Journal of Species Research 5(1):49-156, 2016

Fourteen new species of *Allobathynella* Morimoto and Miura, 1957 from South Korea: with a redescription of *A. coreana* Morimoto, 1970 (Crustacea, Bathynellacea, Parabathynellidae)

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Fourteen new species and *A. coreana* Morimoto, 1970 of *Allobathynella* Morimoto and Miura, 1957 are (re-)described and illustrated from the Korean Penninsula. Comparison of the external morphology of these species and two previously known species, *A. japonica* Morimoto and Miura, 1957 and *A. shinjongieei* Park and Cho, 2008 enables us to amend the generic diagnosis. A 7-segmented antennule turns out to be inconsistent character due to *A. wonjuensis* sp. nov., which has a 6-segmented antennule. On the other hand, the exopodal distal segment of thoracopods I-VII with a tiny terminal knob and with outer seta covered by long and strong barbs is proved to be a autapomorphic character of the genus. The 14 new species belong to the *mirabilis*-group and display more or less similar morphology. However, they differ from *A. coreana*, *A. japonica* and *A. shinjongieei* and from each other not only in quantitative but also in qualitative characters. These differences are summarized in tables. The species inhabit hyporheic zones of rivers and each appears to be highly endemic to a given tributary, having a range limit less than 100 km.

Keywords: hyporheic zone, *mirabilis*-group, short range endemic

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DOI:10.12651/JSR.2016.5.1.049

Introduction

Recently, Korea has been proven to habor a diverse parabathynellids fauna, comprising five valid genera: *Allobathynella* Morimoto and Miura, 1957; *Eobathynella* Birstein and Ljovuschkin, 1964; *Nipponbathynella* Schminke, 1973; *Arisubathynella* Park and Eun, 2012; *Hangangbathynella* Park and Cho, 2013. In relation to the surface area of Korea (100,000 km^2), the number of genera is relative high, especially in comparison to only four genera described from Western Australia, an area of over 2,500,000 km^2, where this fauna has been well studied (Humphreys, 2008). As for the number of species within individual genera, however, the Korean parabathynellid-fauna is rather poorly known. Up to date, only following 13 species have been reported: *Allobathynella coreana* Morimoto, 1970, *A. shinjongieei* Park and Cho, 2008, *Eobathynella matuta* Morimoto, 1970, *E. yeojuensis* Schminke, 2011, *Nipponbathynella pectina* Cho *et al*., 2008, *N. leesookyungae* Park and Cho, 2015, *N. donggangensis* Park and Cho, 2015, *N. wanjuensis* Park and Cho, 2015, *Arisubathynella cheongmiensis* Park and Eun, 2012, *A. imjinensis* Park and Cho, 2015, *A. hongcheonensis* Park and Cho, 2015, *Hangangbathynella taechooni* Park and Cho, 2013 and *Hangangbathynella eunokae* Park and Cho, 2013.

As a part of the project ''Survey of Korean Indigenous Species'' conducted by the National Institute of Biological Resources (Korea), which stated in 2009, we surveyed the Korean stygofauna, sampling more than 100 sites along the large rivers (the Han, the Geum, the Nakdong and the Imjin) and their tributaries. This effort resulted in a discovery of more than 50 species of Parabathynellidae, 14 of which are identified as independent lineages of *Allobathynella*, all described in this paper.

Materials and Methods

The material of the new species was collected using the Karaman-Chappuis method by digging a hole to the groundwater level. After sorting, all specimens were

transferred into 70% alcohol for fixation and later into a mixture of glycerin-formalin (glycerin: 5% formalin = 19 : 1), which was used for dissection and as a mounting medium. Dissected animals were studied under Nikon Eclipse 80i-Microscope with differential interference contrast equipment, and drawings were made with the camera lucida attached to the same microscope. The material is deposited in the collection of the National Institute of Biological Resources, Korea.

SYSTEMATICS

Family PARABATHYNELLIDAE Noodt, 1964

Allobathynella Morimoto and Miura, 1957

Revised diagnosis

Parabathynellidae. Body elongated and cylindrical. Antennule 7- (or 6-) segmented. Antenna 7-segmented with the 1st and 2nd segments lacking seta. Labrum flat, free margin dentate. Mandible with incisor process of four and more teeth; proximal tooth absent; molar process with eight and more spines; palp with one or two apical seta(e). Maxillule 2-segmented; proximal segment with four setae, distal segment with six and more spines. Thoracopods I-II usually without epipod; thoracopods I-VII with multi-segmented exopod; distal segment with one tiny terminal knob and with outer seta covered by long and strong barbs. Right and left female thoracopods VIII present as a tiny process with distal spines. Male thoracopod VIII, bell-formed, perpendicular to body, epipod flat and round, terminal part barely reaching bottom of exopod; basipod drawn into spur, with a small basipodal seta. Pleopod in form of stalk-like process having two setae. Uropod with eight and more spines of similar size on sympod; endopod with two distal spines and additional spines on inner margin, dorsally with two basal plumose setae and one subterminal plumose seta and with two setae on outer distal margin; exopod with six and more setae including one basi-ventral seta. Pleotelson without setae. Anal operculum slightly convex to protruding. Furcal rami with six and more spines.

Allobathynella coreana Morimoto, 1970 (Fig. 1-6)

Material examined

One adult male dissected on seven slides (NIBRIV 0000266821), one adult male dissected on six slides (NIBR IV0000266823), two adult female dissected on six slides (NIBR IV0000266822, 0000266824), eight adult males (NIBR IV0000266825-0000266832) and four adult females (NIBR IV0000266833-0000266836) each as total specimen on a slide and five adult males as total specimen in a vial (NIBRIV 0000266837). All specimen from South-Korea, Gangwon-Do, Yeongwol-Gun Yeongwol-Eup Bangjeol-Ri (37°10′30.1″N, 128°26′27.2″E), 27. October 2012, leg. J.-L. Cho.

Description

Size (mm). Body length: ♂ 2.01 (average of other males: 2.00, n = 9), ♀ 2.00, approximately 11 times as long as wide. Head slightly shorter than anterior three thoracic segments combined (Fig. 1A). Female differs from male in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 1B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin, respectively. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and two dorsal setae and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta and medially with one simple seta on inner margin. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 1C) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 1D) flat, with eight main teeth flanked by three teeth on both lateral sides. Ventral surface concave, with one tiny round median projections bearing three distal spinules beneath free margin, three pairs of teat and numerous combs of ctenidia.

Mandible (Fig. 1E) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of nine spines. Palp of one segment, 2.5 times as long as wide, with one apical seta being basally barbed.

Maxillule (Fig. 2A) two-segmented. Proximal segment with four setae on inner distal margin and with setules. Distal segment with two terminal smooth spines and six dentate spines on inner edge, and with three simple setae on outer distal margin.

Maxilla (Fig. 2B) four-segmented, setal formula 3-5-12-6.

Thoracopods I-VII (Figs. 2C-E, 3A, B, 4A, 5A, B). Thoracopod I-IV increasing in size posteriorly. Thora-

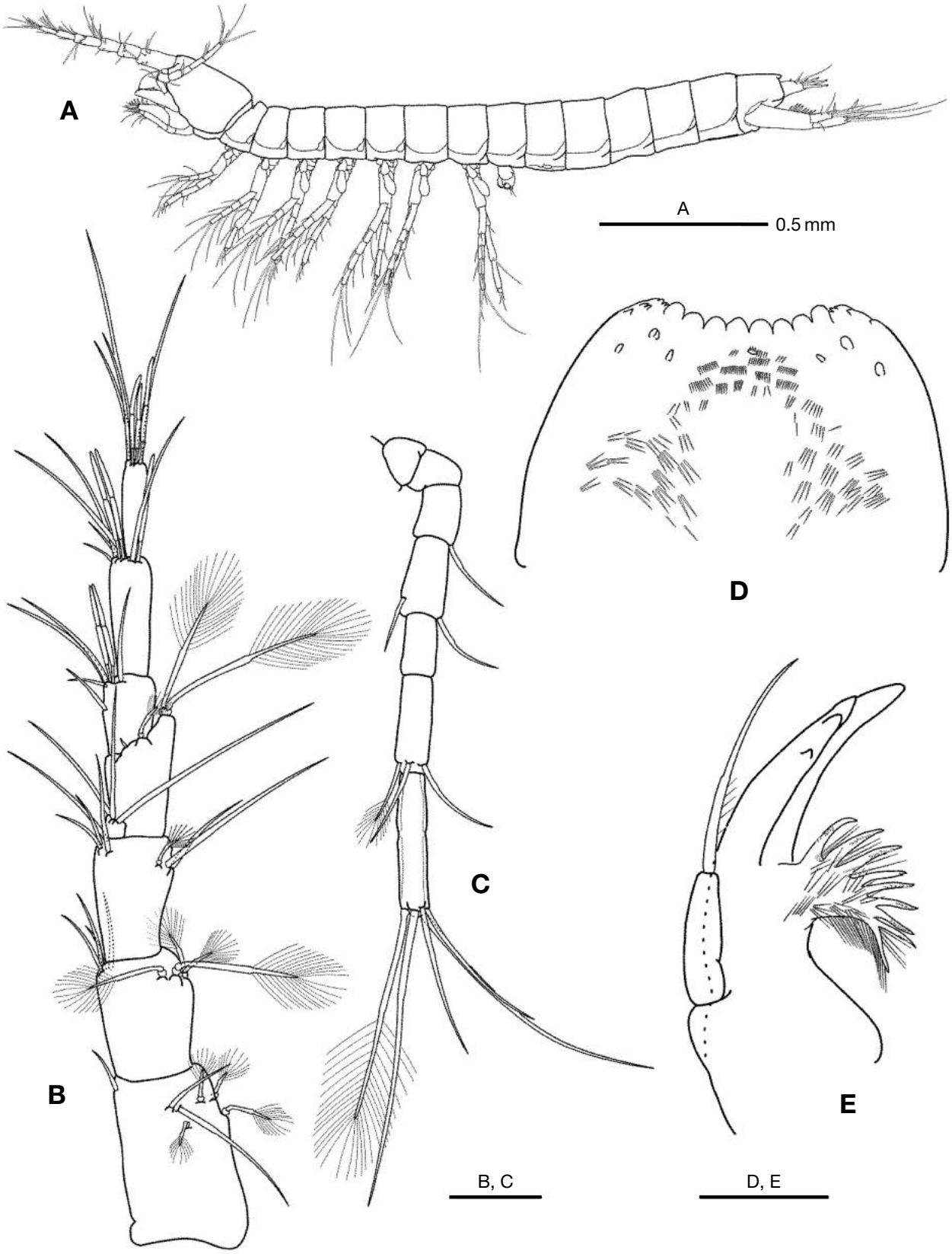


Fig. 1. *Allobathynella coreana* Morimoto, 1970. (A) General habitus ♂ (lateral); (B) Antennule ♂ (dorsal); (C) Antenna ♂ (dorsal); (D) Labrum ♂ (ventral); (E) mandible ♂ (ventral). Scale bars = 0.05 mm, unless specified.



Fig. 2. *Allobathynella coreana* Morimoto, 1970. (A) maxillule ♂ (ventral); (B) maxilla ♂ (dorsal); (C) Thoracopod I ♂ (frontal); (D) Thoracopod II ♂ (frontal); (E) Thoracopod III ♂ (frontal). Scale bars = 0.05 mm.

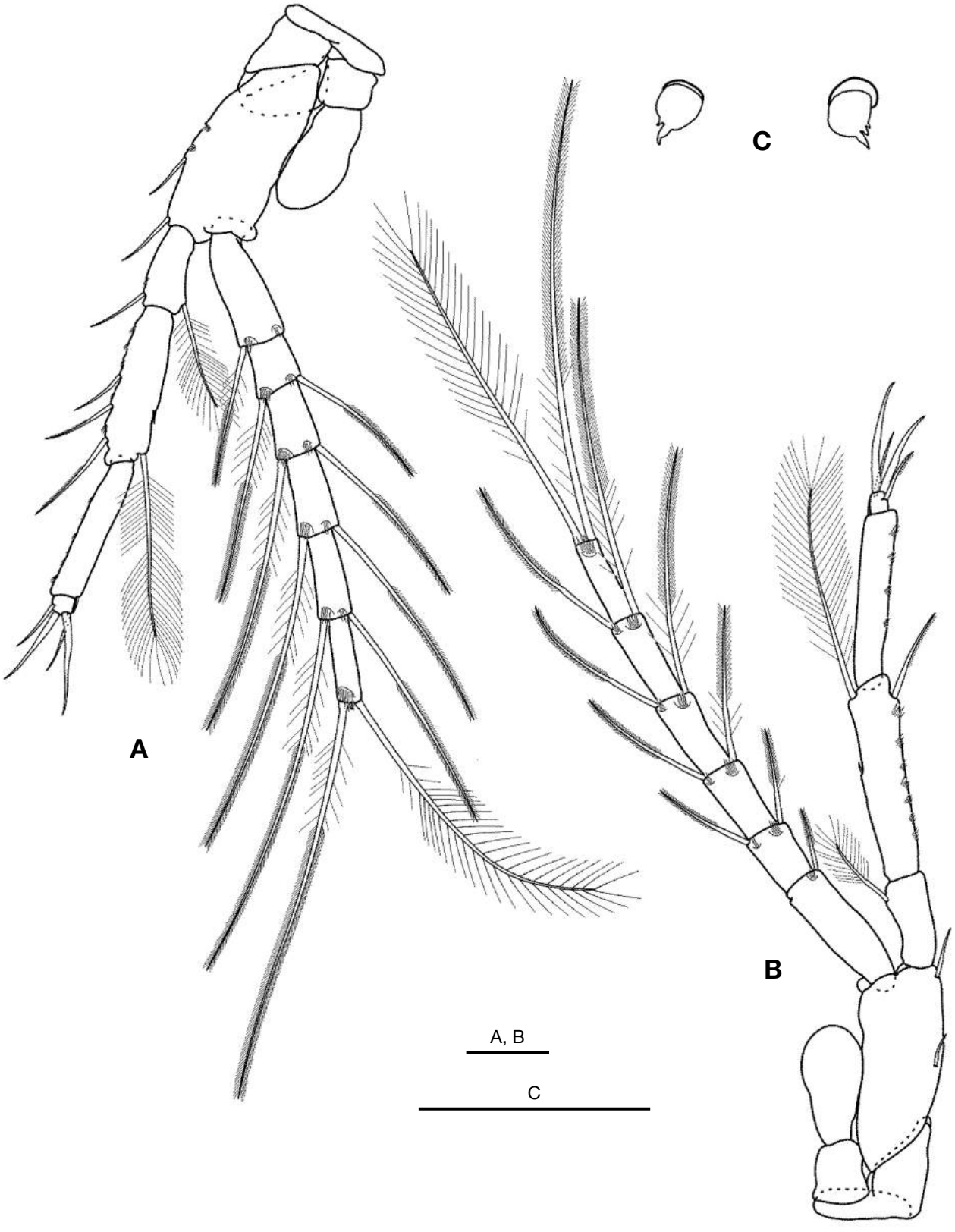


Fig. 3. *Allobathynella coreana* Morimoto, 1970. (A) Thoracopod IV ♂ (frontal); (B) Thoracopod VII ♂ (frontal); (C) Thoracopod VIII ♀ (ventral). Scale bars = 0.05 mm.

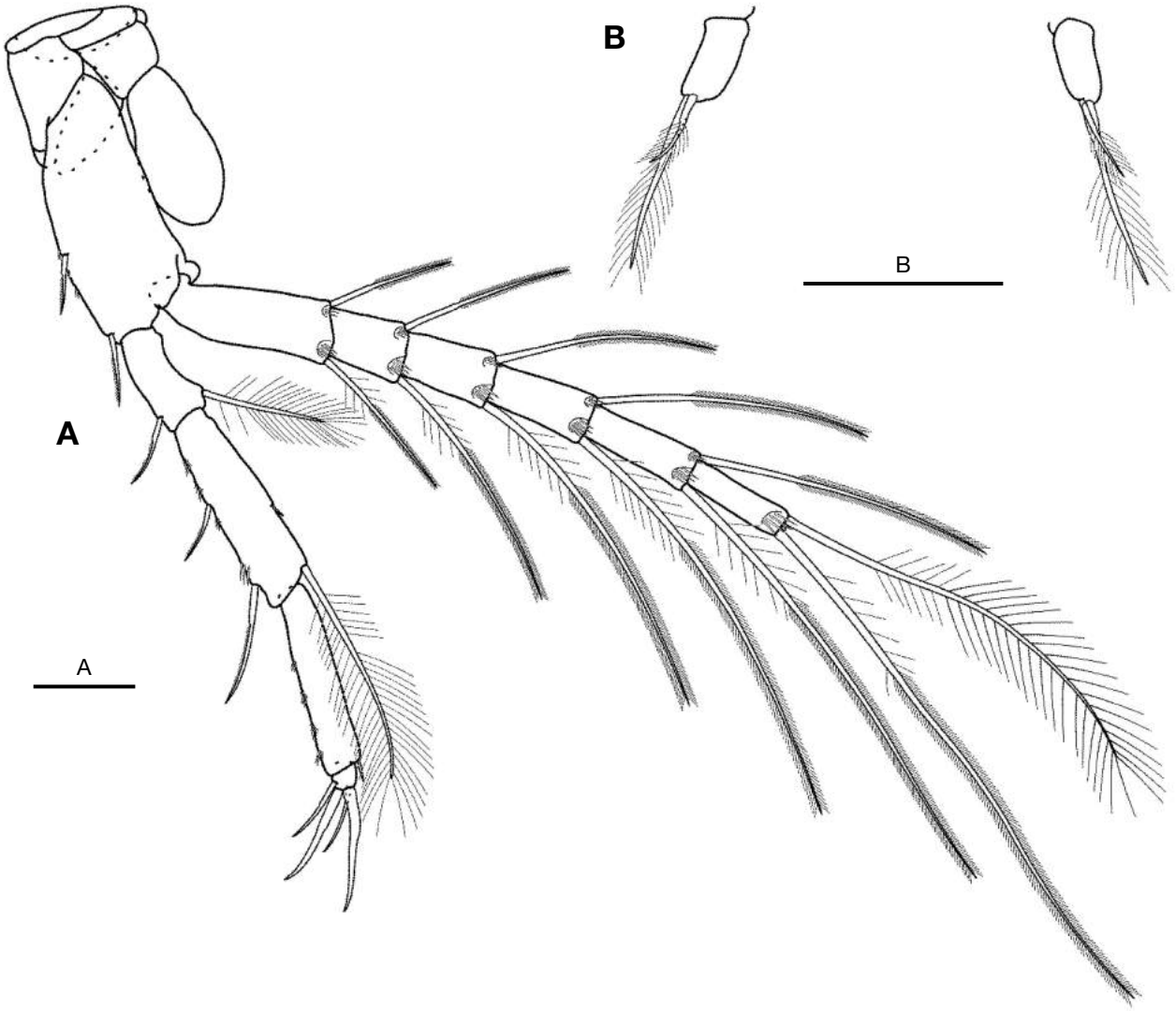


Fig. 4. *Allobathynella coreana* Morimoto, 1970. (A) Thoracopod V ♂ (frontal); (B) Pleopod ♂ (ventral). Scale bars = 0.05 mm.

copods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II and III, and with each one distal and median seta in thoracopods IV-VII. Number of segments of exopod of thoracopods I-VII: 3-4-5-6-6-6-6. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods IV, VI and VII. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/2 + 1/4(2)
Thoracopod II	2 + 1/4 + 2/0 + 1/4(2)
Thoracopods III, IV	1 + 1/3 + 2/0 + 1/4(2)
Thoracopods V, VI	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod VII	0 + 1/1 + 2/0 + 1/4(2)

Thoracopod VIII of male (Fig. 5C, D) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with six or seven teeth. Epipod flat, with flat round distal part not reaching lower margin of exopod. Basipod with one seta near base of endopod, inner margin of basipod with a row of denticles, distally drawn out into round projection, basipodal seta as long as endopod. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe with tiny denticles. Endopod small, round, with two distal setae of different size. Outer seta three times longer than inner one. Thoracopod VIII (Fig. 3C) of female tiny, round in ventral view, with two or three sharp distal projections.

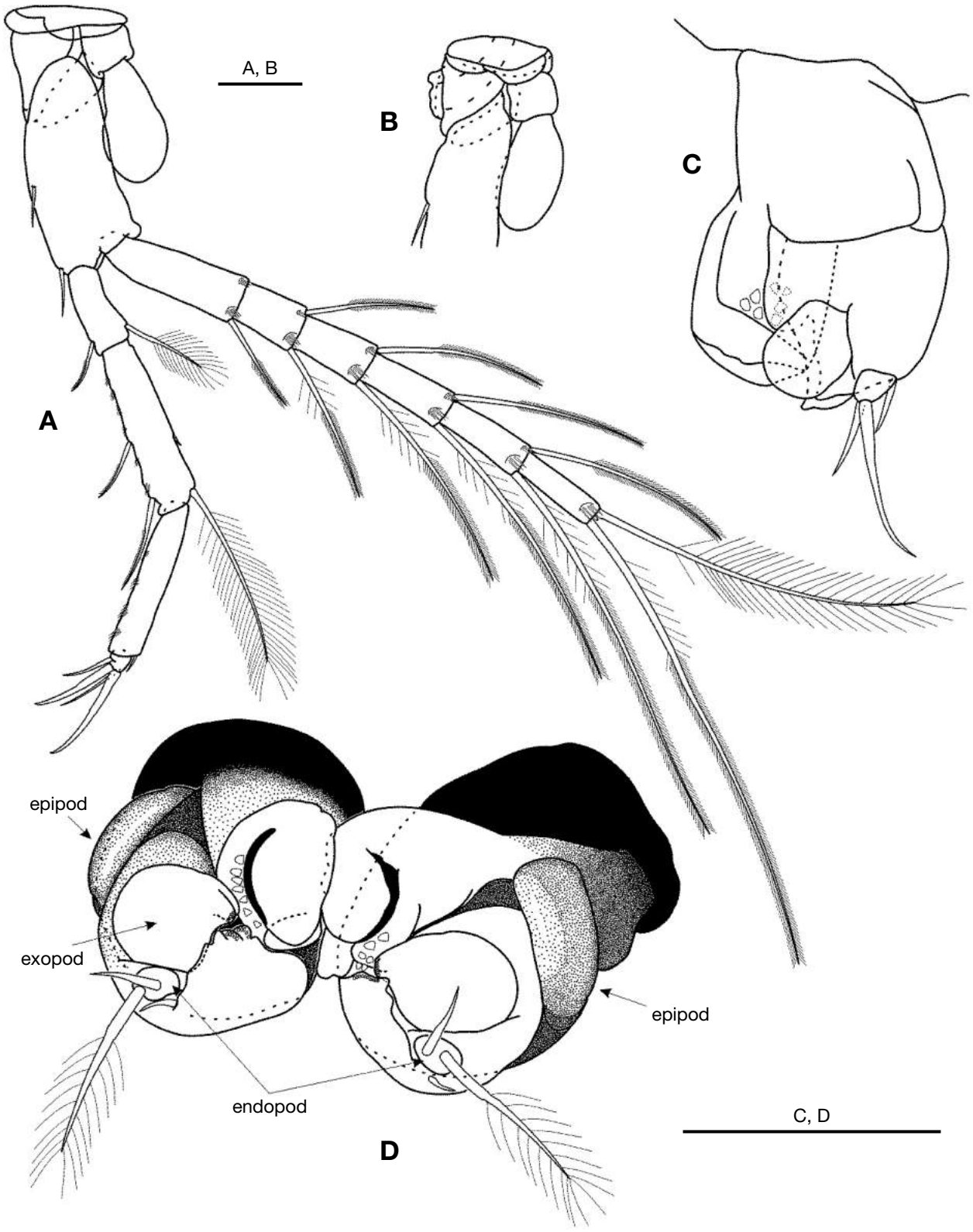


Fig. 5. *Allobathynella coreana* Morimoto, 1970. (A) Thoracopod VI ♂ (frontal); (B) Protopod of thoracopod VI ♀; (C) Thoracopod VIII ♂ (lateral); (D) Thoracopod VIII ♂ (ventral, slightly lateral). Scale bars = 0.05 mm.

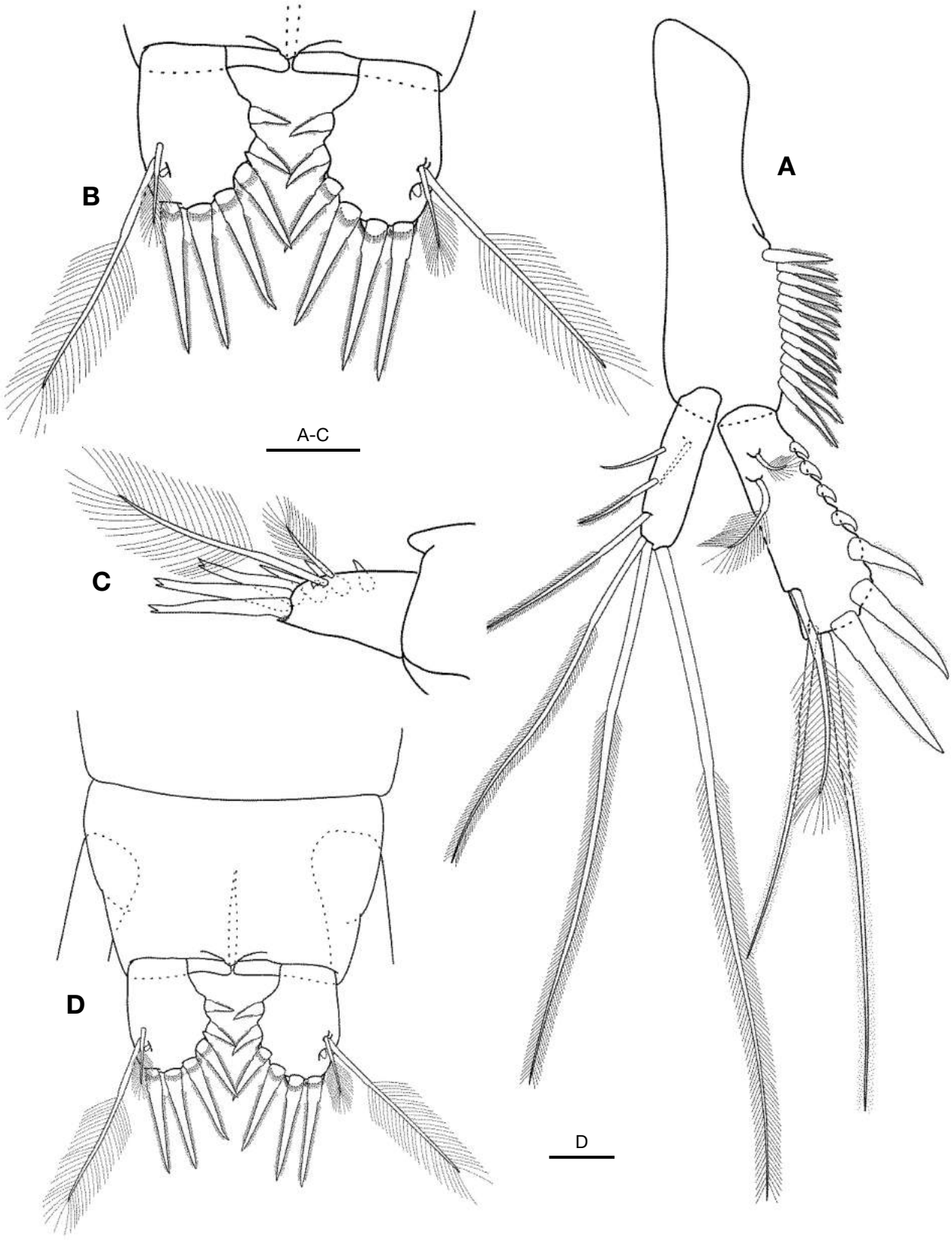


Fig. 6. *Allobathynella coreana* Morimoto, 1970. (A) Uropod ♂ (dorsal); (B) Furcal rami ♂ (dorsal); (C) Furcal ramus ♂ (lateral); (D) Pleotelson ♂ (dorsal). Scale bars = 0.05 mm.

First pleopod (Fig. 4B) in form of stub bearing two distal setae.

Uropod (Fig. 6A) bearing 12 spines on inner margin of sympod, two most distal spines somewhat longer than others of similar length. Endopod 60% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and five additional spines along inner margin. Subterminal spine slightly shorter than terminal spine, Most distal spine of inner-margin two thirds as large as terminal spine and 2.5 times larger than proximal ones of similar size. Exopod remarkably shorter than endopod (40% of sympod), with six setae including one basi-ventral seta.

Pleotelson (Fig. 6B-D) without seta. Anal operculum protruded slightly with sharp tip.

Furcal rami (Fig. 6B-D) 1.2 times as long as wide, with two large distal spines, and four successively smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella imjinensis* sp. nov.** (Figs. 7-12)

Etymology

The species name is derived from the river (Imjin), where the material was collected.

Material examined

Holotype (adult male), allotype (adult female), paratypes (five adult males and ten adult females). Holotype: dissected on seven slides (NIBR IV0000266795). Allotype: dissected on six slides (NIBR IV0000266796). Paratype: one adult male dissected on seven slides (NIBR IV0000266797), two adult females each dissected on six slides (NIBR IV0000266798, 000266799), four adult males (NIBR IV0000266800-0000266803) and eight adult females each as a total specimen on separate slides (NIBR IV0000266804-0000266811).

Type locality

South-Korea, Geonggi-Do, Yeoncheon-Gun Baekhak-Myeon Nogok-Ri (37°59′03.2″N, 126°55′45.9″E), 07. March 2009, leg. J.-L. Cho.

Description

Size (mm). Body length: ♂ 1.75 (other males: 1.74, 1.73, 1.73, 1.72), ♀ 1.75, approximately 10 times as long as wide. Head slightly shorter than anterior three thoracic segments combined. Female differs from male in protopod of thoracopod VI, basipod of thoracopod VII and thoracopod VIII.

Antennule (Fig. 7A) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin, respectively. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and two dorsal setae and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta and medially with one simple seta on inner margin. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 7B) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 1/1 + 1/0 + 0/1 + 1 + 1/5(1). Outer seta of third segment tiny.

Labrum (Fig. 7C) flat, with eight main teeth flanked by three teeth on both lateral sides. Ventral surface concave, with one tiny round median projections without spinules beneath free margin, three pairs of teat and numerous combs of ctenidia.

Mandible (Fig. 7D) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of eight spines. Palp of one segment, 2.5 times as long as wide, with two apical setae of different size.

Maxillule (Fig. 8A) two-segmented. Proximal segment with four setae on inner distal margin and with one setule. Distal segment with two terminal smooth spines and five dentate spines on inner edge, and with three simple setae on outer distal margin. Terminal spine two times larger than other ones.

Maxilla (Fig. 8B) four-segmented, setal formula 3-4-10-6.

Thoracopods I-VII (Figs. 8C-E, 9A, B, 10A, B, 11A, B). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-VI, and with each one distal and median seta in thoracopod VII. In female, basipod with each one distal and median seta in thoracopod VI, and with one distal seta and two median setae in thoracopod VII. Number of segments of exopod of thoracopods I-VII: 3-4-5-5-5-5-5. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods II-VII and second segment lacking dorsal seta in thoracopods VI and VII of female. Tiny process

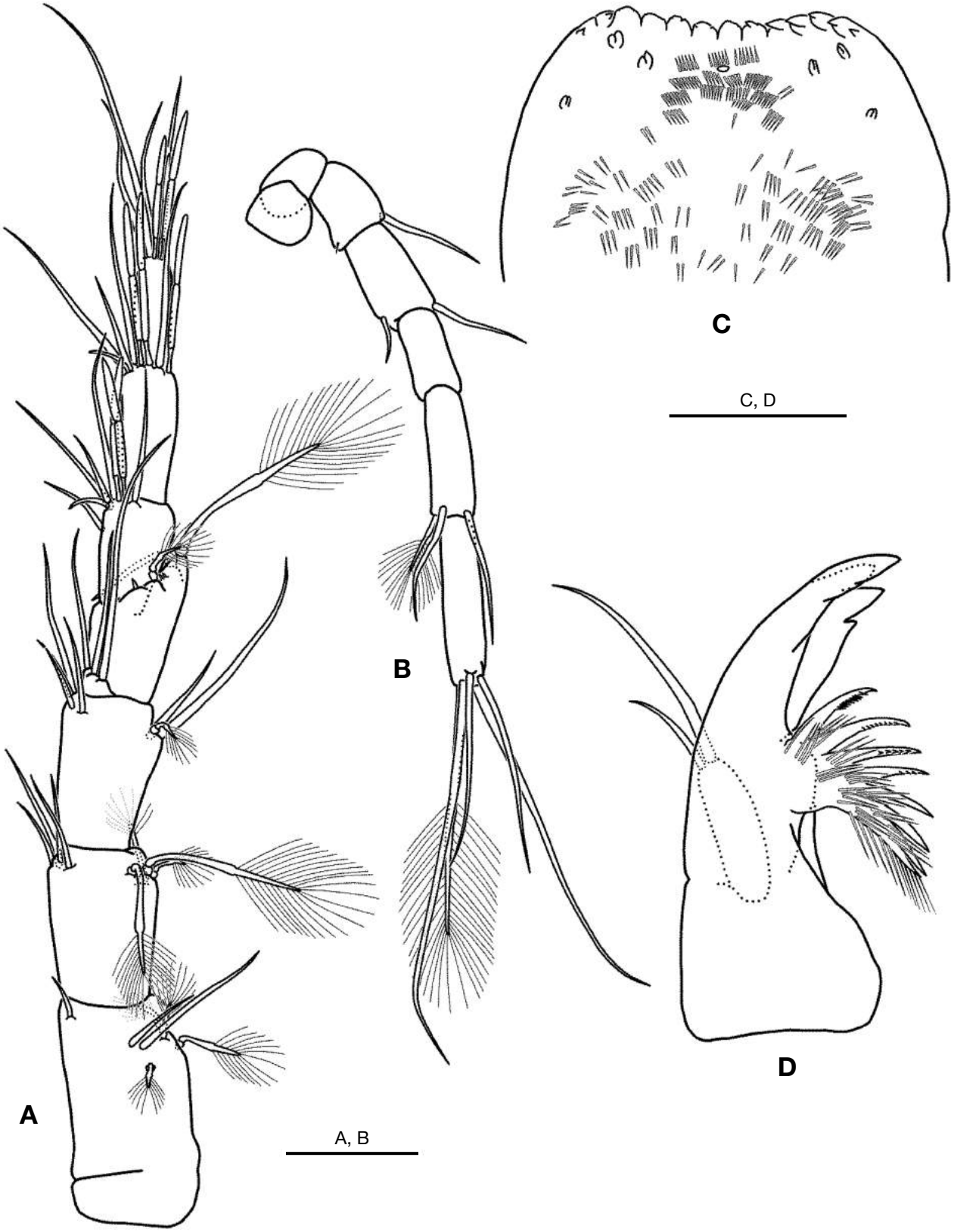


Fig. 7. *Allobathynella imjinensis* (holotype: ♂). (A) Antennule (dorsal); (B) Antenna (dorsal); (C) Labrum (ventral); (D) Mandible (dorsal). Scale bars = 0.05 mm.

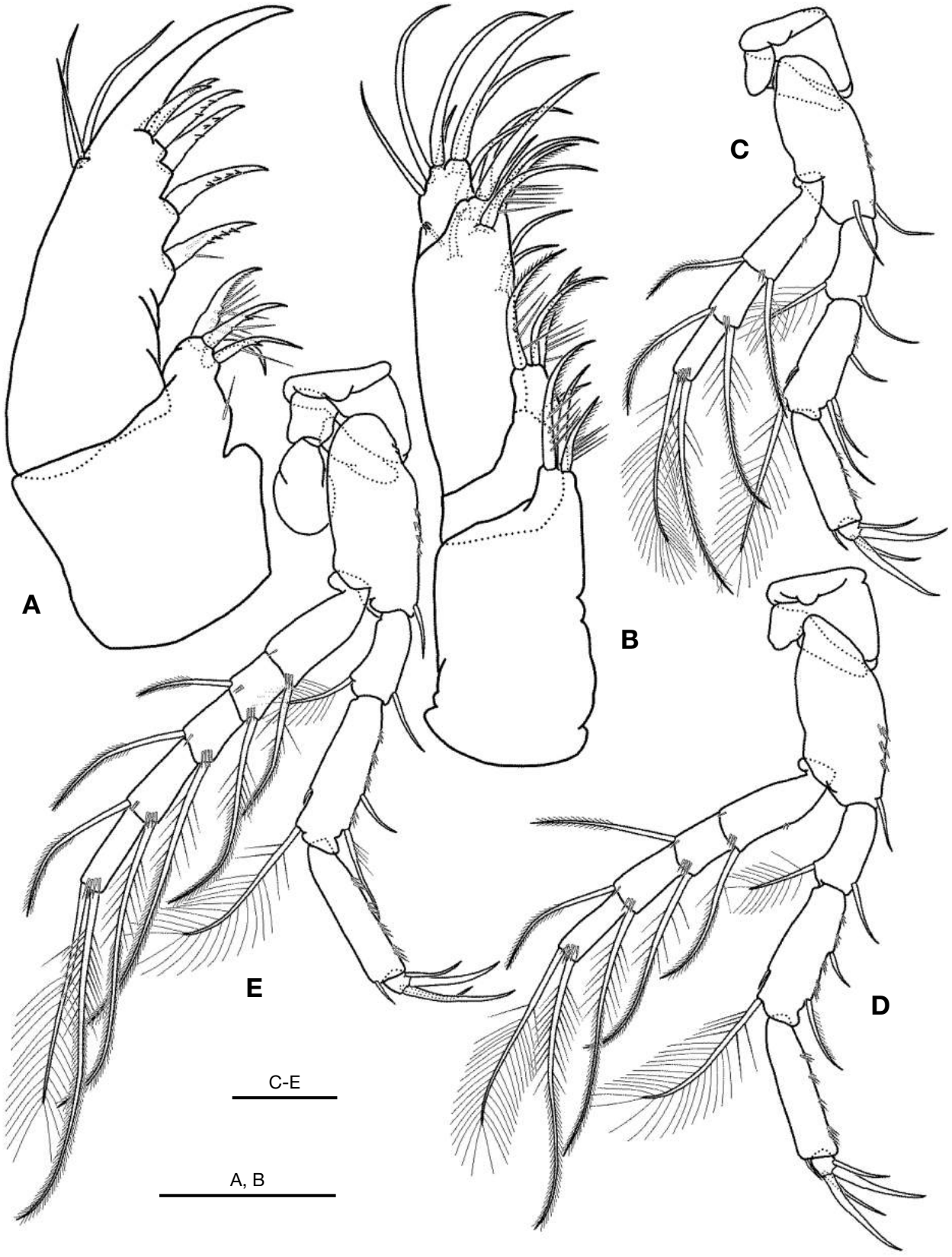


Fig. 8. *Allobathynella imjinensis* (holotype: ♂). (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal); (E) Thoracopod III (frontal). Scale bars = 0.05 mm.

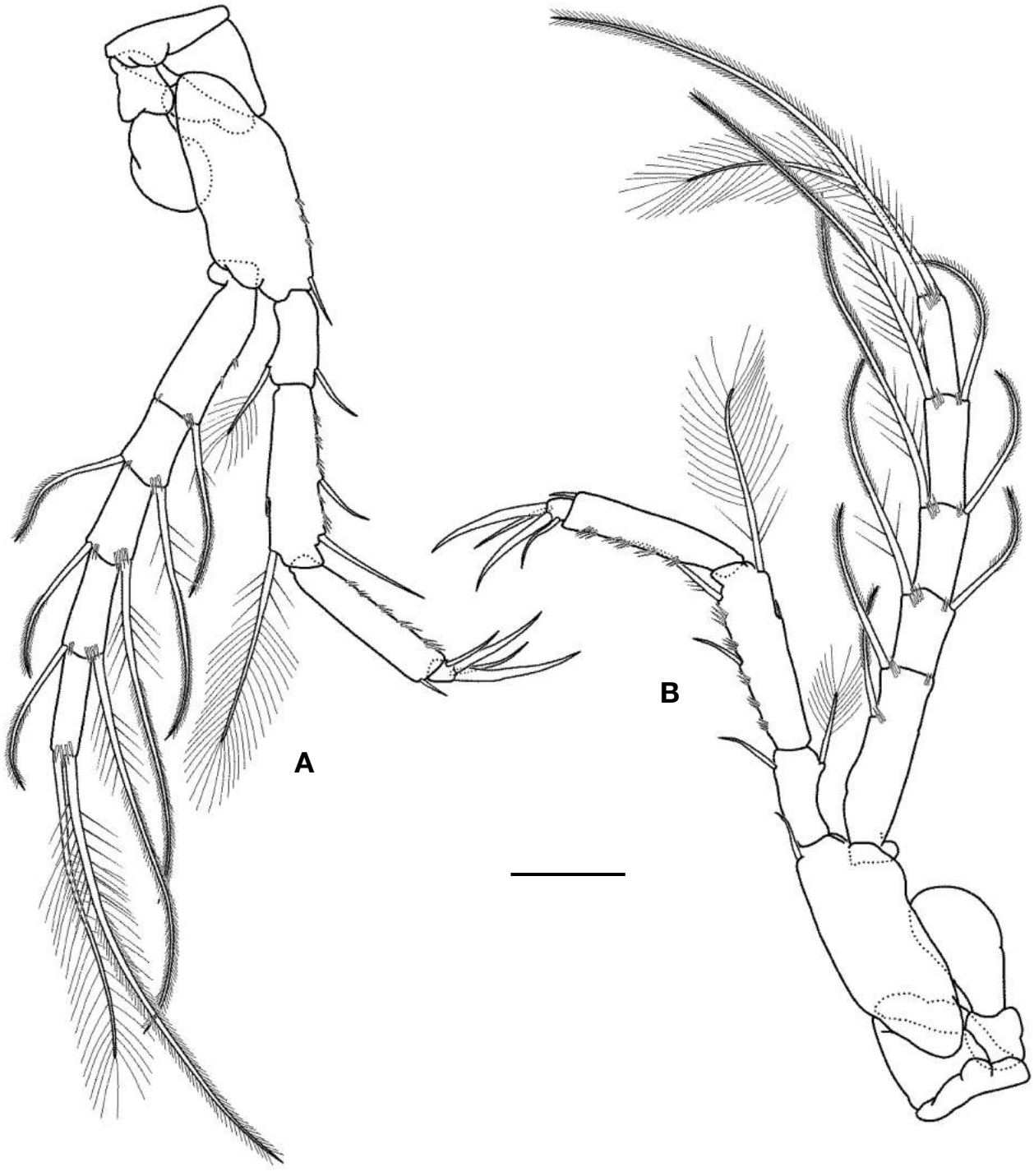


Fig. 9. *Allobathynella imjinensis* (holotype: ♂). (A) Thoracopod IV (frontal); (B) Thoracopod V. Scale bar = 0.05 mm.

present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	1 + 1/3 + 2/0 + 1/4(2)
Thoracopods II-V	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod VI	1 + 1/2 + 2/0 + 1/3(1)
Thoracopod VII	0 + 1/1 + 2/0 + 1/3(1)

Thoracopod VIII (Fig. 11C, D) of male perpendicular to body, in form of a bell in lateral view, 1.5 times lon-

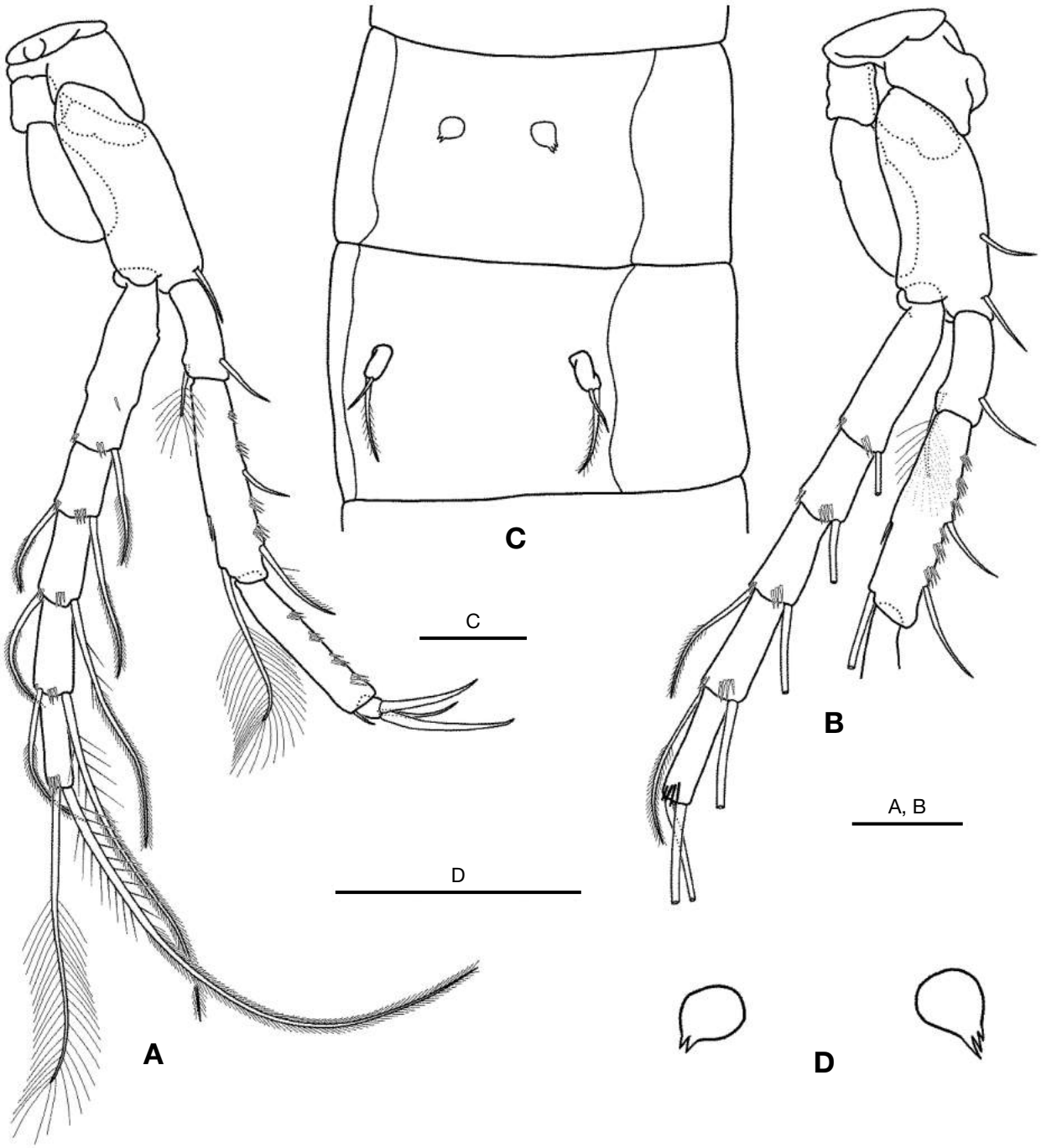


Fig. 10. *Allobathynella imjinensis* (holotype: ♂; Allotype: ♀). (A) Thoracopod VI ♂ (frontal); (B) Thoracopod VI ♀ (frontal); (C) Eight thoracomere and first pleomere ♀ (ventral); (D) Thoracopod VIII ♀ (ventral). Scale bars = 0.05 mm.

ger than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with ten or eleven teeth. Epipod flat, with flat round distal part not reaching lower margin of exopod. Basipod with one short seta near base of endopod, inner margin of basipod serrated, distally drawn out into round projection, basipodal seta one third as long as endopod. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe with three spinules. Endopod small, round, with two distal setae of different size. Outer seta 1.5 times longer than inner one. Thoracopod VIII (Fig. 10D) of female tiny, round in ventral view,

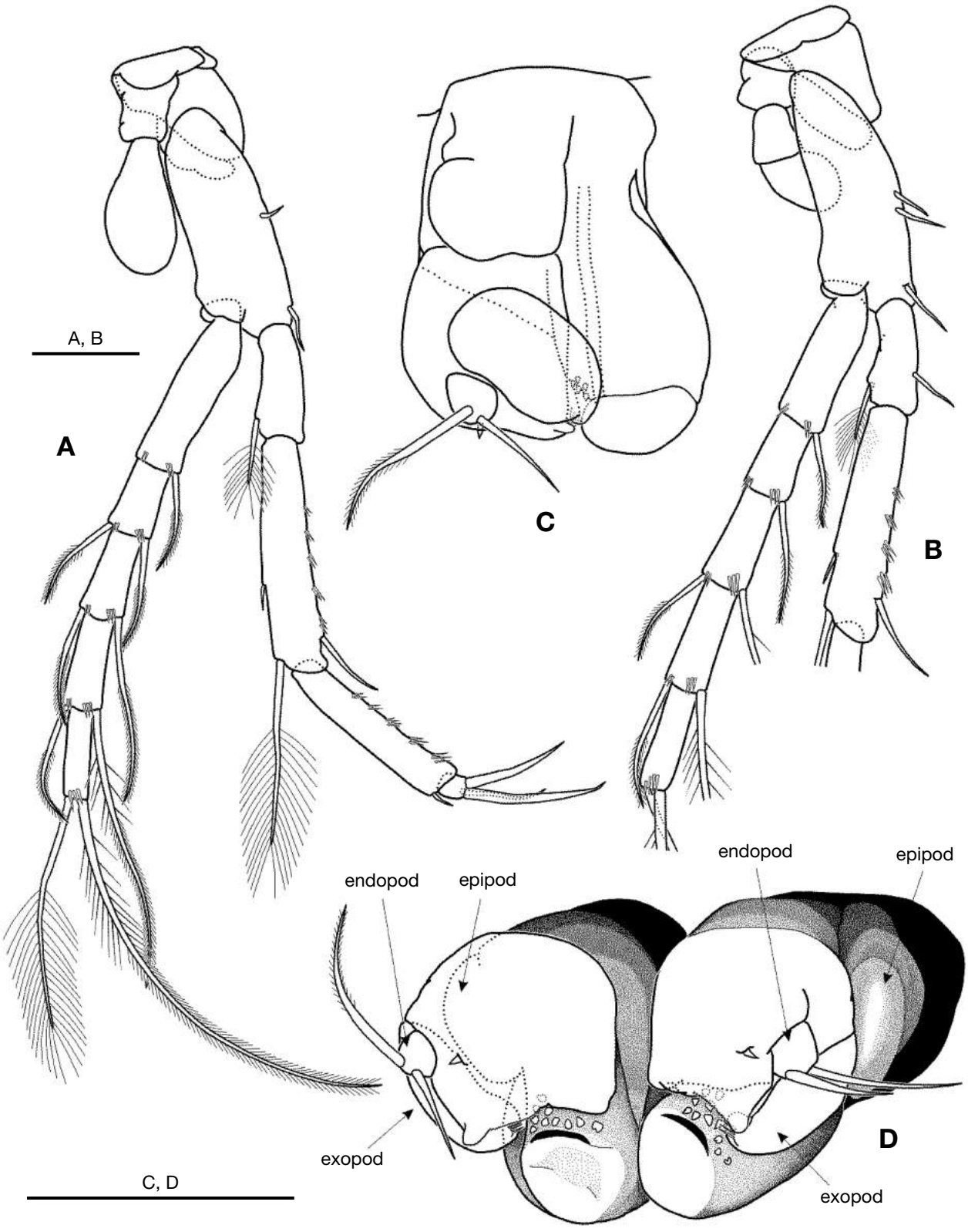


Fig. 11. *Allobathynella imjinensis* (holotype: ♂). (A) Thoracopod VII ♂ (frontal); (B) Thoracopod VII ♀ (frontal); (C) Thoracopod VIII ♂ (lateral); (D) Left and right thoracopods VIII ♂ (ventral). Scale bars = 0.05 mm.

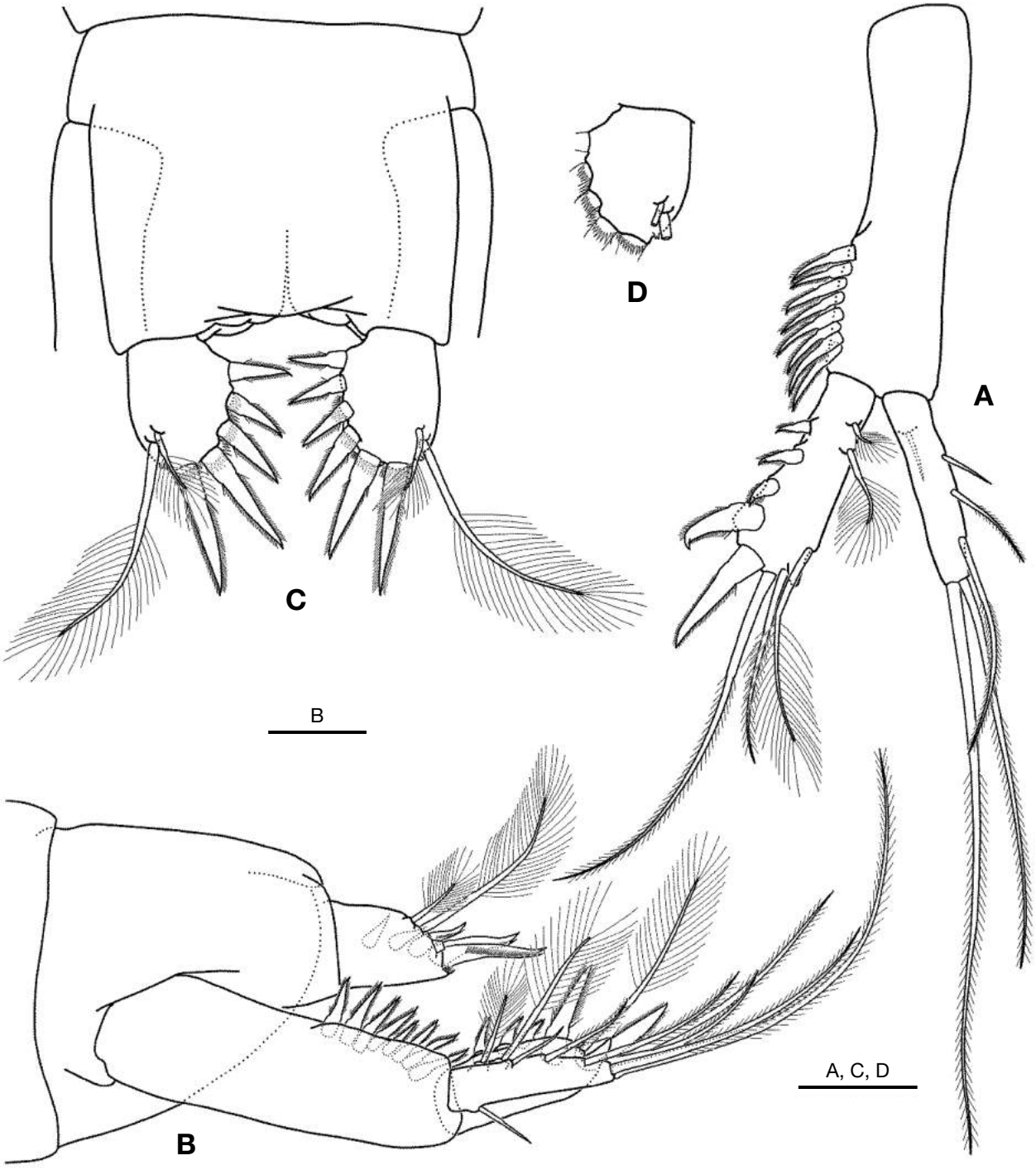


Fig. 12. *Allobathynella imjinensis* (holotype: ♂). (A) Uropod (dorsal); (B) Uropod, pleotelson and furcal rami (lateral); (C) Pleotelson and furcal rami (dorsal); (D) Furcal ramus without spines (ventral). Scale bars = 0.05 mm.

with two or three sharp projection distally.

First pleopod (Fig. 10D) in form of stub bearing two distal setae.

Uropod (Fig. 12A, B) bearing eight spines of similar size on inner margin of sympod. Endopod 47% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and three additional spines along inner margin. Terminal spine slightly thicker and stronger

than subterminal one. Spines of inner margin similar in size, half as large as terminal spine. Exopod slightly shorter than endopod (52% of sympod), with five setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 12B, C) without seta. Anal operculum protruded slightly.

