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Description of a new species of the genus Peltidium Philippi, 1839 from southern Korea (Copepoda, Harpacticoida) - with a review of the genus

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ORIGINAL ARTICLE

Description of a new species of the genus *Peltidium* Philippi, 1839 from southern Korea (Copepoda, Harpacticoida) – with a review of the genus

SUNG JOON SONG[1], HANS-UWE DAHMS[2], PAWANA KANGTIA[3], SUPAWADEE CHULLASORN[3], JONGSEONG RYU[4] & JONG SEONG KHIM[1]*

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Abstract
Peltidium byungwooi sp. nov. is described in morphological detail from samples collected from the macroalgal beds on rocky bottoms using a light trap from Yeoseodo Island, Korea. Our studies revealed the following morphological diagnostic characters: body strongly chitinized and dorsoventrally flattened; antennule 7-segmented; antenna with allobasis, exopod 2-segmented, bearing one and three setae, respectively; allobasis of maxilla bilobed, drawn out into a small claw with two accessory setae; endopod represented by a small protuberance bearing one seta; swimming legs P2–P4 exp-3 with two outer spines; P2 enp-1 without inner seta; P3 enp-3 with two inner setae; inner endopodal lobe of female P5 with very short outer seta (about 5.4 times shorter than inner one, 3.6 times in male); male P2 enp-3 bearing modified inner distal spine with blunt tip. Phylogenetic, zoogeographic, biological, and ecological characteristics of the family Peltidiidae are reviewed for the genus *Peltidium*.

Key words: *Copepoda, Harpacticoida, Korea,* Peltidium byungwooi *sp. nov., taxonomy, zoogeography*

Introduction

The taxon *Peltidium* was established by Philippi in 1839. Representatives are primarily distributed in the phytal zone, living on and among seaweed. Because of its dorsoventrally flattened habitus, Claus (1863) assigned the Peltidiidae together with *Porcellidium* Claus, 1860 and with *Zaus* Goodsir, 1845 to a taxon which did not belong to the Harpacticidae s. str. Historically, there was always some confusion as to whether several harpacticoid taxa actually belong to the Peltidiidae. In addition, taxa were established that later had to be synonymized with existing groups. Several descriptions are not yet updated and are imprecise or lacking detail. A first evaluation of the phylogenetic relationships within the Peltidiidae was discussed by Lang (1948) and Hicks (1986). Concerning the peltidiids from the Pacific, there are 10 species known: from Indonesia (3), Ifaluk, Micronesia (3), Hawaii (2), China (2), Japan (2), Mexico (1), and Korea (1).

We are describing a new species belonging to *Peltidium*, which represents the second species of the genus known from the Korean coastal waters living on macroalgae.

Materials and methods

The material was obtained from macroalgal beds on rocky bottoms in shallow waters off Yeoseodo Island using a light trap. Specimens were subsequently sieved through a 67 μm sieve and fixed in 95% ethanol. Copepods were separated, put in small vials, and preserved in ethanol.

Prior to examination by light microscopy, specimens were cleared and dissected in lactic acid. All measurements and dissections were made under a Leica MZ8 stereo microscope (NY, USA). All

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drawings were made with the aid of a camera lucida on a Nikon compound microscope with Nomarski optics (Tokyo, Japan). The description is based on a paratype female and male. For long-term preservation, dissected preparations were mounted on slides in glycerol and sealed with Eukitt (O. Kindler, Washington, USA). Type specimens are deposited in the collections of the National Institute of Biological Resources (NIBR), Korea. Scale bars in all figures are indicated in μm. For initial identification we used Lang (1948) and Huys et al. (1996).

The descriptive terminology used here is adopted from Huys & Boxshall (1991) and Huys et al. (1996). The following abbreviations are used in the text: ae, aesthetasc; exp, exopod; enp, endopod; P1–P5, first to fifth swimming legs; P6, sixth leg; exp (enp)-1 (2, 3), proximal (middle, distal) segment of a ramus. The term acrothek is used to denote the joint with two setae and one aesthetasc (= tritheca) found apically on the distal segment of the antennule.

Table I. Setal formula of swimming legs of *Peltidium byungwooi* sp. nov.

	Exopod	Endopod
P2	1, 1, 222	0, 2, 120
P3	1, 1, 322	1, 2, 220
P4	1, 1, 322	1, 2, 220

Taxonomy

Family Peltidiidae
Genus *Peltidium* Philippi, 1839
***Peltidium byungwooi* sp. nov.**
(Table I; Figures 1–9)

Holotype

Undissected female preserved in alcohol (NIBRIV 0000266718), 26 October 2012, coll. Dr Sung Joon Song, Yeoseodo Island, Jeollanam-do, Korea (33° 59′17″N, 126°55′25″E), 5 m depth, light trap.

Allotype

Undissected male preserved in ethanol (NIBRIV 0000266719), sampling data as for holotype.

Paratypes

Eight females and four males preserved in alcohol (NIBRIV0000266720). One female (NIBRIV0000 266721) and one male (NIBRIV0000266722) dissected on 13 and nine slides, respectively, having the same collection data as the holotype.

