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Two Semi-subterranean Copepods from Korea

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Key Words:

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Two freshwater cyclopoid species including a new species are added to Korean copepod fauna: *Ochridacyclops coreensis* n. sp. and *Itocyclops yezoensis* (Ito, 1953). Both species were collected from the semi-subterranean waters like springs and wells. The present paper deals with the description of the new species and the systematic accounts on the two species, based on the morphological character comparison with the related congeners.

The freshwater cyclopoid copepod fauna of Korea comprises total 31 species of 13 genera in the family Cyclopidae: since Kim and Chang (1989) first recorded 25 species or subspecies of 12 genera taxonomically from the various freshwater bodies in Korea, Yoo and Lim (1989) reported two estuarine cyclopoid species from Youngsan Lake, and then Chang et al. (1998) added four new records to Korean fauna during the investigation on the distribution of mountainous cyclopoids in Korea.

Recently, the authors have tried to expand the freshwater copepod fauna of Korea by searching scrupulously for the copepods inhabiting the semi-subterranean waters like wells and springs or the so-called 'cryptic' microhabitats (Reid, 1986) like temporary puddles in the mountain area. As a provisional result of the researches, we confirmed two cyclopoid species including a new species. We deal with the systematic accounts on them here.

Materials and Methods

Materials examined in the present study were collected from the wells and mountainous springs since the year of 1987. Collections were made with a dipnet of no. 25 mesh aperture.

Specimens were dissected and mounted in lactophenol on H-S slide (Shirayama et al., 1993), a recent variation of Cobb slide, after the treatment in a solution of 5% glycerin - 95% ethyl alcohol for 1-2 d, then observed using a differential interference contrast microscope (Olympus BX-51) equipped with Nomarski optics. All drawings and measurements were made with the aid of a camera lucida. Type specimens will be deposited in the Natural History Museum, Ewha Womans University in Seoul, Korea.

Abbreviations of enp 1-3 or exp 1-3 are used in the text and figure legend to denote the first to third endopodal or exopodal segment of each leg.

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Description

Family Cyclopidae Sars, 1913
Subfamily Eucyclopinae Kiefer, 1927
Genus *Ochridacyclops* Kiefer, 1937

Ochridacyclops coreensis Chang, n. sp.
(Figs. 1-4)

Material examined

Holotype ♀, spring, Mt. Nochu, Gujeol-ri, Jeongseon (37°30′00″N, 128°44′30E″), 23 Sep. 1993, C. Y. Chang. Holotype was dissected and mounted on lactophenol. Allotype: ♂, spring near Kangnung National University (37°55′13″N, 128°51′39E″), 23 Sep. 1993, C. Y. Chang, dissected in lactophenol on H-S slide. Paratypes: 8♀♀(1 ovi.), spring near Kangnung National University, 23 Sep. 1993, C. Y. Chang. Dissected paratypes (2 ♀♀) will be deposited in the Natural History Museum, Ewha Womans University, and holotype, allotype and the remaining paratypes are kept in the research collection of Department of Biology, Daegu University.

Additional materials examined

1♀, spring near Kangnung National University, 2 Jan. 1991, C. Y. Chang; 1♀, same location, 7 May 1993, C. Y. Chang; 1♀, spring, Cheonunsa Temple, Chungju (36°58′39″N, 127°57′37″E, water temperature: 14°C), 31 May 1991, S. H. Kim; 1♀, spring, Chunyang, 5 May 1987, C. Y. Chang; 1♀, spring, Mt. Jiri, Jungsan-ri, Sancheong, 26 Sep. 1992, C. Y. Chang.

