

***Pontellopsis* Species (Copepoda, Pontellidae) in the Korean Waters, with Notes on the Female Genital Structures and Their Zoogeography**

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Abstract: Neustonic calanoid copepods were collected at the South Sea of Korea using a David-Hempel neuston net. Four *Pontellopsis* species (*P. armata* Giesbrecht, *P. regalis* Dana, *P. villosa* Brady and *P. yamadae* Mori) were identified and the former three species were first recorded in the Korea. We present redescription of the four species with SEM micrographs of female genitalia. Female genital structure is species-specific and can be very useful for species classification in the genus *Pontellopsis*. Also we discuss zoogeography of *Pontellopsis* species and provide with a key to the species hitherto known in the Korean waters.

Key words: *Pontellopsis*, taxonomy, neustonic copepods

INTRODUCTION

The genus *Pontellopsis* Brady, 1883 presently comprising 25 species, inhabits the surface waters (0-30 cm layer) from the tropical to the warm temperate regions and can be used as a biological indicator of the water masses, the inshore-offshore boundaries, and the zoogeographic divisions (Fleminger, 1957, 1967; Heinrich, 1960; Voronina, 1962; Sherman 1963, 1964, Matsuo and Marumo, 1982, Mulyadi, 2002). In the Korean waters, two species (*P. tenuicauda* Giesbrecht, 1889 and *P. yamadae* Mori, 1937) were reported by Kim (1985) and Yoo (1995), and three species (*P. armata* Giesbrecht, 1889, *P. regalis* Dana, 1849, *P. villosa* Brady, 1883) are newly recorded from the South Sea of Korea. Since these species have often not been sufficiently described (e.g., Brady 1883, Mori 1937 (1964), Wilson 1950, Tanaka 1964, Zhang et al. 1965, Chen and

Zhang 1965, Silas and Pillai 1973, Zheng et al. 1982), we provide redescription with additional focus on female external genitalia and their zoogeography.

MATERIALS AND METHODS

Neustonic zooplankton were collected from April 2002 to March 2003 in surface layers (less than 30 cm) of the South Sea of Korea, using a David-Hempel neuston net (Hydro-Bios co. model 300; mesh size 0.3 mm) towed for 10 minutes at a speed of 2.5 knots (see Fig. 1 in Jeong et al., 2008). The samples were immediately preserved in 5% neutralized formalin/seawater after capture. All *Pontellopsis* species were sorted from zooplankton samples. Specimens were dissected and mounted in CMC-10, and illustrated with an optical microscope (Nikon 80i) equipped with a drawing tube. The female genitalia were also examined with a scanning electron microscope (Hitachi S-3000N). Morphological terminology follows Huys and Boxshall (1991).

DESCRIPTION

Pontellopsis villosa Brady, 1883
(Figs. 1-4)

Pontellopsis villosa Brady, 1883, p. 86, pl. 34, figs. 10-13, pl. 35, figs. 14-20 (type locality: the Pacific, 30°32'N, 154°56'W); Giesbrecht and Schmeil 1898, p. 148; Scott A., 1909, p. 172; Sewell 1932, p. 390; Wilson 1950, p. 314, pl. 30, fig. 462; Tanaka 1964, p. 268, figs. 24 a-e; Chen and Zhang 1965, p. 108, pl. 47, figs. 8-11, pl. 48, figs. 1-3; Knusen and Wolff, 1965, p. 194; Owre and Foyo 1967, p. 99, figs. 710-713; Silas and Pillai, 1973, p. 837, fig. 28; Zheng et al., 1982, p. 87, figs. 49-1 a-e, 49-2 f-i; Mulyadi,

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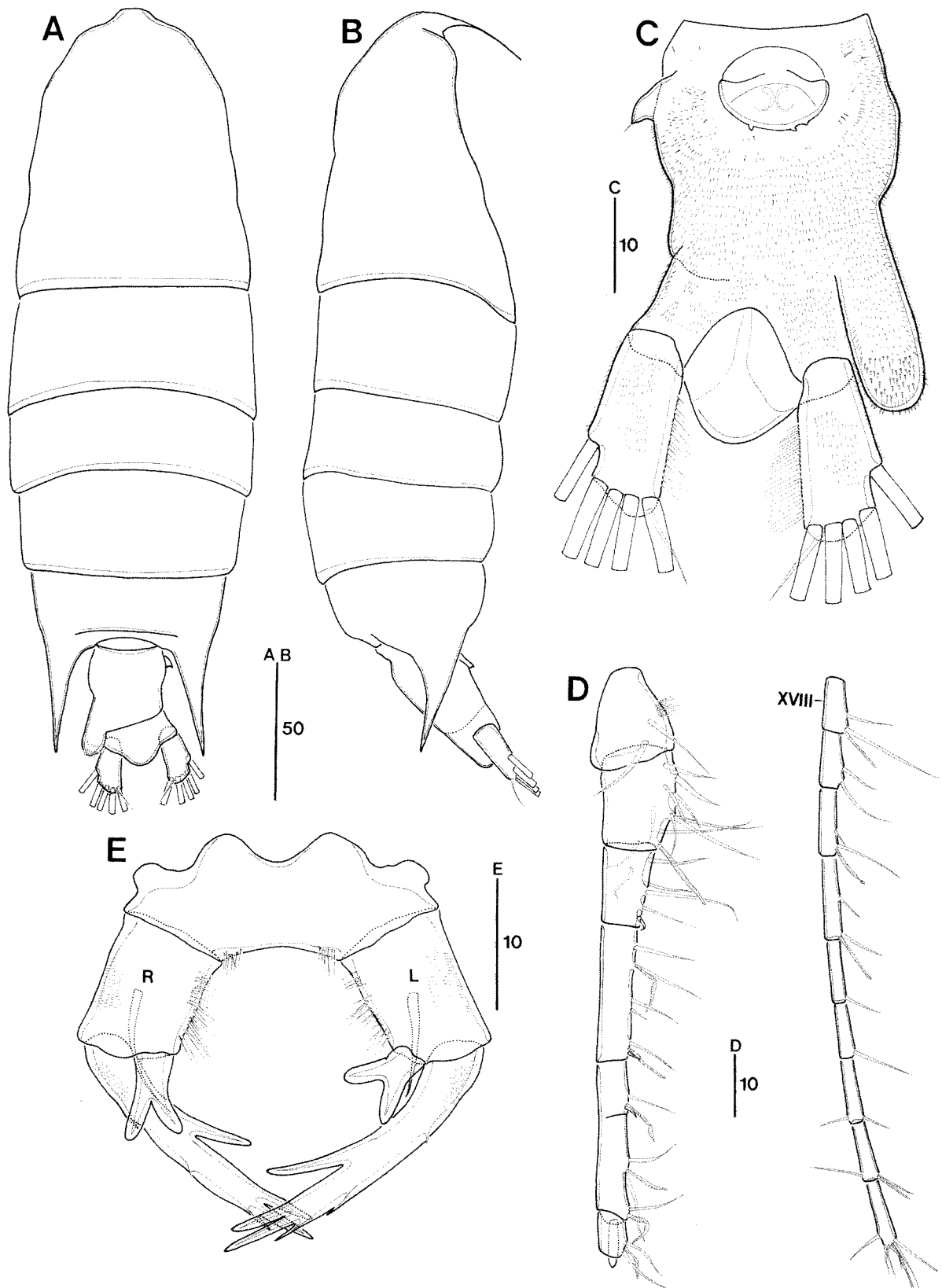


Fig. 1. *Pontellopsis villosa*, female: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) urosome, ventral view; (D) antennule; (E) fifth leg. Scale is in μm .

