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New Report of *Parabopyrella elongata* (Isopoda, Epicaridea, Bopyridae) in Korean Waters, with Notes on Morphological Variations

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ABSTRACT

A branchial parasitic bopyrid, *Parabopyrella elongata* (Shiino, 1949), is newly recorded in Korean fauna. *Parabopyrella elongata* differs from its congeners by the following characteristics: the head is smooth anteriorly in females; the pleon of females has distinct and wide lateral indentations on both sides; the pleotelson has a rounded distal end in females; oostegite 1 has a rounded posterolateral point; the pleon of males is single-segmented; and the uropod is absent in males. In this study, the detailed description and illustrations of the species are presented with an emended key to known *Parabopyrella* species in the Far East. The variations in *P. elongata* were also discussed. This is the first report of the genus *Parabopyrella* from South Korea.

Keywords: Alpheidae, Bopyrinae, *Parabopyrella*, parasitic isopods, South Korea, taxonomy

INTRODUCTION

The *Parabopyrella* Markham, 1985 is the second largest genus within the parasitic isopod subfamily Bopyrinae Rafinesque, 1815 comprising 27 genera (Boyko et al., 2013; An et al., 2015). This genus is characterized by the following features: (1) the head is fused with pereonite 1 except for the anterolateral margin; (2) the maxilliped has an articulated or non-articulated palp; (3) the pleomeres are indicated by the lateral indentations; (4) the head is usually fused with pereonite 1 in males; and (5) the pleon is partly or completely fused in males (Markham, 1985; An et al., 2015). All *Parabopyrella* species are parasites on the branchial chamber of Alpheidae (snapping shrimp) and Hippolytidae (cleaner shrimp) (An et al., 2015).

As the bopyrid isopods are known to show the highest diversity in the Indo-West Pacific (Boyko, 2004; Williams and Boyko, 2012), among 28 known *Parabopyrella* species, 19 species have been reported from this region (Chopra, 1923, 1930; Nierstrasz and Brender à Brandis, 1923; Bourdon, 1979, 1980; Bourdon and Bruce, 1979, 1983; Markham, 1985; An et al., 2015). In the Far East, on the other hand, only seven *Parabopyrella* species have been recorded from China and Japan, none from South Korea: *P. angusta* (Shiino, 1936), *P. crenulata* (Shiino, 1939), *P. pacifica* (Shiino, 1933), and *P. setoensis* (Shiino, 1939) from Japan; *P. cuspidata* An, Boyko and Li, 2015 and *P. hodgarti* (Chopra, 1923) from China; *P. elongata* (Shiino, 1949) from China and Japan (Shiino, 1933, 1936, 1939a, 1939b, 1949; Bourdon and Bruce, 1983; An et al., 2015). Among the seven species, only *P. elongata* shows a wide distribution pattern ranging from East Asia (China and Japan) to Oceania (Australia) (Shiino, 1949; Bourdon, 1980; An et al., 2015).

In this study, the Korean material of *P. elongata* is reported with detailed descriptions and illustrations. The variations of the species were also discussed. This is the first record of the genus *Parabopyrella* from South Korea.

MATERIALS AND METHODS

The hosts were collected under rocks in the intertidal zones of

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Korean waters, which were captured by using hands or a sieve with a 1 mm mesh and then immediately fixed in 95% ethyl alcohol. The parasitic isopods were extracted from the hosts by lifting the carapace in the laboratory. The specimens were observed and dissected under a dissecting microscope (Olympus SZH-ILLD, Japan) and a light microscope (Olympus BX 50). Measurements and drawings were carried out with the aid of a drawing tube equipped on the light microscope. A CCD camera (iCM 3.0; Bernardy, Canada) using an iSolution Lite software (IMT i-solution; Bernardy) was used to take the photographs. The examined specimens were transferred into the small glass vials filled with 95% ethanol and deposited at the National Institute of Biological Resource (NIBR) and Chosun University in South Korea.

SYSTEMATIC ACCOUNTS

Order Isopoda Latreille, 1817
Infraorder Epicaridea Latreille, 1825
Family Bopyridae Rafinesque, 1815
Subfamily Bopyrinae Rafinesque, 1815

[1]*Genus *Parabopyrella* Markham, 1985

Type species. *Bopyrella mortenseni* Nierstrasz and Brender à Brandis, 1929 by original designation.