Holotype female

Body (Fig. 1A) fairly small 0.63 mm long, excluding

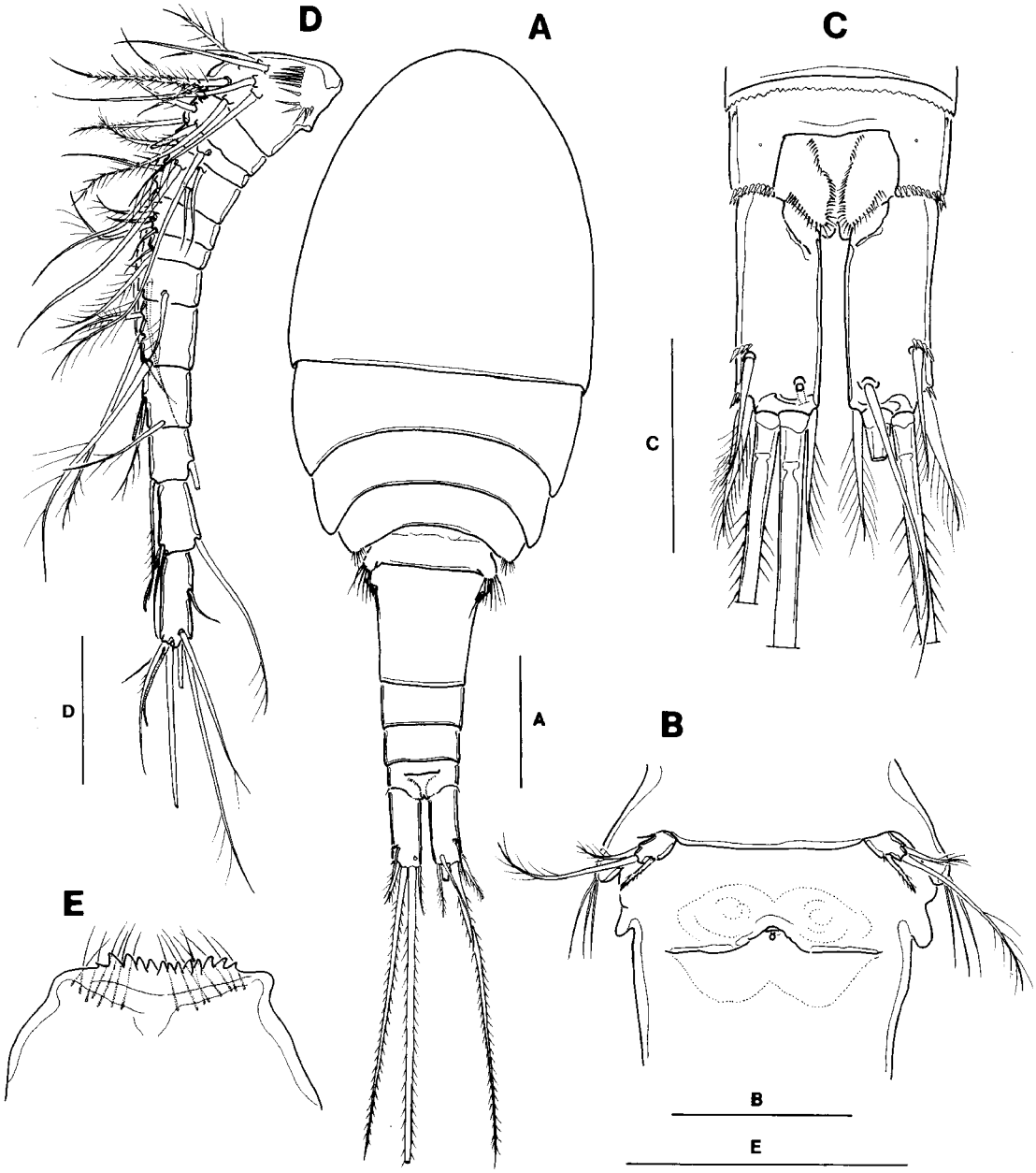

Fig. 1. *Ochridacyclops coreensis* n. sp., female (holotype). A, Habitus, dorsal. B, Genital somite and leg 5, ventral. C, Anal somite and caudal rami, dorsal. D, Antennule. E, Labrum, dorsal. Scale bars = 50 μm (B-E) and 100 μm (A).

caudal seta, and greatest width 0.24 mm. Prosome oblong-oval, much longer than urosome (1.45 times); widest at posterior margin of cephalothorax, and gradually tapering behind. Cephalothorax protruding anteriorly, more than 2 times longer than next three thoracic somites combined. Posterolateral corners of thoracic somites a little produced posteriorly. Fifth pedigerous somite with strong fringe of elongate setules at posterior margin (Fig. 1A).

Genital double-somite a little longer than wide (Fig. 1A); both sides of dorsal surface near proximal quarter to third of genital somite wrinkled with 3 conical projections or spines. Seminal receptacle typical form of *Ochridacyclops,* made up of two wide sections in the shape of human lips, posterior one a little wider, with posteromedial depression (Fig. 1B). Posterior margins of abdominal somites weakly fringed with hyaline membrane, except anal segment having about 9-10 spinules on both dorsal and ventral sides (Fig. 1C). Posterior margin of anal plate slightly convex and smooth (Fig. 1C); row of spinules present in anal cleft, either side of midline.