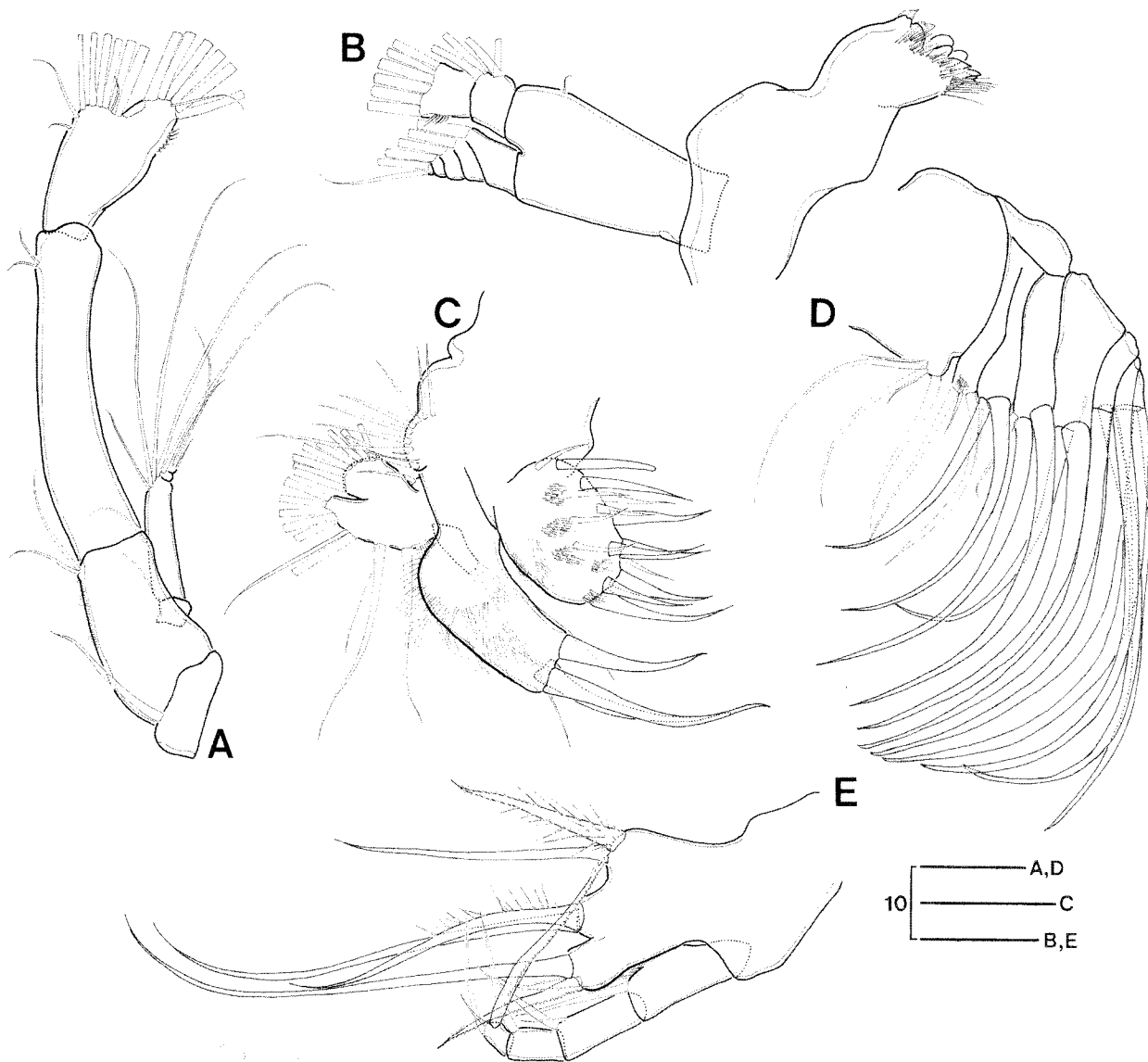


Fig. 2. *Pontellopsis villosa*, female: (A) antenna; (B) mandible; (C) maxillule; (D) maxilla; (E) maxilliped. Scale is in μm .

2002, p. 151, fig. 56.

Monops villosus: Giesbrecht 1893, p. 486, pl. 26, figs. 10, 12, 17, 23, 33, 34, pl. 41, figs. 45, 51, 57, 69.

Materials examined: Five females and six males collected at St. 15 on 26 September 2002. Three females and three males were dissected and closely examined.

Females: Body length 2.41-2.68 mm (n=5). Prosome (Fig. 1A) cylinder: fourth and fifth pedigerous somites partly fused; posterior corners of prosome asymmetrical with acuminate processes, which extends to caudal rami. Cephalosome broadly rounded anteriorly, with projection over base of rostrum. Urosome 2-segmented and segmentation indistinct laterally and ventrally (Figs. 1B, C): genital compound somite asymmetrical, left side with conspicuous digitiform process posteriad and right side with stout conical process anteriorlaterally; genital operculum located

anterioventrally without any process; anal somite medioposteriorly prolonged; caudal rami symmetrical. Antennule (Fig. 1D) symmetrical with 15-segmented: ancestral segments II to VII, VIII to X, XI to XIII and XXVI to XXVIII completely fused and segments XIV to XVI partly fused. Fusion pattern and setal formula as follows: I-3, II-VII-10+3aesthetascs (ae), VIII-X-6+ae, XI-XIII-6+2ae, XIV-XVI-6+3ae, XVII-2+ae, XVIII-2+ae, XIX-2, XX-2+ae, XXI-2+ae, XXII-1, XXIII-1, XXIV-1+1, XXV-1+1+ae, XXVI-XXVIII-6+ae. Segment XVI bearing stout spine. Antenna (Fig. 2A) biramous, endopod larger than exopod: coxa having single plumose seta; basis bearing 2 distal setae; endopod 2-segmented, first segment with 2 setae distally, second segment with 9 and 7 setae on proximal and distal lobes, respectively and row of posterior spinules on distal lobe; exopod 5-segmented, setal formula

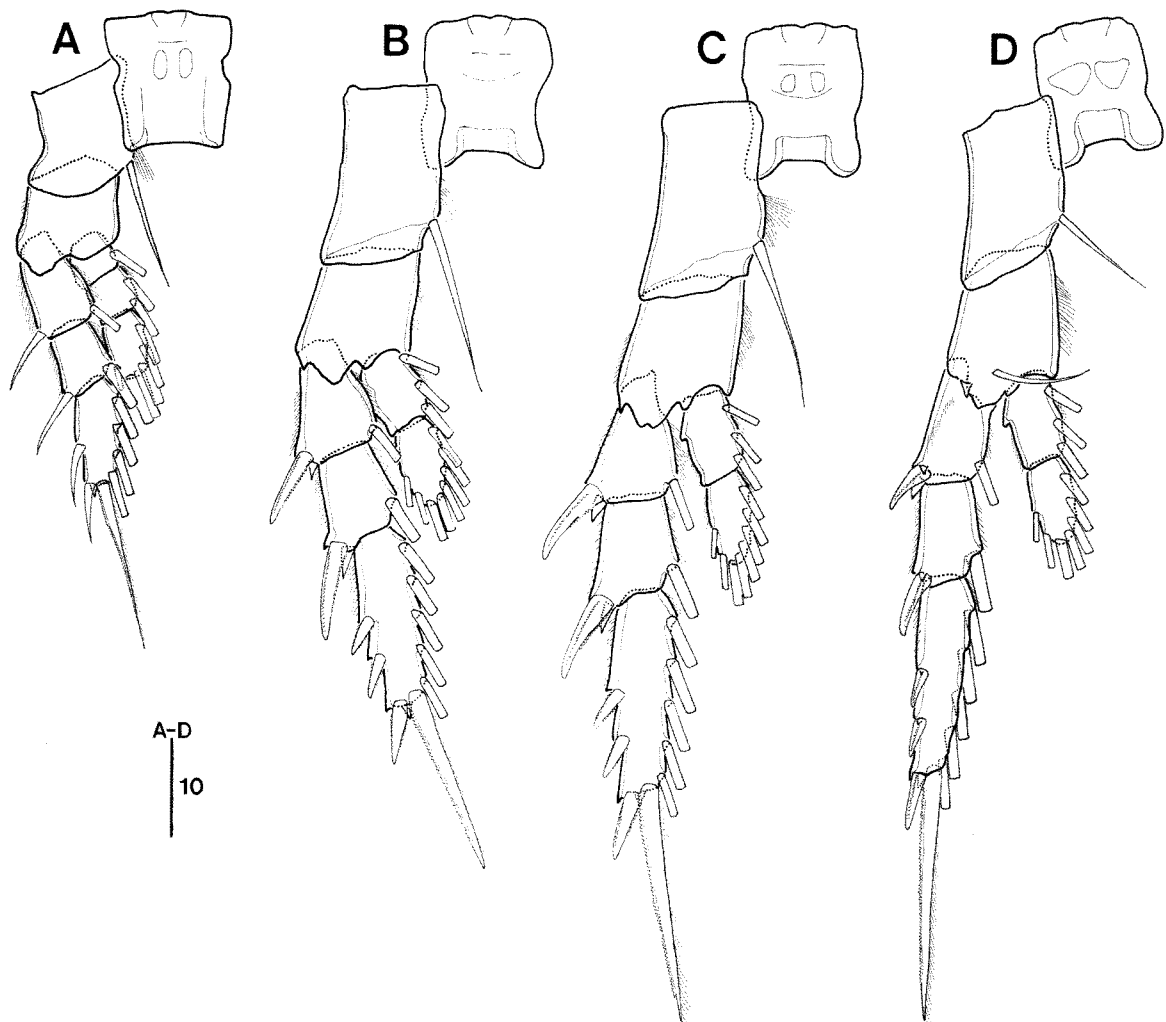


Fig. 3. *Pontellopsis villosa*, female: (A) leg 1; (B) leg 2; (C) leg 3; (D) leg 4. Scale is in μm .

