leg 1 prp 0-0; 1-I exp I-1; I-1; IV-4
 enp 0-1; 0-1; 6
 Leg 2 prp 0-1; 1-0 exp I-1; I-1; IV-5
 enp 0-1; 0-2; 6
 Leg 3 prp 0-1; 1-0 exp I-1; 1-I; III-5
 enp 0-1; 0-2; 6
 Leg 4 prp 0-1; 1-0 exp I-1; I-1; III-5
 enp 0-1; 0-2; 5

Fifth leg uniramous, 2-segmented and inner face ornamented. Basal segment half as long as second segment and with 1 short slender seta on outer distal corner. Second segment with 1 terminal seta.

Caudal ramus (Fig. 10F) with 1 proximal and 1 medial seta on dorsal and ventral margins, and 1 blunt spine and 4 short terminal setae.

Male. Body (Fig. 13B) form typically cyclopoid, consisting of cephalosome, metasome and urosome, body length 2.27mm (from tip of cephalosome to end of caudal rami, except terminal setae). Metasome distinctively 4-segmented. Urosome distinctively 6-segmented. Caudal ramus about 2 times as long as anal segment. Rostrum as in female. Antennule (Fig. 13A) 8-segmented as in female, but with well-developed aesthete on third, fifth, seventh and eighth segments, respectively. Antenna, mandible, maxillule, and maxilla similar to those of female. Maxilliped represented sexual dimorphism: first segment with 8 setae forming 2 groups of 4 distal group and 4 proximal group including 1 tiny seta, second segment with 1 distal and 1 terminal seta in male.

Swimming leg 1 (Fig. 15A) similar to that of female, but setae of endopod shorter than those of