Caudal rami (Fig. 1C) nearly parallel or slightly divergent,

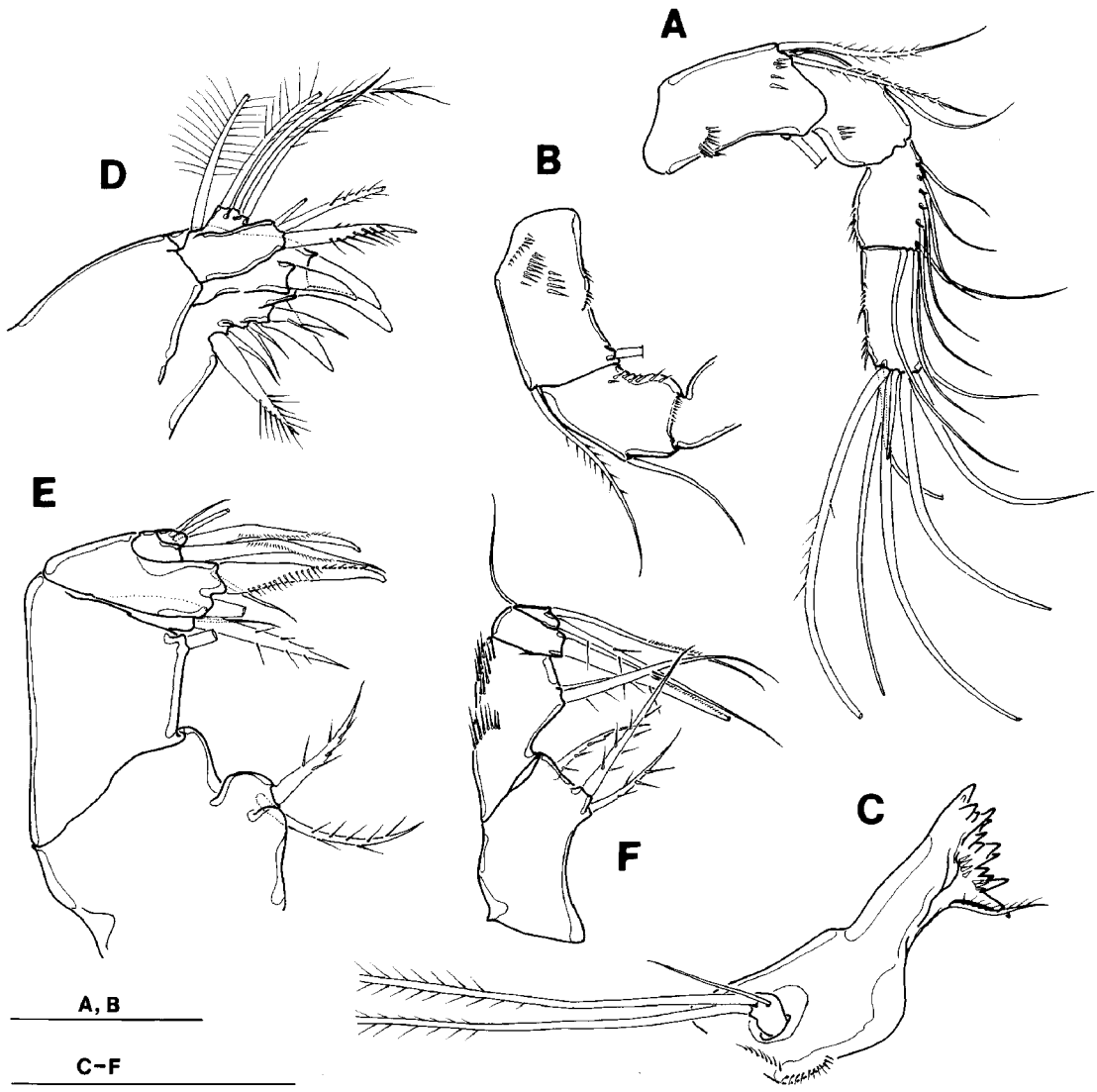

Fig. 2. *Ochridacyclops coreensis* n. sp., female (holotype). A, Antenna, caudal. B, Coxobasis and first endopodal segment of antenna, frontal. C, Mandible. D, Maxillule. E, Maxilla. F, Maxilliped. Scale bars = 50 μm.

2.75 times as long as wide; lateral margins not serrated. Lateral caudal seta (anterolateral seta, II, according to the nomenclature system of Huys and Boxshall, 1991) located at distal quarter of lateral margin of ramus, inserted rather dorsolaterally, with row of spinules anterior to its base, nearly same in length with outer caudal seta (posterolateral seta, III). Inner caudal seta (terminal accessory seta, VI) nearly as long as outer caudal seta. Dorsal caudal seta (dorsal seta, VII) very long, about 2 times longer than inner caudal one. Inner terminal seta (V) about 1.76 times longer than outer terminal seta (IV), and nearly 2/3 times as long as whole body length.

Antennule (Fig. 1D) not reaching posterior margin of cephalothorax, of 12 segments. First segment with spinular row ventrally. Segments 3 and 6 relatively very small. Terminal segment without distinguishable hyaline lamella, much longer than penultimate and antepenultimate ones. Setal formula 8, 4, 2, 6, 4, 2, 2, 3, 2+1 aesthetasc, 2, 2+1 aesthetasc, 7+1 aesthetasc.

Antenna 4-segmented (Fig. 2A), comprising coxobasis and 3-segmented endopod. Coxobasis bearing 1 long outer seta representing exopod, and 2 inner plumose setae, ornamented with several spinules on anteromedial corner; frontal surface with 3 rows of spinules basally, and anterior margin bare (Fig. 2B); caudal surface with several spinules near base of two inner seta, while bare around outerodistal corner (Fig. 2A). First endopodal segment with 1 inner seta and 1 spinule row. Second endopodal segment with 9 setae in total along inner margin and distal margin. Third endopodal segment armed with 7 setae around distal area, with spinule row along outer margin.