Furcal rami (Fig. 12B, C) nearly as long as wide, with two large distal spines, and three (left) or four (right) smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella maseongensis* sp. nov.** (Figs. 13-18)

Etymology

The species name is derived from the Maseong-Myeon, where the material was collected.

Material examined

Holotype (adult male) dissected on eight slides (NIBR IV0000266838).

Type locality

South-Korea, Kyungsangbuk-Do, Munkyeong-Si, Maseong-Myeon, Shinheon-Ri (36°39′39.1″N, 128°07′15.0″E), 13. October 2012, leg. J.-L. Cho.

Description

Size (mm). Body length: 2.55, approximately 12 times as long as wide. Head slightly shorter than anterior three thoracic segments combined (Fig. 13A).

Antennule (Fig. 13B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin, respectively. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and three dorsal setae and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta and medially with one simple seta on inner margin. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 13C) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 13D) flat, with eight main teeth flanked by seven (right) or six (left) teeth on both lateral sides. Ventral surface concave, with one tiny round median projections without spinules beneath free margin, three pairs of teat and numerous combs of ctenidia.

Mandible (Fig. 13E) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of ten spines. Palp of one segment, 2.5 times as long as wide, with two apical setae of different length.

Maxillule (Fig. 14A) two-segmented. Proximal segment with numerous numbers of ctenidia and with four setae on inner distal margin. Distal segment with two terminal smooth spines and five dentate spines on inner edge, and with three simple setae on outer distal margin. Terminal spine 1.5 times larger than other ones.

Maxilla (Fig. 14B) four-segmented, setal formula 4-5-12-6.

Thoracopods I-VII (Figs. 14C-E, 15A, B, 16A, B). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods VI-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II, III, and with each one distal and median seta in thoracopods IV-VII. Number of segments of exopod of thoracopods I-VII: 3-4-6-6-6-6-6. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods III. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/4 + 2/2 + 1/4(2)
Thoracopod II	2 + 1/3 + 2/1 + 1/4(2)
Thoracopod III	1 + 1/2 + 2/1 + 1/4(2)
Thoracopods VI-VI	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod VII	0 + 1/1 + 1/0 + 1/4(2)

Thoracopod VIII (Fig. 17A-C) of male perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with seven teeth. Epipod flat, anteriorly protruded, distal part mostly not, but anterior protrusion reaching bottom of exopod. Basipod with one seta near base of endopod, inner margin of basipod with numerous rows of fine setules, distally drawn out into round projection, basipodal seta as long as endopod. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe with three teeth. Endopod small, round, with two distal setae of different size. Inner seta extremely short, as long as basipodal seta.

First pleopod (Fig. 16C) in form of stub bearing two distal setae.

Uropod (Fig. 18A, B) bearing 12 spines on inner margin of sympod, two most distal spines somewhat longer

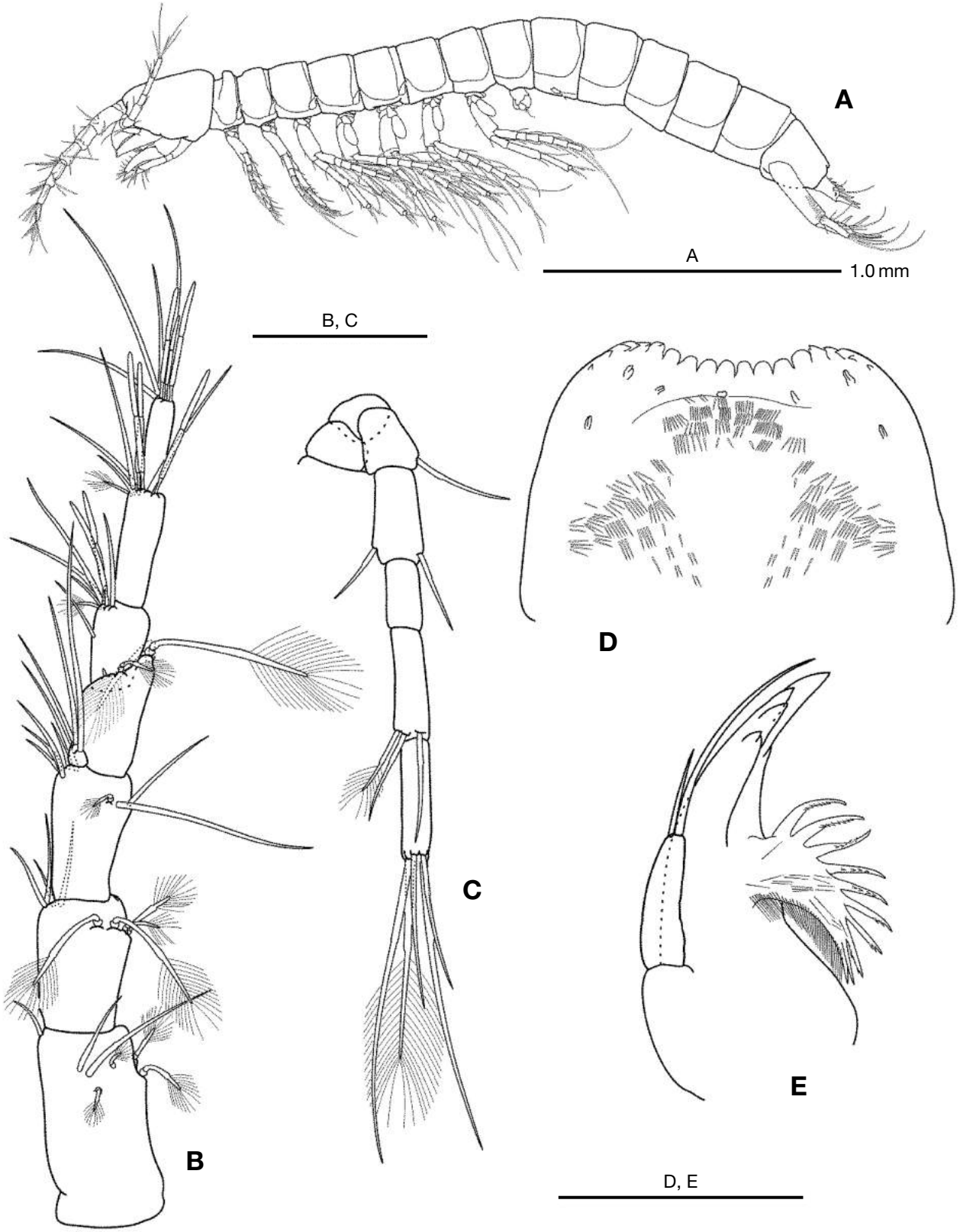


Fig. 13. *Allobathynella maseongensis* (holotype: ♂): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorsal); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.1 mm, unless specified.

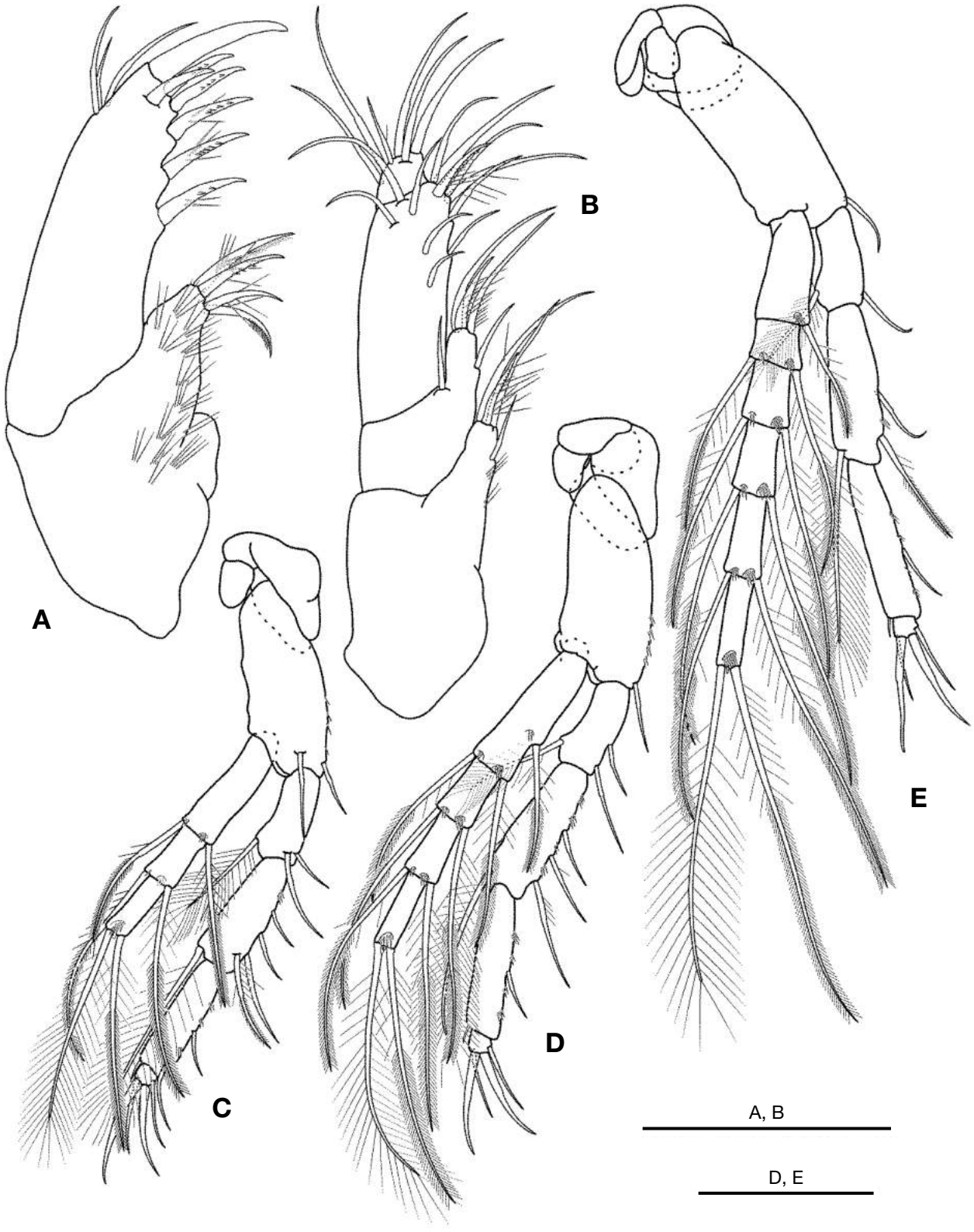


Fig. 14. *Allobathynella maseongensis* (holotype: ♂): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal); (E) Thoracopod III (frontal). Scale bars = 0.1 mm.

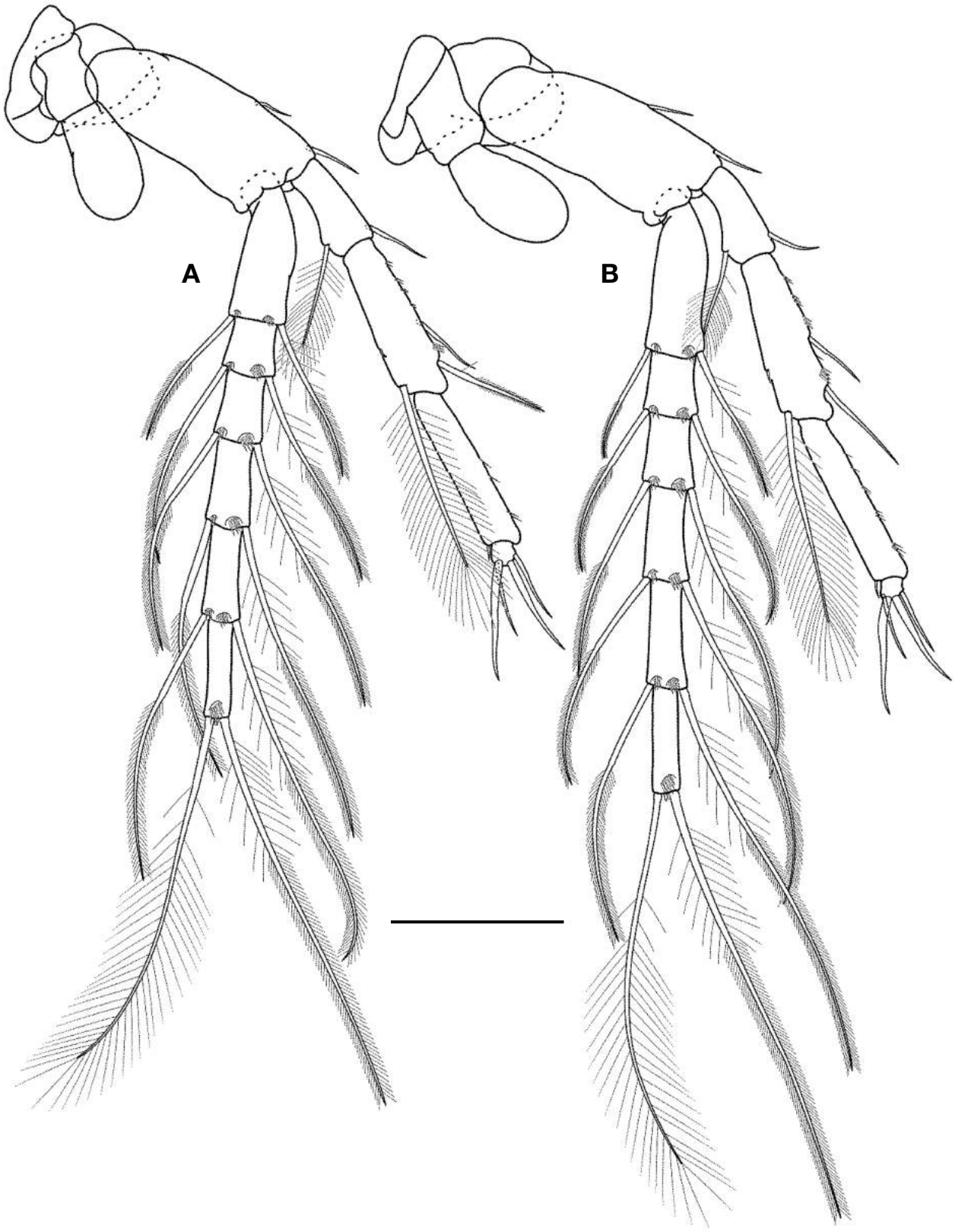


Fig. 15. *Allobathynella maseongensis* (holotype: ♂): (A) Thoracopod IV (frontal); (B) Thoracopod V (frontal). Scale bar = 0.1 mm.

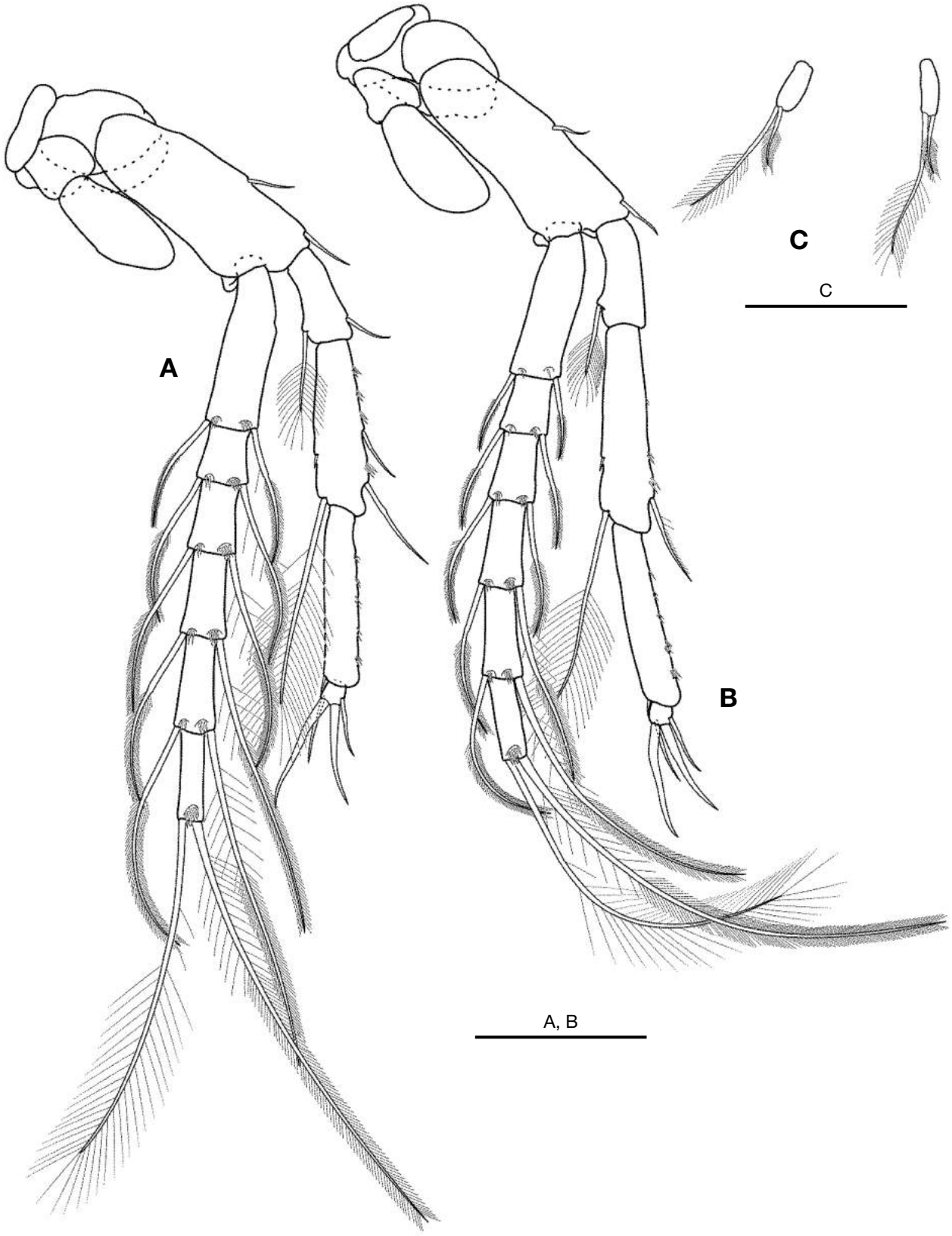


Fig. 16. *Allobathynella maseongensis* (holotype: ♂): (A) Thoracopod VI (frontal); (B) Thoracopod VII (frontal); (C) Pleopod (ventral). Scale bars = 0.1 mm.

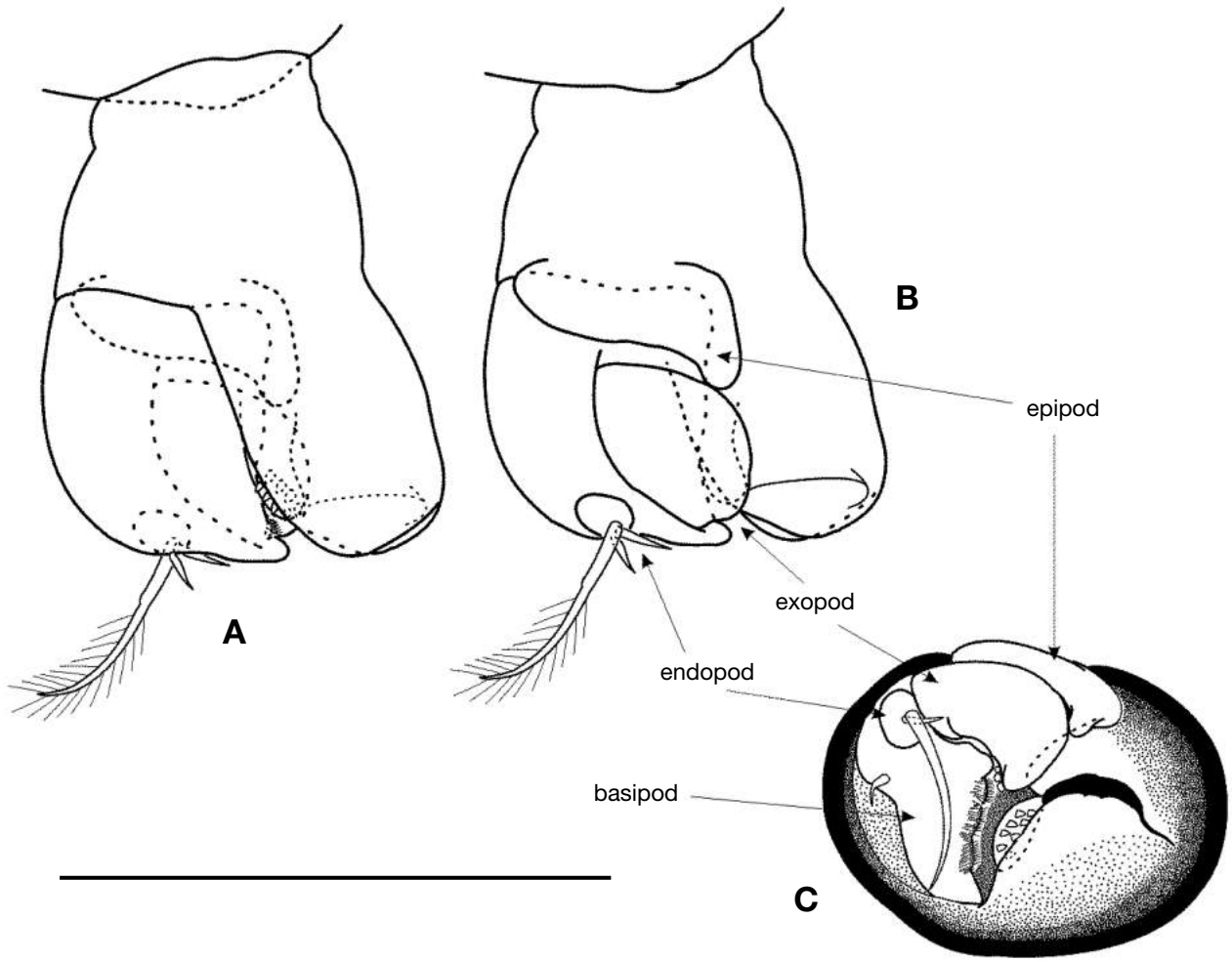


Fig. 17. *Allobathynella maseongensis* (holotype: ♂): (A) Thoracopod VIII (inner lateral); (B) Thoracopod VIII (outer lateral); (C) Thoracopod VIII (ventral). Scale bar = 0.1 mm.

than others. Endopod 52% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and four additional spines along inner margin. Terminal spine slightly longer than subterminal one. Most distal spine of inner margin two thirds as large as terminal spine and 4-5 times larger than proximal three ones of similar size. Exopod slightly shorter than endopod (49% of sympod), with six setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 18B, C) without seta. Anal operculum round and protruded slightly.

Furcal rami (Fig. 18B, C) 1.2 times as long as wide, with two large distal spines, and five successively smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella munsui* sp. nov.** (Figs. 19-23)

Etymology

The species name is derived from the Budist name of a monch (Munsu), who sacrificed his body against the project of the government willing to change the configuration of Korean rives.

Material examined

Holotype (adult female), paratype (adult female). Holotype dissected on seven slides (NIBR IV0000266839). Paratype as whole specimen on a slide (NIBR IV0000 266840).

Type locality

South-Korea, Kyungsangbuk-Do, Cheongsoung-Gun, Pacheon-Myeon, Joongpyeong-Ri (36°28′36.1″N, 129° 01′50.3″E), 21. June 2012, leg. J.-L. Cho.

Description

Size (mm). Body length: 3.41, approximately 12 times

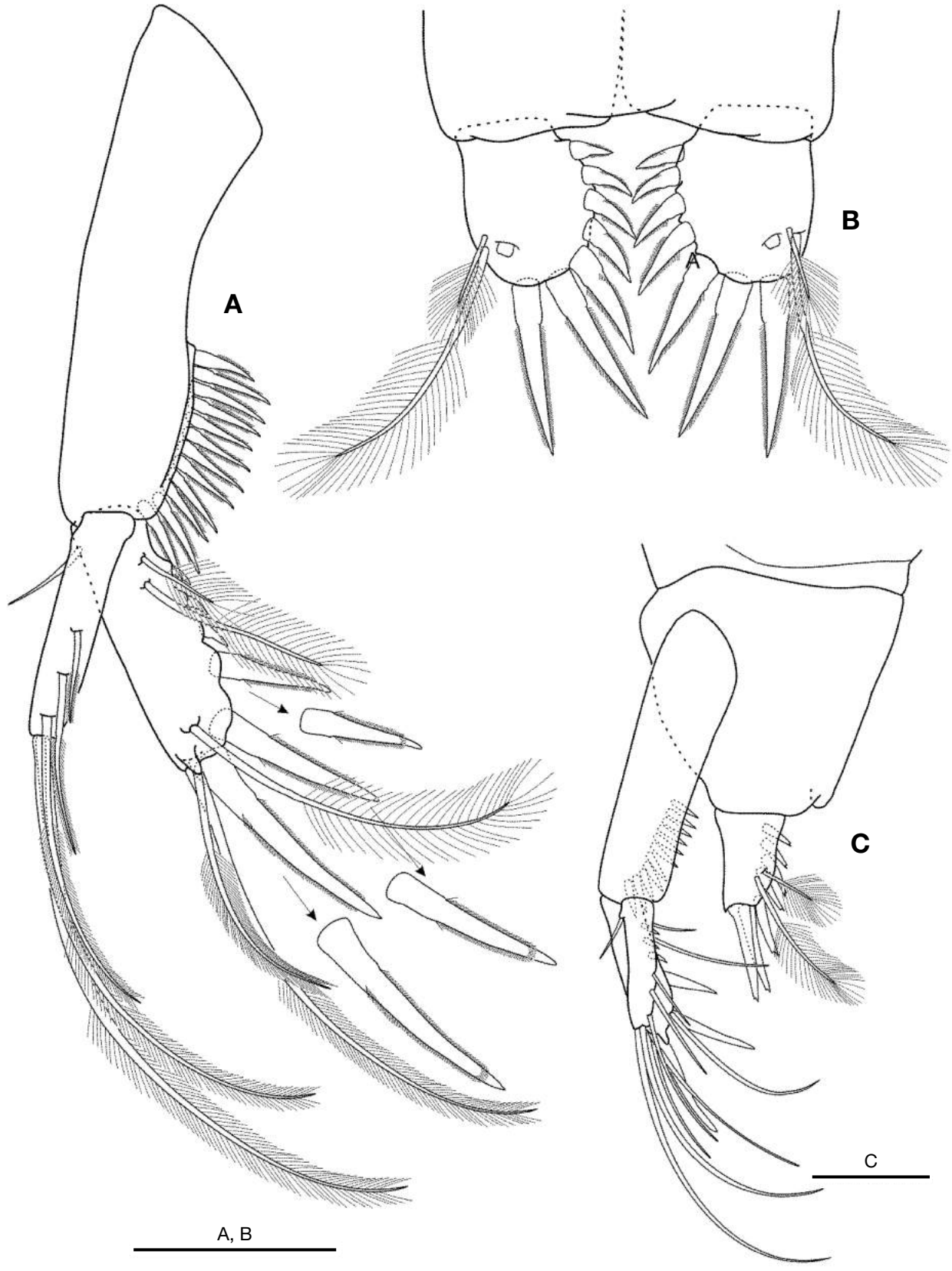


Fig. 18. *Allobathynella maseongensis* (holotype: ♂): (A) Uropod (dorsal); (B) Pleotelson and furcal rami (dorsal); (C) Uropod, pleotelson and furcal rami (lateral). Scale bars = 0.1 mm.

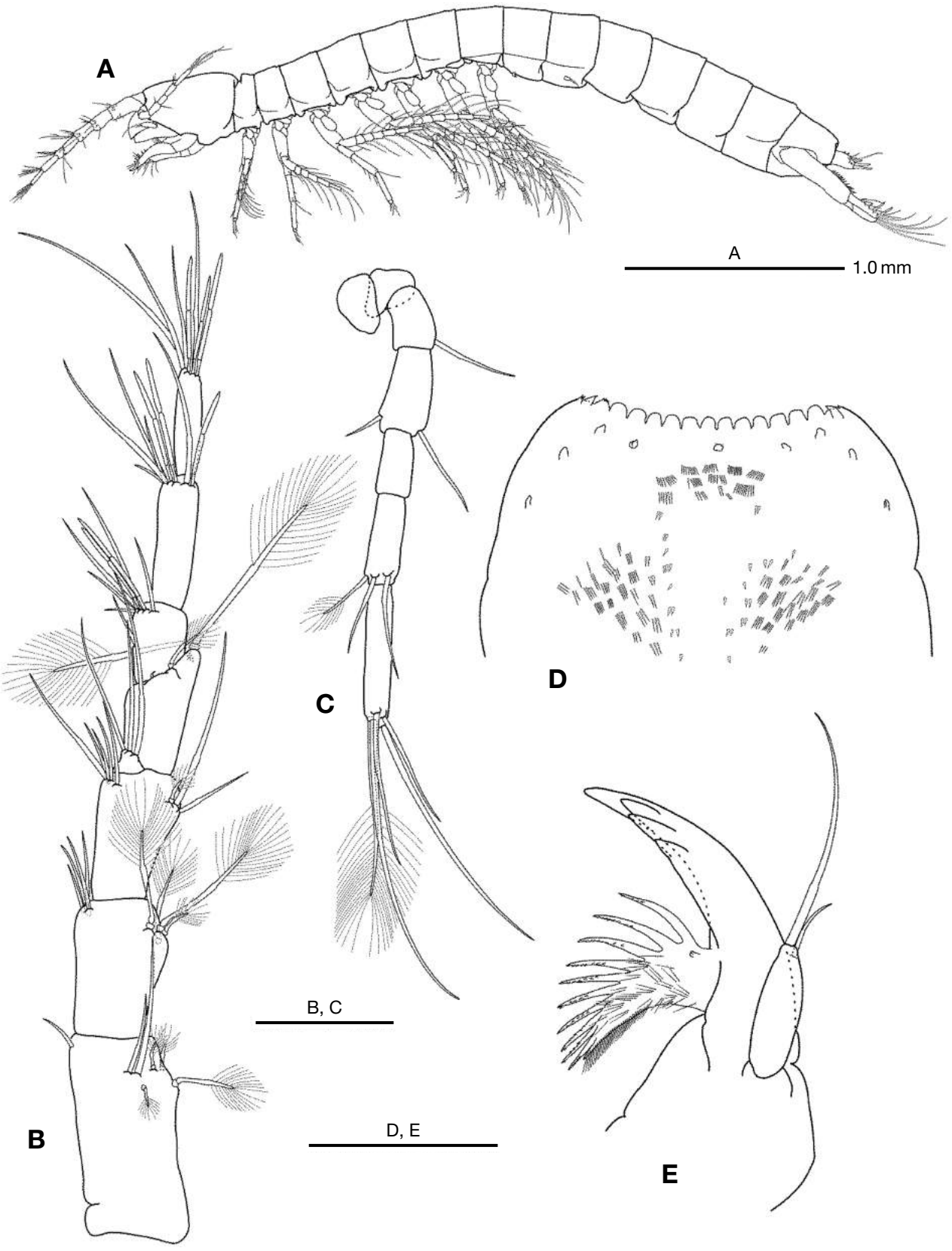


Fig. 19. *Allobathynella munsui* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorsal); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.1 mm, unless specified.

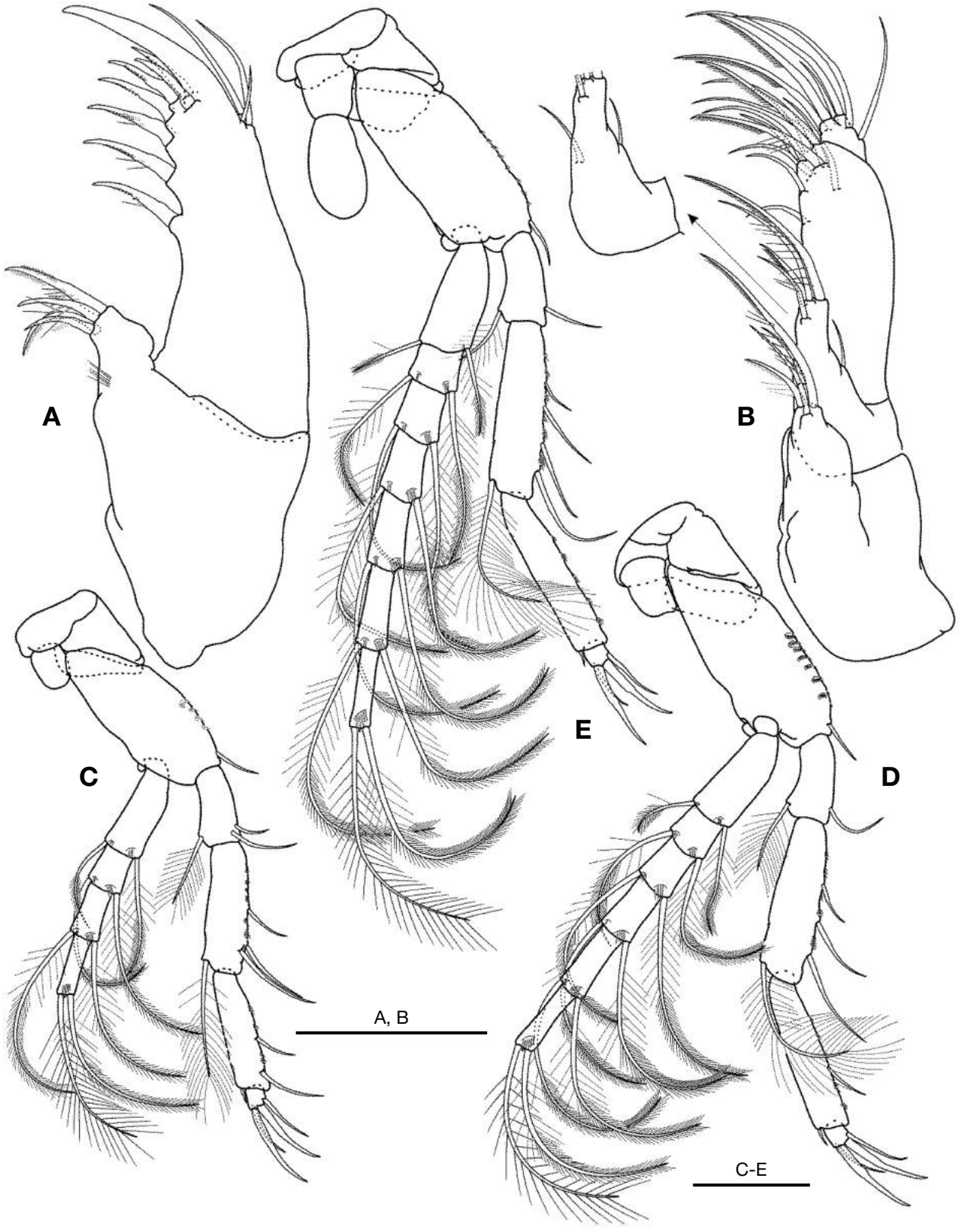


Fig. 20. *Allobathynella munsui* (holotype: ♀): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal); (E) Thoracopod III (frontal). Scale bars = 0.1 mm.

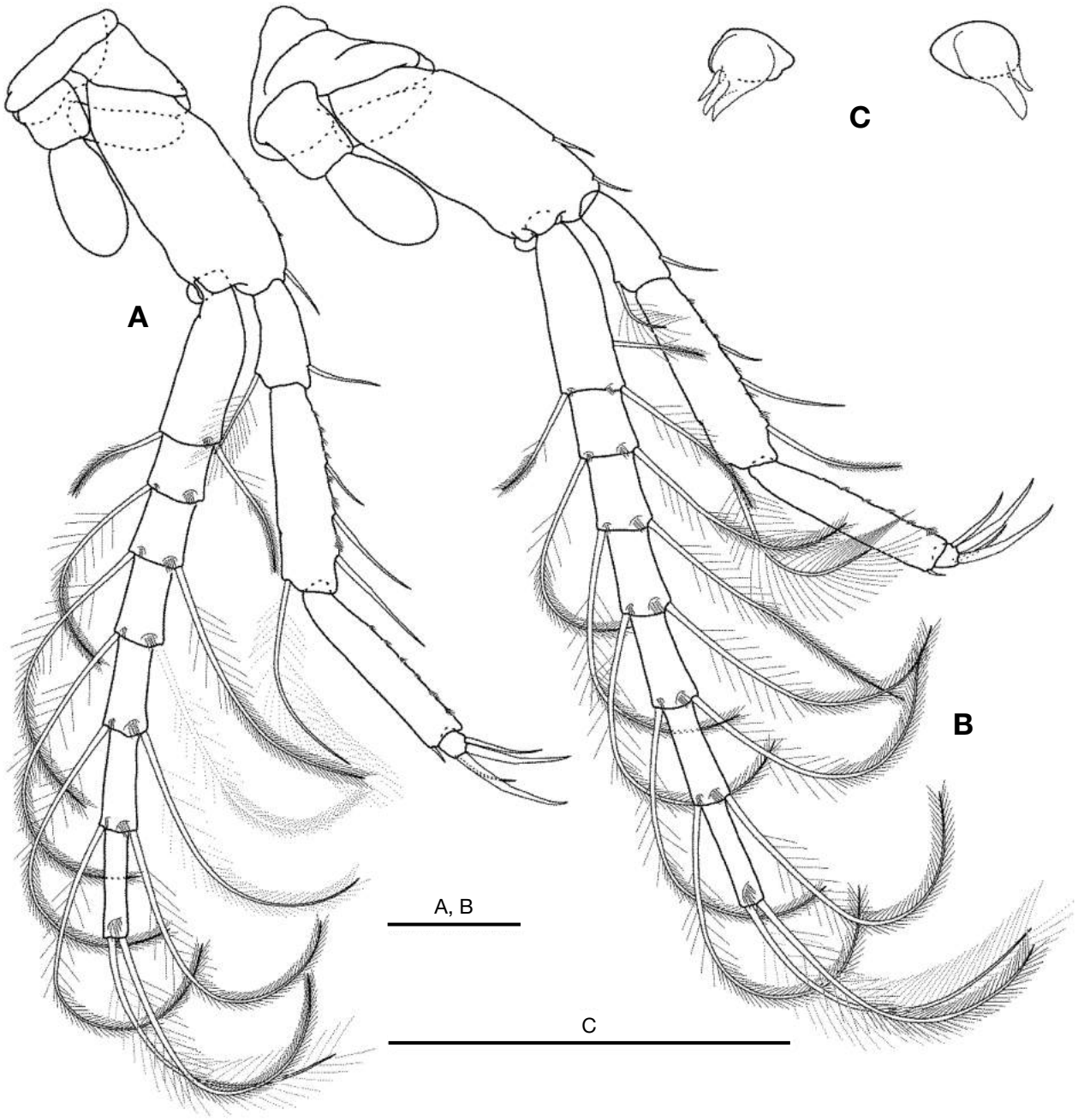


Fig. 21. *Allobathynella munsui* (holotype: ♀): (A) Thoracopod IV (frontal); (B) Thoracopod V (frontal); (C) Thoracopod VIII (ventral). Scale bars = 0.1 mm.

as long as wide. Head slightly shorter than anterior three thoracic segments combined (Fig. 19A).

Antennule (Fig. 19B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin, respectively. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and three dorsal setae and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally

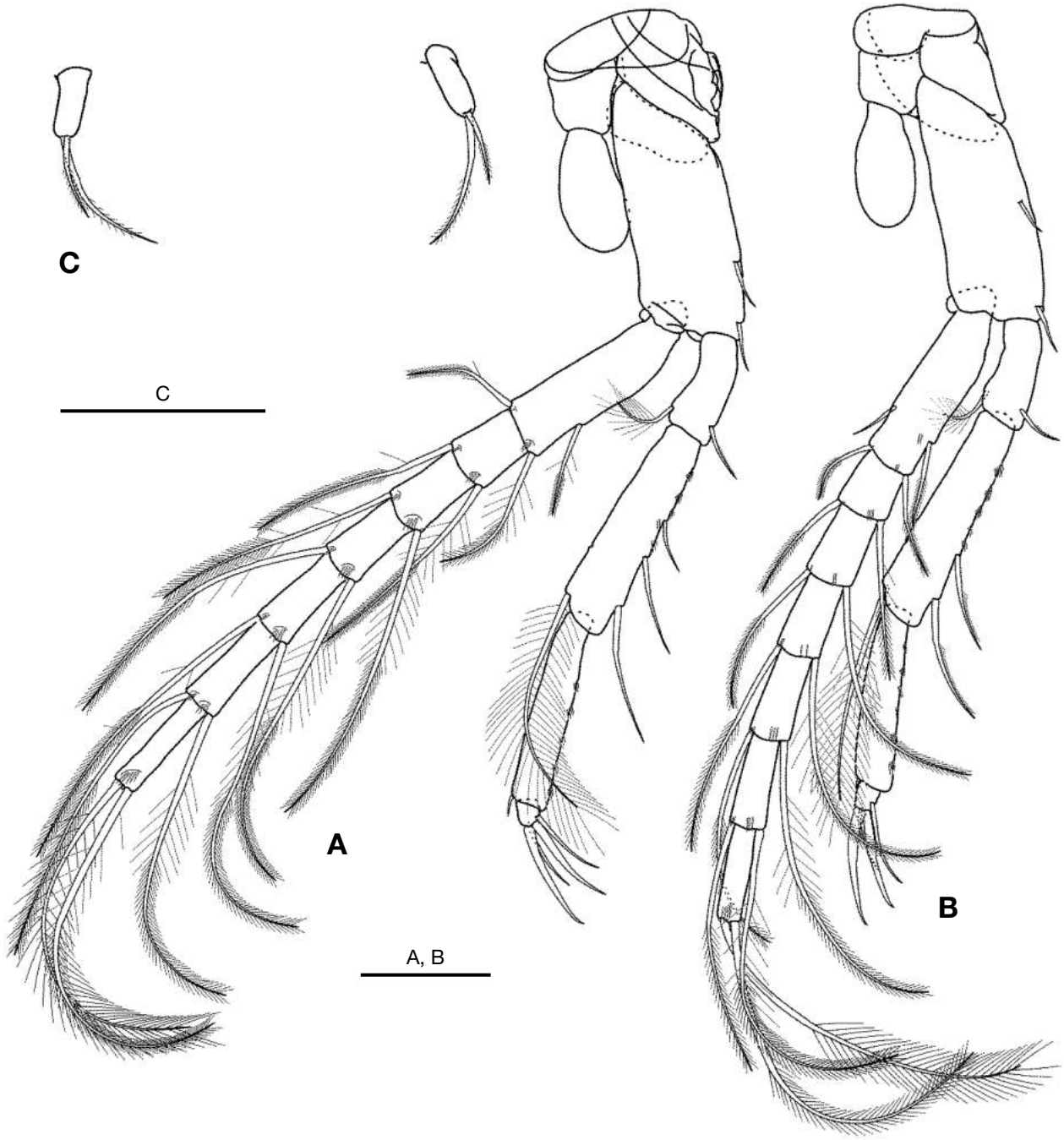


Fig. 22. *Allobathynella munsui* (holotype: ♀): (A) Thoracopod VI (frontal); (B) Thoracopod VII (frontal); (C) Pleopod (ventral). Scale bars = 0.1 mm.

with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta and medially with one simple seta on inner margin. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 19C) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 19D) flat, with 12 main teeth flanked by three teeth on both lateral sides. Ventral surface concave, with one tiny round median projections bearing two distal spinules, four pairs of teat and numerous combs of

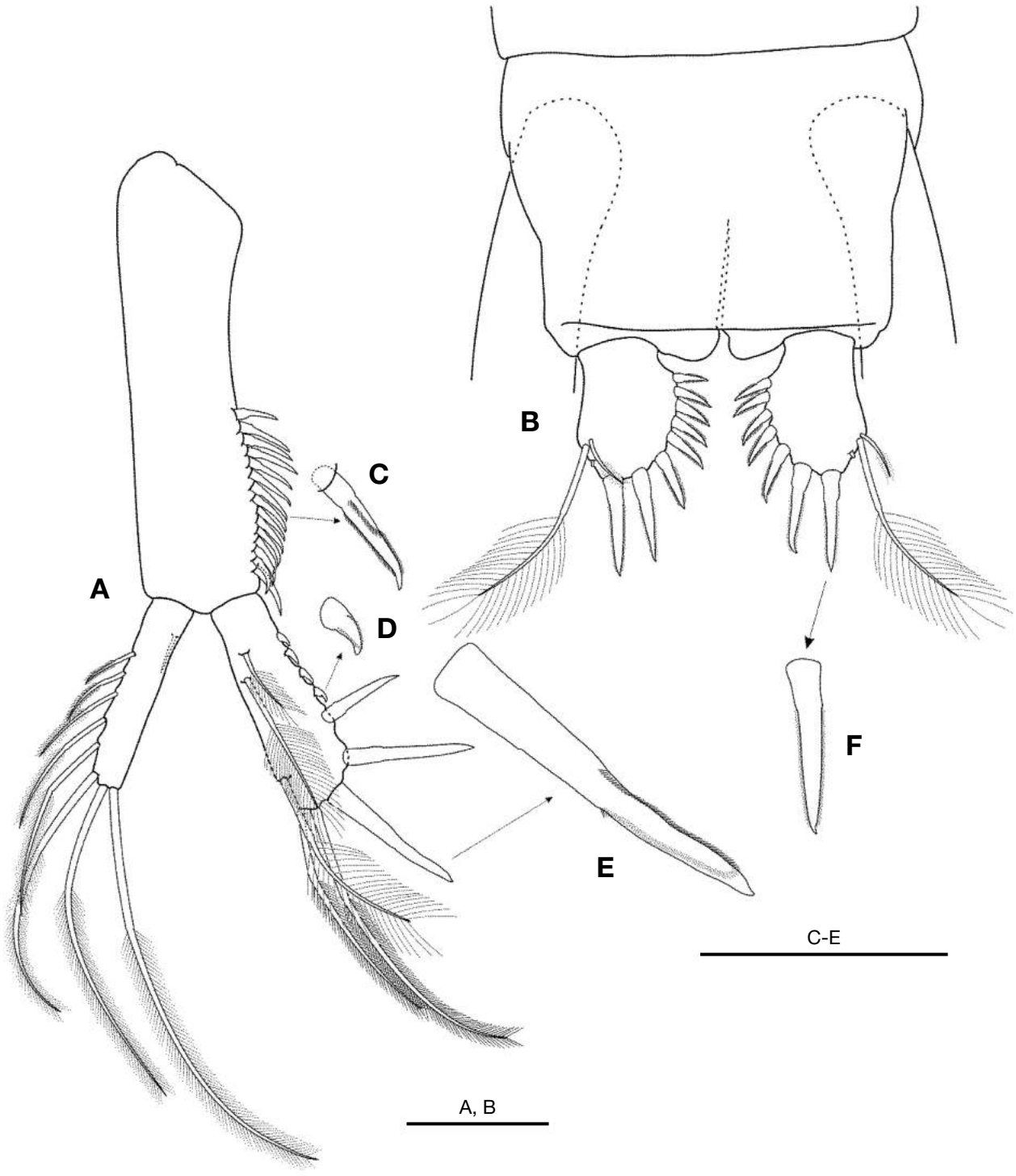


Fig. 23. *Allobathynella munsui* (holotype: ♀): (A) Uropod (dorsal); (B) Pleotelson and furcal rami (dorsal); (C)-(F) Spines. Scale bars = 0.1 mm.

ctenidia.

Mandible (Fig. 19E) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of 11 spines. Palp of one segment, 2.5 times as long as wide, with two apical setae of different length.

Maxillule (Fig. 20A) two-segmented. Proximal segment with numerous numbers of ctenidia and with four setae on inner distal margin. Distal segment with two

terminal smooth spines and six serrated spines on inner edge, and with three simple setae on outer distal margin. Terminal spine two times larger than other ones.

Maxilla (Fig. 20B) four-segmented, setal formula 3-6-10-6.

Thoracopods I-VII (Figs. 20B-D, 21A, B, 22A, B). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with one distal seta in thoracopods I-IV, with each one distal and median seta in thoracopods V-VII. Number of segments of exopod of thoracopods I-VII: 4-6-7-7-7-7-7. Exopodal segments with each one dorsal and ventral seta, except basal segment having one additional medial seta on ventral margin of thoracopods V and VI and each one additional medial seta on ventral and dorsal margin of thoracopod VII. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/2 + 1/4(2)
Thoracopod II	1 + 1/3 + 2/1 + 1/4(2)
Thoracopod III	1 + 1/4 + 2/0 + 1/4(2)
Thoracopods IV-VI	1 + 1/3 + 2/0 + 1/4(2)
Thoracopod VII	1 + 1/2 + 2/0 + 1/4(2)

Dorso-median seta of second segment extremely short.

Thoracopod VIII (Fig. 21C) of female round in ventral view, with two (left) or three (right) spine-like distal projection.

First pleopod (Fig. 22C) in form of stub bearing two distal setae.

Uropod (Fig. 23A) bearing 15 spines of similar length on inner margin of sympod. Endopod 48% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and four additional spines along inner margin. Terminal spine slightly longer than subterminal one. Most distal spine of inner-margin two thirds as large as subterminal spine and 4-5 times larger than proximal three ones of similar size. Exopod slightly shorter than endopod (42% of sympod), with nine setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 23B) without seta. Anal operculum flat.

Furcal rami (Fig. 23B) 1.2 times as long as wide, with two large distal spines, and six (left) or five (right) successively smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella hongcheonensis* sp. nov.** (Figs. 24-29)

Etymology

The species name is derived from the county (Hongcheon), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratype (18 adult females and 11 adult males). Holotype dissected on six slides (NIBR IV0000266858). Allotype dissected on six slides (NIBR IV0000266859). One female paratype (NIBR IV0000266860) dissected on seven slides, one male paratype (NIBR IV0000266861) dissected on six slides, six female paratypes and five male paratypes each as a whole specimen on separate slides (NIBR IV0000266862-0000266872), 11 female and five males paratype in a vial (NIBR IV0000266873).

Type locality

South-Korea, Ganwon-Do, Hongcheon-Gun, Seo-Myeon, Bangok-Ri (37°41′20.8″N, 127°40′52.6″E), 13. November 2012, leg. J.-L. Cho.

Description

Size (mm). Body length: 1.83 (other females: 1.75-1.83; allotype: 1.83; other males: 1.70-1.82), approximately 12 times as long as wide. Head slightly shorter than anterior three thoracic segments combined (Fig. 24A).

Antennule (Fig. 24B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with two simple setae dorsally and one simple seta ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and two dorsal and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta and medially with one simple seta on inner margin. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 24C) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 24D) flat, medially convex, free margin of eight main teeth flanked by three teeth on both lateral sides. Ventrally with one median projection without spinules, two pairs of teats and numerous combs of

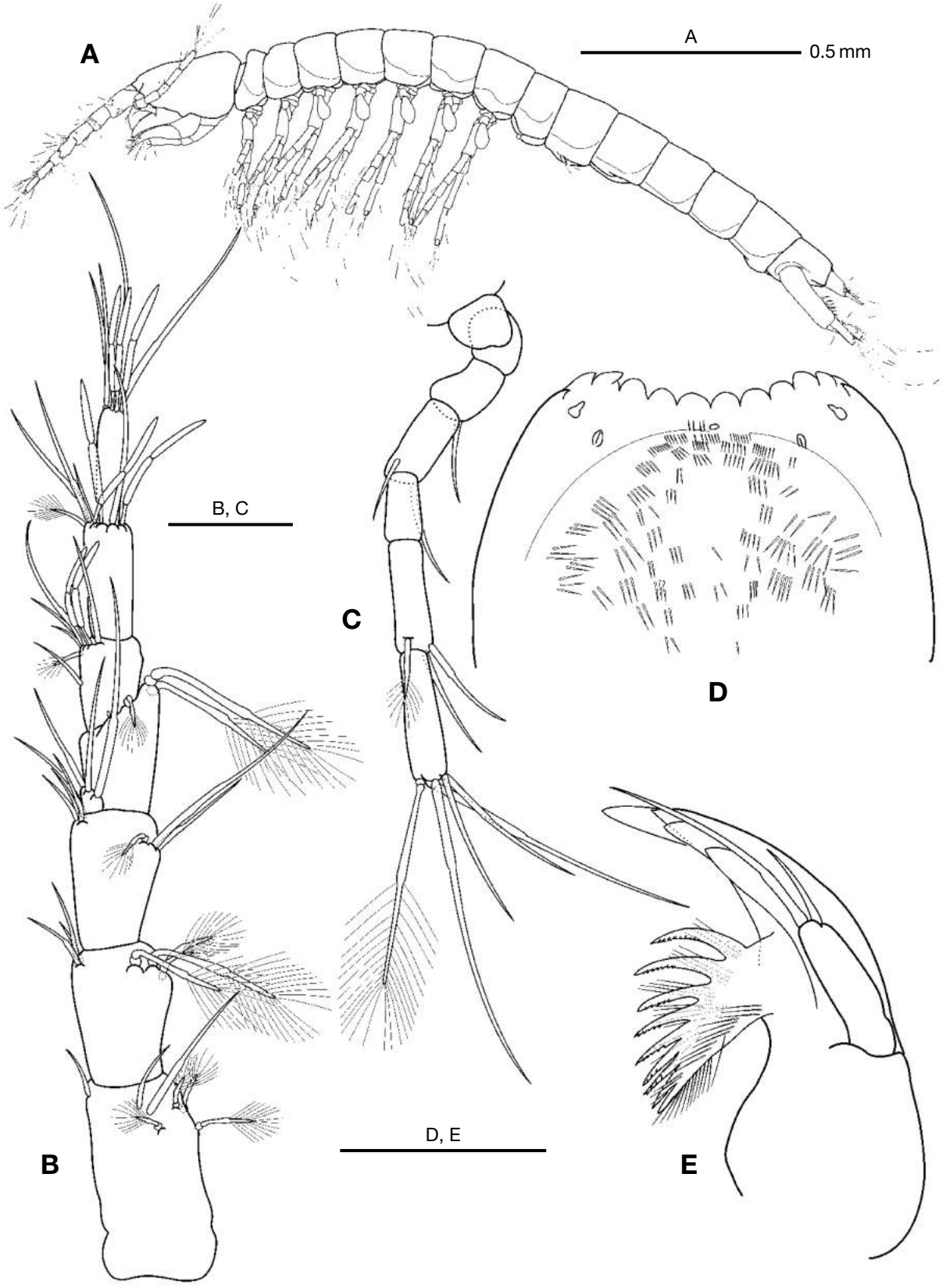


Fig. 24. *Allobathynella hongcheonensis* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorso-lateral); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.05 mm, unless specified.

