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One new *Sclerochilus* (*Praesclerochilus*) Sars (Ostracoda) species from Korea

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Sclerochilus Sars, 1866 is the most diverse genus of the family Bythocytheridae, one of the longest surviving groups of extant ostracods, and the oldest representative of the superfamily Cytheroidea. It has a worldwide distribution at various marine depths, and it includes three subgenera: *Fascichilus* Schornikov, 1981; *Praesclerochilus* Schornikov, 1981; and *Sclerochilus* Sars, 1866. We describe *Sclerochilus* (*Praesclerochilus*) *jejuensis* sp. nov. from Jeju Island, South Korea, raising the number of known *Praesclerochilus* species to 13. Although most species belonging to this subgenus have very similar carapace shape, the new species differs morphologically from its most similar congeners, *S.* (*P.*) *mukaishimensis* Okubo, 1977; *S.* (*P.*) *pruniformis* Schornikov, 1981; and *S.* (*P.*) *ochotensis* Schornikov, 1981, by the large ventral process on the hemipenis. So far, 29 *Sclerochilus* species have been reported from South Korea, only one of which was named, but for which no descriptive information was provided. Therefore, this is the first taxonomic report of a *Sclerochilus* species from South Korea.

Keywords: biodiversity, Bythocytheridae, Cytheroidea, Far East, taxonomy

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Introduction

The family Bythocytheridae is the basal group of the superfamily Cytheroidea (Whatley *et al*., 1993; Boomer *et al*., 1995), and is different from all other families by the presence of five, instead of four muscle scar imprints arranged in a vertical row on the valves, a tube-like caudal process, and the lateral projections on the shell (Schornikov, 1988). Like in the majority of cytheroids, the structure of the male copulatory organ (hemipenis) is one of the most important taxonomic characters, with high morphological diversity even among closely related taxa (Schornikov, 1981). Nevertheless, the hemipenis of all Bythocytheridae has a rounded basal capsule, with the distal lobe bearing a sensory seta, a feature considered to be primitive among cytheroid ostracods (Schornikov and Keyser, 2004).

According to the World Ostracod Database (WOD; Brandão and Karanovic, 2020), Bythocytheridae is the second largest cytheroid family, with approximately 120 genera. Approximately 40% of these genera known exclusively from the fossil record, and therefore their morphological characteristics are based only on the shell. Currently, most genera are divided between seven subfamilies, and 15 genera have no certain position (*incertaesedis*). Most of the living representatives are members of the subfamilies Pseudocytherinae and Bythocytherinae. Schornikov (1976; 1982; 1982a; 1990; 1993) and Schornikov and Mikhailova (1990) have contributed the most to our knowledge on bythocytherid biodiversity and systematics. Bythocytherids are exclusively marine ostracods, found from littoral to abyssal depths (Boomer *et al*., 1995). The deepest record comes from 5090−5200 m and refers to *Vitjasiellabelyaevi* Schornikov, 1976 (Schornikov, 1981).

Sclerochilus, a member of Pseudocytherinae, is the most diverse of all bythocytherid genera with over 150 described, mostly living, species (see Brandão and Karanovic, 2020). It was placed in the tribe Sclerochilini (see Schornikov, 1981; 1982a) and it is divided into three subgenera: *Fascichilus* Schornikov, 1981; *Praesclerochilus* Schornikov, 1981; and *Sclerochilus* Sars, 1866. Differences between subgenera are based on the number of setae on the first endopodal segment of the second antenna (*Praesclerochilus* has two setae and the other two genera only one),

and the appearance of the claws on the terminal segment of the same appendage (only in *Fascichilus* one of the claws is stronglyserrated). *Sclerochilus* is remarkably diverse in the Far East (Schornikov, 1981), with the three named *Fascichilus* species endemic to this region. Of the 12 described *Praesclerochilus* species, only four have been described from the Southern Ocean (Schornikov, 1982a), while others are endemic to Japan and the Russian Far East. The nominal subgenus has a worldwide distribution, although the majority of species are also Far East endemics.