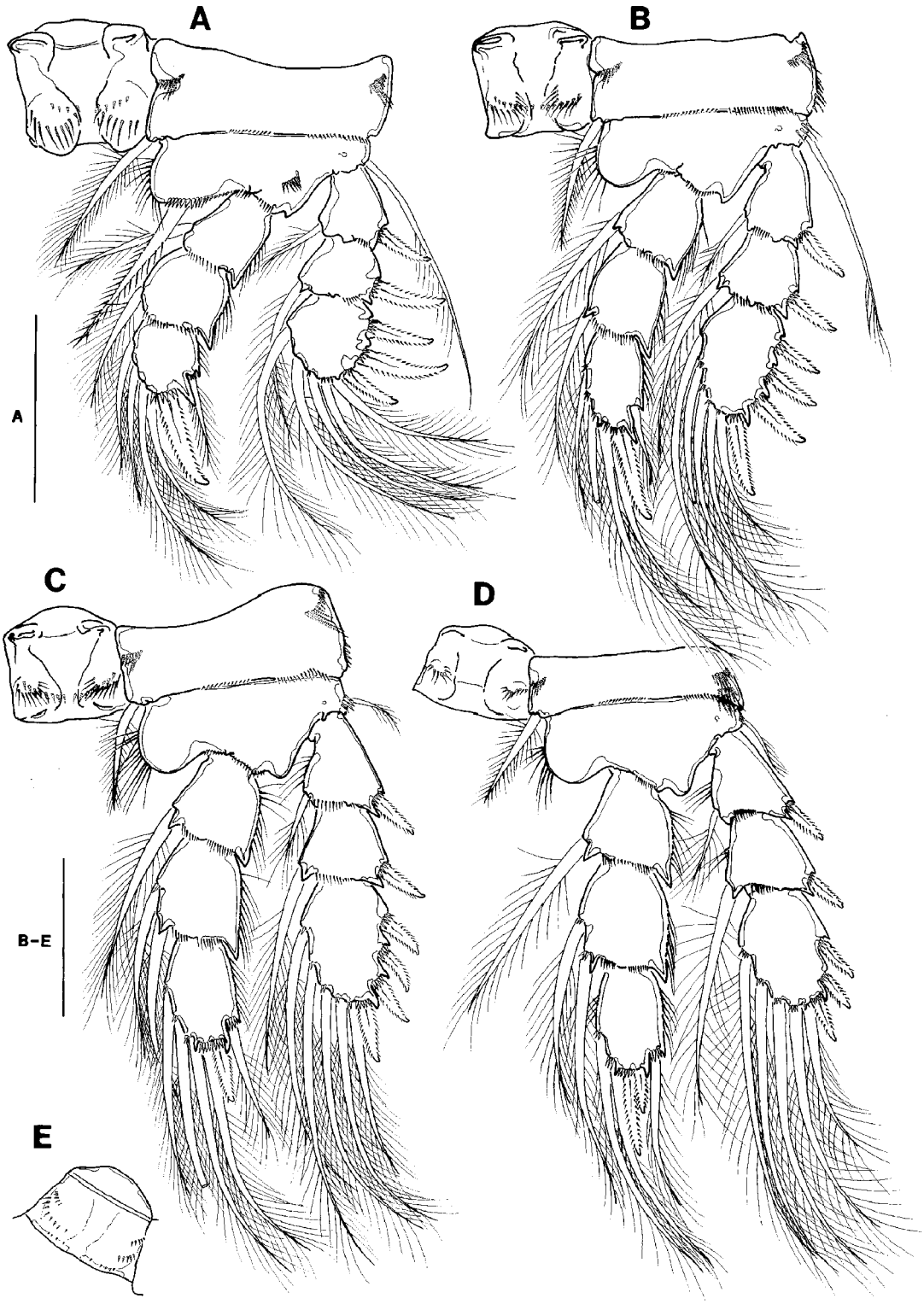

Fig. 3. *Ochridacyclops coreensis* n. sp., female (holotype). A-D, Legs 1-4, anterior. E, Intercoxal sclerite of leg 4, posterior. Scale bars = 50 μm.

Labrum (Fig. 1E), posterior margin with bearing about 13 teeth; ventral surface with paired groups of long setules.

Mandible (Fig. 2C) with coxal gnathobasic blades simple, dorsal seta along inner rim. Palp represented by 3 setae, comprising 2 long plumose setae and 1 short

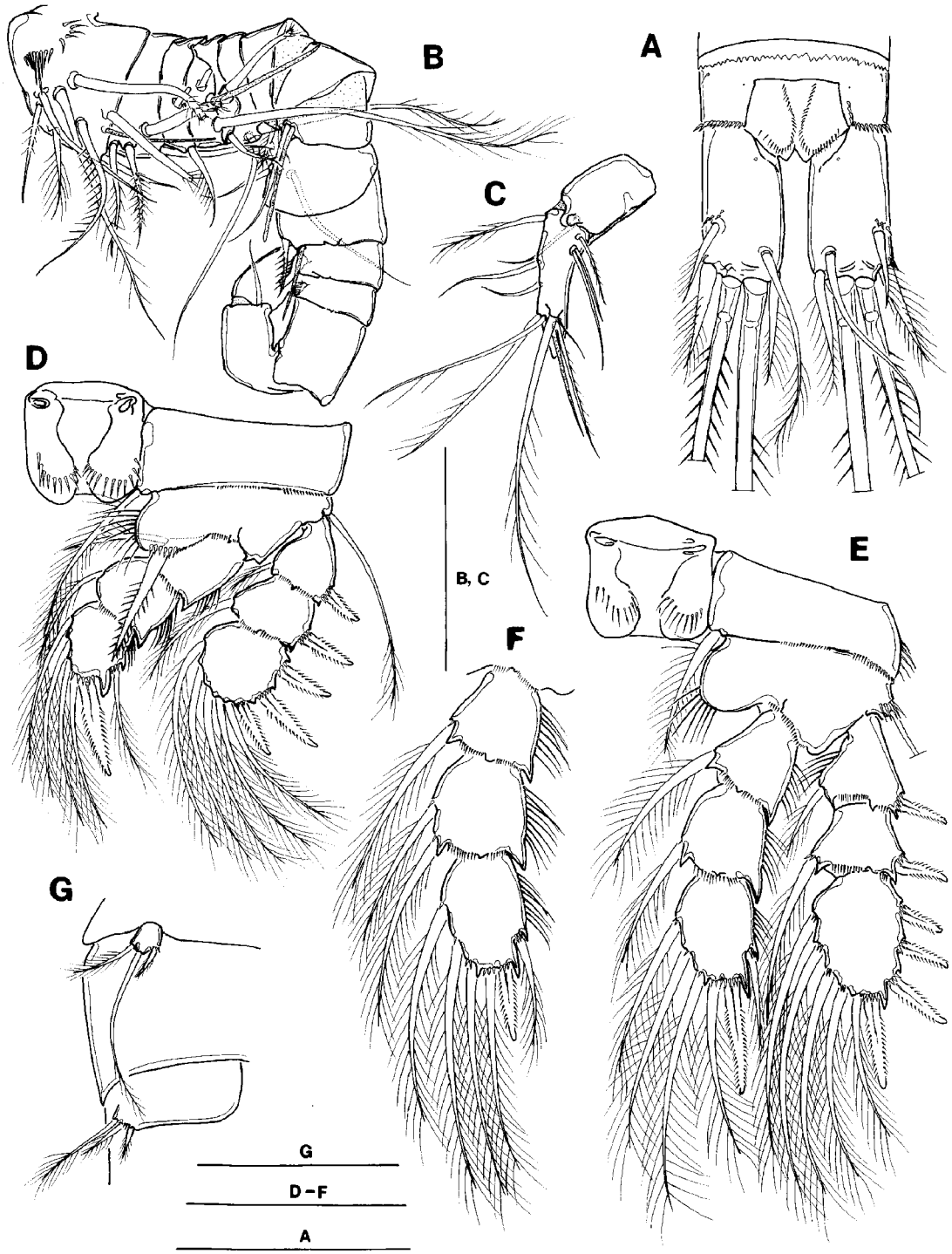

Fig. 4. *Ochridacyclops coreensis* n. sp., male (allotype). A, Caudal rami, dorsal. B, Antennule, ventral. C, Last and penultimate segment of antennule, dorsal. D-E, Legs 1-2, anterior. F, Endopod of leg 3. G, Legs 5-6, ventral. Scale bars = 50 μm.

and naked seta. Outer margin of coxa near base of palp armed with spinular rows.

Maxillule (Fig. 2D) with praecoxal arthrite bearing 7 setae, of which proximalmost seta stout and spinulose. Proximal segment of palp bearing 1 strong spinulose and 2 slender setae distally, plus 1 outer plumose seta representing exopod; distal segment, representing endopod, with 3 long plumose setae.

Maxilla (Fig. 2E) 5-segmented. Praecoxal endite with 2 spinulose setae. Coxa with 1 spinulose seta representing

proximal endite. Basis forming strong spinulate claw and accessory claw with naked seta. First endopodal segment bearing 2 spinulose setae; second segment carrying 1 spinulose and 2 naked setae.