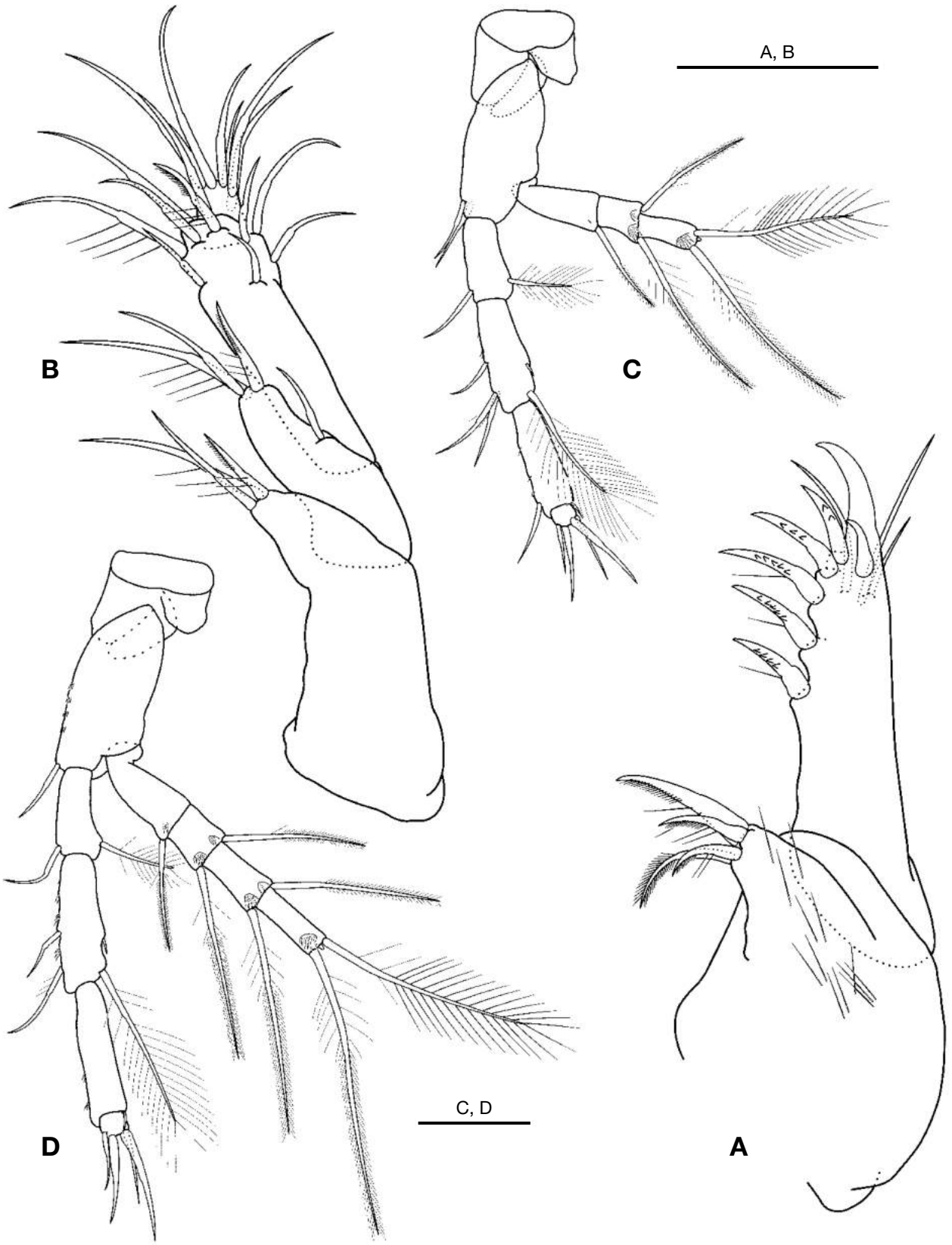


Fig. 25. *Allobathynella hongcheonensis* (holotype: ♀): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal). Scale bars = 0.05 mm.

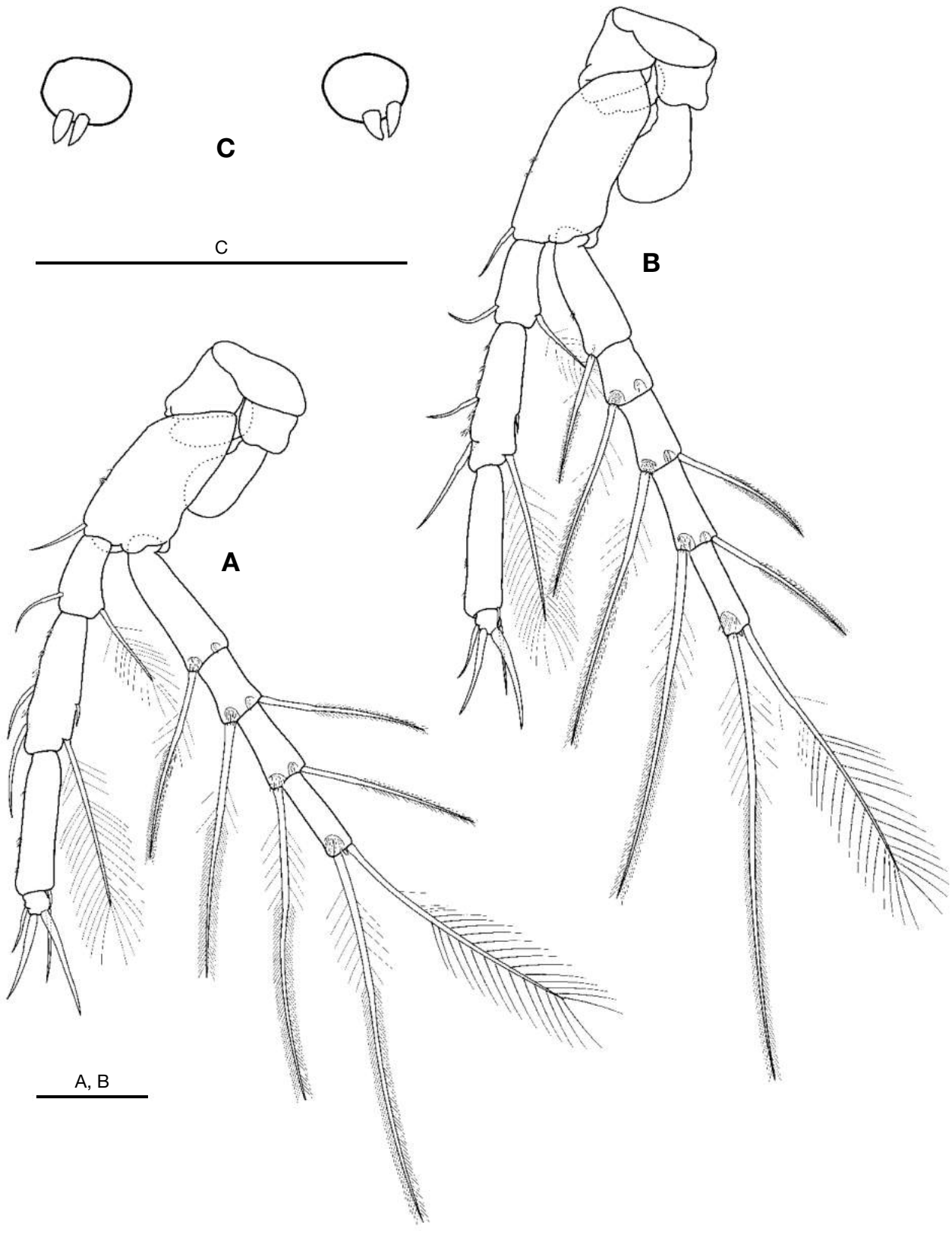


Fig. 26. *Allobathynella hongcheonensis* (holotype: ♀): (A) Thoracopod III (frontal); (B) Thoracopod IV (frontal); (C) Thoracopod VIII ♀ (ventral). Scale bars = 0.05 mm.

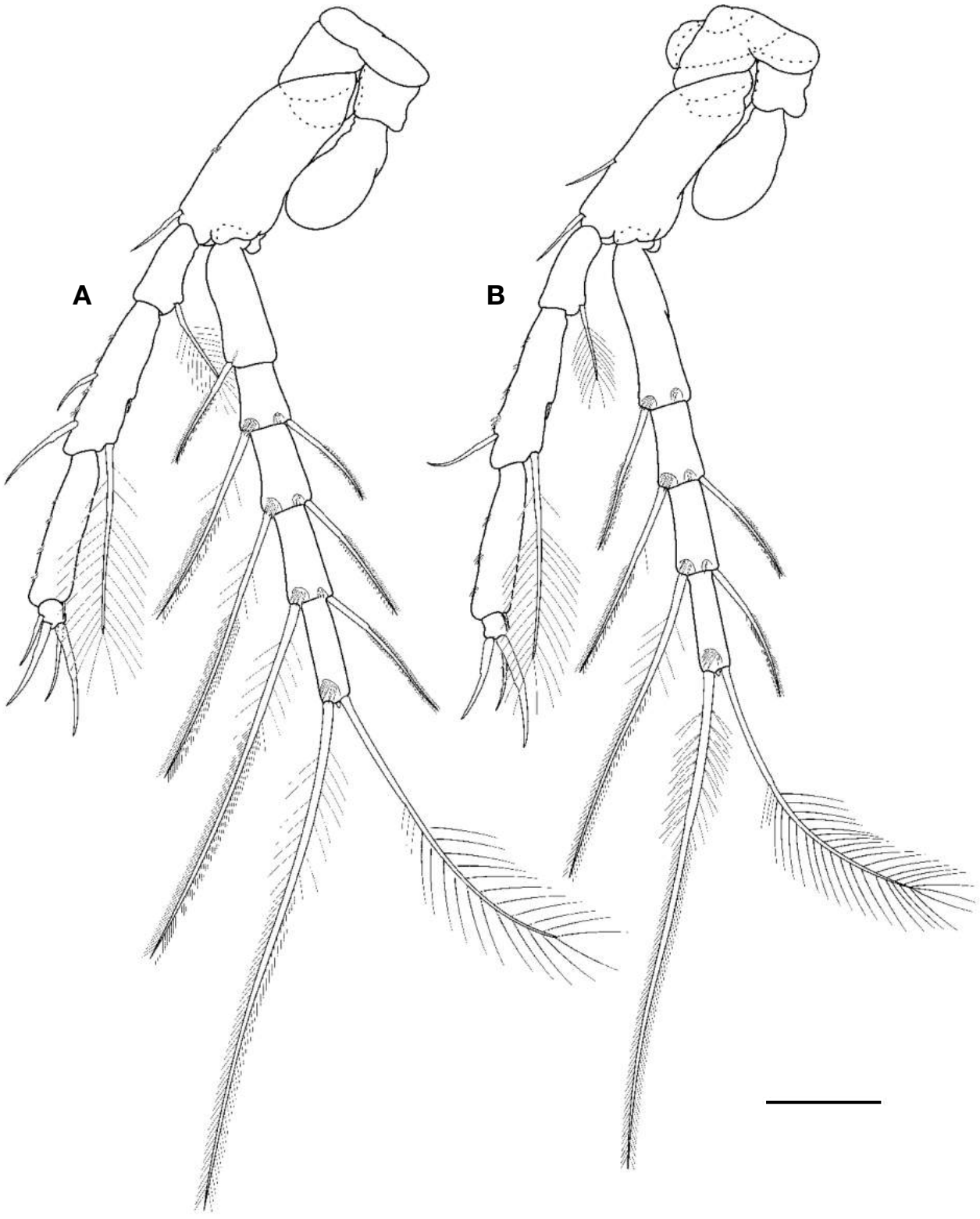


Fig. 27. *Allobathynella hongcheonensis* (holotype: ♀): (A) Thoracopod V (frontal); (B) Thoracopod VI (frontal). Scale bar = 0.05 mm.

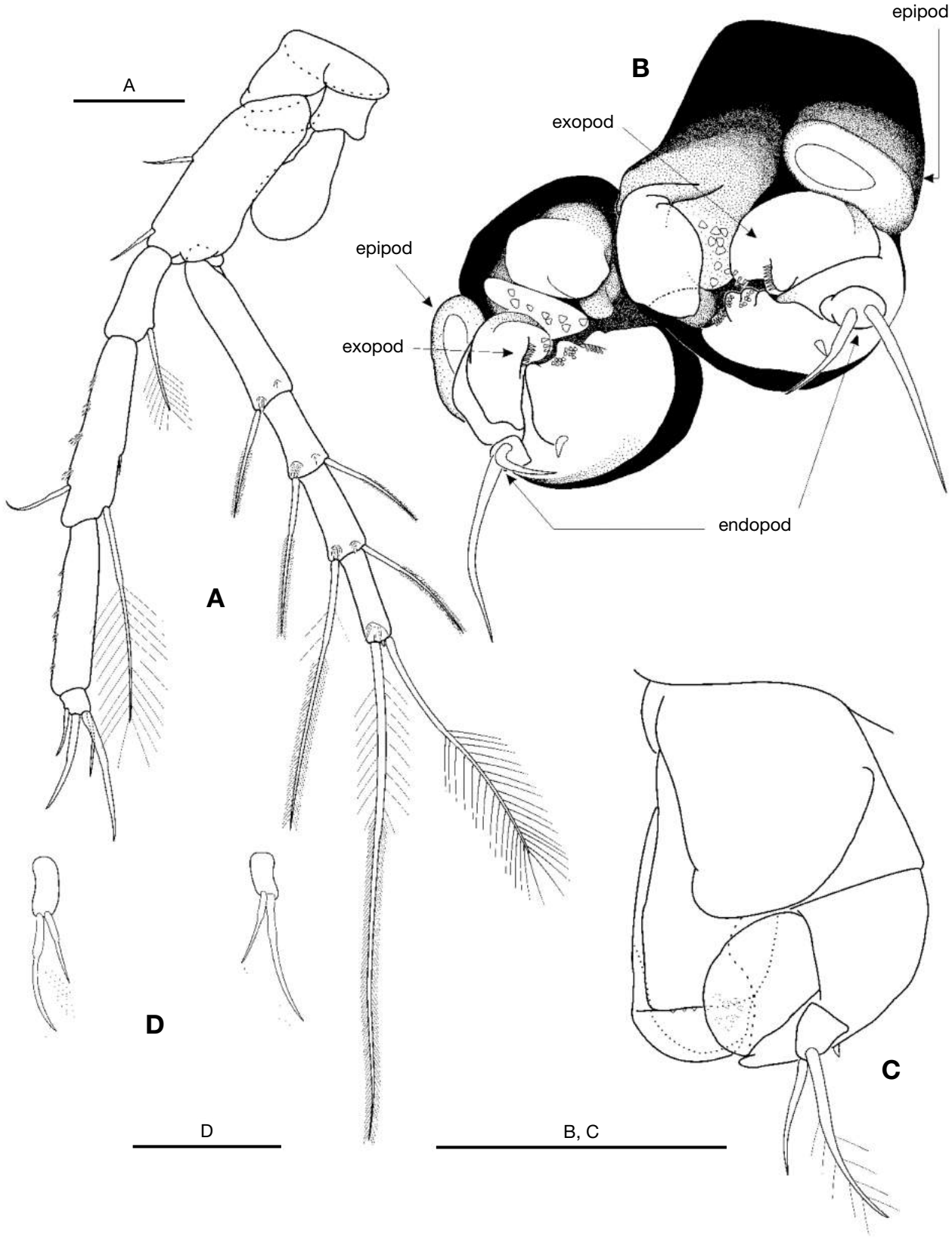


Fig. 28. *Allobathynella hongcheonensis* (holotype: ♀; allotype: ♂): (A) Thoracopod VII ♀ (frontal); (B) Right and left thoracopods VIII ♂ (ventral, slightly lateral); (C) Thoracopod VIII ♂ (lateral); (D) Pleopod ♀ (ventral). Scale bars = 0.05 mm.

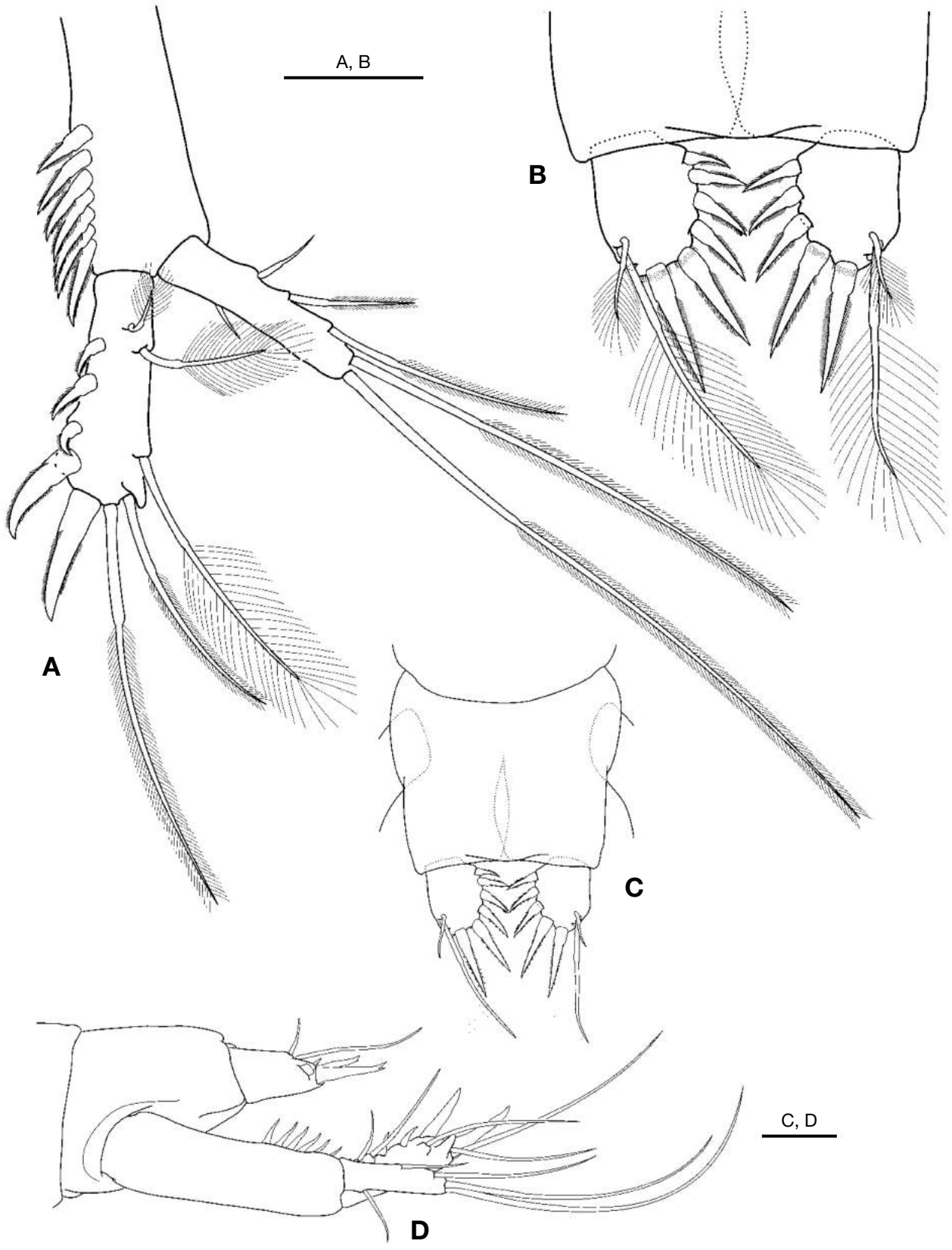


Fig. 29. *Allobathynella hongcheonensis*(holotype: ♀): (A) Uropod (dorsal); (B) Furcal rami (dorsal); (C) Pleotelson and furcal rami (dorsal); (D) Uropod, pleotelson and furcal rami (lateral). Scale bars = 0.05 mm.

ctenidia.

Mandible (Fig. 24A) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of nine spines. Palp of one segment, three times as long as wide, with one long terminal seta and one subterminal seta. Subterminal seta as long as one third of terminal one.

Maxillule (Fig. 25A) 2-segmented. Proximal segment with numerous numbers of ctenidia and with four setae on inner distal margin. Distal segment with two terminal smooth spines and six spines on inner edge, and with three simple setae on outer distal margin. Terminal spine as long as other ones. Five inner spines dentate.

Maxilla (Fig. 25B) four-segmented, setal formula 3-4-10-6.

Thoracopods I-VII (Figs. 25A, B, 26A, B, 27A, B, 28A). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-V, and with each one distal and median seta in thoracopods VI and VII. Number of segments of exopod of thoracopods I-VII: 3-4-4-5-5-4-4. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods I-VII and second segment lacking dorsal seta in thoracopod V. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	1 + 1/3 + 2/1 + 1/4(2)
Thoracopods II-IV	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod V	0 + 1/2 + 2/0 + 1/4(2)
Thoracopods VI, VII	0 + 1/1 + 2/0 + 1/4(2)

Thoracopod VIII of male (Fig. 28B, C) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with with eight or nine teeth. Epipod flat, with round distal part not reaching lower margin of exopod. Basipod with one short seta near base of endopod, inner margin of basipod with numerous teeth and spinules, distally drawn out into round projection, basipodal seta one half as long as endopod. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe with numerous denticles, lower lobe with three spinules. Endopod small, round, with two distal setae of different size. Outer seta 1.5 times longer than inner one.

Thoracopod VIII of female (Fig. 26C) tiny, round in ventral view, with two distal lobes with denticles.

First pleopod (Fig. 28D) in form of stub bearing two distal setae.

Uropod (Fig. 29A, D) bearing seven spines of similar size on inner margin of sympod. Endopod 48% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and three additional spines along inner margin. Terminal spine longer than subterminal one. Three spines of inner margin similar in size, one third as large as terminal spine. Exopod shorter than endopod (42% of sympod), with six setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 29B, C) without seta. Anal operculum slightly convex, nearly flat.

Furcal rami (Fig. 29B, C) 1.3 times as long as wide, with two large distal spines, and three (right) or four (left) successively smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella munmakensis* sp. nov.** (Figs. 30-35)

Etymology

The species name is derived from the town (Munmak-Eup), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratype (four adult females and four adult males). Holotype dissected in five slides (NIBR IV0000267089). Allotype dissected in five slides (NIBR IV0000267090). Four female paratypes and four male paratypes each as a whole specimen in separate slides (NIBR IV0000267090-0000267098).

Type locality

South-Korea, Ganwon-Do, Wonju-Si, Munmak-Eup, Anchang-Ri (37°20′17.2″N, 127°49′34.2″E), 03. November 2011, leg. J.-L. Cho.

Description

Size (mm). Body length: 1.83 (other females: 1.75-1.83; allotype: 1.83; other males: 1.70-1.82), approximately 12 times as long as wide. Head slightly shorter than anterior three thoracic segments combined (Fig. 30A).

Antennule (Fig. 30B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with one ventro-lateral seta, and two dorsal and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub

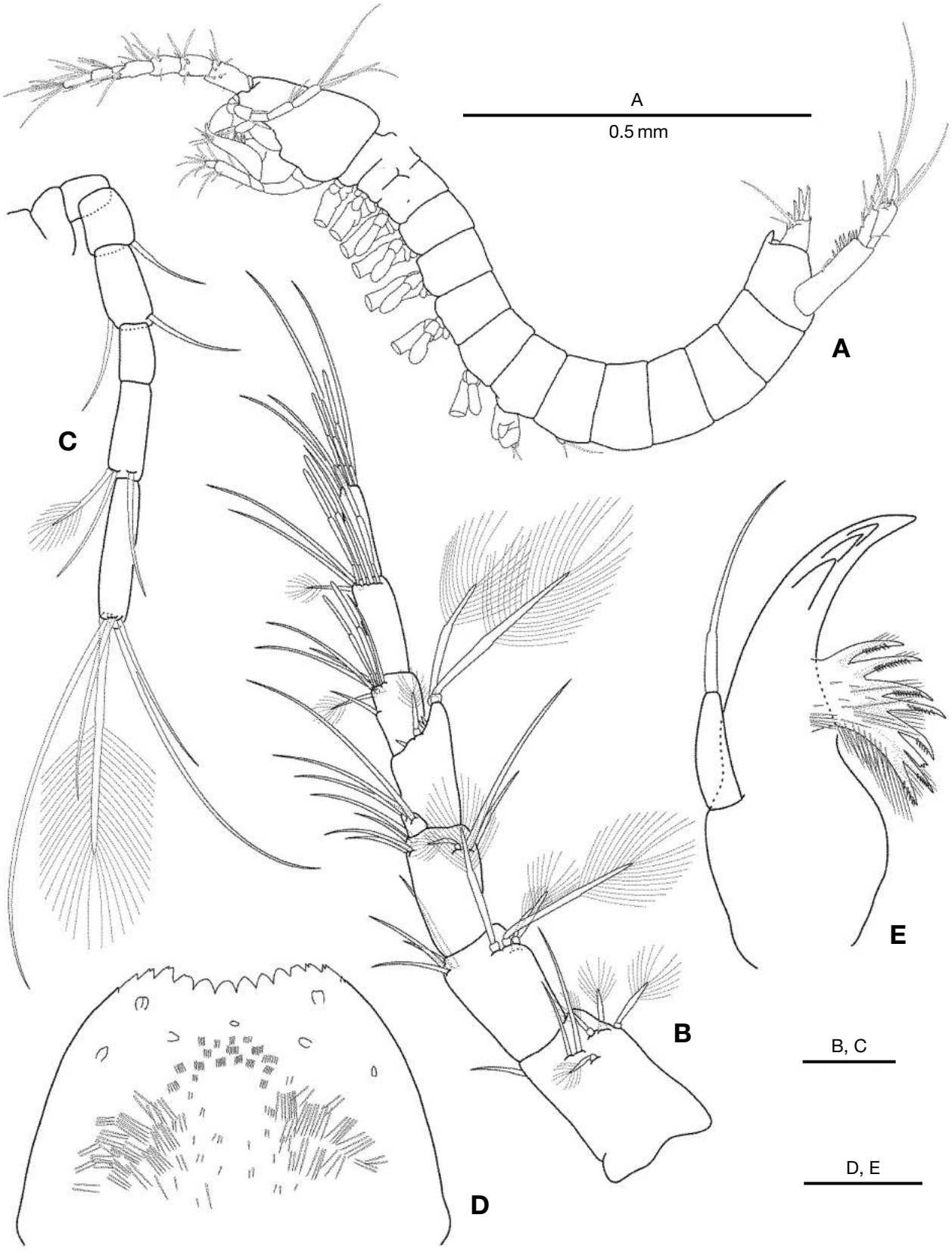


Fig. 30. *Allobathynella munmakensis* (holotype: ♂): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorso-lateral); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.05 mm, unless specified.

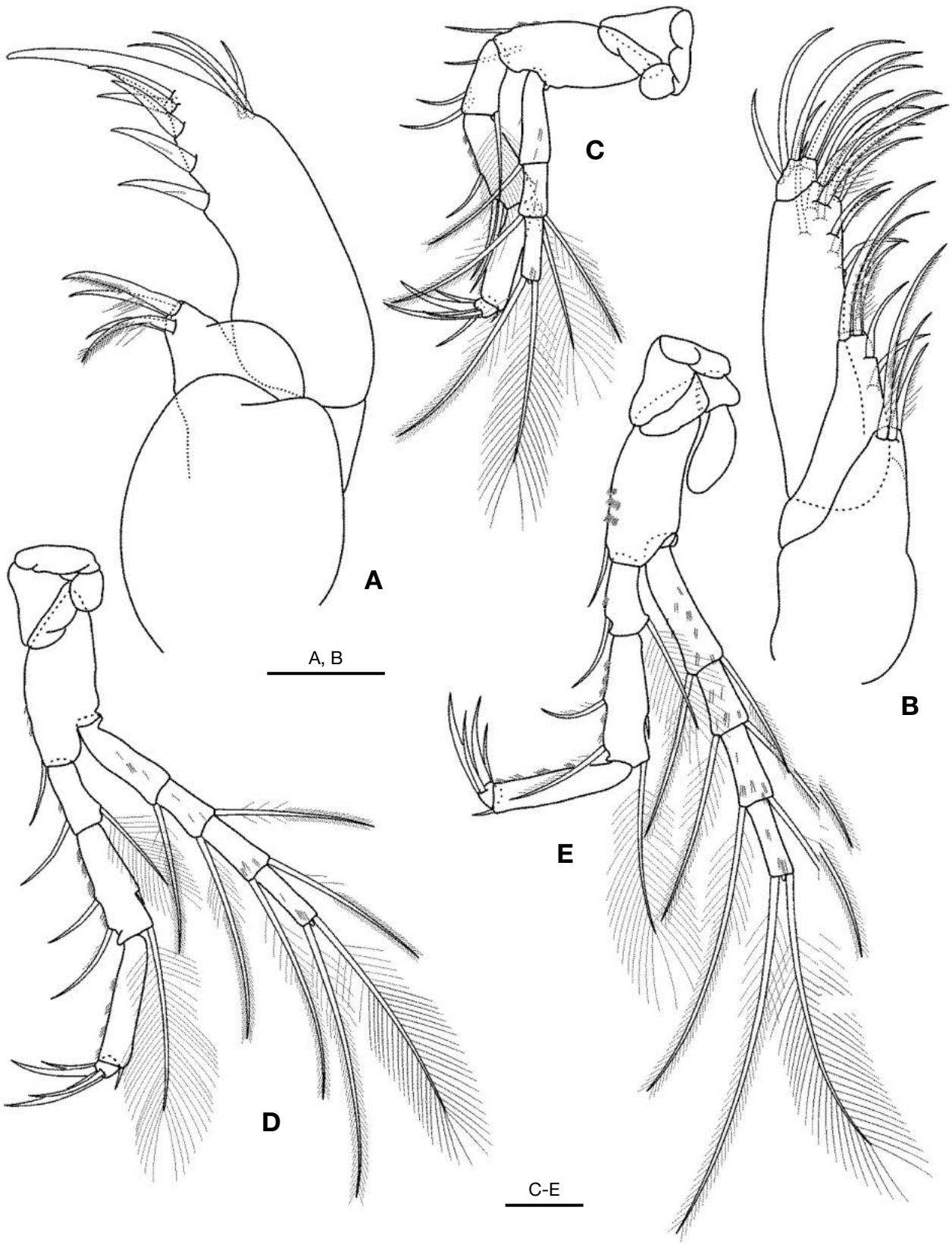


Fig. 31. *Allobathynella munmakensis* (holotype: ♂): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal); (E) Thoracopod III (frontal). Scale bars = 0.05 mm.

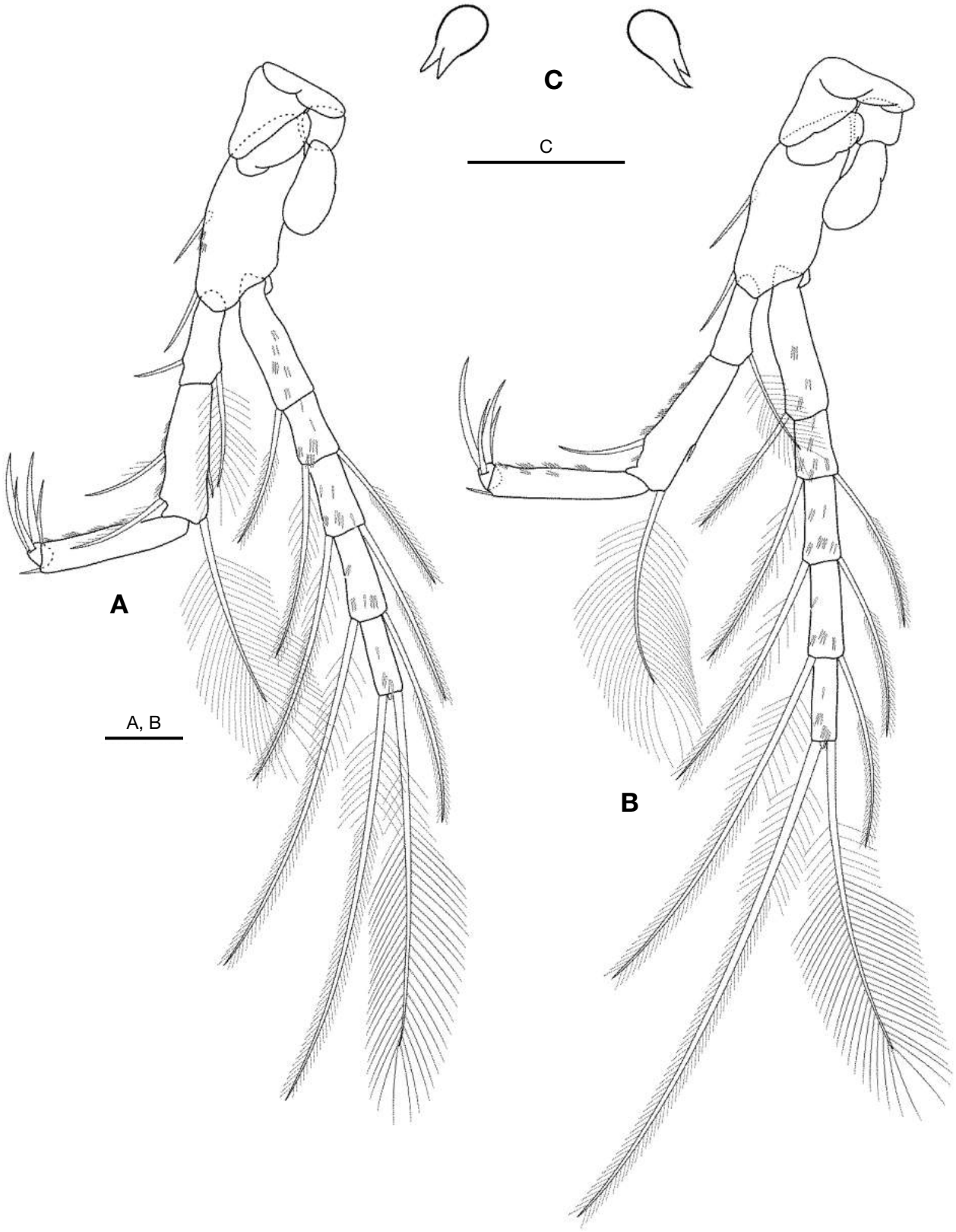


Fig. 32. *Allobathynella munmakensis* (holotype: ♂; allotype: ♀): (A) Thoracopod IV ♂ (frontal); (B) Thoracopod V ♂ (frontal); (C) Thoracopod VIII ♀ (ventral). Scale bars = 0.05 mm.

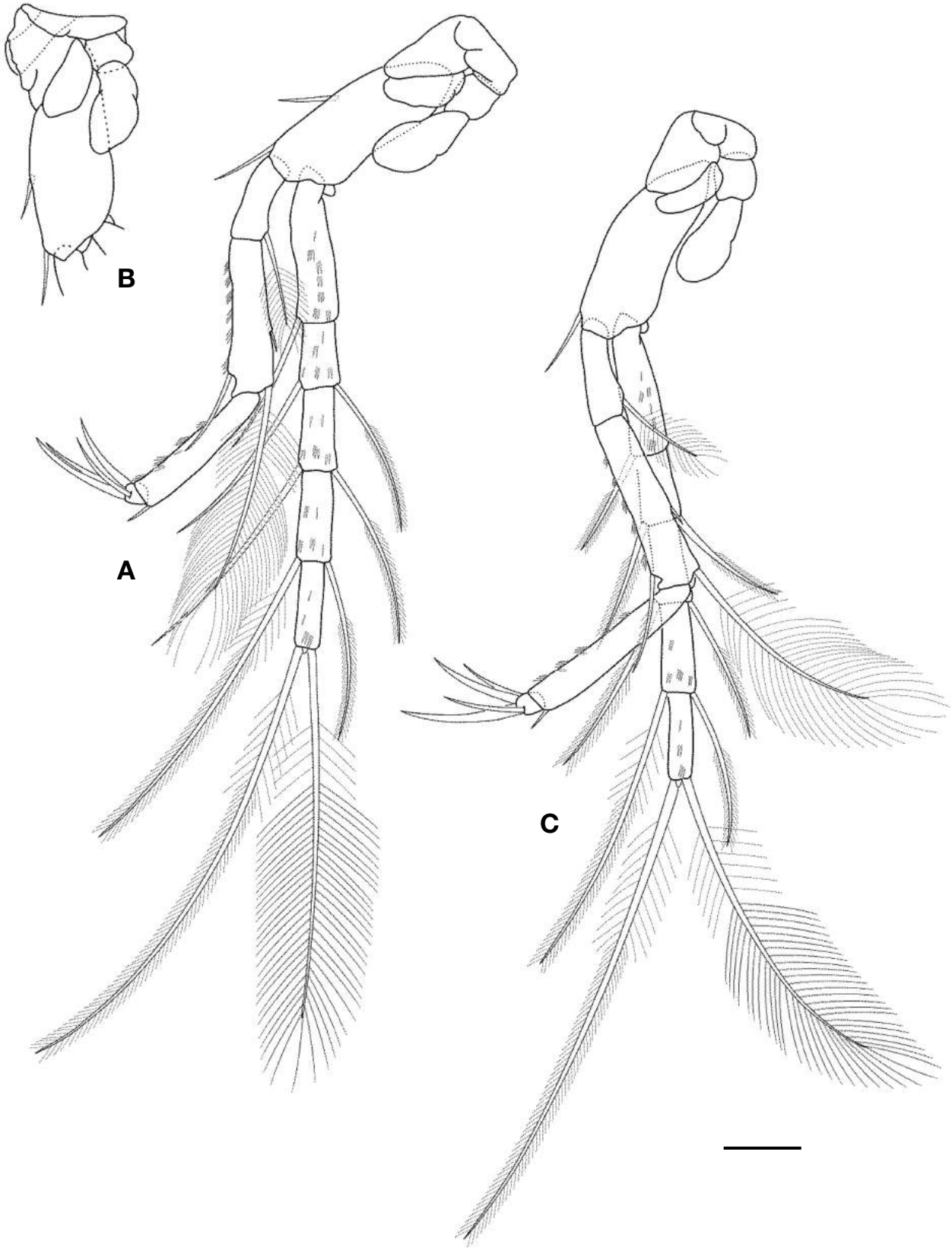


Fig. 33. *Allobathynella munmakensis* (holotype: ♂; allotype: ♀): (A) Thoracopod VI ♂ (frontal); (B) protopod of thoracopod VI ♀ (frontal); (C) Thoracopod VII ♂ (frontal). Scale bar = 0.05 mm.

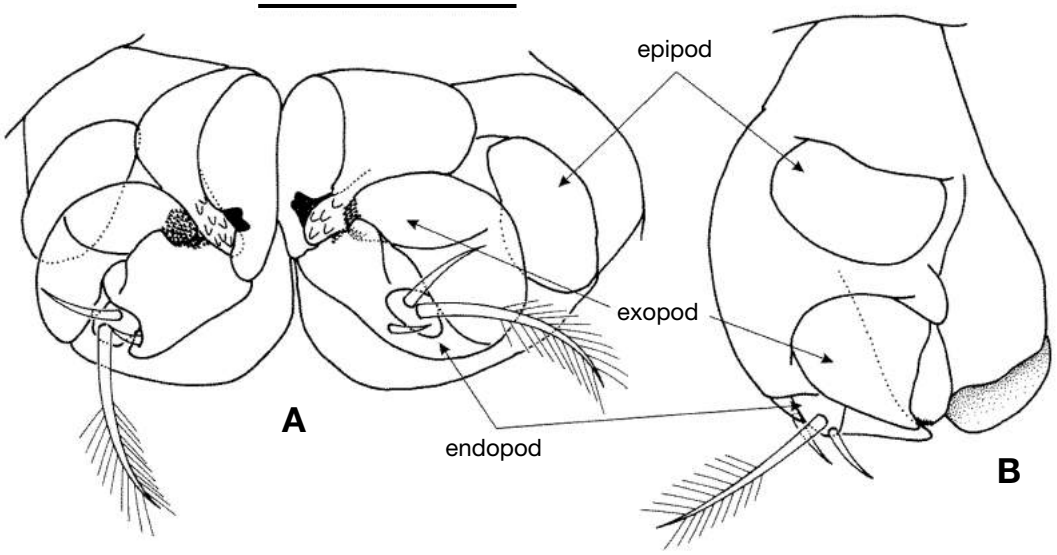


Fig. 34. *Allobathynella munmakensis* (holotype: ♂): (A) Thoracopod VIII (ventral); (B) Thoracopod VIII (lateral). Scale bar = 0.05 mm.

setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta and medially with one simple seta on inner margin. Sixth segment with three setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 30C) 7-segmented, as long as the length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 30D) flat, medially concave, free margin of eight main teeth flanked by three (left) or four (right) teeth on both lateral sides. Ventrally with one median projection without spinules, three pairs of teats and numerous combs of ctenidia.

Mandible (Fig. 30A) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of eight spines. Palp of one segment, 2.5 times as long as wide, with one long terminal seta.

Maxillule (Fig. 31A) 2-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal spines and six spines on inner edge, and with three simple setae on outer distal margin. All spines smooth. Terminal spine nearly two times as long as other ones.

Maxilla (Fig. 31B) four-segmented, setal formula 3-5-11-6.

Thoracopods I-VII (Figs. 31A, B, 32A, B, 33A-C). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II, III and VII, and with each one distal and median seta in thoracopods IV, V and VI. Number of segments of the exopod of the thoracopods I-VII: 3-4-4-5-5-5-5. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods I, II, IV, V and VI. Dorsal seta on distal segment of exopod barbed with strong hairs. Tiny process present between two setae of distal segment. The endopod of the thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/1 + 1/4(2)
Thoracopods II-IV	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod V-VII	0 + 1/1 + 2/0 + 1/4(2)

Thoracopod VIII of male (Fig. 34A, B) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with with eight or nine teeth. Epipod flat with round distal part not reaching lower margin of exopod. Basipod with one short seta near the base of endopod, inner margin of basipod with numerous teeth and spinules, distally drawn out into round projection, basipodal seta as long as endopod. Exopod one third of the size of the basipod, round, with two distal lobes carrying numerous denticles distally. Endopod small, round, with two distal setae of different size. Outer seta 2.5 times longer than inner one.

Thoracopod VIII of female (Fig. 32C) tiny, oval in ventral view, bifurcate distally.

First pleopod in form of stub bearing two distal setae.

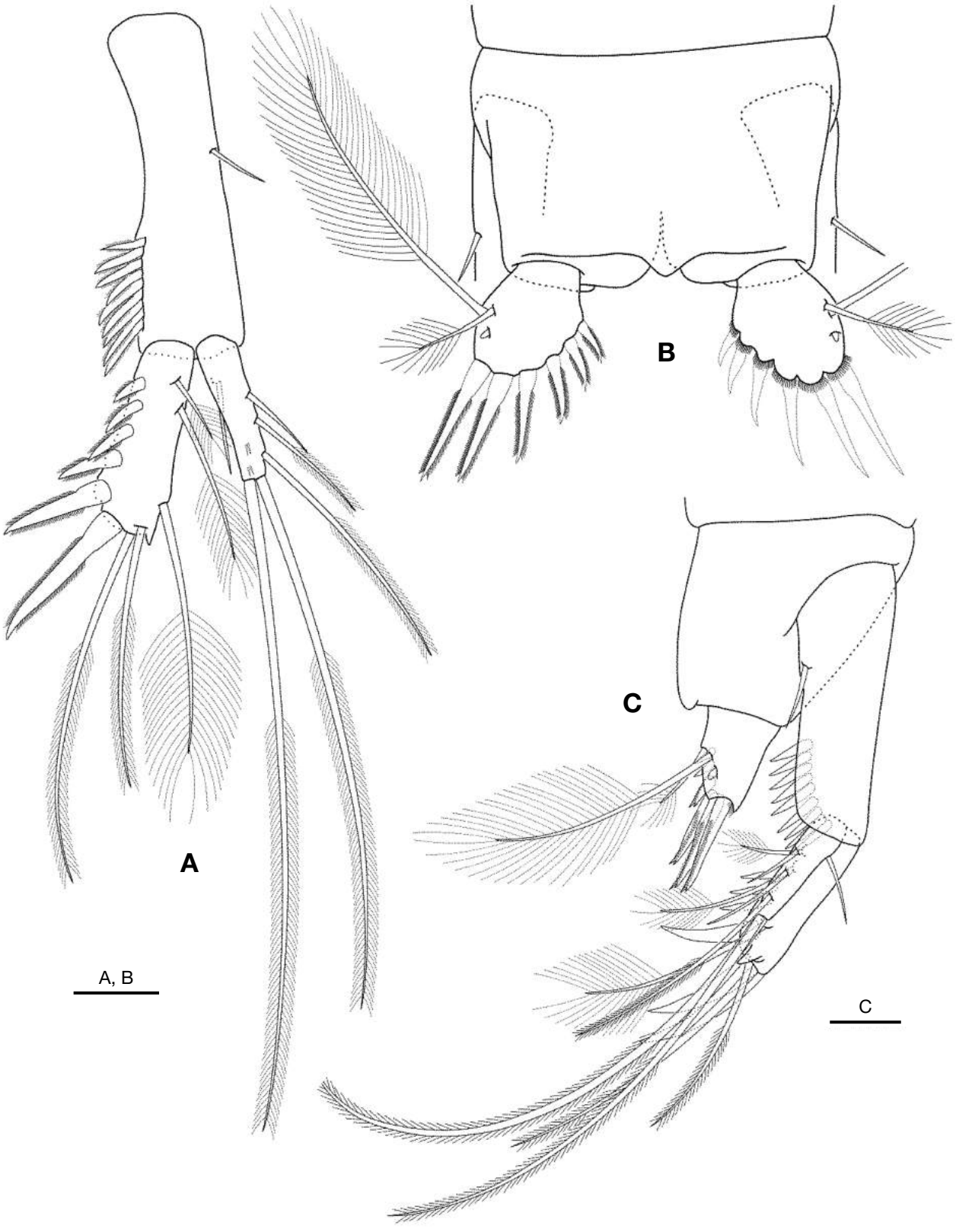


Fig. 35. *Allobathynella munmakensis* (holotype: ♂): (A) Uropod (dorsal); (B) Pleotelson with furcal rami (dorsal); (C) Pleotelson, uropod and furcal ramus (lateral). Scale bars = 0.05 mm.

Uropod (Fig. 35A, C) bearing one lateral seta medially and nine spines of similar size on inner margin of sympod. Endopod 48% as long as sympod, with two dorsal plumose setae near the base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and four additional spines along inner margin. The terminal spine longer than subterminal one. Distal spine of four spines of inner margin half as large as subterminal one, 1.2 times larger than remaining three spines. Exopod shorter than endopod (40% of sympod), with six setae including one basi-ventral seta.

Pleotelson (Fig. 35B, C) without seta. Anal operculum nearly flat with protruding middle part.

Furcal rami (Fig. 35B, C) 1.3 times as long as wide, with two large distal spines, and four successively smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella okcheonensis* sp. nov.** (Figs. 36-40)

Etymology

The species name is derived from the county (Okcheon-Gun), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratype (adult male). Holotype dissected on seven slides (NIBR IV0000140013). Allotype dissected on four slides (NIBR IV0000140014).

Paratype kept as a whole specimen in a slide (NIBR IV0000140015).

Type locality

South-Korea, Chungcheogbuk-Do, Okcheon-Gun Iweon-Myeon (36°14′36.5″N, 127°37′18.5″E), 04. April 2010, leg. J.-L. Cho and J.-G. Park.

Description

Size (mm). Body length: ♀ 2.73, ♂ 2.47, 2.26, approximately 14 times as long as wide. Head slightly shorter than anterior three thoracic segments combined (Fig. 36A). Female differs from male in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 36B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with two simple setae dorsally and one simple seta ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with two ventrolateral setae, and one dorsal seta and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 36C) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 2/5(1).

Labrum (Fig. 37A) flat, with eight main teeth flanked by two teeth on both lateral sides. Ventral surface concave, with two round median projections without spinules, numerous combs of ctenidia and two pairs of teats.

Mandible (Fig. 37B, C) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of 15 spines. Palp of one segment, 2.5 times as long as wide, with one long terminal seta and one subterminal seta. Subterminal seta as long as one third of terminal one.

Maxillule (Fig. 37D) two-segmented. Proximal segment with numerous numbers of ctenidia and with four setae on inner distal margin. Distal segment with two terminal smooth spines and five dentate spines on inner edge, and with three simple setae on outer distal margin. Terminal spine 1.5 times as long as other ones.

Maxilla (Fig. 37F) four-segmented, setal formula 3-5-11-8.

Thoracopods I-VII (Figs. 37F, G, 38A-C, 39A-C). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-VI, and with each one distal and median seta in thoracopod VII. Number of segments of exopod of thoracopods I-VII: 3-4-5-6-6-6-6. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods III-VII. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/1 + 1/4(2)
Thoracopods II, III	1 + 1/2 + 2/1 + 1/4(2)
Thoracopods IV-VI	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod VII	1 + 1/1 + 2/0 + 0/4(2)

Thoracopod VIII of male (Fig. 40A, B) perpendicular to body, in form of a bell in lateral view, 1.5 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region

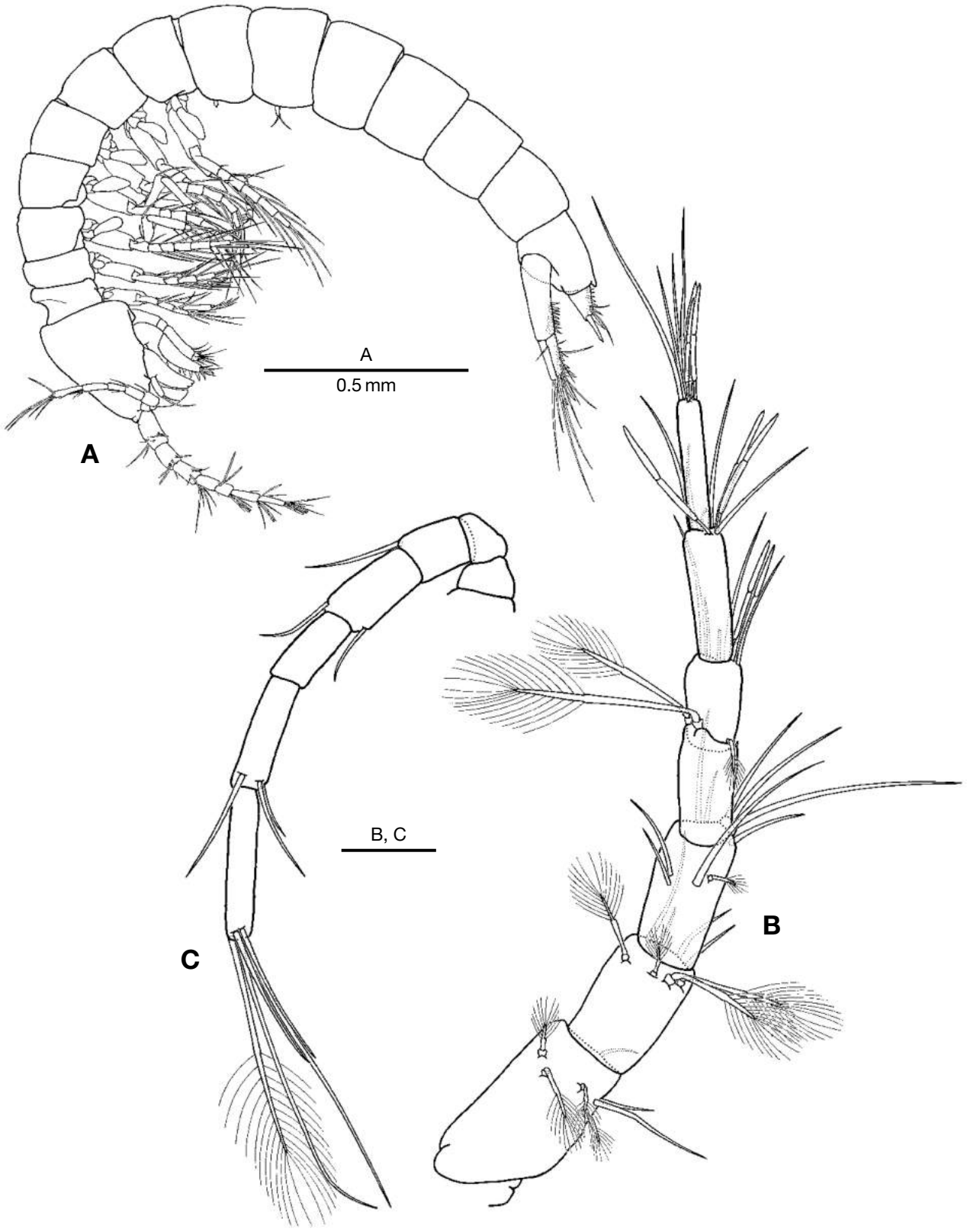


Fig. 36. *Allobathynella okcheonensis* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (lateral); (C) Antenna (dorsal, slightly lateral). Scale bars = 0.05 mm, unless specified.

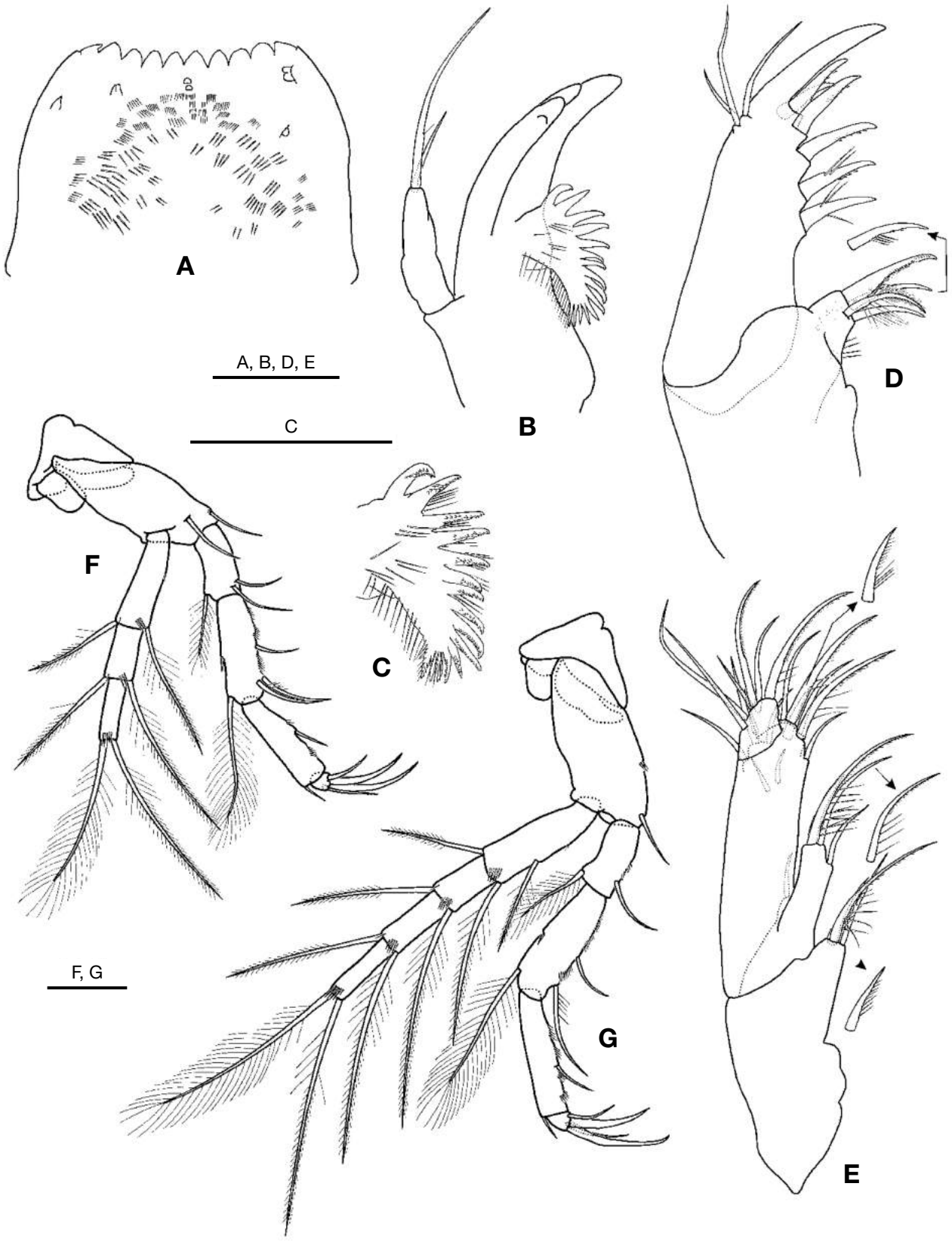


Fig. 37. *Allobathynella okcheonensis* (holotype: ♀): (A) Labrum (ventral); (B) Mandible (dorsal); (C) Molar process; (D) Maxillule (dorsal); (E) Maxilla (dorsal); (F) Thoracopod I (frontal); (G) Thoracopod II (frontal). Scale bars = 0.05 mm.