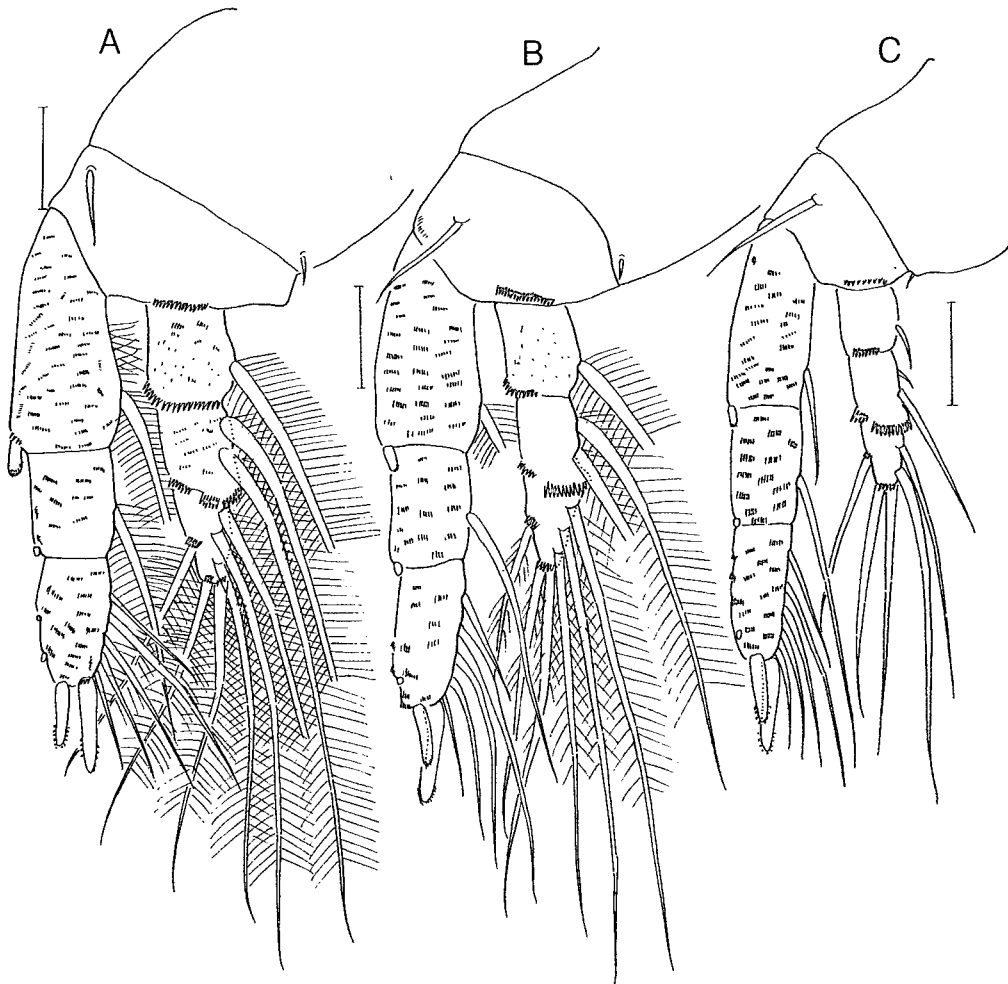


Fig. 12. *Bonnierilla curvicaudata* Ooishi, 1963, female. A, leg 2; B, leg 3; C, leg 4. Scale: A - C = 0.05 mm.

female, while spines and setae of exopod longer than those of female. Swimming legs 2-4 (Figs. 15B, D, E) represented sexual dimorphism, setation of endopod in male shorter than that of female. Fifth leg resembles that female but with three rows of denticles on medial margin of second segment. Sixth leg located on ventral margin of second urosomal somite, carrying spermatophore, and triangular form which with 1 distal and 1 terminal seta.

Caudal ramus 3 times as long as width, differ from that of female in terminal armature. The present specimen consists of 1 blunt spine, 3 long setae and subdistally 1 blunt small spine, which considers variation.

Remarks. This species can be recognized by inflated body. The Korean specimens of *Bonnierilla curvicaudata* Ooishi, 1963 are a little different from the Japanese specimens in the following characteristics: 1) The seventh segment of antennule in the Korean specimens has an aesthete, whereas it is absent in the Japanese specimens; 2) in the both sexes, the first segment of maxilliped