Maxilliped (Fig. 2F) 4-segmented. Syncoxa with 3 spinulose setae representing endites. Basis ornamented with spinule groups along outer margin, bearing long spinulose seta and short naked inner seta. First endopodal segment armed with strong spinulate seta; second segment with 3 setae, one of which spinulose.

Thoracic legs 1-4 (Fig. 3A-D), both endopods and exopods 3-segmented. Spine formula of exopod 3 3, 4, 4, 3. Setal and Spinous ornamentation on exo- and endopods of legs 1-4 as follows (Roman numerals indicate number of spines, and Arabic numerals indicate number of setae):

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-1	I-1; I-1; III, 5	0-1; 0-1; 1, I, 4
Leg 2	0-1	1-0	I-1; I-1; III, I, 5	0-1; 0-1; 1, I, 4
Leg 3	0-1	1-0	I-1; I-1; III, I, 5	0-1; 0-2; 1, I, 4
Leg 4	0-1	1-0	I-1; I-1; II, I, 5	0-1; 0-2; 1, II, 2

Intercoxal sclerites (couplers) of legs 1-3 each ornamented with paired arch of long setules on anterior surfaces; furnished with transverse spinular row medially on posterior surfaces, except for leg 4 with 3 paired rows (Fig. 3E); distal margins of intercoxal sclerites of legs 3-4 rather smooth, with lateral lobes not-produced. Basis of leg 1 bearing long stout spiniform seta posteromedially, reaching middle of leg 1 enp 3. Enp 2 of legs 1-2 each with only 1 medial seta, without any scar of additional seta. Leg 4 enp 3 elongated, 1.7 times as long as wide, and 1.32 times longer than inner apical spine; inner apical spine about 1.9 times longer than outer one. Leg 5 (Fig. 1B) 1-segmented, oblong-pentagonal, about 1.7 times longer than wide, bearing 1 inner spine and 2 plumose setae; middle seta about 2.5 times longer than outer seta; inner spine slender, a little longer than the segment itself.

Male

Caudal rami (Fig. 4A) 2.15 times as long as wide, much shorter than in female; ratio between caudal setae similar to those in female. Antennule (Fig. 4B, C) geniculate, indistinctly 16-segmented; segment 1 armed with 8 setae and 1 aesthetasc; anteroventral corner of segment 10 produced; segments 11-13 each bearing strongly pinnate seta or setal process anteroventrally. Leg 1 (Fig. 4D) similar to that of female. Second endopodal segments of legs 1-2 each bearing only 1 medial seta. Setal or spinous armature of leg 3 endopod (Fig. 4F) not showing sexual dimorphism. Leg 5 similar to that of female, except for a little shorter inner spine (Fig. 4G). Leg 6 represented by oblong plate, bearing 1 innermost spine and 2 outer plumose setae; spine shortest, outermost seta about 2 times longer than middle seta (Fig. 4G).

Variability

The length to width ratio of caudal rami was a little variable, ranging from 2.45 to 2.85 (mean 2.73, standard deviation 0.18) in 12 females examined, and 2.15 in one male (allotype). No significant variation was observed in the setation of caudal rami among the specimens examined: the length ratio of dorsal caudal seta to outer caudal seta ranged from 2.38 to 2.64 (mean 2.50, n=12), and the ratio of inner caudal seta to outer caudal seta from 0.94 to 1.16 (mean 1.05). The length to width ratio of leg 4 enp 3 ranged from 1.34 to 1.73 (mean 1.53), the length ratio of leg 4 enp 3 to inner apical spine on it from 1.15 to 1.32, and length ratio of inner spine to outer spine on leg 4 enp 3 from 1.71 to 1.91, respectively. Male specimen (allotype) showed the asymmetrical spinulation on the posteodorsal margin of anal somite, transverse row of spinules in one side, while 'L'-shaped array in the other side (cf. Fig. 4A).

The only one medial seta on the second endopodal segments of legs 1-2 in both sexes was characteristic and consistent in all the specimens examined. No particular difference was detected in the setal armature of legs 2-4. Sexual dimorphism was not found in the shape or number of setae or spines on thoracic legs.

Habitat

Type specimens were collected from small, cold springs, locating at the foothills near villages, together with *Canthocamptus* or *Bryocamptus* harpacticoids [*C. odaeensis* Chang and Ishida; *C. incurvisetosus* Chang and Ishida; *B. zchokkei* (Schmeil); *B. hiemalis* (Pearse)].

Etymology

The proposed specific name was taken from Korea, the type locality of this species.

Remarks

Since the genus *Ochridacyclops* was established for a new cyclopoid species, *O. arndti*, associated in the freshwater sponge from Lake Ochrid in Yugoslavia by Kiefer (1937), only five species or subspecies have been recorded in the genus: *O. arndti prespensis* Petkovski, 1954 from Yugoslavia, *O. brevicaudatus* Shen and Tai, 1964 from China, *O. nipponensis* Karaytug, Boxshall and Ishida, 1996 from Japan, and *O. iriomotensis* Ishida, 2002 from the Ryukyu Is., Japan.