Here we describe one new species belonging to *Sclerochilus* (*Praesclerochilus*) from littoral waters of Jeju Island (Korea). Lee *et al*. (2000) reported 29 *Sclerochilus* species from South Korea: 27 belonging to the nominal subgenus and one each to the other two subgenera. Only one, *S*. (*P*.) *verecundus* Schornikov, 1981 was named, while all the rest were left in the open nomenclature. Additionally, none of the 29 species was taxonomically described or illustrated. Therefore, our record could be considered as the first taxonomic record accompanied with detail description and illustrations of *Sclerochilus* species from Korea.

Materials and Methods

Samples were collected from shallow littoral zone using an algae rinsing method (see Cohen and Oakley, 2017) with hand net (63 μm mesh size) and directly preserved in 99% ethanol. Ostracods were sorted and dissected under a stereo microscope (Olympus SZX12). The soft parts were mounted in a drop of CMC-10 mounting media (Masters Company, Inc.), while the valves were kept on the micropaleontological slides. Soft parts were studied under a Zeiss Axioskop 50 and drawn with the tube attachment on the same microscope. The length ratio between segments of appendages has been measured using AUTOCAD software with scanned images by appending the midpoints of segments. The valve of one male was coated with platinum for the study under scanning electron microscope (SEM), taken at Eulji University with a Hitachi S-4700 SEM. Holotype is deposited in the invertebrate collection of the National Institute of the Biological Resources (NIBR) in South Korea.

Abbreviations for body parts used in text in figures:

A1, A2 - First and second antenna; Hp - Hemipenis; Md - Mandibula; Mxl - Maxillula; L5, L6, L7 - Thoracopods; LV - Left Valve.

Results

Systematics

Order Podocopida Sars, 1866

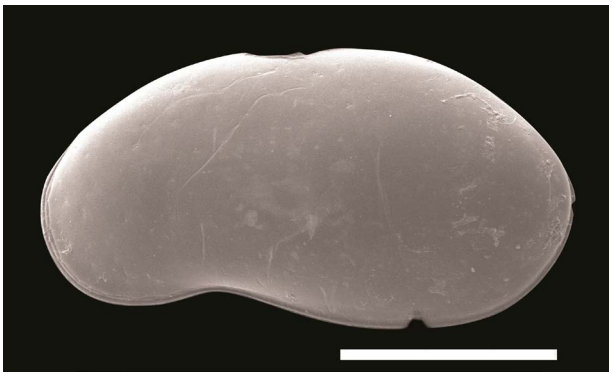

Fig. 1. *Sclerochilusjejuensis* (Sars, 1866): SEM photograph of LV (internal view) of the holotype male. Scale bar: 200 μm.

Superfamily Cytherocopina Baird, 1850
Family Bythocytheridae Sars, 1926
Subfamily Pseudocytherinae Schneider, 1960
Tribe Sclerochilini Schornikov, 1981
Genus *Sclerochilus* Sars, 1866
Subgenus *Praesclerochilus* Schornikov, 1981

***Sclerochilus* (*P.*) *jejuensis* sp. nov.**

Holotype. Male, dissected on one slide kept in a drop of CMC-10 medium (NIBRV0000862858), and shell on micropalaeontological slide; paratypes: two males, dissected on one slide each.

Etymology. The name derives from Jeju Island (South Korea) from where the material was collected. It is an adjective in genitive singular (masculinum).

Type locality. South Korea, Jeju-si, Jocheon-eup, Hamdeok-ri; 33°32′36.38″N, 126°40′11.48″E, littoral zone; 27–28 Nov. 2011, collected by Ivana Karanovic.

