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Labidocera Species (Copepoda: Pontellidae) in Waters of the Tsushima Warm Current with Notes on Their Genital Structure and Zoogeography

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Hyeon Gyeong Jeong, Hae-Lip Suh, Sun Beom Jeong, Yang Ho Yoon, and Ho Young Soh (2009) *Labidocera* species (Copepoda: Pontellidae) in waters of the Tsushima Warm Current with notes on their genital structure and zoogeography. *Zoological Studies* **48**(4): 508-523. Neustonic calanoid copepods were collected monthly between Apr. 2002 and Mar. 2003 in the northeastern area of the East China Sea. Seven species of the genus *Labidocera* Lubbock were identified, 5 of which were found in the months of Aug. to Oct. when the Tsushima Warm Current flows strongly into the East Sea (Sea of Japan). Of these, we redescribe 4 species, *L. acutifrons* (Dana), *L. detruncata* (Dana), *L. kröyeri* (Brady), and *L. minuta* Giesbrecht and describe the female external genitalia and their zoogeography. http://zoolstud.sinica.edu.tw/Journals/48.4/508.pdf

Key words: Redescription, Female external genital structure, Neustonic copepods, East China Sea.

The genus *Labidocera* Lubbock (1853) presently comprises up to 52 species, mainly inhabiting surface waters (0-30 cm layer) of tropical to warm temperate regions. Their assemblages are often good indicators of different or distinctive water masses (Sherman 1963 1964, Matsuo and Marumo 1982, Razouls et al. 2008). In Korean waters, 4 species (*L. acuta* (Dana), *L. euchaeta* Giesbrecht, *L. rotunda* Mori as *L. bipinnata* Tanaka, and *L. pavo* Giesbrecht) are found in neritic waters (Kim 1985). In this study, 4 species (*L. acutifrons* (Dana), *L. detruncata* (Dana), *L. kröyeri* (Brady), and *L. minuta* Giesbrecht) were newly recorded offshore in the northeastern area of the East China Sea during summer to fall (Aug. to Oct.) when the Tsushima Warm Current (TWC) prevails in that area (Seung 1992).

Since the historical descriptions of these 4 species were often not given in sufficient detail (e.g., Brady 1883, Mori 1937 (1964), Wilson 1950, Tanaka 1964, Chen and Zhang 1965, Zhang et al. 1965, Silas and Pillai 1973, Zheng et al. 1982), we provide redescriptions with additional focus on the female external genitalia and their zoogeography.

MATERIALS AND METHODS

Neustonic zooplankton were collected monthly from Apr. 2002 to Mar. 2003 at 16 stations in the surface layer (< 30 cm deep) of the northeastern area of the East China Sea, using a David-Hempel neuston net (with a mesh size of 0.3 mm; Hydro-Bios model 300) towed for 10 min at a speed of 2.5 knots (1.3 m/s; see Fig. 1 in Jeong et al. 2008). Samples were fixed with 5% neutralized formalin/seawater immediately after capture. All *Labidocera* species were sorted from the zooplankton samples. Specimens were dissected and mounted in CMC-10, and illustrated with an optical microscope (Nikon 80i) equipped with a drawing tube. The rostrum and genital double somite of the females were also examined with a scanning electron microscope (Hitachi S-3000N). Morphological terminology followed Huys and Boxshall (1991). We directly confirmed references

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using the synonymies.

TAXONOMY

Labidocera acutifrons (Dana, 1849)
(Figs. 1-3, 9A, D, G)

Pontella acutifrons: Dana 1849, 30 (type locality: Kingsmill, western Pacific Ocean); Brady 1883, 91, pl. 35, Figs. 1-13.
Pontellina acutifrons: Dana 1852, 1149, pl. 80, Fig. 11.
Labidocera acutifrons: Giesbrecht 1893, 445, 447, 454, 458, 460, pl. 23, Figs. 2, 12, 30, 33, 40, 41, pl. 41, Figs. 3, 26, 41; Giesbrecht and Schmeil 1898, 134; Farran 1936, 116; Wilson 1950, 242, pl. 11, figs. 124, 125; Tanaka 1964, 253, fig. 231a-f; Knudsen and Wolff 1965, 187; Owre and Foyo 1967, 97, Figs. 696, 697, 702; Silas and Pillai 1973, 793, Fig. 8a-c; Greenwood 1979, 97; Zheng et al. 1982,

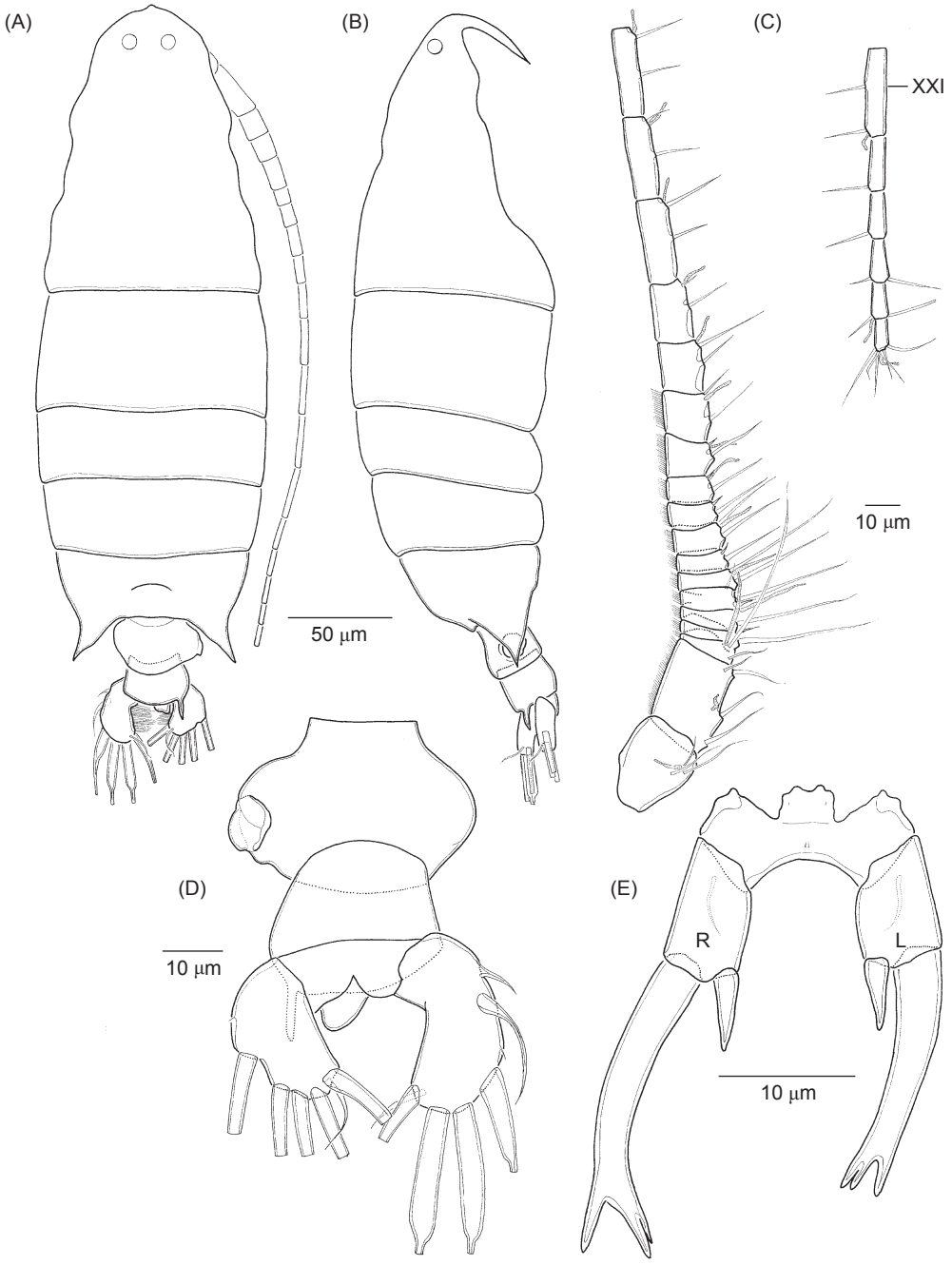

Fig. 1. *Labidocera acutifrons*. Female: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) antennule; (D) urosome, ventral view; (E) 5th leg.