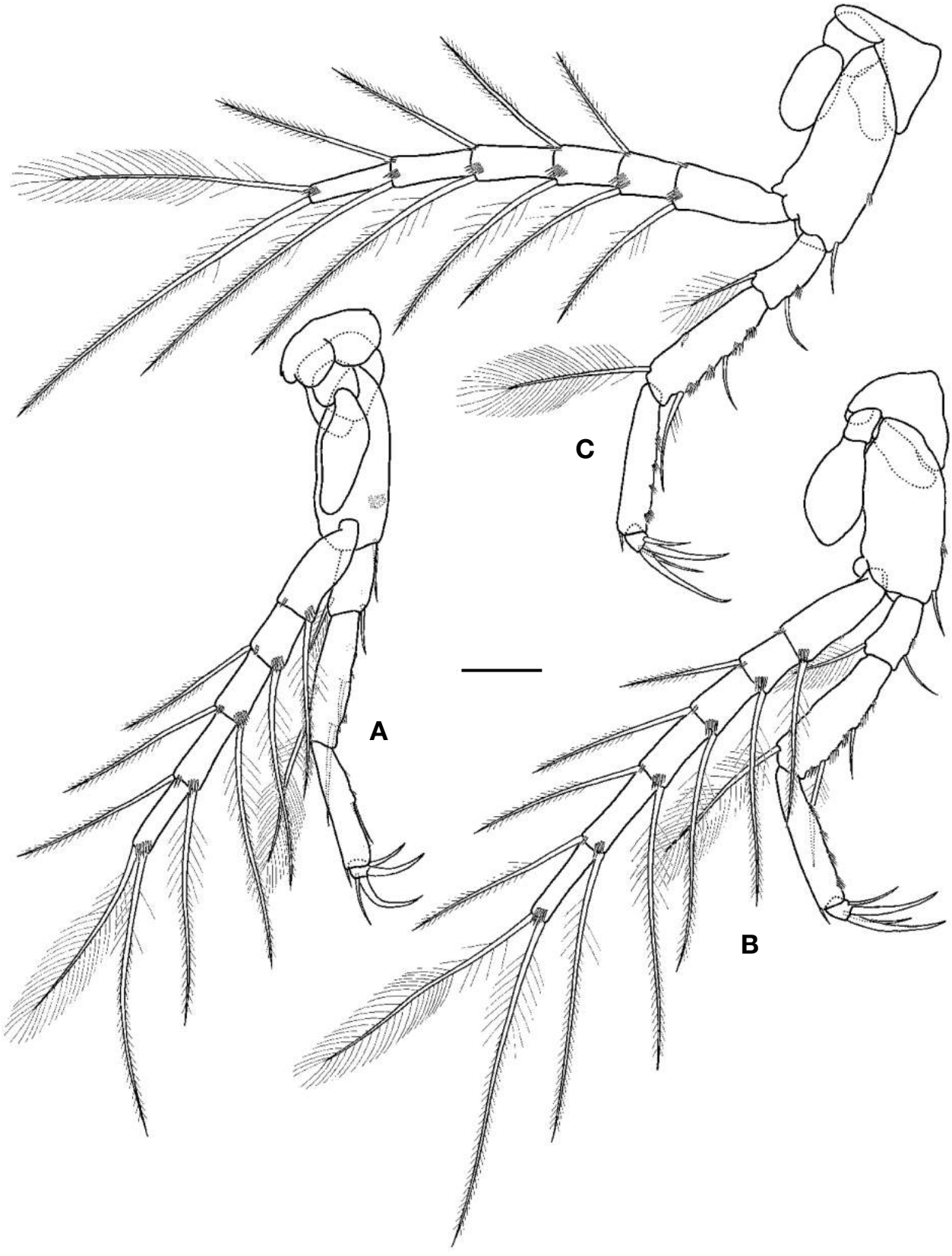


Fig. 38. *Allobathynella okcheonensis* (holotype: ♀): (A) Thoracopod III (frontal); (B) Thoracopod IV (frontal); (C) Thoracopod V (frontal). Scale bar = 0.05 mm.

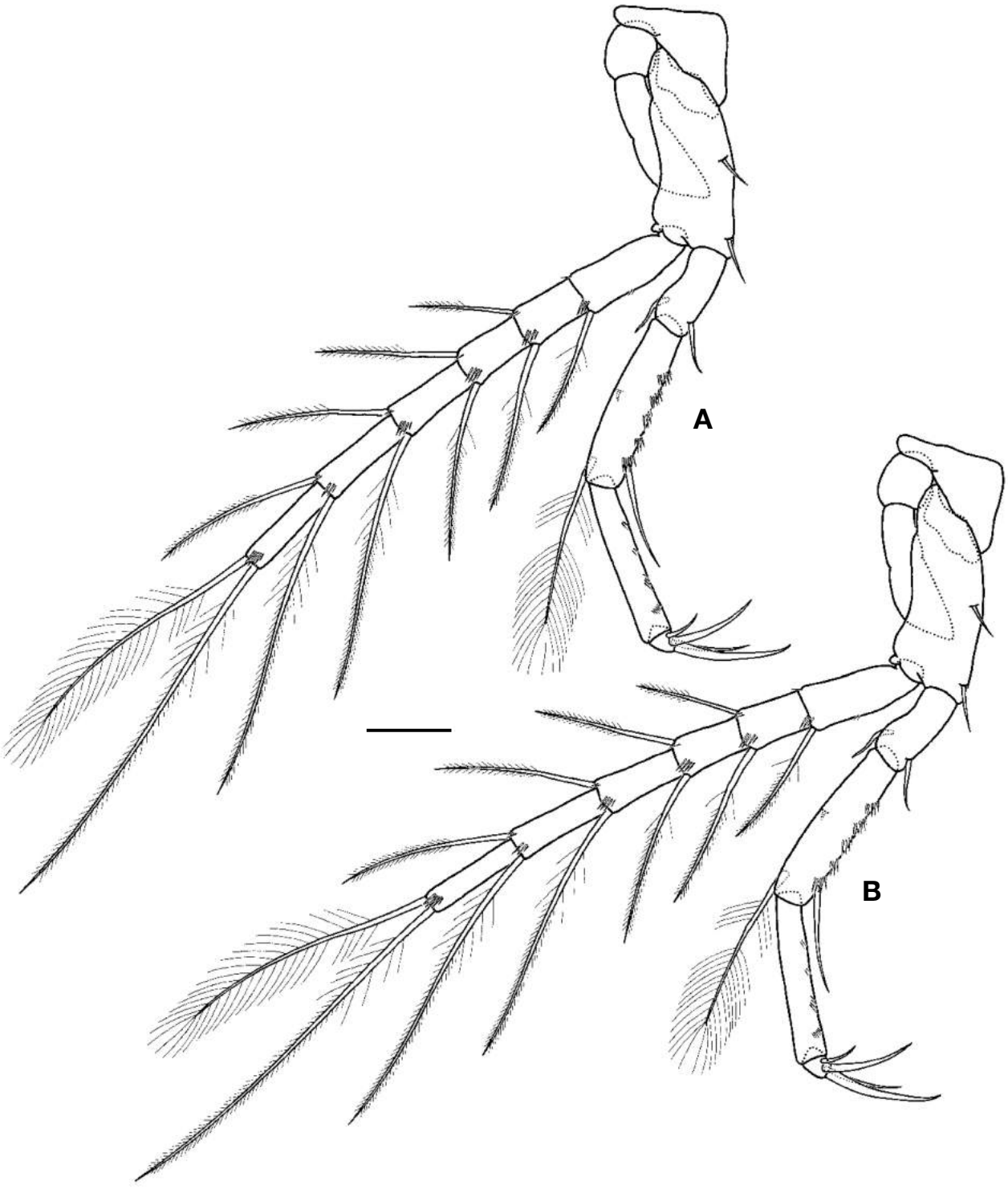


Fig. 39. *Allobathynella okcheonensis* (holotype: ♀): (A) Thoracopod VI (frontal); (B) Thoracopod VII (frontal). Scale bar = 0.05 mm.

with numerous tiny teeth. Epipod flat, with round distal part not reaching lower margin of exopod. Basipod with one short seta near base of endopod, distally drawn out into round projection, basipodal seta two thirds as long as endopod. Exopod one third of size of basipod, round, with two distal lobes. Each lobes with three dentils, respectively. Endopod small, round, with two distal setae of different size. Outer seta two times longer than inner

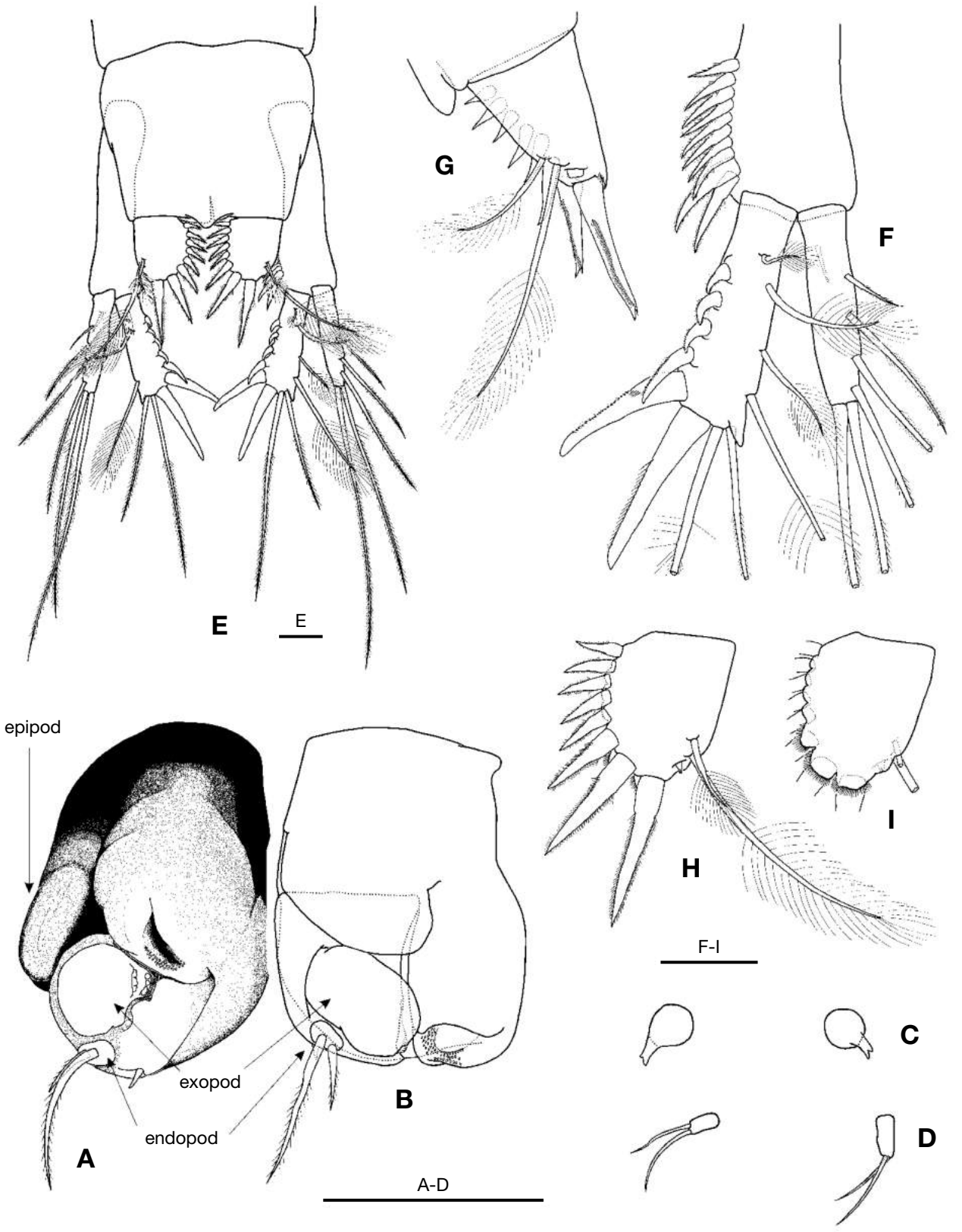


Fig. 40. *Allobathynella okcheonensis* (holotype: ♀; allotype: ♂): (A) Thoracopod VIII ♂ (fronto-ventral); (B) Thoracopod VIII ♂ (lateral); (C) Thoracopod VIII ♀; (D) Pleopod; (E) Uropod, pleotelson and furcal rami (dorsal); (F) Uropod (dorsal); (G) Furcal raums (lateral); (H) Furcal ramus (dorsal); (I) Furcal ramus (ventral). Scale bars = 0.05 mm.

one. Thoracopod VIII of female (Fig. 40C) of female tiny, round in ventral view, with a projection forked distally.

First pleopod (Fig. 40D) in form of stub bearing two distal setae.

Uropod (Fig. 40E, F) bearing ten spines on inner margin of sympod. Two distal spines longer and thicker than others. Endopod 53% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and four (right) or five (left) additional spines on inner margin. Terminal spine slightly thicker and stronger than subterminal one. Most distal spine of inner margin 50% as large as terminal spine and 1.5 times as large as proximal spine. Exopod slightly shorter than endopod (50% of sympod), with seven setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 40E) without seta. Anal operculum protruded with round tip.

Furcal rami (Fig. 40E, G-I) 1.2 times as long as wide, with two large distal spines, and six smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella yeongjuensis* sp. nov.** (Figs. 41-45)

Etymology

The species name is derived from the city (Yeongju-Si), where the material was collected.

Material examined

Holotype (adult male), allotype (adult female), paratype (one adult male and two adulte females). Holotype dissected on six slides (NIBR IV0000140016). Allotype dissected on six slides (NIBR IV0000140017). Paratypes each kept as a whole specimen in separate slides (NIBR IV0000140018-000140020).

Type locality

South-Korea, Kyungsangbuk-Do, Yeongju-Si Munjeong-Myeon (37°27′09.5″N, 127°31′01.5″E), 23. October 2009, leg. J.-L. Cho.

Description

Size (mm). Body length of holotype: 1.86; other male: 1.79. Body length of allothye: 1.73; other females: 1.67, 1.56; approximately 14 times as long as wide. Head as long as anterior three thoracic segments combined (Fig. 41A). Female differs from male in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 41A) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with two ventrolateral setae, and one dorsal seta and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 41C) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 0/0 + 0/1 + 1 + 1/4(1).

Labrum (Fig. 42A) flat, with eight main teeth flanked by three teeth on both lateral sides. Ventral surface concave, with one round median projection without spinules, numerous combs of ctenidia and two pairs of teats.

Mandible (Fig. 42A) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of seven spines. Palp of one segment, 2.5 times as long as wide, with one terminal seta.

Maxillule (Fig. 42B) two-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal smooth spines and four dentate spines on inner edge, and with three simple setae on outer distal margin. Terminal spine 1.2 times as long as other ones.

Maxilla (Fig. 42C) four-segmented, setal formula 3-5-10-6.

Thoracopods I-VII (Figs. 42D, E, 43A-C, 44A-C). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-VI, and with each one distal and median seta in thoracopod VII. Number of segments of exopod of thoracopods I-VII: 3-4-5-5-4-4-4. Exopodal segments with each one dorsal and ventral seta. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/2 + 1/4(2)
Thoracopods II-IV	1 + 1/2 + 2/1 + 1/4(2)
Thoracopod V	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod VI	1 + 1/1 + 2/0 + 1/4(2)
Thoracopod VII	0 + 1/1 + 2/0 + 1/4(2)

Thoracopod VIII of male (Fig. 44D-F) perpendicular to body, in form of a bell in lateral view, 1.2 times lon-

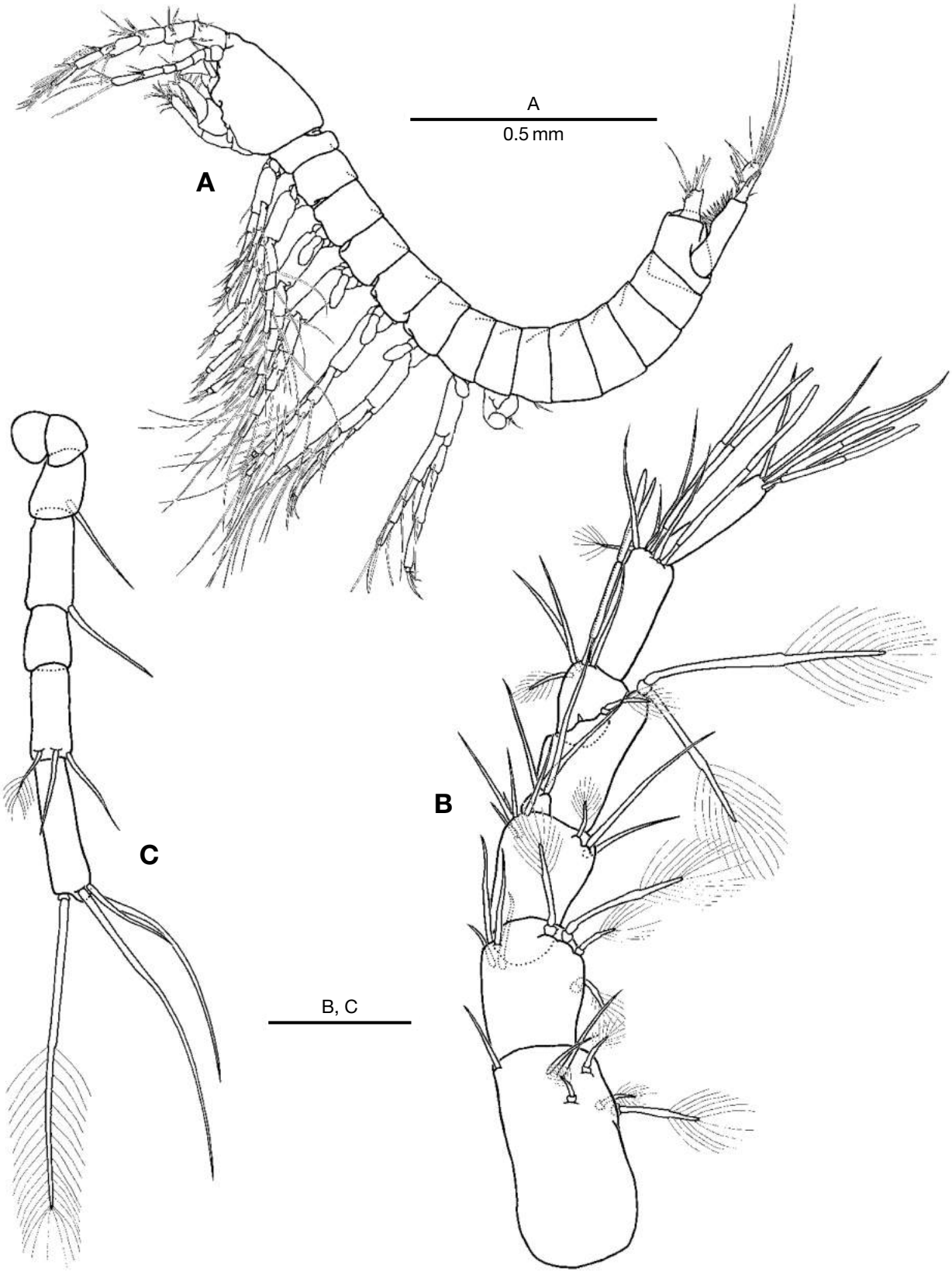


Fig. 41. *Allobathynella yeongjuensis* (holotype: ♂; allotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorsal). Scale bars = 0.05 mm, unless specified.

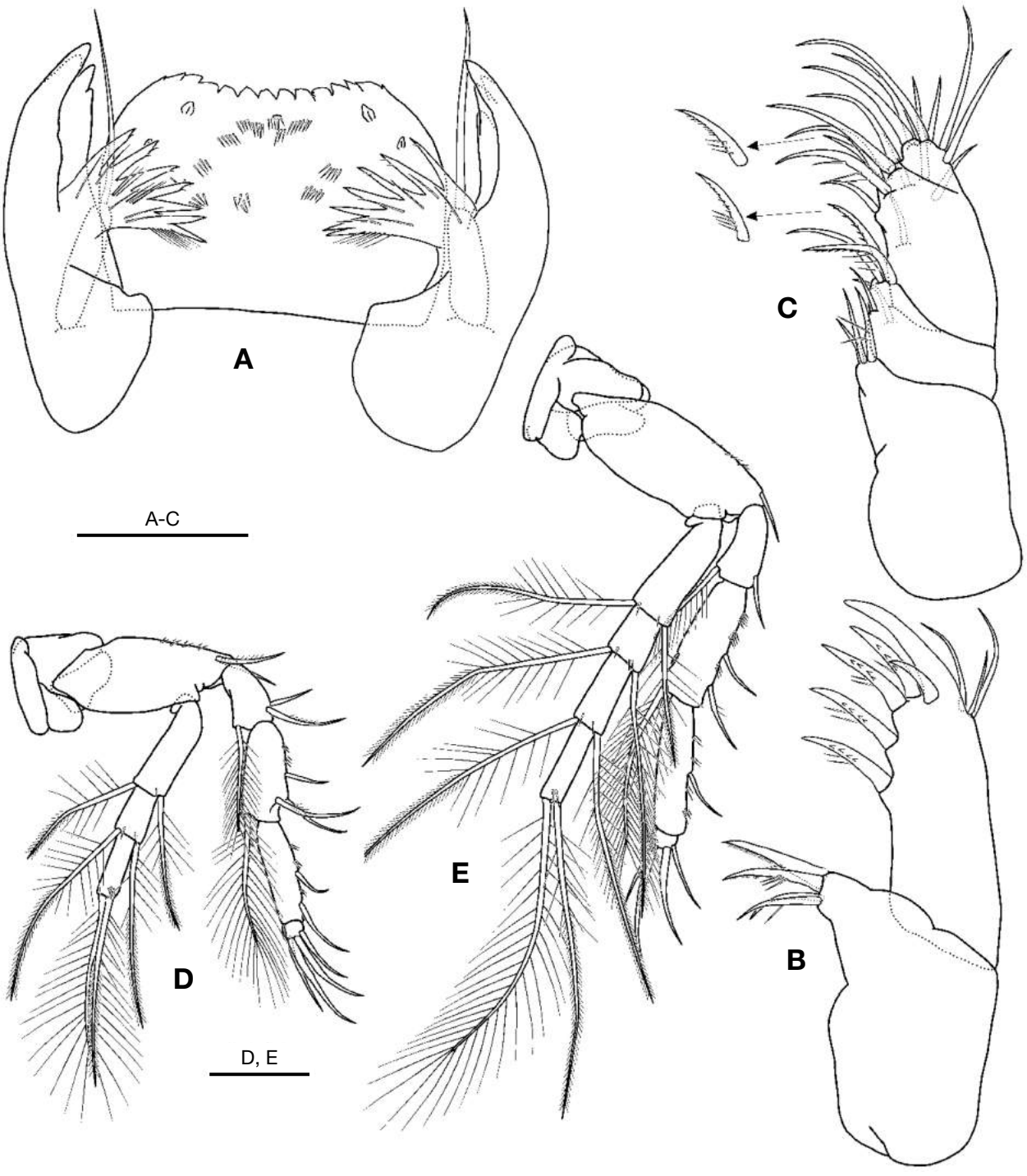


Fig. 42. *Allobathynella yeongjuensis* (holotype: ♂): (A) Labrum and mandibles (ventral); (B) Maxillule (dorsal); (C) Maxilla (dorsal); (D) Thoracopod I (frontal); (E) Thoracopod II (frontal). Scale bars = 0.05 mm.

ger than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region with seven teeth. Epipod flat, with round distal part not reaching lower margin of exopod. Basipod without setae near base of endopod, distally drawn out into round projection. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe smooth, lower lobe distally serrated. Endopod small, round, with two distal setae of different size. Outer seta two times longer than inner one. Thoracopod VIII of female (Fig. 45A) tiny, round

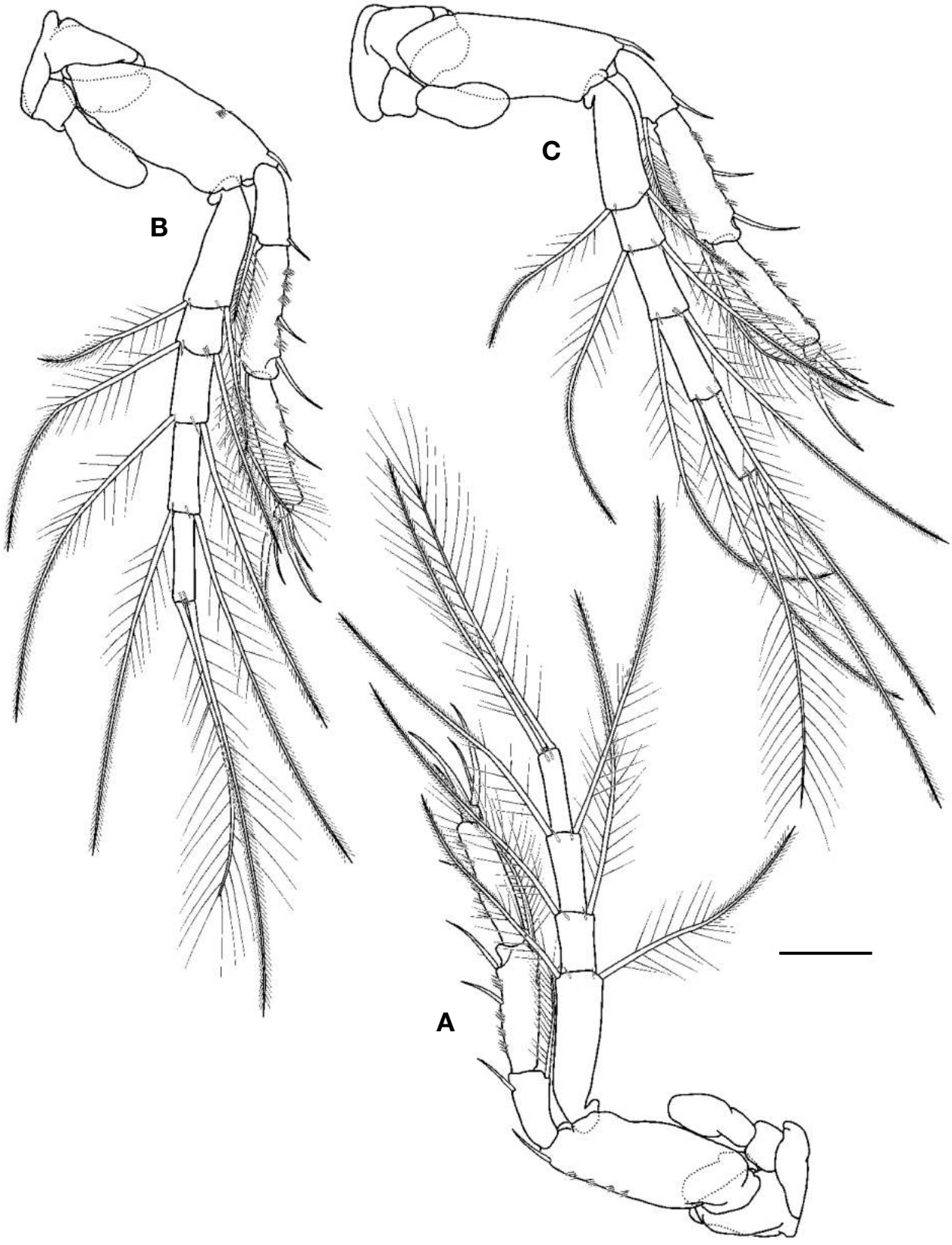


Fig. 43. *Allobathynella yeongjuensis* (holotype: ♂): (A) Thoracopod III (frontal); (B) Thoracopod IV (frontal); (C) Thoracopod V (frontal). Scale bar = 0.05 mm.

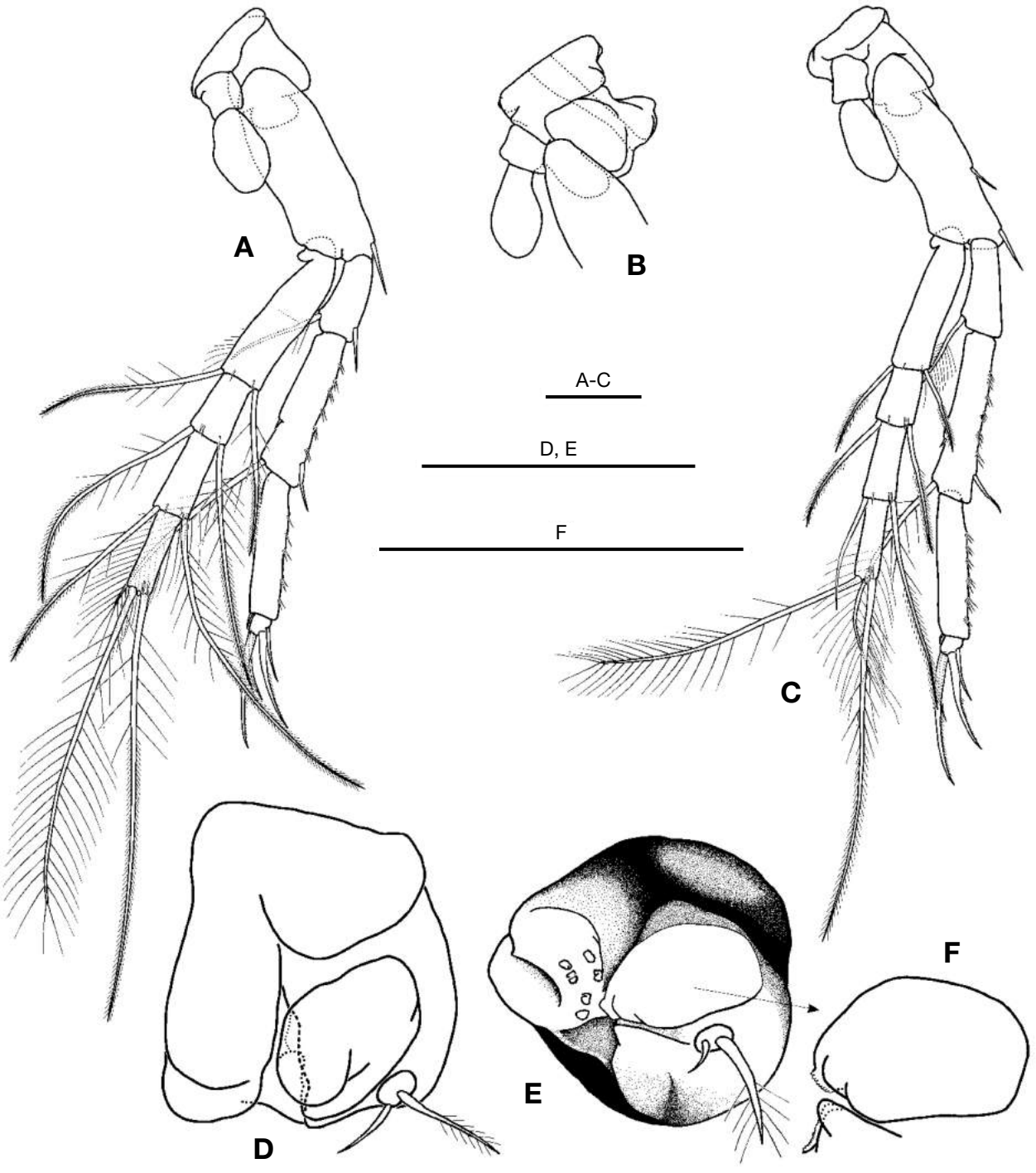


Fig. 44. *Allobathynella yeongjuensis* (holotype: ♂; allotype: ♀): (A) Thoracopod VI ♂ (frontal); (B) Protopod of thoracopod VI ♀ (frontal); (C) Thoracopod VII ♂ (frontal); (D) Thoracopod VIII ♂ (lateral); (E) Thoracopod VIII ♂ (ventral); (F) Exopod of thoracopod VIII ♂. Scale bars = 0.05 mm.

in ventral view, with two spine-like projections.

First pleopod (Fig. 45A) in form of stub bearing one plumose seta and one tiny seta.

Uropod (Figs. 45B, C) bearing ten spines on inner margin of sympod. Most distal spines longer and thicker than others. Endopod 50% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose setae on outer margin and

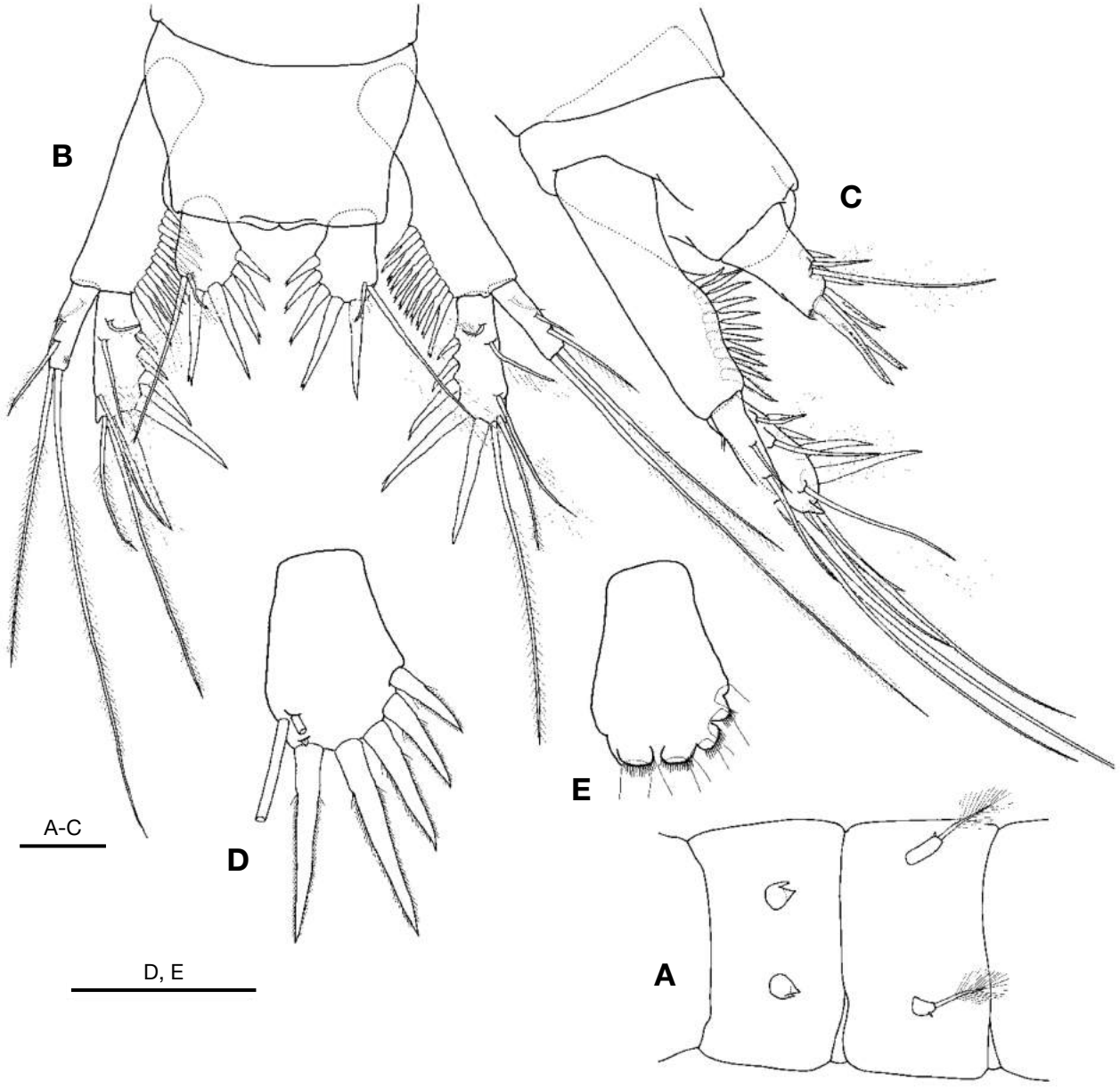


Fig. 45. *Allobathynella yeongjuensis* (holotype: ♂; allotype: ♀): (A) Thoracopod VIII and pleopod ♀ (ventral); (B) Uropod, pleotelson and furcal rami ♂ (ventral); (C) Uropod, pleotelson and furcal rami ♂ (lateral); (D) Furcal ramus ♂ (dorsal): (E) Furcal ramus ♂ (ventral). Scale bars = 0.05 mm.

with one terminal spine, one subterminal spine and three additional spines on inner margin. Terminal spine slightly thicker and stronger than subterminal one. Most distal spine of inner margin 50% as large as terminal spine and two times as large as proximal ones. Exopod shorter than endopod (34% of sympod), with five setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 45B, C) without seta. Anal operculum nearly flat.

Furcal rami (Fig. 45C-E) 1.5 times as long as wide, with two large distal spines, and three smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella buronensis* sp. nov.** (Figs. 46-51)

Etymology

The species name is derived from the town (Buron-Myeon), where the material was collected.

Material examined

Holotype (adult male), allotype (adult female), paratype (nine adult males). Holotype dissected on seven slides (NIBR IV0000266812). Allotype dissected on six slides (NIBR IV0000266813). Six male paratypes each kept as a whole specimen on separate slides (NIBR IV0000266814-0000266819), three adult males in a vial (NIBR IV0000266820).

Type locality

South-Korea, Gangwon-Do, Wonju-Si Buron-Myeon Heungho-Ri (37°14′35.0″N, 127°44′54.7″E), 26. October 2012, leg. J.-L. Cho.

Description

Size (mm). Body length: ♂ 1.66 (other males: 1.66, 1.66, 1.65, 1.64, 1.64, 1.62), ♀ 1.66, approximately 11 times as long as wide. Head slightly shorter than anterior three thoracic segments combined (Fig. 46A). Female differs from male in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 46B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with two ventrolateral setae, and two dorsal setae and three ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 46C) 7-segmented, as long as length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 46D) flat, with six main teeth flanked by two teeth on both lateral sides. Ventral surface convex, with three round median projections without spinules, numerous combs of ctenidia and one pair of teats.

Mandible (Fig. 46E) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of seven spines. Palp of one segment, 2.5 times as long as wide, with one terminal seta and one subterminal seta. Terminal seta two times longer than subterminal seta.

Maxillule (Fig. 47A) two-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal smooth spines and five dentate spines on inner edge, and with three simple setae on outer distal margin. Terminal spine 1.3 times as long as other ones.

Maxilla (Fig. 47B) four-segmented, setal formula 3-4-10-6.

Thoracopods I-VII (Figs. 47C, D, 48A, B, 49A-C, 50A). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-VI, and with each one distal and median seta in thoracopod VII. Number of segments of exopod of thoracopods I-VII: 2-3-4-4-4-4-4. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopod II-VII and ventral seta in thoracopod VII. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/1 + 1/4(2)
Thoracopod II	1 + 1/2 + 2/0 + 1/4(2)
Thoracopods III-V	1 + 1/1 + 2/0 + 1/4(2)
Thoracopods VI-VII	0 + 1/1 + 2/0 + 1/3(1)

Thoracopod VIII of male (Fig. 50B, C) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with seven or eight teeth. Epipod flat, with round distal part not reaching lower margin of exopod. Basipod with one small seta near base of endopod, inner margin smooth, distally drawn out into round projection. Basipodal seta as long as endopod. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe with five spinules, lower lobe smooth. Endopod small, round, with two distal setae of different size. Outer seta two times longer than inner one. Thoracopod VIII of female (Fig. 48C) tiny, round in ventral view, with two distal projections.

First pleopod (Fig. 48D) in form of stub bearing two distal setae.

Uropod (Fig. 51A, C) bearing eight or nine spines of similar size on inner margin of sympod. Endopod 52% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and three additional spines along inner margin. Terminal spine slightly thicker and stronger than subterminal one. Most distal spine of of inner margin half as large as terminal spine and 1.5 times larger than proximal one. Exopod remarkably shorter than endopod (36% of sympod), with five setae including one basi-ventral seta.

Pleotelson (Fig. 51A, B) without seta. Anal operculum

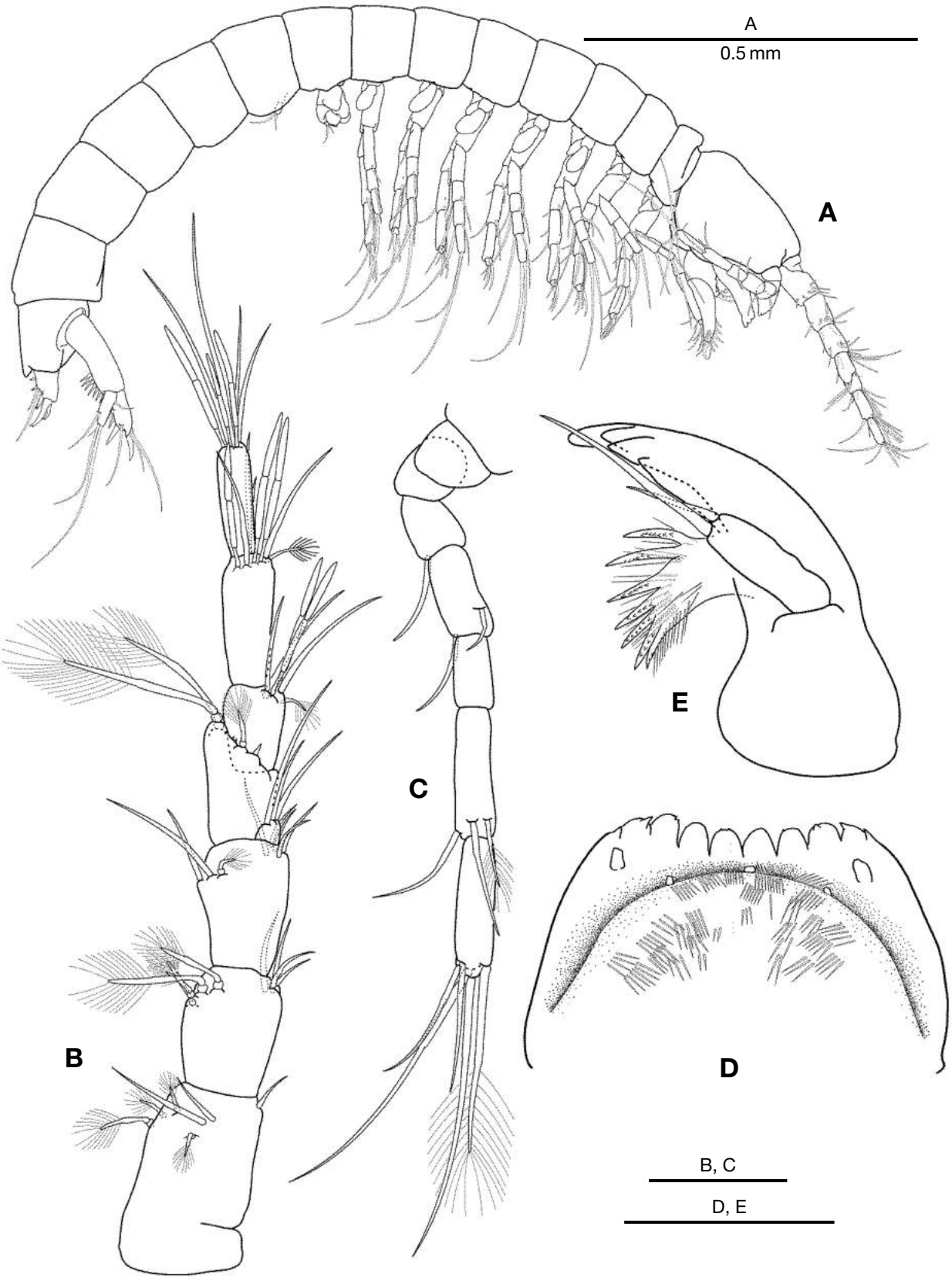


Fig. 46. *Allobathynella buronensis* (holotype: ♂): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorsal); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.05 mm, unless specified.

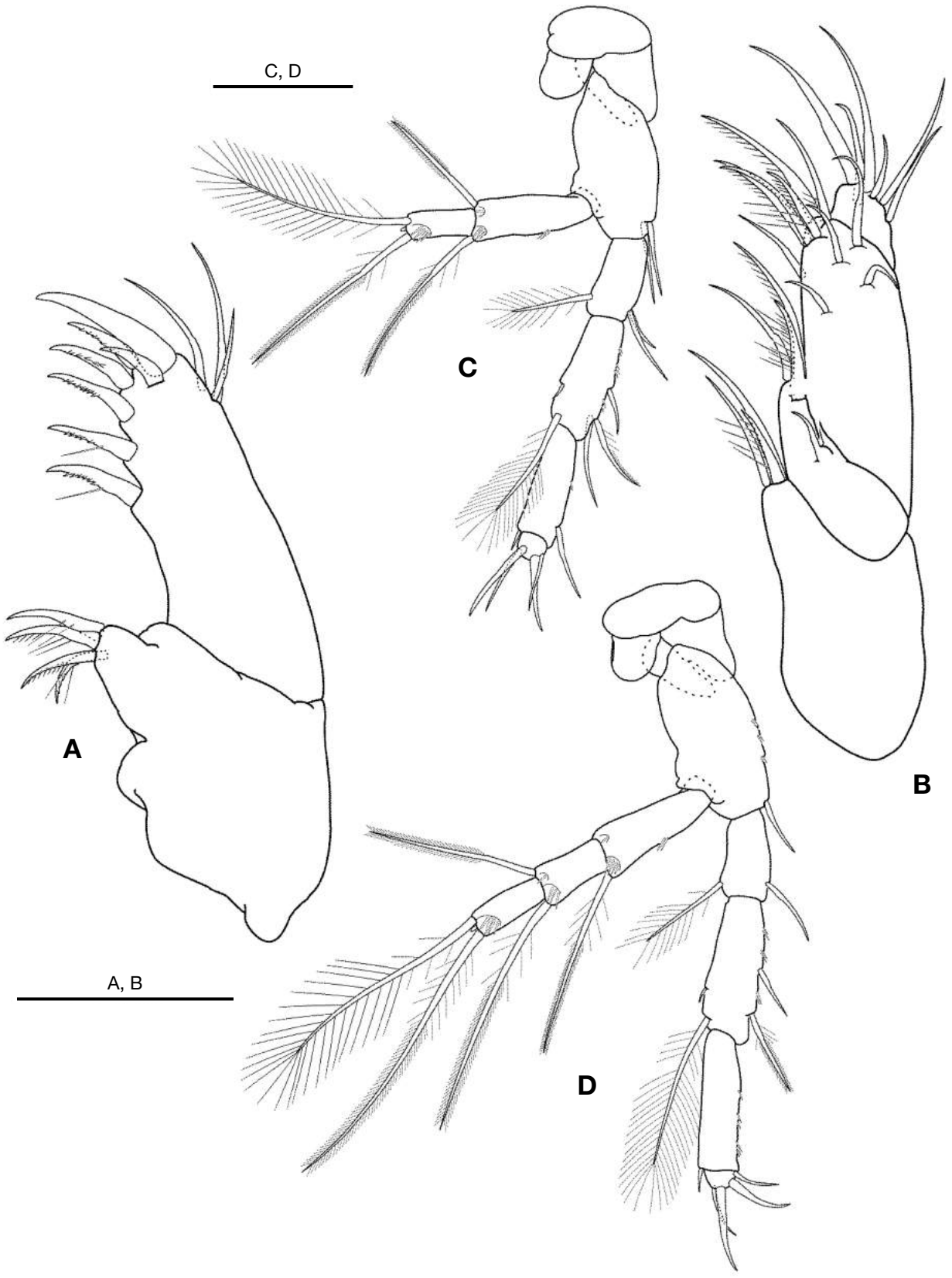


Fig. 47. *Allobathynella buronensis* (holotype: ♂): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal). Scale bars = 0.05 mm.

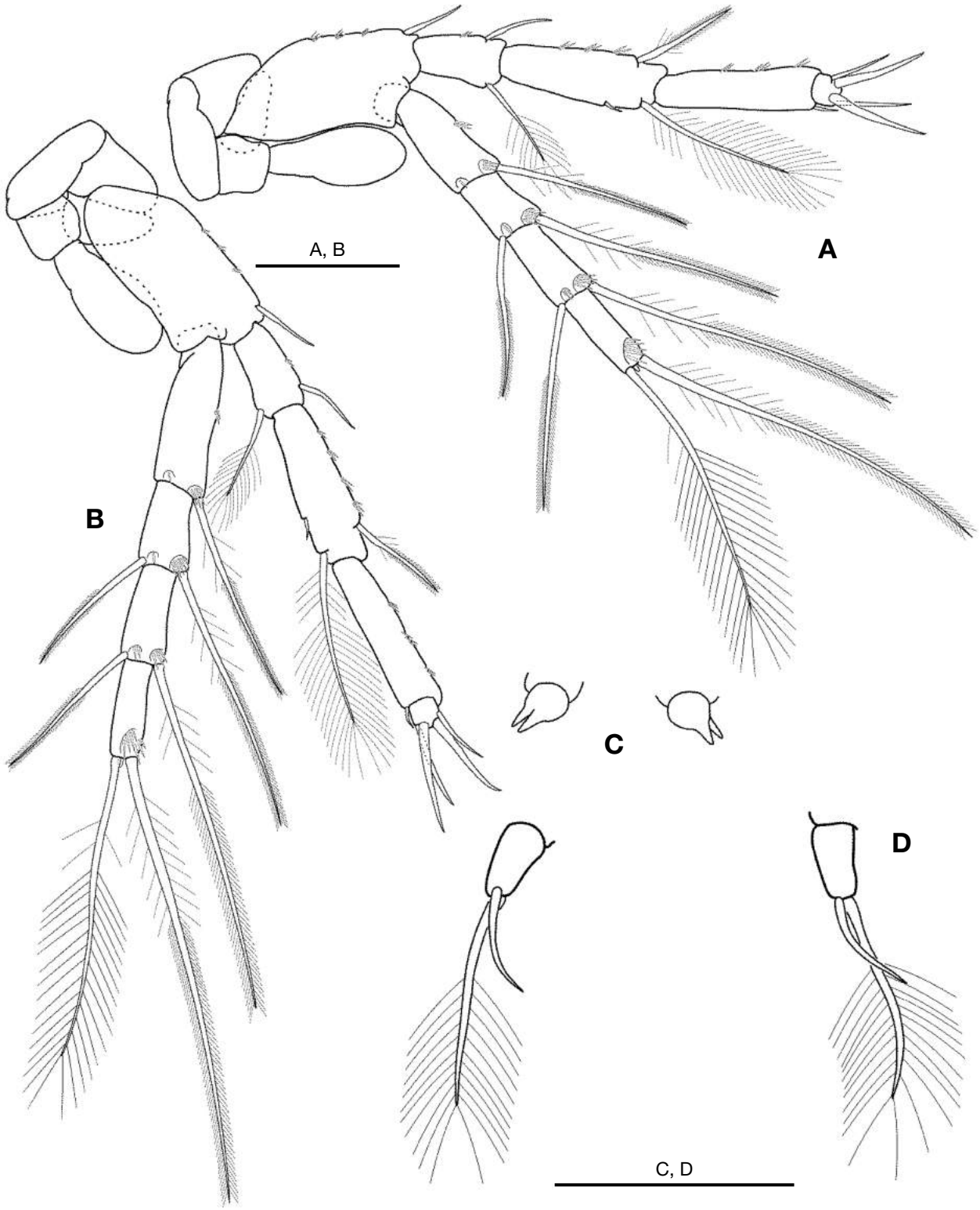


Fig. 48. *Allobathynella buronensis* (holotype: ♂; allotype: ♀): (A) Thoracopod III ♂ (frontal); (B) Thoracopod IV ♂ (frontal); (C) Thoracopod VIII ♀ (ventral); (D) Pleopod ♂ (ventral). Scale bars = 0.05 mm.

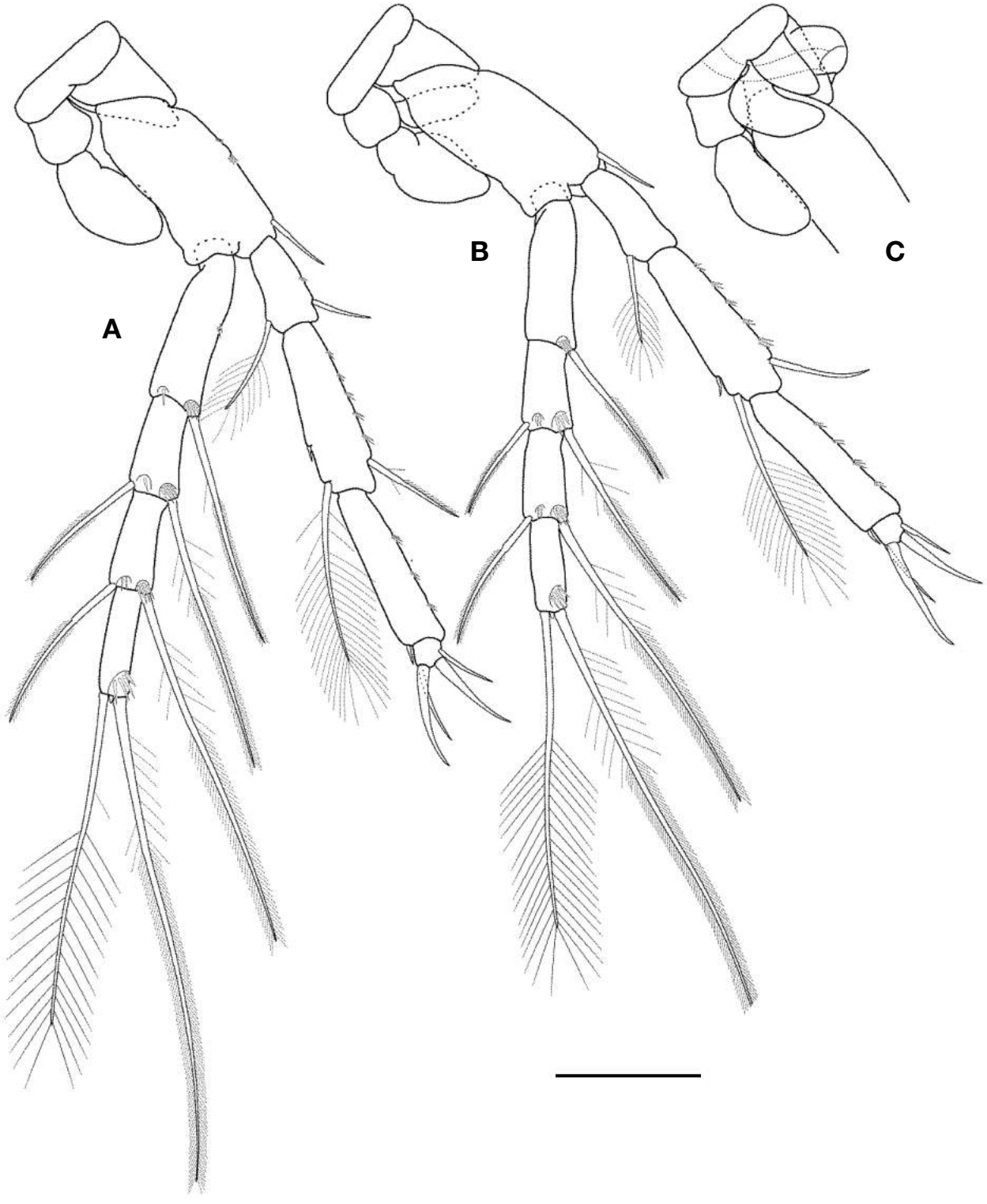


Fig. 49. *Allobathynella buronensis* (holotype: ♂; allotype: ♀): (A) Thoracopod V ♂ (frontal); (B) Thoracopod VI ♂ (frontal); (C) Protopod of thoracopod VI ♀ (frontal). Scale bar = 0.05 mm.