Description. Male. Carapace (Figs. 1, 2A). LV oblongly reniform in lateral view. Length around 0.9 mm, greatest height considerably behind the middle. Dorsal margin highly arched and sloping towards to anterior and posterior margins. Both margins rounded, with a number of normal pore canals scattered along posterior to anterior. Inner lamella widened anteriorly and narrowed ventrally and posteriorly. Five muscle scars organized in a vertical row but forth muscular scar is divided into two parts.

A1. (Fig. 2B). Seven-segmented. Length ratio between seven distal segments: 4.7 : 2.7 : 2.9 : 3.1 : 2.5 : 1 : 3.2, along anterior margin. First segment without setae and setula. Second segment with one bare seta situated anteromedially not reaching distal end of next segment and one seta postero-medially exceeding distal end of the fifth segment. Third segment with three setulae on postero-distally margin and one long posterior seta, reaching distal end of terminal segment. Fourth segment with one short anterior-distal seta and one long seta postero-distally, being four

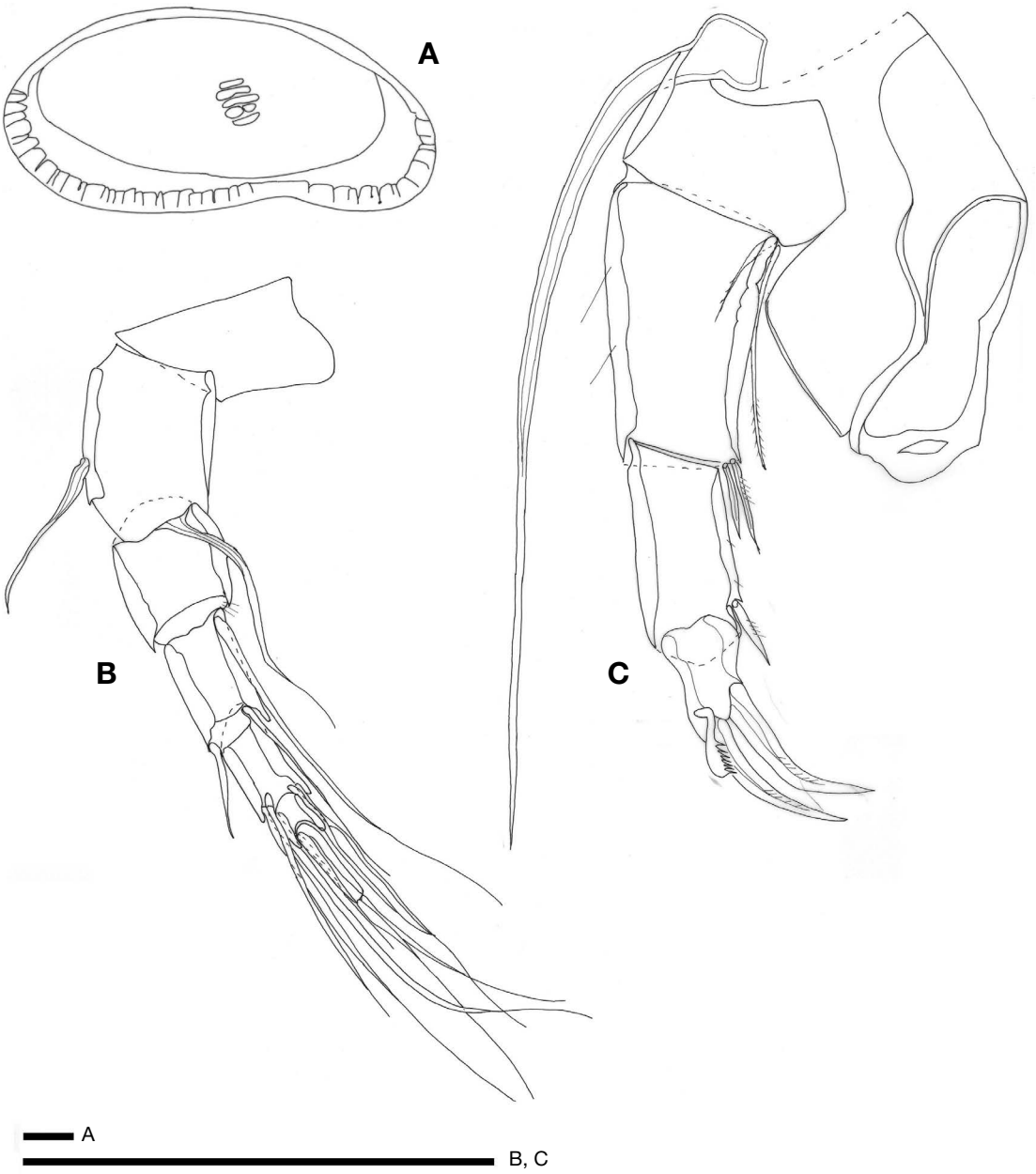

Fig. 2. *Sclerochilusjejuensis* (Sars, 1866): Holotype, male. A, LV internal view; B, A1; C, A2. All scale bar: 100 μm.

times longer than the terminal segment. Fifth segment with three long setae antero-distally and two long postero-distally setae. Sixth segment with one barely visible seta antero-distally. Terminal segment very thin, with two long bare setae distally. All setae bare.

A2. (Fig. 2C). Five-segmented. Length ratio between five distal segments: 1.4 : 1.2 : 2.5 : 1.7 : 1, along anterior margin. Exopodite forms a bare seta, sharply narrowed at the level of its middle length. First segment without setae and setula. Second segment with two setae, both pappose: one reaching distal margin of the following segment, the other twice as short. Third segment with two setulae on the anterior margin and two short setae on posterior distal edge: one robust (almost claw-like) and bare, the other thinner and with a few setulae along the margin. Penultimate segment with short setula along posterior margin and one short robust seta on posterior-distal margin. Fifth segment about half the length of fourth segment, narrowed in the middle, equipped with three claws: one comb-shaped and twice as short as the other two, sub-equally long, claws.

Md. (Fig. 3A, 3B) Plump palp with three segments;