The present new species is closely related with *O. nipponensis* and *O. iriomotensis* in having 12-segmented

Table 1. Character comparison between six known speices of *Ochridacyclops*

	O. arndti	*O. arndti prespensis*	*O. brevicaudatus*	*O. nipponensis*	*O. iriomotensis*	*O. coreensis* n. sp.
No. of segments of female antennule	11	11	11	12	12	12
Posteromedial seta on leg 1 basis	absent	absent	present	present	present	present
Spine formula	3,4,3,3	3,4,3,3	3,4,4,3	3,4,4,3,	3,4,4,3	3,4,4,3
Medial seta on enp 2 of legs 1-2	2/2	2/2	2/2	2/2	2/2	1/1
Posterior lobe of seminal receptacle	broad	broad	oval	broad	broad	broad
L/W ratio of caudal ramus	2.5-3	2.5	slightly longer than broad	2.5	2.7	2.75
Length ratio of caudal setae (inner/outer)	~1.3	~0.9	~1.6	a little longer	3 or more	~1.1
Dorsal caudal seta *vs.* outer caudal seta	much shorter	–	a little longer	a little longer	a little longer	more than 2 times longer
Habitat	found in freshwater sponges	found in freshwater sponges	stream	mountainous waters	stream	springs at hillside
Distribution	Yugoslavia (Kiefer, 1937)	Yugoslavia (Petkovski, 1954)	China (Shen and Tai, 1964)	Japan (Karaytug et al., 1996)	Ryukyu Is., Japan (Ishida, 2002a)	Korea (the present study)

antennule (Table 1). However, *O. coreensis* is clearly differentiated from them by the spinular ornamentation of antennal coxobasis and the number of medial setae on the endopodal segments of legs 1-2, that is, only one in this new species, while two in *O. nipponensis* and *O. iriomotensis* as well as all other congeners. Moreover, *O. coreensis* shows the morphological discrepancies from *O. nipponensis* in having the long dorsal caudal seta (about 2.5 times longer than outer caudal seta, while only a little longer in *O. nipponensis*), the much slender and long inner spine of leg 5 (longer than free segment in *O. coreensis*, while the inner spine stout and about 60% as long as free segment in *O. nipponensis*), and the relatively longer caudal rami (2.75 times as long as broad, while 2.5 times in *O. nipponensis*) (Karaytug et al., 1996; Karaytug, 1999). This new species differs from *O. iriomotensis* by the relatively short inner caudal seta (as long as outer caudal seta in *O. coreensis*, while three times longer in *O. iriomotensis*), and the relatively short inner spine of leg 4 enp 3 (about two times longer than outer spine and a little shorter than enp 3 in *O. coreensis*, while nearly three times longer than outer spine and much longer than enp 3 in *O. iriomotensis*) (Ishida, 2002a).

Genus *Itocyclops* Reid and Ishida, 2000
Itocyclops yezoensis (Ito, 1953)
(Figs. 5, 6)

Speocyclops yezoensis Ito, 1953, p. 20, figs. 43-47; Ito, 1954, p. 373, figs. 175-180; Ishida, 1992, p. 249, figs. 3-8.
Diacyclops yezoensis: Monchenko, 1974, p. 331.
Itocyclops yezoensis: Reid and Ishida, 2000, p. 589, figs. 1-3; Ishida, 2002b, p. 58, fig. 28k-o.

Material examined

1♀, Namae, Yangyang, 18 Oct. 1993, C. Y. Chang; 1♀, spring near Kangnung National University, 21 Jul. 1995, C. Y. Chang; 1♂, 3♀♀(1 ovi.), well at Suryeom 2-ri, Yangnam-myon, Gyeongju-gun, 24 Jul. 1990, C. Y. Chang; 1♂, 1♀, a well at Ponggil-ri, Yangnam-myeon, Gyeongju-gun, 24 Jul. 1990, C. Y. Chang; 1♂, 3♀♀, Cheonwangsa Temple, Mt. Halla, Jeju Is., 8 May 1999, C. Y. Chang; 2♀♀, spring, Dejipo, Changseon Is., Namhae-gun, 27 Jul. 2004, C. Y. Chang.

Diagnosis

Body small, 0.4-0.5 mm long in females and 0.3-0.4 mm in males; habitus (Fig. 5A, H) dorsoventrally flattened; genital somite much swollen laterally, and 1.3 times wider than long; seminal receptacle (Fig. 5B) rather complex, with paired lateral wings; anal operculum (Fig. 5A, C) triangular, its tip a little beyond middle of caudal rami or just reaching in a lateral view, with lateral margins irregularly crenate; caudal rami a little divergent, 1.69 times as long as wide; lateral caudal seta inserted at half of ramus, with row of spinules anteriorly; outer caudal seta swollen at its base, about 2.5 times longer than inner caudal seta; dorsal caudal seta about 2 times longer than outer one; inner terminal caudal seta about