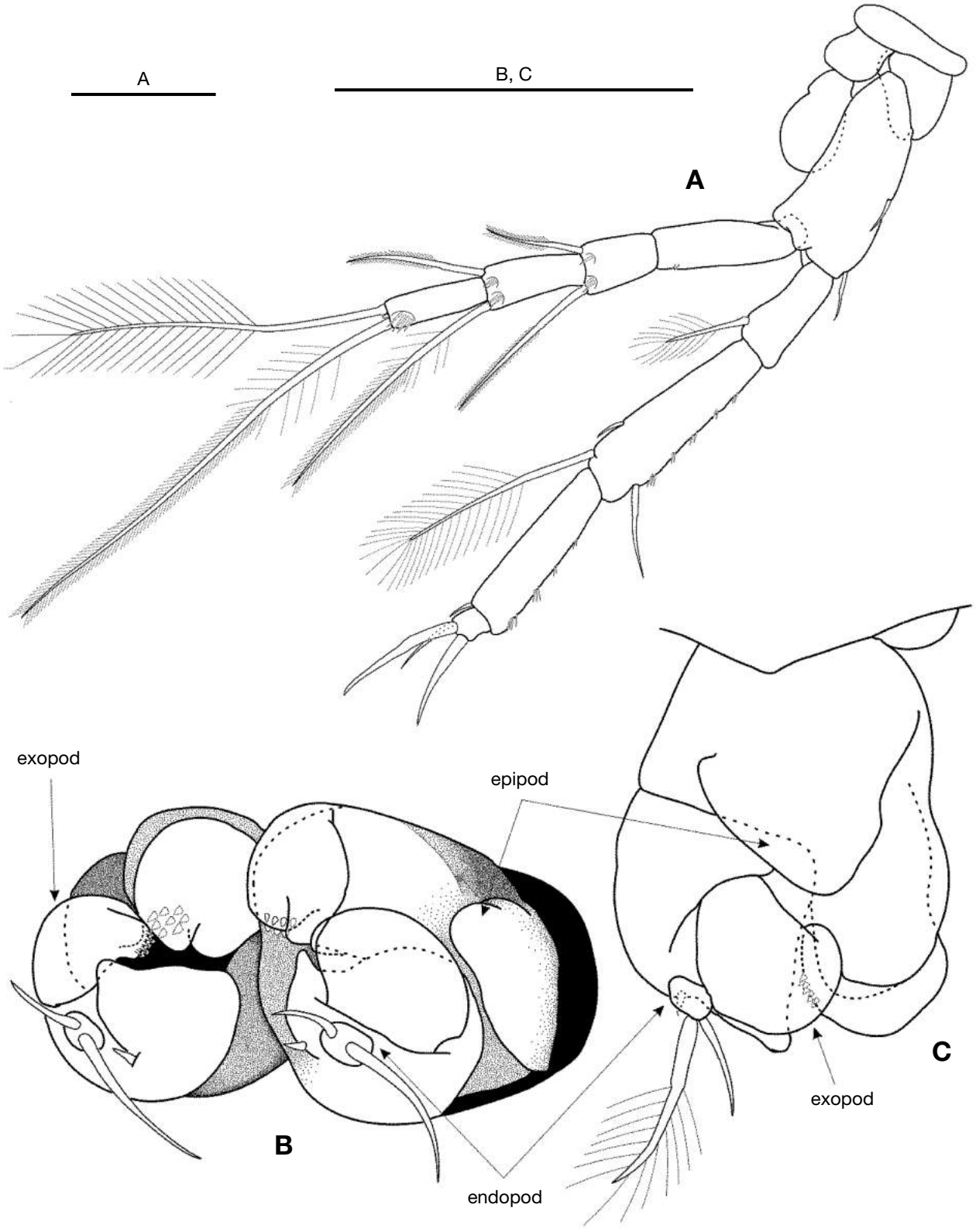


Fig. 50. *Allobathynella buronensis* (holotype: ♂): (A) Thoracopod VII (frontal); (B) Left and right thoracopods VIII (latero-ventral); (C) Thoracopod VIII (lateral). Scale bars = 0.05 mm.

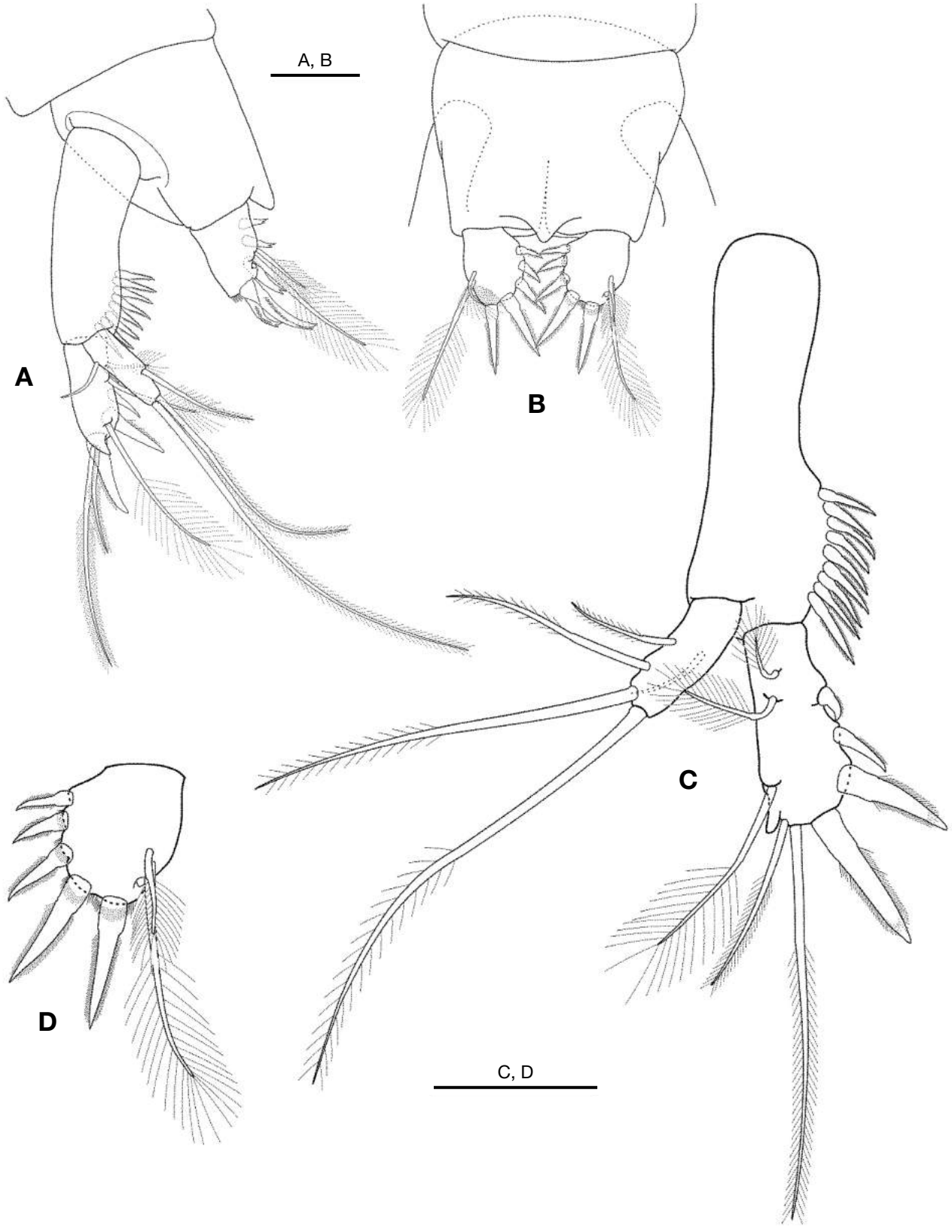


Fig. 51. *Allobathynella buronensis* (holotype: ♂): (A) Uropod, pleotelson and furcal rami (lateral); (B) Pleotelson and furcal rami (dorsal); (C) Uropod (dorsal); (D) Furcal ramus (dorsal). Scale bars = 0.05 mm.

protruded with triangular tip.

Furcal rami (Fig. 51A, B, D) nearly as long as wide, with two large distal spines, and three smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella bangokensis* sp. nov.** (Figs. 52-57)

Etymology

The species name is derived from the village (Bangok-Ri), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratype (19 adult females and two juveniles).

Holotype dissected on six slides (NIBR IV0000266841). Allotype dissected on six slides (NIBR IV0000266842). Each one male and female paratypes dissected on six slides (NIBR IV0000266843, 0000266844) Seven female and five male paratypes each as a whole specimen on separate slides (NIBR IV0000266845-0000266856), 11 adult females and 2 juveniles in a vial (NIBR IV0000 266857).

Type locality

South-Korea, Ganwon-Do, Hongcheon-Gun, Seo-Myeon, Bangok-Ri (37°41′20.8″N, 127°40′52.6″E), 13. November 2012, leg. J.-L. Cho.

Description

Size (mm). Body length: ♀ 2.24 (other females: 2.10-2.24; ♂: 2.20; other males: 2.10-2.20), approximately 12 times as long as wide. Head as long as anterior three thoracic segments combined (Fig. 52A). Male differs from female in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 52B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with two ventrolateral setae, and two dorsal setae and one ventral seta on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Labrum (Fig. 52D) flat, with eight main teeth flanked by three teeth on both lateral sides. Ventral surface concave, with one round median projections with two spinules, numerous combs of ctenidia and three or four teats on both lateral sides.

Mandible (Fig. 52E) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of 11 spines. Palp of one segment, four times as long as wide, with one long terminal seta and one subterminal seta. Terminal seta four times as long as subterminal seta.

Maxillule (Fig. 53A) two-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal smooth spines, with four dentate spines followed by two smooth spines bearing basal bristles on inner edge, and with three simple setae on outer distal margin. Terminal spine two times as long as other ones.

Maxilla (Fig. 53B) four-segmented, setal formula 3-5-11-6.

Thoracopods I-VII (Figs. 53C, D, 54A, B, 55A, B, 56A). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods IV-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II and III, with each one distal and median seta in thoracopods IV-VII. Number of segments of exopod of thoracopods I-VII: 3-5-5-6-6-6-6. Exopodal segments with each one dorsal and ventral seta, except basal segment bearing one additional ventral seta in thoracopod I, lacking dorsal seta in thoracopods II and IV. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/1 + 1/4(2)
Thoracopod II	2 + 1/3 + 2/0 + 1/4(2)
Thoracopods III-IV	1 + 1/3 + 2/0 + 1/4(2)
Thoracopods V-VI	1 + 1/2 + 2/0 + 1/4(2)
Thoracopod VII	0 + 1/1 + 2/0 + 1/4(2)

Thoracopod VIII of male (Fig. 56B, C) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with eight teeth. Epipod flat, with round distal part barely reaching lower margin of exopod. Basipod with one small seta near base of endopod, inner margin dentate, distally drawn out into round projection. Basipodal seta one half as long as endopod. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe dentate, lower lobe smooth. Endopod small, round, with two distal setae of different size. Outer seta 1.5 times longer than inner one. Thoracopod VIII of female (Fig. 60C) tiny, conical in ventral view, trifurcated

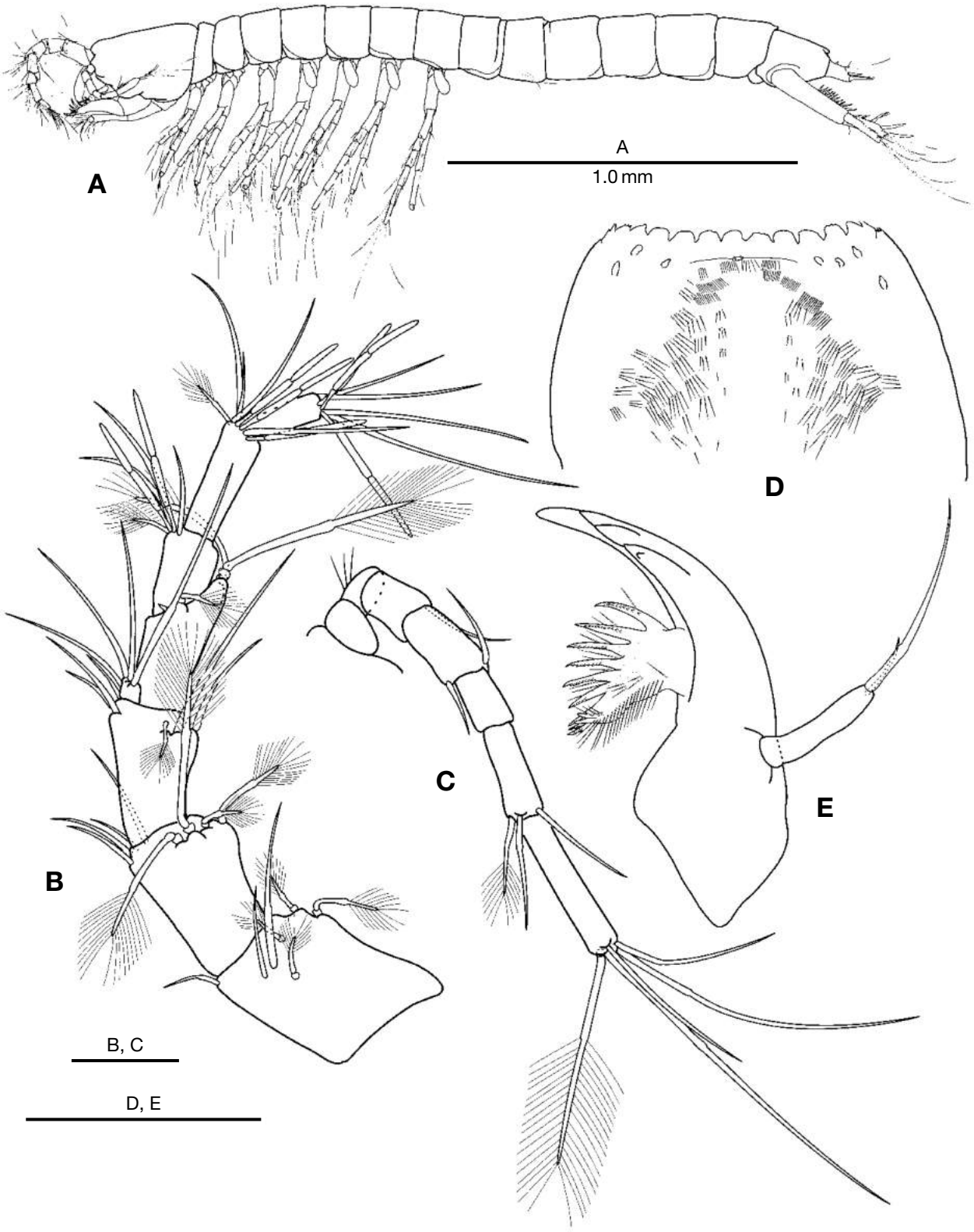


Fig. 52. *Allobathynella bangokensis* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal, slightly lateral); (C) Antenna (dorsal); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.05 mm, unless specified.

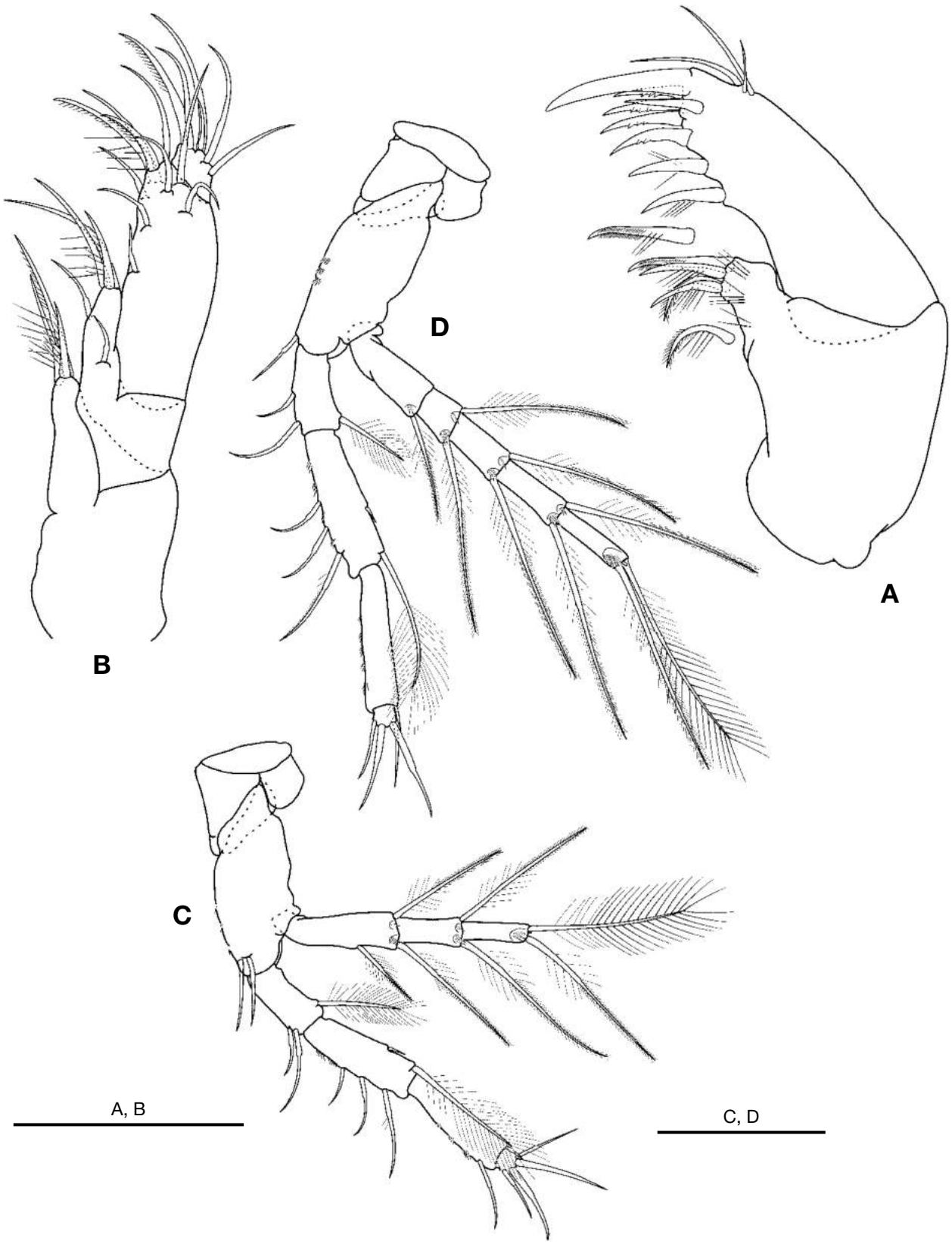


Fig. 53. *Allobathynella bangokensis* (holotype: ♀): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal). Scale bars = 0.05 mm.

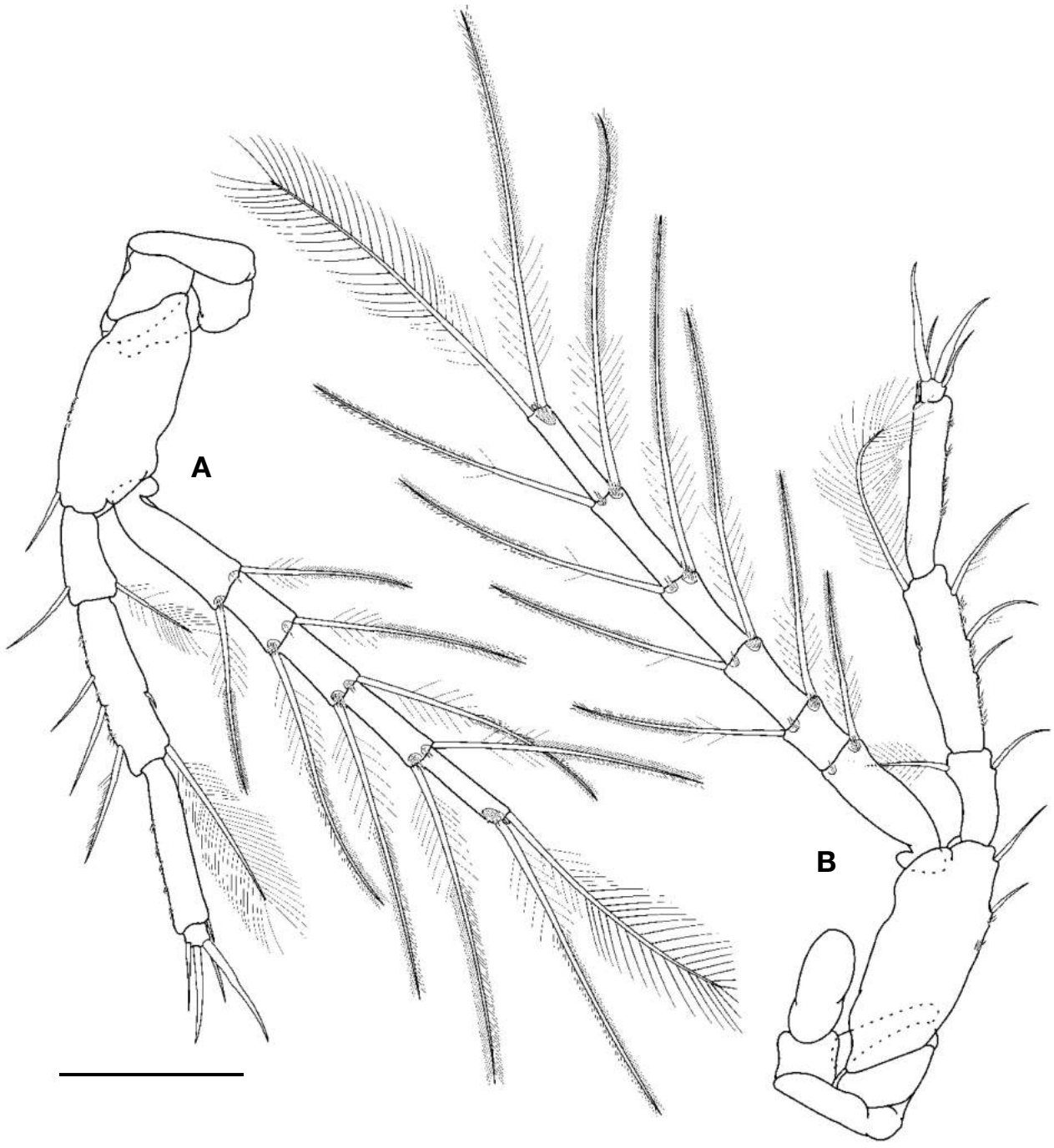


Fig. 54. *Allobathynella bangokensis* (holotype: ♀): (A) Thoracopod III (frontal); (B) Thoracopod IV (frontal). Scale bar = 0.05 mm.

distally.

First pleopod (Fig. 56D) in form of stub bearing two distal setae.

Uropod (Fig. 57A) bearing ten spines on inner margin of sympod, two most distal spines significantly larger than other ones of similar size. Endopod 48% as long as sympod, with two dorsal plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and four additional spines along inner margin. Terminal spine longer than subterminal one. Distal spine of inner-margin smaller than subterminal one, 50% as large as terminal one. Three proximal spines of inner-margin small, one fourth as large as distal one. Ex-

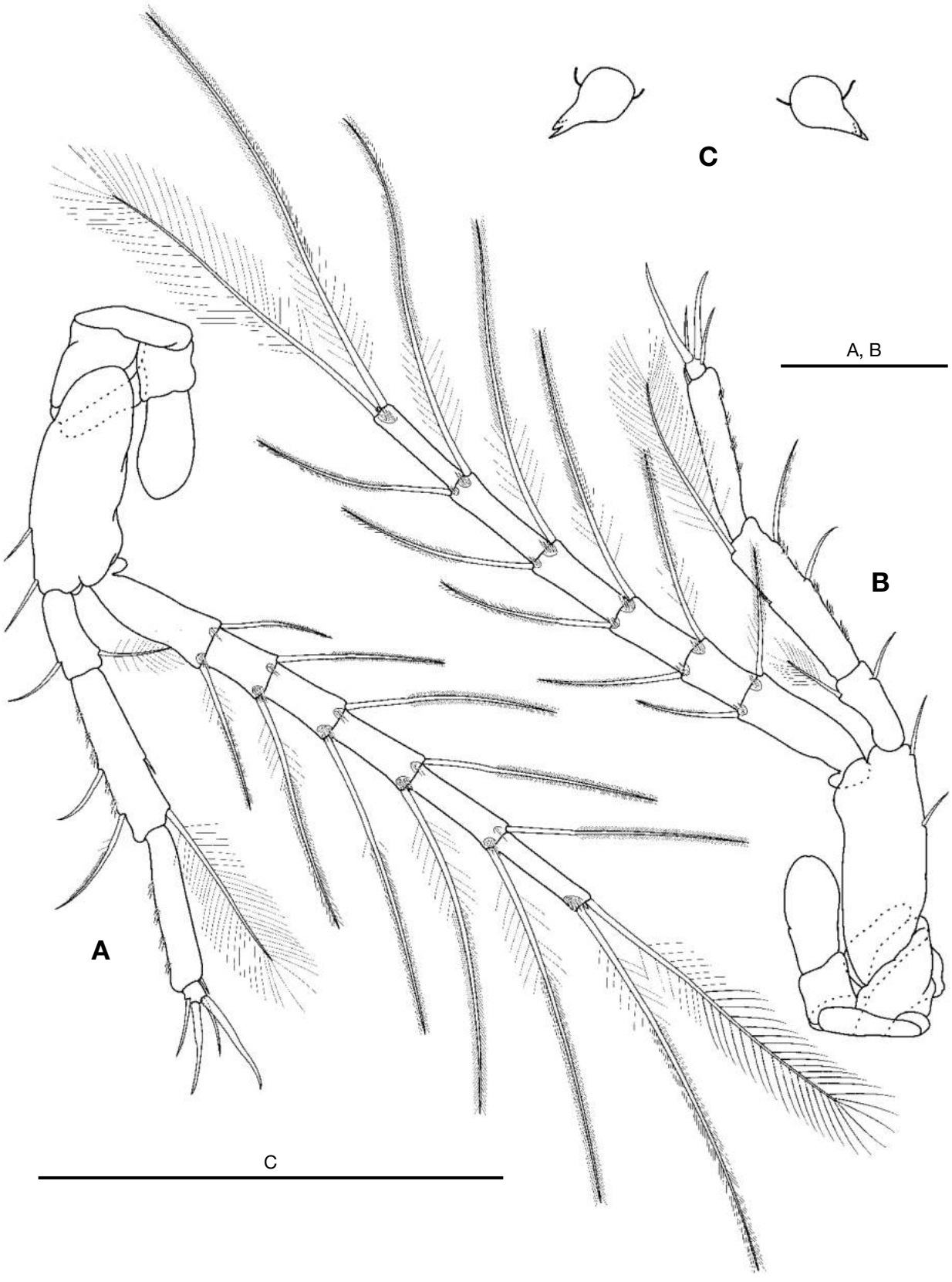


Fig. 55. *Allobathynella bangokensis* (holotype: ♀): (A) Thoracopod V (frontal); (B) Thoracopod VI (frontal); (C) Thoracopod VIII (ventral). Scale bars = 0.05 mm.

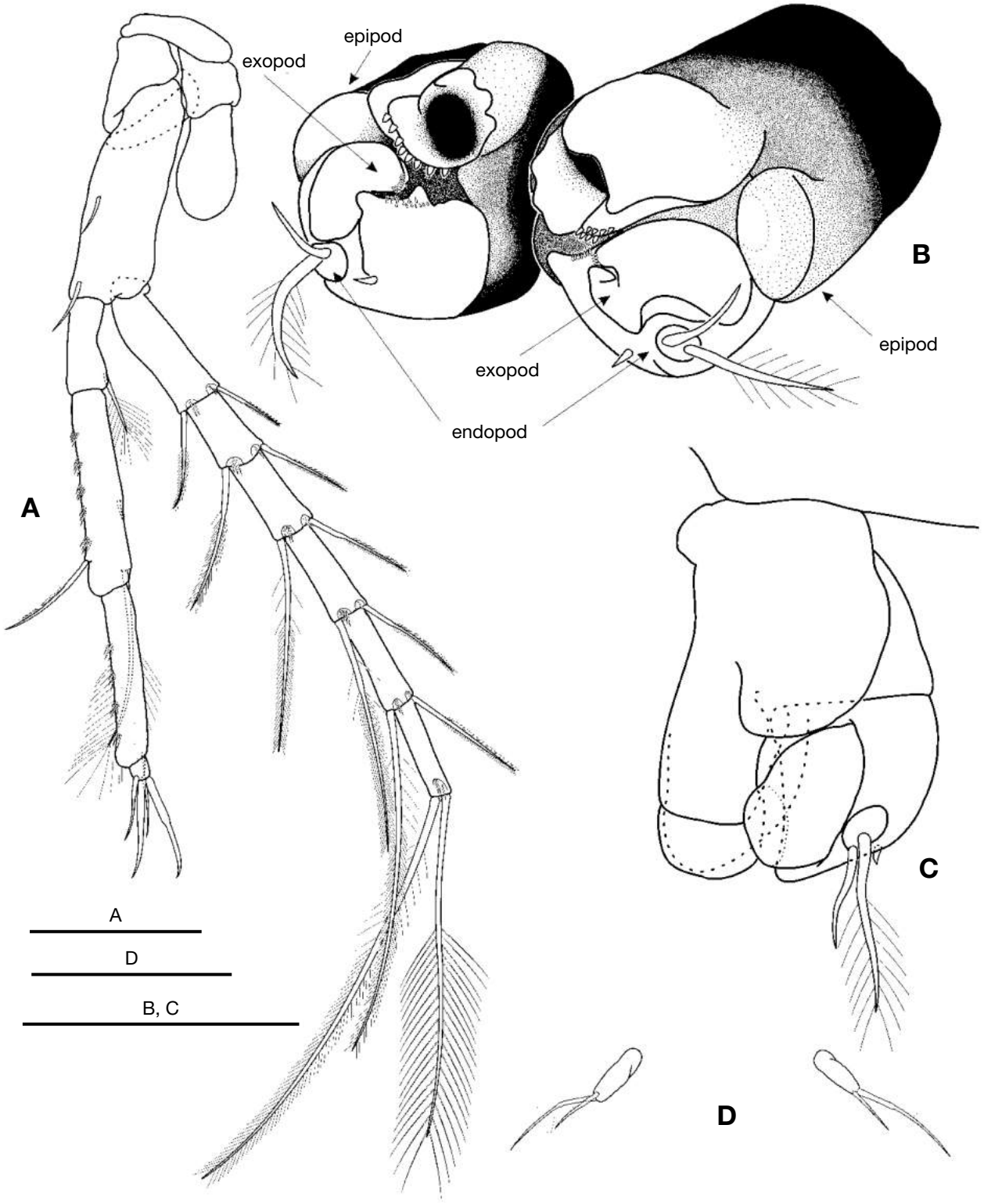


Fig. 56. *Allobathynella bangokensis* (holotype: ♀; allotype: ♂): (A) Thoracopod VII ♀ (frontal); (B) Right and left thoracopods VIII ♂ (ventral, slightly lateral); (C) Thoracopod VIII ♂ (lateral); (D) Pleopod ♀ (ventral). Scale bars = 0.05 mm.

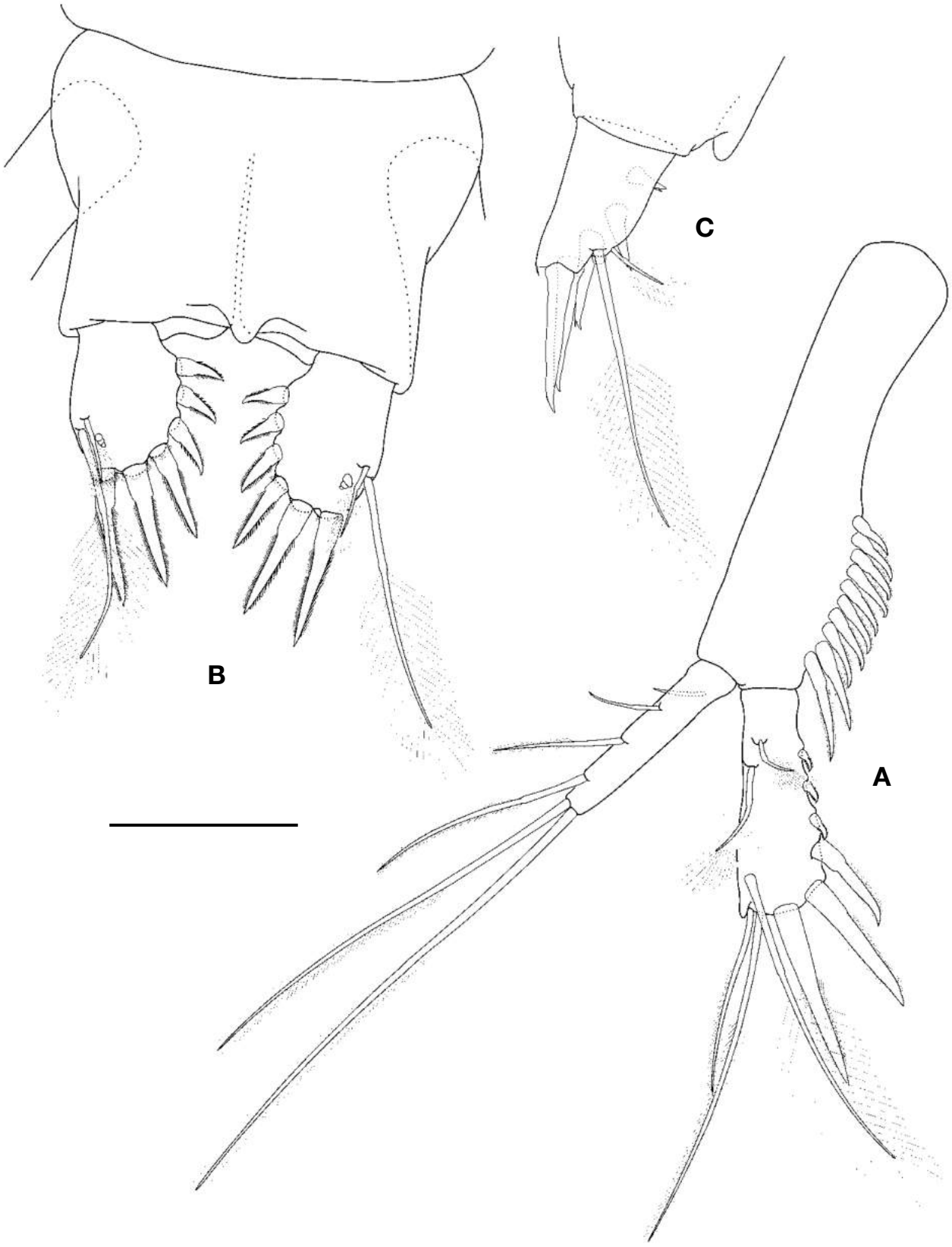


Fig. 57. *Allobathynella bangokensis* (holotype: ♀): (A) Uropod (dorsal); (B) Pleotelson and furcal rami (dorsal); (C) Furcal ramus (lateral). Scale bar = 0.05 mm.

opod shorter than endopod (43% of sympod), with six setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 57B, C) without seta. Anal operculum protruded somewhat sharply with round tip.

Furcal rami (Fig. 57B, C) 1.2 times as long as wide, with two large distal spines, and four successively smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella yecheonensis* sp. nov.** (Figs. 58-62)

Etymology

The species name is derived from the county (Yecheon-Gun), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratype (two adult females and one adult male). Holotype dissected on eight slides (NIBR IV0000267084). Allotype dissected on eight slides (NIBR IV0000267085). One female paratype dissected on seven slides (NIBR IV0000267086), one male and one female paratypes (NIBR IV0000267087, 0000267088) each as a whole specimen in separate slides.

Type locality

South-Korea, Gyeongsangbuk-Do, Yecheon-Gun, Yonggung-Myeon (36°35′10.2″N, 120°19′27.5″E), 07. October 2012, leg. J.-L. Cho.

Description

Size (mm). Body length: ♀ 2.40 (other females: 2.20-2.38; ♂: 2.18-2.37), approximately 10 times as long as wide. Head as long as anterior three thoracic segments combined (Fig. 58A). Male differs from female in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 58B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with two ventrolateral setae, and two dorsal setae and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 58C) 7-segmented, as long as the length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 58D) flat, with eight main teeth flanked by three (left) or five (right) teeth on both lateral sides. Ventral surface convex, with shield-shaped chitin plate, with one round median projection bearing two spinules and one pair of teats and with numerous combs of ctenidia on convex surface.

Mandible (Fig. 59A) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of eight spines. Palp of one segment, 2.5 times as long as wide, with one long terminal seta and one short subterminal seta. Terminal seta 2.5 times longer than subterminal seta.

Maxillule (Fig. 59B) two-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal smooth spines, with four smooth spines on inner edge, and with three simple setae on outer distal margin. Terminal spine two times as long as other ones.

Maxilla (Fig. 59C) four-segmented, setal formula 3-4-10-6.

Thoracopods I-VII (Figs. 59D-F, 60A-C, 61A). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods IV-VII each bearing one epipod on protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II and III, with each one distal and median seta in thoracopods IV-VII. Number of segments of exopod of thoracopods I-VII: 3-4-4-5-5-5-4. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods I, II, IV, V, VI, VII. Tiny process present between two setae of distal segment. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/1 + 1/4(2)
Thoracopod II	1 + 1/2 + 2/1 + 1/4(2)
Thoracopods III, IV, V	1 + 1/2 + 2/0 + 1/4(2)
Thoracopods VI, VII	0 + 1/1 + 2/0 + 1/3(1)

Thoracopod VIII of male (Fig. 61E, F) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with nine teeth. Epipod flat, with round distal part barely reaching lower margin of exopod. Basipod with one small seta near base of endopod, inner margin dentate, distally drawn out into round projection bearing three spinules. Basipodal seta one half as long as endopod. Exopod one third of size of basipod, round,

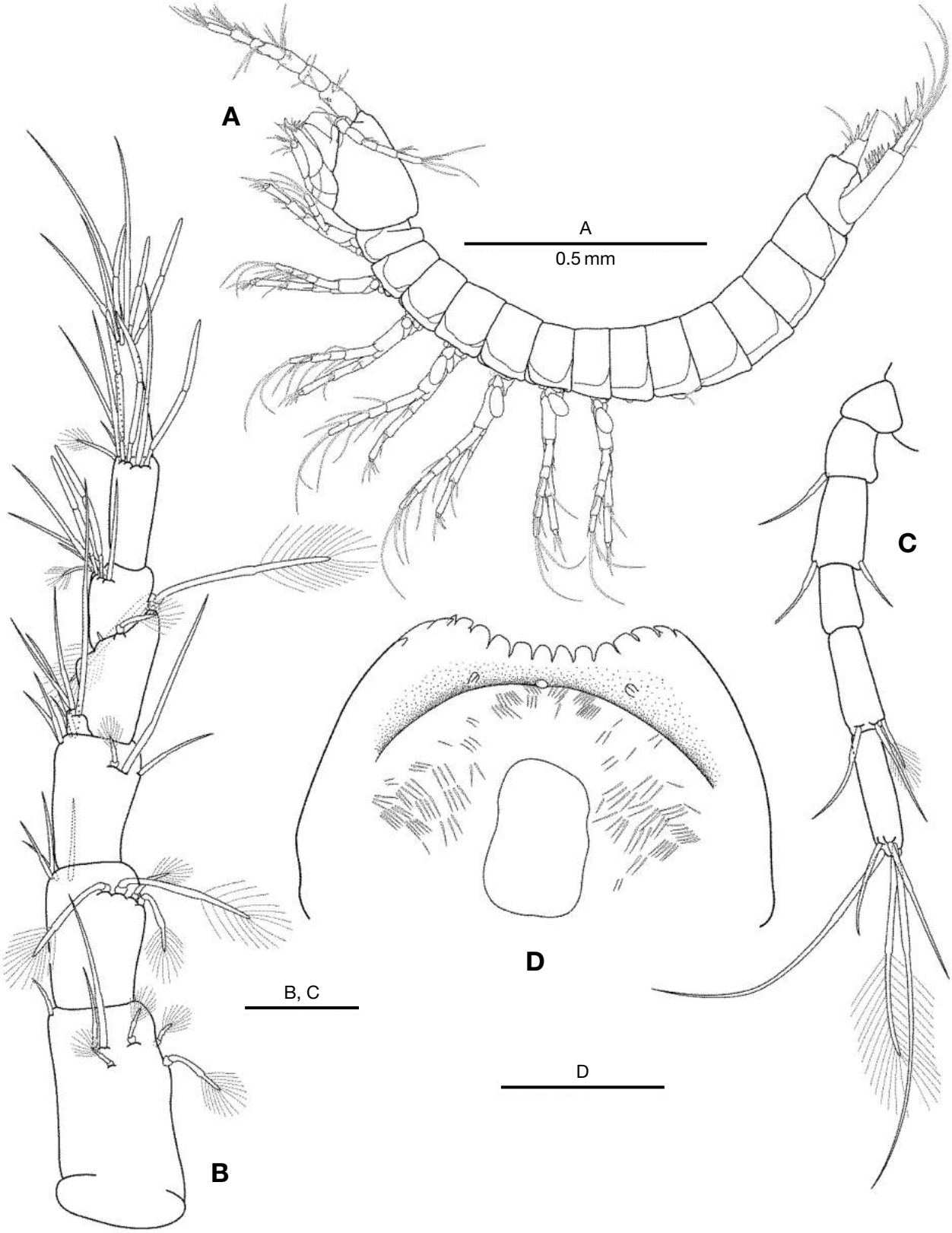


Fig. 58. *Allobathynella yecheonensis* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorsal); (D) Labrum (ventral). Scale bars = 0.05 mm, unless specified.

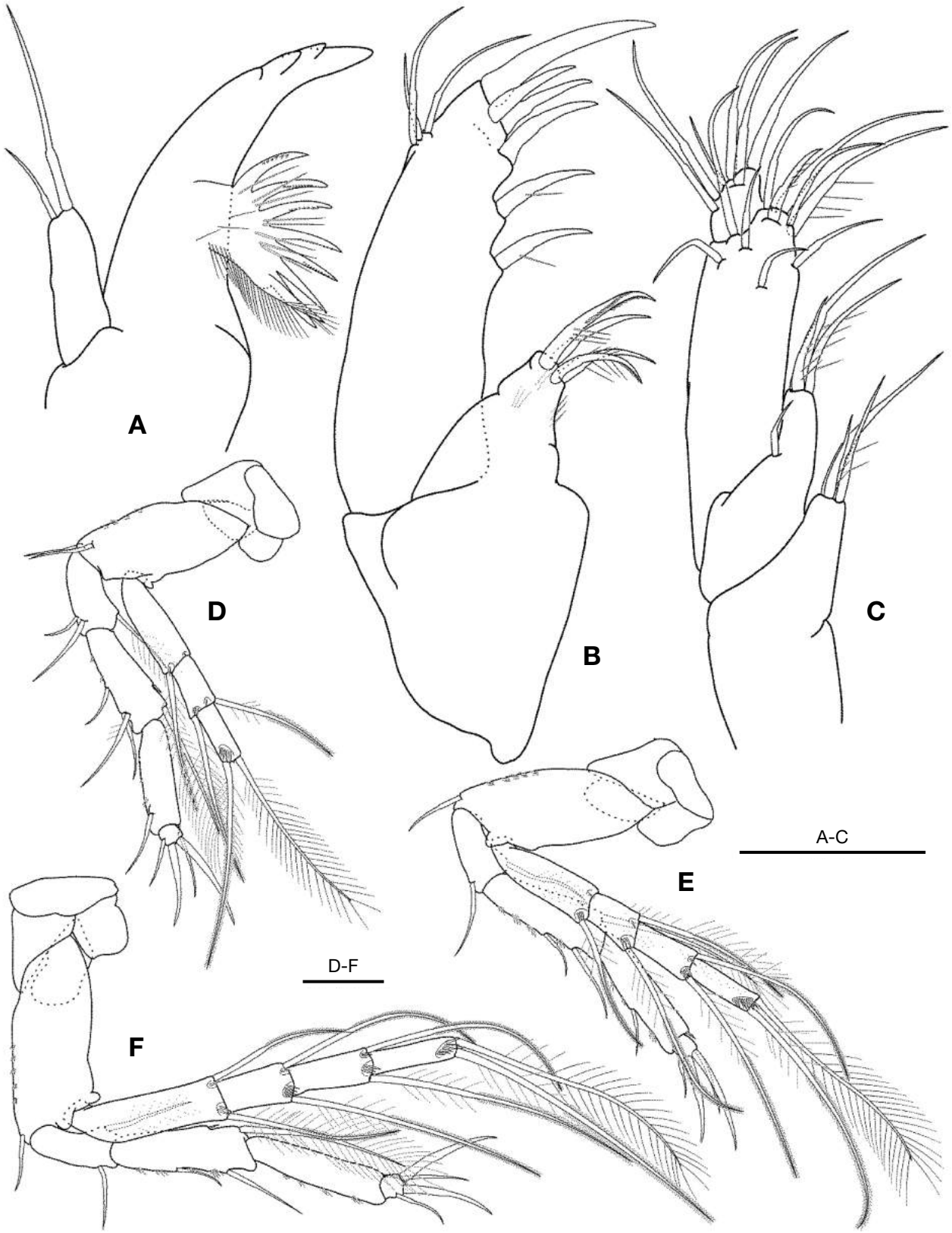


Fig. 59. *Allobathynella yecheonensis* (holotype: ♀): (A) Mandible (ventral); (B) Maxillule (dorsal); (C) Maxilla (dorsal); (D) Thoracopod I (frontal); (E) Thoracopod II (frontal); (F) Thoracopod III (frontal). Scale bars = 0.05 mm

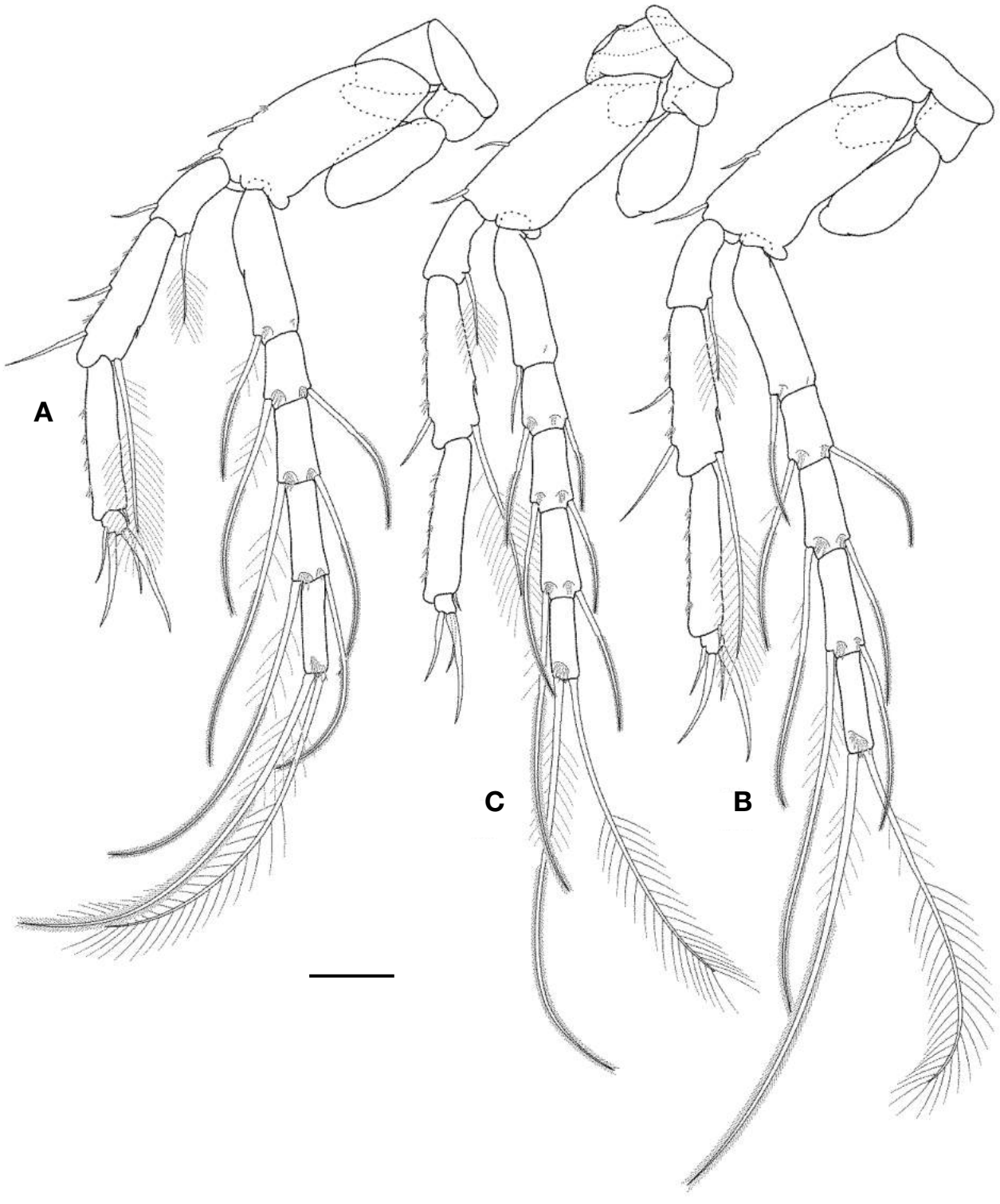


Fig. 60. *Allobathynella yecheonensis* (holotype: ♀) (A) Thoracopod IV (frontal); (B) Thoracopod V (frontal); (C) Thoracopod VI (frontal). Scale bar = 0.05 mm.

with two distal lobes bearing three spinules each respectively. Endopod small, round, with two distal setae of different size. Outer seta three times longer than inner one. Thoracopod VIII of female (Fig. 61C) conical in ventral view, with two spine-like distal projections.

First pleopod (Fig. 61D) in form of stub bearing two

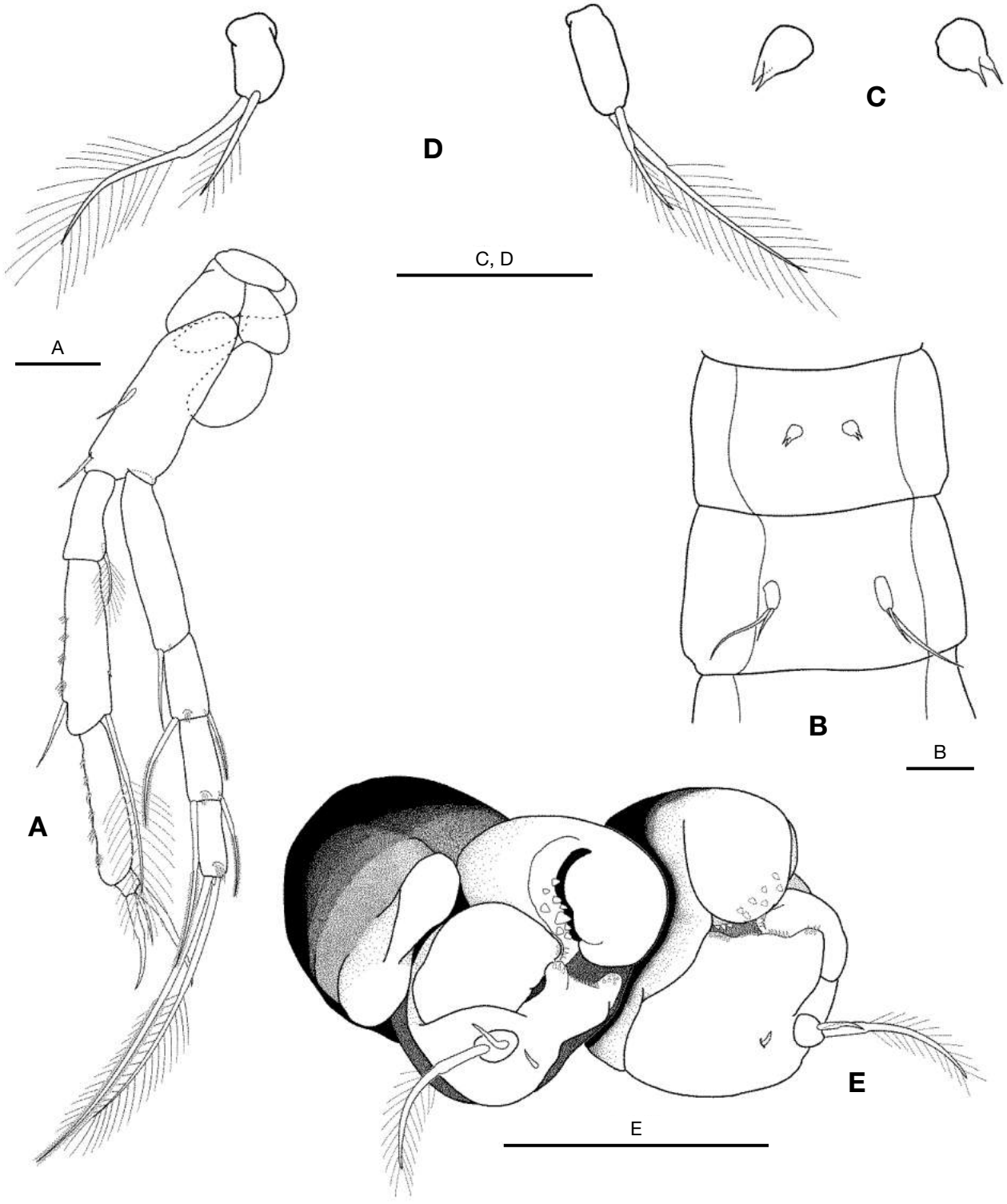


Fig. 61. *Allobathynella yecheonensis* (holotype: ♀; allotype: ♂): (A) Thoracopod VII ♀ (frontal); (B) 8th thoracomere and 1st pleomere with thoracopod VIII ♀ (ventral); (C) Thoracopod VIII ♀ (ventral); (D) Pleopod I (ventral); (E) Thoracopods VIII ♂ (outer lateral). Scale bars = 0.05 mm.

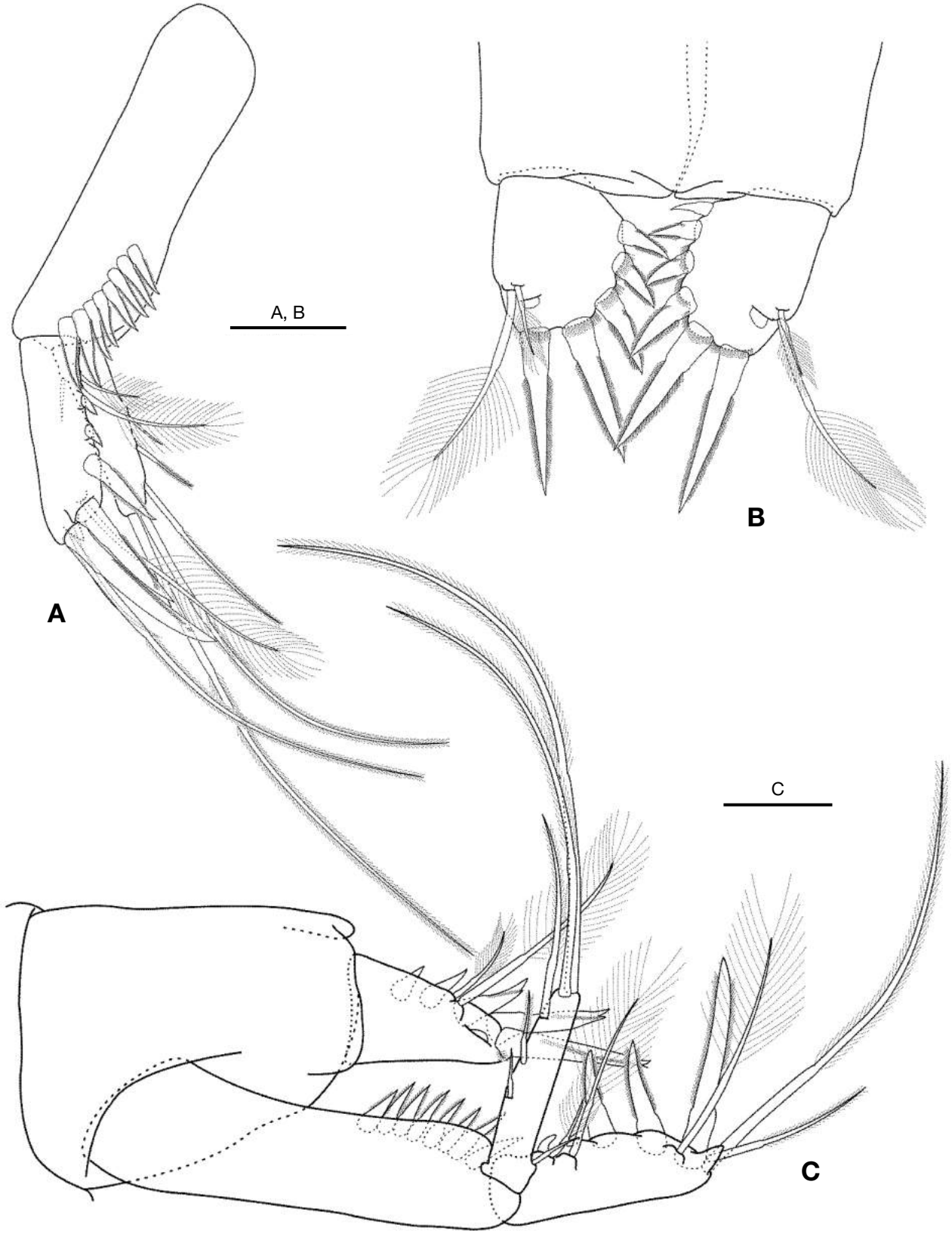


Fig. 62. *Allobathynella yecheonensis* (holotype: ♀): (A) Uropod (inner-lateral, slightly dorsal); (B) Pleotelson and furcal rami (dorsal); (C) Pleotelson, uropod and fucal rami (lateral). Scale bars = 0.05 mm

distal setae.