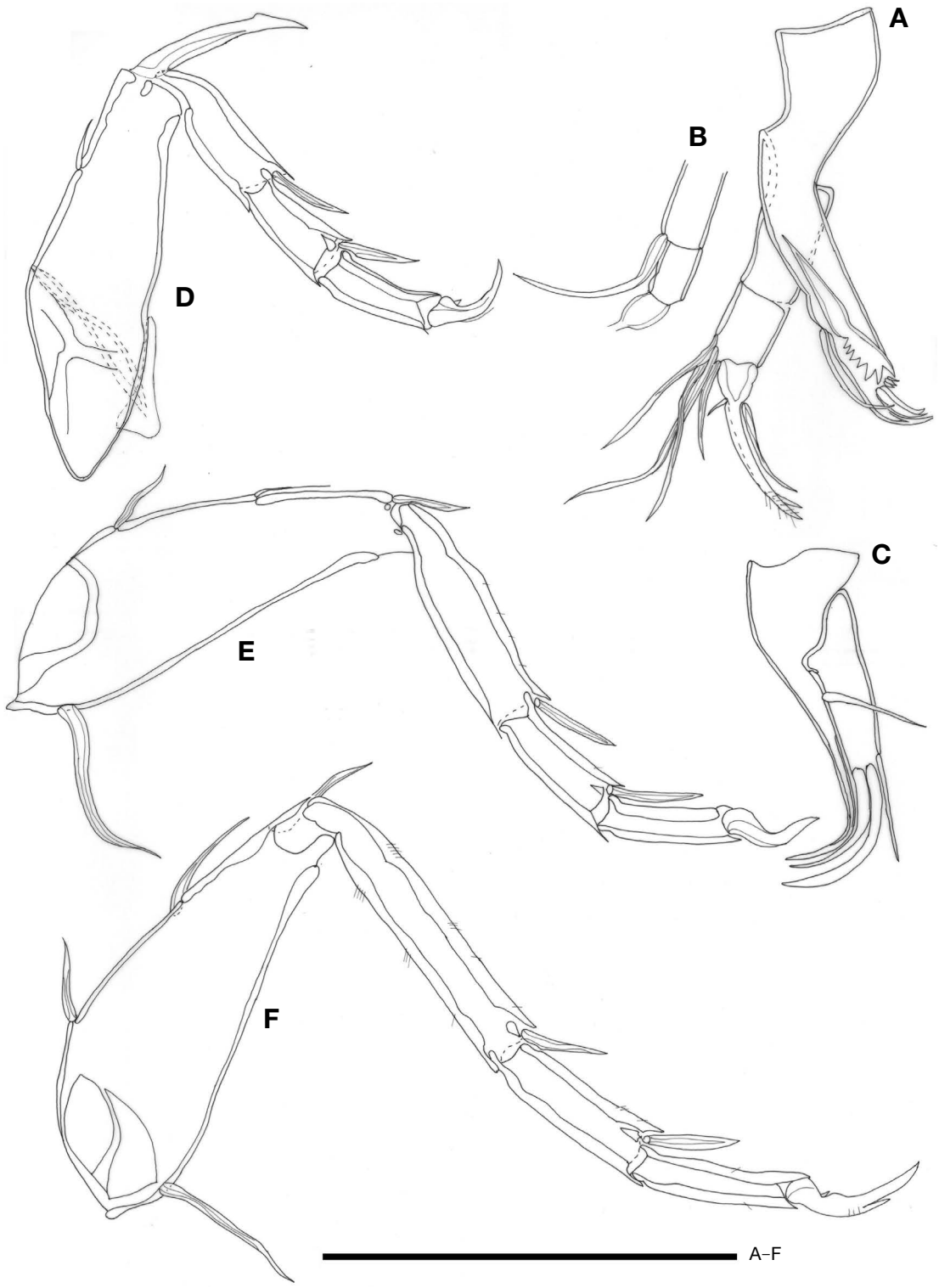

Fig. 3. *Sclerochilusjejuensis* (Sars, 1866): Holotype, male. A, Md of holotype; B, Md of paratype; C, Mxl; D, L5; E, L6; F, L7. All scale bar: 100 μm.

first segment with one long seta antero-distally reaching end of the distal claw, second segment with four slender setae situated antero-distally, third segment with one fine, short seta on anterior-distal edge, one slender seta and one strong plumose seta. Stout coxa narrowly produced with one slender seta medially reaching distal end of coxa and

