

Descriptions of Two Cymothoid Isopods (Crustacea, Isopoda, Cymothoidea) from Korean Waters

Sung Hoon Kim, Seong Myeong Yoon*

Department of Biology, College of Natural Sciences, Chosun University, Gwangju 61452, Korea

ABSTRACT

Two cymothoid isopods, *Rocinela niponia* Richardson, 1909 and *Bopyrus squillarum* Latreille, 1802, are first reported from Korean waters. *Rocinela niponia* can be distinguished from its congeners by the following characteristics: the rostral point is round; the eyes are separated from each other; and each pereopods 1–3 has the propodal blade bearing eight robust setae. *Bopyrus squillarum* is distinguishable from its related species by the following characteristics: the head is separated from pereonite 1, but partially fused on the lateral margins; the first pleonite on the short side is much smaller than other segments; and it is parasitic on the branchial chamber of *Palaemon serrifer*. Detailed descriptions and figures of these two species are provided in this paper.

Keywords: *Bopyrus*, *Rocinela*, isopods, morphology, Korea

INTRODUCTION

Among the cymothoid isopods, the species belonging to the genus *Rocinela* Leach, 1818 have a property that attaching temporarily on fish to feed on their blood or mucus. This genus can be distinguished from other related genera in that pleonite 1 is not abruptly narrower than pereonite 7 and the maxillipedal palp is 3-articled (Bruce, 2009; Smit et al., 2019). To date, about 41 *Rocinela* species have been reported worldwide (Boyko et al., 2008c; Bruce, 2009; Cardoso et al., 2017). Among them, seven species have been recorded in the Far East: *Rocinela affinis* Richardson, 1904; *Rocinela angustata* Richardson, 1904; *Rocinela belliceps* (Stimpson, 1864); *Rocinela japonica* Richardson, 1898; *Rocinela lukini* Vasina, 1993; *Rocinela maculata* Schioedte and Meinert, 1879; and *Rocinela niponia* Richardson, 1909 (Schioedte and Meinert, 1879; Richardson, 1898, 1904, 1905, 1909; Kussakin, 1974, 1979; Brusca and France, 1992; Vasina, 1993; Nunomura, 2006; Bruce, 2009). In Korea, only one species, *R. maculata*, was recorded in this genus (Kussakin, 1979; National Institute of Biological Resources, 2012).

The genus *Bopyrus* Latreille, 1802 differs from other parasitic isopod taxa in that all members parasitize on the branchiae of caridean shrimps and have five pairs of well-developed uniramous pleopods (Markham, 1985; An et al., 2015; Smit

et al., 2019). So far, only three species are regarded as valid ones in this genus: *Bopyrus bimaculatus* Chopra, 1923; *Bopyrus foliosus* Krøyer, 1846; and *Bopyrus squillarum* Latreille, 1802 (Boyko et al., 2008a). In spite of all the species are accepted as *Bopyrus*, however, *B. foliosus* has a problem that the original description could not be found (Boyko et al., 2008b). Another species, *B. bimaculatus*, has also other problem that some diagnostic characteristics of the species described in the original description could be regarded as variations (Chopra, 1923; Bourdon, 1968). At this point, all *Bopyrus* species are required further taxonomic studies.

During the survey of Korean isopods, two cymothoid isopods new to Korean fauna, *R. niponia* and *B. squillarum*, were collected. In this study, we report these species with detailed descriptions and illustrations. The genus *Bopyrus* is first reported from Korea by the present study.

MATERIALS AND METHODS

Samples were collected from the intertidal and subtidal zones of Jindo Island and Chujado Island in Korea. Sampling in the subtidal zone was made by SCUBA diving and using Smith-McIntyre grab. The collected samples were immediately fixed in 95% ethanol and then transferred to the labora-

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***To whom correspondence should be addressed**
Tel: 82-62-230-7018, Fax: 82-62-230-7018
E-mail: smyun@chosun.ac.kr

tory. The parasitic specimens were extracted from the hosts by lifting the carapace of host. The specimens were observed and dissected under the stereomicroscope (SZH-ILLD; Olympus, Japan) and bright-field microscope (BX50; Olympus). Measurements and drawings were conducted by the aid of a drawing tube. The materials of the present study were deposited at the National Institute of Biological Resource (NIBR) and Chosun University in Korea.

SYSTEMATIC ACCOUNTS

Order Isopoda Latreille, 1817
 Suborder Cymothoidea Wägele, 1989
 Superfamily Cymothoidea Leach, 1814
 Family Aegidae White, 1850
 Genus *Rocinela* Leach, 1818

¹**Rocinela niponia* Richardson, 1909 (Figs. 1–3)

Rocinela niponia Richardson, 1909: 83, figs. 9, 10.

Material examined. Korea: 1♀ (juvenile), Jeju-si, Chujameon, Chujado Island, 33°56'39"N, 126°21'37"E, 24 Oct 2018, depth 30–40 m, Smith-McIntyre grab; 1♀ (juvenile), 33°58'50"N, 126°20'23"E, 16 Apr 2019, depth 30–40 m, Smith-McIntyre grab; 1♀, 4♀ (juvenile), 33°59'07"N, 126°19'12"E, 6 Jul 2019, depth 10 m, SCUBA diving, NIBR-IV0000876683; 1♀ (juvenile), 33°58'53"N, 126°17'46"E, 6 Jul 2019, depth 10 m, SCUBA diving; 5♀ (juvenile), 33°58'48"N, 126°21'02"E, 6 Jul 2019, depth 10 m, SCUBA diving.