73, Fig. 43; Bradford-Grieve 1999, 188, Fig. 136e, f.

Materials examined: 4 ♀♀, 2 ♂♂ collected from northeastern area of East China Sea (34°26'N, 127°34'E) 20 Aug. 2002. Of these, 2 females and both males were dissected.

Female: Body length 3.49-3.67 mm (*n* = 4). Prosome (Figs. 1A, B) cylindrical without lateral hooks: cephalosome and 1st pedigerous somite completely separated; 4th and 5th pedigerous somites incompletely fused; posterior corners of prosome directed slightly outwards with acute triangular processes. Cephalosome with median crest and pair of dorsal lenses; rostrum bifid, gap between rostral rami narrow (Figs. 1A, 9A). Urosome 3 segmented: genital double somite onion-shaped, asymmetrical, with small lateral lump on right side bearing genital operculum (Figs.

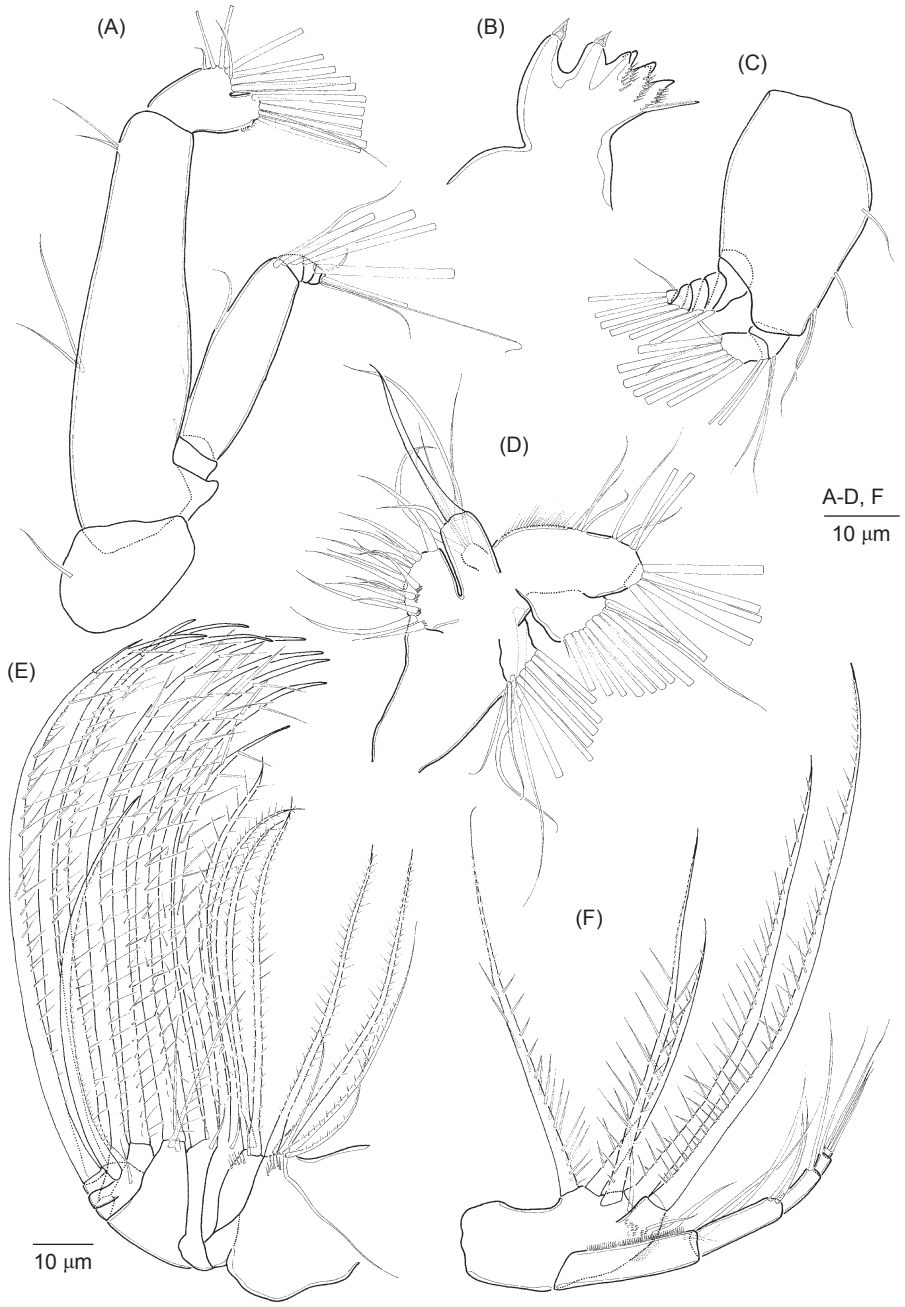

Fig. 2. *Labidocera acutifrons*. Female: (A) antenna; (B) mandibular gnathobasic cutting edge; (C) mandibular palp; (D) maxilla; (E) maxillule; (F) maxilliped.

1D, 9D, G); 2nd urosomite 1.5 times wider than long, with elongated process on right distal margin that extends straight posteriorly; anal somite covered to 2nd urosomite, anal operculum extend posteriad and slightly to the right; caudal rami strongly asymmetrical, left ramus larger than right, left ramus bearing 7 setae: 2 inner setae (I and II), 3 terminal setae (III-V) proximally thickened, 2 outer setae (VI and VII), right ramus with 6 setae except for dorsal seta (VII). Antennule (Fig. 1C) symmetrical, 23 segmented; posterior margin of 2nd-12th segments fringed with fine hairs; ancestral segments II-IV and XXVII-XXVIII completely fused while VII-IX incompletely fused. Fusion pattern and setal formula as follows: I-3+ae (aesthetasc), II-IV-4+ae, V-2+ae, VI-2, VII-IX-6+2ae, X-2, XI-2+ae, XII-2, XIII-2+ae, XIV-2+ae, XV-2+ae, XVI-2+ae, XVII-2+ae, XVIII-2+ae, XIX-2+ae, XX-2+ae, XXI-2+ae, XXII-1, XXIII-1, XXIV-1+1, XXV-1+1+ae, XXVI-2, XXVII-XXVIII-4+ae. Antenna (Fig. 2A) biramous: coxa with plumose seta; basis and 1st endopodal segment completely fused, forming allobasis, bearing 4 setae; 2nd endopodal segment with 9 and 7 setae on proximal and distal lobes, respectively, distal one armed with row of posterior spinules; exopod 6 segmented, with setal formula of 1, 4, 2, 1, 1, 3. Mandible (Figs. 2B, C) with large coxal gnathobase (Fig. 2B) and biramous palp (Fig. 2C): gnathobase bearing 5 teeth along its distomedial margin and dorsal seta; 3rd and 4th dorsalmost teeth bicuspidate; patch of dagger-like spinules ornamented on base of 3rd-5th dorsalmost teeth; basis of mandibular palp bearing 4 elongated setae; endopod 2 segmented, with setal formula of 4, 8; exopod 5 segmented, with setal formula of 1, 1, 1, 1, 2. Maxillule (Fig. 2D): praecoxal arthrite with 16 setae; coxa with 3 setae on endite and 9 setae on epipodite; basis with 4 and 3 setae on proximal and distal endite, respectively, with 1 seta on exite; 1st and 2nd endopod segments, each with 2 setae, incorporated into basis, distal endopod segment with 5 apical setae; exopod 1 segmented, with 10 setae and 1 setule distally.

