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A new species of the genus *Bryocamptus* (Copepoda: Harpacticoida: Canthocamptidae) from Korea

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Abstract.—*Bryocamptus* (*Echinocamptus*) *cheongokensis* sp. nov. is a harpacticoid copepod of the family Canthocamptidae that was collected from a pool in Cheongok cave, Donghae-shi, Kangwon-do, Korea. The new species is characterized by the following diagnostic characters: 1) an eight-segmented female antennule, 2) the absence of an inner seta on the second exopodal segment of P1, 3) the distal segments of the exopod of P2 to P4 are as long as the other two segments combined, and 4) there are six setae on the basoendopod of the female P5. This species has a slight resemblance to the ''*hiemalis*'' group. However, the new species is clearly distinguishable from the species in the ''*hiemalis*'' group by the combination of ornamentation of the free margin of the operculum, the number of setae on the P4 endopod, the length/width ratio of the P5 exopod in the female, and the number of setae on the first endopod segment and the lengths of each apical seta on the last endopod segment of P3 in the male. Thus far, 22 species have been reported in the subgenus *Echinocamptus*, and the ''*hiemalis*'' group includes ten species. Species in this group are typically found in the interstitial groundwater around springs, lakes, streams, and caves. The new species described herein is the first described member of the subgenus *Echinocamptus* from caves in Korea.

Chappuis (1929) named the genus *Echinocamptus*, which includes two subgenera: *Echinocamptus* s.s. and *Limocamptus*. The genus *Echinocamptus* is characterized by the distal exopodal segment of P2–P4 being as long as the other two segments combined, and the lack of an inner seta on the second exopod segment of P1. He proposed *Canthocamptus echinatus* Mrázek, 1893 as the type species of *Echinocamptus*. However, the taxonomic validity of placing the subgenus *Limocamptus* in the genus *Echinocamptus* has been debated (Lang 1948, Wilson & Yeatman 1959, Lewis 1986, Rouch 1986, Ishida 1992). Lang (1948) moved the subgenus *Limocamptus* into the genus *Bryocamptus* and also relocated *C. echinatus* to *Limocamptus*, and Wells (2007) referred the subgenus *Limocamptus* to the genus *Bryocamptus* based mainly on the synapomorphy of the stepped outer lateral margin of P2 enp-2 in the male. The validity of the subgenus *Limocamptus* has recently been refuted by Huys (2009); he declared that the valid name of this subgenus is *Bryocamptus* (*Echinocamptus*) and not *Bryocamptus* (*Limocamptus*).

To date, 22 species are included within the subgenus *Echinocamptus*. The type species of the subgenus, *B. echinatus*, was

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initially described from Europe (Mrázek 1893) and has a Palaearctic distribution (Dussart & Defaye 1990). *Bryocamptus hiemalis* s.s. (Pearse 1905) was initially recorded from Nebraska, U.S.A. and is now known in Asia, Japan, and probably Europe (Dussart & Defaye 1990, Pesce 1999–2010). Douwe (1908) described *B. hoferi* from cave water in Europe. Scourfield (1912) reported *B. praegeri* from northern Europe, and Willey (1925) reported *B. douwei* and *B. nivalis* from North America. Brehm (1927) reported *B. calvus* from Japan. Chappuis (1929) described *B. horai* from Asia and *B. morrisoni* s.s. and *B. morrisoni elegans* from cave water in Kentucky, U.S.A. Since Chappuis's 1929 paper, 12 species and subspecies have been added: Borutsky (1931) reported *B. verestschagini*, *B. lacustris*, *B. smirnovi*, and *B. parvus* from Lake Baikal, Russia; Coker (1934) reported *B. h. brevifurcatus* from Nebraska and Montana, U.S.A.; Kiefer (1952) reported *B. viduus* from Algeria; Borutsky (1952) reported *B. yunnanensis* from China; Shen & Tai (1964) reported *B. elongatus* from China; Löffler (1968) reported *B. yetii* from Nepal; Basamakov (1969) reported *B. dacicus* from Europe; and Borutzky (1952) reported *B. hostensis* from cave water, Caucasia. Most recently, Ishida (1992) reported *B. pacificus* from Japan and discussed the morphological affinities of four species.

During a survey of groundwater fauna in Korea, a new species of the subgenus *Echinocamptus* was collected from a limestone cave. Here, we provide an illustrated description of this new species and discuss its relationships with other members of the subgenus.

Materials and Methods

Samples were collected from the interstitial habitats in pools in the Cheongok limestone cave at Donghae-shi, Kangwon-do near the east coast of Korea on 4 Feb and 2 Sep 2005. The specimens were fixed and preserved with 70% ethanol. Before dissection, the habitus was drawn and the body length was measured from whole specimens temporarily mounted in lactophenol. Specimens were dissected in lactic acid, and the dissected parts were mounted on slides in lactophenol mounting medium.

The coverslips were sealed with transparent nail varnish. All drawings were made using a drawing tube on an Olympus BX51 differential interference contrast microscope. Some specimens were also examined by scanning electron microscopy (SEM; Philips XL30). Specimens were dehydrated through a graded alcohol series and dried using a critical-point dryer, and the dried specimens were mounted onto stubs and coated with gold using an ion sputterer.

The descriptive terminology follows Huys et al. (1996). Abbreviations used in the text are as follows: A1, antennule; A2, antenna; ae, aesthetasc; exp, exopod; enp, endopod; P1–P6, first to sixth thoracopod; exp(enp)-1(2,3) to denote the proximal (middle, distal) segment of a ramus. The type series is deposited in the collections of the National Institute of Biological Resources (NIBR) in Korea. Specimens prepared for SEM were deposited in one of the author's (WL) collections in the Laboratory of Biodiversity, Department of Life Science, Hanyang University, Seoul (WL). Scale bars in the figures are in micrometers.

Systematics

Order Harpacticoida Sars, 1903
Family Canthocamptidae Sars, 1906
Genus *Bryocamptus* Chappuis, 1929
Subgenus *Echinocamptus* Chappuis, 1929