1, 3, 1, 2, 3. Mandible (Fig. 2B) with large coxal gnathobase and biramous palp: gnathobase heavily chitinized bearing 6 teeth and dorsal seta; patch of spinules at base of teeth and third to fourth teeth plate-form; basis of mandibular palp elongated bearing 1 seta; endopod 2-segmented, first segment with 4 setae, second with 6 setae; exopod 5-segmented, setal formula 1, 1, 1, 1, 2. Maxillule (Fig. 2C): praecoxal arthrite with 15 stout setae; minute spinules and fine hairs near base of these setae; coxal endite with 3 setae and epipodite with 9 setae; basal exite with single seta and first basal endite with 2 setae; second basal endite to second endopodal segments fused with long hairs and 5 setae; distal endopodal segment with 5 setae; exopod with 8 setae. Maxilla (Fig. 2D) uniramous: praecoxa with 2 endites, proximal bearing 5 setae, distal 3 setae; coxa with 2 endites, each with 3 setae; basis with 3 setae; endopod 4-segmented, setal formula 1, 2, 2, 2. Maxilliped (Fig. 2E) uniramous: praecoxa and coxa completely fused, setal formula 0, 2, 2, 3; basis and first endopod segment fused with row of small setula subdistally and 3 setae; second to fourth endopod

segments with 2, 1, 3 setae, respectively. Swimming legs 1 to 4 biramous and coxa bearing inner seta. First leg (Fig. 3A) bearing inner seta on basis, both 3-segmented rami and terminal endopod segment ending in long and apical process. Second to fourth legs (Figs. 3B-D) with 2-segmented endopod and 3-segmented exopod. Leg 4 (Fig. 3D) having plumose seta on basis. Seta and spine formula as follows (spines, Roman numerals; setae, Arabic numerals):

	Coxa	Basis	Exopodal segment	Endopodal segment
Leg 1	0-1	0-0	I-1; I-1; II, I, 4	0-1; 0-2; 1, 2, 3
Leg 2	0-1	0-0	I-1; I-1; III, I, 5	0-3; 2, 2, 4
Leg 3	0-1	0-0	I-1; I-1; III, I, 5	0-3; 2, 2, 4
Leg 4	0-1	1-0	I-1; I-1; III, I, 5	0-3; 2, 2, 3

Fifth leg (Fig. 1E) asymmetrical, hirsute: intercoxal sclerite and coxa divided; left leg longer than right one; exopod with 2 outer spinules, 3 distal processes and 1 inner stout process; endopod bifid.

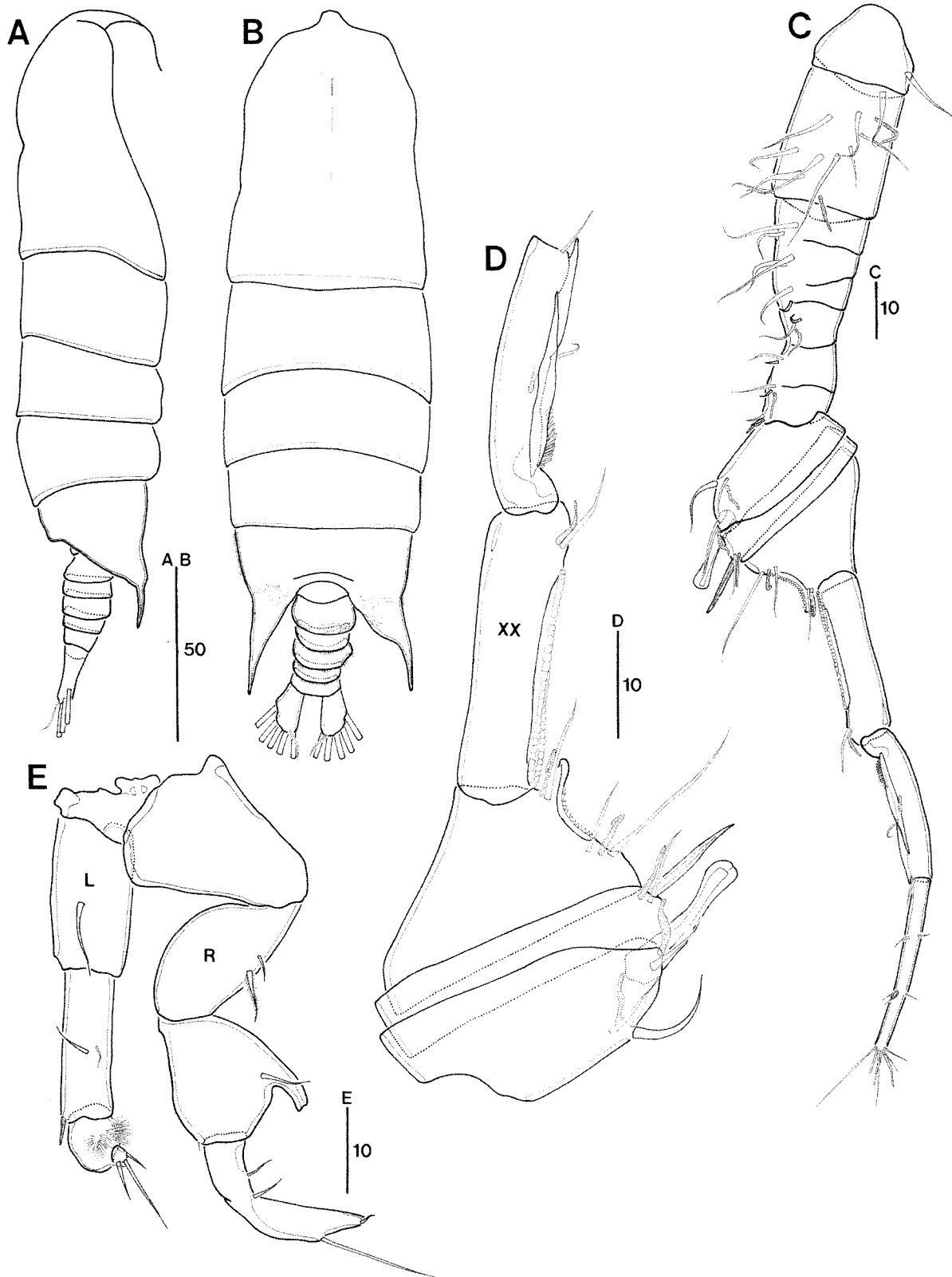


Fig. 4. *Pontellopsis villosa*, male: (A) habitus, right lateral view; (B) habitus, dorsal view; (C) right antennule; (D) ancestral segments XV to XXIII in right antennule; (E) fifth leg. Scale is in μm .

Males: Body length 2.12-2.41 mm (n=6). Prosome (figs. 4A, B) similar to female: posterior corners of prosome asymmetrical, with acuminate process. Urosome 5-segmented, having a hirsute: third urosomite with right side swelling; caudal rami symmetrical. Right antennule indistinctly 10-segmented (Fig. 4C). Fusion pattern and setal formula as follows: I-2+ae, II-VII-10+2ae, VIII-XI-8+ae, XII-XIV-6+2ae, XV-XVI-4+2ae, XVII-2+ae, XVIII-XIX-3+p+2ae, XX-1+p+ae, XXI-XXIII-2+2p+ae, XXIV-XXVIII-10+3ae. Segments XVI and XVII each with stout spine, compound segment XVIII to XIX with 1 small toothed plate, segment XX with rectangular tooth ridge and compound segment XXI to XXIII with serially arranged radiating spines on its proximal base (Fig. 4D). Fifth leg (Fig. 4E) uniramous and asymmetrical: intercoxal sclerite and left coxa fused; basis bearing 2 setae which one plumose seta and the other nominal seta; right leg 2-segmented exopod; first segment with 2 setae and short digitiform process; second segment elongated and curved with 2 inner setae, apical seta and outer long spine; left leg 3-segmented exopod; first segment with outer spine distolaterally and 2 medial setae; second segment globular with outer minute spinule and inner hirsute; third segment short with 3 apical spines.

Remarks: The present specimens well coincide with Brady's (1883) illustrations, except for genital compound somite bearing conical process anteriolaterally. However, Giesbrecht's (1893) description shows the minor morphological differences with Korean specimens: in the female (1) posterior process of prosome not extends to caudal rami, and (2) left distolateral process in genital compound somite not reaching the caudal rami. On the other hand, Tanaka's illustrations of female of *P. villosa* (1964) in fact refer to those of *P. regalis*.

Pontellopsis armata (Giesbrecht, 1889)
(Figs. 5, 6)

Monops armatus Giesbrecht, 1889, p. 28 (type locality: Philippines); Giesbrecht, 1893, p. 487, pl. 26, figs. 19, 26, 27, pl. 41, figs. 46, 47, 58.

Pontellopsis armata: Giesbrecht and Schmeil, 1898, p. 148; Scott A., 1909, p. 170; Sewell, 1932, p. 385; Mori, 1937(1964), p. 97, pl. 45, figs. 5-8; Wilson, 1950, p. 304, pl. 30, figs. 450-452; Tanaka, 1964, p. 269; Chen and Zhang, 1965, p. 108, pl. 48, figs. 4, 5; Silas and Pillai, 1973, p. 846, fig. 33; Zheng et al., 1982, p. 88, figs. 50 a-g; Mulyadi, 2002, p. 126, fig. 46.

Materials examined: One female and one male were collected at Sts. 12 and 14 on 26 September 2002. All specimens were dissected.

Female: Body length 2.37 mm (n=1). Prosome (Fig. 5A) robust without lateral cephalic hooks: fourth and fifth

pedigerous somites incompletely fused; posterior corners of prosome with pointed process extending anterior of anal somite. Cephalosome broadly rounded anteriorly and mid frontal protrusion: rostrum bifid with long filaments and without ventral ocellus (Fig. 5B). Urosome 2-segmented, segmentation indistinct laterally, covered with small spinules and hairs (Fig. 5C): genital compound somite with pair of transperant setules anteriolaterally; lower margin of genital opening bearing rightward triangular process; anal somite prolonged both anteriorly and posteriorly, and partly covers caudal rami; caudal rami asymmetrical, left ramus longer and wider than right ramus. Antennule similar to that of *P. villosa* except for segment I bearing 1 seta (Fig. 5D). Fifth leg (Fig. 5E) symmetrical: exopod with 3 outer spinules and 3 distal spines, of which middle one longest.