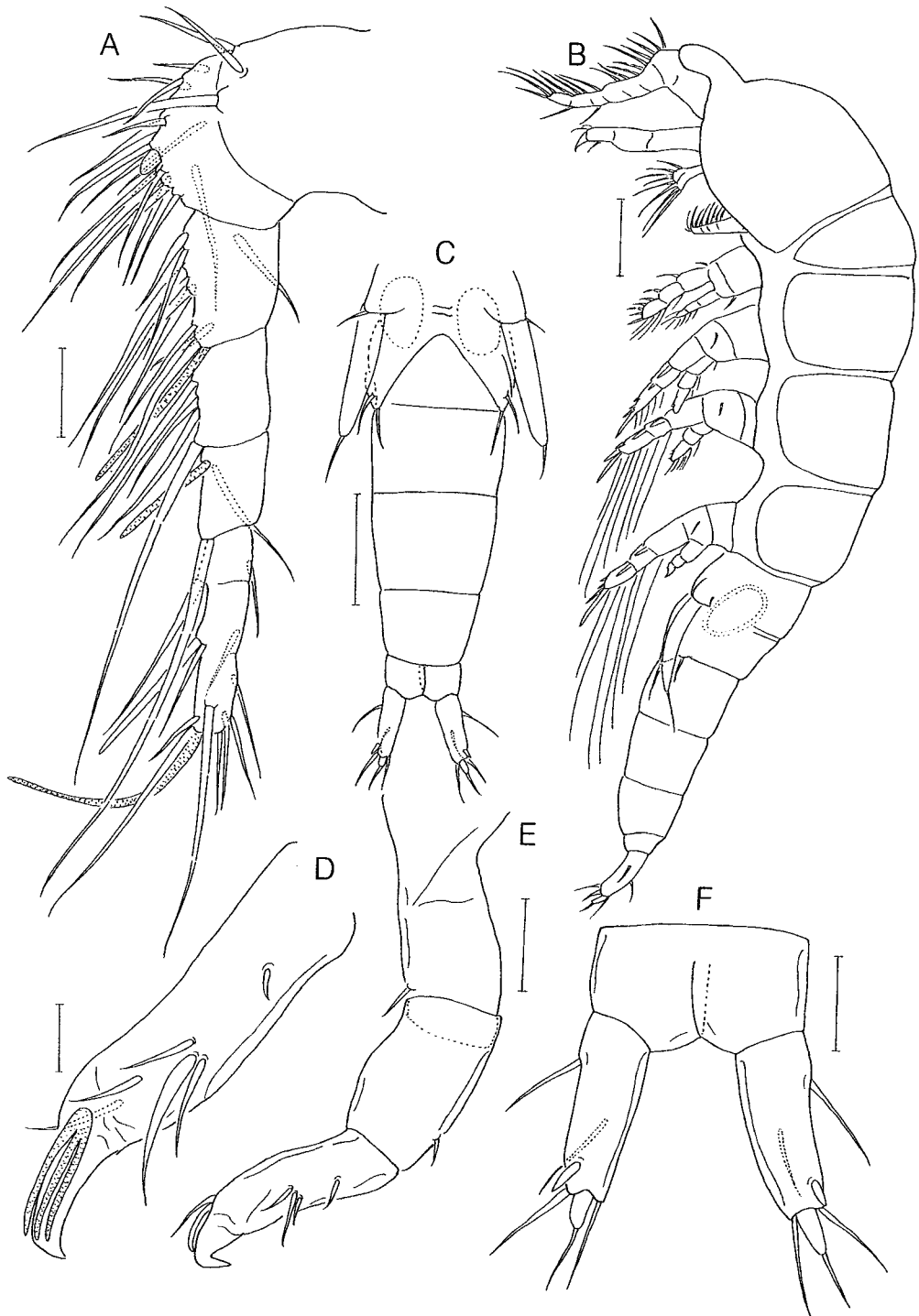


Fig. 13. *Bonnierilla curvicaudata* Ooishi, 1963, male. A, antennule; B, habitus, lateral; C, urosome, ventral; D, terminal portion of antenna; E, antenna; F, caudal rami. Scales: A, E, F = 0.03 mm; B = 0.2 mm; C = 0.1 mm; D, 0.01 mm.