Bryocamptus* (*Echinocamptus*) *cheongokensis, new species

Figs. 1–8

Type locality.—Pool in Cheongok Cave, at Donghae-shi, Kangwon-do,

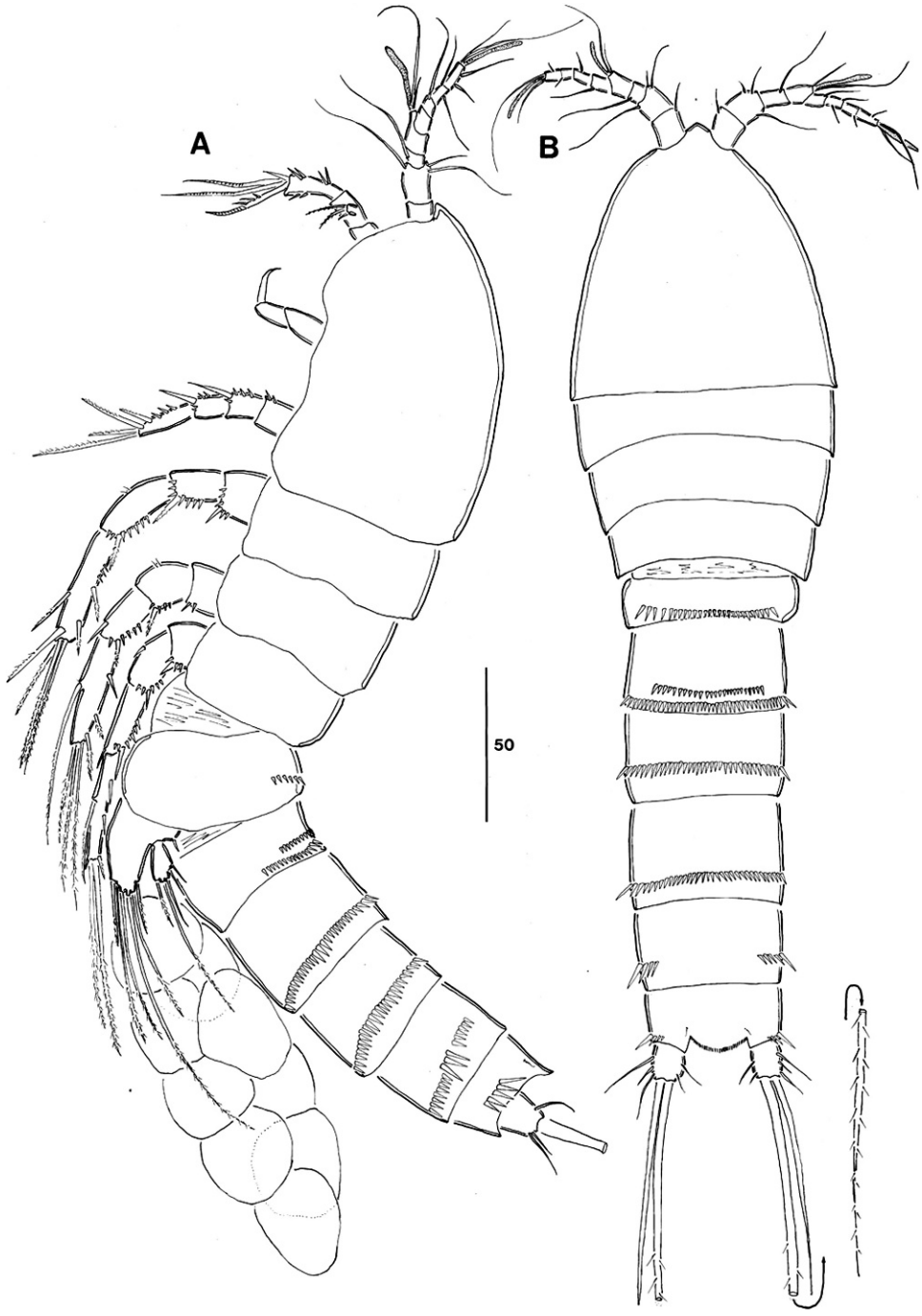

Fig. 1. *Bryocamptus* (*Echinocamptus*) *cheongokensis* (♀). A, Habitus, lateral view. B, Habitus, dorsal view.

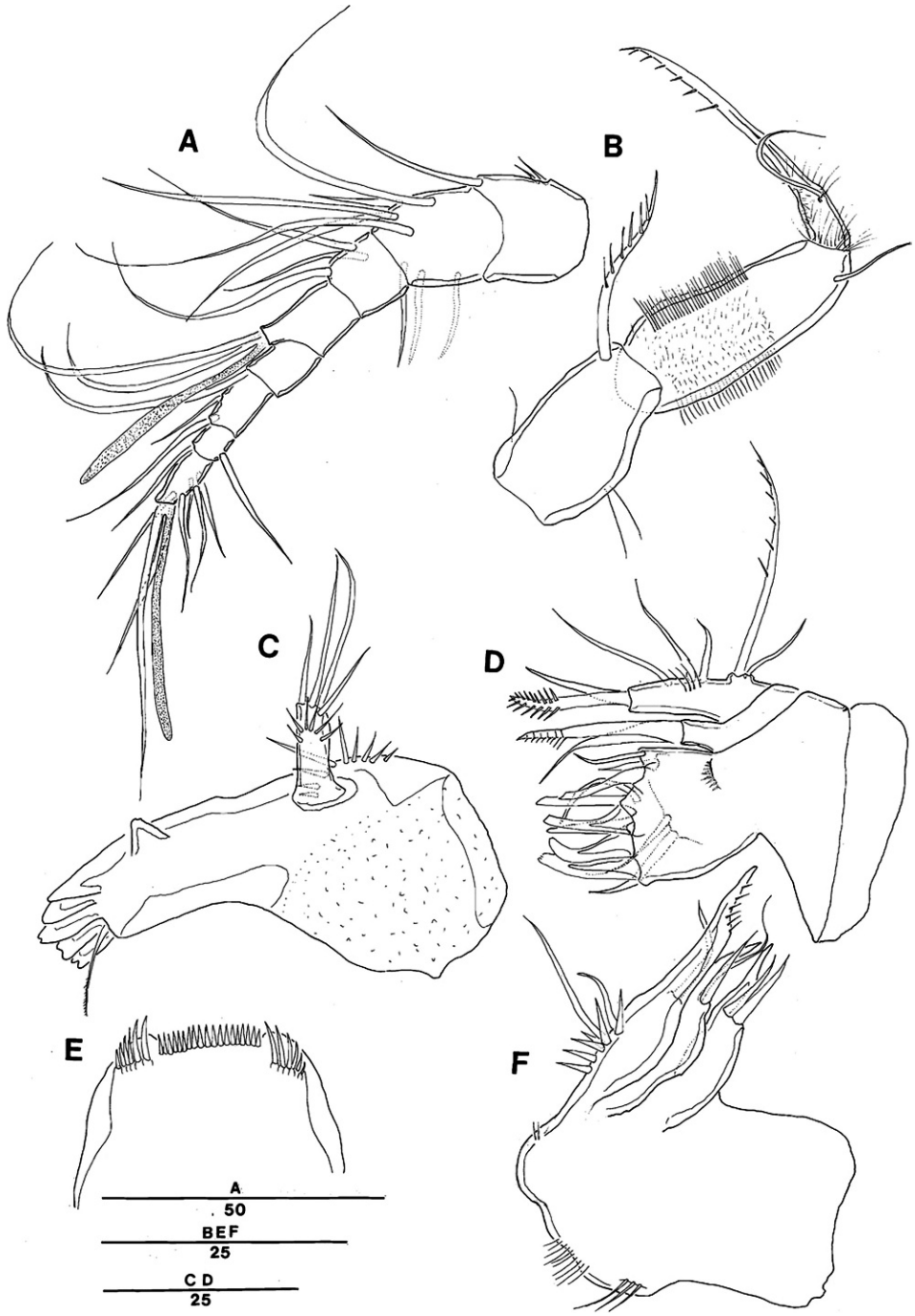

Fig. 2. *Bryocamptus* (*Echinocamptus*) *cheongokensis* (♀). A, Antennule. B, Maxilliped. C, Mandible. D, Maxillule. E, Labrum. F, Maxilla.