Description of female. Body (Fig. 1A, B) 20.7 mm, 2.1 times longer than wide, oval, smooth, dorsoventrally flattened. Cephalon (Fig. 1C, D) triangular, slightly tri-sinuated on posterior margin; rostrum rounded; frontal lamina anteriorly acute, with round apex; labrum projecting ventrally; eye large, with numerous ommatidia. Pereonites similar to each other while pereonite 7 shortest; pereonites 4–6 widest. Coxal plates visible on dorsal side; coxal plates 2–4 with rounded posteriorly, whereas 5–7 with acute posteriorly. Pleonites narrower than pereonites, but not abrupt; pleonite 1 almost hidden on dorsal side; pleonites 2–4 similar in shape, with acute posteriorly; pleonite 5 narrower than preceding pleonites, surrounded by pleonite 4. Pleotelson (Fig. 1E) triangular or shield-shaped, tapering posteriorly, with 1 pair of depressions divided by mesial carina on proximal region; distal region with numerous short robust and plumose setae distally; apex rounded.

Antennule (Fig. 1F) reaching posterior margin of cephalon, consisting of 3 peduncular articles and 6 flagellar articles;

peduncular article 1 subsquare, with 1 penicillate seta and 1 simple seta distally; article 2 oblong with 4 penicillate setae laterally, article 3 longest, 1.9 times longer than article 2, with 3 penicillate setae distally; flagellar articles square, sequentially smaller; article 1 with 1 short simple seta distally; articles 2–5 with 3 aesthetascs on distal end respectively; article 6 smallest, with 4 aesthetascs and 3 simple setae distally. Antenna (Fig. 1G) extending to posterior margin of pereonite 2; composed of 5 peduncular articles and 17 flagellar articles; peduncular article 1 globular or pentagonal; article 2 oblong, slightly extending mesially, with 2 short simple setae; article 3 almost 4 times longer than article 2; article 4 subequal to article 3, with 2 simple setae distally; article 5 longest, 1.5 times longer than article 4, with 5 simple setae distally; flagellar articles similar to each other in length, sequentially narrower, with several short simple setae on distal end.

Mandible (Fig. 1H–J), incisor acute, unicuspid, with 2 processes covered by minute spines; molar process rounded; palp consisting of 3 articles, palp article 2 with 11 serrate setae and 2 long simple setae on distal region, article 3 with 19 serrate setae laterally. Maxillule (Fig. 1K) slender, acute distally, with 2 robust setae distally. Maxilla (Fig. 1L, M), stouter than maxillule, consisting of 2 lobes; inner lobe with 2 curved robust setae and numerous fine setae distally; outer lobe with 1 curved robust seta distally and 2 protrusions laterally. Maxilliped (Fig. 1N, O) 3-articled; first article oblong, longest, with 1 plumose seta on distal end; second article 0.4 times as long as first article, with 2 curved robust setae distally; third article shortest, with 4 curved robust setae and 1 simple seta distally.

Pereopods (Fig. 2A–G) slender, sequentially longer; pereopods 1–3 prehensile whereas pereopods 4–7 ambulatory. Pereopods 1–3 (Fig. 2A–D), basis elongated oblong, with 3–6 penicillate setae on anterior margin; ischium oblong, 0.4 times as long as basis, expanding to anterior distal angle, with 1 robust seta anterodistally; merus trapezoidal, with 3–4 simple setae on anterodistal angle, 4 robust setae in pereopod 1 or 5 robust setae in pereopods 2 and 3 on posterior margin; carpus partly hidden by merus, with 1 robust seta on posterodistal angle; propodus with blade on palm; propodal blade 0.7 times as long as wide, with 8 blunt robust setae distally; dactylus slightly longer than propodus and curved. Pereopods 4–7 (Fig. 2E–H), basis elongated oblong, with 2–9 penicillate setae on anterior margin and 1–2 robust setae on posterodistal margin; ischium 0.7 times as long as basis, tapering posteriorly, with several robust setae along posterior margin and distal end; merus oblong, 0.6 times as long as ischium, with several robust setae distally; carpus subequal to merus in length, rectangular, with several robust setae laterally and distally; propodus much slender than preceding articles, 1.2 times lon-

Korean name: ¹*두눈손날부채벌레 (신칭)