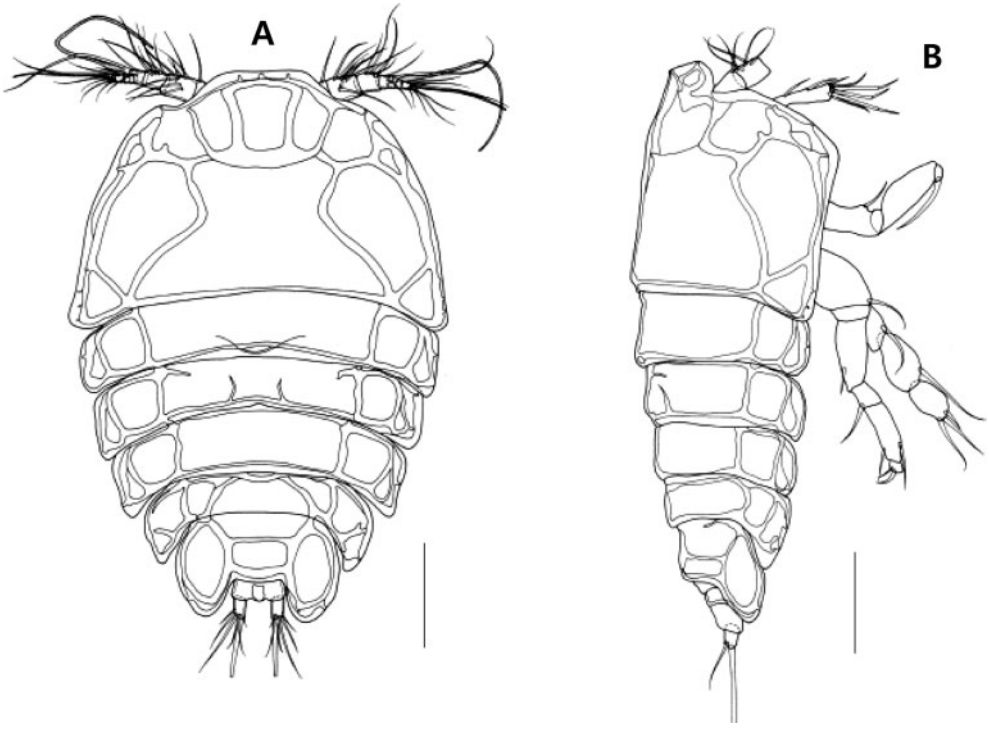

Figure 1. *Peltidium byungwooi* sp. nov., paratype female. (A) Habitus, dorsal, (B) habitus, lateral. Scale bars: 160 μm.

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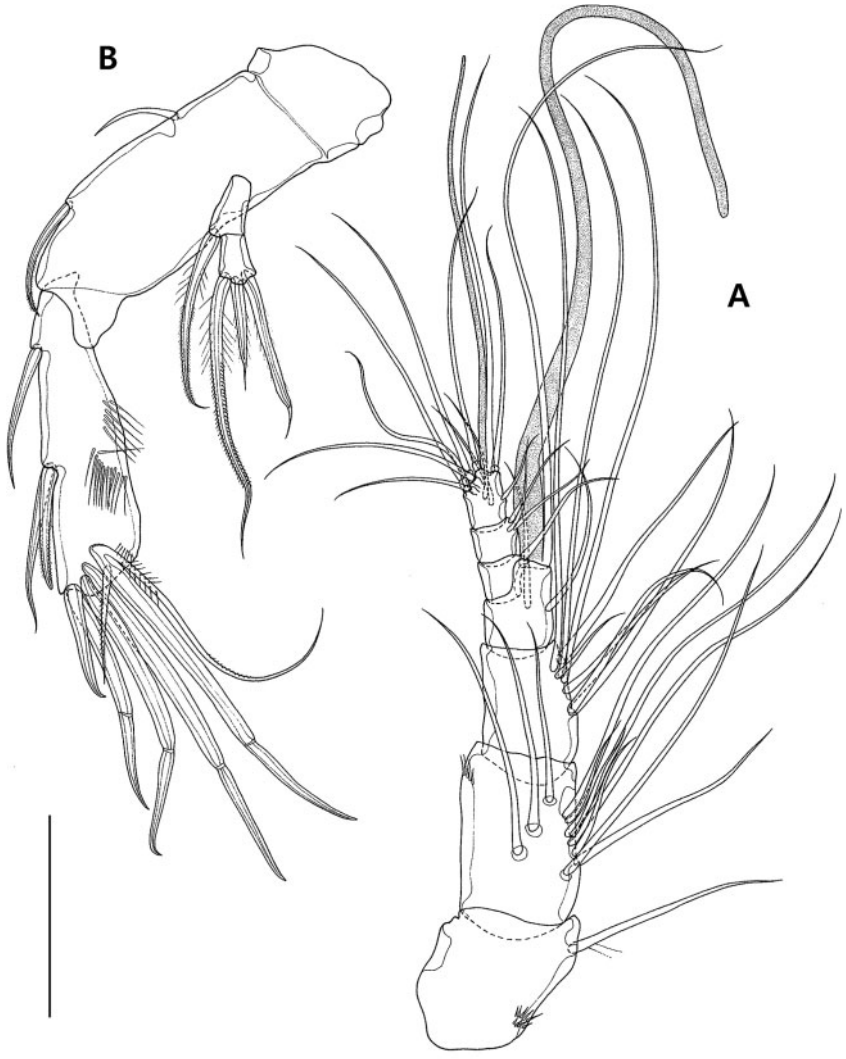

Figure 2. *Peltidium byungwooi* sp. nov., paratype female. (A) Antennule; (B) antenna. Scale bar: 63 μm.

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Differential diagnosis

Peltidium byungwooi sp. nov. can be distinguished from its congeners as follows: The allobasis of the maxilla is bilobed and drawn out into a small claw with two accessory setae, its endopod is represented by a small protuberance bearing one seta. Swimming legs P2–P4 exp-3 have two outer spines, P2 enp-1 without inner seta, P3 enp-3 with two inner setae. The inner endopodal lobe of the female P5 has a very short outer seta (about 5.4 times shorter than the inner one, 3.6 times in the male). Male P2 enp-3 has a modified inner distal spine with a blunt tip.

Description

Female. Body (Figure 1a,b, paratype) strongly chitinized, dorsoventrally flattened, bright red coloured, gradually tapering posteriorly. Total body length 844 μm (range 788–879 μm, mean 833 μm, n = 10) measured from the anterior tip of the rostrum to the posterior margin of the caudal rami. The maximum width measured at the posterior margin of the cephalic shield is 585 μm. The cephalothorax is semicircular with a strongly developed integument. The rostrum is small, broad and directed downward. There are pedigerous somites with strong integuments on both lateral surfaces, with a smooth posterior margin.