Species composition. *Parabopyrella* angulosa (Bourdon, 1980), *P. angusta* (Shiino, 1936), *P. australiensis* (Bourdon, 1980), *P. barnardi* (Nierstrasz and Brender à Brandis, 1931), *P. bonnieri* (Nierstrasz and Brender à Brandis, 1923), *P. choprai* (Nierstrasz and Brender à Brandis, 1929), *P. crenulata* (Shiino, 1939), *P. cuspidata* An, Boyko and Li, 2015, *P. delagoae* (Bourdon, 1982), *P. distincta* (Nierstrasz and Brender à Brandis, 1923), *P. elongata* (Shiino, 1949), *P. essingtoni* (Bourdon and Bruce, 1983), *P. hodgarti* (Chopra, 1923), *P. incisa* (Bourdon, 1982), *P. indica* (Chopra, 1923), *P. intermedia* (Nierstrasz and Brender à Brandis, 1923), *P. lata* (Nierstrasz and Brender à Brandis, 1929), *P. megatelson* (Nierstrasz and Brender à Brandis, 1929), *P. mortenseni* (Nierstrasz and Brender à Brandis, 1929), *P. nierstraszi* (Chopra, 1930), *P. pacifica* (Shiino, 1933), *P. perplexa* Markham, 1990, *P. richardsonae* (Nierstrasz and Brender à Brandis, 1929), *P. saronae* (Bourdon and Bruce, 1979), *P. setoensis* (Shiino, 1939), *P. symmetros* An, Boyko and Li, 2015, *P. tanyensis* (Bourdon, 1979), and *P. thomasi* (Nierstrasz and Brender à Brandis, 1929).

Diagnosis. Female: Head fused with pereonite 1, while anterolateral region indicated by suture; barbula with 1 or 2 pairs of projections on both sides of maxillipeds; pereonites 1–4 with coxal plates and dorsolateral bosses dorsolaterally; oostegite 1, internal ridge unadorned or with several simple projections; pleomeres indicated by lateral indentations on both sides; pleopods 5 pairs, flap-like, biramous; uropod absent. Male: Head normally fused with pereonite 1; pleon variously fused; pleonite 1 wider than pereonite 7; uropod usually lacking (An et al., 2015).

Remarks. Although this genus resembles the genus *Bopyrella* Bonnier, 1900 in that the head and pereonite 1 are fused at least mesially, the biramous pleopods are well developed, and the uropod is lacking in males, the former is easily distinguishable from the latter by having lateral indentations on both sides of the pleon (vs. lacking and completely fused in the latter) (An et al., 2015). All species are known to infest members of the caridean families Alpheidae and Hippolytidae (An et al., 2015).

[2]**Parabopyrella elongata* (Shiino, 1949) (Figs. 1, 2)

Bopyrella elongata Shiino, 1949: 45, fig 1; Bourdon, 1980: 194, fig. 4.

Parabopyrell elongata: Markham, 1985: 67; An et al., 2015: 52, fig. 15.

Material examined. 1♂ (2.1 mm) 1 ovigerous ♀ (17.0 mm) (infesting right branchial chamber of host), Korea: Gyeongsangnam-do: Namhae-gun, Gohyeon-myeon, Chamyeon-ri, 34°55′06″N, 127°51′15″E, 22 May 2020, Kim SH; same data as former except for 5♂♂ 5♀♀, 3 Sep 2020, NIBRIV 0000876682, Kim SH; 1♂ 1♀, Jeju-do: Jeju-si, Udo-myeon, Yeonpyeong-ri, 33°31′07″N, 126°56′56″E, 17 Jun 2019, NIBRIV0000876681, Kim SH; 1♂ 1♀, Jeju-si, Udo-myeon, Yeonpyeong-ri, 33°31′24″N, 126°57′01″E, 20 Oct 2022, Kim SH; 1♂ 1♀, Jeju-si, Gujwa-eup, Hado-ri, 33°31′38″N, 126°53′23″E, 21 Oct 2022, Kim SH; 1♂ 1♀, Jeju-si, Gujwa-eup, Hado-ri, 33°31′37″N, 126°53′03″E, 21 Oct 2022, Kim SH.

Diagnosis. Female: Body approximately distorted 21°; length 17.0 mm; head medially fused with pereonite 1, indicated by ambiguous suture anterolaterally; eye present; maxillipedal palp articulated; pereonites 1–4 with coxal plates and dorsolateral bosses; pleon with distinct and wide lateral indentations; pleotelson incised and quadrate distally. Male: Head fused with pereonite 1; eye small; pleon single-segmented, with concavity distally; lateral indentations of pleon indistinct; uropod lacking.