Uropod (Fig. 62A, C) bearing eight spines on inner margin of sympod, two most distal spine significantly larger than other ones of similar size. Endopod 52% as long as sympod, dorsally with two plumose setae near base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and three additional spines on inner margin. Terminal spine longer than subterminal one. Most distal spine of inner margin smaller than subterminal one, 50% as large as terminal one. Two proximal spines of inner margin small, one fourth as large as distal one. Exopod shorter than endopod (47% of sympod), with six setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 62B, C) without seta. Anal operculum protruded with round tip.

Furcal rami (Fig. 62B, C) 1.2 times as long as wide, with two large distal spines and three successively smaller spines on inner margin, and dorsally with two plumose setae.

***Allobathynella cheongdoensis* sp. nov.** (Figs. 63-67)

Etymology

The species name is derived from the county (Cheongdo-Gun), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratype (five adult females, five adult males and three instars). Holotype dissected on seven slides (NIBR IV0000267064). Allotype dissected on eight slides (NIBRIV 0000267065). One female paratype dissected on eight slides (NIBR IV0000267066), one male paratype dissected on seven slides (NIBR IV0000267067), four female paratypes and four male paratypes each as a whole specimen on separate slides (NIBR IV0000267068-0000267075), three instars together as total specimen in a slide (NIBRIV0000267076).

Type locality

South Korea, Kyungsangbuk-Do, Cheongdo-Gun, Maejeon-Myeon, Geumgok-Ri, Dongchang stream (River Nakdong tributary) (35°40′28.0″N, 128°52′03.1″E), 12. March 2013, leg. J.-G. Park.

Description

Size (mm). Body length: ♀ 2.15 (other females: 2.00-2.15), ♂: 1.82 mm; other males: 1.70-1.78 mm), approximately 12 times as long as wide. Head slightly shorter than anterior four thoracic segments combined (Fig. 63A). Male differs from female in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 63B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with two ventrolateral setae, and two dorsal setae and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 63C) 7-segmented, as long as the length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 63D) flat, with eight main teeth flanked by three (left) or five (right) teeth on both lateral sides. Ventral surface concave, with shield-shaped chitin plate, with one round median projection bearing two spinules and one pair of teats and with numerous combs of ctenidia on concave surface.

Mandible (Fig. 63E) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of eight spines. Palp of two segments, proximal segment as long as wide, distal segment two times as long as wide, with one long terminal seta and one short subterminal seta. Terminal seta four times longer than subterminal seta.

Maxillule (Fig. 64A) two-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal smooth spines, with four smooth spines on inner edge, and with three simple setae on outer distal margin. Terminal spine 1.5 times as long as other ones.

Maxilla (Fig. 64B) four-segmented, setal formula 3-4-10-6.

Thoracopods I-VII (Figs. 64C-E, 65A-C, 66A). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on the protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-IV, with each one distal and median seta in thoracopods V-VII. Number of segments of the exopod of the thoracopods I-VII: 3-4-5-5-6-5-5. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods III, IV, VI, VII and lacking dorsal and ventral setae in thoracopod V.

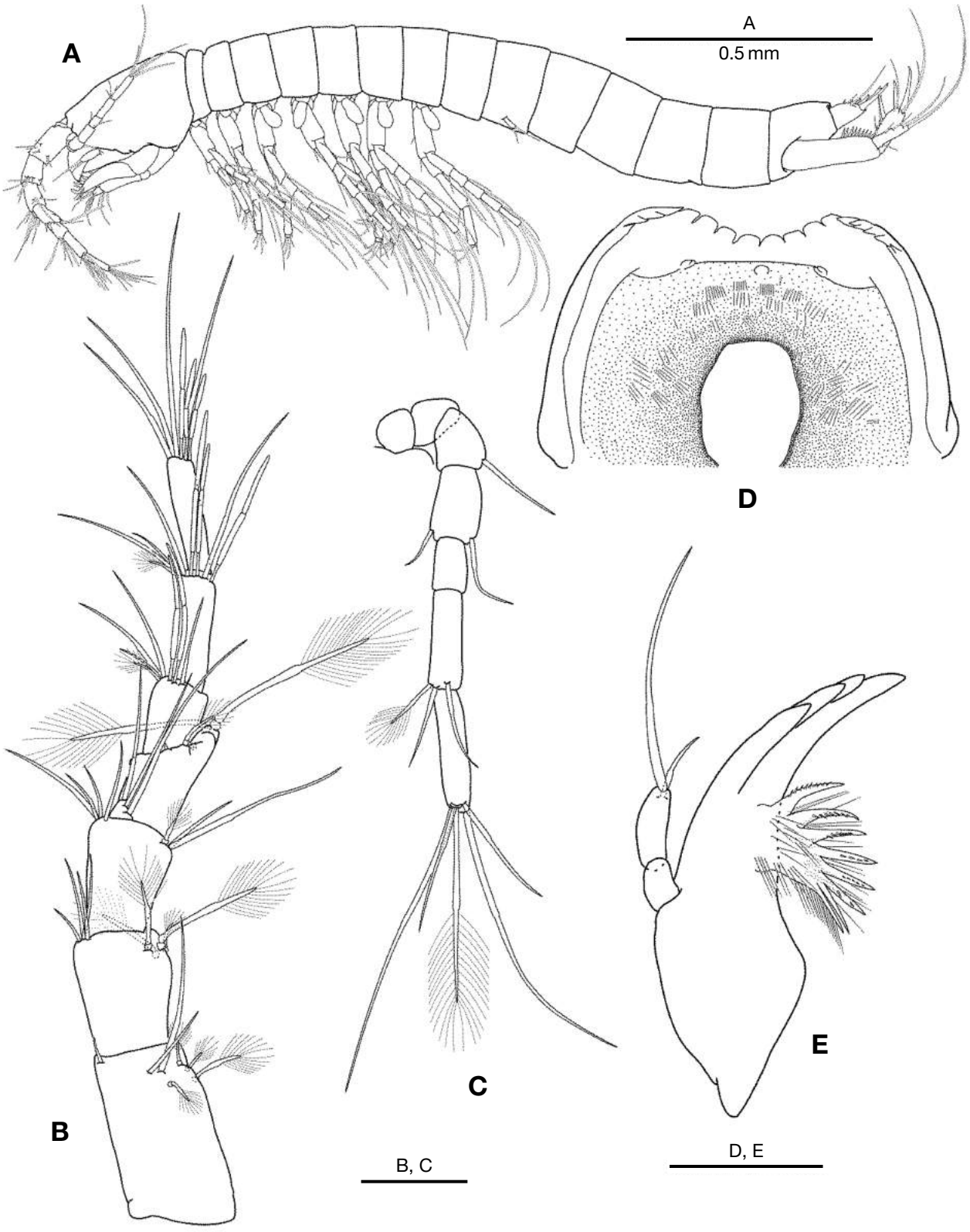


Fig. 63. *Allobathynella cheongdoensis* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal, slightly lateral); (C) Antenna (dorsal); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.05 mm, unless specified.

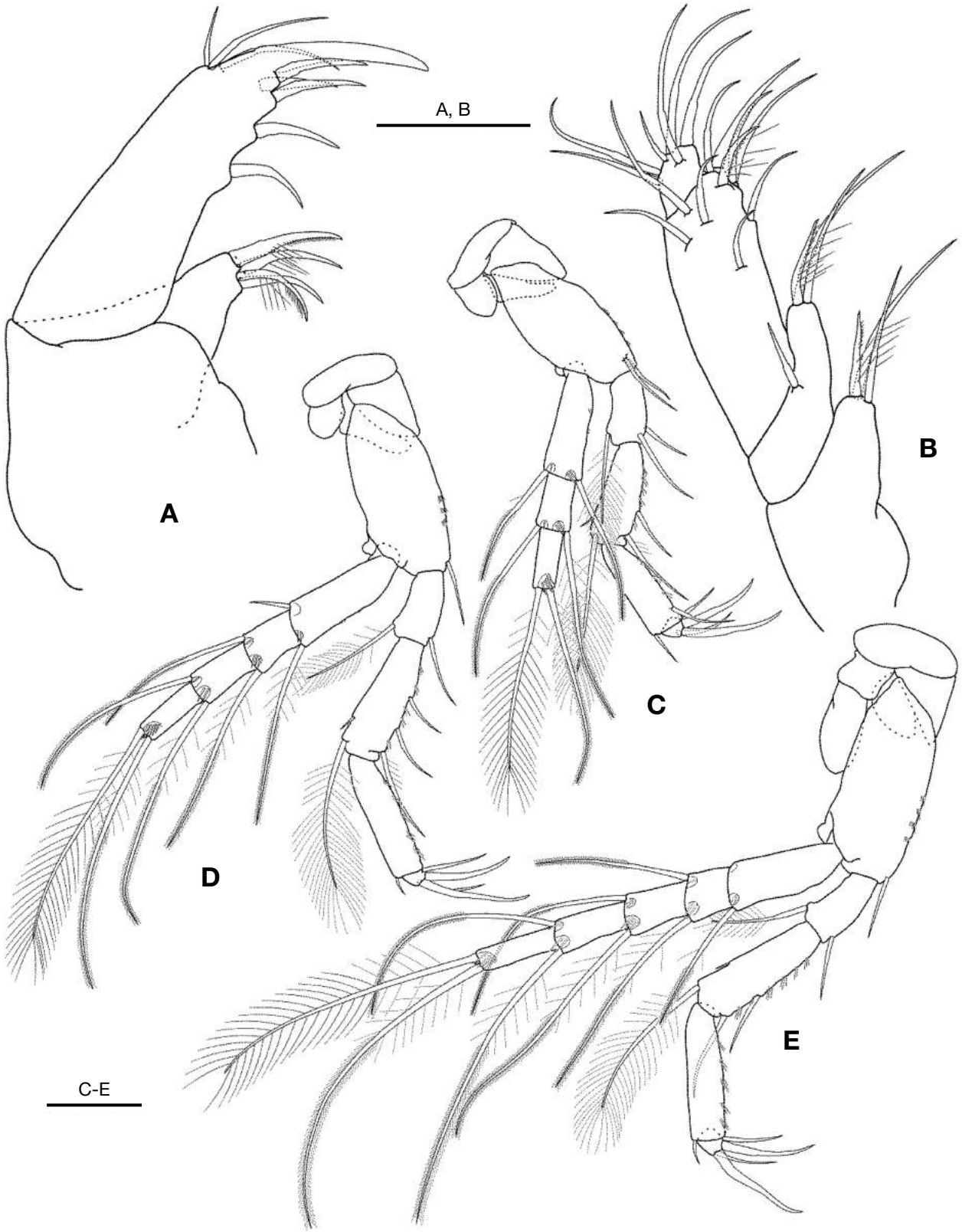


Fig. 64. *Allobathynella cheongdoensis* (holotype: ♀): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal); (E) Thoracopod III (frontal). Scale bars = 0.05 mm.

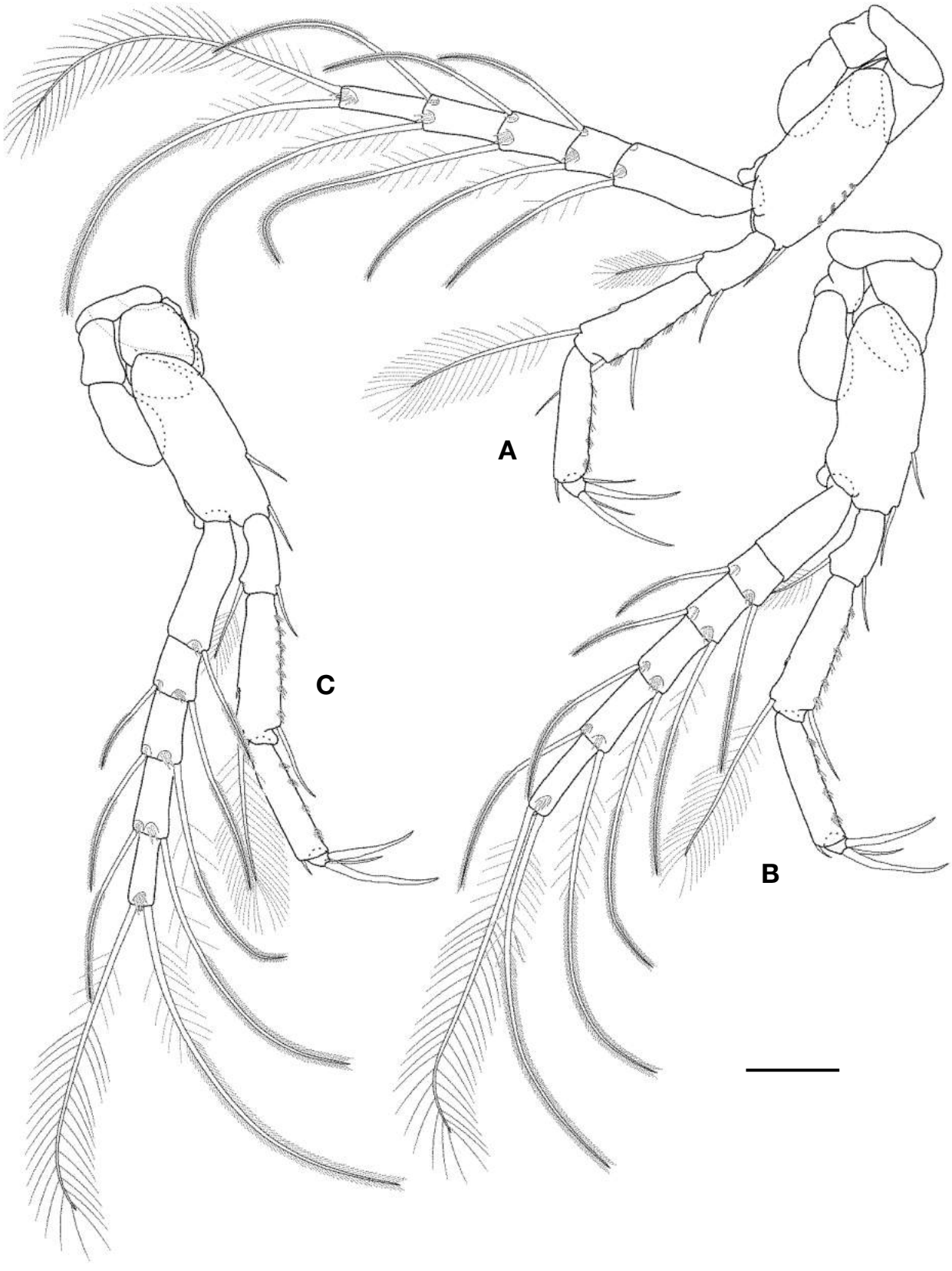


Fig. 65. *Allobathynella cheongdoensis* (holotype: ♀): (A) Thoracopod IV (frontal); (B) Thoracopod V (frontal); (C) Thoracopod VI (frontal). Scale bar = 0.05 mm.

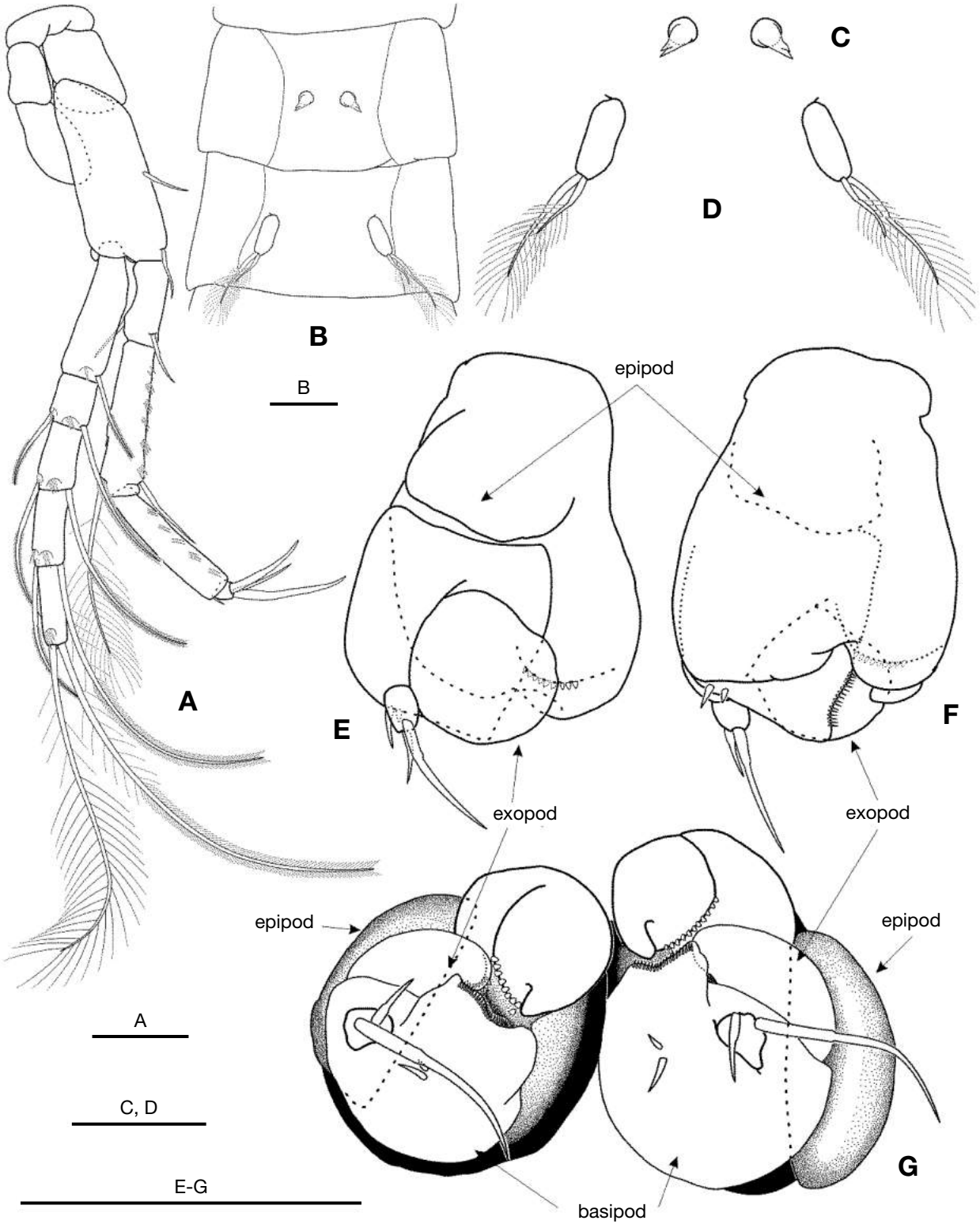


Fig. 66. *Allobathynella cheongdoensis* (holotype: ♀; allotype: ♂): (A) Thoracopod VII ♀ (frontal); (B) 8th thoracomere and 1st pleomere with thoracopod VIII ♀ (ventral); (C) Thoracopod VIII ♀ (ventral); (D) Pleopod I (ventral); (E) Thoracopods VIII ♂ (outer lateral); (F) Thoracopods VIII ♂ (inner lateral); (G) Right and left thoracopods VIII ♂ (ventral). Scale bars = 0.05 mm.

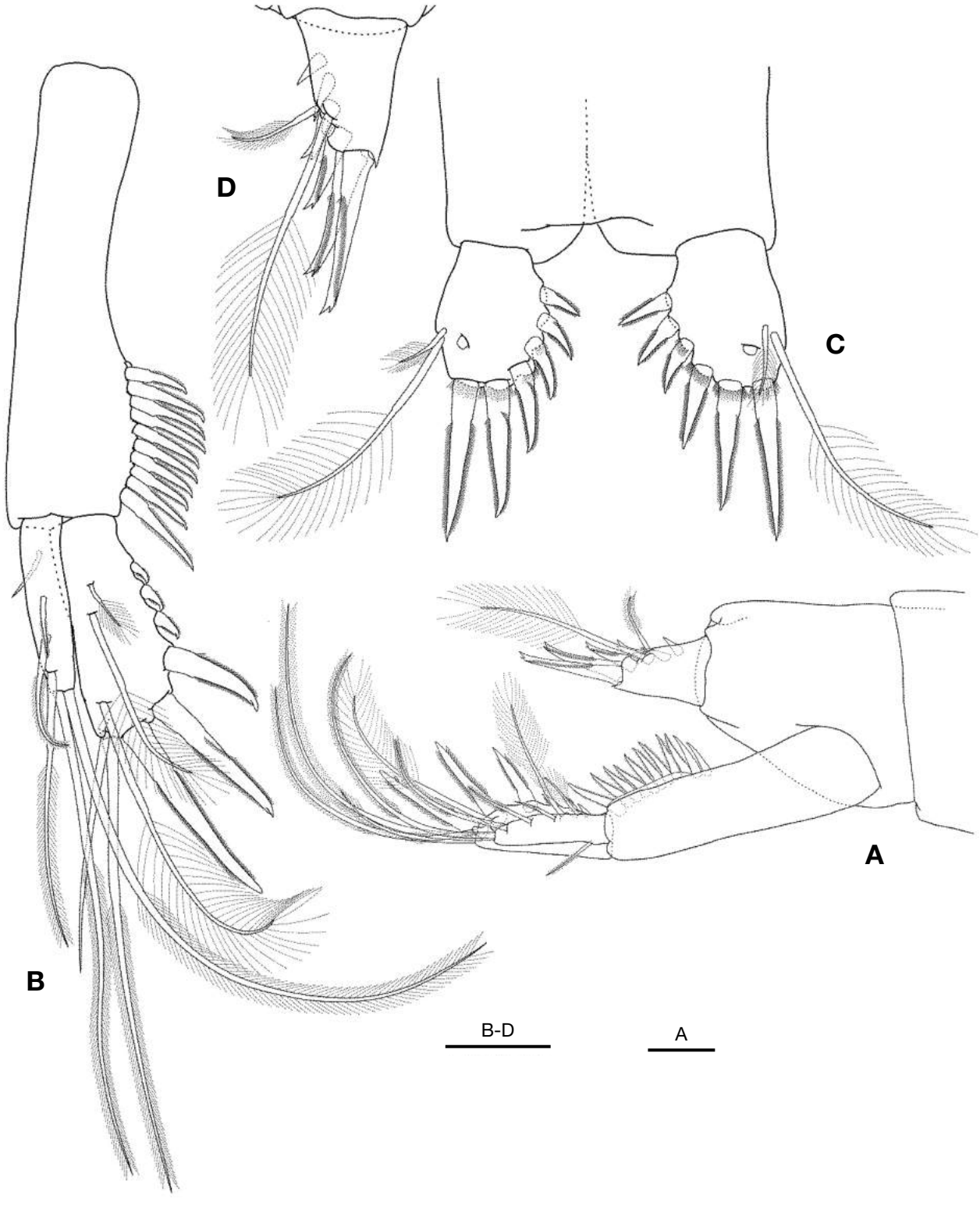


Fig. 67. *Allobathynella cheongdoensis* (holotype: ♀): (A) Pleoteson and uropod (lateral); (B) Uropod (dorsal); (C) Pleotelson and furcal rami (dorsal); (D) Furcal ramus (lateral). Scale bars = 0.05 mm.

Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of the thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/2 + 2/1 + 1/4(2)
Thoracopod II	1 + 1/3 + 2/0 + 1/4(2)
Thoracopods III-IV	1 + 1/2 + 2/0 + 1/4(2)
Thoracopods V-VII	1 + 1/1 + 2/0 + 1/3(1)

Thoracopod VIII of male (Fig. 66E-G) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with nine teeth. Epipod flat, with round distal part not reaching lower margin of exopod. Basipod with two small setae of different length near base of endopod, inner margin with spinules, distally drawn out into round projection. Long basipodal seta as long as endopod, two times as long as shorter one. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe with three spinules, lower lobe with five dentils. Endopod small, round, with two distal setae of different size. Outer seta three times longer than inner one. Thoracopod VIII of female (Fig. 66B, C) conical in ventral view, with two spine-like distal projections.

First pleopod (Fig. 66B, D) in form of stub bearing two distal setae.

Uropod (Fig. 67A, B) bearing ten spines on inner margin of sympod, most distal spine significantly larger than other ones of similar size. Endopod 49% as long as sympod, with two dorsal plumose setae near the base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and four additional spines along inner margin. The terminal spine longer than subterminal one. Most distal spine of inner margin smaller than subterminal one, 50% as large as terminal one. Three proximal spines of inner margin small, one fourth as large as distal one. Exopod shorter than endopod (39% of sympod), with six setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 67A, C) without seta. Anal operculum slightly convex, nearly flat.

Furcal rami (Fig. 67A, C, D) 1.3 times as long as wide, with two large distal spines, and four successively smaller spines on inner margin, and with two dorsal plumose setae.

***Allobathynella donggangensis* sp. nov.** (Figs. 68-72)

Etymology

The species name is derived from the name of the river (Donggang), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratypes (one adult females and four adult males). Holotype dissected on eight slides (NIBR IV0000267102). Allotype dissected on eight slides (NIBR IV0000267103). One female paratype and five male paratypes each as a whole specimen on separate slides (NIBR IV0000267104-0000267108).

Type locality

South-Korea, Kangwon-Do (province), Jeongseon-Gun (county), Jeongseon-Eup (town), A gravel bank of small stream (Eochun) of Donggang (37°22′20.9″N, 128°40′48.4″E), 24. May 2014 (J.-L. Cho and J.-G. Park)

Description

Size (mm). Body length: ♀ 2.54 (other female: 2.50), ♂: 2.50 mm; other males: 2.30-2.50 mm), approximately 10 times as long as wide. Head slightly shorter than anterior four thoracic segments combined. Male differs from female in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 68A) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and with one dorsal seta and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with three setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 68B) 7-segmented, as long as the length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/0 + 1 + 1/4(1).

Labrum (Fig. 68C) flat, with nine main teeth flanked by four teeth on both lateral sides. Ventral surface concave, with one round median projection bearing two spinules and three pair of teats and with numerous combs of ctenidia on concave surface medially covered by tiny grain-like protrusions.

Mandible (Fig. 68D) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of nine spines. Palp of one segment with one long terminal seta.

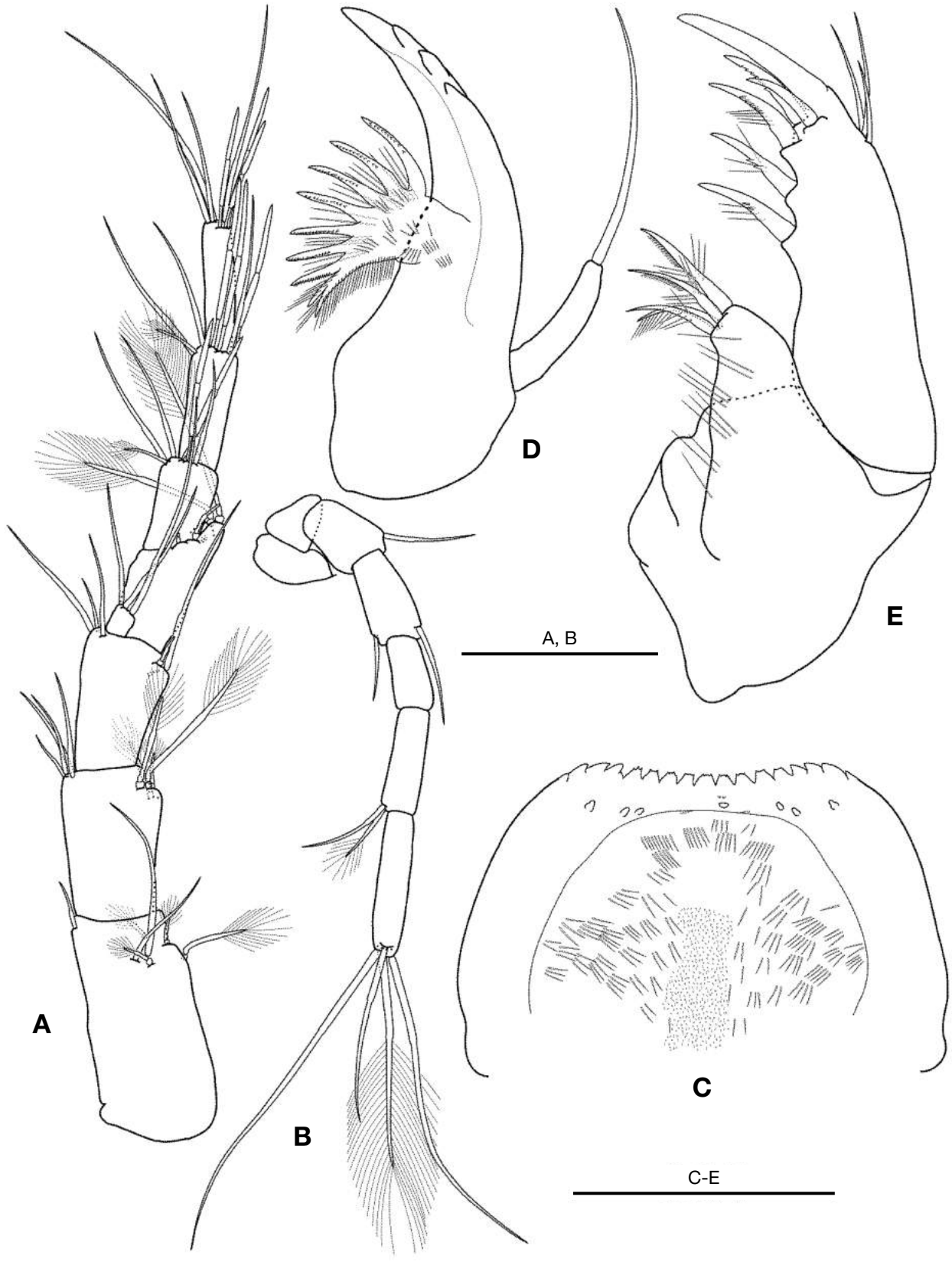


Fig. 68. *Allobathynella donggangensis* (holotype: ♀): (A) Antennule (dorsal); (B) Antenna (dorsal); (C) Labrum (ventral); (D) Mandible (ventral); (E) Maxillule (ventral). Scale bars = 0.1 mm.

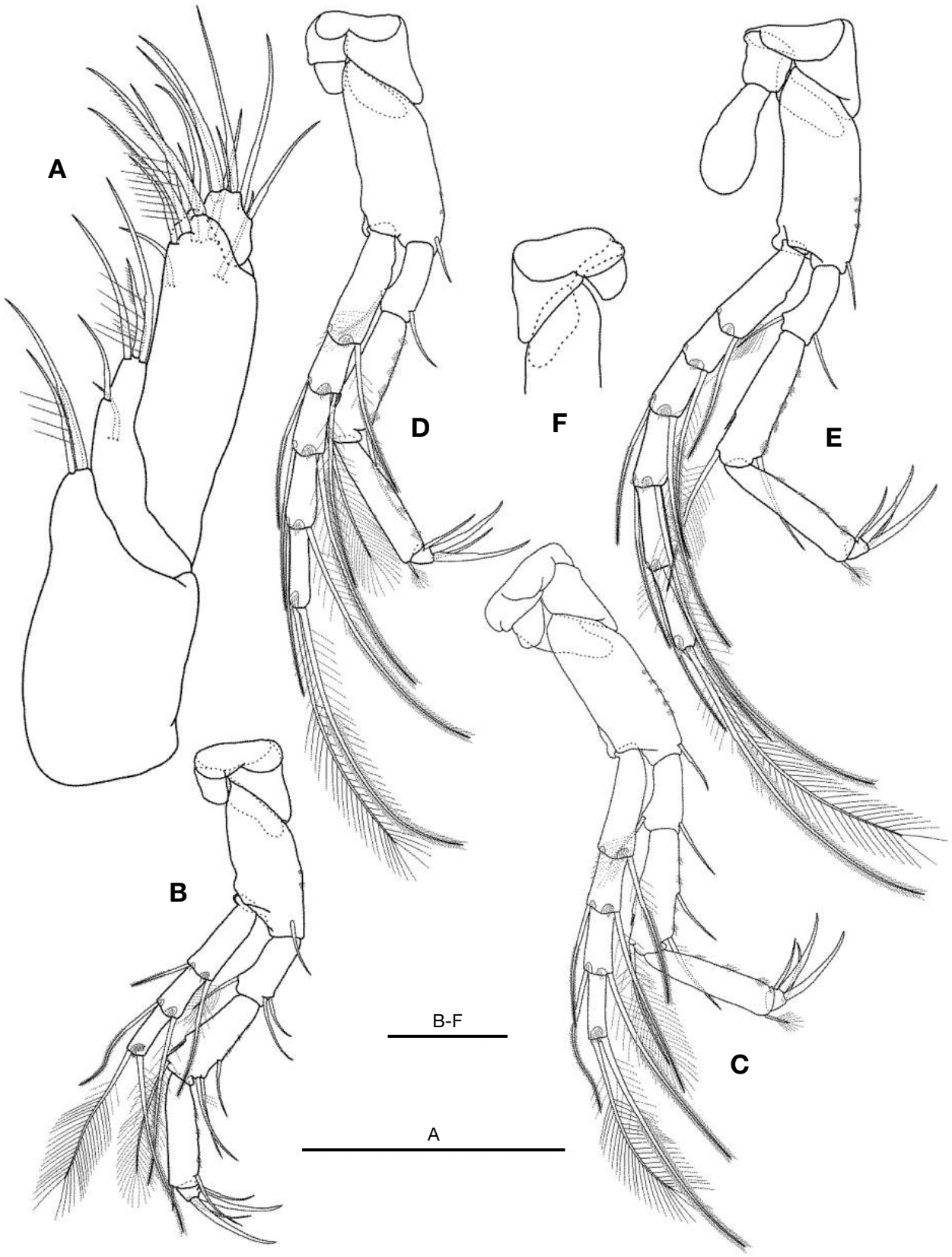


Fig. 69. *Allobathynella donggangensis* (holotype: ♀): (A) Maxilla (dorsal); (B) Thoracopod I (frontal); (C) Thoracopod II (frontal); (D) Thoracopod III (frontal); (E) Thoracopod IV (frontal); (F) Protopod of thoracopod IV (frontal). Scale bars = 0.1 mm.

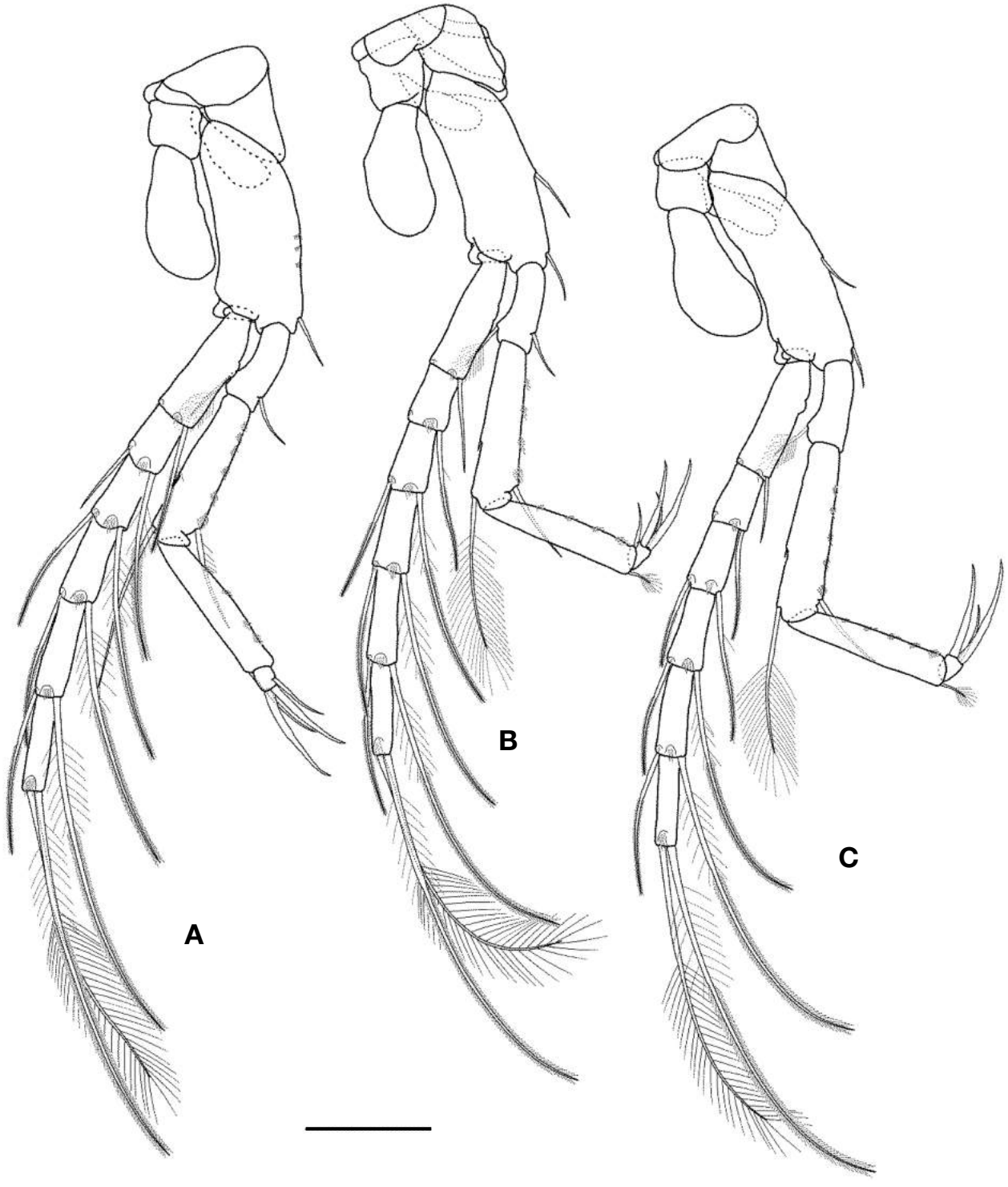


Fig. 70. *Allobathynella donggangensis* (holotype: ♀): (A) Thoracopod V (frontal); (B) Thoracopod VI (frontal); (C) Thoracopod VII (frontal). Scale bar = 0.1 mm.

Maxillule (Fig. 68E) two-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal smooth spines, with four smooth spines on inner edge, and with three simple setae on outer distal margin. Terminal spine 1.3 times as long as other ones.

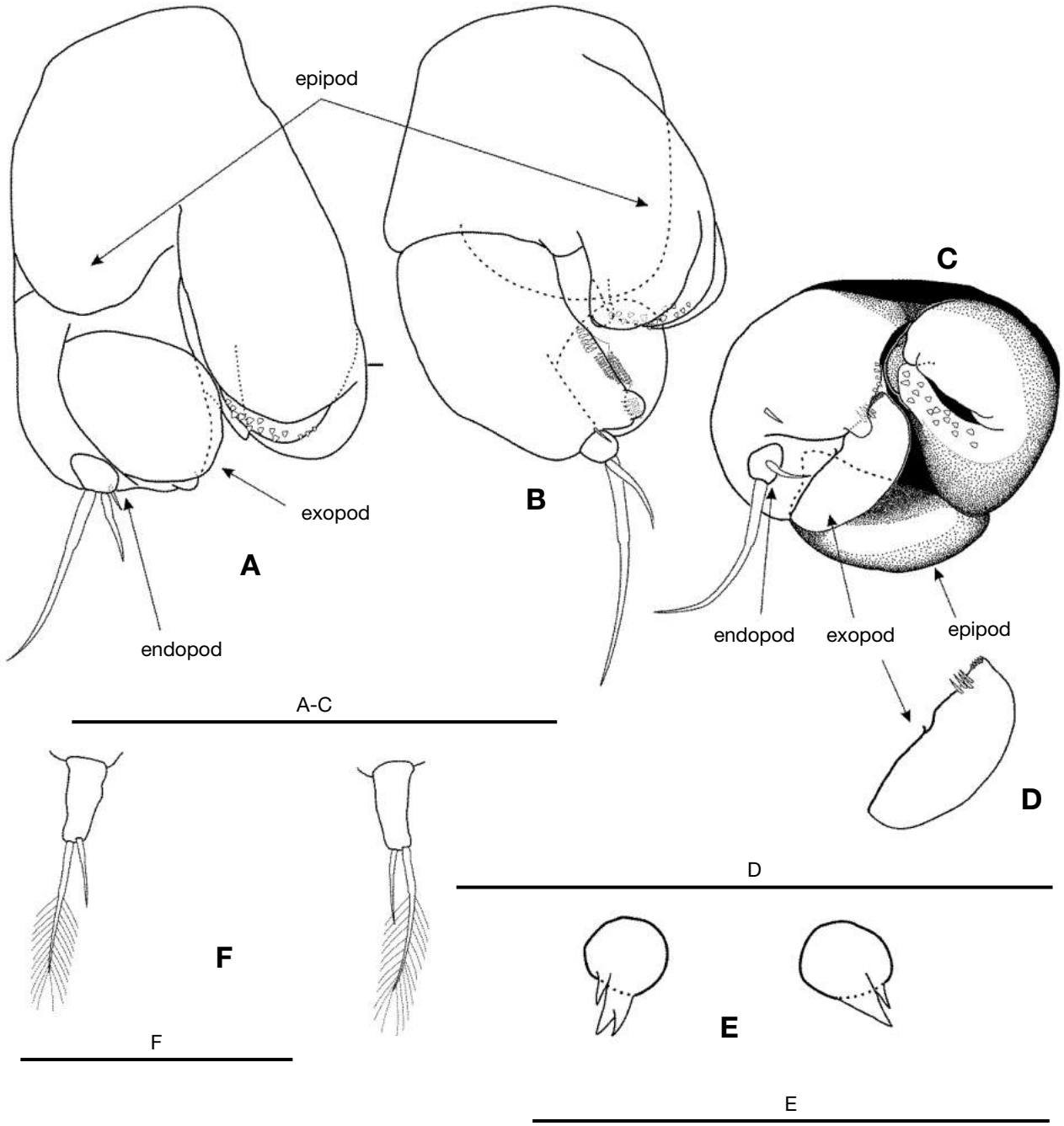


Fig. 71. *Allobathynella donggangensis* (holotype: ♀; allotype: ♂): (A) Thoracopod VIII ♂ (inner lateral); (B) Thoracopod VIII ♂ (lateral); (C) Thoracopod VIII ♂ (ventral); (D) Exopod of thoracopod VIII ♂ (ventral); (E) Thoracopod VIII ♀ (ventral); (F) Pleopod I (ventral). Scale bars = 0.1 mm.

Maxilla (Fig. 69A) four-segmented, setal formula 3-5-9-6.

Thoracopods I-VII (Figs. 69B-F, 70A-C). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods IV-VII (or V-VII in left) each bearing one epipod on the protopod. Basipod with one distal seta in thoracopods I-V, with each one distal and median seta in thoracopods VI-VII. Number of segments of the exopod of the thoracopods I-VII: 3-4-5-6-6-6-6. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods II-VII and second segment lacking dorsal

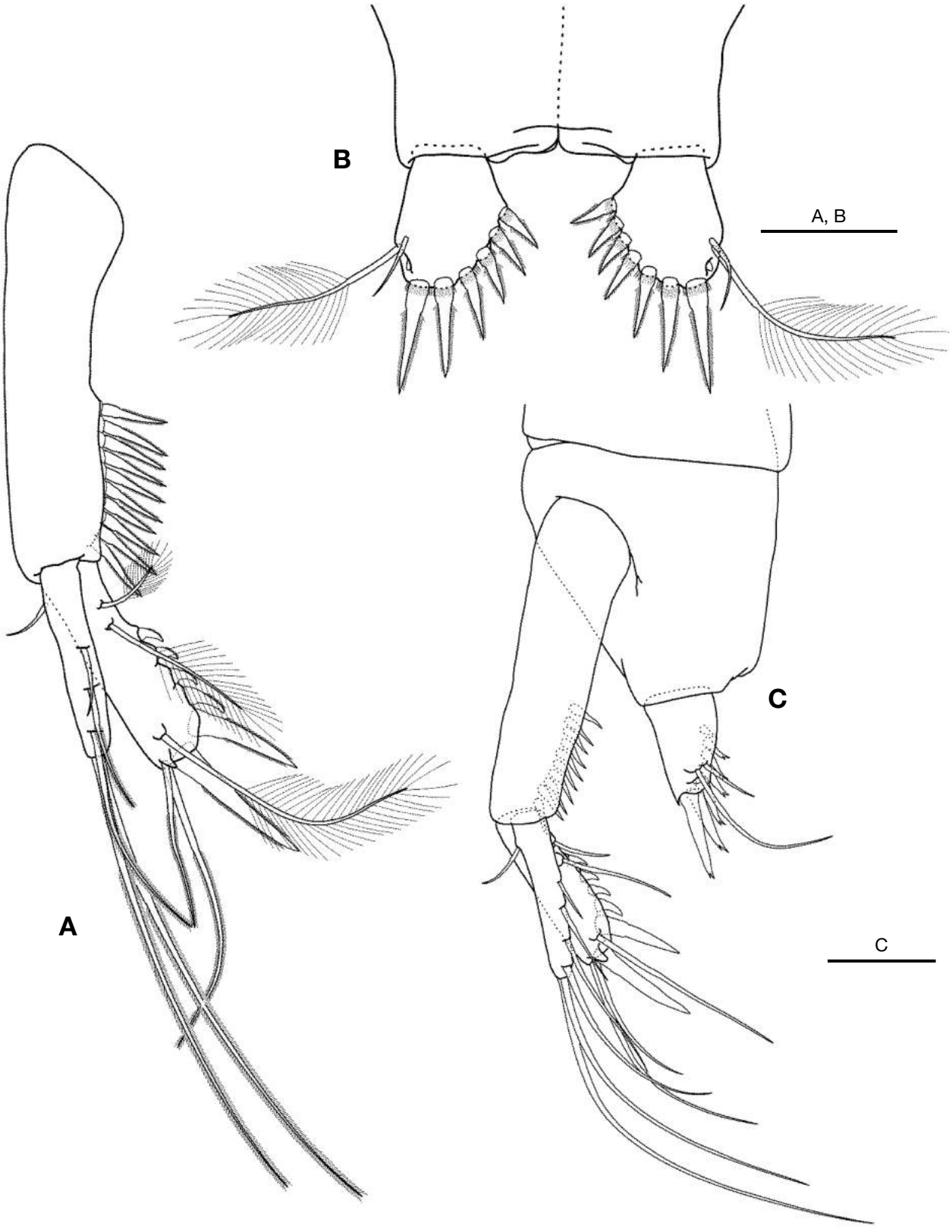


Fig. 72. *Allobathynella donggangensis* (holotype: ♀): (A) Uropod (dorsal); (B) Pleotelson and furcal rami (dorsal); (C) Pleotelson, uropod and furcal ramus (lateral). Scale bars = 0.1 mm.

seta in thoracopod V-VII. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of the thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	2 + 1/3 + 2/1 + 1/4(2)
Thoracopod II	1 + 1/2 + 2/0 + 1/4(2)
Thoracopods III-VI	1 + 1/1 + 2/0 + 1/4(2)
Thoracopods VII	1 + 1/1 + 2/0 + 1/3(1)

Thoracopod VIII of male (Fig. 71A-D) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Inner margin of penial region (dental lobe) with 15 teeth. Epipod flat, with round distal part not reaching lower margin of exopod. Basipod with one small seta near base of endopod, inner margin with spinules, distally drawn out into round projection. Exopod one third of size of basipod, round, with two distal lobes. Upper lobe with four spinules, lower lobe with five dentils. Endopod small, round, with two distal setae of different size. Outer seta three times longer than inner one. Thoracopod VIII of female (Fig. 71E) conical in ventral view, with two or three spine-like distal projections.

First pleopod (Fig. 71F) in form of stub bearing two distal setae.

Uropod (Fig. 72A, C) bearing ten spines on inner margin of sympod of similar size. Endopod 53% as long as sympod, with two dorsal plumose setae near the base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and four additional spines along inner margin. The terminal spine longer than subterminal one. Most distal spine of inner margin smaller than subterminal one, one third as large as terminal one. Three proximal spines of inner margin small, half as large as distal one. Exopod shorter than endopod (45% of sympod), with six setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 72B, C) without seta. Anal operculum nearly flat.

Furcal rami (Fig. 72B, C) 1.3 times as long as wide, with two large distal spines, and four (left) or five (right) successively smaller spines on inner margin, and with two dorsal setae.

***Allobathynella gangneungensis* sp. nov.** (Figs. 73-76)

Etymology

The species name is derived from the name of the city (Gangneung-Si), where the material was collected.

Material examined

Holotype (adult female), paratypes (five adult females and two juveniles). Holotype dissected on seven slides (NIBR IV0000267077). One female paratype dissected on seven slides (NIBR IV0000267078), three females each as a whole specimen in separate slides (NIBR IV0000267079-267081), two juveniles together as a whole specimen in a slide (NIBR IV0000267082).

Type locality

South Korea, Kangwon-Do, Gangneung-Si, Gangdong-Myeon, Imgok-Ri (37°39′44.9″N, 128°58′06.3″E), 07 October 2011, leg. J.-G. Park.

Description

Size (mm). Body length: 1.28 (other females: 1.05-1.25), approximately 10 times as long as wide. Head as long as anterior three thoracic segments combined (Fig. 73A).

Antennule (Fig. 73B) 7-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with one simple seta dorsally and two simple setae ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and one dorsal seta and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with two simple setae and one small plumose seta, two dorsal aesthetascs and one simple seta. Sixth segment with four setae including one plumose seta on inner margin, and with two aesthetascs and one simple seta and one aesthetasc dorsally. Seventh segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 73C) 7-segmented, as long as the length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/5(1).

Labrum (Fig. 73D) flat, with six main teeth flanked by one tooth on both lateral sides. Ventral surface concave, with one round median projection bearing two spinules and two pairs of teats and with numerous combs of ctenidia on concave surface.

Mandible (Fig. 73E) with incisor process of three teeth. Tooth of ventral edge absent. Spine row consisting of six spines. Palp of one segment, with one terminal seta.

Maxillule (Fig. 74A) two-segmented. Proximal segment with four setae on inner distal margin. Distal segment with two terminal smooth spines, with four smooth spines on inner edge, and with three simple setae on outer distal margin. Terminal spine nearly two times as long as other ones.

Maxilla (Fig. 74B) four-segmented, setal formula 3-4-

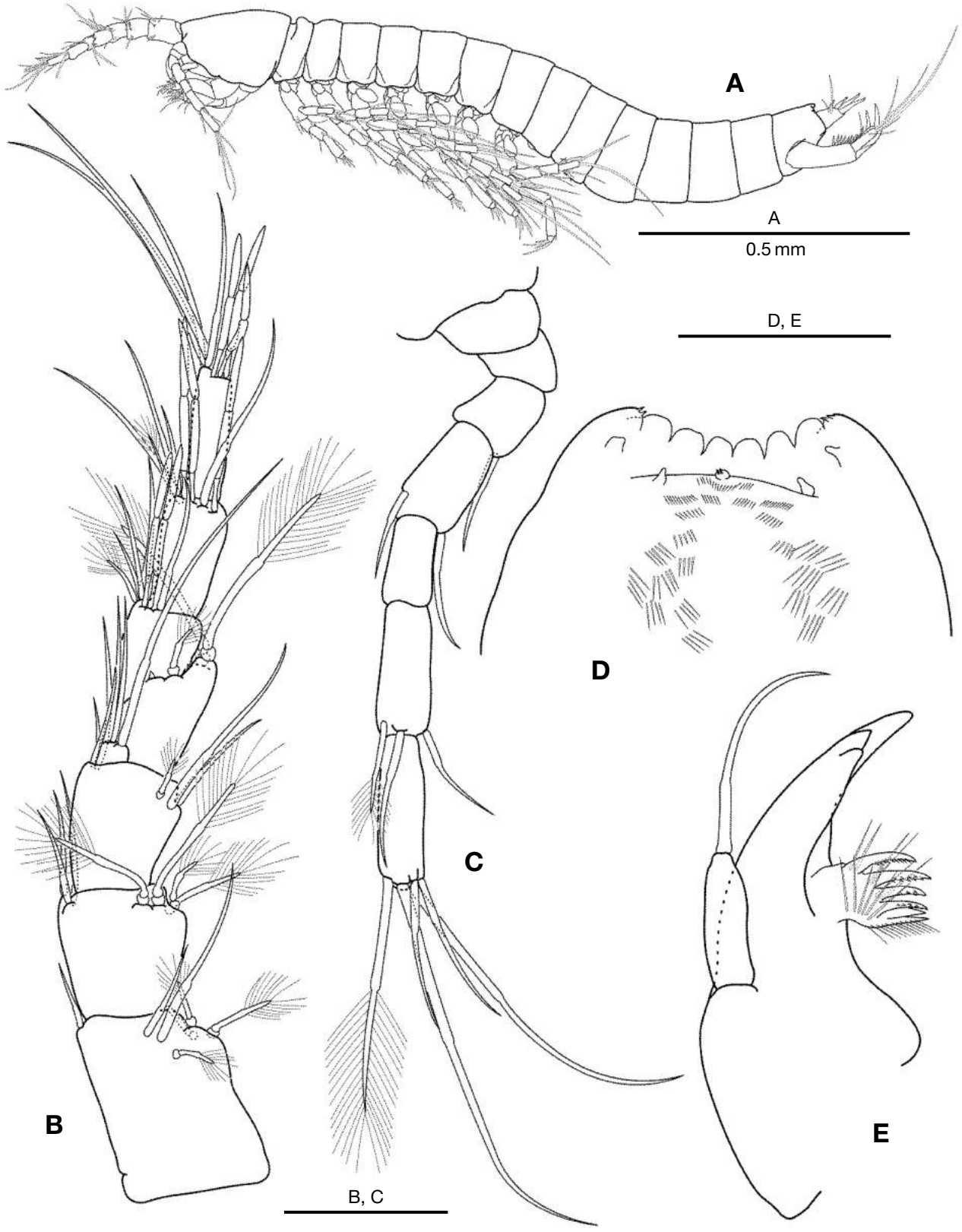


Fig. 73. *Allobathynella gangneungensis* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorsal); (D) Labrum (ventral); (E) mandible (dorsal). Scale bars = 0.05 mm, unless specified.