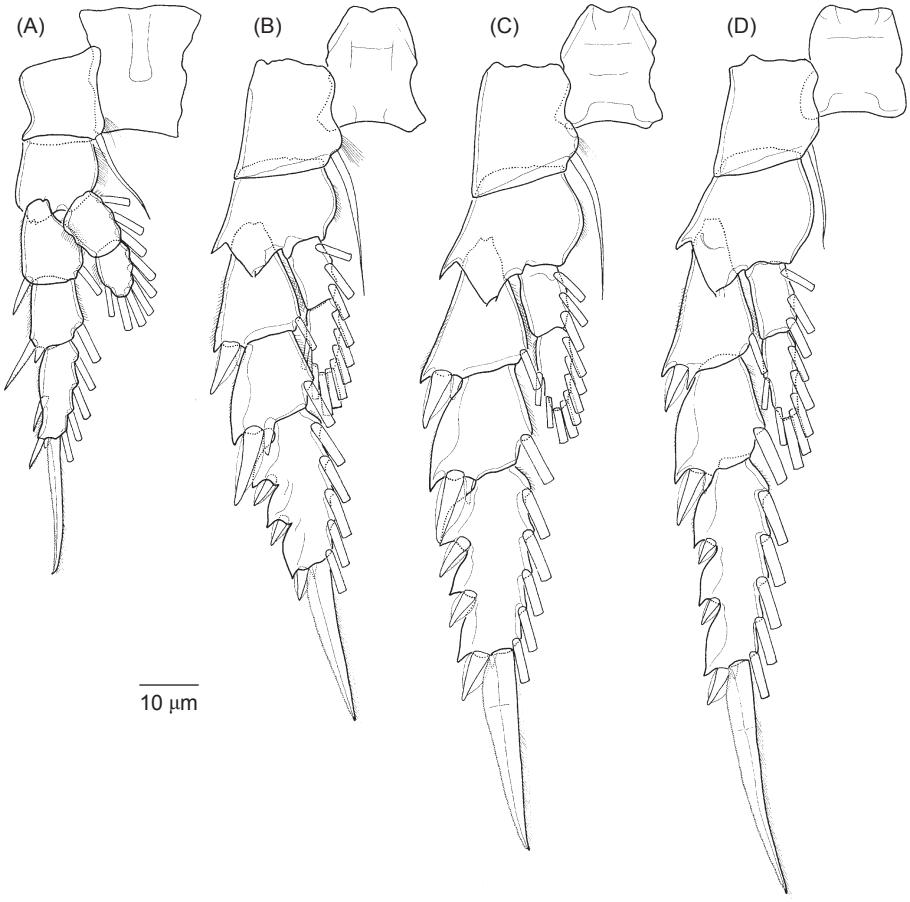

Fig. 3. *Labidocera acutifrons*. Female: (A) right leg 1; (B) left leg 2; (C) left leg 3; (D) left leg 4.

Maxilla (Fig. 2E) uniramous: 1st praecoxal endite bearing 6 setae, 2nd one with 3 setae; 2 coxal endites each with 3 setae; basis with 3 setae; endopod 4 segmented, with setal formula of 1, 2, 2, 2. Maxilliped (Fig. 2F) uniramous: praecoxa and coxa completely fused, with setal formula of 0, 2, 3, 3; basis fringed with row of small teeth subdistally and bearing 2 setae distally; 1st endopodal segment with 2 setae incompletely incorporated into basis; endopod 4 segmented, with setal formula of 2, 1, 1, 3. Swimming legs 1-4 with 2 segmented endopods and 3 segmented exopods

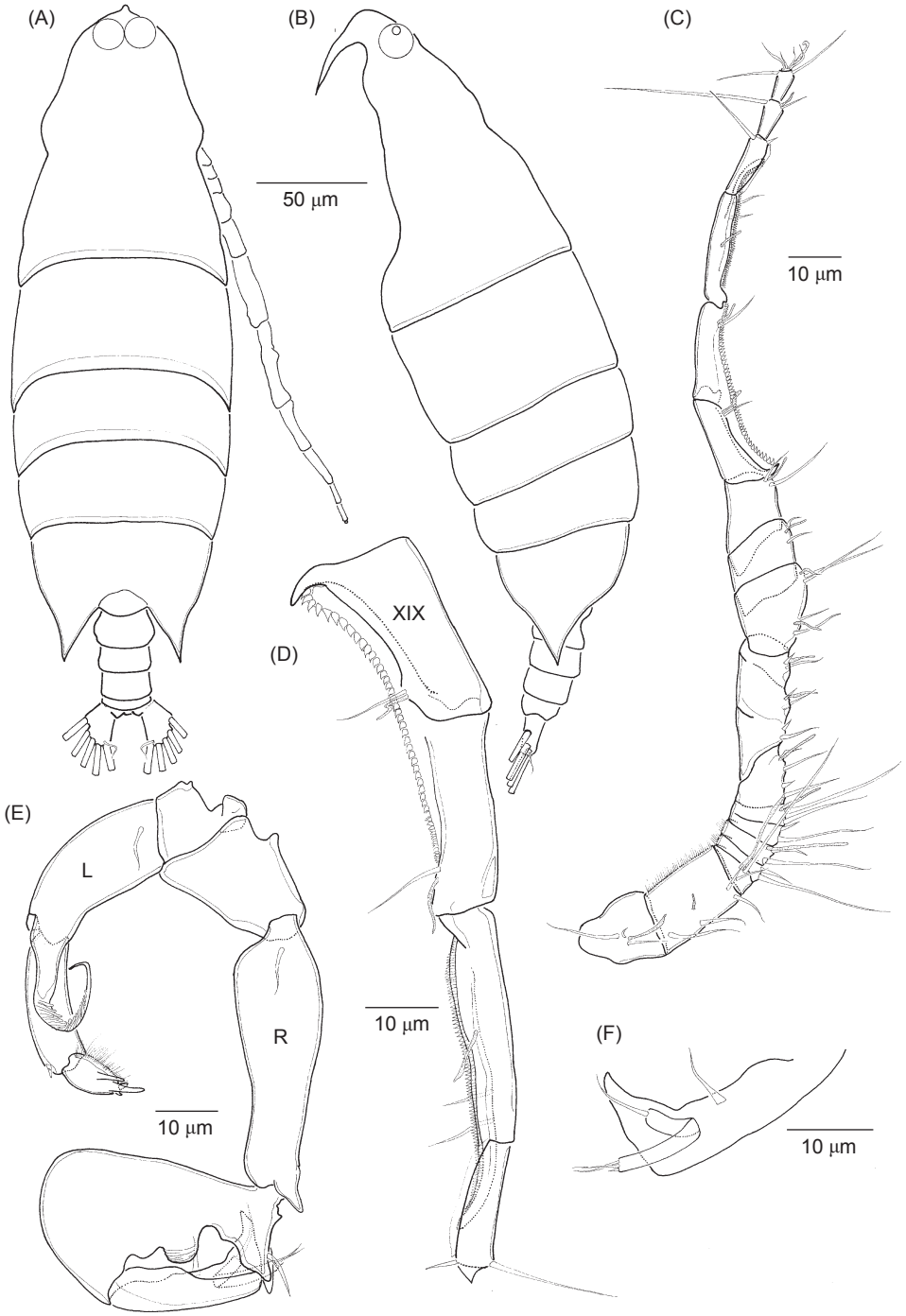

Fig. 4. *Labidocera acutifrons*. Male: (A) habitus, dorsal view; (B) habitus, left lateral view; (C) right antennule; (D) ancestral segments XIX-XXIV in right antennule; (E) 5th leg; (F) 2nd and 3rd segments of right 5th leg.

(Figs. 3A-D): coxa bearing inner seta; basis of leg 4 with tiny outer seta. 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	0-3; 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, right leg longer; coxa and intercoxal sclerite completely fused; basis with outer seta; endopod spiniform; exopod uni segmented and elongate with 3 unequal apical processes.

Male: Body length 3.45-3.53 mm (*n* = 2). Prosome (Figs. 4A, B) more compact than female; dorsal lenses well-developed; cephalosome and 1st pedigerous somite completely separated; 4th and 5th pedigerous somites completely fused; posterior corners of prosome symmetrical with sharp triangular process directed posteriorly. Urosome 5 segmented: genital somite swollen laterally; 3rd urosomite longer than other somites; caudal rami symmetrical, each ramus with 6 setae but lacking seta VII. Antennule (Fig. 4C) geniculate on right side only, left one resembling that of female: right one indistinctly 15 segmented, posterior margin of 2nd-5th segments fringed with fine hairs; segments X, XI, and XII-XIV with incompletely formed arthrodial membranes, segments II-IV, XV and XVI, and XXI-XXIII completely fused. Fusion pattern and setal formula as follows: I-3+ae, II-IV-4+ae, V-IX-10+3ae, X-XI-4+ae, XII-XIV-6+2ae, XV-XVI-4+2ae, XVII-2+ae, XVIII-2+ae, XIX-1+p (hooked process)+ae, XX-1+p+ae, XXI-XXIII-2+p+ae, XXIV-1+1+p, XXV-1+1+ae, XXVI-2, XXVII-XXVIII-4+ae. Segment XIX with proximal, anterior, triangular hooked process; segment XX with canoe-shaped tooth ridge which extends anterior of segment XIX; compound segments XXI-XXIII with tooth ridge extending to distal 1/3 of segment XXIV; segment XXIV with lamelliform process (Fig. 4D). Fifth leg (Figs. 4E, F) uniramous, asymmetrical; coxa of right 5th leg and intercoxal sclerite completely separated; basis with distal triangular process and proximal outer seta; right exopod 3 segmented, 1st segment with fingerprint-like rounded process on inner medial part and stout thumb bearing 1 seta on proximal outer margin; 2nd segment boot-like with medial inner spine; 3rd segment bifid, longer segment bearing 3 setae, shorter segment with elongated seta distally; coxa of left exopod coalesced into intercoxal sclerite; basis and rudimentary endopod fused; endopod with peculiar twisted and laciniate appendage; exopod 2 segmented, 1st segment with small distal spine; 2nd segment bearing 4 spines and inner hirsute border.