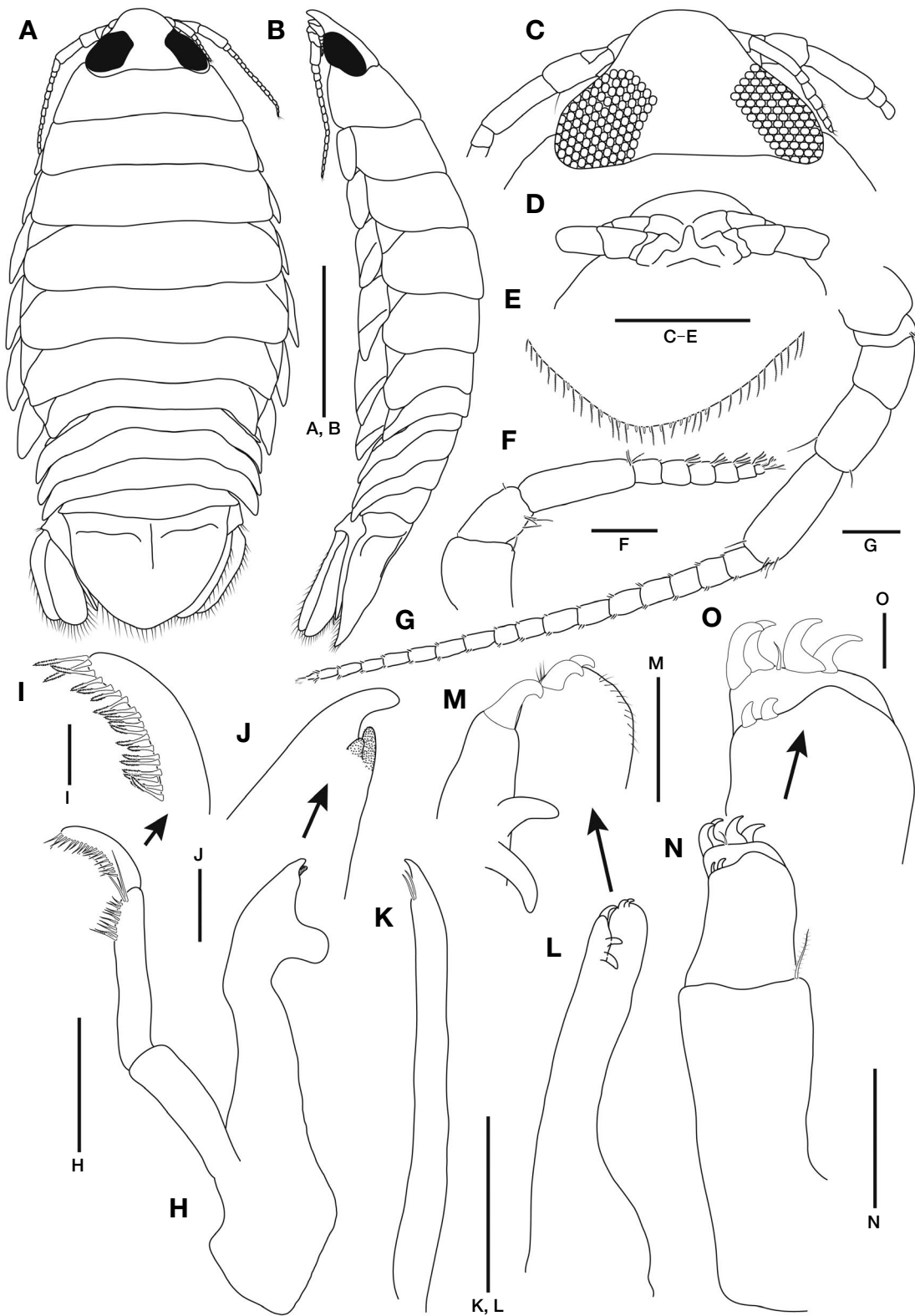


Fig. 1. *Rocinela niponia*, female. A, Habitus, dorsal view; B, Habitus, lateral view; C, Cephalon, dorsal view; D, Distal end of cephalon, ventral view; E, Distal end of pleotelson; F, Antennule; G, Antenna; H, Mandible; I, Last article of mandibular palp; J, Mandibular incisor; K, Maxillule; L, Maxilla; M, Distal end of maxilla; N, Maxilliped; O, Distal end of maxilliped. Scale bars: A, B=5 mm, C-E=2 mm, F-H, K, L, N=0.5 mm, I, J, M, O=0.1 mm.