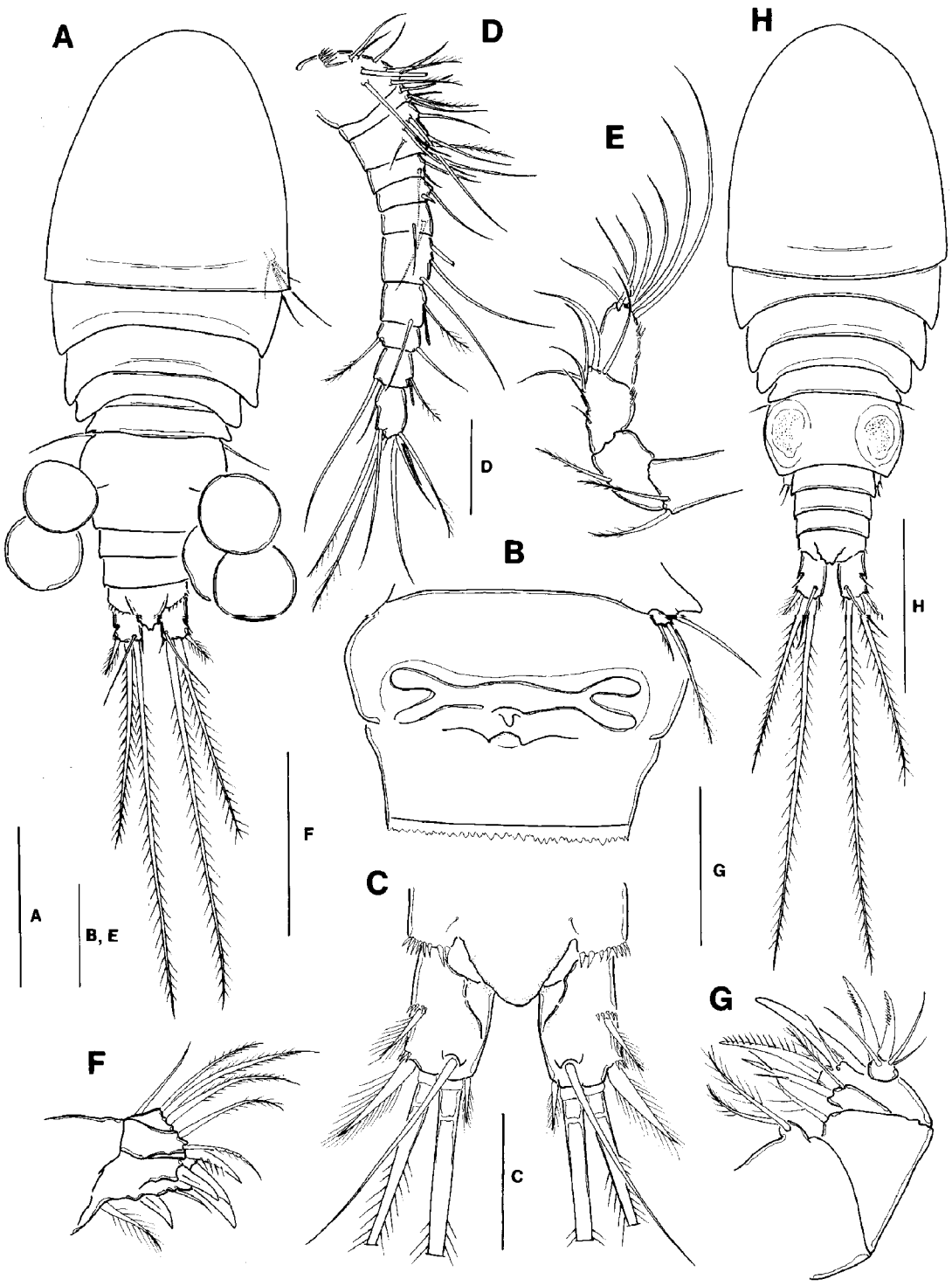

Fig. 5. *Itocyclops yezoensis* (Ito, 1953). A-G, female: A, Habitus, dorsal. B, Leg 5 and genital segment, ventral. C, Anal segment and caudal rami, dorsal (another specimen). D, Antennule. E, Antenna. F, Maxillule. G, Maxilla. H, Male habitus, dorsal. Scale bars = 30 μm(B-G) and 50 μm(A, H).

1.8 times longer than outer terminal seta, and about 60% of whole body length; antennule (Fig. 5D) not reaching posterior margin of cephalothorax, of 11 segments; exopods of legs 1-4 composed of 2, 2, 3, 3 segments respectively, endopods all 2-segmented (Fig. 6A-D); spine formula of exopodal segments 3 of legs 1-4 3, 4, 3, 3; leg 4 enp 2 oval, about 1.25 times as long as wide, inner apical spine nearly same in length with enp

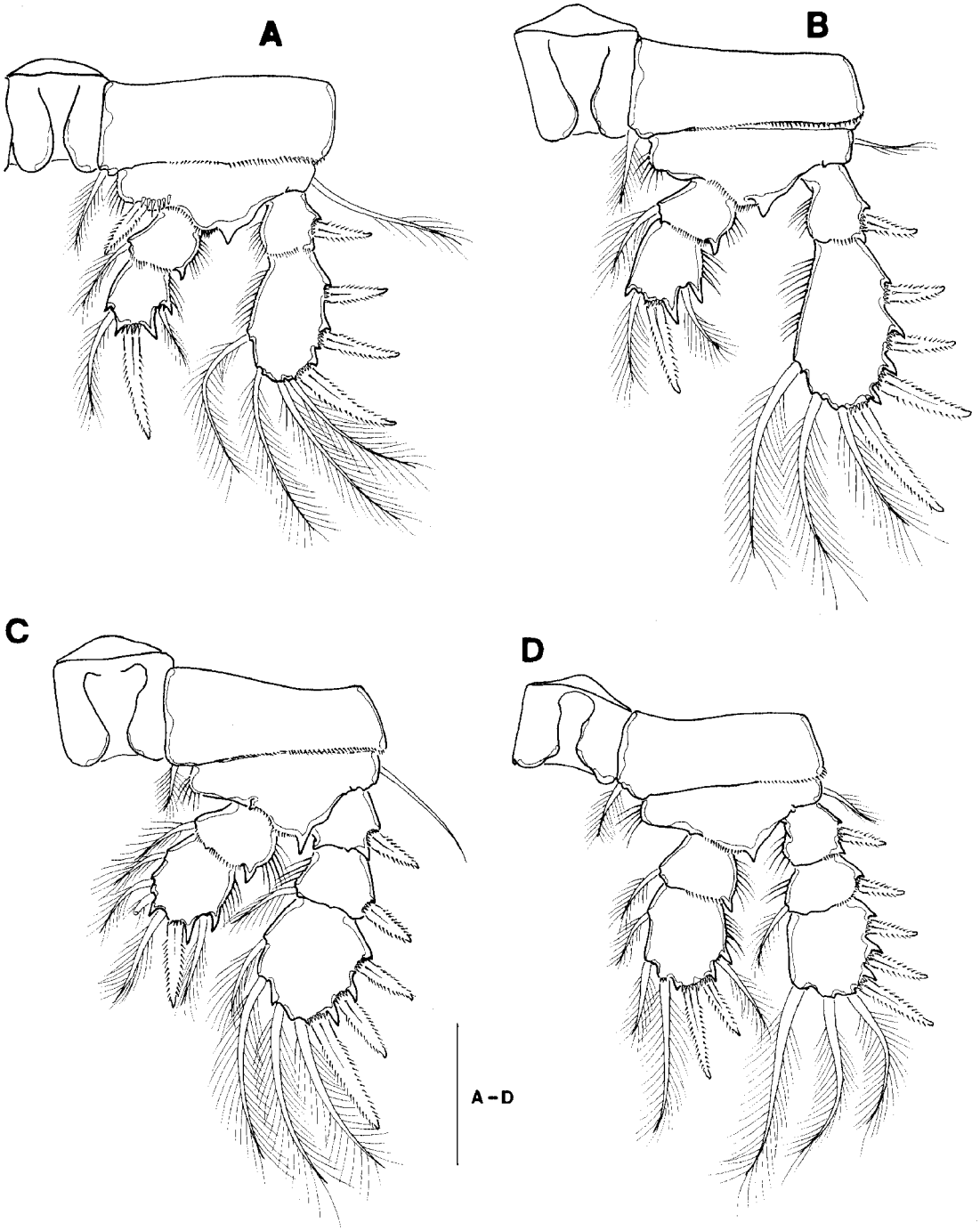

Fig. 6. *Itocyclops yezoensis* (Ito, 1953), female. A-D, Legs 1-4. Scale bar = 30 μm.