Remarks: *Labidocera acutifrons* is easily distinguished by the anterior crest, the absence of lateral cephalic hooks, and the structure of the 5th legs of both sexes. In the female, 1) a genital operculum is located on the right side, 2) the 2nd urosomite has a right posterior process, 3) the caudal rami are asymmetrical, with 3 right terminal setae (seta III-V) swollen proximally, and 4) the 5th leg has a spiniform endopod and trifid exopod. In the male, 1) the posterior corners of the prosome have an acute triangular process, 2) the left 5th leg has a rudimentary endopod, and 3) the right 5th leg bears 3 segmented exopod.

Labidocera acutifrons described by Giesbrecht (1893) from the Gulf of Napoli obviously differs from the Korean specimens because the elongated process is directed slightly towards the midline in the female 2nd urosomite, and the 2 additional processes are terminal figure-like and claw-like lobes on the 2nd exopodal segment of the right 5th leg in the male.

***Labidocera detruncata* (Dana, 1849)**

(Figs. 5, 6, 9B, E, H)

Pontella detruncata: Dana 1849, 29 (type locality: Kingsmill, western Pacific Ocean); Brady 1883, 90, pl. 26, Figs. 8-15, pl. 45, Fig. 20.

Pontellina detruncata: Dana 1855, 1143, pl. 80, Fig. 7a-i.

Labidocera detruncatum: Giesbrecht 1893, 445, pl. 23, Figs. 14, 34, pl. 25, Fig. 28, pl. 41, Figs. 9, 30, 31.

Labidocera detruncata: Giesbrecht and Schmeil 1898, 135; Scott 1909, 165; Sewell 1932, 359; Mori 1937 (1964), 92, pl. 42, Figs. 1-6; Wilson 1942, 191, Figs. 53, 69; Wilson 1950, 244, pl. 16, Figs. 192, 193; Tanaka 1964, 254; Chen and Zhang 1965, 101, pl. 43, Figs. 1-4; Zhang et al. 1965, 123, pl. 57; Silas and Pillai 1973, 797, Fig. 10; Bradford-Grieve 1999, 191, Fig. 139; Mulyadi 2002, 58, Fig. 5f, g.

Materials examined: 3 ♀♀ and 1 ♂ collected from the northeastern area of the East China Sea (34°30'N, 128°E) on 19 Aug. 2002. All specimens were dissected.

Female: Body length 2.56-2.75 mm (*n* = 3). Prosome (Figs. 5A, B) cylindrical without lateral cephalic hooks; cephalosome and 1st pedigerous somite completely separated; 4th and 5th

pedigerous somites incompletely fused; posterior corners of prosome slightly asymmetrical, rounded in lateral view and with small pointed subterminal process on each side. Cephalosome bluntly rounded anteriorly and with pair of dorsal lenses; rostrum bifid lying immediately adjacent to ventral ocellus (Fig. 9B). Urosome 2 segmented; genital compound somite resulting from incompletely fusion of genital double somite and 2nd urosomite, dorsal surface uneven, lined, and notched; genital operculum located posteromedially (Figs. 5C, 9E); anal somite with large posterior anal flap; caudal rami nearly oval in dorsal view and directed laterally, 2nd innermost terminal seta swollen proximally. Fifth leg (Fig. 5D) symmetrical: coxa and intercoxal sclerite completely fused; exopod uni segmented, with 3 outer processes and 2 unequal apical processes; endopod uni segmented and conical.

Male: Body length 2.44 mm (*n* = 1). Prosome (Figs. 6A, B) similar to female's except for well-developed pair of contiguous dorsal lenses. Urosome 5 segmented: caudal rami symmetrical, with 6 unmodified setae. Fusion pattern and setal formula of antennule (Fig. 6C) same as those of *L. acutifrons*. Segment XIX with crescent-shaped tooth ridge; segment XX and compound segments XXI-XXIII each with toothed ridge possessing serrated denticles, latter segment rounded posteriorly which extends anterior of segment XXIV (Fig. 6D). Fifth leg (Fig. 6E) uniramous, asymmetrical; coxa of right exopod coalescent into intercoxal sclerite; basis with small proximal outer seta; right exopod 2 segmented, 1st segment bearing 2 spines one of which is distal and the other lying at base of thumb; 2nd segment with 3 elongate setae curved inward; left exopod 2 segmented, 1st segment with distolateral process; 2nd segment with 4 spine-like apical processes and inner hirsute border.

Remarks: This species belongs to the *detruncata* group as proposed by Fleminger (1967). The *detruncata* group includes *L. bataviae* A. Scott, *L. caudata* Nicholls, *L. cervi* Kramer, *L. detruncata* Dana, *L. farrani* Greenwood and Othman, *L. jaafari* Othman, *L. madurae* A. Scott, *L. pavo* Giesbrecht, *L. sinilobata* Shen and Lee, and *L. tasmanica* Taw. *Labidocera detruncata* is easily

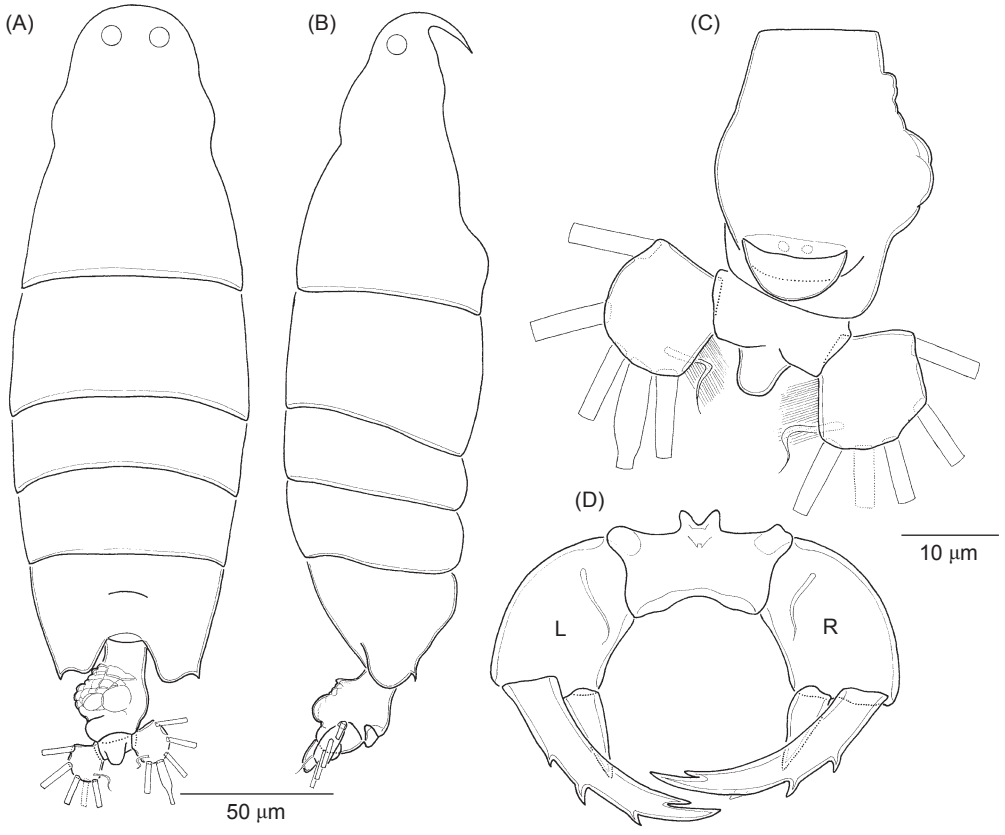

Fig. 5. *Labidecera detruncata*. Female: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) urosome, ventral view; (D) 5th leg.

distinguished from the other species of this group. In the female, 1) the dorsal surface of the genital compound somite is uneven and bulbous in shape, 2) the genital operculum is located ventrally on the posteromedial border, and 3) the anal somite has a conspicuous posterior flap medially. In the male, 1) the left 5th leg has 4 apical processes, the 2nd outermost process is longest, and 2) the 1st exopod segment of the right 5th leg has a broad conical thumb and the 2nd segment lacks a projection.