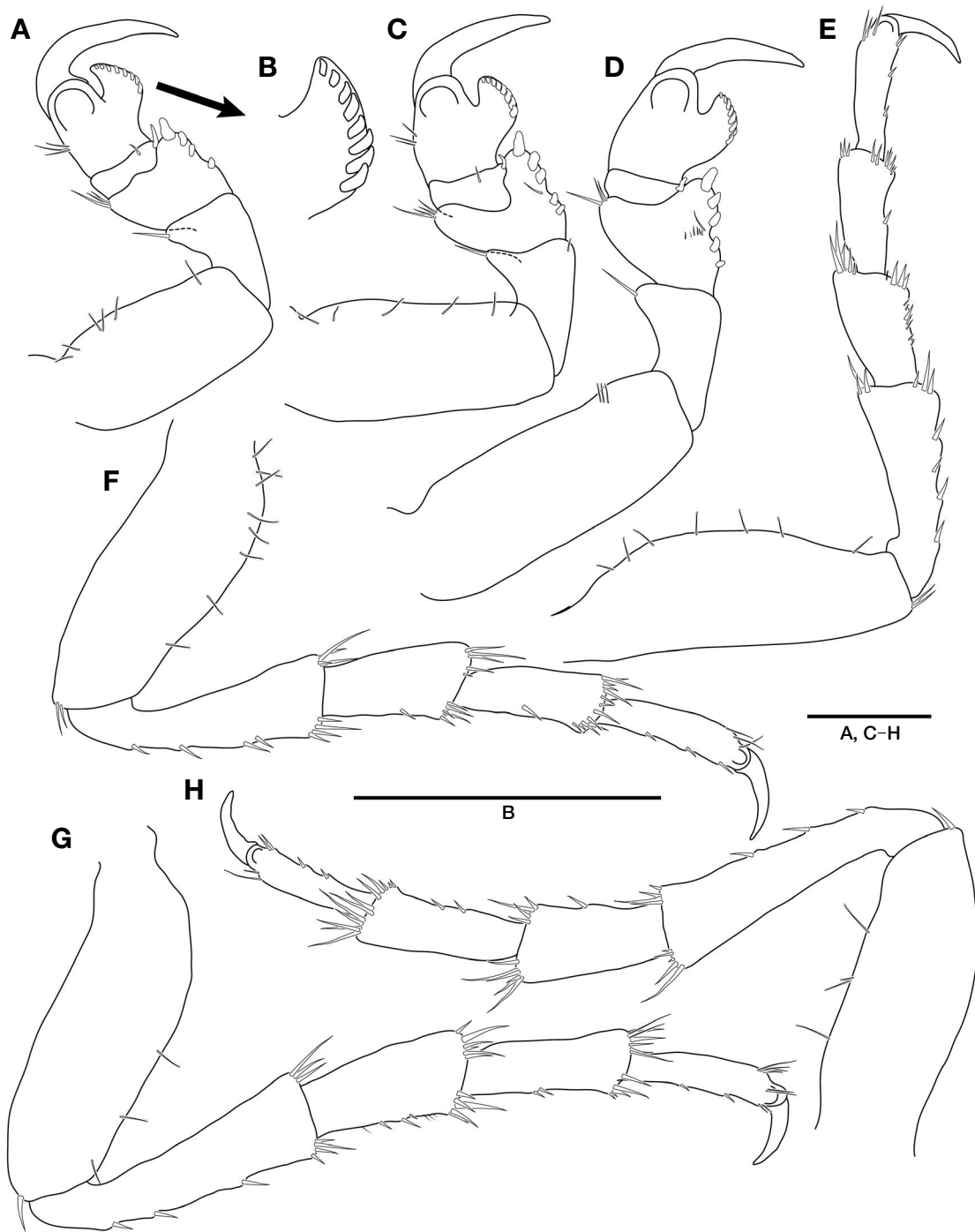


Fig. 2. *Rocinela niponia*, female. A, Pereopod 1; B, Propodal blade of pereopod 1; C, Pereopod 2; D, Pereopod 3; E, Pereopod 4; F, Pereopod 5; G, Pereopod 6; H, Pereopod 7. Scale bars: A-H=1 mm.

ger than carpus, with robust setae along with posterior margin and simple setae on distal end; dactylus 0.4 times as long as propodus, slightly curved.

Pleopods (Fig. 3A-E) sequentially larger; pleopods 2-4

with globular patterns along with lateral margin of exopod. Pleopod 1 (Fig. 3A), protopod with 6 coupling hooks and 4 plumose setae on inner margin and 3 simple setae on outer margin; rami with numerous plumose setae; exopod slightly