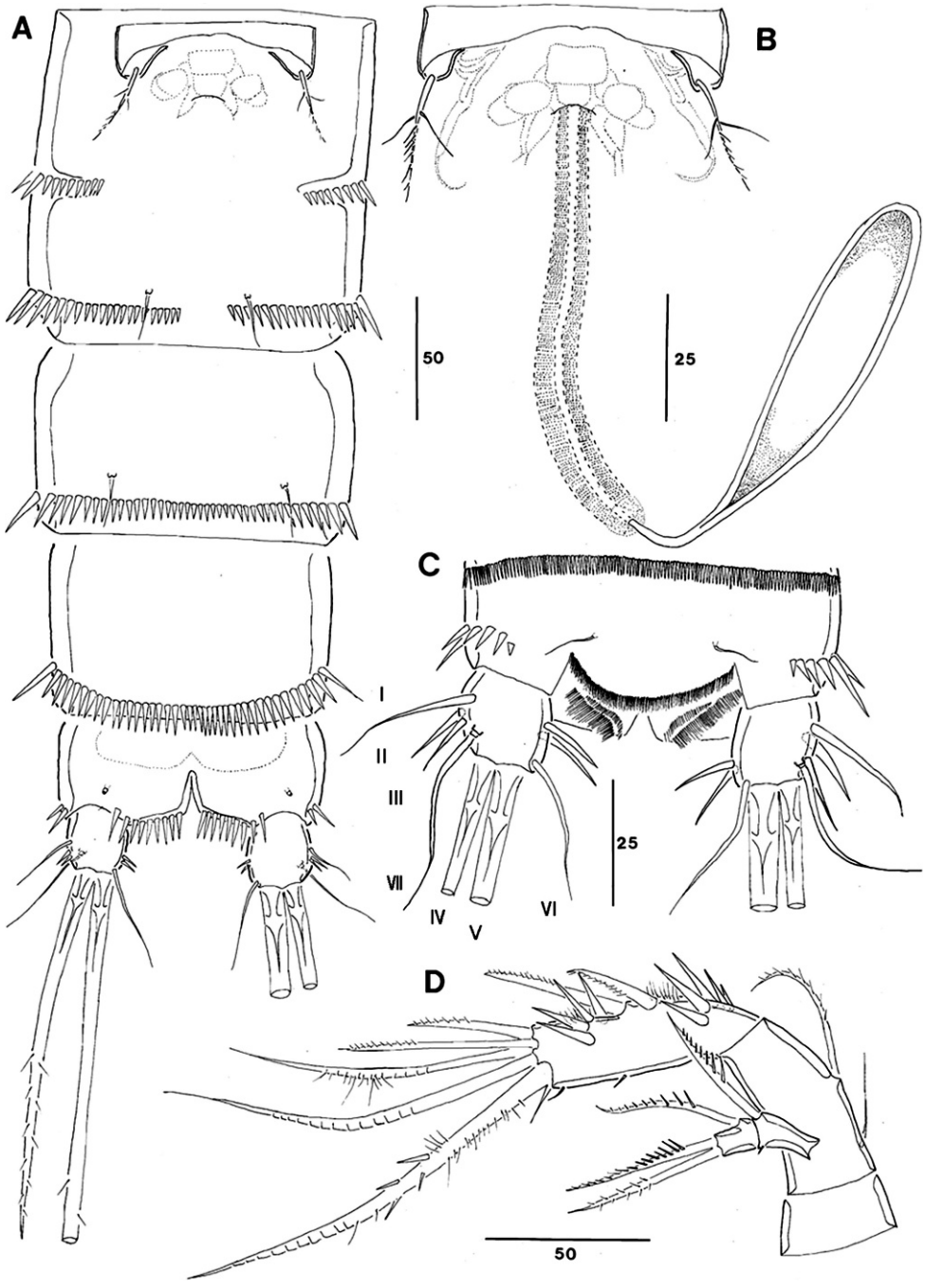

Fig. 3. *Bryocamptus* (*Echinocamptus*) *cheongokensis* (♀). A, Urosome, ventral view. B, Genital field. C, Anal somite and rami, dorsal, setae I–VII indicated. D, Antenna.

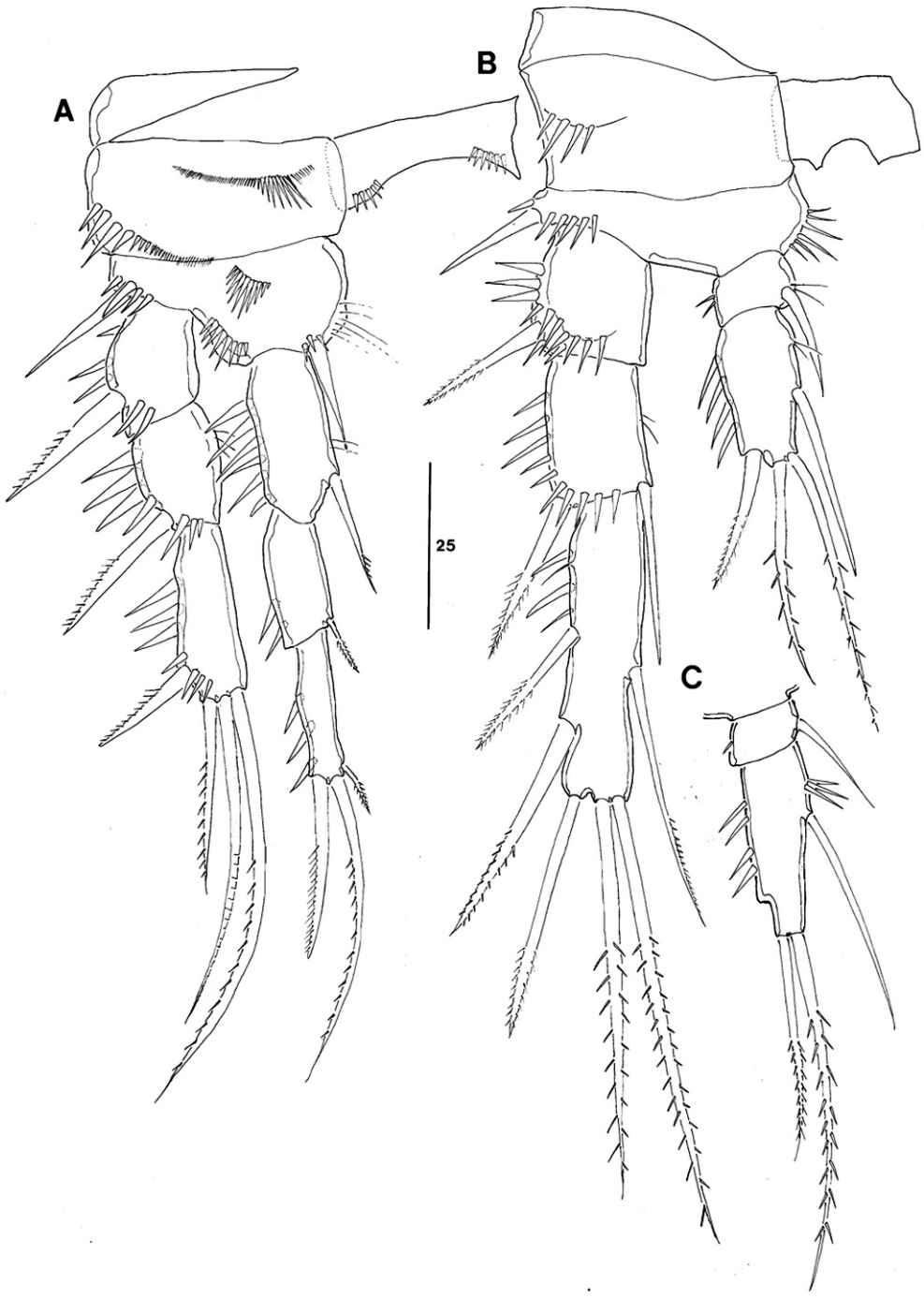

Fig. 4. *Bryocamptus* (*Echinocamptus*) *cheongokensis*. A, P1 (♀). B, P2 (♀). C, P2 endopod (♂).