Male: Body length 2.13 mm (n=1). Posterior corners of prosome asymmetrical, left corner with sharp process and right corner rounded lobe bearing slender, long and curved spine (Figs. 6A, B). Urosome 5-segmented: genital somite with 2 setae on right side; third urosomite with thumb-like process bearing lots of small spinules at right apex; caudal rami symmetrical. In right antennule (Fig. 6C), segments XVI and XVII each with stout spine; segments XIX and XX with rows of small denticles, compound segment XXI to XXIII with 2 toothed plates (Fig. 6D). Fifth leg (Fig. 6E) intercoxal sclerite and left coxa fused: right coxa bearing inner seta and basis with 2 setae; right leg, first exopod with stout digitiform process bearing 1 seta at its base; second exopod elongated, bent medially with 2 inner setae and 1 outer seta apically; left leg, first exopod with outer spine; second exopod with outer spine medially, inner hirsute and 3 spines at apex.

Remarks: This species is distinguishible from the other species by the following characteristics: in the female (1) hirsute body, (2) posterior corners of prosome with sharp process reaching half of anal somite, (3) genital compound somite bearing transperant setules in anteriolateral both side, and (4) genital operculum with rightward triangular process ventromedially; in the male (1) the right posterior corner of prosome bearing flagella process, and (2) right side of the third urosomite with thumb-like protrusion bearing a lot of spinules.

Pontellopsis regalis (Dana, 1849)
(Fig. 7)

Pontella regalis Dana, 1849, p. 31 (type locality: Sulu Sea).
Pontella streuna: Brady (in part), 1883, p. 95, pl. 45, fig. 18.

Monops regalis: Giesbrecht 1893, p. 486, pl. 1, fig. 6, pl. 26, figs. 1-9, 11, 13, 14, 20-22, 24, 29, pl. 41, figs. 50, 54, 56, 62, 64, 66-67.

Pontellopsis regalis: Giesbrecht and Schmeil, 1898, p. 147;

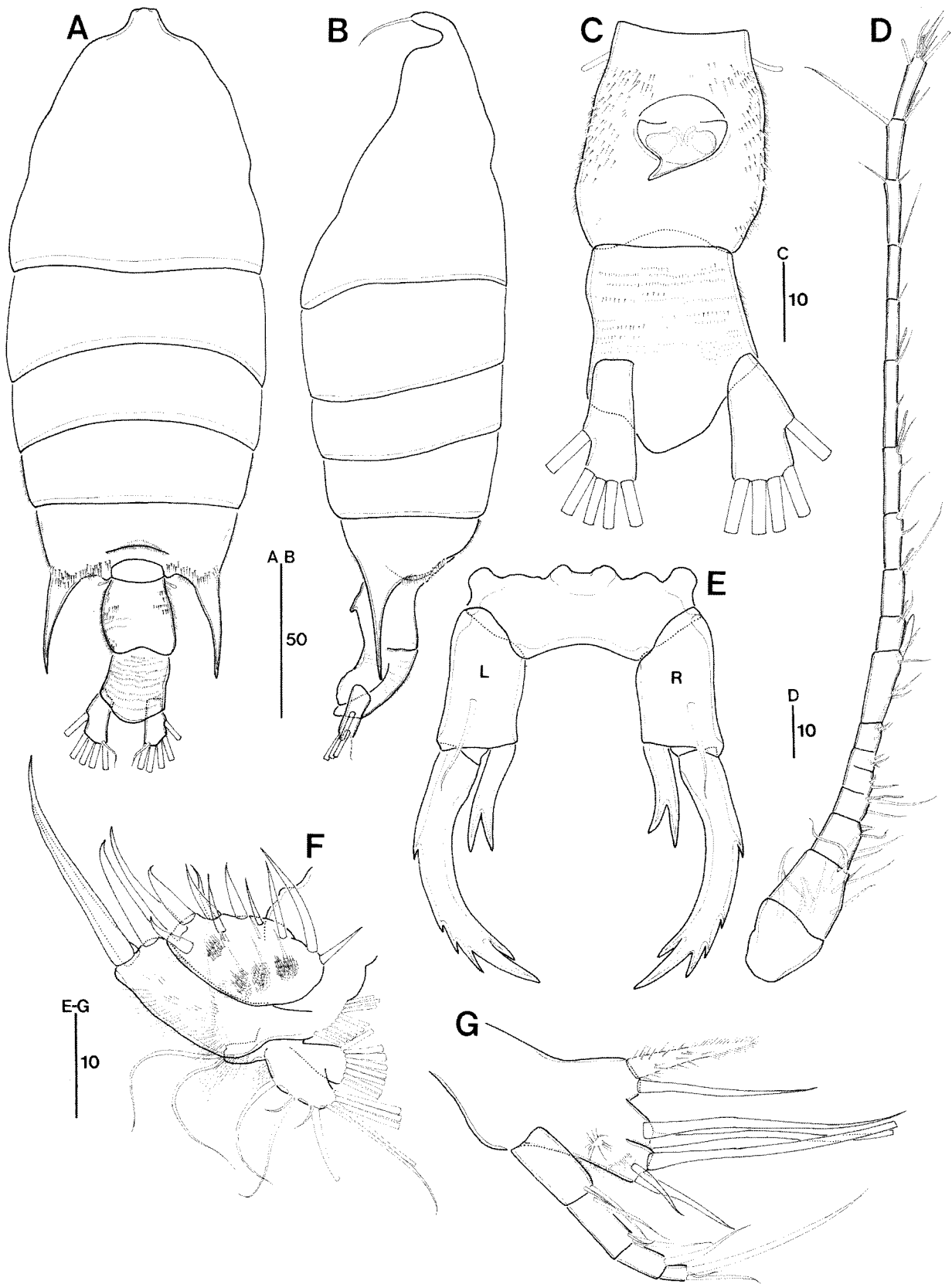


Fig. 5. *Pontellopsis armata*, female: (A) habitus, dorsal view; (B) habitus, left lateral view; (C) urosome, ventral view; (D) antennule; (E) fifth leg; (F) maxillule; (G) mexilliped. Scale is in μm .

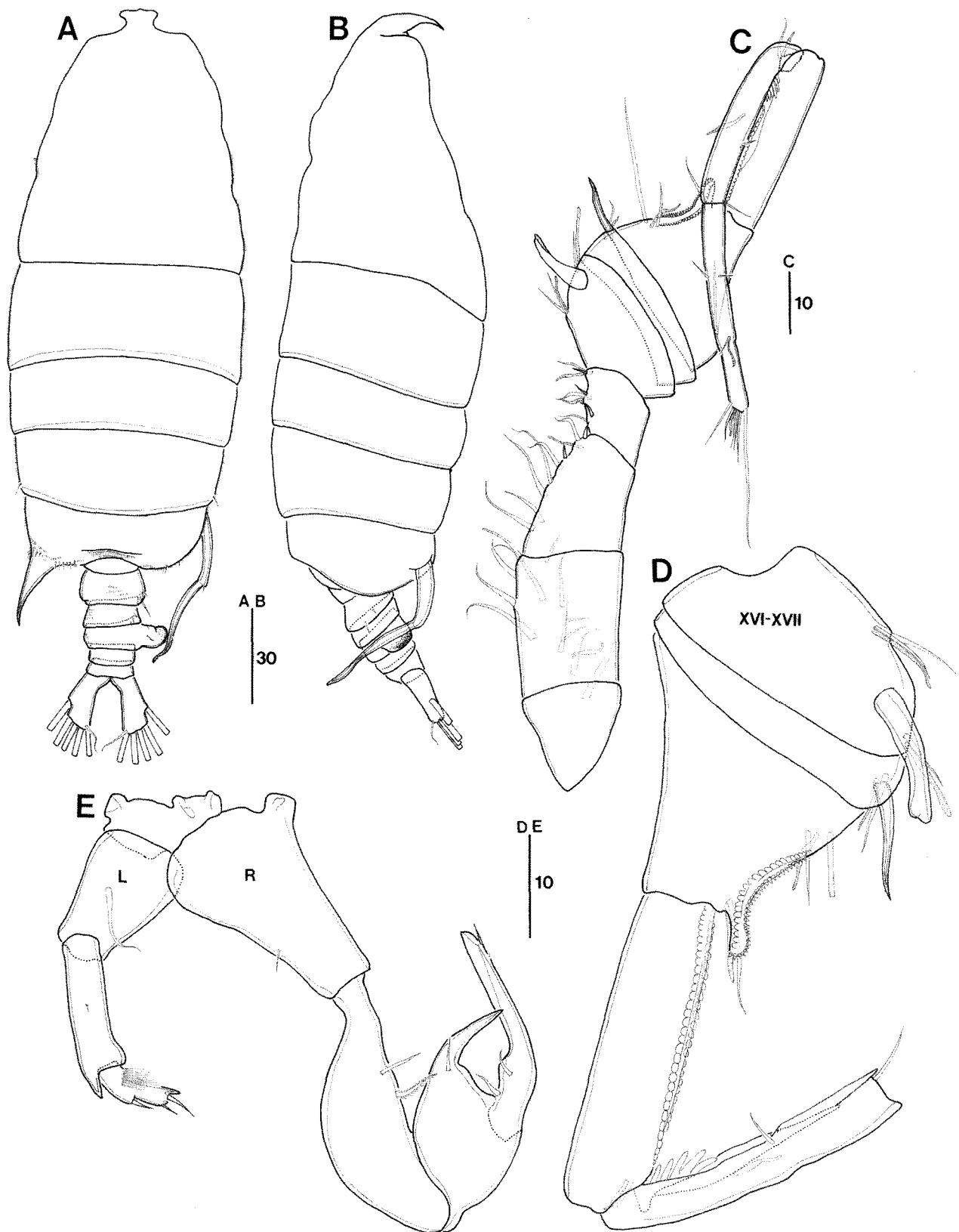


Fig. 6. *Pontellopsis armata*, male: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) right antennule; (D) ancestral segments XVI to XXIII in right antennule; (E) fifth leg. Scale is in μm .