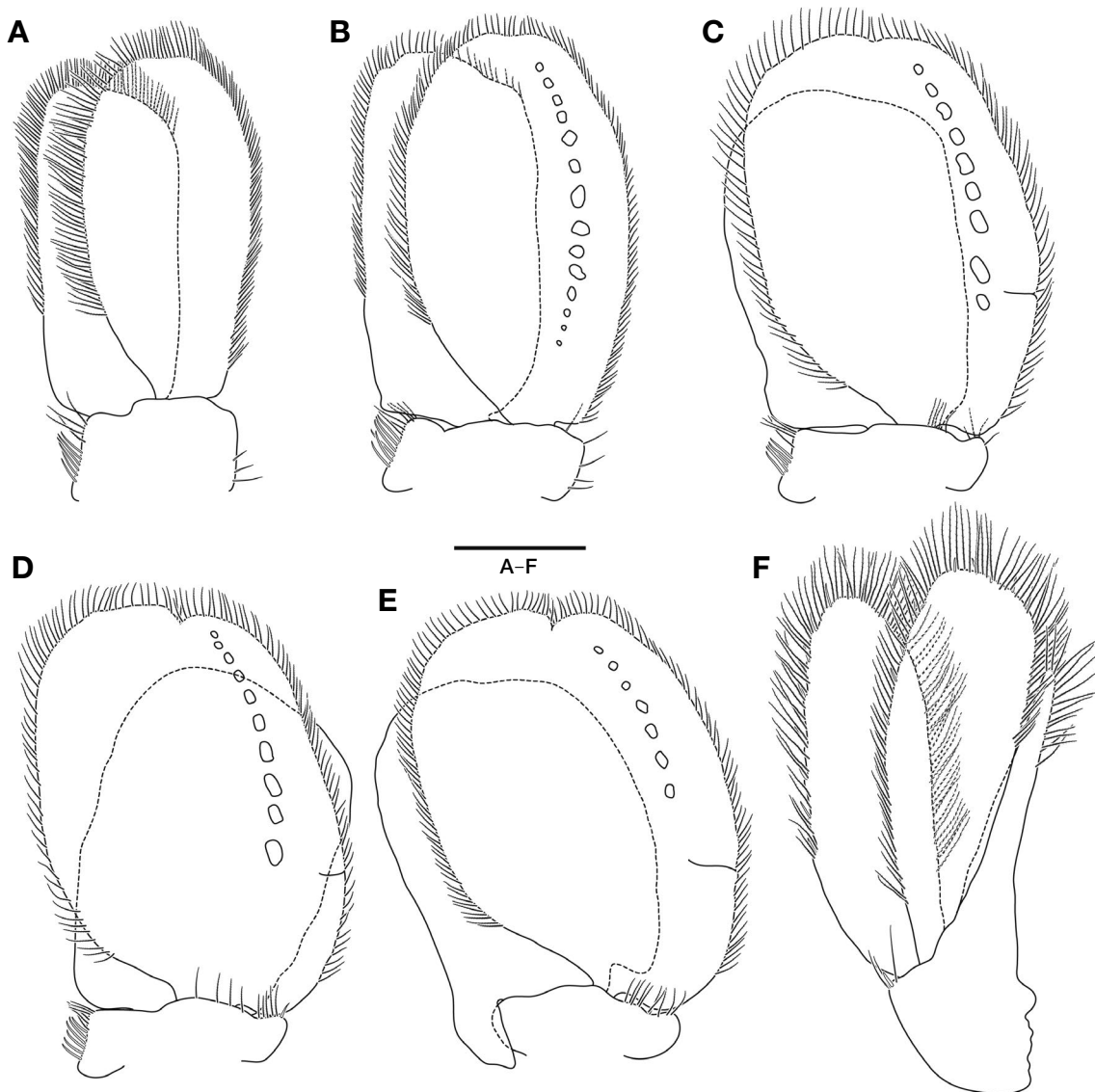


Fig. 3. *Rocinela niponia*, female. A, Pleopod 1; B, Pleopod 2; C, Pleopod 3; D, Pleopod 4; E, Pleopod 5; F, Uropod. Scale bar: A-F=1 mm.

wider than endopod. Pleopod 2 (Fig. 3B), protopod with 6 coupling hooks and 7 plumose setae on inner margin and 5 simple setae on outer margin; rami with plumose setae; exopod wider than endopod, with several patches along with outer margin; distal end of exopod slightly concave. Pleopods 3 and 4 (Fig. 3C, D), protopod with 5–6 coupling hooks and 4–6 plumose setae on inner margin, 8–9 plumose setae distal end, and 1 robust seta on outer margin; endopod without plumose setae, smaller than exopod; exopod with plumose setae; distal end concave; partial suture present on outer margin. Pleopod 5 (Fig. 3E) similar to pleopods 3 and 4, but endopod expanding beyond protopod and without coupling hooks and

plumose setae on inner margin.

Uropod (Fig. 3F), not exceeding distal end of pleotelson; protopod greatly extending on inner distal end, with numerous plumose setae on distal end and 3 simple setae and 1 robust seta on outer margin; rami elongated oval, with numerous plumose setae and robust setae; exopods slightly shorter than endopod.

Variation. The setation of the palm of pereopod 1 varies according to individuals. Among the specimens examined, one juvenile has six robust setae on the palm of pereopod 1 and others have seven (nine juvenile) or eight setae (two juvenile and one adult). There is no tendency that the number of ro-

bust setae is varied according to the size of individuals.

Remarks. Because *R. niponia* was originally described with only one specimen, it needs further study including redescription of the species with large materials (Richardson, 1909; Bruce, 2009). Although the Korean materials of *R. niponia* have a minor difference from the original description in having eight robust setae on the propodal blade in pereopod 1 (vs. ten in the latter), they are well corresponded with the original description in terms of the broadly round rostral point, the separated eyes, the length of antennae, the presence of the propodal blade, and the number of the robust setae in pereopods 2 and 3 (Richardson, 1909; Bruce, 2009). This difference of the setation between the Korean materials and the original description seems to be a variation according to the regional populations.

Within the genus *Rocinela*, only five species have the propodal blade as wide as palm and bearing more than eight robust setae: *Rocinela affinis* Richardson, 1904; *Rocinela niponia* Richardson, 1909; *Rocinela kapala* Bruce, 1988; *Rocinela oculata* Harger, 1883; and *Rocinela pakari* Bruce, 2009 (Bruce, 2009). Among them, *R. niponia* is rapidly distinguished from *R. affinis*, *R. kapala*, and *R. oculata* by having separated eyes (vs. united eyes in the latter species) (Bruce, 2009). *Rocinela niponia* is most similar to *R. pakari* in having the separated eyes and propodal blade as wide as the palm, but the former differs from the latter in terms of the number of robust setae on the propodal blade in pereopod 1 (8–10 in the former vs. 13 in the latter) (Richardson, 1909; Bruce, 2009).