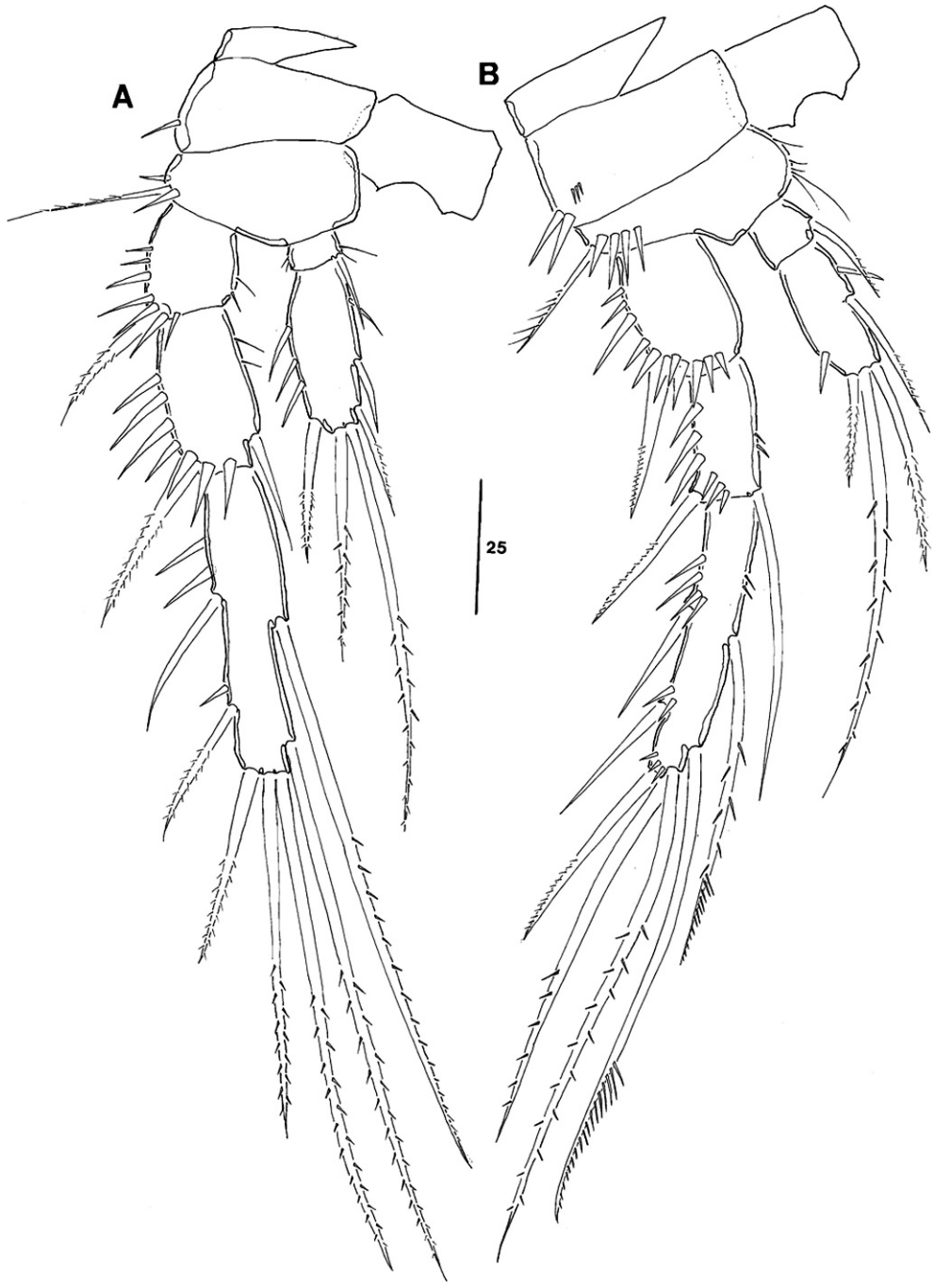

Fig. 5. *Bryocamptus* (*Echinocamptus*) *cheongokensis* (♀). A, P3. B, P4.

east coast of Korea (37°30′59.07″N, 129°6′37.71″E).

Material examined.—Holotype 1 ♀ (NIBRIV 0000170418) dissected on nine slides, collected on 4 Feb 2005. Paratypes: 1♂ (NIBRIV 0000170419) dissected on five slides, collected on 2 Sep 2005; 2♀♀, 1♂ (NIBRIV 0000170420) in 70% etha-

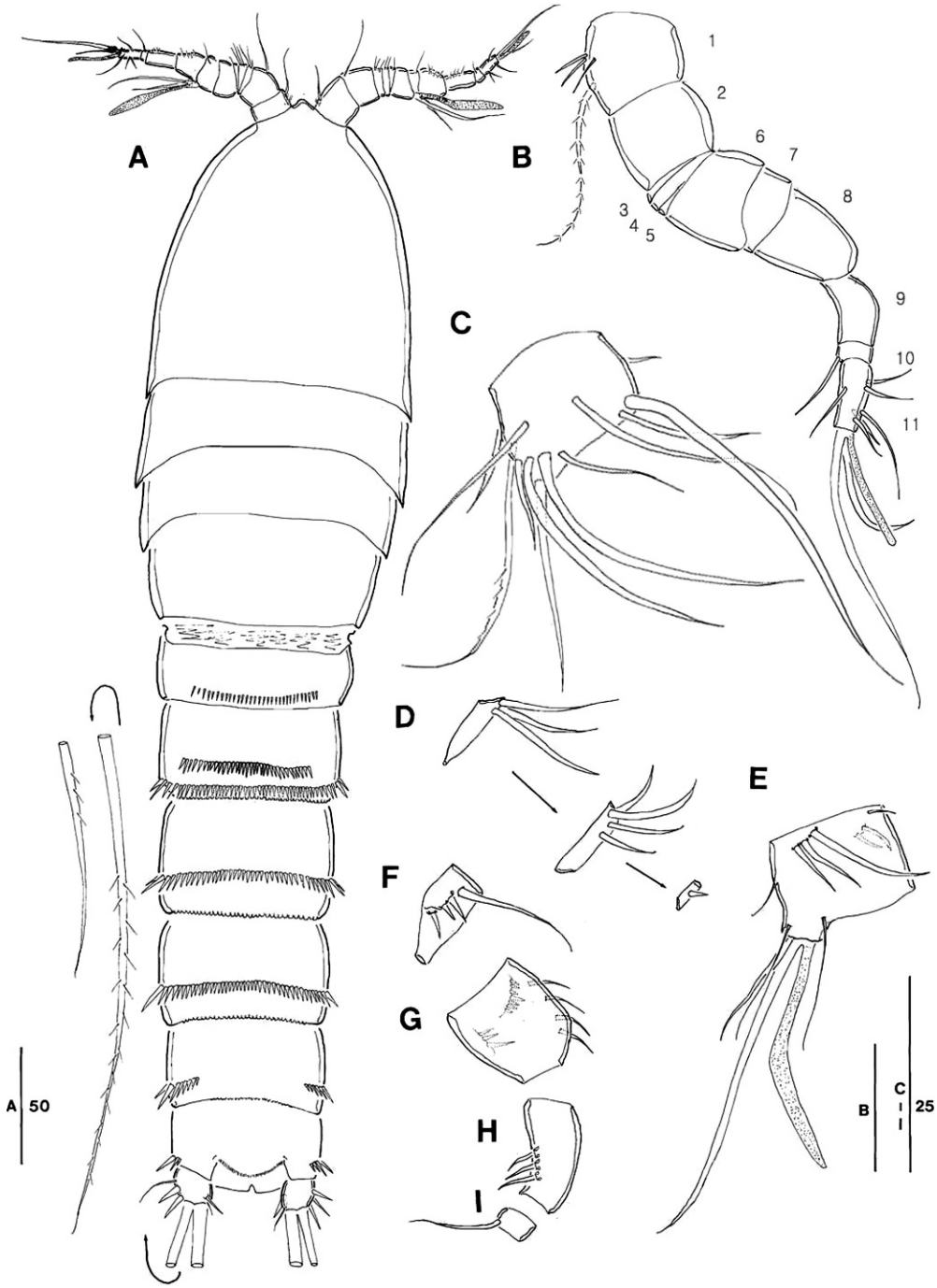

Fig. 6. *Bryocamptus* (*Echinocamptus*) *cheongokensis* (♂). A, Habitus, dorsal view. B, Antennule.., numbers indicate segments. C, Second antennular segment. D, Third–fifth antennular segments. E–I, Sixth–tenth antennular segments.