The urosome (Figures 1a,b, 5a) is 4-segmented, comprising a P5-bearing somite, a genital double somite and two free abdominal somites. All urosomites have strongly chitinized lateral epimeres except for the anal somite. The P5-bearing somite is strong and expanded laterally, reaching halfway along the following somite. The genital double somite is well developed, wider than long, and reaches the posterior margin of the caudal rami. The caudal rami (Figure 8c) are about 1.5 times as long as wide; each

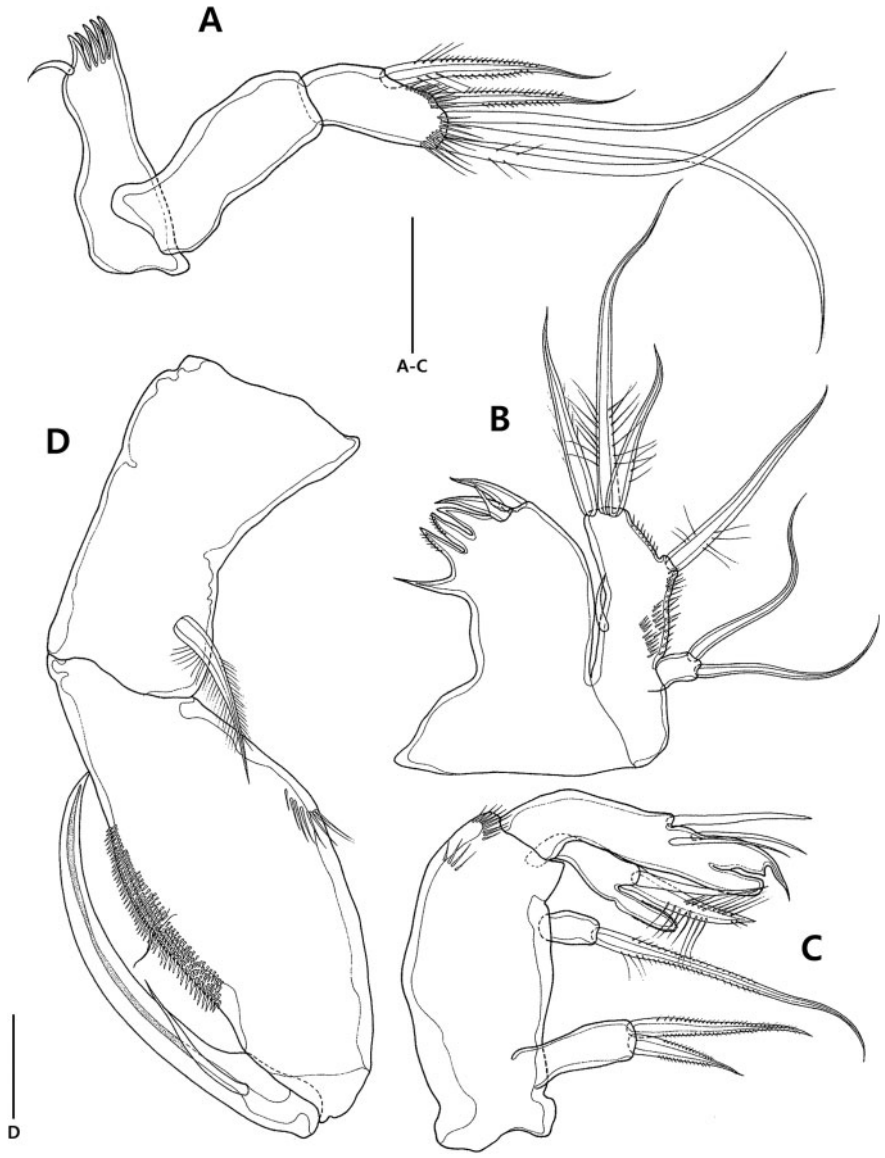

Figure 3. *Peltidium byungwooi* sp. nov., paratype female. (A) Mandible; (B) maxillule; (C) maxilla; (D) maxilliped. Scale bars: 32 μm.

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ramus slightly tapering distally. All seven setae are located on the distal third; seta VI is the shortest and seta VII is tri-articulate at the base.

The antennule (Figure 2a) is 7-segmented; segment 1 with one seta at the distal anterior corner and two setule rows on the anterior surface, segment 2 is the longest with a setule row on the posterior surface, segment 4 has an aesthetasc fused basally to one bare seta, segment 6 is the shortest. The terminal acrothek consists of two bare setae basally fused to the asthetasc. Armature formula: 1–[1], 2–[11], 3–[8], 4[2+(1+ae)], 5–[1], 6–[3], 7–[9+acrothek].

The antenna (Figure 2b) is 3-segmented, comprising the coxa, allobasis and free endopodal segment. The coxa is without ornamentation on the surface. The allobasis is as long as the endopod, with two abexopodal setae at 1/3 and 2/3. The endopod is ornamented with long spinules on the anterior surface. The lateral armature consists of three spines; the distal armature consists of one spine, four geniculate setae and two slender pinnate setae. The exopod is 2-segmented, bearing one lateral seta on exp-1 and three distal setae on exp-2.

The mandible (Figure 3a) has a well-developed gnathobase bearing several long, multicuspidate teeth distally and one seta on the dorsal corner; it is without ornamentation on the surface. The palp is uniramous; the basis is about two times longer than wide; the endopod is furnished with two rows of setules distally, with two setae laterally and three long setae distally.

Maxillule (Figure 3b). The praecoxa is unarmed. The arthrite is strongly developed, with seven ornamented spines around the distal margin. The