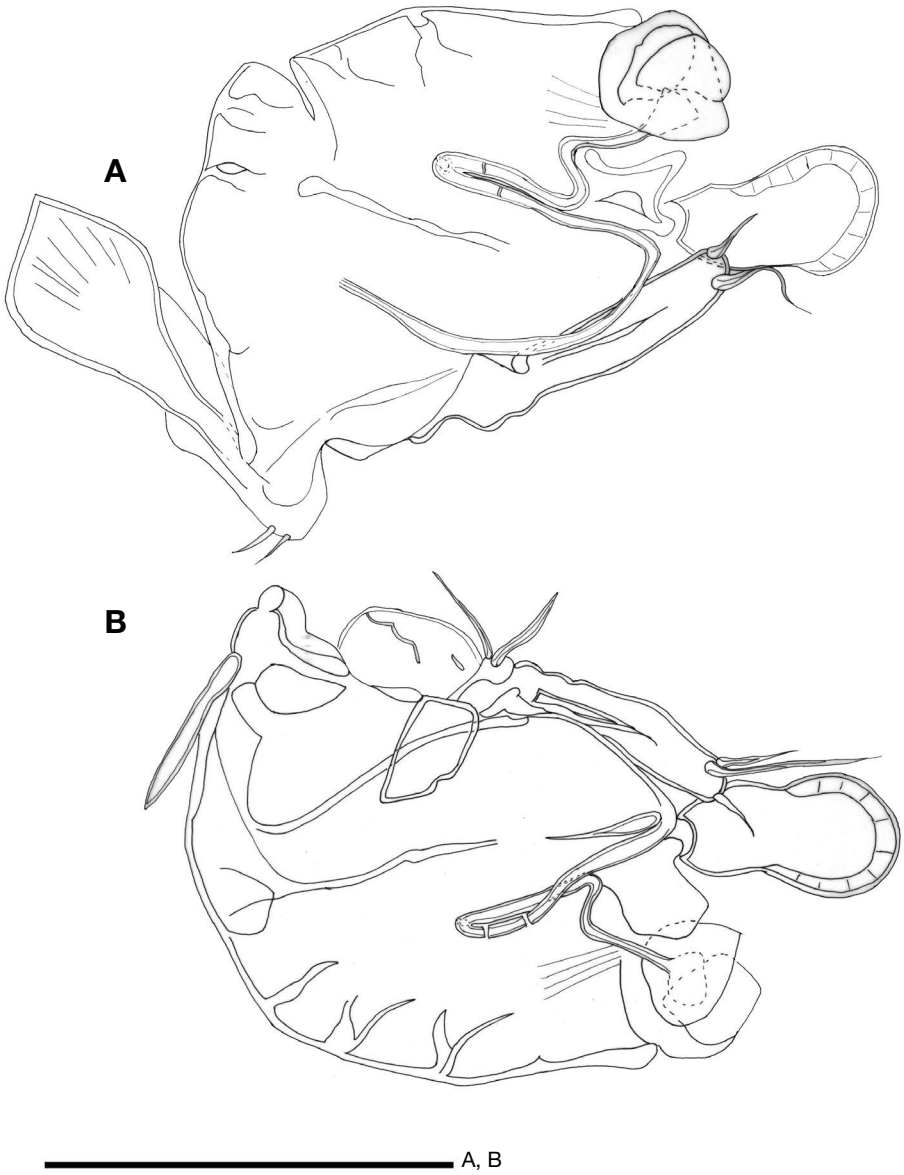

Fig. 4. *Sclerochilusjejuensis* (Sars, 1866): Holotype, male. A, Left Hp; B, Right Hp. All scale bar: 100 μm.

three teeth at lower distal end.

Mxl. (Fig. 3C). Palp one-segmented with one slender seta medially on the outer margin, two claws distally, and one juxtaposed setae on posterior margin.

L5. (Fig. 3D). Four-segmented. Length ratio between four distal segments: 3.8 : 1.3 : 1 : 1.2, along anterior margin. First segment with two juxtaposed setae in which two of sub-equal lengths near posterior proximal edge, one of which is shorter and stronger than the others, also having a strong claw on antero-distal margin reaching end of the following segment. Second and third segments with only one bare anterior seta. Terminal segment with one apical claw including one setula on posterior margin and one spine-like setula antero-medially.

L6. (Fig. 3E). Four-segmented. Length ratio between four distal segments: 3.6 : 1.9 : 1 : 1, along anterior margin. First segment with one bare seta on posterior margin not reaching end of this segment, two bare anterior setae dividing anterior margin into three sub-equal parts, and one bare seta on anterior-distal margin. Second segment with spines along anterior margin and one bare short seta antero-distally. Penultimate segment with one bare antero-distal, strong and one short postero-distally spine. Only one apical claw on terminal segment.