***Labidocera kröyeri* (Brady, 1883)**
(Fig. 7)

Pontella kröyeri: Brady 1883, 93, pl. 39, figs. 1-13, 16-19 (type locality: Arafura Sea, Philippine).

Labidocera kröyeri: Giesbrecht 1893, 446, pl. 23, Figs. 13, 38, pl. 25, Fig. 30, pl. 41, Figs. 6, 11, 39; Breemen 1908, 151; 1908, 151; Scott 1909, 165; Mori 1937 (1964), 93, pl. 42, Figs. 7-10; Wilson 1950, 246; Silas and Pillai 1973, 809; Greenwood 1979, 99, Fig. 3a-j; Mulyadi 2002, 65, Fig. 20.

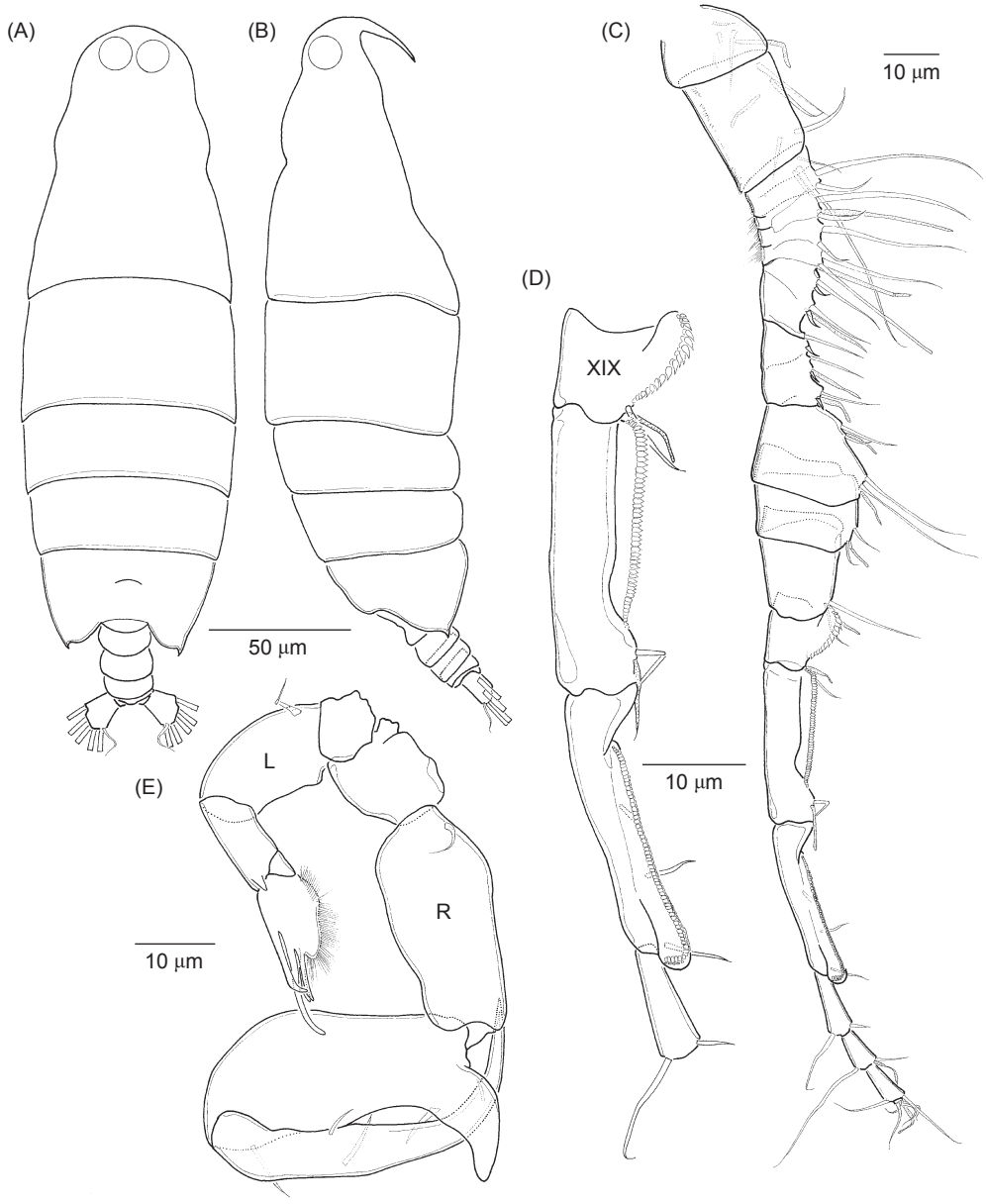

Fig. 6. *Labidocera detruncata*. Male: (A) habitus, dorsal view; (B) habitus, right lateral view; (C) right antennule; (D) ancestral segments XIX-XXIV of right antennule; (E) 5th leg.

Materials examined: 3 ♂♂ collected from the northeastern area of the East China Sea (34°16'N, 127°34'E) on 26 Sept. 2002, and all specimens were dissected.

Male: Body length 2.1-2.16 mm (*n* = 3). Prosome (Figs. 7A, B) slender; cephalosome and 1st pedigerous somite completely separated; 4th and 5th pedigerous somites incompletely fused. Posterior corners of prosome asymmetrical; left corner with acute process; right corner with bifid processes and longer outer branch reaching distal border of 2nd urosomite. Cephalosome