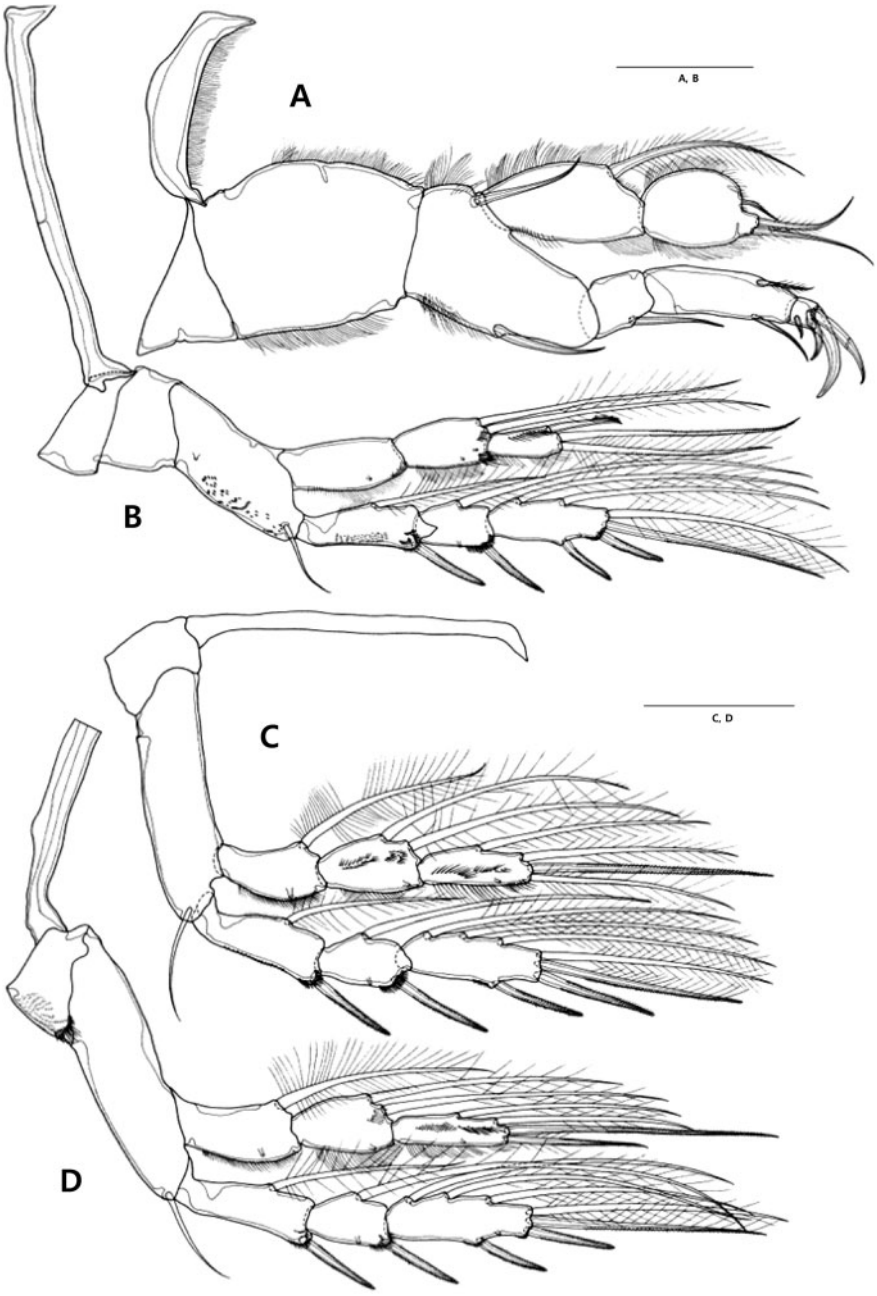

Figure 4. *Peltidium byungwooi* sp. nov., paratype female. (A) P1; (B) P2; (C) P3; (D) P4. Scale bars: 63 μm.

coxobasis bears setules on the anterior surface and the outer margin, with one small seta proximally, three pinnate setae distally and one outer seta on a small protuberance. The exopodal lobe has two long distal setae.

Maxilla (Figure 3c). The syncoxa has two setule rows distally and three endites. The proximal endite has two pinnate setae; the middle endite has one long seta; the distal endite has one bare seta, one plumose spine and one ornamented spine. The allobasis is bilobed, drawn out into a small claw with two accessory setae. The endopod is represented by a small protuberance bearing one bare seta.

Maxilliped (Figure 3d). The syncoxa is much longer than wide, the outer margin concave, with one pinnate seta subdistally. The basis is longer than the syncoxa, ornamented with a spinular row along the palmar margin and a few spinules along the outer margin, and with a tiny seta at the midlength of the palmar margin. The endopod is represented by an apically curved claw; the accessory armature consists of one long, bare seta.

P1 (Figure 4a) has a wide intercoxal sclerite with long setules along the distal margin. The coxa has two rows of spinules on both margins. The basis is elongate with setules on the outer and inner margins,

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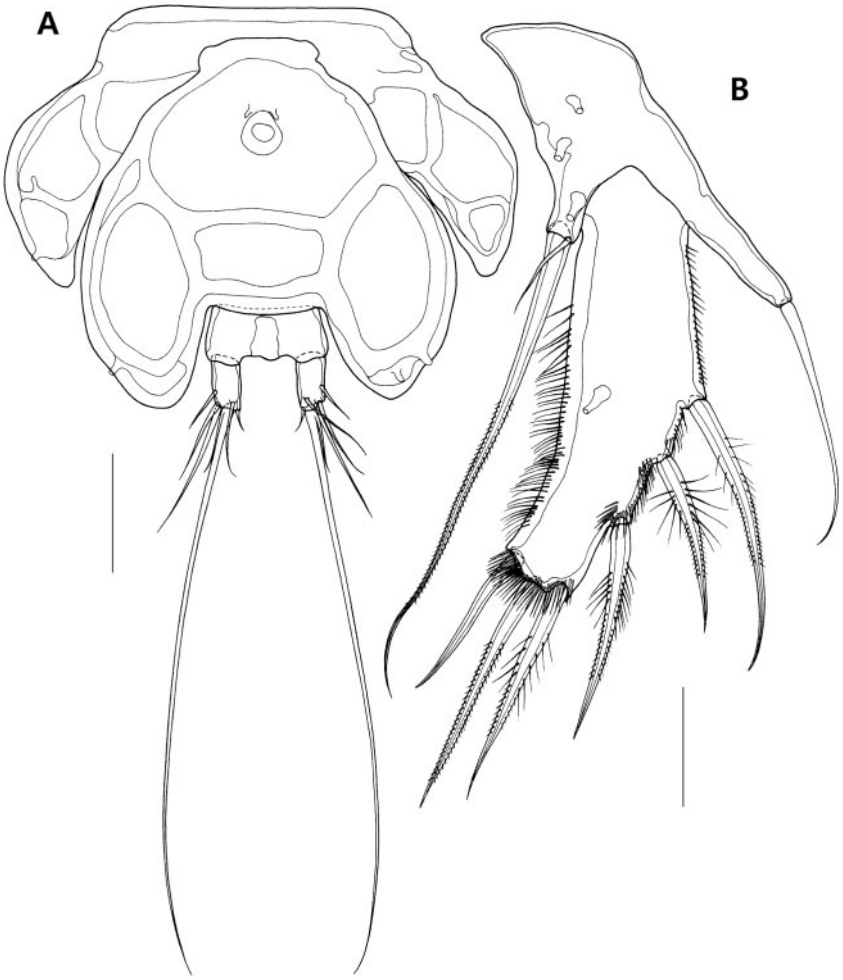

Figure 5. *Peltidium byungwooi* sp. nov., paratype female. (A) Urosome, ventral; (B) P5. Scale bars: A = 80 μm, B = 32 μm.

with a seta/spine on the inner corner and the middle of the outer margin. The exopod is 3-segmented, longer than the endopod; exp-1 with one outer spine; exp-2 much longer than the other segments, with one outer spine and one bipinnate seta on the inner margin; exp-3 is the shortest, with one claw on the surface and three claws distally. The endopod is 2-segmented and both margins are swollen; enp-1 bears setules along the inner and outer margins, with one long plumose inner seta; enp-2 is a little longer than wide, with outer setular rows on both margins, with one small inner seta subdistally and two setae distally.