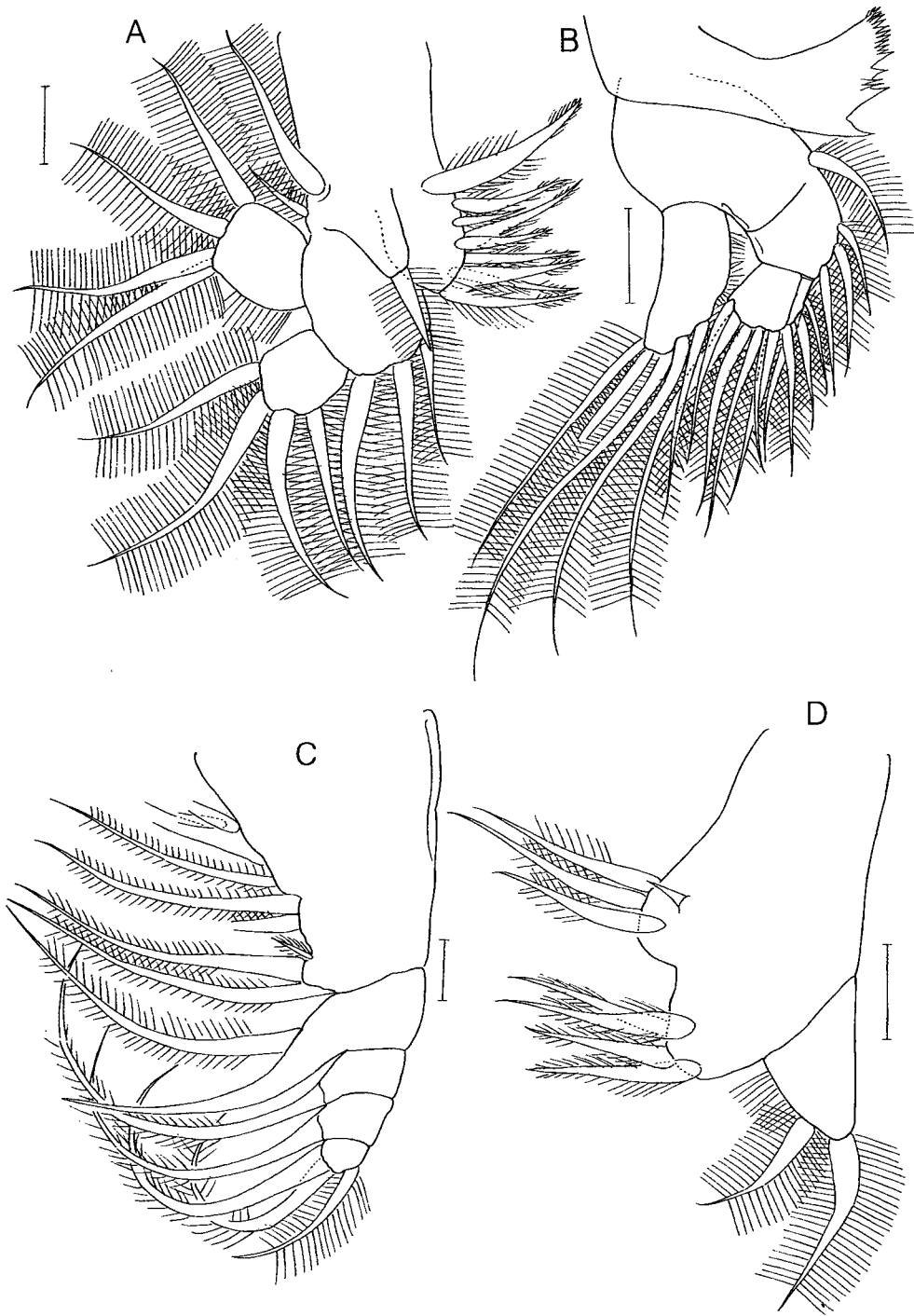


Fig. 14. *Bonnierilla curvicaudata* Oishi, 1963, male. A, maxillule; B, mandible; C, maxilla; D, maxilliped. Scales: A, C, D = 0.01 mm; B = 0.03 mm.