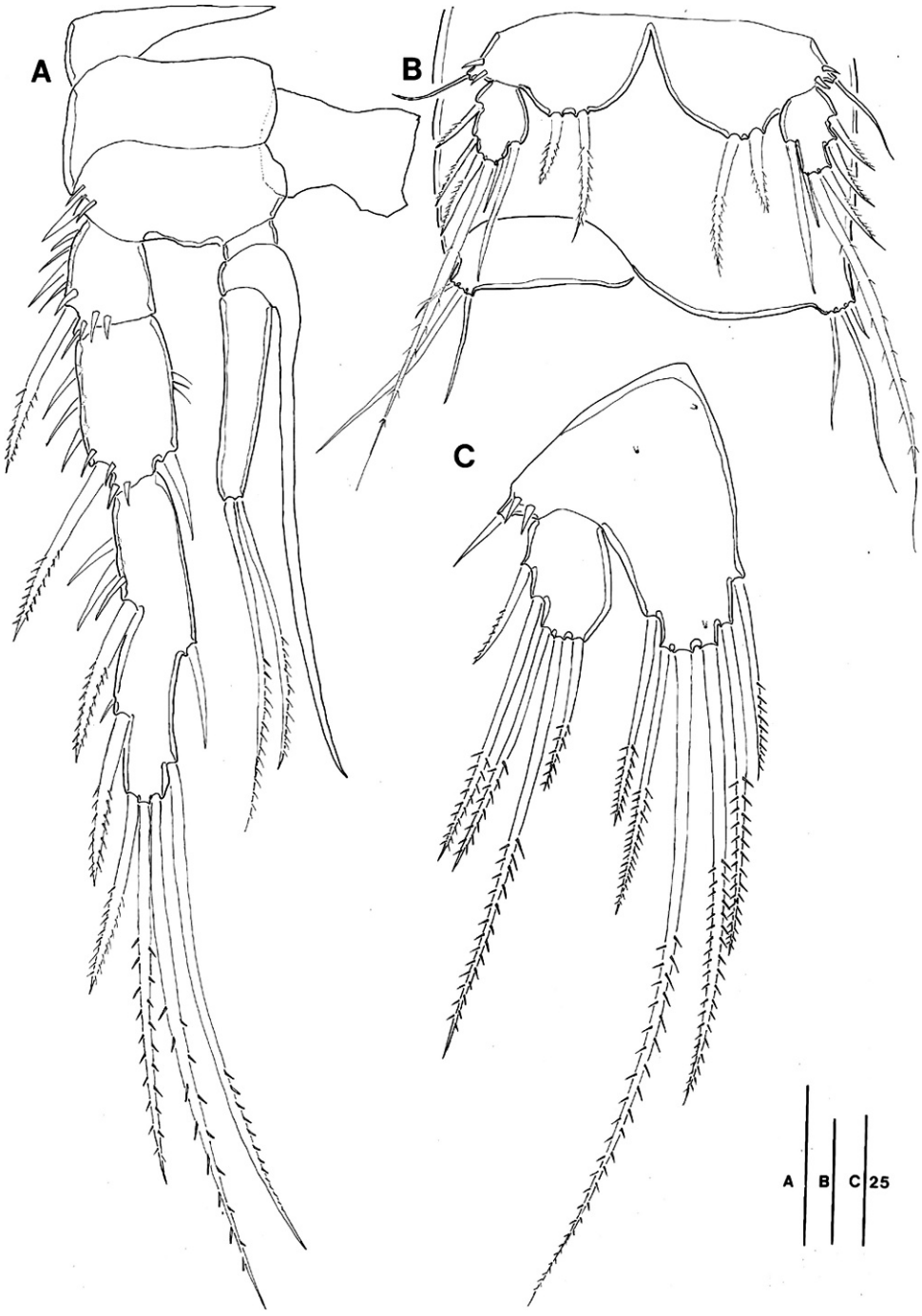

Fig. 7. *Bryocamptus* (*Echinocamptus*) *cheongokensis*. A, P3 (♂). B, P5 and P6 (♂). C, P5 (♀).

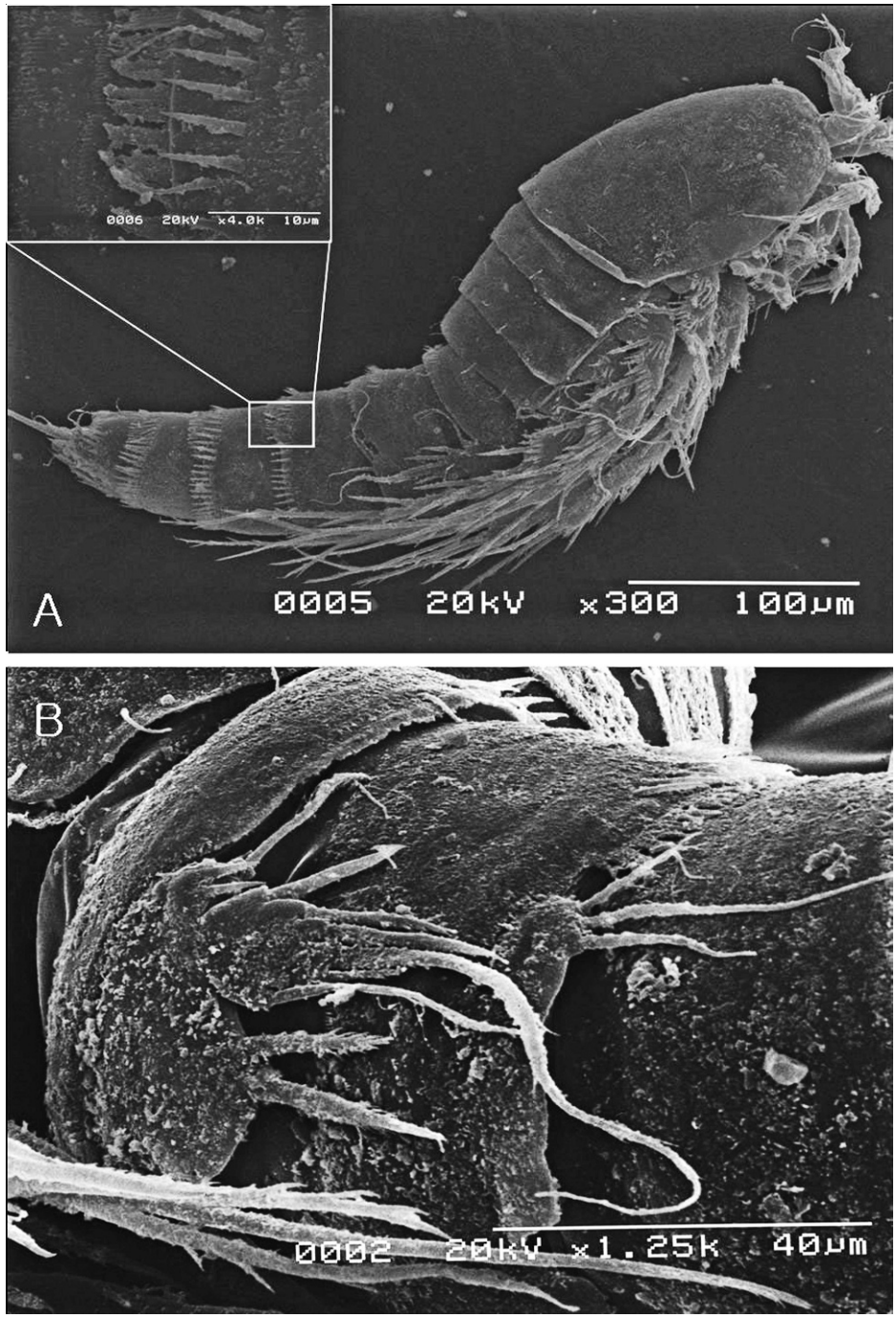

Fig. 8. SEM photographs of *Bryocamptus* (*Echinocamptus*) *cheongokensis* (♂). A, Habitus, lateral (ornament hyaline frill in box). B, P5 and P6.