2, and 1.67 times longer than outer spine; basal segment of leg 5 partly fused with thoracic somite, much enlarged, about 3 times broader than distal segment (Fig. 5B); distal segment of leg 5 with 2 setae on its tip, inner seta rather short, less than half of outer seta; setal and spinous ornamentation on exo- and endopods of legs 1-4 as follows:

	Coxa	Basis	Exp	Enp
Leg 1	0-1	1-I	I-0; II,I,4(3)	0-1; 1,I,1(2)
Leg 2	0-1	1-0	I-0; III,I,3(4)	0-1; 1,I,1(2,3)
Leg 3	0-1	1-0	I-0; I-1; II,I,4(3)	0-1; 1,I,4(2)
Leg 4	0-1	1-0	I-1; I-1; II,I,3	0-1; 1,II,3

Habitat

This species has been known as the semi-subterranean species, usually occurring from wells, springs, and the non-planktonic habitats like trickles, mountainous puddles or riverside marsh (Reid and Ishida, 2000). In Korea the specimens were collected from wells and springs, especially not far from coast.

Remarks

Reid and Ishida (2000) established the genus *Itocyclops* to accomodate this species, which showed the evident generic differences of the segmentation of legs, the partly fused proximal segment of leg 5 and the peculiar shape of seminal receptacle from the genera *Speocyclops*, *Diacyclops*, *Metacyclops*, and so on (see Reid and Ishida, 2000: 593-595). *Itocyclops yezoensis* still remains as the monotypic species of the genus.

Specimens from Korea were well coincided with the original description and Reid and Ishida's (2000) redescription, except for the relatively longer caudal ramus (more than 1.6 times as long as wide, while 1.4 times in Japanese specimens). The shape of anal operculum (its length and number of teeth on lateral margin) showed rather wide range of variation, that is, it passed over middle of rami in about 60% of individuals examined, while it nearly reached middle of caudal rami in a lateral view in others, and the lateral margins of anal operculum varied in the shape from heavily crenate to weakly undulate. Setal armature of legs 1-3 was most variable as shown in the armament table above.

Distribution

Japan (from Hokkaido to Tsushima Is.), U.S.A. (Alaska, Mississippi River drainage basin), Korea.

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References

Chang CY, Yoon SM, Lee SK and Kim W (1998) Distribution of mountainous cyclopoids in Korea. *Korean J Environ Biol* 16: 299-304.

Huys R and Boxshall GA (1991) Copepod Evolution. Ray Society, London, pp 1-468.

Ishida T (1992) Cyclopoid and harpacticoid copepods (Crustacea) from southwestern Alaska, U.S.A. *Proc Biol Soc Wash* 105: 249-254.

Ishida T (2002a) The second species of *Ochridacyclops* Kiefer, 1937 (Copepoda, Cyclopoida) from Japan. *Biogeography* 4: 19-23.

Ishida T (2002b) Illustrated fauna of the freshwater cyclopoid copepods of Japan *Bull Biogeogr Soc Japan* 57: 37-106.

Ito T (1953) Subterranean-water copepods from Japan III. *Suido Kyokai Zasshi* 228: 20-26.

Ito T (1954) Cyclopoida copepods from subterranean waters. *Rep Fac Fish Pref Univ Mie* 1: 372-416.

Karaytug S (1999) Copepoda: Cyclopoida. Genera *Paracyclops*, *Ochridacyclops* and key to the Eucyclopinae. Guides to the identification of the microinvertebrates of the continental waters of the world, Vol 14. Backhuys Publishers, Leiden, pp 1-217.

Karaytug S, Boxshall GA and Ishida T (1996) A new species of *Ochridacyclops* (Kiefer, 1937) (Copepoda, Cyclopoida) from Japan. *Hydrobiologia* 332: 111-117.

Kiefer F (1937) Eine neuer Cyclopidae (Crust. Copepoda) aus dem Ochridasee. *Zool Anz* 120: 133-143.

Kim HS and Chang CY (1989) Freshwater cyclopoid copepods (Cyclopoida, Cyclopidae) of Korea. *Korean J Syst Zool* 5: 225-256.

Monchenko VI (1974) Gnathostome cyclopoids, cyclopids (Cyclopidae). *Fauna Ukraini* 27: 1-449.

Petkovski T (1954) Beitrag zur Kenntnis der jugoslavischen Cyclopiden. *Acta Mus Maced Sci Nat Skopje* 2: 1-31.

Reid JW (1986) Some usually overlooked cryptic copepod habitats. *Syllogeus* 58: 594-598.

Reid JW and Ishida T (2000) *Itocyclops*, a new genus proposed for *Specocyclops yezoensis* (Copepoda: Cyclopoida: Cyclopidae). *J Crust Biol* 20: 589-596.

Shen CJ and Tai AY (1964) Description of new species of freshwater Copepoda from Kwangtung Province, south China. *Acta Zootaxon Sinica* 1: 367-396.

Shirayama Y, Kaku T and Higgins RP (1993) Double-slided microscopic observation of meiofauna using an HS-slide. *Benth Res* 44: 41-44.

Yoo KI and Lim BJ (1989) Systematic studies on the freshwater Copepoda (Crustacea) in Lake Yongsan, Korea. *Korean J Limnol* 22: 127-146.

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