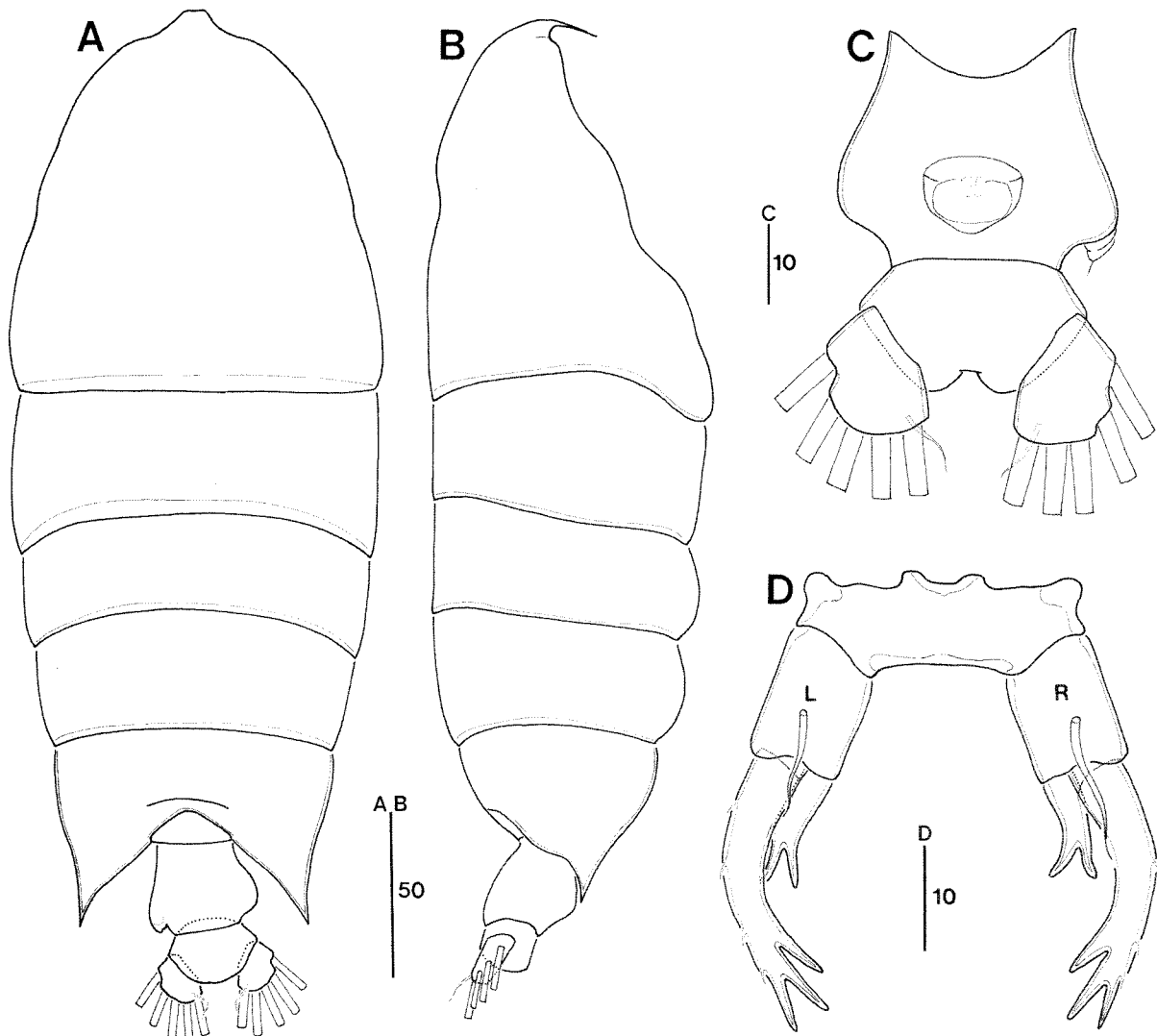


Fig. 7. *Pontellopsis regalis*, female: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) urosome, ventral view; (D) fifth leg. Scale is in μm .

Scott A., 1909, p. 171; Farran, 1936, p. 118; Chen and Zhang 1965, p. 107, pl. 47, figs. 5-7; Knusen and Wolff, 1965, p. 193; Park, 1968, p. 568, pl. 13, figs. 1-14; Silas and Pillai, 1973, p. 838, fig. 29; Zheng et al., 1982, p. 90, figs. 51 a-i; Mulyadi, 2002, p. 141, figs. 52 a-b.

Pontellopsis villosa: Tanaka, 1964, p. 268, figs. 24 f-g.

Material examined: One female was collected at St. 6 on 23 October 2002. It was dissected and closely examined.

Female: Body length 3.28 mm ($n=1$). Prosome (Figs. 7A, B) robust with projection in the center: posterior corners of prosome asymmetrical with triangular process. Rostrum bifid with slender and long ramus. Urosome 2-segmented (Fig. 7C): genital compound somite asymmetrical, left side with digitiform process backward and right side swelling outward; caudal rami symmetrical. Fifth leg (Fig. 7D) symmetrical: intercoxal sclerite and coxa completely fused; exopod with 3 outer spinules, 1 inner process and 2 apical processes; bifid endopod.

Male: No male specimen was found from the study area.

Remarks: *Pontellopsis regalis* originally described from the Sulu Sea (Dana, 1849) indicates some morphological variations in the genital compound somite of the female and fifth leg of both sexes by previous authors (Wilson, 1950; Tanaka, 1964; Chen and Zhang, 1965; Silas and Pillai, 1973; Zheng et al., 1982). Zheng et al. (1982) divided the females into 2 types by characteristic features in the genital compound somite and fifth leg: in the type I, (1) one side swelling on genital compound somite, and (2) the fifth leg with 1 stout apical spine at apex in exopod; in the type II, (1) swelling on both sides, and (2) the fifth leg with 2 equal apical spines. Female occurring in the South Sea agrees very well with type II. In view of the consistent differences shown by the two varieties, the possibility of recognising type II as a distinct species from type I cannot be ruled out. *P. regalis* most closely resembles *P. grandis*, and there is a considerable confusion between the species, due to the