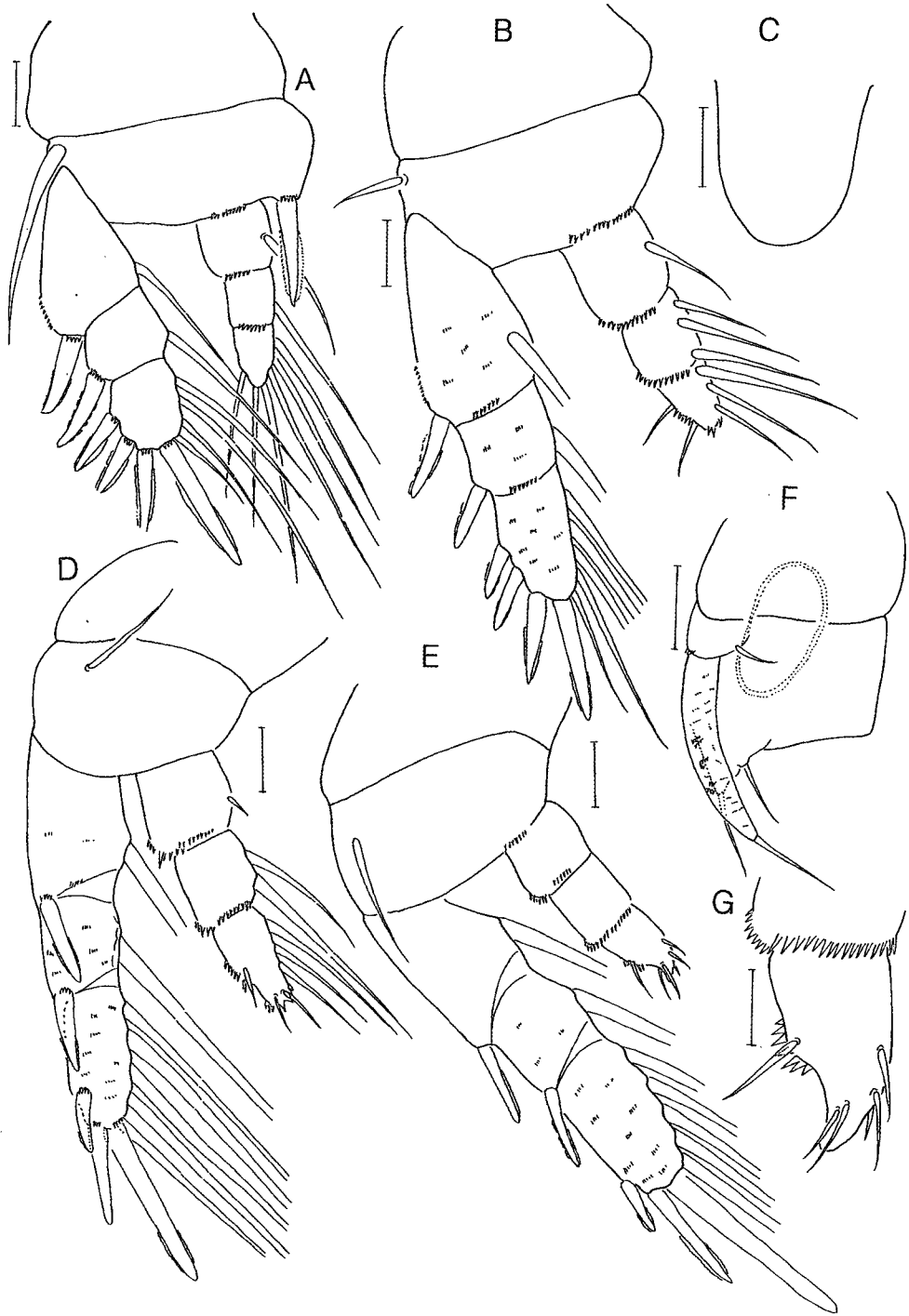


Fig. 15. *Bonnierilla curvicaudata* Ooishi, 1963, male. A, leg 1; B, leg 2; C, rostrum; D, leg 3; E, leg 4; F, leg 5 and leg 6, lateral; G, distal segment of endopod, leg 4. Scales: A, B, D, E = 0.02 mm; C = 0.03 mm; F = 0.05 mm; G = 0.01 mm.

in the Korean specimens bears 1 tiny seta, whereas it is absent in the Japanese specimens; 3) the third segment of exopod of leg 2 in the Korean specimens bears 2 small lateral spines, whereas that in the Japanese specimens have 1 small lateral spine.

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서 인 순·이 경 숙*

(환경부 생태계조사단 · *단국대학교 생물학과)

요 약

해초류 (피낭류)로부터 채집된 한국산 요각류 3미기록종 (*Doropygus curvipes* Gotto; *Notodelphys agilis villosus* Ooishi; *Bonnierilla curvicaudata* Ooishi) 이 확인되어 재기재한다. 따라서 해초류에 공생하는 한국산 요각류는 11종이 보고 되어진다.