Description of female. Body (Figs. 1C, D, 2A, B) smooth, approximately distorted 21°, oval, tapering posteriorly; length 17.0 mm; maximal width 14.8 mm in pereonite 3. Head (Figs. 1C, D, 2A) medially fused with pereonite 1, indicated

Korean name: [1]*딱총새우아감벌레속(신칭), [2]*홈발딱총새우아감벌레(신칭)

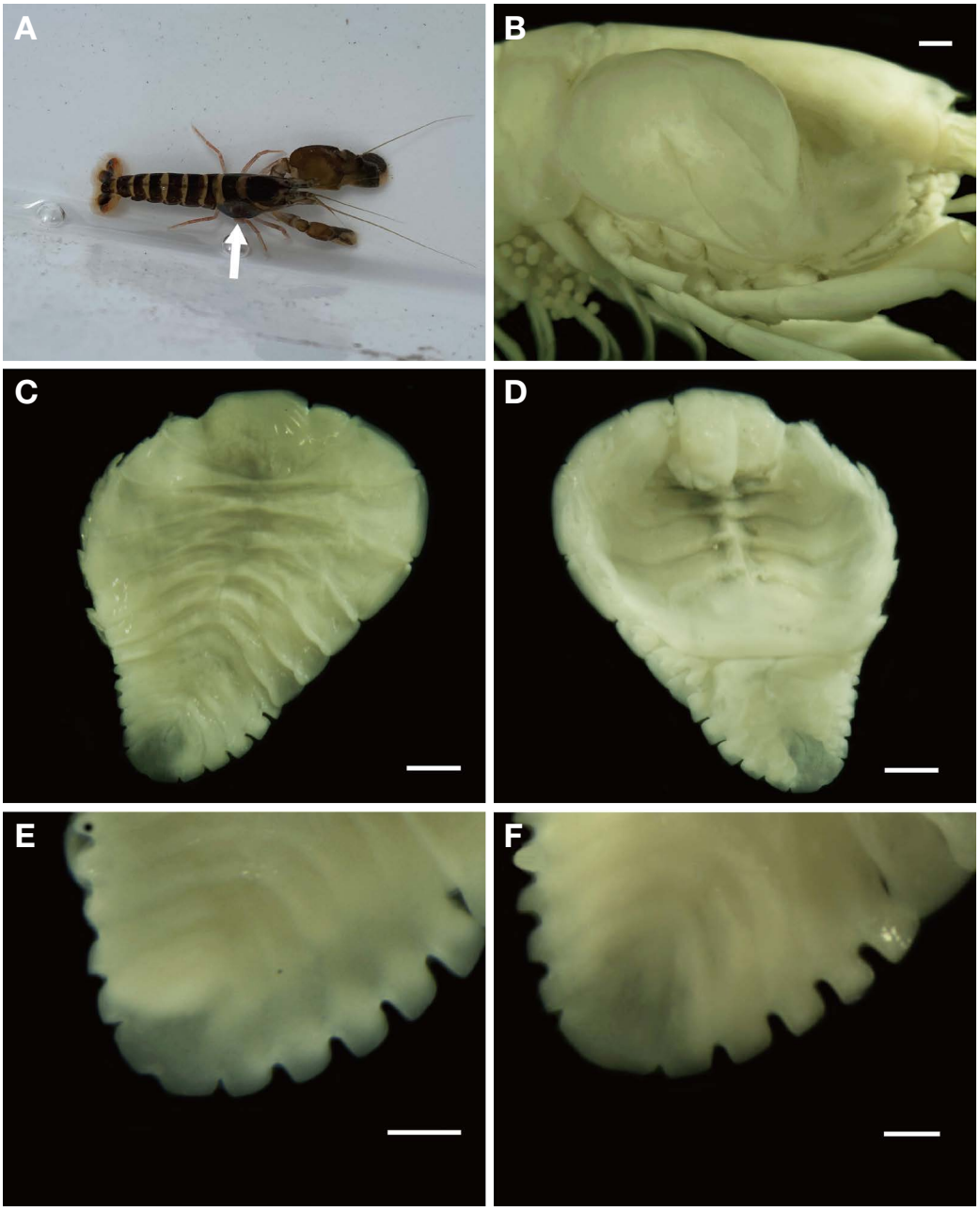

Fig. 1. Microphotographs of hosts (A, B) and *Parabopyrella elongata* (Shiino, 1949) (C–F). A, Live specimen, arrow indicates bulged branchial chamber; B, Fixed specimen; C, Habitus, dorsal view; D, Habitus, ventral view; E, Distally incised pleotelson, dorsal view; F, Distally rounded pleotelson, dorsal view. Scale bars: B–D = 1 mm, E, F = 0.5 mm.

by ambiguous suture anterolaterally, occasionally indistinct according to population; frontal lamina lacking; eye present, but small.