Infraorder Epicaridea Latreille, 1825
Family Bopyridae Rafinesque, 1815
Subfamily Bopyrinae Rafinesque, 1815
Genus *Bopyrus* Latreille, 1802

¹****Bopyrus squillarum* Latreille, 1802 (Figs. 4, 5)**

Monoculus crangorum Fabricius, 1798: 306.

Bopyrus squillarum Latreille, 1802: 15, Pl. LIX, figs. 2–4; White, 1850: 82; Sars, 1899: 197, Pl. 84, fig. 1; Chopra, 1923: 519; Shiino, 1933: 283, fig. 13; Bourdon, 1968: 372, figs. 172–182.

Bopyrus fougerouxii Giard and Bonnier, 1890: 369; Bonnier, 1900: 358, Pl. XXXV, figs 1–9, Pl. XXXVI, figs. 1–15.

Bopyrus helleri Giard and Bonnier, 1890: 369; Bonnier, 1900: 362, Pl. XXXVII, figs. 5–7.

Bopyrus rathkei Giard and Bonnier, 1890: 369; Bonnier, 1900: 363.

Bopyrus xiphias Giard and Bonnier, 1890: 369, figs. 3, 4; Bonnier, 1900: 363, Pl. XXXVII, figs. 8–10.

Material examined. Korea: 1♂, 1♀ (infesting right branchial chamber of host), Jeju-do: Seogwipo-si, Seongsan-eup, Goseong-ri, 33°25'58"N, 126°55'56"E, 18 Jun 2019; 4♂♂, 1 immature ♂, 5♀♀ (infesting right or left branchial chamber of host), same location as previous, 13 Aug 2019, NIBRIV0000876684; 1♂, 1♀ (infesting right branchial chamber of host), Jeollanam-do: Jindo-gun, Uisin-myeon, Geumgap-ri, 34°23'44.4"N, 126°16'32"E, 22 Jul 2020.

Description of female. Body (Figs. 4D–G, 5A, B) oval, smooth, dorsoventrally compressed, asymmetrical, distorted about 35°, narrowing posteriorly; length 6.6 mm; maximal width 4.7 mm. Head (Fig. 5A) partially fused with pereonite 1, but distinctly separated on posterior margin; eye lacking; obscure patterns of minute dots irregularly distributed around eye region; anterior margin curved upwardly. Maxilliped (Fig. 5B, C) trapezoid; palp non-articulated, with several simple setae distally. Barbula (Fig. 5C) with 2 pairs of projections on each maxilliped; projections curved inwardly.

Pereonites (Fig. 5A) not fused with each other, distinct; pereonite 3 widest; pereonites 1–4 with dorsolateral bosses and coxal plates. Oostegites (Figs. 4F, G, 5B, D, E) widely opened, surrounding ventral side of pereonites; oostegite 1 symmetrical, 2-articulated; internal ridge with simple projections; posterolateral point directed posteriorly, slightly curved inwardly, with fine setae on inner margin; apex rounded.

Pereopods (Fig. 5E–G) hardly visible on dorsal side, smaller anteriorly; basis larger than other articles, stout, serrated on superior margin; merus and carpus with serrated inferior margin; carpus with simple setae on inferior distal angle; propodus ovate, slightly serrated inferodistally; dactylus blunt and curved.

Pleon (Fig. 5B) curved upwardly on long side; all pleomeres dorsally fused with each other; segments indicated by laterally; first pleonite on short side much smaller than other segments; lateral indentation of short side of pleonite 1 distinct whereas other lateral indentations indistinct; lateral plates provided with longitudinal ridge on ventral side, indistinct on short side; pleotelson with rounded apex. Pleopods (Fig. 5B) 5 pairs, uniramous, triangular, reduced posteriorly in size.

Uropod lacking.

Description of male. Body (Fig. 5I, J) symmetrical, smooth, convex; length 1.1 mm. Head (Fig. 5I) semicircular, with eye dorsolaterally, separated from pereonite 1.

Antennule (Fig. 5K) consisting of 2 articles; second article with several simple setae distally. Antenna (Fig. 5L) composed of 2 articles; second article with several simple setae on distal end.

Pereonites (Fig. 5I, J) subequal in length, rectangular, wider than long; pereonites 6 and 7 slightly narrower than other

Korean name: ¹*줄새우아재비아감벌레 (신칭)