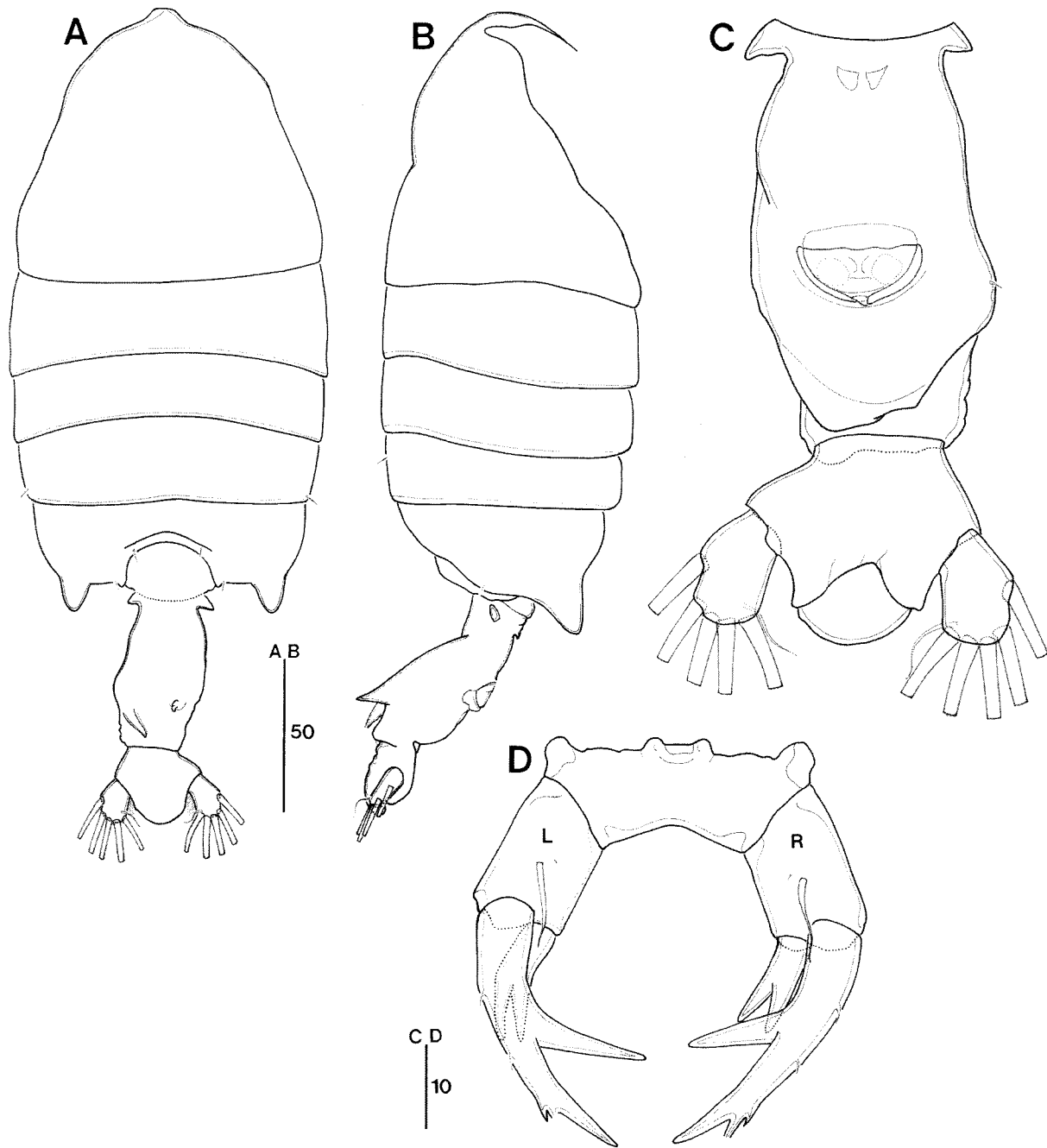


Fig. 8. *Pontellopsis yamadae*, female: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) urosome, ventral view; (D) fifth leg. Scale is in μm .

synonymy established by Giesbrecht (1893). However, Bradford-Grieve (1999) confirm that these species are distinct. Therefore females of *P. regalis* described by Wilson (1950, fig. 496') and Tanaka (1964, figs. 23a-f) is *P. grandis*. Meanwhile, we consider that the males of *P. regalis* reported by Mulyadi (2002) and Othman and Toda (2006) were misidentified: (1) in Mulyadi's figures, right posterior process of prosome extending to the third urosomite while that of Giesbrecht's description reaching

caudal rami, and (2) in right fifth leg of former, digitiform process of the first exopodal segment shorter than the second exopodal segment, while that of latter longer; (1) Othman and Toda's illustrations with small body length (1.64 mm) and Giesbrecht's description 2 times longer than the former (3.4-3.5 mm), and (2) right fifth leg of former bearing blunt apex in distal segment while the latter with acuminate apex.

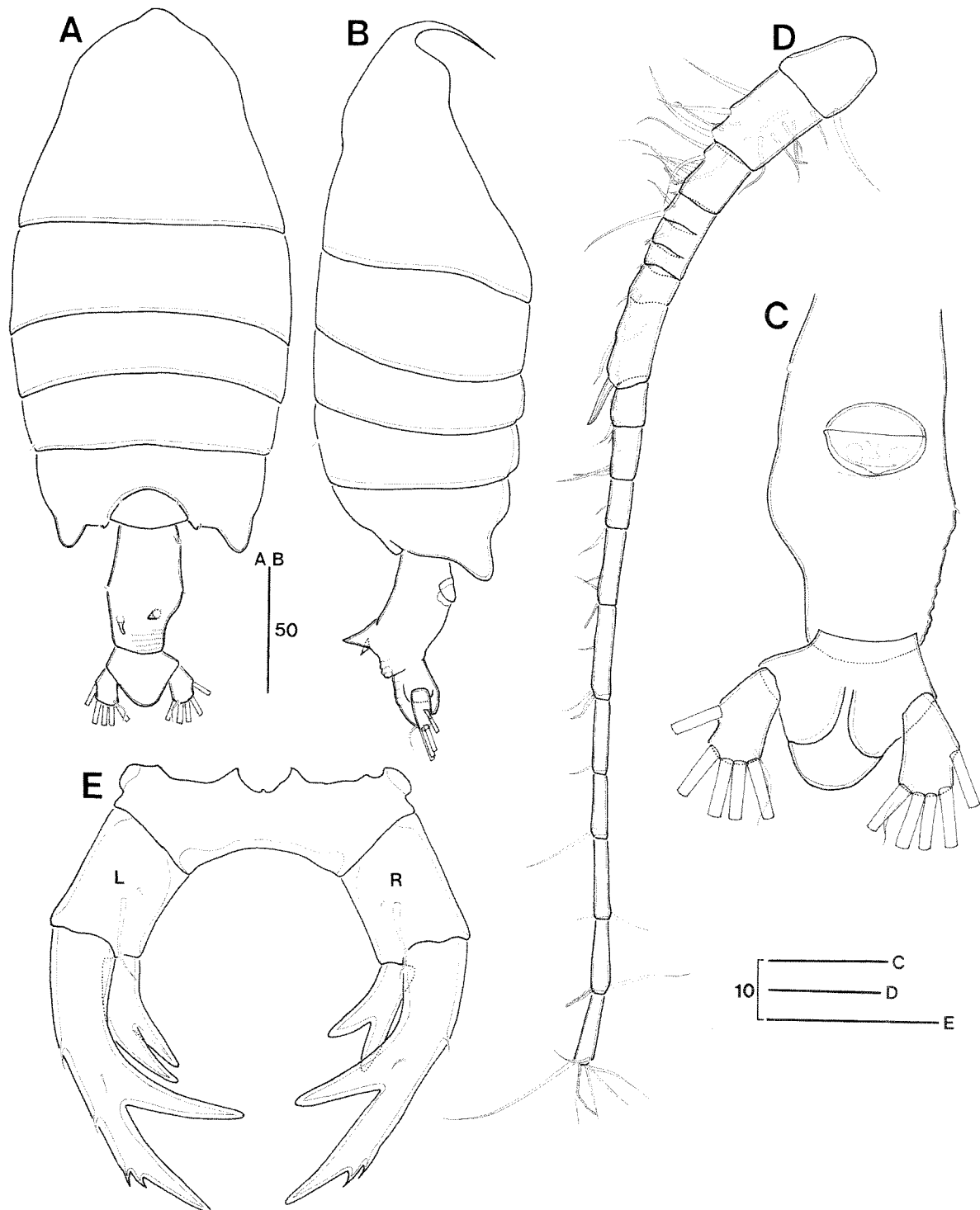


Fig. 9. *Pontellopsis yamadae*, female variant: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) urosome, ventral view; (D) antennule; (E) fifth leg. Scale is in μm .

Pontellopsis yamadae Mori, 1937
(Figs. 8-10)

Pontellopsis yamadae Mori, 1937 (1964), p. 98, pl. 47, figs. 1-6, pl. 48, fig. 13 (type locality: Yellow Sea); Tanaka, 1964, p. 269; Zhang et al., 1965; Chen and Zhang, 1965, p.

107, pl. 46, figs. 15, 16, pl. 47, figs. 1-4; Kim, 1985, p. 130, pl. 44, figs. f, g.

Materials examined: Five females and eight males collected at St. 3 on 20 August 2002. Of these, five females and five males were dissected and closely examined.