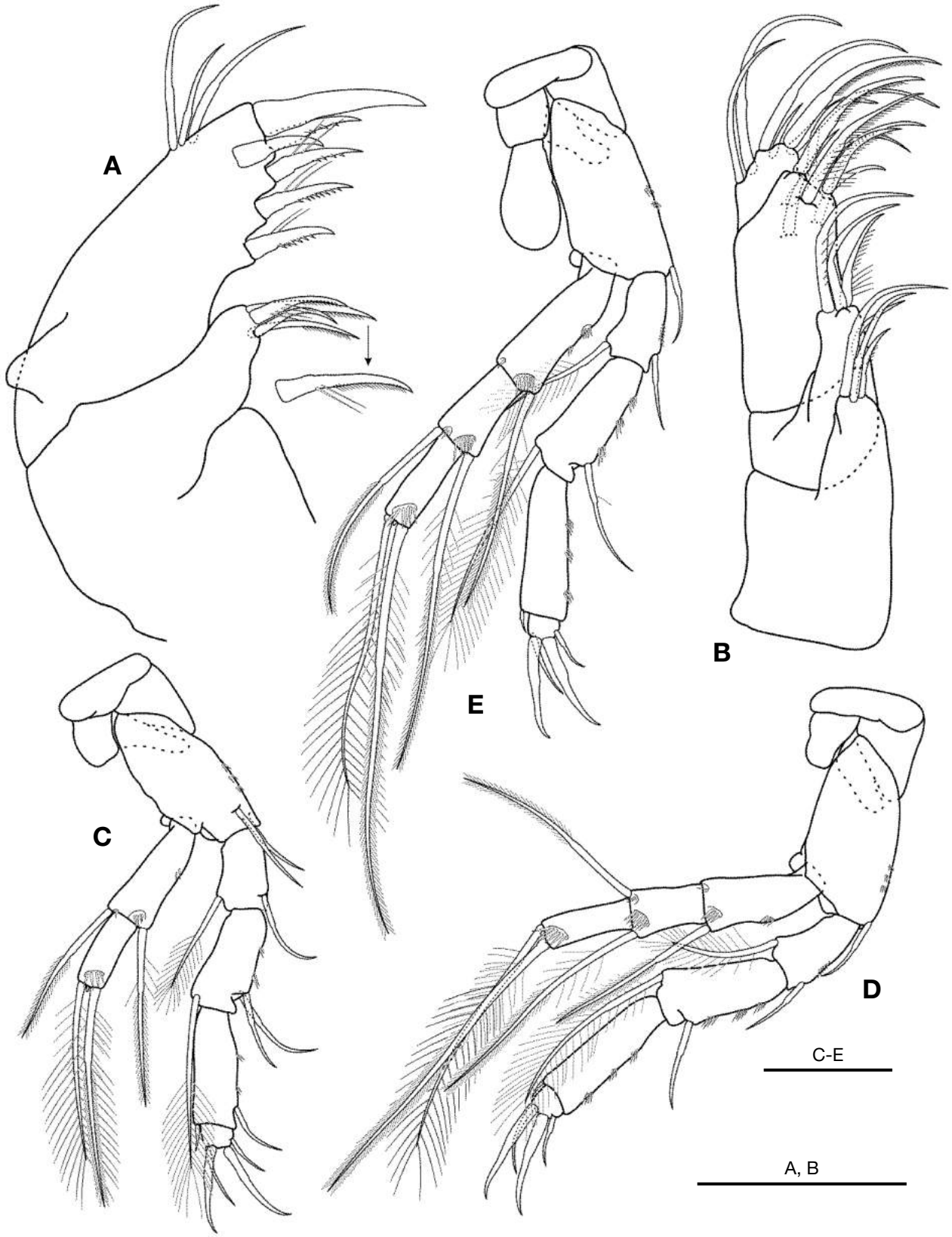


Fig. 74. *Allobathynella gangneungensis* (holotype: ♀): (A) maxillule (ventral); (B) maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal); (E) Thoracopod III (frontal). Scale bars = 0.05 mm.

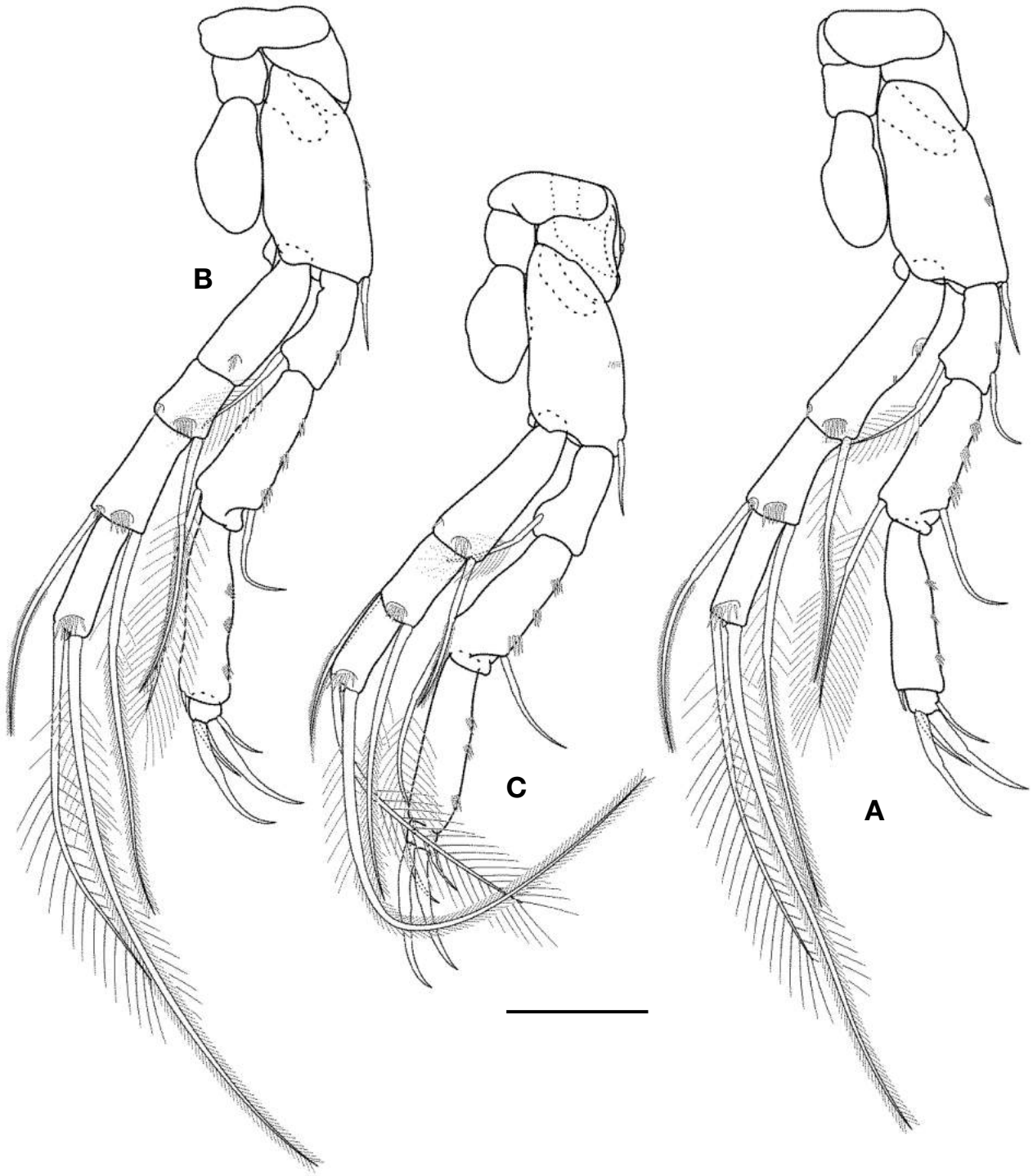


Fig. 75. *Allobathynella gangneungensis* (holotype: ♀): (A) Thoracopod IV (frontal); (B) Thoracopod V (frontal); (C) Thoracopod VI (frontal). Scale bar = 0.05 mm.

8-6.

Thoracopods I-VII (Figs. 74A-C, 75A-C, 76A). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on the protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-VI, with each one distal and median seta in thoracopod VII. Number of segments of the exopod of the tho-

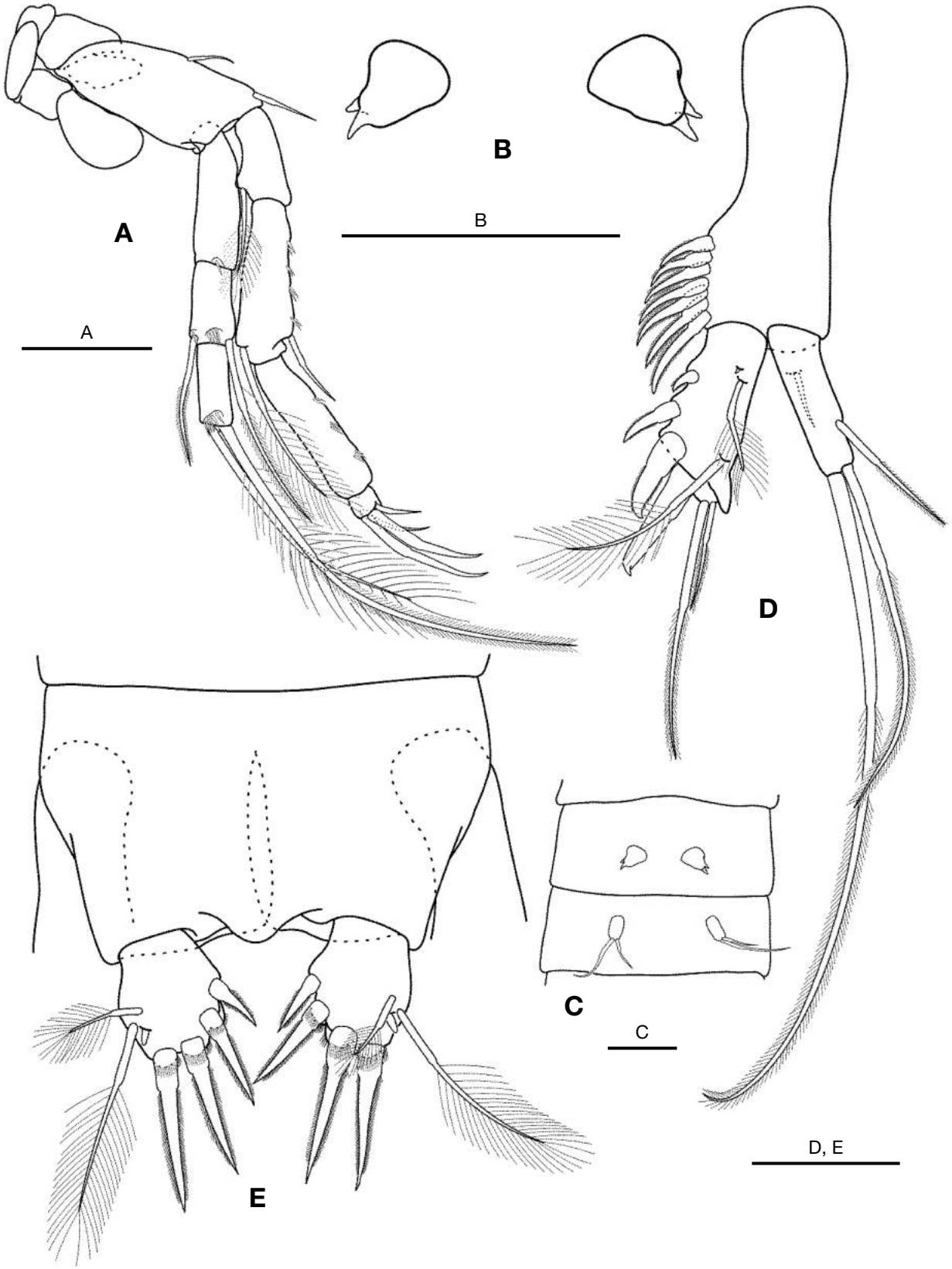


Fig. 76. *Allobathynella gangneungensis* (holotype: ♀): (A) Thoracopod VII (frontal); (B) Thoracopod VIII (ventral); (C) 8th thoracomere and 1st pleomere (ventral); (D) Uropod (dorsal); (E) Pleotelson and furcal rami (dorsal). Scale bars = 0.05 mm.

racopods I-VII: 2-3-3-3-4-3-3. Exopodal segments with each one dorsal and ventral seta, except basal segment lacking dorsal seta in thoracopods II-VII and except second segment lacking dorsal seta in thoracopod V. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of the thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	1 + 1/2 + 1/1 + 1/4(2)
Thoracopods II-IV	1 + 1/1 + 1/0 + 1/4(2)
Thoracopods V-VII	0 + 1/0 + 1/0 + 1/4(2)

Thoracopod VIII of female (Fig. 76B, C) conical in ventral view, with two spine-like distal projections. Thoracopod VIII of male unknown.

First pleopod (Fig. 76B, C) in form of stub bearing two distal setae.

Uropod (Fig. 76D) bearing seven spines on inner margin of sympod, two most distal spine slightly larger than other ones of similar size, most proximal spine significantly smaller than other ones. Endopod 53% as long as sympod, dorsally with one tiny spine and one plumose setae near the base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and two additional spines on inner margin. The terminal spine longer than subterminal one. Distal spine of inner-margin smaller than subterminal one, 1/3 as large as terminal one. Proximal spine of inner-margin small, one third as large as distal one. Exopod shorter than endopod (44% of sympod), with four setae inclusive of one basi-ventral seta.

Pleotelson (Fig. 76E) without seta. Anal operculum protruded with round tip.

Furcal rami (Fig. 76E) 1.3 times as long as wide, with two large distal spines and two successively smaller spines on inner margin, and dorsally with two plumose setae.

***Allobathynella wonjuensis* sp. nov.** (Figs. 77-82)

Etymology

The species name is derived from the name of the city (Wonju-Si), where the material was collected.

Material examined

Holotype (adult female), allotype (adult male), paratypes (three adult females and two adult males). Holotype dissected on six slides (NIBR IV0000266881). Allotype dissected on six slides (NIBR IV0000266882). Seven female paratypes and eight male paratypes each as a whole specimen on separate slides (NIBR IV0000266883-266895).

Type locality

South-Korea, Gangwondo, Wonju-Si Jijeong-Myeon Wolho-dong (37°22′32.0″N, 127°51′18.0″E). 07 June 2011, leg. J.-G. Park.

Description

Size (mm). Body length: ♀ 1.85 mm (other females: 1.75 mm-1.80 mm), ♂: 1.82 mm (other males: 1.70-1.78 mm), approximately 12 times as long as wide. Head slightly shorter than anterior four thoracic segments combined (Fig. 77A). Male differs from female in protopod of thoracopod VI and thoracopod VIII.

Antennule (Fig. 77B) 6-segmented. First segment with one seta on inner distal margin, with two simple dorsal setae and with four plumose setae. Position of each plumose setae: dorsally, dorso-laterally, laterally and ventro-laterally. Second segment with one group of four plumose setae and with each two simple setae dorsally and ventrally on inner distal margin. Third segment with two lateral setae including one plumose seta, with one ventrolateral seta, and two dorsal seta and two ventral setae on inner distal margin. Inner flagellum of third segment with three simple setae. Fourth segment with one stub setae and one plumose seta on dorsal margin, and with two stub setae and two plumose setae on outer distal apophysis. Fifth segment distally with three simple setae and one small plumose seta, two dorsal aesthetascs, one simple seta and one aethetasc, and dorso-medially with two simple setae. Sixth segment with three subterminal aesthetascs and four simple setae.

Antenna (Fig. 77C) 7-segmented, as long as the length of antennular segments 1-5. Setal formula: 0 + 0/0 + 0/1 + 0/1 + 1/0 + 0/1 + 1 + 1/4(1).

Labrum (Fig. 77D) flat, with eight main teeth flanked by three teeth on both lateral sides. Ventral surface concave, with one round median smooth projection, two pairs of teats and with numerous combs of ctenidia.

Mandible (Fig. 77E) with incisor process of four teeth. Tooth of ventral edge absent. Spine row consisting of eight spines. Palp of one segment, with one terminal seta.

Maxillule (Fig. 78A) two-segmented. Proximal segment with four setae on inner distal margin and ctenidia. Distal segment with two terminal smooth spines, with three smooth spines and two spines bearing basal bristles on inner edge, and with three simple setae on outer distal margin. Terminal spine two times as long as other ones.

Maxilla (Fig. 78B) four-segmented, setal formula 3-4-9-6.

Thoracopods I-VII (Figs. 78C, D, 79A, B, 80A, 81A, B). Thoracopod I-IV increasing in size posteriorly. Thoracopods IV-VII similar in size. Thoracopods III-VII each bearing one epipod on the protopod. Basipod with two distal setae in thoracopod I, with one distal seta in thoracopods II-VI, with each one distal and median seta

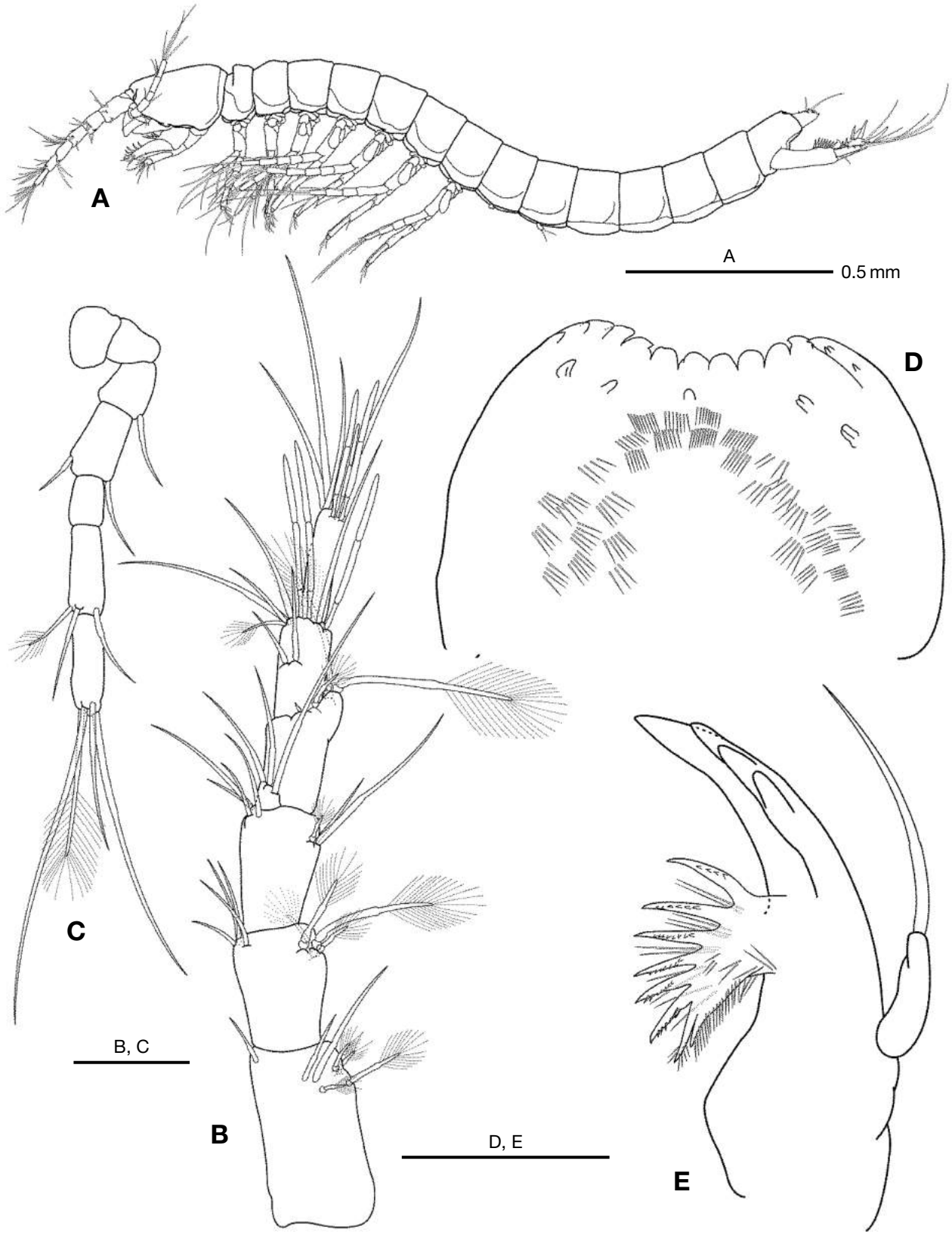


Fig. 77. *Allobathynella wonjuensis* (holotype: ♀): (A) General habitus (lateral); (B) Antennule (dorsal); (C) Antenna (dorsal); (D) Labrum (ventral); (E) Mandible (ventral). Scale bars = 0.05 mm, unless specified.

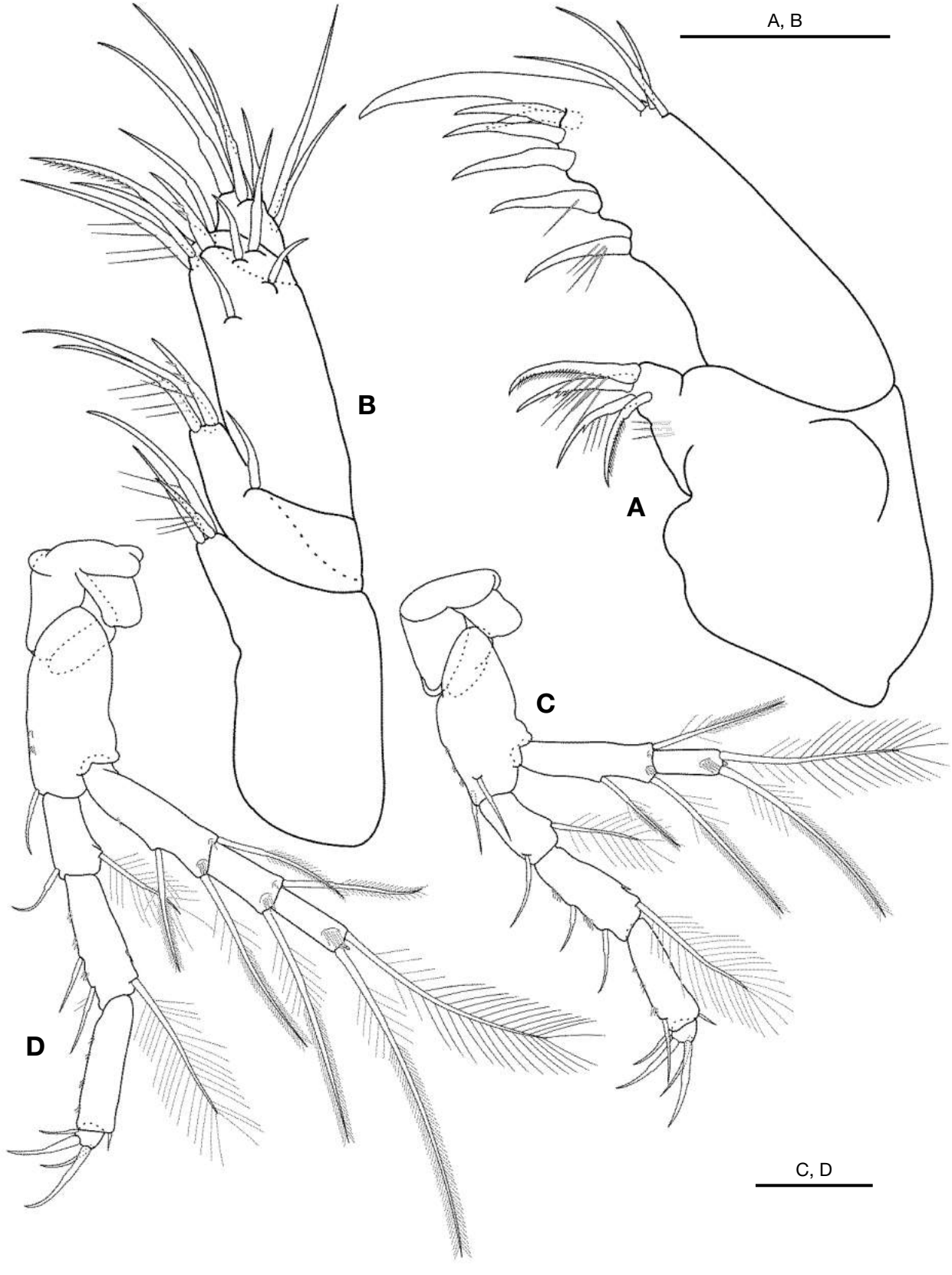


Fig. 78. *Allobathynella wonjuensis* (holotype: ♀): (A) Maxillule (dorsal); (B) Maxilla (dorsal); (C) Thoracopod I (frontal); (D) Thoracopod II (frontal). Scale bars = 0.05 mm.

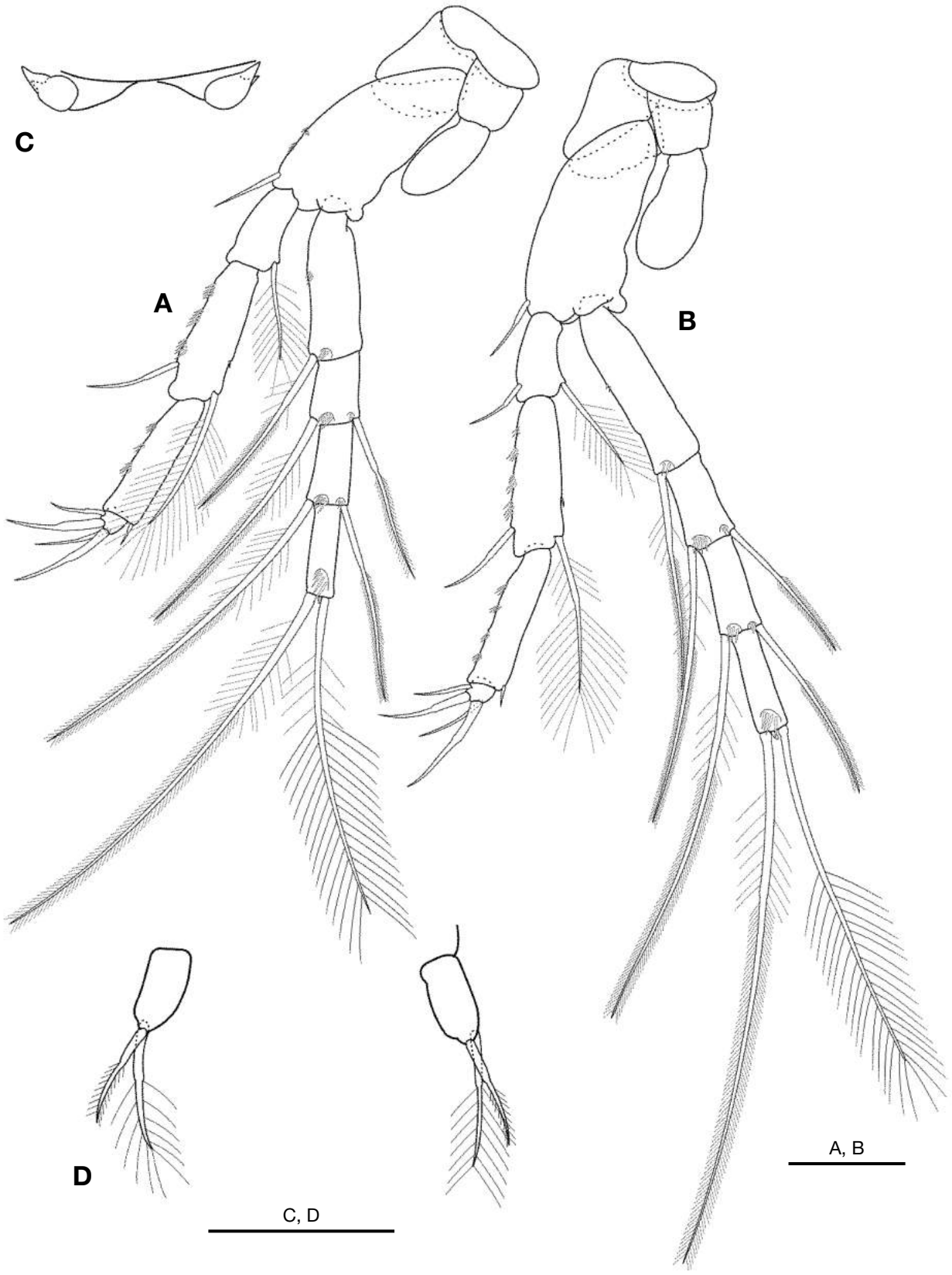


Fig. 79. *Allobathynella wonjuensis* (holotype: ♀): (A) Thoracopod III (frontal); (B) Thoracopod IV (frontal); (C) Thoracopod VIII ♀ (ventral); (D) Pleopod (ventral). Scale bars = 0.05 mm.

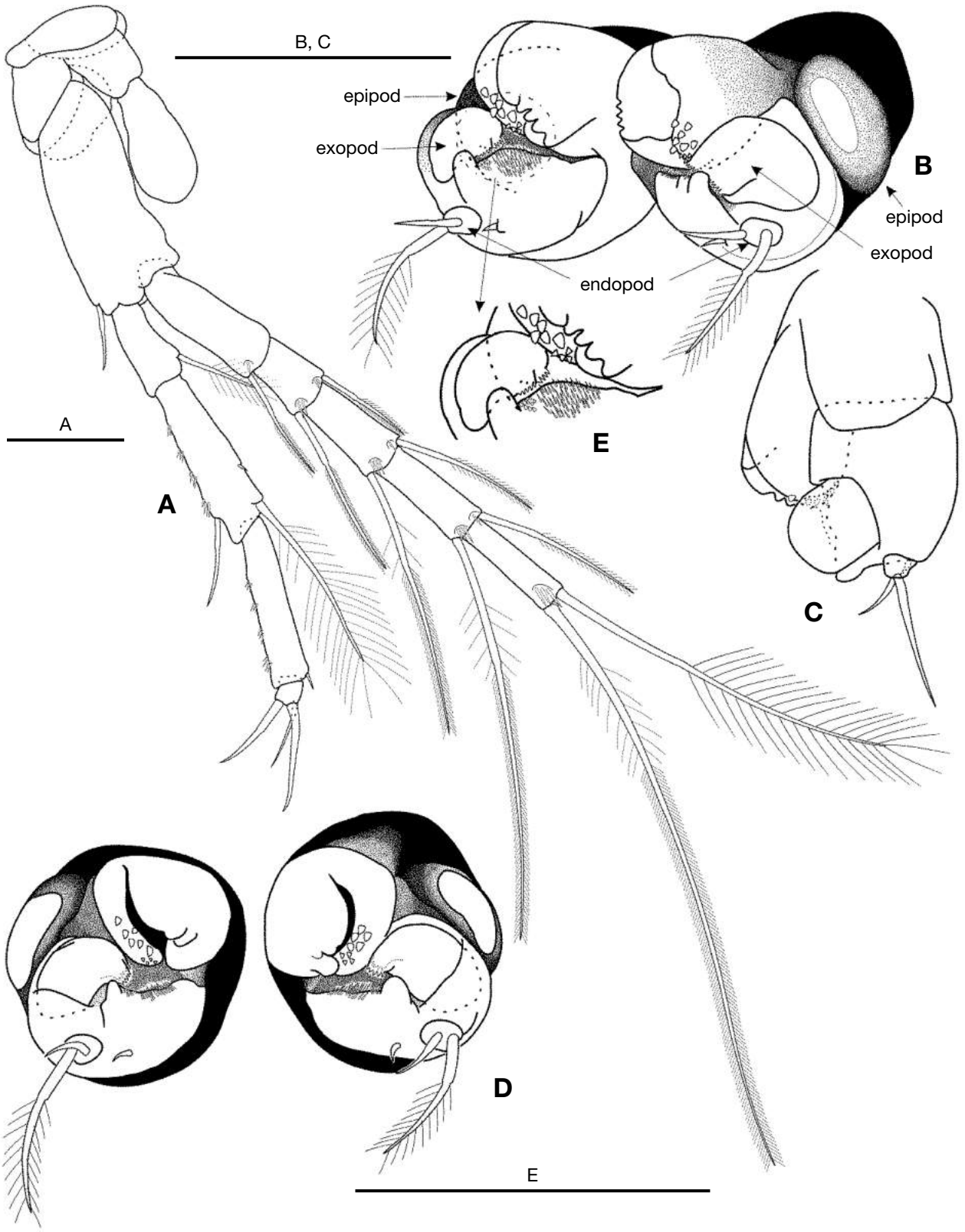


Fig. 80. *Allobathynella wonjuensis* (holotype: ♀; allotype: ♂): (A) Thoracopod V ♀ (frontal); (B) Right and left thoracopods VIII ♂ (ventral, slightly lateral); (C) Thoracopod VIII ♂ (lateral); (D) Right and left thoracopods VIII ♂ (ventral); (E) Penial region, basipod and exopod of thoracopod VIII ♂. Scale bars = 0.05 mm.

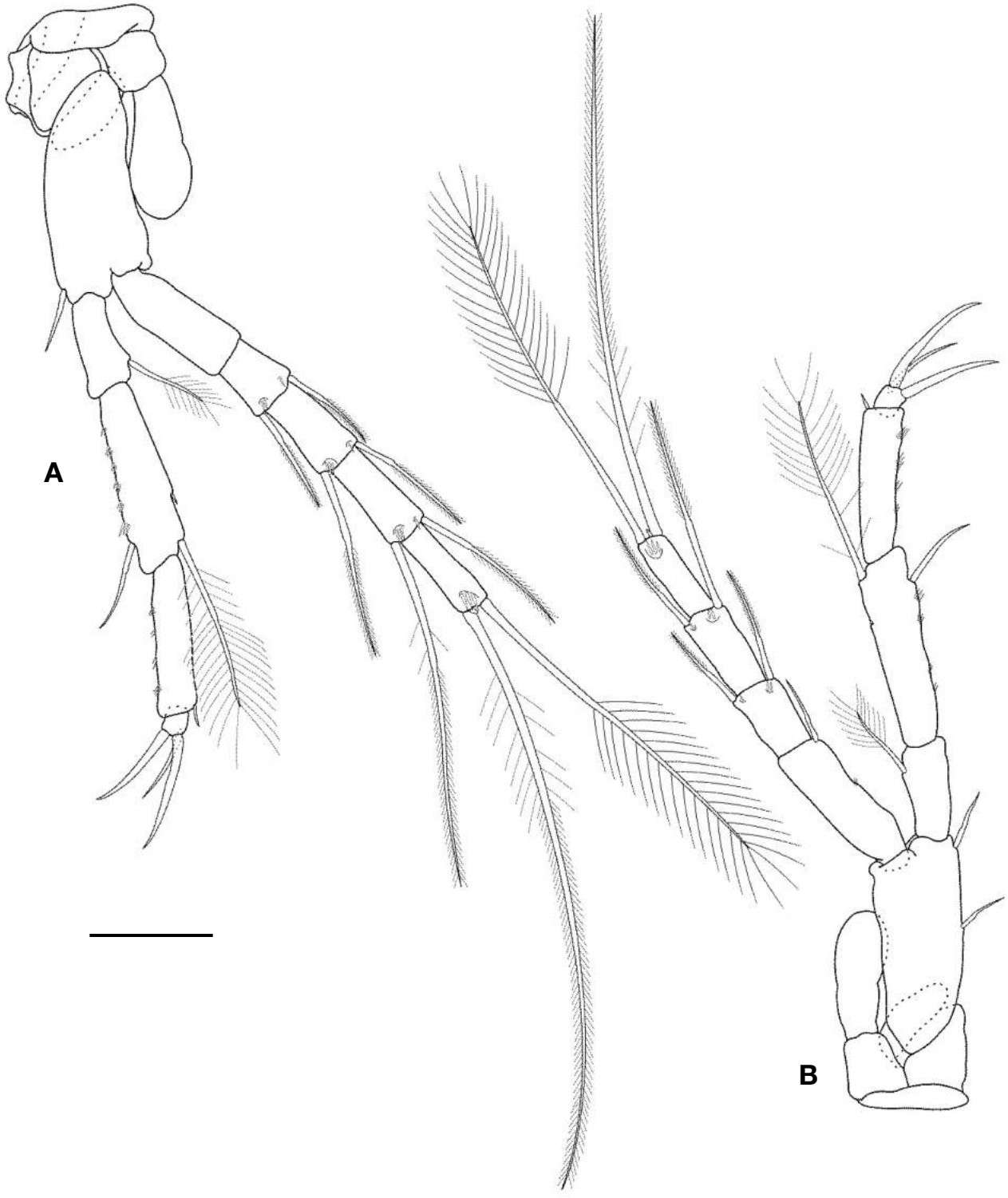


Fig. 81. *Allobathynella wonjuensis* (holotype: ♀): (A) Thoracopod VI ♀ (frontal); (B) Thoracopod VII (frontal). Scale bar = 0.05 mm.

in thoracopod VII. Number of segments of the exopod of the thoracopods I-VII: 2-3-4-4-5-5-4. Exopodal segments with each one dorsal and ventral seta, except basal segment bearing one ventro-medial seta in thoracopods I and II, lacking dorsal seta in thoracopods III, IV, V and VII, and lacking dorsal and ventral setae in tho-

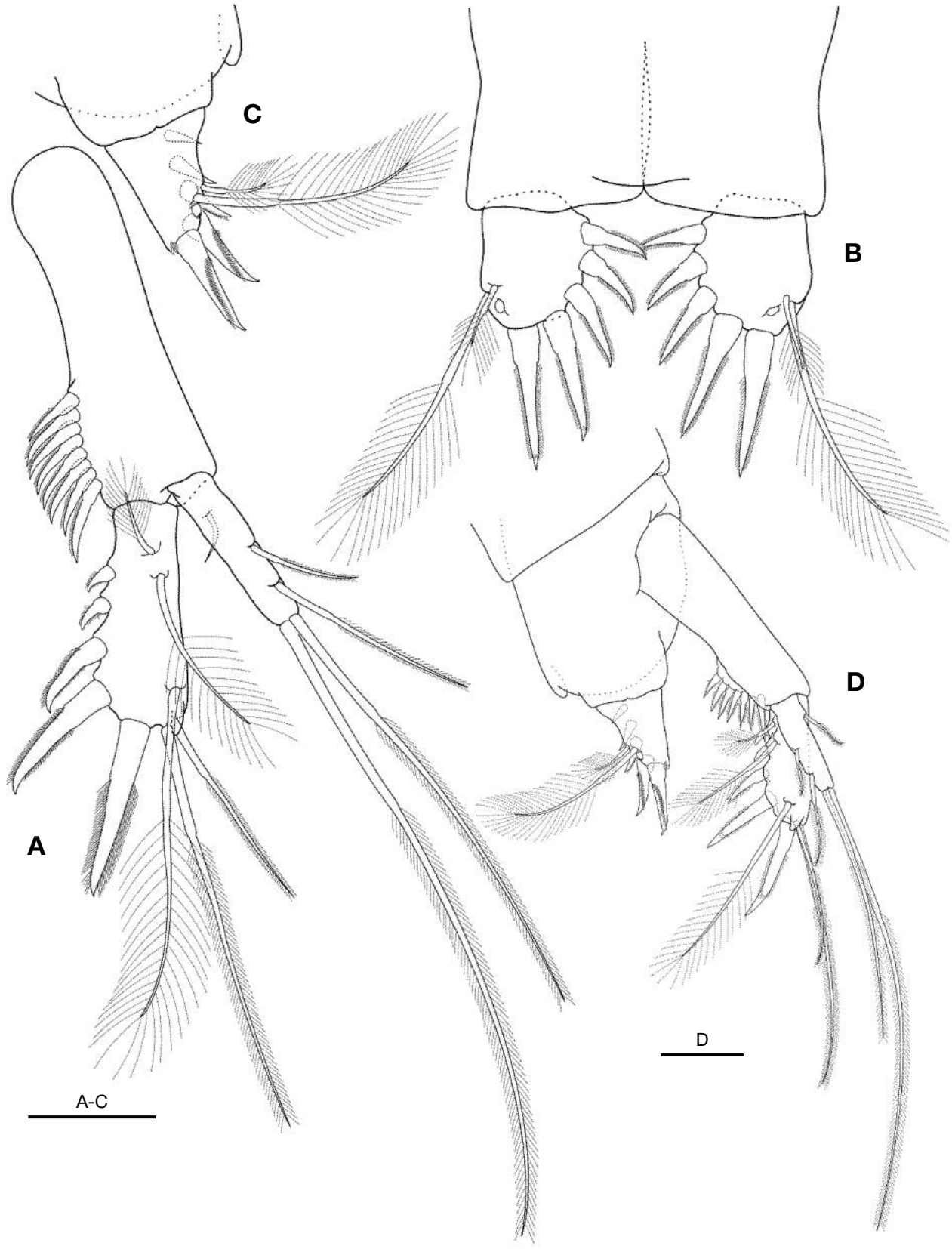


Fig. 82. *Allobathynella wonjuensis* (holotype: ♀): (A) Uropod (dorsal); (B) Furcal rami (dorsal); (C) Furcal ramus (lateral); (D) Uropod, pleotelson and furcal rami (lateral). Scale bars = 0.05 mm.

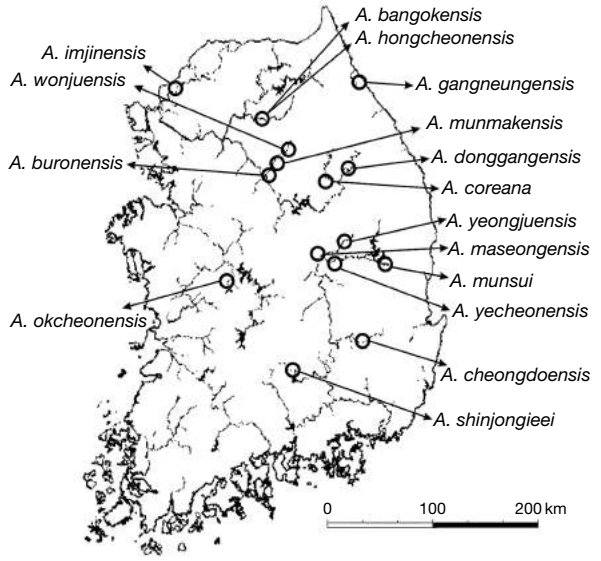


Fig. 83. Map showing the distribution of *A. coreana* Morimoto, 1970, *A. shinjongieei* Park & Cho, 2008, *A. imjinensis* sp. nov., *A. maseongensis* sp. nov., *A. munsui* sp. nov., *A. hongcheonensis* sp. nov., *A. munmakensis* sp. nov., *A. okcheonensis* sp. nov., *A. yeongjuensis* sp. nov., *A. buronensis* sp. nov., *A. bangokensis* sp. nov., *A. yecheonensis* sp. nov., *A. cheongdoensis* sp. nov., *A. donggangensis* sp. nov., *A. gangneungensis* sp. nov., *A. wonjuensis* sp. nov. in South Korea.

racopod VI. Tiny process present between two setae of distal segment. Dorsal seta on distal segment of exopod barbed with strong hairs. Endopod of the thoracopods I-VII four-segmented, setal formulae:

Thoracopod I	1 + 1/2 + 2/1 + 1/4(2)
Thoracopod II	1 + 1/2 + 2/0 + 1/4(2)
Thoracopods III-IV	1 + 1/1 + 2/0 + 1/4(2)
Thoracopods V-VII	0 + 1/1 + 2/0 + 1/3(1)

Dorso-median seta of second segment extremely short.

Thoracopod VIII of male (Fig. 80B-E) perpendicular to body, in form of a bell in lateral view, 1.3 times longer than wide. Protopod with a prominent penial region bearing a distal opening. Frontal margin of penial region undulated, inner margin (dental lobe) with 11 teeth. Epipod flat, with round distal part not reaching lower margin of exopod. Basipod with one small seta near base of endopod, inner margin with tiny dentils and spinules, distally drawn out into round projection. Basipodal seta half as long as endopod. Exopod one third of size of basipod, round, with two distal serrated lobes. Endopod small, round, with two distal setae of different size. Outer seta 2.5 times longer than inner one. Thoracopod VIII of female (Fig. 79C) conical in ventral view, with two spine-like distal projections.

First pleopod (Fig. 79D) in form of stub bearing two distal setae.

Uropod (Fig. 82A, D) bearing eight spines on inner margin of sympod, most distal spine significantly larger than other ones of similar size. Endopod 59% as long as sympod, with two dorsal plumose setae near the base, with two terminal setae and one subterminal plumose seta on outer margin and with one terminal spine, one subterminal spine and three additional spines along inner margin. The terminal spine longer than subterminal one. Most distal spine of inner margin smaller than subterminal one, 50% as large as terminal one. Three proximal spines of inner-margin small, one third as large as distal one. Exopod shorter than endopod (46% of sympod), with five setae including one basi-ventral seta.

Pleotelson (Fig. 82B-D) without seta. Anal operculum nearly flat, slightly convex.

Furcal rami (Fig. 82B-D) 1.5 times as long as wide, with two large distal spines, and three successively smaller spines on inner margin, and with two dorsal plumose setae.

Discussion

Taxonomic affinities

Similar to the type species of the genus, *A. japonica* Morimoto & Miura, 1957, as well as *A. shinjongieei* Park & Cho, 2008, both of which belong to *mirabilis*-group of *Allobathynella* (Park and Cho 2008), all 14 new species show (1) a 7-segmented antennule (except in *A. wonjuensis* sp. nov. with a 6-segmented antennule), (2) a 7-segmented antenna, (3) a flat labrum with dentate free margin, (4) the absence of mandibular proximal tooth, (5) the absence of epipod in thoracopods I-II, (6) exopodal distal segment of thoracopods I-VII with a tiny terminal knob and with outer seta covered by long and strong barbs, (7) a female thoracopod in form of tiny process with distal spines, (8) a bell formed male thoracopod VIII being perpendicular to body and carrying flat epipod and a seta on basipod drawn into spur, (9) a pleopod in form of stalk-like process having two setae, (10) an uropod carrying spine of similar size on sympod, two distal spines and additional spines on inner margin of endopod and a basivenral seta on exopod, and (11) the absence of setae on pleotelson.

Comparison of visible external structure

Morphological differences among the three known (*A. japonica* Morimoto & Miura, 1957, *A. coreana* Morimoto, 1970, *A. shinjongieei* Park & Cho, 2008) and 14 new species (*A. imjinensis* sp. nov., *A. maseongensis* sp. nov., *A. munsui* sp. nov., *A. hongcheonensis* sp. nov., *A. munmakensis* sp. nov., *A. okcheonensis* sp. nov., *A. yeongjuensis* sp. nov., *A. buronensis* sp. nov., *A. bangoken-*

sis sp. nov., *A. yecheonensis* sp. nov., *A. cheongdoensis* sp. nov., *A. donggangensis* sp. nov., *A. gangneungensis* sp. nov. and *A. wonjuensis* sp. nov.) of *Allobathynella* are listed in Tables 1-4. In general, 17 species compared in this study display a somewhat homogeneous body structure, although the body size ranges from 1.28 (*A. gangneungensis*) to 3.41 mm (*A. munsui*). Only a few meristic characters of the 17 species of *Allobathynella* examined here, taken from Tables 1-4, have a positive relationship with body length (proxy for body size), a relationship established by regressing the meristic character against body length. A total of 17 out of 26 comparisons were significant at $p<0.05$ in individual tests using the program 'Microsoft Excel'. The regression coefficiency higher than 0.500 is displayed by the number of exopodal segments on thoracopod III ($r^2=0.623$, $p<0.05$), on thoracopod IV ($r^2=0.678$, $p<0.05$), on thoracopod V ($r^2=0.585$, $p<0.05$) and on thoracopod VI ($r^2=0.582$, $p<0.05$), as well as the number of setae on the uropodal exopod ($r^2=0.547$, $p<0.05$) and the number of spines on the furcal ramus($r^2=0.586$, $p<0.05$). As explicated below, most characters distributed among species are irrespective of body size.

Antennule

With an exception of *A. wonjuensis*, all species have a 7-segmented antennule. In *Eobathynella* Birsirstein & Ljovuschkin, 1964, the antennule is also either 7- (in *E. mesasiatica* Birstein and Ljovuschkin, 1964) or 6-segmented (in the four remaining species). However, it is to be noted that *E. mesasiatica* is morphologically quite different from its congeners, which display a very homogeneous feature and for which even an erection of a separate genus has been suggested (Camacho, 2005). With this single exception, the number of of antennular segment is known to be a constant character in a genus. However, this picture changes with the state found in *A. wonjuensis* sp. nov., a species which has a 6-segmented antennule, similar to *Nipponbathynella* Schminke, 1973, with an exception that the fifth segment carries a group of setae on the medial inner margin. Although the setal group does not include an aesthetasc as in *Nipponbathynella* (see Cho *et al.,* 2008), it also indicates that the fusion of fifth and sixth segments of the 7-segmented antennule occured repeatedly within the family.

The variation of setal ornaments is displayed on the segments 2, 3, 5 and 6. The segment 2 usually carries four plumose setae (two setae on each dorsal and ventral inner margin), while *A. hongcheonensis* sp. nov. is the only species displaying a single seta on the ventral inner margin. The segment 3 typically carries each two setae on the dorsal and ventral inner margin respectively; two lateral setae including one plumose seta; and one ventrolateral seta. In *A. japonica* Morimoto & Miura, 1957, *A. donggangensis* and *A. gangneungensis*, the dorsal inner margin carries only one seta, while three setae are present on the ventral inner margin in *A. maseongensis* and *A. munsui*. The ventrolateral seta could be either absent (in *A. japonica*), or very short (in *A. donggangensis*), while *A. okcheonensis* sp. nov. carries two ventrolateral setae.

The segment 5 displays a notable variation in its setal ornamentation. In *A. coreana* Morimoto, 1970, *A. shinjongieei*, *A. imjinensis*, *A. maseongensis*, *A. munsui*, *A. hongcheonensis* and *A. munmakensis*, there is a medial seta on the inner margin, which is smooth in the remaining species. As far as we know, the presence of such seta is unique within the family. On the segment 5, *A. japonica* lacks two aesthetascs, which are present in all other species. As mentioned above, the segments 5 and 6 seem to be fused to a single segment in *A. wongjuensis*. At this stage, however, a comparison of the two dorsomedial setae in this species with the setation of the segment 5 of the remaining species is not possible.

Antenna

The antenna of all 17 species of *Allobathynella* compared is 7-segmented. In *A. coreana*, the segment 7 is long and there is a discontunity of its chitinized exoskeleton around the middle length. If this condition indicates the vestige of an articulation between two segments, is not clear, since no parabathynellid has an antenna of more than 7 segments. Except in the segment 1, the ornamentation of the antennal segments varies according to species. In *A. shinjongieei* and *A. bangokensis*, the segment 2 carries a row of ctenidia on the inner margin, while it is smooth in the remaining species. The segment 3 usually carries one seta on the inner margin. In *A. imjinensis*, there is a seta on the outer margin. The segment 4 usually carries one seta each on the inner and outer margin. The outer seta is absent only in *A. yeongjuensis*. Except in *A. shinjongieei*, a species having one inner seta, the segment 5 is always smooth. The segment 6 usually carries one plumose seta on the outer margin and one simple seta each on the inner and dorsal margin. In *A. japonica* and *A. donggangensis*, the plumose seta is lacking. The segment 7 carries, beside the ventral plumose seta, either three (*A. japonica*, *A. yeongjuensis*, *A. donggangensis*, *A. wonjuensis*) or four simple setae (in the remaining species).