P2–P4 (Figure 4b–d) have wide intercoxal sclerites lacking ornamentation. The coxae are wider than long, without setules on the surface except for P4, which bears many setules on its surface; the basis is much elongated, with outer distal bare seta; only P2 has surface setules. Each ramus consists of a 3-segmented exopod and an endopod; the armature formula of P2–P4 as in Table I.

P5 (Figure 5b) has a separate baseoendopod and an exopod. The baseoendopod is longer than wide, with three tube pores on the surface, and with one long, bipinnate seta (inner) and one tiny, bare seta (outer) on the endopodal lobe (about 5.4 times shorter than the inner one). The exopod is much elongated, ornamented with one tube pore on the surface, minute setule line on the outer margin and long setule line on the inner margin, and with three outer bipinnate setae and three distal setae.

Male. Total body length (Figure 6a) 694 μm (range 667–738 μm, mean 701 μm, $n = 6$), measured from the anterior margin of the rostrum to the posterior margin of the caudal rami. The largest width measured at the posterior margin of the cephalic shield is 454 μm. The general shape of the surfaces on each segment is as in the female. The urosome (Figure 6a) is 4-segmented, comprising a P5-bearing somite, a genital somite and two abdominal somites. Surface ornamentation and caudal rami are as for the female.

The antennule (Figure 7a) is 8-segmented, subchirocer; segment 1 is ornamented with one seta on the outer distal corner; segment 2 is the longest; segments 3, 5, and 8 with aesthetasc.

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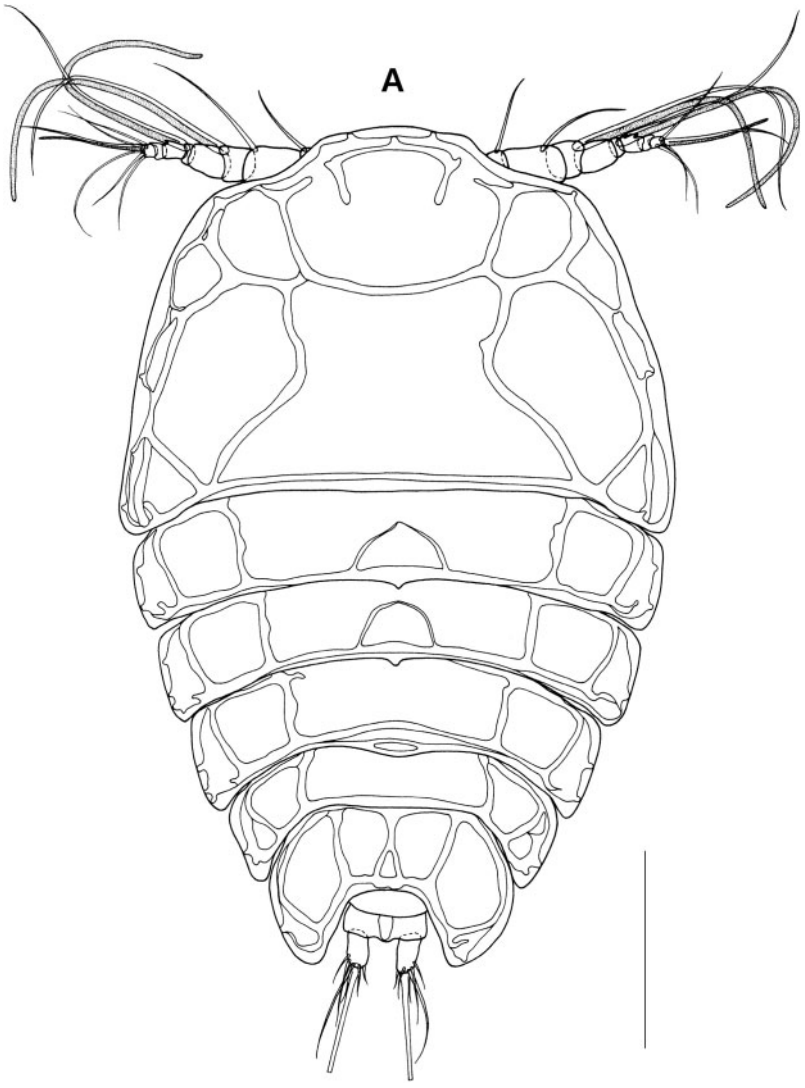

Figure 6. *Peltidium byungwooi* sp. nov., paratype male. Habitus, dorsal. Scale bar: 160 μm.

Armature formula: 1–[1], 2–[10], 3–[5+(1+ae)], 4–[4], 5–[1+ae], 6–[0], 7–[2], 8–[10+acrothek].

Antenna (Figure 7b) with a longer coxa than that of the female, and exp-2 slightly shorter than the first one. The apical acrothek consists of two long setae and an aesthetasc.

Mouth appendages as in female.

P1 (Figure 7c) has a wide intercoxal sclerite. The coxa has scattered spinules on the distal corner surface. The basis is elongate with setules on the outer and inner margins, with a seta/spine on the inner corner and the middle of the outer margin. The exopod is 3-segmented, much longer than the endopod; exp-1 has one outer spine; exp-2 is much longer than the other segments, with tiny spinules along the outer margin, with one outer spine and one bipinnate seta on the inner margin; exp-3 is the shortest, with one claw on surface and three claws distally. The endopod is 2-segmented, reaching the end of exp-2 and not swollen; enp-1 bears setules along the outer margin, with one long plumose inner seta; enp-2 is longer than wide, with the setule row along the inner margin and many setules along the outer surface, with three setae distally.

P2 (Figure 7d). The exopod, enp-1 and enp-2 are as in the female. Enp-3 is modified with one curved spine with a blunt tip.