Females: Body length 2.67-2.81 mm (n=5). Prosome

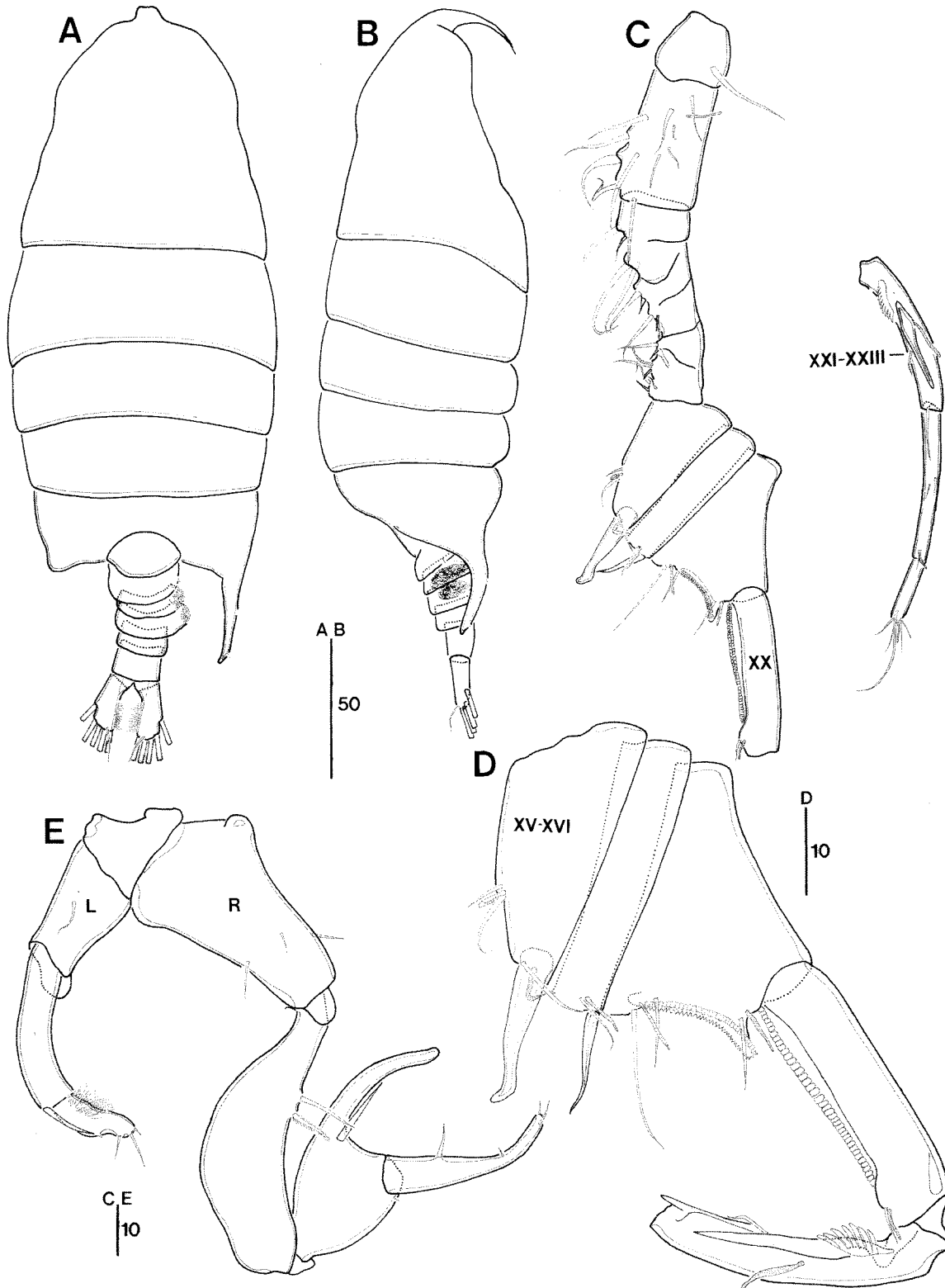


Fig. 10. *Pontellopsis yamadae*, male: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) right antennule; (D) ancestral segments XV to XXIII in right antennule; (E) fifth leg. Scale is in μm .

oval shape: fourth and fifth pedigerous somites fully fused; posterior corners of prosome with bluntly rounded process (Figs. 8A, B). Rostrum long and slender. Urosome-2 segmented (Fig. 8C), segmentation indistinct laterally;

genital compound somite large and long with 2 pair of processes which one anteriolaterally and the other posteriorly; anal somite prolonged posteriorly; caudal rami almost symmetrical. Fifth leg (Fig. 8E) asymmetrical, left

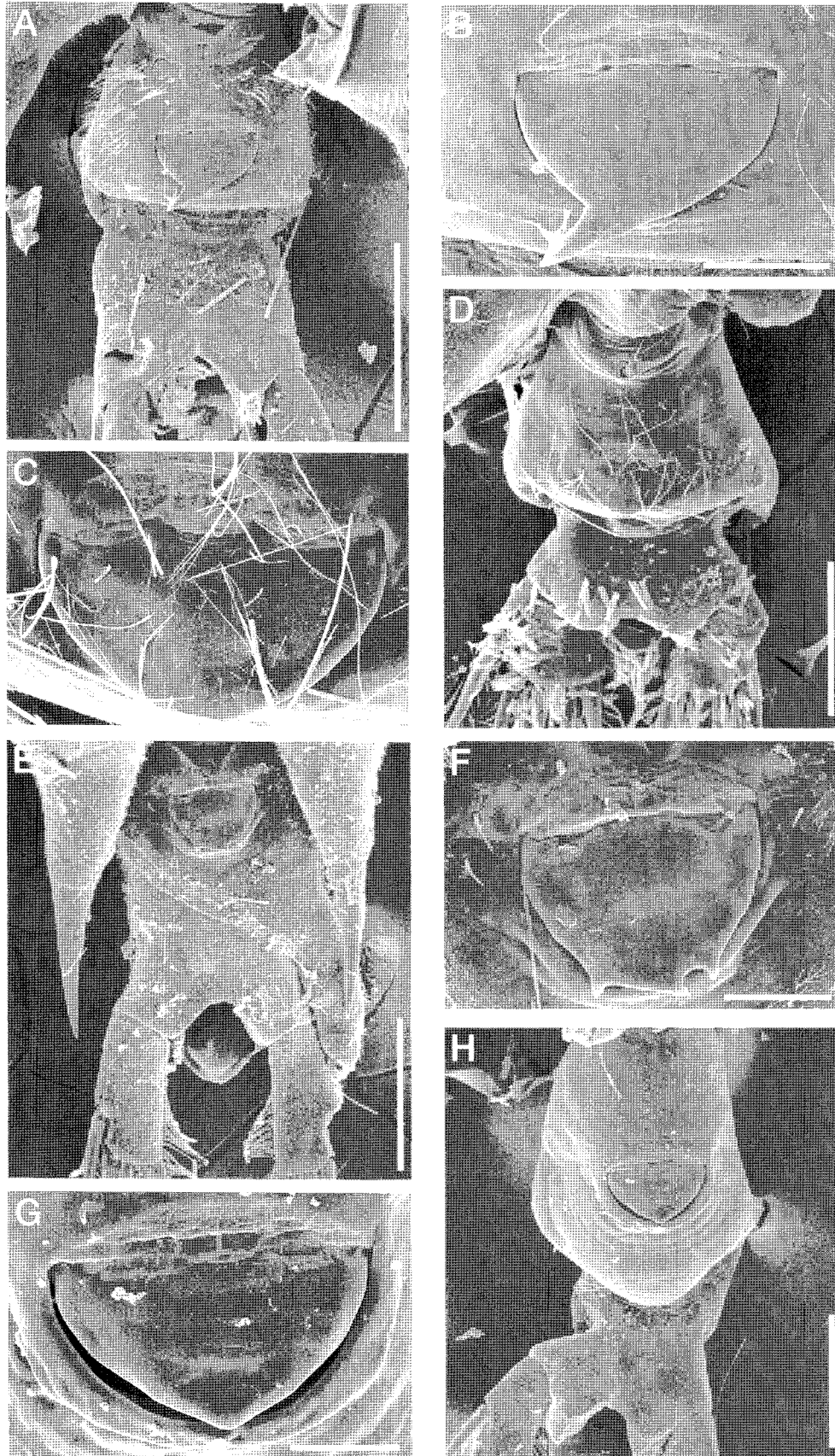


Fig. 11. Scanning electron micrographs of female genital area in *P. armata* (A, B), *P. regalis* (C, D), *P. villosa* (E, F), and *P. yamadae* (G, H). Scale bars= 100 µm (A, D, E, H), 50 µm (B, C, F, G).