nol, collected on 4 Feb 2005; 2♀♀ in 70% ethanol, and 2♂♂ mounted on SEM stub, collected on 4 Feb 2005 and deposited in the second author's (WL) collection in the Laboratory of Biodiversity, Department of Life Science, Hanyang University, Seoul. All samples are from the type locality and were collected by D. J. Lee and B. W. Kim.

Description of female.—Total body length 399.4 μm (n = 5, range 307.0–512.2 μm, measured from tip of rostrum to distal margin of caudal ramus). Greatest width, measured at posterior margin of cephalic shield: 104.4 μm.

Prosome (Fig. 1A, B) comprising cephalothorax, incorporating first pedigerous somite and 3 free pedigerous somites. All prosomites without defined hyaline frills, and hind margins smooth. Rostrum fused, small and triangular. Body slightly constricted between each somite.

Urosome (Figs. 1A, B, 3A) 5-segmented, comprising P5 bearing somite, genital double-somite (representing fused genital and first abdominal somites), 2 free abdominal somites, and anal somite.

Genital double-somite (Fig. 3A) longer than wide, partially fused (divided dorsally; partially merged ventrally), and 2 rows of spinules dorsally and laterally along dorsal separation. Genital field located rather proximally and with medial copulatory pore. Characteristic elongated tubule connected to copulatory pore and spermatophore (Fig. 3B).

Anal somite (Fig. 3C) ornamented with pair of sensilla dorsally, 2 ventral tubepores, and laterodistal spinulose row. Anal operculum convex and with setulose posterior margin.

Caudal rami (Fig. 3C) short and round, width and length almost equal, with 7 setae and spinules: seta I longer than setae II and III; setae II and III almost equal in length and shortest; setae IV and V well developed; seta VI subequal to seta I; seta VII longest, basally tri-articulated. Additionally, 2 spines along inner distal margin.

Antennule (Fig. 2A) 8-segmented, with slender aesthetasc on segments 4 and 8, respectively. All setae slender and naked. Armature formula: 1-[1], 2-[8], 3-[3], 4-[1+(1+ae)], 5-[1], 6-[2], 7-[2], 8-[5+acrothek]. Segment 1 with row of spinules on anterior margin. Segment 4 with long aesthetasc extended to over segment 8; aesthetasc basally fused to 1 slender seta. Segment 7 smallest. Apical acrothek consisted of 1 aesthetasc fused to 2 slender setae of different lengths.

Antenna (Fig. 3D). Coxa without ornamentation. Allobasis with 1 abexopodal seta and long spinule. Exopod small, 2-segmented with seta formula 1.120; all setae pinnate. Endopod 1-segmented with 2 pinnate spines and 3 geniculate setae apically (inner geniculate seta fused basally to 1 short seta) and 2 pinnate spines laterally. Rows of spinules between distal lateral pinnate spine and apical margin of endopod.

Labrum (Fig. 2E) trapezoidal with elaborate spinular ornamentation along distal margin.

Mandible (Fig. 2C) with large coxa bearing well-developed gnathobase; cutting edge with several blunt teeth overlapping each other, with 1 pinnate seta; row of long spinules near proximal area of palp. Mandibular palp small, 1-segmented, with 4 apical setae and row of spinules.

Maxillule (Fig. 2D) precoxa with arthrite bearing 9 apical setae and spines, and 2 subdistal setae. Coxa with cylindrical endite with 1 pinnate geniculate seta and 1 slender seta. Basis with 1 pinnate seta and 1 naked apical seta; exopod and endopod fused to basis, represented by 3 and 2 setae, respectively; row of spinules near insertion of endopod setae.

Maxilla (Fig. 2F) syncoxa with 2 rows of spinules on outer margin, and 2 endites; proximal and distal endites each with 3 spines. Allobasis produced into

strong pinnate claw with 1 naked distal seta; endopod fused to allobasis and represented by 2 slender naked setae with several spinules near their insertion. Maxilliped (Fig. 2B) syncoxa with strong plumose seta on distal inner corner. Basis with 2 rows of spinules, each row on dorsal surface near anterior margin and on ventral surface near posterior margin; 1 slender naked seta on outer distal margin. Endopod produced into strong pinnate spine with 1 slender apical seta and several proximal rows of setules.

Swimming legs (Figs. 4, 5) with 3-segmented exopods. P1 with 3-segmented endopod, P2–P4 with 2-segmented endopods. Intercoxal sclerites of all swimming legs concave. Coxae of all swimming legs with rows of spinules.

P1 (Fig. 4A). Intercoxal sclerite with 1 distal row of 5 spinules anteriorly on each side. Coxa with 2 rows of spinules on anterior surface. Basis with stout outer seta and several spinules around its insertion, and with 1 seta and 1 row of hairs along inner margin. Endopod and exopod almost same length. Exp-2 with 1 outer pinnate spine (no seta on inner margin). Exp-3 with 1 outer pinnate spine, apically with 1 pinnate spine, 1 plumose and 1 geniculate seta. Enp-3 narrower than other endopodal segments and bearing 3 setae of different lengths.

P2–P4 (Figs. 4B, 5A, B). Exp-3 very strong and extended, exp-3 longer than exp-1 and exp-2 combined. Endopod not reaching to distal margin of exp-2. Enp-1 small and with only 1 seta. Outer margin of basis with normal seta (P2) or slender plumose seta (P3, P4). Exp-3 longer than exp-1 and exp-2 combined. Outer spines on exp-3 of P2–P4 pinnate, except 1 naked on exp-3 of P4. Inner seta of distal exopodal segment in P3 and P4 well elongated and developed. Endopod not reaching to distal margin of exp-2. Enp-1 small and with only 1 seta.

Spine and seta formula as follows:

	Exopod	Endopod
P1	0.0.121	1.1.120
P2	0.1.123	1.121
P3	0.1.223	1.221
P4	0.1.232	1.121

P5 (Fig. 7C). Baseoendopod with 3 pores and 6 plumose setae, 2 median setae long, outer median seta longest and extending beyond egg sac. Spinules surrounding insertion of basal seta. Exopod bearing 5 plumose setae; apical seta longest, outermost seta shortest.

P6 with small protuberance bearing 1 plumose seta on each side.

Description of male.—Body length 456.4 μm (n = 3; measured from tip of rostrum to distal margin of caudal ramus). Greatest width, measured at posterior margin of P2-bearing somite: 110.3 μm. Body similar to female in general appearance, except thoracic and abdominal segments wider than in female (Fig. 6A).