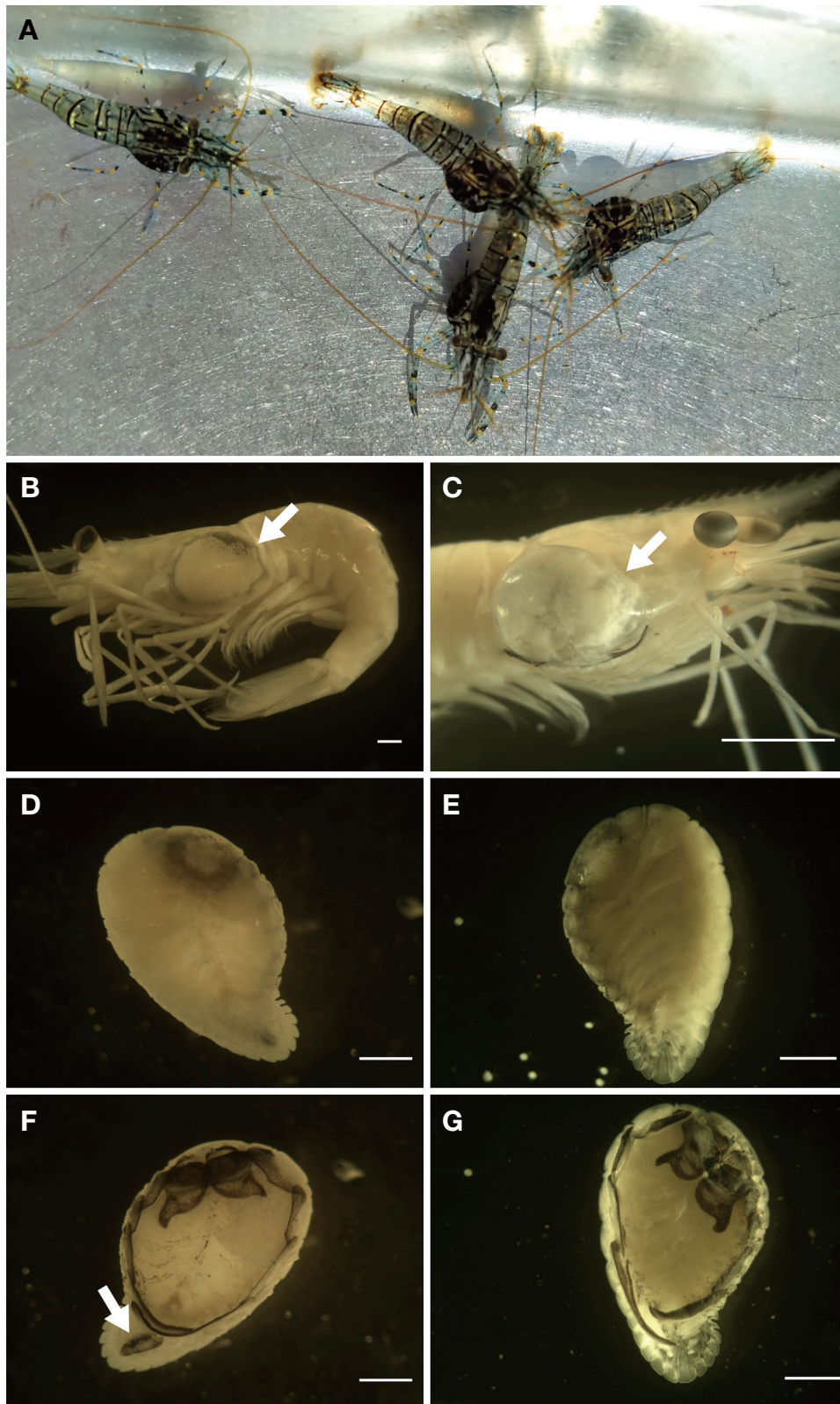


Fig. 4. Photographs of host and *Bopyrus squillarum*. A-C, Host of *Bopyrus squillarum* from live (A) and microphotograph (B, C), arrows point to left (B) and right (C) bulged brachial chambers, respectively; D-G, *Bopyrus squillarum* attached to left (D, F) and right (E, G) brachial chamber of host, respectively, arrow indicates male. Scale bars: B-G = 1 mm.