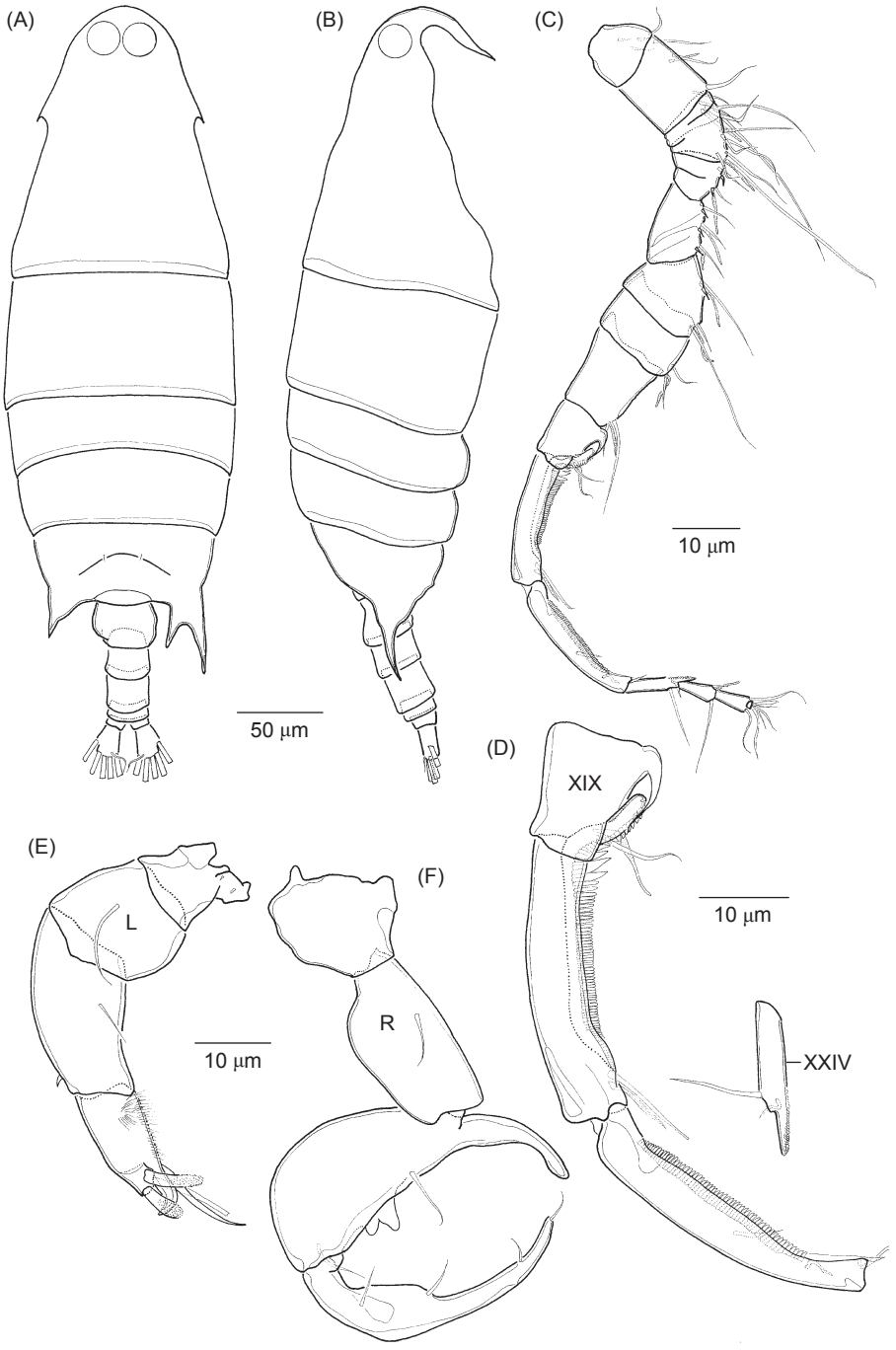

Fig. 7. *Labidocera kröyeri*. Male: (A) habitus, dorsal view (B) habitus, right lateral view; (C) right antennule; (D) ancestral segments XIX-XXIV of right antennule; (E, F) 5th leg.

with lateral cephalic hooks and 2 large contiguous dorsal lenses. Urosome 5 segmented; genital segment asymmetrical, left side expanded; caudal rami symmetrical. Right antennule (Fig. 7C) geniculate, indistinctly 14 segmented; segments II-IV, XV and XVI, and XXI-XXIII completely fused; V-IX and X-XIV incompletely fused, with suture lines visible. Fusion pattern and setal formula as follows: I-1, II-IV-4+ae, V-IX-10+3ae, X-XIV-10+3ae, XV-XVI-4+2ae, XVII-2+ae, XVIII-2+ae, XIX-1+p+ae, XX-1+p+ae, XXI-XXIII-2+p+ae, XXIV-2+p, XXV-1+1+ae, XXVI-1+1, XXVII-XXVIII-4+ae. Segment XIX with anterior crescentic process; segment XX and compound segments XXI-XXIII each with toothed ridge possessing comb-like denticles; anterior margin of segment XX with canoe-shaped tooth ridge which extends backs to middle of segment XIX; segment XXIV with prolonged, distally directed, spur-like process distally (Fig. 7D). Fifth leg (Figs. 7E, F) uniramous, asymmetrical; basis with outer seta; right exopod 2 segmented, 1st segment comprising palm with medial bilobed process medially, 2 setae, and slender thumb, 2nd segment elongate, finger-like with 3 inner setae and 1 distal seta; left exopod 2 segmented, 1st segment with distolateral spine and small inner seta, 2nd segment with 2 tuberculate finger-like papillae, 1 claw-like process, 2 unequal spines, and inner fringe of hairs.

Female: No female specimen was found in the study area.

Remarks: *Labidocera kröyeri* is readily distinguishable from the other species by the following characteristics: 1) cephalosome with lateral hooks, 2) distal segment of male left 5th leg with 2 tuberculated papillae, 1 claw-like process, and 2 unequal spines, and 3) right posterior corner bearing 2 unequal processes with a narrow gap between processes. Giesbrecht (1893) described it from the Gulf of Napoli, but his male 5th leg showed minor morphological differences with Korean specimens. In Giesbrecht's figure, the left 2nd exopod has a plumose seta and a nominal seta, while that of the Korean specimen has 2 nominal setae.

***Labidocera minuta* Giesbrecht, 1889**
(Figs. 8, 9C, F, I)

Labidocera minutum: Giesbrecht 1893, 446, pl. 23, Figs. 16, 35, 36, pl. 25, Fig. 32, pl. 41, Figs. 8, 15, 16, 35 (type locality: Hong Kong).

Labidocera minuta: Giesbrecht and Schmeil 1898, 137; Scott 1909, 167; Farran 1936, 116; Dakin and Colefax 1940, 101, Fig. 145a-e; Wilson 1950, 247, pl. 24, Figs. 356-359; Tanaka 1964, 257, Fig. 233a-f; Chen and Zhang 1965, 99, pl. 41, Figs. 11-16; Silas and Pillai 1973, 800, Fig. 12; Greenwood 1979, 101, pl. 5, Figs. a, d, e; Othman and Toda 2006, 310, Figs. 10, 11.

Materials examined: 2 ♀♀ and 5 ♂♂ collected from the northeastern area of the East China Sea (34°30'N, 128°E) on 26 Sept. 2002. Of these, both females and 2 males were dissected.

Female: Body length 1.77-1.92 mm (*n* = 2). Prosome (Fig. 8A) elongated; cephalosome and 1st pedigerous somite completely separated; 4th and 5th pedigerous somites incompletely fused; posterior corners of prosome rounded in dorsal view, but with short ventrally directed process visible in lateral view (Fig. 8C). Cephalosome anteriorly rounded, with lateral hooks and small pair of dorsal lenses; rostrum bifid, widely spaced and distant from ventral ocellus (Fig. 9C). Urosome 3 segmented: genital double somite asymmetrical with small processes, one anteroventral and the other posteroventral (Figs. 8F, 9F, I); anterior and posterior parts of right side swollen (Fig. 8A); genital operculum located ventroposteriorly of midline; right ventral surface of 2nd urosomite with chitinous tubercles (Fig. 9F); caudal rami asymmetrical, right ramus slightly wider than left one. Fusion pattern and setal formula of antennule same as those of *L. acutifrons* except for no hairs posteriorly on 2nd-10th segments. Fifth leg (Fig. 8F) slightly asymmetrical, left leg longer than right: exopod with 2 outer spinules and 2 apical processes; endopod bifurcate, inner process shorter.

Male: Body length 1.63-1.71 mm (*n* = 5). Prosome similar to female except for pair of large, contiguous dorsal lenses (Fig. 8B). Cephalosome and 1st pedigerous somite completely separated; 4th and 5th pedigerous somites fully fused; posterior corners of prosome asymmetrical, acutely pointed on left and blade-like on right and longer than left. Urosome 5 segmented: genital segment wider than long; caudal rami symmetrical. Fusion pattern and setal formula of antennule (Fig. 8D) same as those of *L. acutifrons*. Segment XIX with elongated process lying parallel to anterior border of segment and extending to distal border of segment; segment XX and compound segments XXI-XXIII each with toothed ridge; segment XXIV with spur-like process distally (Fig. 8E). Fifth leg (Fig. 8G) uniramous, asymmetrical; right basis with outer seta and patch of inner spinules; right exopod 2 segmented, 1st segment comprising

palm with bilobed process and 2 setae, 2nd segment elongate, finger-like, with 1 transparent flap, 3 setae along inner margin, and 2 apical setae; left exopod 2 segmented, 1st segment with small distolateral spine, 2nd segment with 2 stout processes, 2 triangular processes, and hirsute inner margin.

Remarks: *Labidocera minuta* is closely related to *L*. *bengalensis* (Silas and Pillai, 1973; Mulyadi, 2002), but can be distinguished by the following characteristics. In the female, 1) the genital double somite is ca. 1.5 times longer than the 2nd urosomite (2.5 times longer in *L*. *bengalensis*), 2) the 2nd urosomite has prominent chitinous tubercles (no tubercles in *L*. *bengalensis*), 3) the caudal rami are asymmetrical (symmetrical in *L*.