Labrum

The number of teeth on the free margin of the labrum varies from 7 (*A. gangneungensis*) to 15 (*A. maseongensis*), but there are eight main teeth in most species, while occationally 12 in *A. maseongensis* and six in *A. bu-*

Table 1. Mophological differences in antennule and antenna among species of *Allobathynella*. The antennules of *Al. mirabilis*, *Al. gigantea gigantea*, *Al. gigantea pluto*, *Al. kuma*, *Al. carinata* is not considered. 1: *A. japonica* Morimoto & Miura, 1957, 2: *A. coreana* Morimoto, 1970, 3: *A. shinjongieei* Park & Cho, 2008, 4: *A. imjinensis* sp. nov., 5: *A. maseongensis* sp. nov., 6: *A. munsui* sp. nov., 7: *A. hongcheonensis* sp. nov., 8: *A. munmakensis* sp. nov., 9: *A. okcheonensis* sp. nov., 10: *A. yeongjuensis* sp. nov., 11: *A. buronensis* sp. nov., 12: *A. bangokensis* sp. nov., 13: *A. yecheonensis* sp. nov., 14: *A. cheongdoensis* sp. nov., 15: *A. donggangensis* sp. nov., 16: *A. gangneungensis* sp. nov., 17: *A. wonjuensis* sp. nov. Abbrevations used in table are: a = aethetasc; d = dorsal seta; da = dorsal aesthetasc; dm = dorso-medial seta; dp = dorsal plumose seta; i = seta on inner distal margin; id = dorso-inner seta; im = medial seta on inner margin; ip = inner plumose seta; iv = ventro-inner seta; lp: lateral plumose seta; p = plumose seta; pa = plumose seta on apophysis; s = simple seta; ss = stub seta; vl = ventro-lateral seta; vp = ventral plumose seta.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Body (max., mm)	2.10	2.01	1.53	1.75	2.55	3.41	1.83	1.66	2.73	1.86	1.66	2.24	2.40	2.15	2.54	1.28	1.85
Antennules																	
No. of segment	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	6
Setal ornaments																	
Segment 2	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	2id, **1iv**	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	2id, 2iv	**1id**, 2iv	2id, 2iv
Segment 3	**1id**, 2iv	1vl, 2id, 2iv	1vl, 2id, 2iv	1vl, 2id, 2iv	1vl, 2id, **3iv**	1vl, 2id, **3iv**	1vl, 2id, 2iv	1vl, 2id, 2iv	2vl, 2id, 2iv	1vl, 2id, 2iv	1vl, 2id, 2iv	1vl, 2id, 2iv	1vl, 2id, 2iv	1vl, 2id, 2iv	1vl (short), **1id**, 2iv	1vl, **1id**, 2iv	1vl, 2id, 2iv
Segment 5	2i, 1ip, 1d	2i, 1ip, 2da, 1d, 1im	2i, 1ip, 2da, 1d, 1im	2i, 1ip, 2da, 1d, 1im	2i, 1ip, 2da, 1d, 1im	2i, 1ip, 2da, 1d, 1im	2i, 1ip, 2da, 1d, 1im	2i, 1ip, 2da, 1d, 1im	2i, 1ip, 2da, 1d	2i, 1ip, 2da, 1d	2i, 1ip, 2da, 1d	2i, 1ip, 2da, 1d	2i, 1ip, 2da, 1d	2i, 1ip, 2da, 1d	2i, 1ip, 2da, 1d	2i, 1ip, 2da, 1d	2 dm, 2i, 1ip, 2da, 1d
Segment 6	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	2i, 1ip, 2da, 1d, 1a	3i, 1ip, 2da, 1d, 1a	
Antenna																	
Segment 2	Smooth	Smooth	Ctenidia on inner margin	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Ctenidia on inner margin	Smooth	Smooth	Smooth	Smooth	Smooth
Segment 3	1 inner seta	1 inner seta	1 inner seta	1 inner seta + 1 outer seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta	1 inner seta
Segment 4	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta	1 inner seta + 1 outer seta
Segment 5	Smooth	Smooth	1 inner seta	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth	Smooth
Segment 6	2 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	3 setae	2 setae	3 setae	3 setae
Segment 7	4 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	5 setae	4 setae	5 setae	5 setae	5 setae	5 setae	4 setae	5 setae	4 setae

Table 2. Mophological differences in mouthparts among species of *Allobathynella*. The antennules of *Al. mirabilis, Al. gigantea gigantea, Al. gigantea* pluto, *Al. kuma, Al. carinata* is not considered. 1: *A. japonica* Morimoto & Miura, 1957, 2: *A. coreana* Morimoto, 1970, 3: *A. shinjongieei* Park & Cho, 2008, 4: *A. imjinensis* sp. nov., 5: *A. maseongensis* sp. nov., 6: *A. munsui* sp. nov., 7: *A. hongcheonensis* sp. nov., 8: *A. munmakensis* sp. nov., 9: *A. okcheonensis* sp. nov., 10: *A. yeongjuensis* sp. nov., 11: *A. buronensis* sp. nov., 12: *A. bangokensis* sp. nov., 13: *A. yecheonensis* sp. nov., 14: *A. cheongdoensis* sp. nov., 15: *A. donggangensis* sp. nov., 16: *A. gangneungensis* sp. nov., 17: *A. wonjuensis* sp. nov.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Labrum																	
Main teeth	8	8	8	8	12	8	8	8	8	8	6	8	8	8	9	6	8
Laternal teeth	5	3	3	5 or 6	3	2 or 3	2	3	2	3	2	3	3 or 5	4 or 5	4	1	3
Ventral surface	Concave	Concave	Concave	Concave	Concave	Concave	Concave	Concave	Concave	Concave	Convex	Concave	Concave	Concave	Concave	Convex	Concave
Chintin-plate	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Absent	Present	Present	Absent	Absent	Absent
Incisor process																	
No. of teeth	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	3	4
Spine row																	
No. Spine	9	9	9	8	10	11	9	8	15	7	7	11	8	8	9	6	8
Palp																	
Segments	1	1	1	1	1	1	1	1	1	1	1	1	1	2	1	1	1
No. of seta	1	1	2	2	2	2	2	1	2	1	2	2	2	2	1	1	1
Maxillule																	
No. of spines on distal segment	6	8	7	7	7	8	7	7	7	6	7	8	6	6	6	6	7
Maxilla																	
Segment 1	3	3	3	3	4	3	3	3	3	3	3	3	3	3	3	3	3
Segment 2	4	5	5	4	5	6	4	5	5	5	4	5	4	4	5	4	4
Segment 3	9	12	10	10	12	10	10	11	12	10	10	11	10	10	9	8	9

Table 3. Mophological differences in thoracopods I-VII among species of *Allobathynella*. The antennules of *Al. mirabilis, Al. gigantea gigantea, Al. gigantea* pluto, *Al. kuma*, *Al. carinata* is not considered. 1: *A. japonica* Morimoto & Miura, 1957, 2: *A. coreana* Morimoto, 1970, 3: *A. shinjongieei* Park & Cho, 2008, 4: *A. imjinensis* sp. nov., 5: *A. maseongensis* sp. nov., 6: *A. munsui* sp. nov., 7: *A. hongcheonensis* sp. nov., 8: *A. munmakensis* sp. nov., 9: *A. okcheonensis* sp. nov., 10: *A. yeongjuensis* sp. nov., 11: *A. buronensis* sp. nov., 12: *A. bangokensis* sp. nov., 13: *A. yecheonensis* sp. nov., 14: *A. cheongdoensis* sp. nov., 15: *A. donggangensis* sp. nov., 16: *A. gangneungensis* sp. nov., 17: *A. wonjuensis* sp. nov.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Thoracopods I-VII																	
Epipod in	Th III-VII	Th III-VII	Th IV-VII	Th III-VII	Th IV-VII	Th III-VII	Th III-VII	Th III-VII	Th III-VII	Th III-VII	Th III-VII	Th IV-VII	Th IV-VII	Th III-VII	Th IV-VII	Th III-VII	Th III-VII
No. of basipodal setae																	
th I	1	2	2	2	2	1	2	2	2	2	2	2	2	2	1	2	2
th II	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
th III	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
th IV	1	2	2	1	2	1	1	2	1	1	1	2	2	1	1	1	1
th V	2	2	2	1	2	2	1	2	1	1	1	2	2	2	1	1	1
th VI	2	2	2	1	2	2	2	2	1	1	1	2	2	2	2	1	1
th VII	2	2	1	2	2	2	2	1	2	2	2	2	2	2	2	2	2
No. of exopodal segments																	
th I	2	3	3	3	3	4	3	3	3	3	2	3	3	3	3	2	2
th II	3	4	4	4	4	6	4	4	4	4	3	5	4	4	4	3	3
th III	4	5	4	5	6	7	4	4	5	5	4	5	4	5	5	3	4
th IV	5	6	5	5	6	7	5	5	6	5	4	6	5	5	6	3	4
th V	5	6	5	5	6	7	5	5	6	4	4	6	5	6	6	4	5
th VI	5	6	5	5	6	7	4	5	6	4	4	6	5	5	6	3	5
th VII	4	6	5	5	6	7	4	5	6	4	4	6	4	5	6	3	4
No. of setae on endopod																	
th I																	
Segment 1	1+1	2+1	2+1	1+1	2+1	2+1	1+1	2+1	2+1	2+1	2+1	2+1	2+1	2+1	2+1	1+1	1+1
Segment 2	3+1	3+2	2+2	2+2	4+2	3+2	3+2	3+2	3+2	3+2	3+2	3+2	3+2	2+2	3+2	2+1	2+2
Segment 3	1+1	2+1	1+1	0+1	2+1	2+1	1+1	0+1	1+1	2+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1
Segment 4	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)
th II																	
Segment 1	1+1	2+1	1+1	1+1	2+1	1+1	1+1	1+1	1+1	1+1	1+1	2+1	1+1	1+1	1+1	1+1	1+1
Segment 2	2+2	4+2	2+2	2+2	3+2	3+2	2+2	2+2	2+2	2+2	2+2	3+2	2+2	3+2	2+2	1+1	2+2
Segment 3	0+1	0+1	0+1	0+1	1+1	1+1	0+1	0+1	1+1	1+1	0+1	0+1	1+1	0+1	0+1	0+1	0+1
Segment 4	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)
th III																	
Segment 1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1
Segment 2	1+2	3+2	2+2	2+2	2+2	4+2	2+2	2+2	2+2	2+2	1+2	3+2	2+2	2+2	1+2	1+1	1+2
Segment 3	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	1+1	1+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1
Segment 4	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)

Table 3. Continued.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
th IV																	
Segment 1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1
Segment 2	1+2	3+2	2+2	2+2	2+2	3+2	2+2	2+2	2+2	2+2	1+2	3+2	2+2	2+2	1+2	1+1	1+2
Segment 3	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	1+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1
Segment 4	3(1)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)
th V																	
Segment 1	0+1	1+1	1+1	1+1	1+1	1+1	0+1	0+1	1+1	1+1	1+1	1+1	1+1	1+1	1+1	0+1	0+1
Segment 2	1+2	2+2	1+2	2+2	2+2	3+2	2+2	1+2	2+2	2+2	1+2	2+2	2+2	1+2	1+2	0+1	1+2
Segment 3	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1
Segment 4	3(1)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	3(1)	4(2)	4(2)	3(1)
th VI																	
Segment 1	0+1	1+1	1+1	1+1	1+1	1+1	0+1	0+1	1+1	1+1	0+1	1+1	0+1	1+1	1+1	0+1	0+1
Segment 2	1+2	2+2	1+2	2+2	2+2	3+2	1+2	1+2	2+2	1+2	1+2	2+2	1+2	1+2	1+2	0+1	1+2
Segment 3	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1
Segment 4	3(1)	4(2)	4(2)	3(1)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	3(1)	4(2)	3(1)	3(1)	4(2)	4(2)	3(1)
th VII																	
Segment 1	0+1	0+1	1+1	0+1	0+1	1+1	0+1	0+1	1+1	0+1	0+1	0+1	0+1	1+1	0+1	0+1	0+1
Segment 2	1+2	1+2	1+2	1+2	1+1	2+2	1+2	1+2	1+2	1+2	1+2	1+2	1+2	1+2	1+2	0+1	1+2
Segment 3	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+0	0+1	0+1	0+1	0+1	0+1	0+1	0+1	0+1
Segment 4	3(1)	4(2)	4(2)	3(1)	4(2)	4(2)	4(2)	4(2)	4(2)	4(2)	3(1)	4(2)	3(1)	3(1)	3(1)	4(2)	3(1)

Table 4. Mophological differences in male thoracopod VI, uropod and furcal ramus among species of *Allobathynella*. The antennules of *Al. mirabilis*, *Al. gigantea gigantea*, *Al. gigantea pluto*, *Al. kuma*, *Al. carinata* is not considered. 1: *A. japonica* Morimoto & Miura, 1957, 2: *A. coreana* Morimoto, 1970, 3: *A. shinjongieei* Park & Cho, 2008, 4: *A. imjinensis* sp. nov., 5: *A. maseongensis* sp. nov., 6: *A. munsui* sp. nov., 7: *A. hongcheonensis* sp. nov., 8: *A. munmakensis* sp. nov., 9: *A. okcheonensis* sp. nov., 10: *A. yeongjuensis* sp. nov., 11: *A. buronensis* sp. nov., 12: *A. bangokensis* sp. nov., 13: *A. yecheonensis* sp. nov., 14: *A. cheongdoensis* sp. nov., 15: *A. donggangensis* sp. nov., 16: *A. gangneungensis* sp. nov., 17: *A. wonjuensis* sp. nov.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Male thoracopod VIII																	
No. teeth on dentate lobe	9	6-7	Smooth	10-11	7	?	8-9	Numerous denticles	Numerous denticles	7	7-8	8	9	9	14	?	11
Inner margin of basipod	Smooth	Dentate	Dentate	Serrated	Spiculate	?	Dentate & spiculate	Smooth	Smooth	Smooth	Smooth	Dentate	Dentate	Spiculate	Spiculate	?	Dentate & spiculate
Basipodal setae	1 tiny	1 long	1 tiny	1 tiny	1 long	?	1 tiny	1 long	1 tiny	Absent	1 tiny	1 tiny	1 tiny	2 tiny	1 tiny	?	1 tiny
Exopodal lobes																	
Upper lobe	Serrated	Dentate	Serrated	Spiculate	Dentate	?	Numerous denticles	Numerous denticles	Dentate	Smooth	Spiculate	Dentate	Spiculate	Spiculate	Spiculate	?	Serrated
Lower lobe	Serrated	Smooth	Serrated	Smooth	Smooth	?	Spiculate		Dentate	Serrated	Smooth	Smooth	Spiculate	Dentate	Dentate	?	Serrated
Uropod																	
No. of spines on sympod	5	12	10	8	12	14	7	9	10	11	9	10	8	10	10	7	8
Endopod																	
No. of spines on inner margin	2	5	3	3	4	5	3	4	4	3	2	4	3	4	4	2	3
Relative length of spines on inner margin	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine = other spines	Distal spine > other spines	Distal spine > other spines	Distal spine = other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines	Distal spine > other spines
No. of setae on outer margin of exopod	1	3	3	3	3	6	3	3	4	2	2	3	3	3	3	1	2
No. of spines on furcal ramus	5	6	6	6	7	8	6	6	8	5	5	6	5	6	6-7	4	5

ronensis and *A. gangneungensis*. Notable variations are that the ventral surface is usually concave, but convex in *A. buronensis* and *A. gangneungensis* and that there is a chitinized middle plate on the ventral surface of the labrum in *A. cheongdoensis* and *A. yecheonensis*.

Mandible

Regarding the mandible, species-specific variations are present in all parts of this appendage, except that the proximal tooth of incisor process is lacking in all 17 species. The number of teeth of incisor process is usually four, but three in *A. gangneungensis*. This species display also the least number of spines on the spine rows, which varies from six to 15 (*A. okcheonensis*). The palp is usually of 1-segment, while of 2-segments in *A. cheongdoensis*. It carries either one seta in *A. japonica*, *A. coreana*, *A. munmakensis*, *A. yeongjuensis*, *A. donggangensis*, *A. gangneungensis* and *A. wonjuensis*, or two setae in the remaining species.

Maxillule

In all 17 species compared, the maxillular segment 1 carries four spines. The maxillular segment 2 carries either eight (*A. coreana*, *A. munsui* and *A. bangokensis*), seven (*A. shinjongieei*, *A. imjinensis*, *A. maseongensis*, *A. hongcheonensis*, *A. munmakensis*, *A. okcheonensis*, *A. buronensis* and *A. wonjuensis*), or six spines (*A. japonica*, *A. yeongjuensis*, *A. yecheonensis*, *A. cheongdoensis*, *A. donggangensis* and *A. gangneungensis*).

Maxilla

With an exception of the segment 4 with six setae, the number of setae on the segments 1, 2 and 3 varies among species. The segment 1 usually carries three setae, while there are four setae in *A. maseongensis*. *A. munsui* displays the highst number of setae (six) on the maxillar segment 2. In the remaining species, it is either four (*A. japonica*, *A. imjinensis*, *A. hongcheonensis*, *A. buronensis*, *A. yecheonensis*, *A. cheongdoensis*, *A. gangneungensis*, *A. wonjuensis*) or five (*A. coreana*, *A. shinjongieei*, *A. maseongensis*, *A. munmakensis*, *A. okcheonensis*, *A. yeongjuensis*, *A. bangokensis* and *A. donggangensis*). The number of setae on the segment 3 varies from eight (*A. gangneungensis*) to 12 (*A. maseongensis* and *A. okcheonensis*).

Thoracopods I-VII

Considering the rich ornamentation and the multi-segmented exopod, the thoracopods I-VII of *Allobathynella* are similar to those present in the genera which are regarded as being more primitive (e.g., *Billibathynella*, *Brevisomabathynella*, etc.). However, the distal segment of exopod with a tiny terminal knob and the outer seta covered by long and strong barbs, are characters otherwise unknown in the family.

As mentioned above, only a few morphological differences in thoracopods I-VII are significantly correlated with body size of species. They are the numbers of exopodal segments on thoracopods III-VI. Other variations such as the number of epipods and the pattern of the setal ornamentation on basipod are rather independent of the body size, while the number of exopodal segments of thoracopods I and VII and the total number of setae on the four endopodal segment of thoracopods I-VII display a slight correlation to the body size.

Male thoracopod VIII

In all species compared in this study, the right and left female thoracopods VIII are separated and display a nearly uniform feature of a tiny process with distal spines. The male thoracopod VIII is also homogeneous in that it is bell-formed and perpendicular to the body, that the terminal part of the flat and rounded epipod barely reaches the bottom of exopod, that the exopod is distally 2-lobed, and that the basipod, which carries a small basipodal seta, is drawn into a spur. However, there are many differences among the species, if one looks into details of the morphology. The dentate lobe is either smooth (*A. shinjongieei*) or dentate (in the remaining species). In the latter case, the number of teeth varies from 6 (*A. coreana*) to 14 (*A. yecheonensis*) or the dentate lobe is covered by numerous denticles (*A. munmakensis*, *A. okcheonensis*). The inner margin of the basipod could be smooth (*A. japonica*, *A. munmakensis*, *A. okcheonensis*, *A. yeongjuensis*), dentate (*A. coreana*, *A. shinjongieei*, *A. bangokensis*, *A. yecheonensis*), spiculated (*A. maseongensis*, *A. cheongdoensis*, *A. donggangensis*), or serrated (*A. imjinensis*). It is even dentate and spiculated in *A. hongcheonensis* and *A. wonjuensis*. Except in *A. yeongjuensis*, the basipod carries a basipodal seta, of which size is variable according to species. It is longer than endopod in *A. coreana*, *A. maseongensis* and *A. munmakensis*, while tiny in the remaining species. The two lobes of the exopod also vary between species (Table 4).

Uropod

In the 17 species compared in this study, the uropodal endopod is shorter than exopod. Quantitative characters present on the uropod are more (number of setae on exopod) or less (number of spines on sympod and number of spines on endopod) correlated with the body size of each species. The relative length of the spines on the inner margin of the endopod is the only characters by which the species are distinguished qualitatively. For in-

Table 5. Sampling sites of *A. coreana* Morimoto, 1970, *A. shinjongieei* Park and Cho, 2008 and the 15 new species of *Allobathynella* Morimoto and Miura, 1957, and the associated bathynellacean fauna. All the species are from South Korea.

	River system	Geographical designation / tributary (length)	Coordinates	Associated bathynellacean fauna	
				Parabathynellidae	Bathynellidae
A. coreana	Han River	Gangwon-Do, Yeongwol/ West River of South Han River (220 km)	37°10′30.1″N, 128°26′27.2″E	–	*Uenobathynella* sp. *Nihobathynella* sp. *Bathynella* cf. *rufa*
A. donggangensis	Han River	Gangwon-Do, Jeongseon/ East River of South Han River (65 km)	37°22′20.9″N, 128°40′48.4″E	*Nipponbathynella* sp. *Allobathynella* sp.	*Bathynella fodinarum* *Bathynella* cf. *rufa*
A. munmakensis	Han River	Gangwon-Do, Wonju/ Seom River of South Han River (73 km)	37°20′17.2″N, 127°49′34.2″E	*Eobathynella* sp.	*Uenobathynella* sp. *Bathynella* cf. *rufa*
A. buronensis	Han River	Gangwon-Do, Wonju/ Seom River of South Han River (73 km)	37°14′35.0″N, 127°44′54.7″E	*Eobathynella* sp.	*Uenobathynella* sp. *Nihobathynella* sp. *Bathynella* cf. *rufa*
A. wonjuensis	Han River	Gangwondo, Wonju/ Seom River of South Han River (73 km)	37°22′32.0″N, 127°51′18.0″E	*Eobathynella* sp. *Arisubathynella* sp.	*Uenobathynella* sp. *Nihobathynella* sp. *Bathynella* cf. *rufa*
A. hongcheonensis	Han River	Gangwon-Do, Hongcheon/ Hongcheon River of North Han River (143 km)	37°41′20.8″N, 127°40′52.6″E	*A. bangokensis*, *Eobathynella* sp. *Arisubathynella* sp.	*Uenobathynella* sp. *Morimotobathynella* sp. *Bathynella* cf. *rufa*
A. bangokensis	Han River	Gangwon-Do, Hongcheon/ Hongcheon River of North Han River (143 km)	37°41′20.8″N, 127°40′52.6″E	*A. hongcheonensis*, *Eobathynella* sp. *Arisubathynella* sp.	*Uenobathynella* sp. *Morimotobathynella* sp. *Bathynella* cf. *rufa*
A. yeongjuensis	Nakdong River	Kyungsangbuk-Do, Yeongju/Naeseong Stream (106 km)	37°27′09.5″N, 127°31′01.5″E	*Eobathynella* sp.	*Uenobathynella* sp. *Bathynella* cf. *rufa*
A. yecheonensis	Nakdong River	Gyeongsangbuk-Do, Yecheon/Naeseong Stream (106 km)	36°35′10.2″N, 120°19′27.5″E	*Eobathynella* sp. *Hangangbathynella* sp.	*Uenobathynella* sp. *Bathynella* cf. *rufa*
A. maseongensis	Nakdong River	Kyungsangbuk-Do, Munkyeong/Yeong River (78 km)	36°39′39.1″N, 128°07′15.0″E	*Eobathynella* sp.	*Uenobathynella* sp. *Bathynella* cf. *rufa*
A. munsui	Nakdong River	Kyungsangbuk-Do, Cheongsoung/Yongjoen Stream (53 km)	36°28′36.1″N, 129°01′50.3″E	*Eobathynella* sp.	*Uenobathynella* sp. *Bathynella* cf. *rufa*
A. cheongdoensis	Nakdong River	Kyungsangbuk-Do, Cheongdo/Milyang River (101 km)	35°40′28.0″N, 128°52′03.1″E	*Eobathynella* sp.	*Uenobathynella* sp. *Bathynella* cf. *rufa*
A. shinjongieei	Nakdong River	Kyungsangnamdo, Geochang/Hwang River (111 km)	35°43′13″N, 127°55′34″E	–	–
A. imjinensis	Imjin River	Gyeonggi-Do, Yeoncheon/Main Stream (254 km)	37°59′03.2″N, 126°55′45.9″E	*Arisubathynella* sp.	*Uenobathynella* sp. *Nihobathynella* sp. *Bathynella* cf. *rufa*
A. okcheonensis	Geum River	Chungcheogbuk-Do, Okcheon/Main Stream (395 km)	36°14′36.5″N, 127°37′18.5″E	–	–
A. gangneungensis	Gunseon Stream	Gangwon-Do, Gangneung/ Stream of east coast (14 km)	37°39′44.9″N, 128°58′06.3″E	–	–

stance, the most distal spine is similar to the other spines on the inner margin in *A. imjinensis* and *A. hongcheonensis*, while significantly large in the remaining species.

Biogeographic notes

Except for *Allobathynella gangneungensis* sp. nov. from a stream (Gunseon Stream) flowing into the east coast of the Korean Peninsula, the species (re)described here and in Park and Cho (2008) are from the west part of South Korea (Fig. 83, see also Table 5), of which area can be divided into six drainage basins of following river systems: Han river (HR), Nakdong River (NR), Imjin River (IR), Geum River (GR), Seomjin River (SR) and Yeongsan River (YR). The hyporheic zone of the last river system has not yet been visited in the context of this study.

In the HR occupying the largest drinage area of 26,000 km^2, a total of seven species have been found. Two of them are from the North Han River (NHR) and five species are from the South Han River (SHR). The two species (*H. bangokensis* sp. nov.; *H. hongcheonensis* sp. nov.) from NHR were found sympatrically in the same samples. Such coexistence of species belonging to a genus of parabathynellids is not frequent and known only for *H. africana* Cho and Schminke, 2006 and *H. monoaesthetasca* Cho and Schminke, 2006 of *Hexabathynella* Schminke, 1972 (Cho and Schminke, 2006) and four sympatric species pairs of *Brevisomabathynella* Cho *et al*., 2006 (*B. uramurdahensis* Cho and Humphreys, 2010 and *B. clayi* Cho and Humphreys, 2010; *B. jundeeensis* Cho and Humphreys, 2010 and *B. cooperi* Cho *et al*., 2006; *B. parooensis* Cho and Humphreys, 2010 and *B. eberhardi* Cho and Humphreys, 2010; *B. leijsi* Cho and Humphreys, 2010 and *B. cunyuensis* Cho *et al*., 2006). In these cases, sympatric species are well separated either in body size or in different body form, while sympatric *H. bangokensis* and *H. hongcheonensis* differ in body size at 1.83 mm and 2.24, respectively, as well as in the morphology of several extremities as discussed above (see Tables 1-4).

Of the five species found in SHR, *A. munmakensis* sp. nov., *A. buronensis* sp. nov. and *A. wonjuensis* sp. nov. occur in the same tributary (Seom River) branching off from the middle reaches of SHR. The Seom River is only 70 km long, and the sampling sites of these species are at distance of 10 km. Each of these species are outstanding in having a medial seta on the uropodal sympod (*A. munmakensis*), a labrum with the convex ventral surface (*A. Buronensis*), and a 6-segmented antennule (*A. wonjuensis*), respectively, suggesting remote relationships between them. On the other hand, *A. coreana* and *A. donggangensis* sp. nov. were found in two different tributaries of of SHR, while the distance of the corresponding sampling sites is about 30 km.

Six species of *Allobathynella* were found in NR, which flows southwards into the south coast of the Korean Peninsula. This river has also a large drinage area of 23,400 km^2 and includes more than 30 tributaries. The five rivers or streams in which the species of *Allobathynella* were found, are the largest in the area. As in the case of the Seom River, two species (*A. yeongjuensis* sp. nov. and *A. yecheonensis* sp. nov.) occur in a same tributary, the Naeseong Stream. The sampling site of *A. yeongjuensis* is located at upper reaches and that of *A. yecheonensis* near the main stream, while the distance is around 40 km. The sampling site being closest to *A. yecheonensis* is that in the Yeong River, where *A. maseongensis* was found. It is to note that the type locality of *A. maseongensis* is 8 km away from the locality, where a geographic form of *A. coreana* was found (see Morimoto, 1970). Because the description of this form does not fit into the present-day standard, it is not clear, if it belongs to *A. maseongensis*. However, *A. maseongensis* differs from *A. coreana* in having a higher number of exopodal segments on the thoracopods I-VII and more spinal ornments on the uropod.

Short-range endemic species can be defined as those that occupy a small spatial area (Yen, 2002), for which Harvey (2002) suggests a nominal range of less than 10,000 km^2 as a woking definition, while Eberhard *et al*. (2009), favor a smaller area of less than 1,000 km^2. For macro-stygobionts, the range seems to be much narrower, being within 200 km or even within some tens of km (Trontelji *et al*., 2009). This study is not directly designed to measure the distributional range of each species and more intensive sampling is required. Combining the unexpected high degree of diversity of *Allobathynella* and the fact that most tributaries are less than 100 km long (Table 5), however, we are led to believe that each species of *Allobathynella* are highly endemic to a given tributary, having a range limit less than 100 km.

With exceptions of *A. okcheonensis* sp. nov. and *A. gangneungensis* sp. nov., the species (re)described here were found sympatrically with species of the other four genera of Parabathynellidae known from South-Korea (*Eobathynella* Birstein and Ljovuschkin, 1964; *Arisubathynella* Park and Eun, 2012; *Hangangbathynella* Park and Cho, 2013; *Nipponbathynella* Schminke, 1973) and with those of Bathynellidae. It is worth mentioning that bathynellids are more abundant than parabathynellids in South Korea. However, their taxonomy is still a work in progress. *Eobathynella* is the genus most frequently found living with diverse species of *Allobathynella*. In IR, however, the *Eobathynella* species were not found in spite of repeated survey. On the other hand, the species of *Arisubathynella* were found sympatrically with

Allobathynella in IR, in NHR and in the down stream of SHR, while that of *Hangangbathynella* in SHR and in the middle reaches of NR. It is to be noted that sympatric *Allobathynella* and *Nipponbathynella* are not confined for the upper stream of SHR, but are also present in the middle reaches of GR (unpublished data). *Allobathynella* is the genus of the family, which occupies the widest distribution range in Korea.

Acknowledgements

This work is supported by a grant from the National Institute of Biological Resources (Project: Survey of Korean Indigenous Species, NIBR201501103), funded by the Ministry of Environment (MOE) of the Republic of Korea.

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Submitted: September 14, 2015
Revised: November 9, 2015
Accepted: February 16, 2016

Journal of Species Research 5(1):157-165, 2016

Distribution of Meiobenthic Arthropod Communities in the Hyporheic Zone of Nakdonggang

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The hyporheic zone is an ecologically important area for investigating habitat biodiversity. However, only few studies have been conducted on this aspect in Korea. This study aimed to investigate the distribution of arthropod communities in the hyporheic zone of Nakdonggang River between 2012 and 2013. The meiobenthic arthropod communities found in the hyporheic zone were identified using a stereomicroscope and classified into 9 taxanomic groups. The abundance of arthropod communities was higher in the hyporheic zones of streams having well-formed sandbanks and gravelly areas. The arthropod communities found along the Nakdonggang River differed depending on the conditions of levees and the regions of the river from where they were collected. The frequency of species of the order Harpacticoida was high in the Nakdonggang main stream and western downstream region. The abundance of species belonging to Cyclopidae was high in the upstream region, midstream region, and eastern downstream region of the river. The frequency of species of the order Bathynellacea was high in the riverside parks or cement levees, but that of species belonging to Cyclopidae was high in the natural levees and gabion levees. Our findings suggested that arthropod communities preferred natural levees.

Keywords: arthropod, hyporheic zone, meiobenthos, Nakdonggang

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DOI:10.12651/JSR.2016.5.1.157

Introduction

The hyporheic zone refers to a region along the streambed where there is an interaction between the surface stream water and ground water (Kim and Kang 2009). The hyporheic zone was initially defined as a discrete region by Orghidan (1959), and its ecological significance was recognized by Schwoerbel (1961a). Since there is continuous interaction between surface water and ground water in a hyporheic zone, contamination or development of any one water body can affect the other, which, in turn, influences the ecosystem. Studies of the hyporheic zone are critical for the management of water resources, and it cannot be considered as an independent water source (Kim *et al*. 2008). Various biogeochemical processes occur in the hyporheic zone because of its unique spatial characteristics (Brunke and Gonser 1997; Storey *et al*. 1999; Chapelle 2001; Hancock 2002; Appelo and Postma 2005; Hyun *et al*. 2011). The hyporheic zone is a habitat of various living organisms and is considered to be an ecologically important zone (Kim *et al*. 2012). It causes substantial changes to biodiversity and population dynamics and becomes a shelter for organisms during floods (NWMC 2004). Furthermore, since fluctuations in temperature occur less frequently in the hyporheic zone than in the surface water, it provides an optimal environment for organisms that are sensitive to temperature changes (Schwoerbel 1961b; Evans and Petts 1997). Further, the hyporheic zone has unique ecological and environmental characteristics (Hyun and Kim 2013).

The concept of sustainable development that can satisfy the needs of both present and future generations has been widely used in various fields since "our common future" was published by the World Commission for Environment and Development (WCED) of the UN in 1987. Since then, interest in improving the sustainability of water resources and environment has increased worldwide (Ewen and Parkin 1996; Bronstert *et al*. 2002; Asselman *et al*. 2003; Chang 2003; Legesse *et al*. 2003; Lee and Chung 2007) and efforts are being made to maintain better quality of life (Kim 2013). Sustainable use of water requires the regulation of the interface of surface and

ground water in an aquifer (Hyun and Kim 2013). However, such studies have mainly focused on quantitatively securing water resources and overlooked the ecological aspects, which are important for sustainable development (Hyun and Kim 2013).

Although many international studies have investigated the diverse organisms inhabiting the hyporheic zone (Barlocher and Murdoch 1989; Robertson *et al*. 2000; Dumas *et al*. 2001), local studies in this regard are insufficient except for those conducted by the National Institute of Biological Resources, Korea, and by Hyun and Kim (2013).

Meiobenthic arthropod communities are mostly found in sediments. Because they require a stable environment for inhabitation and have a short generation time, they are sensitive to environmental changes, unlike macrozoobenthos (Sandulli and De Nicola-Giudici 1990). In Europe, zoobenthos are used to derive the index of stream by determining their level of response to environmental disturbances (Borja *et al*. 2000). Furthermore, biocenosis inhabiting streams are known to affect the ecosystem (Yoon *et al*. 1992).

This study aimed to investigate the distribution and population of meiobenthic arthropod communities inhabiting the Nakdonggang hyporheic zone. Kim *et al*. (2009) stressed on the importance of waterside soil; hence, we determined the biomass and population distribution of these communities according to the form of levees present at the investigation sites. Our findings might increase the awareness regarding hyporheic zones that harbor various species and the importance of their management and provide useful data for conducting local studies on this aspect. Moreover, our data might be used for establishing environmental policies that advocate ecosystem preservation, such as stream maintenance project that focuses on ecologically sustainable development.

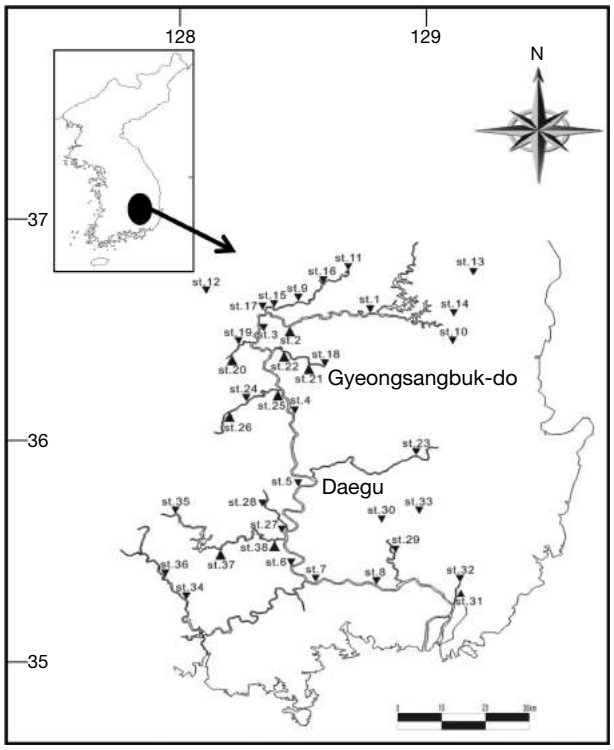


Fig. 1. Map showing the sampling sites at Nakdonggang.

Materials and Methods

1. Investigation period and study site

The investigation was conducted between March 2012 and October 2013 at 38 sites around Nakdonggang (Fig. 1); the geographic information of each site is shown in Table 1. For the survey, Nakdonggang River was divided into main stream and upstream, midstream, western downstream, and eastern downstream regions. This stratification was necessary to investigate the communities of meiobenthic arthropod inhabiting the hyporheic zone because Kim *et al*. (2011) showed that the water quality and characteristics at Nakdonggang vary across different regions due to the effluent water from the upstream dam, which contaminates the midstream regions such as Gumi and Daegu, and the influence and stagnation caused by Namgang dam and estuary banks in the downstream region. The river basins in Nakdonggang and names of each region are shown in Table 2. Specimens were collected from 7 rivers and streams - Banbyeoncheon, Yongjeoncheon, Naeseongcheon, Weechon, Byeongseongcheon, Ssanggyecheon, and Yeonggang - from the upstream region of Nakdonggang; 3 rivers and streams - Gamcheon, Hoecheon, and Geumhogang - in the midstream region; 2 rivers - Hwanggang and Namgang - in the western downstream region; and 3 rivers and streams - Cheongdocheon, Yangsancheon, and Miryanggang - from the eastern downstream region.

2. Study methods

Among the hyporheic zones, sites with well-formed sandbanks and gravelly areas were selected, and water was sampled using two methods. First, a 1 × 1 m pit was dug at the selected collection sites 5-10 m away from the stream by using a shovel, and the water flowing out from the ground was collected. Second, a 1-m sampling core was mounted in the same location by using a hammer, and water was collected using a manual pump. The sampling core was a device for sampling water from the hyporheic zone; the dimensions of this device are shown

Table 1. Administrative region, latitude, longitude, and altitude of study sites.

	Site	Latitude (N)	Longitude (E)	Altitude (m)
st.1	Gb Andong-si Ogya-dong	36°33′27″	128°43′32″	91
st.2	Gb Uiseong-gun Dain-myeon Yonggok-ri	36°31′50″	128°21′54″	59
st.3	Gb Uiseong-gun Danmil-myeon Nakjeong-ri	36°21′22″	128°18′3″	40
st.4	Gb Gumi-si Haepyeong-myeon Haepyeong-ri	36°11′43″	128°22′1″	30
st.5	Gb Goryeong-gun Dasan-myeon Hochon-ri	35°48′49″	128°28′30″	13
st.6	Gn Hapcheon-gun Cheongdeok-myeon Angjin-ri	35°32′24″	128°21′10″	4
st.7	Gn Changnyeong-gun Namji-eup Namji-ri	35°23′7″	128°27′5″	6
st.8	Gn Miryang-si Hanam-eup Susan-ri	35°22′4″	128°43′12″	6
st.9	Gb Yecheon-gun Yecheon-eup Saengcheon-ri	36°40′37″	128°27′35″	96
st.10	Gb Cheongsong-gun Pacheon-myeon Jungpyeong-ri	36°28′13″	129°2′2″	177
st.11	Gb Yeongju-si Munjeong-dong	36°47′56″	128°37′1″	135
st.12	Gb Mungyeong-si Gaeun-eup Hagoe-ri	36°39′36″	128°3′23″	153
st.13	Gb Yeongyang-gun Irwol-myeon Gokgang-ri	36°40′54″	129°7′15″	259
st.14	Gb Cheongsong-gun Pacheon-myeon Hwangmok-ri	36°28′16″	129°1′56″	177
st.15	Gb Yecheon-gun Yonggung-myeon Daeeun-ri	36°34′55″	128°19′51″	62
st.16	Gb Yeongju-si Munsu-myeon Sudo-ri	36°44′0″	128°37′14″	114
st.17	Gb Yecheon-gun Yonggung-myeon Hyangseok-ri	36°34′59″	128°17′27″	60
st.18	Gb Gunwi-gun Uiheung-myeon Eumnae-ri	36°10′32″	128°42′59″	120
st.19	Gb Sangju-si Inpyeong-dong	36°23′54″	128°10′12″	55
st.20	Gb Sangju-si Cheongni-myeon Susang-ri	36°20′36″	128°7′29″	69
st.21	Gb Uiseong-gun Geumseong-myeon Sanun-ri	36°15′4″	128°41′1″	92
st.22	Gb Uiseong-gun Bongyang-myeon Gusan-ri	36°18′37″	128°36′9″	63
st.23	Gb Yeongcheon-si Geumho-eup Namseong-ri	35°54′33″	128°51′24″	59
st.24	Gb Gimcheon-si Apo-eup Ui-ri	36°11′6″	128°13′26″	63
st.25	Gb Gumi-si Goa-eup Hwangsan-ri	36°14′13″	128°17′26″	50
st.26	Gb Gimcheon-si Apo-eup Daesin-ri	36°9′45″	128°11′34″	53
st.27	Gn Hapcheon-gun Deokgok-myeon Hak-ri	35°40′49″	128°20′13″	16
st.28	Gb Goryeong-gun Ugok-myeon Yajeong-ri	35°41′20″	128°19′38″	26
st.29	Gn Miryang-si Sangdong-myeon Oksan-ri	35°33′56″	128°45′43″	43
st.30	Gb Cheongdo-gun Cheongdo-eup Won-ri	35°36′39″	128°46′1″	55
st.31	Gn Yangsan-si Sangbuk-myeon Soseok-ri	35°24′11″	129°3′24″	29
st.32	Gn Yangsan-si Habuk-myeon Sunji-ri	35°29′28″	129°5′3″	123
st.33	Gb Cheongdo-gun Maejeon-myeon Geumgok-ri	35°40′28″	128°52′3″	80
st.34	Gn Sancheong-gun Danseong-myeon Changchon-ri	35°15′54″	127°53′43″	77
st.35	Gn Geochang-gun Gabuk-myeon Yongsan-ri	35°45′6″	127°59′5″	337
st.36	Gn Sancheong-gun Saengcho-myeon Eoseo-ri	35°28′59″	127°48′29″	126
st.37	Gn Hapcheon-gun Yongju-myeon Yongji-ri	35°32′45″	128°6′33″	39
st.38	Gn Hapcheon-gun Cheongdeok-myeon Gahyeon-ri	35°34′20″	128°20′30″	8

Gb = Gyeongsangbuk-do, Gn = Gyeongsangnam-do

in Figure 2. Next, 30 L of sampled water was concentrated per tube by installing a 50-mL capped tube (SPL Lifesciences, Korea) having a 50-μm net.

The pH, electrical conductivity, and temperature of the collected samples were measured using a multi-purpose water quality analyzer (Thermo 5 ORION Star, Thermo Electron Coporation, USA). Then it was transferred to the laboratory, substituted with 70% ethanol, and kept at 4°C before microscopic examination. For microscopic examination and classification of meiobenthic arthropod fauna in the concentrated specimen, stereomicroscope (Nikon SMZ 800, Japan) was used with 10-63× magnification. Classified organisms were stored in 70% ethanol for each group.

The classification criteria by Thorp and Covich (2009) were followed.

Results and Discussion

1. Distribution of meiobenthic arthropod communities in the hyporheic zone of Nakdonggang

Meiobenthic arthropod communities were found at all the 38 sites of the hyporheic zone in Nakdonggang. The identified organisms belonged to Arthropoda and were classified into 9 taxonomic groups (Table 3). Among them, Ostracoda was classified up to the class level; Harpacticoida, Amphipoda, Isopoda, and Acari, up to the order level; Parabathynellidae, Bathynellidae, and Cyclopidae, up to the family level; and *Parastenocaris*, up to the genus level. The composition rates of these organisms are shown in Figure 3.

Table 2. Composition of Nakdonggang mainstream and the 4 regions.

Region	Riverbasin	Location
Nakdonggang mainstream	1. mainstream I	Andong
	2. mainstream II	Gumi
	3. mainstream III	Goa, Seongju, Waegwan
	4. mainstream IV	Dalseong
	5. mainstream V	Changnyeong, Namji
	6. mainstream VI	Bugok, Namji
Nakdonggang upstream	1. Imhadam	Yeongyang, Cheongsong
	2. Naeseongcheon	Yeongju, Bonghwa, Yecheon
	3. Yeonggang	Mungyeong, Gaeun
	4. Byeongseongcheon	Sangju
	5. Ssanggyecheon	Uiseong
	6. Wicheon	Gunwi
Nakdonggang midstream	1. Gamcheon	Gimcheon
	2. Geumhogang	Yeongcheon, Daegu
	3. Hoecheon	Goryeong
Nakdonggang downstream western	1. Hwanggang	Geochang, Hapcheon
	2. Namgang	Sancheong
Nakdonggang downstream eastern	1. Cheongdocheon	Cheongdo
	2. Miryanggang	Miryang
	3. Yangsancheon	Yangsan

2. Biotic communities of the Nakdonggang mainstream

In all, 75 organisms were found in Nakdonggang mainstream (sites 1, 2, 3, 4, 5, 6, 7, and 8). Their composition rates are shown in Figure 4. In the Nakdonggang mainstream, Cyclopidae were low in number, and its total biomass was also lower than that at the other collection sites. You (2013) showed that the construction of stank had greater influence on living organisms than by the physical quality of water; the stank at Nakdonggang has likely affected the organisms inhabiting the hyporheic zone.

3. Biocenosis in each region of Nakdonggang

1) Organisms in the Nakdonggang upstream region

In all, 4,286 organisms were collected from the Nakdonggang upstream region. Their composition rates are shown in Figure 5. Cyclopidae showed the highest composition rate at 42.3%. The second and third highest were two families belonging to Bathynellacea (combined rate, 49.0%). The composition rate of Harpacticoida was 6.6%, and that of Isopoda, Amphipoda, Acari, and Ostracoda was less than 2.0%.

The organisms found in the 7 streams of the upstream region of Nakdonggang are shown in Table 4. The abun-

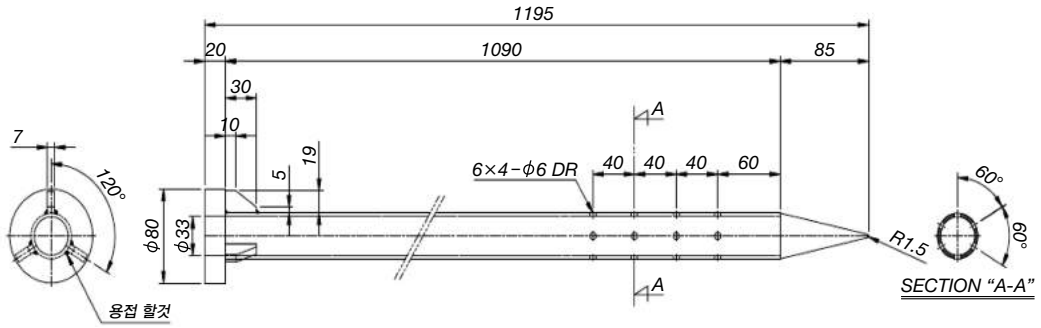


Fig. 2. The detailed dimensions of the sampling core used in this study.

Table 3. Taxonomic groups at the 38 hyporheic zone sites.

Kingdom	Phylum	Class	Order	Family	Genus
Animalia	Arthropoda	Malacostraca	Bathynellacea	Bathynellidae	
			Bathynellacea	Parabathynellidae	
			Isopoda		
			Amphipoda		
		Maxillopoda	Cyclopoida	Cyclopidae	
			Harpacticoida		
			Harpacticoida	Parastenocaridae	Parastenocaris
		Archnida	Acari		
		Ostracoda			

dance of Cyclopidae was the highest or the second highest at all the 7 streams. Although NIBR (2010) showed Weechon and Byeongseongcheon were the most frequent species in Nakdonggang, Weechon (site 18), Byeongseongcheon (sites 19 and 20), and Ssanggyecheon (sites 21 and 22) were found in the least frequency in the upstream region in this study. This could be attributed to the fact that these 3 streams have undergone or are currently undergoing construction from 2011. Naeseongcheon (sites 9, 11, 15, 16, and 17) showed the presence of all 9 taxonomic groups and had the highest number of organisms among all regions. Most parts of the stream in Naeseongcheon consist of sand, and there are no artificial structures (Park *et al*. 2005). Furthermore, no constructions were ongoing around the stream during the investigation. Thus, the Naeseongcheon hyporheic zone might have become a suitable habitat for living organisms.

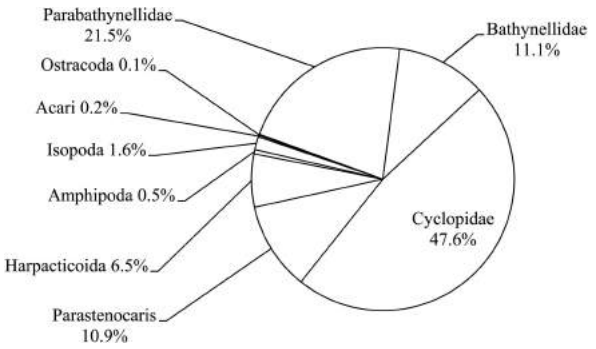


Fig. 3. Composition rate of meiobenthic faunal groups found at the 38 sites in the hyporheic zone of Nakdonggang.

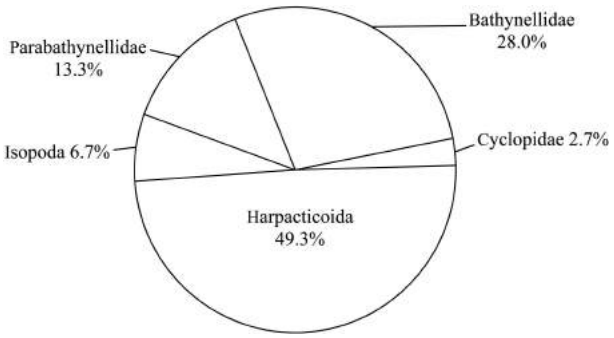


Fig. 4. Composition of meiobenthic faunal groups in the hyporheic zone of Nakdonggang main stream.

2) Organisms found in the Nakdonggang midstream region

In all, 1,422 organisms were found in the midstream region of Nakdonggang. Their composition rates are shown in Figure 5. Cyclopidae showed the highest composition rate (80.0%), followed by Harpacticoida (11.6 %), Bathynellacea (5.1%), and Isopoda (2.7%). The following organisms were detected at a rate of less than 1.0%: Amphipoda (0.2%), Acari (0.2%), and Ostracoda (0.1%).

The organisms found in the 3 streams in the midstream region are shown in Table 4. Cyclopidae showed the highest appearance in Gamcheon (sites 24, 25, and 26) and Hoecheon (sites 27 and 28). Gamcheon (sites 24, 25, and 26) showed the presence of all 9 taxonomic groups and was considered to be a desirable habitat for organisms. However, Geumhogang (site 23) did not show any appearance of arthropod communities. This could be because the average index of biological integrity (IBI) of Geumhogang obtained for fish was either "poor" or "very poor" (Yeom *et al*. 2000), although the habitat environment and food sources are different between fish and meiobenthic arthropod communities. This suggests the importance of controlling the interface of surface water and ground water as revealed by Kim *et al*. (2008).

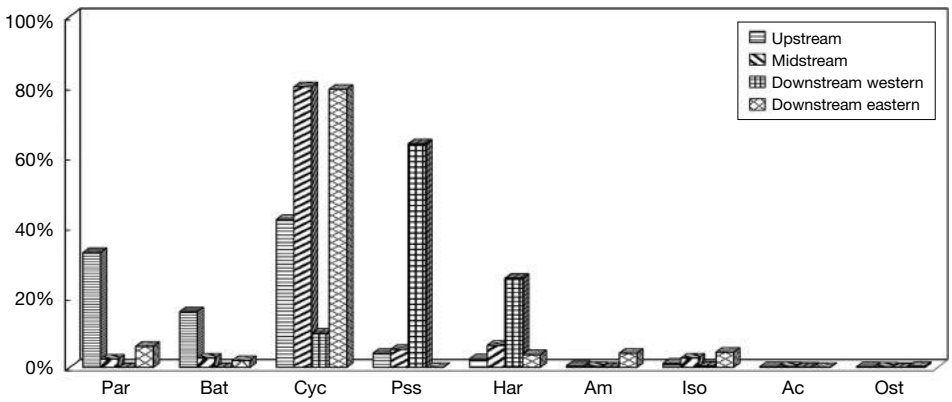


Fig. 5. The relative importance of the 4 regions for the occurrence of the major meiobenthic organisms in Nakdonggang. (Par = Parabathynellidae, Bat = Bathynellidae, Cyc = Cyclopidae, Har = Harpacticoida, Pss = Parastenocaris, Am = Amphipoda, Iso = Isopoda, Ac = Acari, Ost = Ostracoda.)

Table 4. Biomass and composition rate (%) at the hyporheic zone of Nakdonggang.

Four regions at Nakdonggang	Riverbasin	Number	Par	Bat	Cyc	Har	Pss	Am	Iso	Ac	Ost
Nakdonggang upstream region	Naeseongcheon	3715	38.0	17.9	37.3	2.5	3.3	0.1	0.7	0.1	0.2
	Yeonggang	18	5.6	27.8	27.8	16.7	5.6	5.6	5.6	–	5.6
	Banbyeoncheon	269	–	6.3	67.7	4.1	19.0	1.1	1.1	0.7	–
	Yongjeoncheon	70	–	7.1	61.4	–	–	12.9	15.7	2.9	–
	Ssanggyecheon	203	–	0.5	93.6	–	–	2.5	3.4	–	–
	Byeongseongcheon	5	–	–	40.0	20.0	–	–	40.0	–	–
	Wicheon	6	–	–	66.7	–	–	16.7	16.7	–	–
Nakdonggang midstream region	Gamcheon	691	4.6	1.4	69.3	12.2	10.7	0.1	1.0	0.4	0.1
	Hoecheon	731	0.3	4.0	90.2	1.0		0.3	4.4	–	–
	Geumhogang	–	–	–	–	–	–	–	–	–	–
Nakdonggang downstream western region	Hwanggang	761	–	–	10.0	24.4	65.2	0.1	0.3	–	–
	Namgang	16	–	–	6.3	81.3	–	–	6.3	6.3	–
Nakdonggang downstream eastern region	Cheongdocheon	268	6.3	1.9	80.6	1.9	–	4.5	4.5	–	0.4
	Yangsancheon	27	3.7	3.7	66.7	22.2	–	–	3.7	–	–
	Miryanggang	–	–	–	–	–	–	–	–	–	–

Par = Parabathynellidae, Bat = Bathynellidae, Cyc = Cyclopidae, Har = Harpacticoida, Pss = Parastenocaris, Am = Amphipoda, Iso = Isopoda, Ac = Acari, Ost = Ostracoda.

3) Organisms found in the western downstream region of Nakdonggang

In all, 777 organisms were found in the western downstream region of Nakdonggang. Their composition rates are shown in Figure 5. Harpacticoida showed the highest composition rate (89.4%), followed by Cyclopidae with (9.9%), Isopoda (0.4%), and Acari and Amphipoda (0.1%). No species of Bathynellacea were found in this region.

The organisms found in the 2 streams of this region are shown in Table 4. Hwanggang (sites 35, 37, and 38) and Namgang (sites 34 and 36) showed the highest composition rates of Harpacticoida and Parastenocaris, unlike the other regions that had the highest composition rate of Cyclopidae, which mostly inhabit sandbanks. The species richness and aggregation index of benthic macroinvertebrates were largely affected by the habitat characteristics; dams are known to adversely affect species aggregation by simplifying habitats (Kil *et al*. 2010). The difference in the composition of meiobenthic arthropod communities at Hwanggang and Namgang could be attributed to the presence of dams in the upstream region of these sites.

4) Organisms found in the eastern downstream region of Nakdonggang

In all, 295 organisms were found in the eastern downstream region of Nakdonggang; their composition rates are shown in Figure 5. Cyclopidae showed the highest composition rate (79.3%), followed by Bathynellacea (8.1%), Isopoda (4.4%), Amphipoda (4.1%), Harpacticoida (3.7%), and Ostracoda (0.3%).

The organisms found in the 3 streams of this region are shown in Table 4. In Cheongdocheon (sites 30 and 33) and Yangsancheon (sites 31 and 32), the composition rate of Cyclopidae was the highest. The number of organisms or taxonomic groups was relatively lower in this region than in the other regions. Interestingly, not a single organism was observed in Miryanggang (site 29). Because meiobenthic arthropod communities are extremely sensitive to environmental pollution, they can be used for investigating the degree of pollution and developing measures to reduce pollution (Lee *et al*. 2002). The water system at Miryanggang was unstable due to various construction activities (Park and Park 2000), which likely resulted in the absence of Cyclopidae and Harpacticoida.

4. Relationship between biocenosis and environmental factors around the hyporheic zone

The biocenosis in the habitat around the hyporheic zone was investigated by classifying the levees at the hyporheic zone at the investigation site into waterside parks or cement, gabion, and natural levees. Comparison of the number of organisms that were found at each site among the 3 levees showed that 11 individuals were present in the waterside park or cement levee; 129, in the gabion levee; and 480, in the natural levee (Fig. 6). Further, 102 individuals from 5 of the 9 taxonomic groups were found in the waterside park or cement levee (Fig. 7). Harpacticoida was the highest number of species at the park or cement levee (42.2%), followed by Bathynellacea (32.4%), Cyclopidae (19.6%), and Isopoda (5.9%).

In all, 2,437 organisms were found in the gabion levee. Cyclopidae showed the highest composition rate (58.3

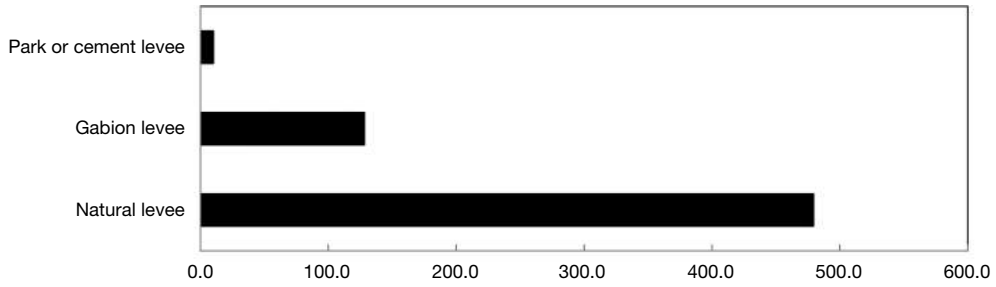


Fig. 6. Individual numbers of meiobenthic fauna at each levee.

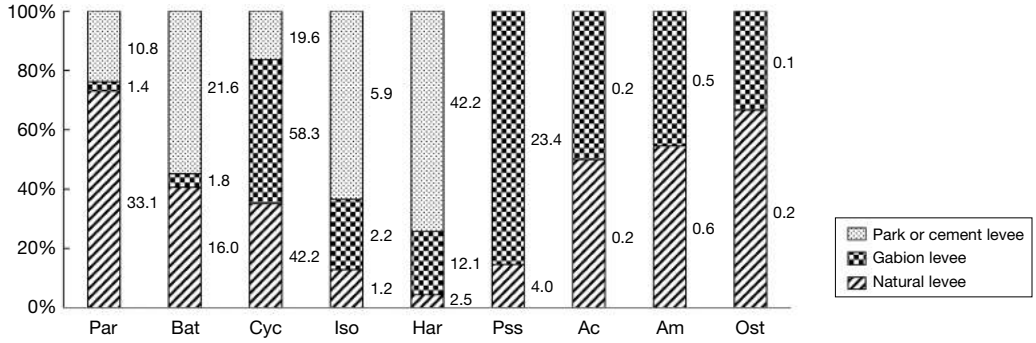


Fig. 7. Composition of meiobenthic faunal groups in the 3 levees. (Par = Parabathynellidae, Bat = Bathynellidae, Cyc = Cyclopidae, Har = Harpacticoida, Pss = Parastenocaris, Am = Amphipoda, Iso = Isopoda, Ac = Acari, Ost = Ostracoda.)

%), followed by Harpacticoida (35.5%), Bathynellacea (3.2%), and Isopoda (2.2%). The following organisms showed less than 1% of appearance: Amphipoda (0.5%), Arachnida (0.2%), and Ostracoda (0.1%).

In all, 4,316 organisms were found in the natural levee. Cyclopidae showed the highest composition rate (42.2 %), followed by Bathynellacea (49.1%), Harpacticoida (6.5%), and Isopoda (1.2%). Amphipoda, Arachnida, and Ostracoda showed less than 1% of appearance.

The levee with the lowest biomass was park or site constructed with cement. Only 5 taxonomic groups were observed at such sites. Gabion levee also had lower number of organisms than those found in natural levee.

Shin *et al*. (2014) showed that construction of levees reduces the space of stream and causes discontinuation of ecosystem connectivity, thereby decreasing the environmental function of the stream. While building parks, cement or gabion levees are introduced around the stream; this might affect the environment at the hyporheic zone in which organisms inhabit. In addition, Jeon (2011) reported that, although levees are necessary for the prevention of floods and regulating water flow, concrete levees might restrict the migration of living organisms. In other words, construction of levees on streams is likely to negatively affect biodiversity. This is because extraneous water in the hyporheic zone enters through streams and ground water from adjacent regions, and levees made of cement or gabion prevent such inflow. Therefore, the analysis of the biomass at the 3 kinds of levees suggests that natural levees are desirable for the growth of meiobenthic arthropod communities in the hyporheic zone of streams.

Summary

The hyporheic zones of streams had well-established sandbanks or gravelly areas. We found that the environments at each stream varied across the regions, and sandbanks and gravelly areas disappeared toward the downstream region of the river and streams. Furthermore, they were absent at sites that had levees around the streams. This affected the biomass composition at the 38 sites of hyporheic zones in Nakdonggang. The number of organisms per region with levees around the stream was markedly lower than that in regions without levees. In all, 480 organisms per site were found in regions with natural levees, whereas 11 organisms per site were found in regions with parks or cement levees. This suggests that construction around streams largely affects the inhabitation of meiobenthic arthropod communities in the hyporheic zone. Moreover, the total number of organisms

at the 8 investigation sites in Nakdonggang mainstream was 75, which was very low. Most of these sites had ongoing constructions. Our findings suggest that organisms inhabiting hyporheic zone are affected by the construction of artificial structures around streams.

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Submitted: September 15, 2015
Revised: October 14, 2015
Accepted: February 16, 2016