Maxilliped (Fig. 2C), palp articulated, setose distally. Barbula (Fig. 2C) with 2 pairs of falcate projections on each side of maxillipeds.

Pereon (Figs. 1C, 2A) distinct; coxal plates and dorsolateral bosses well-developed on both sides of pereonites 1–4. Oostegites (Figs. 1D, 2B, D, E) widely opened; oostegite 1 symmetrical; posterolateral point bearing fine setae on inner margin, rounded posteriorly; oostegite 5 about twice longer than proceeding oostegites. Pereopods (Fig. 1D) short, slightly visible dorsally only on short side of body. Pereopods 1, 6, and 7 (Fig. 2B, F–H) basis stout; ischium and merus with serrated

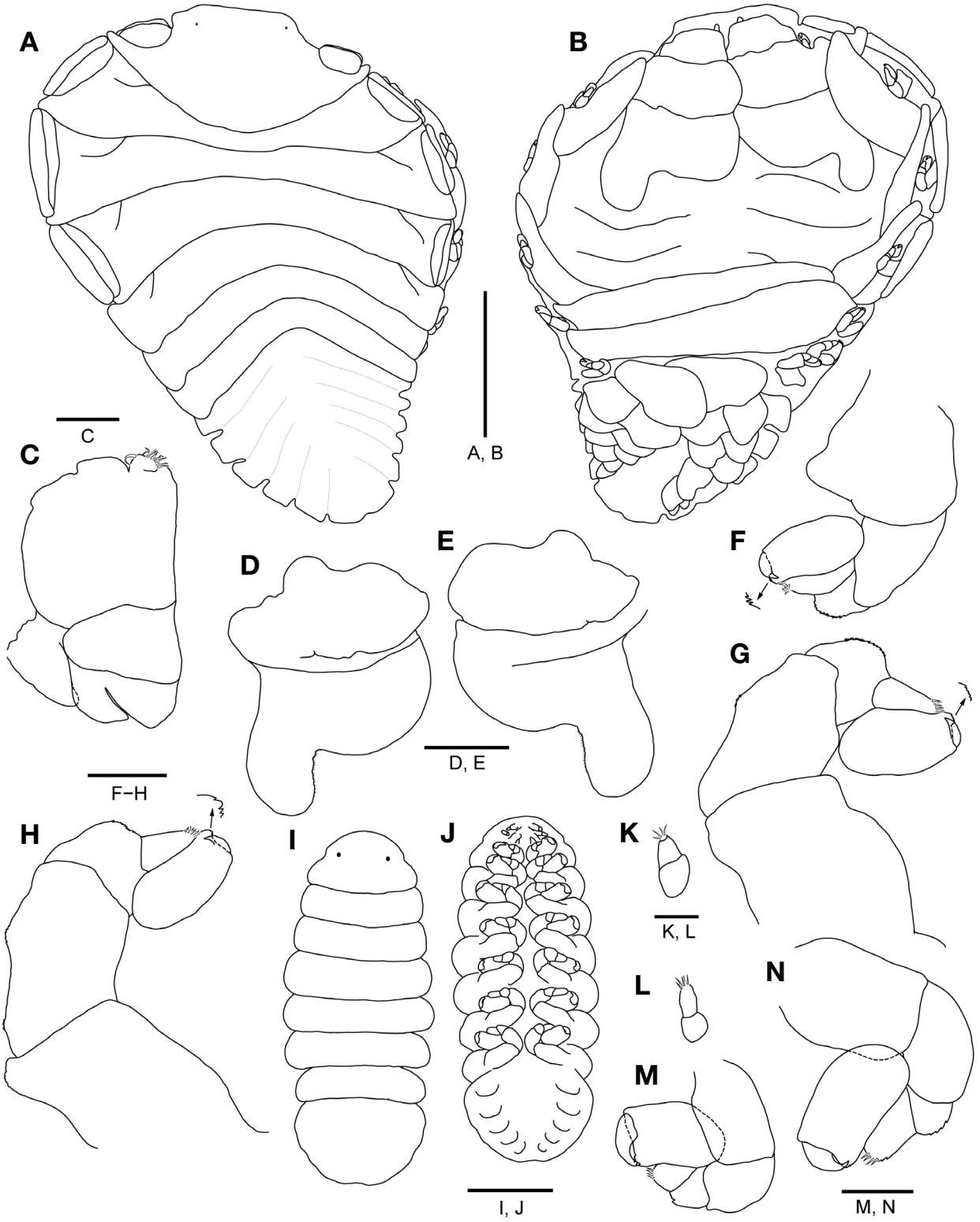

Fig. 2. *Parabopyrella elongata* (Shiino, 1949), female (A–H) and male (I–N). A, Habitus, dorsal view; B, Habitus, ventral view; C, Maxilliped and barbula; D, Right oostegite 1, external view; E, Left oostegite 1, external view; F, Pereopod 1; G, Pereopod 6; H, Pereopod 7; I, Habitus, dorsal view; J, Habitus, ventral view; K, Antennule; L, Antenna; M, Pereopod 1; N, Pereopod 7. Arrows each indicates serrated margin of pereopod's propodus. Scale bars: A, B=5 mm, C, I, J=0.5 mm, D, E=1 mm, F–H, K, L=0.2 mm, M, N=0.1 mm.

on inferior margins in pereopods 6 and 7, while merus with serrated margin in pereopod 1; carpus with several simple setae on inferior distal angle; propodus oval, swollen, serrated on inferior distal angle; dactylus blunt and curved.

Pleon (Figs. 1D, F, 2A, B) fused with each other, while indicated by obscure sutures dorsally; lateral indentations distinct and wide; pleotelson with incision and lobes quadrate distally. Pleopods (Figs. 1F, 2A) consisting of well-developed 5 pairs of biramous. Uropod absent.

Description of male. Body (Fig. 2I, J) smooth dorsally; length 2.1 mm. Head (Fig. 2I) fused with pereonite 1, with lateral junction of head and pereonite 1; eye small.

Antennule (Fig. 2K) 3-articled; first and second articles subequal in length; third article minute and with simple setae distally. Antenna (Fig. 2L) 2-articled; last article with simple setae distally.

Pereonites (Fig. 2I, J) oblong; pereonites 4–6 slightly wider than other pereonites. Pereopods (Fig. 2J), larger posteriorly. Pereopods 1 and 7 (Fig. 2M, N), merus and carpus with serrated margins inferiorly in pereopod 7, while merus with inferiorly serrated margin in pereopod 1; carpus with simple setae inferodistally; propodus with serrated margin inferodistally; dactylus curved.

Pleon (Fig. 2I) consisting of single segment; lateral margin slightly sinuous; lateral indentations indistinct; distal end slightly concave. Pleopods (Fig. 2J) composed of 5 pairs of obscure uniramous. Uropod lacking.