P3 and P4 as in female.

P5 (Figure 8a). The rami are distinct. The baseo-endopodal lobe is much shorter than the exopod, with three pores on the surface and a tiny setule row between the baseoendopodal lobe and the endopodal lobe, with long outer basal seta; the endopodal lobe with one long inner seta and one short outer seta (about 3.5 times shorter than the inner one). The exopod is about three times as long as wide, with three outer setae and three distal setae.

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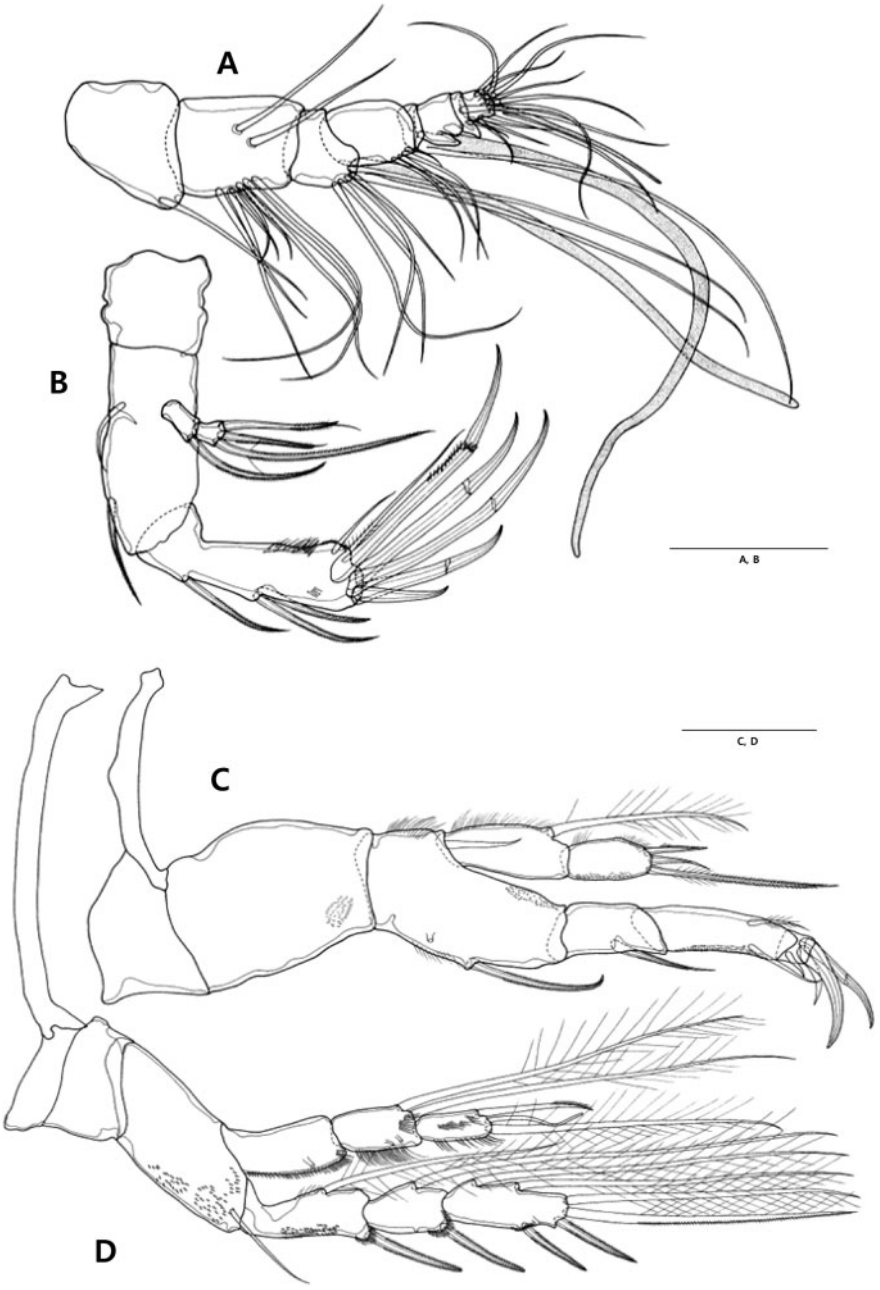

Figure 7. *Peltidium byungwooi* sp. nov., paratype male. (A) Antennule; (B) antenna; (C) P1; (D) P2. Scale bars: 63 μm.

P6 (Figure 8b) is represented by three subequal, long setae on a single elongated lobe.

Distribution

Yeoseodo Island (Jeju Strait) of Korea; known only from the type locality.

Etymology

The present species is named after the late Dr Byungwoo Kim (Korean National Park Service) in recognition of his important contributions to the study of Arachnida of Korea.

Discussion

Systematics of the Peltidiidae

According to the identification key of Huys et al. (1996) and Boxshall & Halsey (2004), the new species described here belongs to the genus *Peltidium*, possessing a 2-segmented antennal exopod, P1 endopod with a broad endopodal segment, and a separated P5 baseoendopod and exopod, and lacking a mandibular exopod as the diagnostic characters of the genus. Geddes (1968) described four new species – *Peltidium nichollsi*, *P. lerneri*, *P. perturbatum*, and *P. fenestratum* – from the Bahamas and then divided all known species of the genus into four