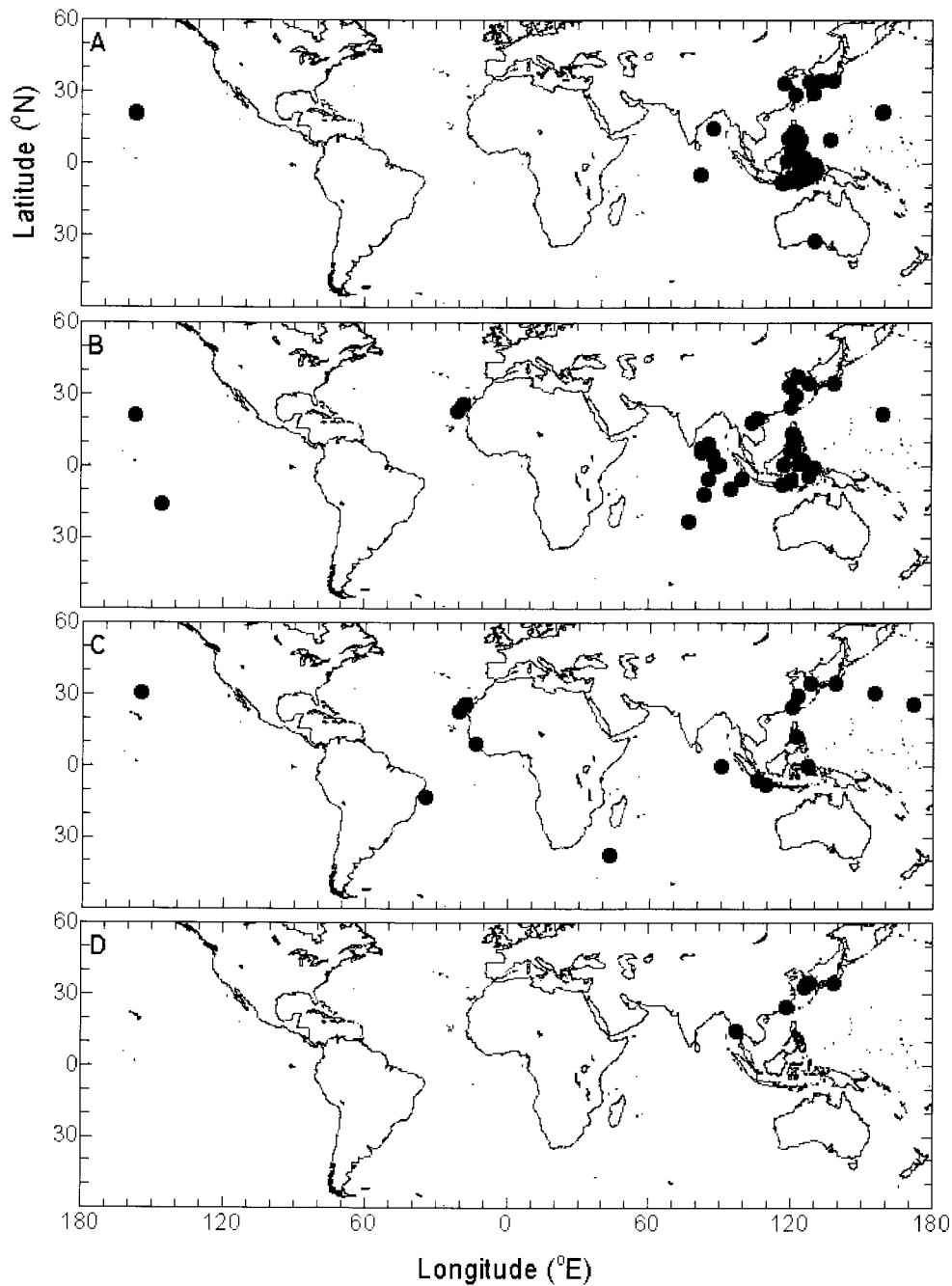


Fig. 12. Distribution of *Pontellopsis* species based on previous records and on the present study. References are: *P. armata* (A) by Giesbrecht (1889), A. Scott (1909), Wilson (1950), Mori (1964), Tanaka (1964), Chen and Zhang (1965), Silas and Pillai (1973); *P. regalis* (B) by Dana (1849), A. Scott (1909), Farran (1936), Wilson (1950), Tanaka (1964), Chen and Zhang (1965), Knudsen and Wolff (1965); *P. villosa* (C) by Giesbrecht (1889), Giesbrecht (1893), T. Scott (1894), Brady (1883), A. Scott (1909), Wilson (1950), Tanaka (1964), Chen and Zhang (1965), Knudsen and Wolff (1965), Zheng et al. (1982), Mulyadi (2002); *P. yamadae* (D) by Mori (1937), Mori (1964), Tanaka (1964), Chen and Zhang (1965), Zhang et al. (1965), Kim (1985), Mulyadi (2002).

leg longer than right leg; exopod with 4 outer spinules, distal spine and inner stout process.

Males: Body length 1.84-2.28 mm (n=8). Posterior corners of prosome asymmetrical, right side with long and stout process, and left side bluntly rounded (Figs. 10A, B). Urosome-5 segmented: first urosomite with single small seta on right postero-lateral margin; second and third

urosomites swelling on right side with minute spinules at apex; caudal rami symmetrical. Antennule (Fig. 10C) same as *P. armata*. Compound segment XV and XVI with elongated hooked spine distally, segment XVII with stout spine, segment XIX prolonged distally into spur-like process, segment XX with rectangular tooth ridge and fused segments XXI-XXIII with serially arranged spinules

on its proximal base (Fig. 10D). Fifth leg (Fig. 10E) intercoxal sclerite and left coxa fused: right coxa and basis bearing 2 setae; first exopodal segment with a long and stout thumb-like process bearing 1 seta at its base; second exopodal segment elongated and curved with 2 inner setae and 2 setae at apex; left leg bearing a single plumose seta on basis; first exopodal segment with 1 slender outer spine; second exopodal segment having inner hirsute and 3 apical spines of which innermost one longest.

Remarks: Mori (1937) described this species based on 4 females and 1 male collected from the Yellow Sea (34°18'N, 126°25'E) and the present specimen was well coincide with original description, together with illustrations of Zhang et al. (1965). However, some female specimens showed the morphological differences in genital compound somite bearing small spine on right anterior-laterally and 2 distal processes (Fig. 9) and it is similar to the figures of Chen and Zhang (1965) and Kim (1985). In addition, Mori (1937) reported exopod having 2 inner processes in female fifth leg, but we didn't find the specimens.

The present specimens are slightly different from Mori's specimen in the absence of 1 spine on inner base of right first exopodal segment in male fifth leg. In the male, *P. yamadae* closely resembles *P. regalis*, but it differs from the latter as follows: (1) left posterior corner of prosome rounded, (2) digitiform process of first exopodal segment in right fifth leg shorter than the second exopodal segment, and (3) the second exopodal segment of right fifth leg no modification and bearing two apical setae. Meanwhile, Mulyadi's description (2002) was doubtful as *P. yamadae*: in the male (1) right posterior process of prosome great curved, (2) in right leg, digitiform process of the first exopodal segment longer than the second exopodal segment, and (3) the first exopodal segment of left leg as long as basis.

DISCUSSION

Female genital area always locates on the ventral face of the genital somite and forms a more or less marked bulge. The hypothetical ancestral calanoid copepods proposed by Huys and Boxshall (1991) has medioventral genital area with adjoining gonopores and copulatory pores, connected respectively to paired oviducts and seminal receptacles. However, diaptomoid copepod including the relatively primitive superfamily is radically divergent from an ancestral condition by the presence of a single genital operculum and absence of seminal receptacles (Barthélémy et al. 1998, Barthélémy 1999). *Pontellopsis* species belonging to diaptomoid copepod show the species-specific in shape and position of their genitalia (Fig. 11). The genital area is situated on posterior edge of genital compound somite in *P. armata* and *P. regalis*, while it is done on the medial

position in *P. villosa* and *P. yamadae*. Their single genital operculum is subrectangular. However, *P. armata* bears a curved single triangular process on the distal margin of the genital operculum, while *P. villosa* has three denticulate processes and the other two species lack the processes. Barthélémy et al. (1998) reported that the position and shape of the genital operculum of diaptomoid copepods are species-specific and have considerable taxonomical value at the species level. Many recent studies have also proposed that the genital structure can be very useful for species classification, in particular, in acartiids (Barthélémy 1999), diaptomoids (Cicchino 1994; Defaye et al. 2000), metridinids (Cuoc et al. 1997) and pseudodiaptomids (Ohtsuka et al. 2000, Soh et al. 2001, Walter et al. 2002). Therefore, the position and shape of the female genital operculum could provide a useful characteristic for identifying *Pontellopsis* species.

Four *Pontellopsis* species, *P. armata*, *P. regalis*, *P. villosa*, and *P. yamadae* exhibits two schematic distribution patterns. *Pontellopsis armata* and *P. yamadae* are restricted to the Indian Ocean and Pacific Ocean, whereas other two species are widely distributed from the tropical to temperate regions of worldwide oceans (Fig. 12). The zoogeography of the former two species can be explained as extensive speciation through geological vicariance events such as climatic or hydrological changes during glacial periods, as proposed for the speciation mechanisms of pontellids (Fleminger 1982, 1986), tortanids (Ohtsuka et al. 1992, Ohtsuka and Reid 1998) and pseudodiaptomids (Walter et al. 2002). While the latter two species can be explained that their ancestors could have been introduced to the western Atlantic via the Panama passage, as proposed for the calanoid copepod *Tortanus* by Ohtsuka and Reid (1998), the pelagic shrimp *Acetes* (Spoel 1983) and the deep-sea fish *Cyclothone alba* Brauer (Miya and Nishida 1997). Also they are possible to transport into the Atlantic Ocean by the warm Agulhas Current as other pontellids of Indo-Pacific origin (Weikert, 1975). However, the phylogenetic relationship of *Pontellopsis* species needs additional investigation such as morphological and molecular analyses.

Key to species of the genus *Pontellopsis* in the Korean waters

1. Urosome of 2 free somites 2 (Female)
 Urosome of 5 free somites 6 (Male)
2. Posterior corners of prosome bluntly rounded 3
 Posterior corners of prosome with acute lobes 4
3. Genital compound somite with bilateral processes
 P. yamadae
 Genital compound somite with 2 processes in right side *P. tenuicauda*

4. Caudal rami broader than long *P. regalis*
 Caudal rami longer than broad 5
5. Anal somite as long as genital compound somite
P. armata
 Anal somite half of genital compound somite
P. villosa
6. Left corner of prosome with sharp lobe 7
 Left corner of prosome with blunt lobe 9
7. Right corner of prosome rounded lobe with acuminate
 and elongate spine *P. armata*
 Right corner of prosome with acuminate process 8
8. Third urosomite with right side swelling *P. villosa*
 Third urosomite with thumb-like lobe in right side
P. armata
9. Right process of prosome reaching to the anal somite;
 in right fifth leg, finger-like process of the first
 exopodal segment longer than the second exopodal
 segment *P. tenuicauda*
 Right process of prosome fall short the anal somite; in
 right fifth leg, finger-like process of the first exopodal
 segment shorter than the second exopodal segment
 *P. yamadae*

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