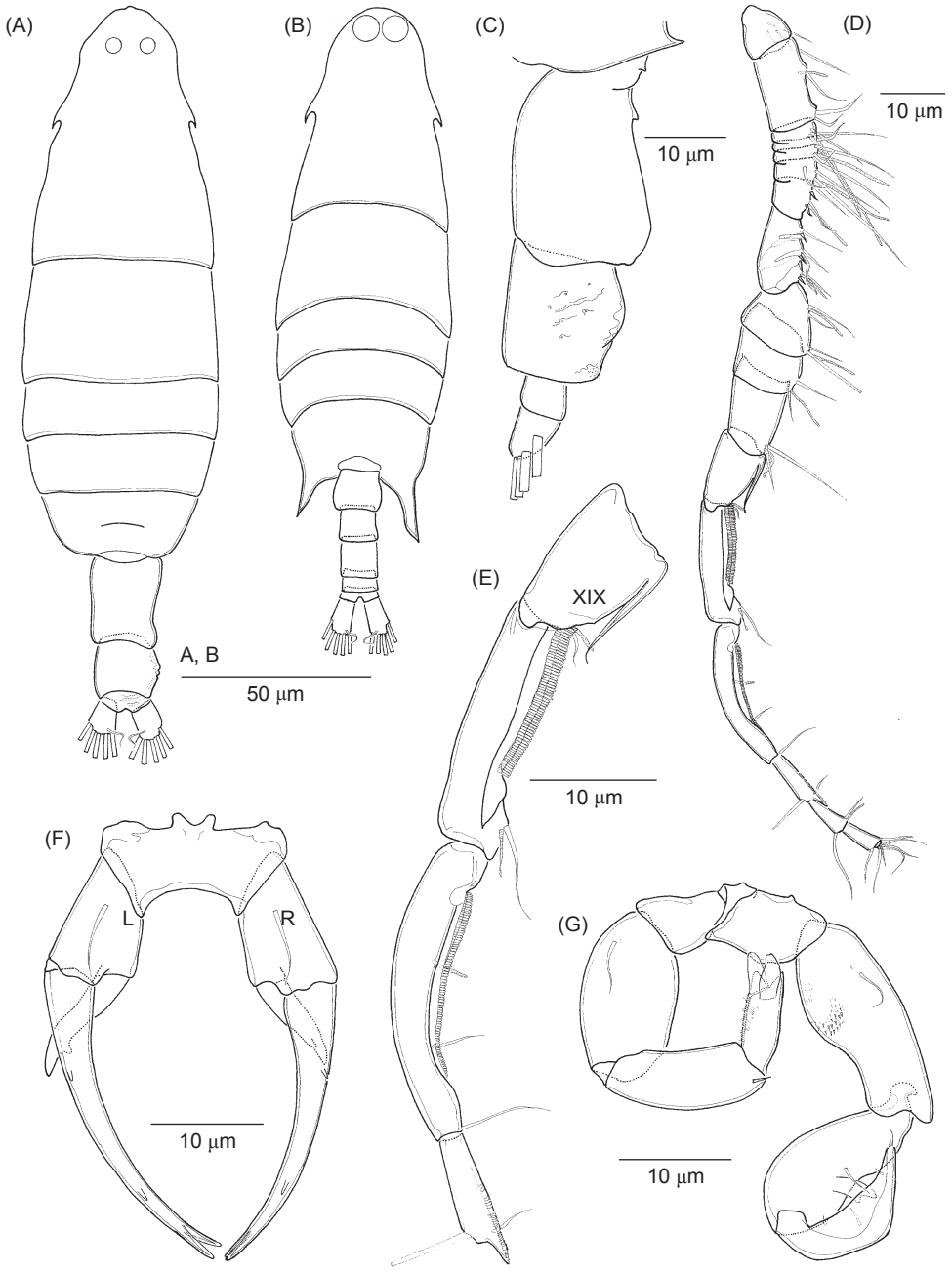

Fig. 8. *Labidocera minuta*. Female: (A) habitus, dorsal view; (C) urosome, right lateral view; (F) 5th leg. Male: (B) habitus, dorsal view; (D) right antennule; (E) ancestral segments XIX-XXIV of right antennule; (G) 5th leg.

bengalensis), and 4) the 5th legs have a bifurcate endopod (conical endopod in *L*. *bengalensis*); in the male, 1) the right posterior process of the prosome extends to the 2nd urosomite, and 2) the left 5th leg has 2 pairs of stout processes on the distal segment. Greenwood (1979) described it from Moreton Bay, Australia, but his female figures (see Figs. 5c, g in Greenwood 1979) clearly differ from *L*. *minuta* described above. As such, his description must be regarded as *L*. *bengalensis*. Giesbrecht's figure of *L*. *minuta* in 1893 showed minor morphological differences with Korean specimens: 1) the anal somite was asymmetrical in Giesbrecht's description, while that of Korean specimen is symmetrical, and 2) the right basis of the male 5th leg has no spinules in the former, while that of latter has a patch of spinules.

DISCUSSION

Female external genital structure

The female genital structure is greatly diversified in relatively primitive superfamilies of calanoid copepods, such as the Arietelloidea and Diaptomoidea (Fleminger 1975, Huys and Boxshall 1991, Ohtsuka et al. 1994, Cuoc et al. 1997, Barthélémy et al. 1998a b, Defaye et al. 2000, Soh et al. 2001, Walter et al. 2002). However, the female genital structure of diaptomoidean copepods radically diverges from the ancestral calanoid condition by the presence of a single genital operculum and the complete absence of seminal receptacles (Barthélémy et al. 1998a, Barthélémy 1999). In particular, the genital area of *Labidocera* species which belong to diaptomoidean copepods has a species-specific position and shape (Fig. 9). The genital area of *L*. *acutifrons* is displaced to the right posterior margin of the female double-somite, while those of *L*. *detruncata* and *L*. *minuta* are located medioventrally on the posterior border of the genital somite. All species showed an oval genital operculum. Barthélémy et al. (1998a) reported that the position of the genital area and operculum morphology of diaptomoid copepods are species-specific, and have considerable taxonomical value at the species level. Among species reported by Barthélémy (1998a), the genital area of *L*. *pavo* as a pontellid

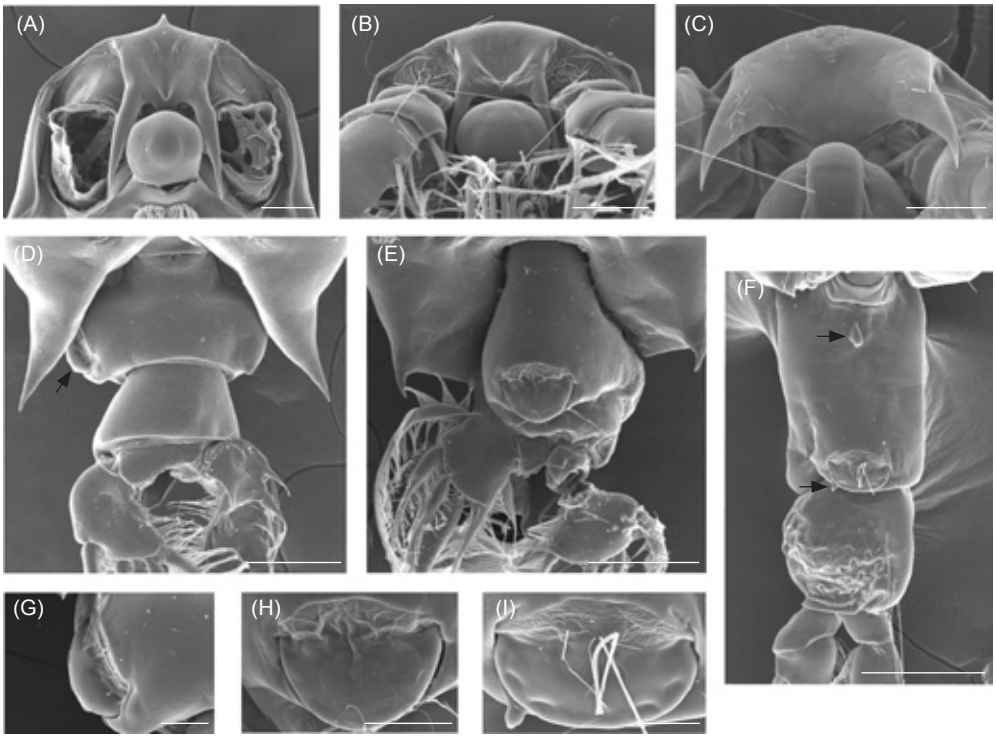

Fig. 9. Scanning electron micrographs of the female rostrum of *Labidocera acutifrons* (A), *L*. *detruncata* (B), and *L*. *minuta* (C); and the genital area of *L*. *acutifrons* (D, G), *L*. *detruncata* (E, H), and *L*. *minuta* (F, I). The arrow indicates the genital operculum (D) and the 2 ventral processes (F). Scale bars: A, B = 100 μm; C, G, and H = 50 μm; D-F = 200 μm; I = 20 μm.