L7. (Fig. 3F). Four-segmented. Length ratio between four distal segments: 2.7 : 2 : 1.1 : 1, along anterior margin. First segment with four bare setae, one on posterior medial margin, not reaching end of the first segment, and the

remaining three setae dividing anterior margin into three sub-equal parts in length in which two setae situated antero-medially and one antero-distally. Second segment with setulae along both posterior and anterior margins, and one bare seta on antero-distally. Third segment with one seta antero-distally. Terminal segment with one setula on each side of the margin and one apical claw curving rectangularly carrying a spinulamedially on the posterior margin and one spine on the anterior margin.

Hp. (Fig. 4A, 4B). Hp strongly symmetrical. Basal section oval with three processes. Three lamelliform processes: two overlapping and occupying posterior margin and one situated medially and strongly asymmetrical on left and right hemipenis. The process on the anterior margin calabash shaped and with structures that resemble pore canals. Caudal ramus with elongated shaft reaching basis of the anterior process and strongly asymmetrical: on one hemipenis carrying three distal setae and three basal setae, and on the other carrying two distal and one basal seta.

Females not collected.

Discussion

With the addition of *Sclerochilus* (*P.*) *jejuensis*, the subgenus *Praesclerochilus* now accounts for 13 living representatives. All species described so far have relatively similar outline of the valves (all being more or less reniform) and cheatotaxy of all appendages. The latter mostly differs between species in the number and length of the setae on A1 and A2, as well as the morphology of the terminal claws on the thoracopods. The major differences between species is in the morphology of the Hp, in particular the shape of the largest process situated on the anterior side, as well as the position and terminal endings of the two overlapping posterior processes. We have described the anterior Hp process of the new species as calabash shaped, and in this regard, it bears similarity with *S.* (*P.*) *mukaishimensis* Okubo, 1977; *S.* (*P.*) *pruniformis* Schornikov, 1981; and *S.* (*P.*) *ochotensis* Schornikov, 1981. The first species was described from the Inland Sea of Japan (Okubo, 1977), while the latter two were described from the Kuril Islands and the Sea of Okhotsk (Schornikov, 1981) respectively. In comparison to *S.* (*P.*) *mukaishimensis*, the new Korean species has a more evenly rounded posterior margin on the valves. In addition, the Japanese species has three (instead of two) setae on the second segment of the A1, and does not have distinct spines on terminal claw of the L7. The posterior-most projection on the Hp is beak-like in *S. mukaishimensis* and rounded in *S. jejuensis*. While the large anterior extension in the Korean species has a distinct "neck" and "ball" part, the "neck" part in the Japanese species is not pronounced.

Sclerochilus (*P.*) *pruniformis* has a more similar carapace shape to the new species than *S.* (*P.*) *mukaishimensis* and it also has distinct spines on terminal claws. In contrast to *S. jejuensis*, *S. pruniformis* possesses anterior seta on the third segment of A1, the posterior extensions on the Hp are much smaller than in *S. jejuensis*, and the large ventral process completely lacks the "neck" part.

Sclerochilus (*P.*) *ochotensis* is very similar to *S. pruniformis* and therefore differs from *S. jejuensis* by the same characters. In addition, *S. pruniformis* has a flatter dorsal margin of the carapace and one of the posterior extensions on the Hp has a beak-like extension.

The only other *Sclerochilus* (*P.*) species reported from Korea is *S.* (*P.*) *verecundus* (see Lee *et al*., 2000). The species was originally described from the Kuril Islands, but Schornikov (1981) also stated that its distribution included Peter the Great Bay in Russia and the Sea of Japan (in general). This species differs from *S. jejuensis* by a less rounded posterior margin on the carapace, and the large anterior extension on the Hp does not have a ball-like distal part, but possesses a flat, inclined distal margin, giving it a more subtriangular appearance.

Considering a large number of unnamed Bythocytheridae species reported from Korea by Lee *et al*. (2000), the named and taxonomically described bythocytherids should be implemented by the further studies of Korea's marine ostracods.

Conflicts of Interest Statement

The authors declare no conflict of interest and take complete responsibility for the integrity of the data and the accuracy of the data analysis.

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