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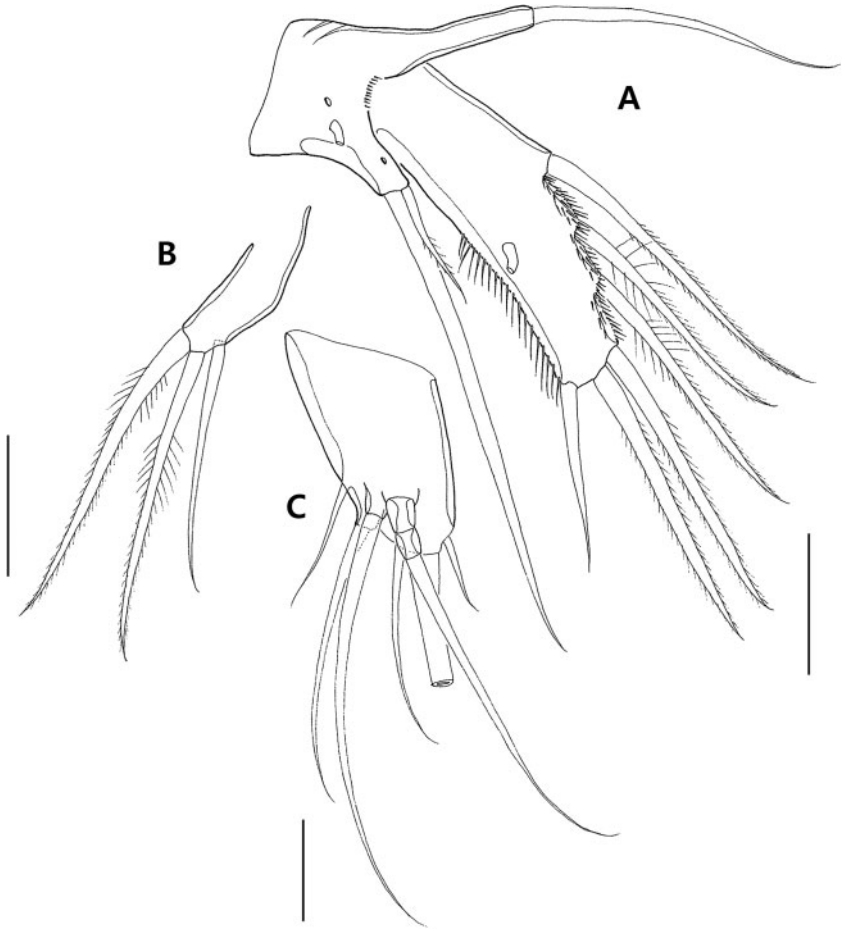

Figure 8. *Peltidium byungwooi* sp. nov., paratype male. (A) P5; (B) P6; (C) caudal ramus of female. Scale bars: 30 μm.

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groups by the shape of the P5 exopod and its setal number (see Geddes 1968: 16–17, Figure 5). This new species could be included in the first group, characterized by the P5 exopod with six setae on the outer margin or the distal part. Four species were allocated to this group: *Peltidium gracile* (Claus, 1889), *P. purpureum* Philippi, 1839, *P. robustum* (Claus, 1889), and *P. sacesphorum* Monard, 1928. Nicholls (1941) previously discussed identification problems, such as incomplete or inadequate descriptions, and Wells & Rao (1987) also mentioned that type specimens of most species were lost. There are also some difficulties in comparing the species mentioned above with the new species, particularly for appendages. However, *Peltidium byungwooi* sp. nov. is very easily distinguished from its congeners by the unique setal formula of its swimming legs, P2–P4 exp-3 with only two outer spines, P2 enp-1 without inner seta, and P3 enp-3 with two inner setae. *Peltidium fenestratum* shows the same setal formula of P2–P4, except for having the P2 enp-1 with one inner seta. The new species has a unique structure of the maxillar allobasis as shown in Figure 3c, and we could observe a similar structure in *P. ovale* Thompson & Scott, 1903 sensu Sewell (1940), *P. perturbatum*, *P. sacesphorum*, and *P. simplex* Nicholls, 1941. However, it should also be noted that our new representative carries a deeply divided allobasis and has a sharp process on its outer tip.

Zoogeography of the Peltidiidae

Among the eight genera of the Peltidiidae, *Peltidium* Philippi, 1839 and *Alteutha* Baird, 1846 are widely distributed. *Peltidium* is a very widely distributed genus with records from different regions of the world, but it is not very diverse in a given area; for instance, two species are known to occur in East Asia (Song & Yun 1999), and only three species are known from the Mediterranean: *P. gracile*, *P. purpureum*, and *P. robustum* (Todaro & Ceccherelli 2010). Records include the recently described *P. proximus* Varela, 2005 from Cuba, which should not be confused with Nicholls' (1941) *P. proximum* from South Australia. Only five species of *Peltidium* occur in the Caribbean region (Suarez-Morales et al. 2006). There were no records of Peltidiidae in Mexican waters of the Atlantic and the Pacific Oceans

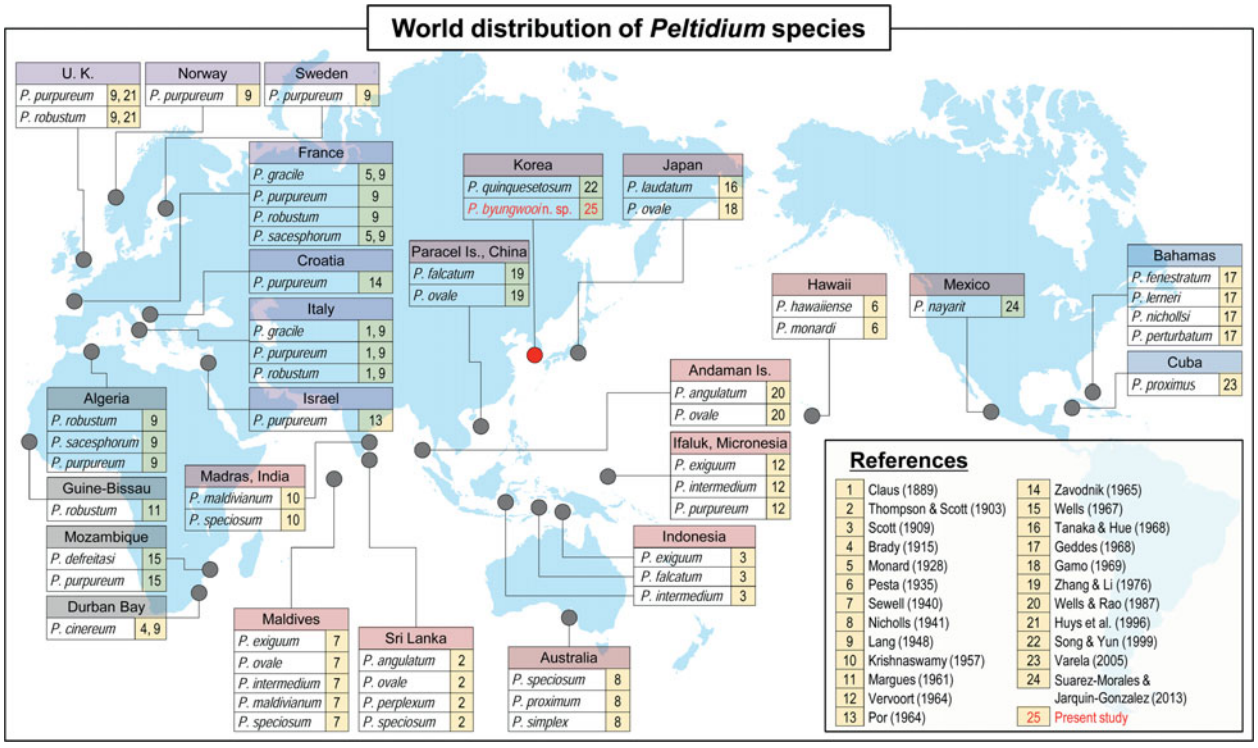

Figure 9. World distribution of *Peltidium* species, with a total of 27 species reported including two species in Korea.