Variation. Among the ten specimens, one showed larger size than others and distally rounded pleotelson (Fig. 1F). Furthermore, the degree of the medial incision of the pleotselon was vary according to the individuals. The length of anterolateral suture between the head and pereonite 1 differs from each other according to the specimens. Sometimes, the suture is also quite difficult to distinguish according to the specimens (Figs. 1C, 2A).

Hosts. *Alpheus bisincisus* De Haan, 1849 (Fig. 1A, B).

Habitats. Muddy sand flat, gravelly sandy mud flat.

Remarks. An et al. (2015) discriminated the *Parabopyrella* species into three groups based on the shape of the distal end of the pleotelson in females: A group, truncate or convex and pointed; B group, convex and rounded; and C group, incised. The C group was divided again into four subgroups in terms of the morphology of the distal end of the pleotelson in their grouping of the *Parabopyrella* species: C1 subgroup with the medial incision shallow and the lobes quadrate distally; C2 subgroup with the medial incision shallow and the lobes rounded distally; C3 subgroup with the medial incision deep and the lobes long and pointed; and C4 subgroup with the medial incision shallow and produced into two small points (An et al., 2015). Considering An et al. (2015)'s criterion, *Parabopyrella elongata* belongs to the C1 subgroup including five species, *P. australiensis*, *P. barnardi*, *P. cuspidata*, *P. elongata*, and *P. pacifica* (An et al., 2015). Among these five species, *P. elongata* is easily distinguishable from *P. australiensis* by the pleon lacking a dorsal tubercle (vs. having in the latter) (Bourdon, 1980). *Parabopyrella elongata* also can be distinguished from *P. barnardi* by having distinct and wide lateral indentations on both sides of the pleon (vs. having only on the short side in the latter) (Bourdon, 1980). *Parabopyrella elongata* differs from *P. cuspidata* in that oostegite 1 has a rounded posterolateral point (vs. acute posterolateral point in the latter), the head is fused with the pereonite 1 in male (vs. separated in the latter), and the pleon consists of a single segment in male (vs. six distinct segments in the latter) (An et al., 2015). *Parabopyrella elongata* differs from the *P. pacifica* in that the eyes are present (vs. absent in the latter), the lateral indentations on the pleon are more distinct and wider than the latter, and the uropod is absent in male (vs. present in the latter) (Shiino, 1933).