Urosome distinctly narrower than prosome and comprising P5-bearing somite and 5 free abdominal somites (Fig. 6A). P5-bearing somite about 1.5 times broader than long, with dorsal longitudinal spinular row. Following 3 abdominal somites with distal spinular row. First free abdominal somite with distal ventral spinule row extending laterally (Figs. 6A, 8A). First abdominal somite about 1.5 times broader than long; ventral surface smooth and ventral posterior margin with large spinule row laterally and medially, dorsal surface with 2 rows of spinules along posterior margin. Hyaline frills of urosomites well developed (Fig. 8A).

Antennule (Fig. 6B–I) 11-segmented. Segment 1 with spinule row along anterior margin. Segments 3 to 5 very reduced (Fig. 6D). Major geniculation between segments 8 and 9. Armature formula: 1-[1], 2-[12], 3-[3], 4-[4], 5-[1], 6-[6+(1+ae)], 7-[4], 8-[4], 9-[3], 10-[1], 11-[7+(1+ae)].

Table 1.—Morphological features of the *Bryocamptus* (*Echinocamptus*) *hiemalis* group and of *B. cheongokensis*.

Character		*hiemalis* s.s.	*h. verestschagini*	*h. brevifurcatus*	*h. yunnanensis*
Body length (mm) (male)		0.77 (0.55)	—	0.63–0.77 (0.51–0.58)	—
P1	Exp	0. 0. 1-2-1	0. 0. 1-2-1	0. 0. 0-2-2	—
	Enp	1. 1. 1-2-0	1. 1. 1-2-0	1. 1. 1-2-0	—
	length exp./enp.	exp. < enp.	exp. < enp.	exp. < enp.	—
P2	Enp.	1. 2-2-1	1. 2-2-1	1. 2-2-1	1. 1-2-1
	Enp. (♂)	1. 1-2-0	—	—	—
P3	Enp.	1. 2-2-1	? . 2-2-1	1. 2-2-1	—
	Enp. (♂)	1. 1. 0-2-0	—	1. 1. 0-2-0	—
P4	Enp.	1. 2-2-1	1. 2-2-1	1. 2-2-1	0. 2-2-1
P5 Exp.	length/width	×1.2	×1.4	×1.5	×2.0
	length/inner distal seta	×2.2	—	×1.7	×2.0
	Exp. (♂)	6	5	6	—
Operculum marginal ornamentation		naked	naked	setulose	naked
Distribution		China, Japan	Russia	U.S.A.	China
Author, date		Pearse, 1905	Borutzky, 1931	Coker, 1934	Borutsky, 1952

Antenna, mandible, maxillule, maxilla, maxilliped, P1 and P4, P2 exopod, and anal operculum as in female.

P2 (Fig. 4C) endopod 2-segmented; enp-1 with 1 seta; enp-2 with stepped outer lateral margin and 1 long naked inner seta and 2 apical pinnate setae of different lengths.

P3 (Fig. 7A). Basis with short and stout spine on outer margin. Endopod 3-segmented, strongly modified, with no seta on enp-1, apophysis on enp-2, and 2 apical setae on enp-3.

P5 (Figs. 7B, 8B) fused medially. Baseoendopod with 2 setae; inner seta longer than outer. Exopod with 2 outer, 3 apical, 1 inner setae; midapical seta longest, inner apical shortest.

P6 (Figs. 7B, 8B) asymmetrical, each represented by small swollen triangular chitinous plate (fused to ventral wall of supporting somite: right plate articulated at base, left plate covering gonopore and not articulated at base but fused to somite, both plates bearing 3 setae, middle seta longest, and outer seta shortest).

Etymology.—The species name refers to its type locality, Cheongok Cave, which is located near the east coast of Korea.

Discussion

Bryocamptus cheongokensis belongs to the subgenus *Echinocamptus*. According to Wells (2007), it is closely related to the *hiemalis* group that includes *Bryocamptus lacustris*, *B. pacificus*, *B. calvus*, *B. nivalis*, and *B. hiemalis* s.s., as well as *B. h. elongatus*, *B. h. verestschagini*, *B. h. yunnanensis*, *B. h. brevifurcatus*, and *B. h. yetii*. These species share the following character sets: 1) an eight-segmented female antennule, 2) a two-segmented antennary exopod, 3) a P5 baseoendopod with six setae (female) or two setae (male), an exopod with five setae (female and male), and 4) a naked anal operculum.

Bryocamptus cheongokensis has a unique set of apomorphies, including 1) the P1 exopod and endopod are of the same length, 2) the presence of inner seta on enp-1 of P2–P4, and 3) the setal formula of the species belongs to the *hiemalis* group (Table 1).

Bryocamptus lacustris displays the same setal formula as does the new species. However, these taxa are easily distinguished by the somite ornamentation, the shape of the apical endopodal segment of the female P3, and the lengths of the inner

Table 1.—Extended.

h. elongatus	*h. yetii*	*nivalis*	*calvus*	*pacificus*	*lacustris*	*cheongokensis*
0.45 (0.40)	—	0.54 (0.44)	0.70	0.50 (0.40–0.52)	—	0.40 (0.46)
0. 0. 0-2-1	0. 0. 1-2-1	—	0. 0. 1-2-1	0. 0. 0-2-2	0. 0. 1-2-1	0. 0. 1-2-1
1. 1. 1-2-1	1. 1. 1-2-0	—	1. 1. 1-2-0	1. 1. 1-2-0	1. 1. 1-1-1	1. 1. 1-2-0
exp. < enp.	exp. < enp.	—	exp. < enp.	exp. ≈ enp.	exp. ≈ enp	exp. ≈ enp.
1. 2-2-1	1. 1-2-1	—	1. 1-2-1	1. 1-2-1	1. 1-2-1	1. 1-2-1
1. 0-2-0	1. 1-2-0	—	—	?. 1-2-0	—	1. 1-2-0
	1. 2-2-1	1. 2-2-1	1. 3-2-1	1. 2-2-1	1. 2-2-1	1. 2-2-1
1. 1. 0-2-0	1. 1. 0-2-0	—	—	1. 1. 0-2-0	—	0. 1. 0-2-0
1. 2-2-1	1. 2-2-1	1. 2-2-1	1. 2-2-1	1. 2-2-1	1. 1-2-1	1. 1-2-1
×2.6	×1.2	—	×2.4	×2.0	×1.6	×1.6
×1.1	×3.7	—	×2.7	×1.0	×1.6	×1.2
5	6	—	—	6	6	6
naked	naked	setulose	naked	naked	naked	setulose
China	Nepal	Canada	Japan	Japan	Russia	Korea
Shen & Tai, 1964	Löffler, 1968	Willey, 1925	Brehm, 1927	Ishida, 1992	Wells, 2007	Present study

seta on the P3 last exopod segment and the apical seta on the P5 baseoendopod. First, *B. lacustris* lacks the anterodorsal row of spinules on the genital somite (see Ishida 1992, Fig. 17a), whereas the new species has a spinule row on each urosomal somite and two spinule rows on the first genital somite. Second, the seta lengths are different. In *B. lacustris*, an inner seta on exp-3 of P3 appears to just reach the end of the segment, but the corresponding seta in the new species is much longer. The endopods of P2–P4 are also different: the two apical setae of the last endopod P2 have similar lengths and are as long as the enp-2 in *B. lacustris*, whereas at least one apical seta is 2–3 times longer than is enp-2 in the new species. The apical seta on the P5 baseoendopod of the new species has long setae; the longest seta reaches the first free abdominal segment (Fig. 1A). The new species has a short basal seta on P5, whereas *B. lacustris* has a relatively long basal seta. Furthermore, the two apical setae on the last endopodal segment in the male P3 are of similar length, but the corresponding setae in *B. lacustris* are not equivalent in length. Third, *B. lacustris* has an ovoid P3 enp-2 (see Lang 1948, p. 1113, Abb. 446-2, Ishida 1992, Fig. 18b), whereas in the new species, P3 enp-2 is rectangular.