(Suarez-Morales et al. 2000) until Gomez & Varela (2013) described a new species of the genus *Alteutha* Baird, 1846 from Sinaloa, northwest Mexico in the Gulf of California. From the Eastern Pacific only a few species of Peltidiidae have been recorded and among them there are some unidentified records of *Peltidium* (Lang 1965; Cordell 2006).

So far, 27 valid species belonging to the genus *Peltidium* have been recorded (see Wells 2007; Varela 2005; Suarez-Morales & Jarquin-Gonzalez 2013) from all except the polar seas. From the Pacific Ocean seven species have been reported as new to science – *Peltidium falcatum* Scott, 1909 (Indonesia), *P. hawaiiense* Pesta, 1935 and *P. monardi* Pesta, 1935 (Hawaii), *P. laudatum* Tanaka & Hue, 1966 (Japan), *P. nayarit* Suarez-Morales & Jarquín-González, 2013 (Mexico), *P. quinquesetosum* Song & Yun, 1999, and *P. byungwooi* sp. nov. (Korea). *Alteutha* are found in the Arctic-boreal belt, but also in the Mediterranean Sea, as well as in the Black Sea, the Red Sea, the Kerguelen Archipelago, in New Zealand, and in the Southern Antilles (Antarctica) (Dahms 1992). *Eupelte* Claus, 1860 comprises 11 valid species and is distributed in three major oceans: the Atlantic Ocean (four species), Pacific Ocean (four species) and Indian Ocean (three species). However, recent records of *Eupelte villosa* (Brady, 1910) expand its distribution to the Weddell Sea, Antarctica (see Dahms 1992). *Alteuthella* A. Scott, 1909 includes three species collected from the NW coast of New Guinea and the Banda Sea that were described by Scott (1909) – *Alteuthella spinicauda*, *A. pellucida*, and *A. pygmaea*; Gurney (1927) attributed a single male from the Gulf of Suez to *A. spinicauda*. Given the great distance from New Guinea, this record requires verification. *Alteuthellopsis* Lang, 1944 has two species – *Alteuthellopsis oblivia* Scott, 1909 from NW New Guinea and *A. corallina* Humes, 1981 from Australia (the Great Barrier Reef), Indonesia (Seram), and New Caledonia (Humes 1981, 1984). *Parapeltidium* Scott, 1909 consists of five species from Sri Lanka, India, Indonesia, and Australia. *Neopeltopsis* Hicks, 1976 contains three species and has been recorded from littoral and sublittoral macroalgae in New Zealand, South Australia, and Argentina. The most recently established peltidiid genus, *Alteuthoides* Hicks, 1986, has two species – *Alteuthoides kootare* Hicks, 1986 from New Zealand and *A. affinis* Kim & Kim, 1998 from Korea.

Because of the scarce taxonomical surveys of the phytal meiofauna in Korean waters, only one species of *Peltidium* having been recorded so far, it is assumed that the family and generic diversity remains underestimated in the area.

Ecology of the Peltidiidae

Peltidiidae are exclusively marine, mainly in shallow coastal waters. More precise accounts on habitat and biology were rare in earlier records. Sars (1911)

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mentioned in his 'Account of the Crustacea of Norway' only that he found peltidiids 'in moderate depths among algae' or on 'muddy bottoms'. Peltidiids live epibenthically on sediments and on the surfaces of macroalgae. More precise information is not available from these early ecological notes.

Some later accounts mentioned that macroalgal assemblages are the main habitat of peltidiids; they belong primarily to phytal species. Primarily red algae, but also green and brown algae, were reported to be their main habitat. This also holds for algae that were not immersed in seawater during low tide. Peltidiids co-occur with other phytal harpacticoid representatives such as Tegastidae and share with them particular morphological adaptations. Several peltidiids are also found in tidal pools, where they were most likely washed in by water movements. There they are reported to survive despite substantial fluctuations of temperature and salinity. Some species occur from below freezing point to > 26°C.

An exception to this is *Alteutha oblonga* (Goodsir, 1845) that Lang (1936) described as ubiquitous with respect to habitats from the Gullmarfjord. There he recorded this species from the phytal zone as well as from sand, mud, mussel beds, and bottoms covered with algal fragments. More recent records show that several species are present on such phytal bottoms (Wells 2007). There are records of symbiotic associations between peltidiids and macroinvertebrates (Hicks 1986). Several representatives have also been retrieved from corals and sponges. Humes (1981) recorded 250–1000 individuals of a single species, *Alteuthellopsis corallin*a Humes, 1981, from the Indo-Pacific (from 1964 to 1975). He described this species as widely distributed on different Octocorallia belonging to the genera *Merulina*, *Platygyra*, *Astreopora*, *Poecillopora*, *Acropora* and *Goniastrea*.

Collections from deeper waters are rare. Isolated peltidiids were found from depths down to 1500 m (Dahms 1992). This seems, however, to be an exception. Another example is provided by two deep-water species of *Alteuthella* that Lang (1948: 1530) claimed to be incorrectly assigned.

Peltidiids are also recorded from the water column (Veit-Köhler & Fuentes 2007). Such pelagic records were usually taken in autumn or winter after heavy storms. It is reasonable to assume that the individuals were dislodged from certain habitats and became relocated to the plankton. Such planktonic occurrences are also known from the island of Helgoland in the German Bight of the North Sea. Klie (1927) found high planktonic abundances of peltidiids and assumed that the individuals were swarming for reproduction.

There seems to be no particular restriction to a specific biotope in the Peltidiidae. However, this notion needs to be verified in the future in species-specific studies.

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