DISCUSSION

The Korean materials are generally well agreed with the previous descriptions of *P. elongata* including the original description in the following features: (1) both sexes have eyes; (2) coxal plates and dorsolateral bosses are present on pereonites 1–4; (3) lateral indentations are distinct on both sides of the pleon; (4) the pleotelson has a medial incision distally; and (5) the pleon is single-segmented in males (Shiino, 1949; Bourdon, 1980; An et al., 2015). An et al. (2015), meanwhile, reported several variations in this species, which had not been known from other previous descriptions of Shiino (1949) and Bourdon (1980), such that the male has no eyes and lateral indentations of the pleon are absent in males. In these respects, the Korean materials of the present study show intermediate states of features between the original description (Shiino, 1949) and An et al. (2015)'s description for the variations. That is, males of the present study have eyes as described in the original description, whereas lateral indentations of the pleon are indistinct as like those in An et al. (2015) (Shiino, 1949; Bourdon, 1980; An et al., 2015). The Korean materials also show additional variations according to individuals: the female pleotelson occasionally possesses a distally rounded end, although an incised distal end of the pleotelson is known as a diagnostic character state of this species (Shiino, 1949; Bourdon, 1980; An et al., 2015); the pleotelson's distal end varies in the degree of incision (Fig. 1C–F); the length of the anterolateral suture between head and pereonite 1 differs from each other, sometimes, it's really indistinct. Taken all together, *P. elongata* has variations in the pleon of both sexes and the eyes of males according to the specimens in this study.

In considering that the previous studies for bopyrid species have reported that the shape of the pleon in both sexes is a highly variable to individuals though they are commonly collected from the same host, the Korean materials of the present study should be identified as *P. elongata* despite that they show some differences mentioned above (Chopra, 1923; Shiino, 1949; Bourdon, 1980; An et al., 2015). However, it is noticeable that some of these variations connected with the diagnostic character of *P. elongata* having a wide distribution (Shiino, 1949; Bourdon, 1980; An et al., 2015). In this study, specimens were collected from quite different kinds of habitats. Those taken from the southern coast of the Korean Peninsula were from a muddy sand flat, whereas those from Jeju Island were from a gravelly sandy mud flat. In other words, the specimens collected from Jeju Island represented those from more fine-grained substrate than from the southern coast of the Korean Peninsula in the environmental condition. Additionally, this species is known to parasite to *Alpheus* species (An et al., 2015). *Alpheus bisincisus*, the host of the Korean specimens of *P. elongata*, is known to inhibit both muddy sand flats and gravelly sandy mud flats (Kim, 1977). It is supposed that some variations described in this study may come from the different environmental effects on the populations according to the habitats of their host. Further study on these variations is required in *P. elongata*.

Emended key to known species of the genus *Parabopyrella* in the Far East

1. Head crenulated anteriorly ····· *P. crenulata* (Shiino, 1939)
− Head not crenulated anteriorly ····· 2
2. Lateral indentations distinct and wide ····· 3
− Lateral indentations indistinct ····· 6
3. Distal lobes of pleotelson pointed ····· *P. hodgarti* (Chopra, 1923)
− Distal lobes of pleotelson quadrate ····· 4
4. All pleonites separated in male ····· *P. cuspidata* An, Boyko and Li, 2015
− Pleonites fused in male ····· 5
5. Uropod present in male ····· *P. pacifica* (Shiino, 1933)
− Uropod absent in male ····· *P. elongata* (Shiino, 1949)
6. Pereonites 1−4, coxal plates and dorsolateral bosses absent ····· *P. setoensis* (Shiino, 1939)
− Pereonites 1−4, coxal plates and dorsolateral bosses present ····· *P. angusta* (Shiino, 1936)

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CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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