species is displaced to the left posterior margin of the double-somite, and its operculum is produced posteriorly in a spatula-like form. Many recent studies also proposed that the genital structure can be very useful for species classification, particularly in acartiids (Barthélémy 1999), diaptomids (Cicchino 1994, Defaye et al. 2000), metridinids (Cuoc et al. 1997) and pseudodiaptomids (Soh et

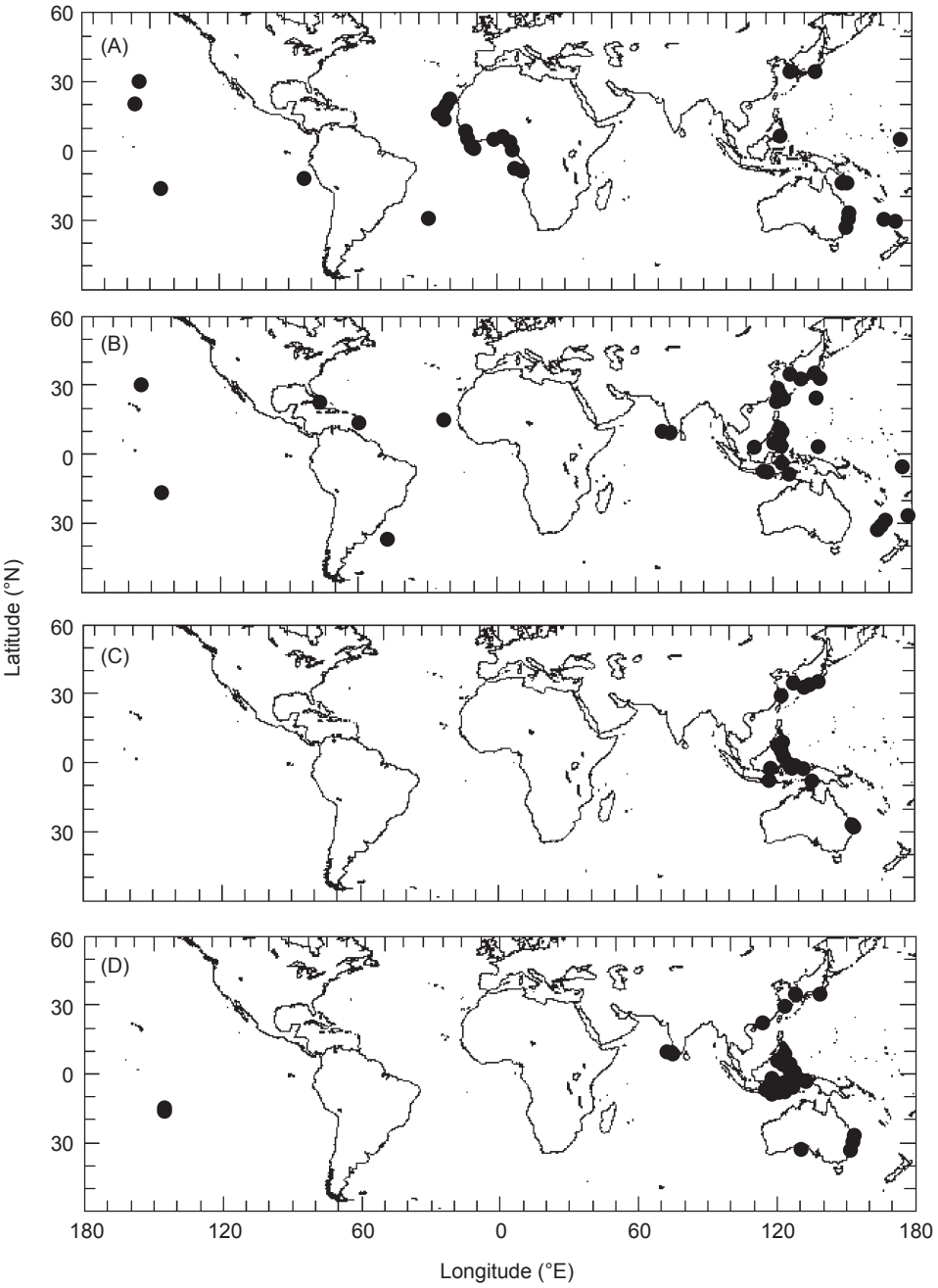

Fig. 10. Distribution of *Labidocera* species based on previous records and on the present study. References for *L. acutifrons* are (A) by Dana (1849), Brady (1883), Silas and Pillai (1973), Tanaka (1964), Knudsen and Wolff (1965), Greenwood (1979), and Bradford-Grieve (1999); those for *L. detruncata* are (B) by Dana (1849), Brady (1883), Scott (1909), Silas and Pillai (1973), Mori (1964), Chen and Zhang (1965), Silas and Pillai (1973), and Bradford-Grieve (1999); those for *L. kröyeri* are (C) by Scott (1909), Mori (1964), Chen and Zhang (1965), and Greenwood (1979); and those for *L. minuta* are (D) by Brady (1883), Giesbrecht (1892), Scott (1909), Farran (1936), Chen and Zhang (1965), Silas and Pillai (1973), and Greenwood (1979).

al. 2001, Walter et al. 2002). Therefore, detailed morphological descriptions of genital structures can provide useful characteristics for identifying *Labidocera* species.

Zoogeography

The schematic distributions of 4 *Labidocera* species, *L. acutifrons*, *L. detruncata*, *L. kröyeri*, and *L. minuta*, have 2 patterns. The former 2 species are distributed over the entire tropical and subtropical Atlantic, Pacific, and Indian Oceans, whereas the latter 2 species are restricted to the Indian and Pacific Oceans, between 35°N and 35°S (Fig. 10). Their zoogeography can be explained as follows: the ancestors of *L. acutifrons* and *L. detruncata*, which originated from the Indo-Malayan region, could have been introduced to the western Atlantic via the Panama passage, as proposed for the evolution of *Tortanus* by Ohtsuka and Reid (1998). Dispersal from the tropical Pacific to Atlantic waters, via the Panama passage was also suggested for the pelagic shrimp *Acetes* (Spoel 1983) and the deep-sea fish *Cyclothone alba* Brauer (Miya and Nishida 1997). However, although *L. acutifrons* is found in all oceans, it has a proximate distribution in coastal waters of central Africa (see Fig. 9A). It can be concluded that at least some species of *Labidocera* originated in Atlantic tropical waters of central Africa and dispersed to the Indo-West Pacific, as suggested by Van der Spoel (1983). The other 2 species, *L. kröyeri* and *L. minuta* belong to a different species group. The *kröyeri* group is composed of 5 species: *L. dakini*, *L. gallensis*, *L. kröyeri*, *L. muranoi*, and *L. stylifera* (Fleminger 1967 1982 1986, Greenwood 1978, Mulyadi 1997). The *minuta* group consists of *L. bengalensis* and *L. minuta* (Mulyadi 1997). The groups occur allopatrically or sympatrically within a restricted area (Mulyadi 2002). This suggests extensive speciation of these groups 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). However, the phylogenetic relationship of the *Labidocera* genus needs additional investigation by morphological and molecular analyses.

The 4 species described herein are recorded in Korean waters for the first time. They appeared from Aug. to Oct. when the Tsushima Warm Current most strongly affects the northeastern area of the East China Sea (Seung 1992). *Labidocera detruncata*, known as an euneustonic pontellid in Kuroshio areas (Matsuo and Marumo 1982), was most abundant (< 2500 individuals (ind.)/ 100 m^3) offshore in Sept., whereas the abundance of *L. acutifrons* was very low (< 100 ind./100 m^3) in coastal waters in Aug. in the northeastern area of the East China Sea (Jeong et al. unpubl. data). The other 2 species, *L. kröyeri* and *L. minuta* were also reported in Kuroshio waters (Matsuo and Marumo 1982), although their abundances were relatively low (< 800 ind./100 m^3) in that area. Based on the results of this study, we suggest that these species can act as useful indicators of the Tsushima Warm Current.

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