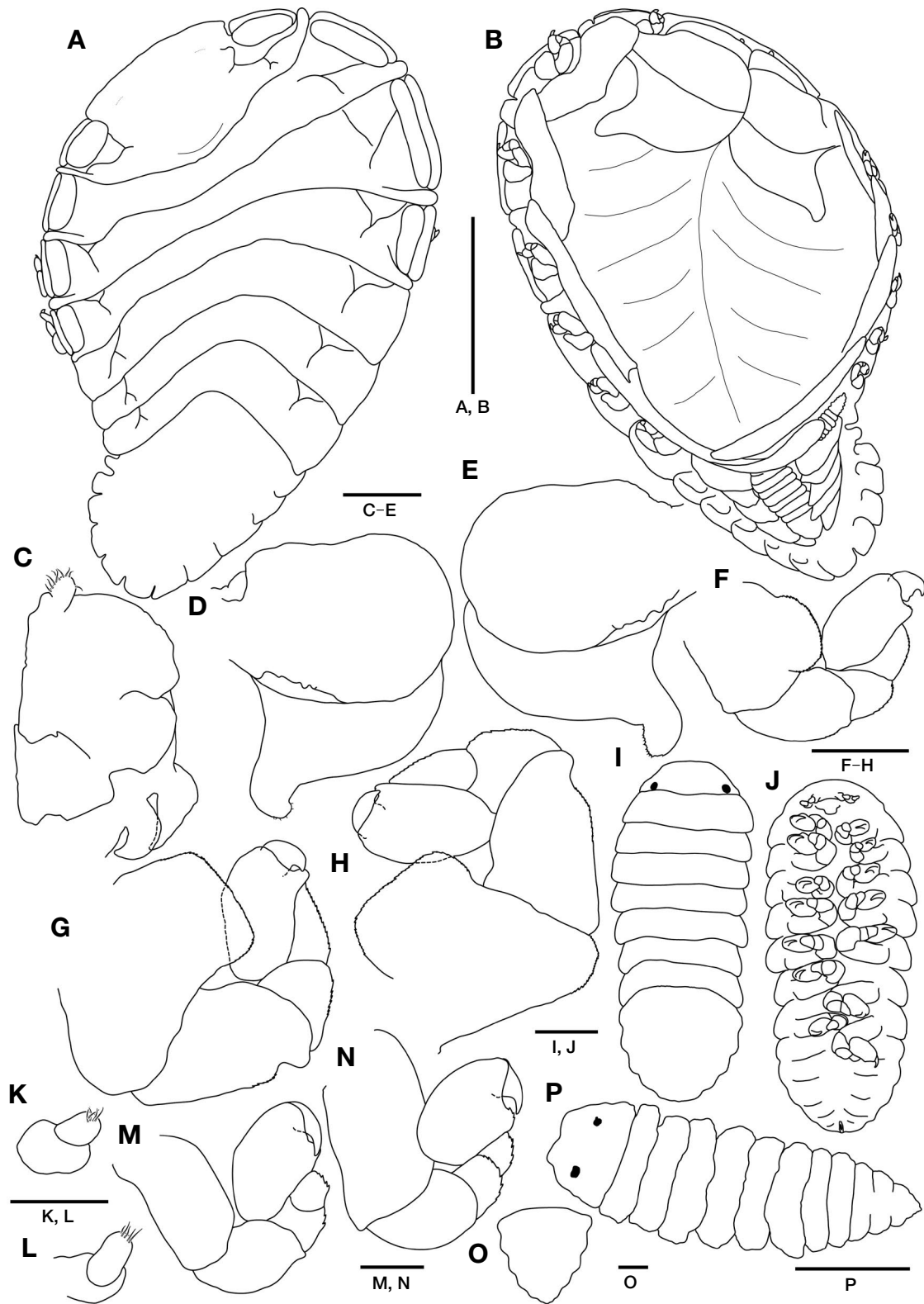


Fig. 5. *Bopyrus squillarum*, female (A-H) and male (I-P). A, Habitus, dorsal view; B, Habitus, ventral view; C, Maxilliped and bar-bular; D, Left oostegite 1; E, Right oostegite 1; F, Pereopod 1; G, Pereopod 6; H, Pereopod 7; I, Habitus, dorsal view; J, Habitus, ventral view; K, Antennule, L, Antenna; M, Pereopod 1; N, Pereopod 7; O, Variation of pleon in male; P, Immature male. Scale bars: A, B=2 mm, C-E=0.5 mm, F-J, P=0.2 mm, O=0.1 mm, K-N=0.5 mm.

pereonites. Pereopods (Fig. 5M, N), basis elongated oval; merus and carpus serrated on inferior margin; propodus produced and serrated on inferior distal angle; dactylus strongly curved.

Pleon (Fig. 5I, J, O) fused into single segment; segments indicated by lateral indentations, tapering posteriorly. Pleopods (Fig. 5J) 5 pairs, uniramous, ovate, obscure.

Uropod absent.

Variation. Although the head is defined dorsally by the posterior margin, its range is different from each other in Korean specimens. The minute dots that form obscure and irregular patterns on the anterior region of head are much variable in the size and number according to specimens. These patterns could be confused with eyes because they are usually replaced eyes at their region. The apex of pleotelson of the female is either rounded or sinuous as previously noticed by Bourdon (1968).

Remarks. The erroneous hypothesis that one epicarid infests only on one host species had made a complex history of discussion on *B. squillarum* (Sars, 1899; Chopra, 1923).

Sars (1899) early opposed this hypothesis and synonymized many species under the old name of *B. squillarum* (Chopra, 1923). After to this, several *Palaemon* species including *Palaemon serratus* (Pennant, 1777), *Palaemon elegans* Rathke, 1837, *Palaemon adspersus* Rathke, 1837, *Palaemon xiphias* Risso, 1816, *Palaemon serrifer* (Stimpson, 1860), and *Palaemon pacificus* (Stimpson, 1860) have been known as the hosts of *B. squillarum* (Sars, 1899; Chopra, 1923; Shiino, 1933; Bourdon, 1968). All the materials of this study were collected from *P. serrifer*. They are generally well agreed with the previous reports of the species by the following characteristics combined: (1) the eye is lacking; (2) the barbula consists of two pairs of projections on each maxilliped; (3) oostegite 1 has a posterolateral point; (4) the dorsolateral bosses and coxal plates are present on pereonites 1–4; (5) the first pleonite on the short side is much smaller than other segments; and (6) the pleon is fused into a single segment and sinuous laterally in male (Giard and Bonnier, 1890; Sars, 1899; Bonnier, 1900; Chopra, 1923; Shiino, 1933; Bourdon, 1968).

ORCID

Sung Hoon Kim: <https://orcid.org/0000-0001-7271-7308>

Seong Myeong Yoon: <https://orcid.org/0000-0002-3246-3021>

CONFLICTS OF INTEREST

Seong Myeong Yoon, a contributing editor of the Animal

Systematics, Evolution and Diversity, was not involved in the editorial evaluation or decision to publish this article. All remaining authors have declared no conflicts of interest.

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