Bryocamptus hiemalis s.s. has plumose setae on the first and seventh antennular segments and a very long apical seta on the eighth antennular segment (see Pearse 1905, Pl. 16, 28), whereas the new species has naked setae on the first and seventh antennular segments and a relatively short apical seta on the last segment. In *B. hiemalis* s.s., the outer seta is long and the inner is short in the male P6 (see Pearse 1905, Pl. 42), whereas the opposite pattern is present in the new species (Fig. 7B). In terms of body length, *B. hiemalis* s. str. (770 μm in the female) and *B. h. calvus* (700 μm in the female) are longer than *B. cheongokensis* (399.4 μm in the female), which in turn is similar to *B. h. elongatus* (450 μm in the female). Nevertheless, the length/width ratio of the female P5 exopod is different in the new species and these other two species: in *B. h. elongatus*, the P5 exopod is 2.6 times longer than it is wide, and in *B. h.*

calvus, it is 2.4 times longer than wide, whereas in the new species, it is only 1.6 times longer than wide (Table 1).

The outer spine on the second endopod segment of P2 of the male is lacking in the new species; only a stepped margin is present (Fig. 4C). The new species shares the modified endopod of the male P3, with an apophysis and two apical setae present on the last segment (Fig. 7A), similar to *B. hiemalis*s. (see Pearse 1905, Pl. 17) and *B. pacificus* (see Ishida 1992, Fig. 5). However, males of these species are distinguished from *B. cheongokensis* by the presence of a seta on P3 enp-1, the lengths of the apical setae on P3, and the length of apical seta on the P5 exopod.

In terms of genital morphology, *Bryocamptus borus* (see Karanovic & Bobic 1998, Fig. 27) and *Echinocamptus hypophyllus* (see Defaye & Heymer 1996, Fig. 2b) have a similar copulatory tubule to that of the new species. All three species have a peculiar, long copulatory tubule that reaches to the free abdominal segment next to the genital segment (Fig. 3B). The function of this morphological adaptation is unknown.

The subgenus *Echinocamptus* is distributed mainly in Eurasia, including Russia, China, Japan, and Nepal. This study is the first to report a species of *Echinocamptus* in Korea, thereby expanding the distributional region of this subgenus (Table 1).

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Literature Cited

Basamakov, I. D. 1969. Apport vers l'étude d'Harpacticoida (Crustacea, Copepoda) de la montagne de Rodopa en Bulgarie.—Fragmenta Balcanica 7(10):77–85.

Borutsky, E. V. 1931. Materialien zur Harpacticidenfauna des Baikalsees III.—Zoologischer Anzeiger 94:281–287.

———. 1952. Harpacticoida presnykh vod.—Fauna SSSR, Rakoobraznye 3(4):1–426. (Harpacticoida of freshwaters. Crustaceans, III(4), The U.S.S.R. Fauna, new series. Zoological Institute of the Russian Academy of Sciences, St. Petersburg, 426 pp.) (in Russian).

Brehm, V. 1927. Über die Tiefenfauna japanischer Seen.—Archiv für Hydrobiologie 18:132–150.

Chappuis, P. A. 1929. Die Unterfamilie der Canthocamptidae.—Archiv für Hydrobiologie 20: 471–516.

Coker, R. E. 1934. Contribution to knowledge of North American freshwater harpacticoid copepod Crustacea.—Journal of the Elisha Mitchell Scientific Society 50:75–141.

Defaye, D., & A. Heymer. 1996. Crustacés copépodes de litière de la forêt ombrophile du Kivu (Zaïre).—Bulletin du Muséum National d'Histoire Naturelle, Paris, 4e Série, Section A, Zoologie, Biologie et Écologie Animales 18:185–209.

Douwe, C. van. 1908. Zur Kenntnis der Süsswasser-Copepoden Deutschlands.—Zoologischer Anzeiger 32:581–585.

Dussart, B., & D. Defaye. 1990. Répertoire mondial des Crustacés Copépodes des eaux intérieures. III. Harpacticoïdes.—Crustaceana Supplement 16:1–384.

Huys, R. 2009. Unresolved cases of type fixation, synonymy and homonymy in harpacticoid copepod nomenclature (Crustacea: Copepoda).—Zootaxa 2183:1–99.

———, J. M. Gee, C. G. Moore, & R. Hamond. 1996. Marine and Brackish Water Harpacticoid Copepods, part 1. Synopses of the British Fauna (New Series) No. 51. Field Studies Council, Shrewsbury, 352 pp.

Ishida, T. 1992. *Bryocamptus pacificus*, a new harpacticoid copepod (Crustacea) from Japan and the neighbouring areas.—Bulletin of the Biogeographical Society of Japan 47: 77–81.

Karanovic, T., & M. Bobic. 1998. Two species of Copepoda Harpacticoida from East Serbia (Balkan Peninsula): *Parastenocaris serbica* sp. n. and *Bryocamptus* (*R.*) *borus* sp. n.—Crustaceana 71:171–184.

Kiefer, F. 1952. Beitrag zur Kenntnis der Copepodenfauna Algeriens. Contribution à la connaissance de la faune des Copépodes d'Algérie.—Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord 43:87–112.

Lang, K. 1948. Monographie der Harpacticiden. Volumes I & II. Håkan Ohlsson, Lund, 1683 pp.

Lewis, M. H. 1986. Biogeographic trends within the freshwater Canthocamptidae (Harpacticoida).—Syllogeus 58:115–125.

Löffler, H. 1968. Zur Harpacticidenfauna des östlichen Nepal mit besonderer Berücksichtigung der Gattung *Maraenobiotus*.—Archiv für Hydrobiologie 65:1–24.

Mrázek, A. 1893. Beitrag zur Kenntniss der Harpacticidenfauna des Süsswassers.—Zoologische Jahrbücher, Abtheilung für Systematik, Geographie und Biologie der Thiere 7:89–130.

Pearse, A. S. 1905. Contributions to the Copepod fauna of Nebraska and other states.—Transactions of the American Microscopical Society 26:145–160.

Pesce, G. L. 1999–2010. Copepod Web Portal. Available at http://www.luciopesce.net/copepods/index.html.

Rouch, R. 1986. Copepoda: les harpacticoïdes souterrains des eaux douces continentales. Pp. 321–355 *in* L. Botosaneanu, ed., Stygofauna Mundi. E. J. Brill, Leiden, 740 pp.

Scourfield, D. J. 1912. A Biological Survey of Clare Island in the County of Mayo, Ireland and of the Adjoining District, part 46. Fresh-water Entomostraca.—Proceedings of the Royal Irish Academy 31:1–18.

Shen, C. J., & A. Y. Tai. 1964. On the freshwater copepods of Yunnan Province.—Acta Zoologica Sinica 16:611–642.

Wells, J. B. J. 2007. An annotated checklist and keys to the species of Copepoda Harpacticoida (Crustacea).—Zootaxa 1568:1–872.

Willey, A. 1925. Copepods in the Northern Hemisphere.—Nature 116:206.

Wilson, M. S., & H. C. Yeatman. 1959. Free-living Copepoda: Harpacticoida. Pp. 815–861 *in* W. T. Edmondson, ed., Fresh-Water Biology, Second edition. John Wiley & Sons, New York, 1248 pp.

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