

First record of the family Cletopsyllidae (Copepoda: Harpacticoida) from Korean waters, with description of a new species

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A new species of the Cletopsyllidae belonging to the genus *Isocletopsyllus* Huys and Lee, 1999 is described from the materials collected from subtidal sandy bottoms at Jeju Island and Ulleung Island, Korea. So far, only two species of the genus *Isocletopsyllus*, viz. *I. tertius* (Por, 1964) from Israel and *I. quartus* (Soyer, 1966) from Banyuls-sur-Mer (France) are recorded, both from the Mediterranean Ocean. The new species can be clearly distinguished from its congeners by the combination of the following characters: (1) female antennule with a large process on the outer margin of first segment, (2) caudal rami with a bulbous proximal inner expansion, and shorter than those of other species (about four times long as wide in the new species), (3) second segment of P1 exopod with a short rod-like inner seta, (4) sexual dimorphism presented in the second endopodal segment of male P2, not in exopod of P4, and (6) female P5 with a very long exopod with very short second outer seta. A table comparing the modifications of swimming legs in the family Cletopsyllidae Huys and Lee, 1999 is presented. This is the first record of this family from Korea.

Keywords: taxonomy; *Isocletopsyllus maximus*, sp. nov.; Copepoda; Harpacticoida; Cletopsyllidae; Korea

Introduction

Jeju Island is the largest volcanic island off the south coast of Korea, and erupted about 2 million years ago. Its marine realm shows a high diversity of invertebrates (Je et al. 2002), due to its temperate and subtropical climate influenced by the warm Kuroshio current.

Although the region is known for its high faunal diversity, marine meiobenthic harpacticoid copepods from Jeju are poorly known. Song and Chang (1993) first recorded five harpacticoid species of the family Harpacticidae in Jeju. Since then, only 18 species distributed in 15 genera and nine families have been recorded since 1993. All 18 species were found in different habitats of the island (Song and Chang 1993; Chang and Song 1995, 1997a, b; Song et al. 1999, 2001, 2003; Nam and Lee 2006; Chang 2008) and most were found to be free-living species inhabiting algae or sediments, except for *Neotachidius parvus* Huys, Ohtsuka, Conroy-Dalton and Kikuchi, 2005 sensu Chang (2008) collected from brackish water, *Porcellidium similis* Kim and Kim, 1996 and *Alteuthoides affinis* Kim and Kim, 1998, associated with hermit crabs and sponges, respectively.

Of these 18 species, only eight species (*Dactylopusia pauciarticulata* Chang and Song 1997a; *Paradactylopusia koreana* Chang and Song 1997a; *Parathalestris parviseta* Chang and Song 1997b; *Parasthenelia pyriformis*

Song, Kim and Chang 2003; *Heteropsyllus coreanus* Nam and Lee 2006; *Neotachidius parvus* Huys, Ohtsuka, Conroy-Dalton and Kikuchi, 2005; *P. similis* Kim and Kim, 1996 and *A. affinis* Kim and Kim, 1998) were new to science.

On the other hand, the additional specimens were collected from Ulleung Island. The small island is also a representative volcanic island off the east coast of Korea (the East Sea) and consists primarily of trachyandesite rock. Also the harpacticoid species of Ulleung Island are poorly known; only 12 species are reported from the macroalgae mainly. Since Song and Chang (1993) first recorded *Tigriopus japonicus* Mori, 1938 and *Zaus robustus* Ito, 1974, subsequently 10 species were added to the fauna of Ulleung Island [*Eudactylopus andrewi* Sewell, 1940 and *E. spectabilis* (Brian, 1923) (Chang and Song 1995b), *Parathalestris bulbiseta* Lang, 1965, *P. verrucosa* Ito, 1970, *P. pacificus* Chislenko, 1971 and *P. areolata* Ito, 1972 (Chang and Song 1997a), *Dactylopus pauciarticulata* Chang and Song, 1997b and *Paradactylopusia koreana* Chang and Song, 1997b (Chang and Song 1997b), *Diosaccus ezoensis* Ito, 1974 (Song et al. 1999), and *Phyllothalestris sarsi* Sewell, 1940 (Song et al. 2001)].

In the course of benthic subtidal copepod study conducted in Jeju and Ulleung Islands during the period 2003–2006, a new species, *Isocletopsyllus*

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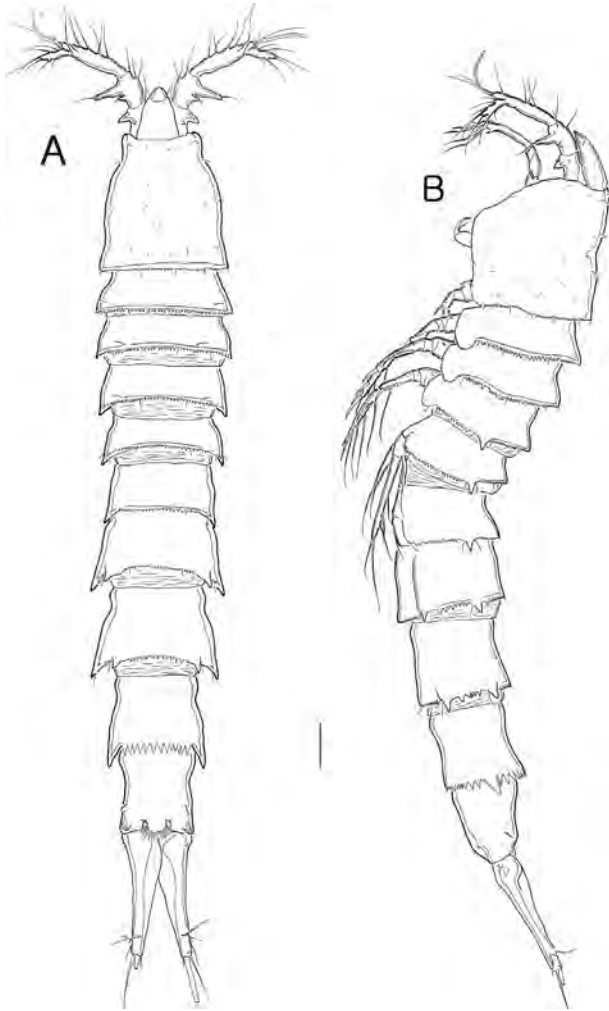


Figure 1. *Isocletopsyllus maximus* sp. nov. Female (paratype): A, habitus, dorsal; B, habitus, lateral. Scale bar = 100 μ m.

maximus of Cletopsyllidae, was found, and is herein described.

Materials and methods

Sediment samples were taken from Jeju Island and Ulleung Island (Korea). Specimens were fixed in 95% ethanol. Specimens were cleared and dissected in lactic acid. Dissected parts were mounted on slides in lactophenol as mounting medium. Preparations were sealed with transparent nail varnish. All drawings were prepared using an Olympus BX60 differential interference contrast microscope equipped with Nomarski optics and drawing tube.

The descriptive terminology is adopted from Huys et al. (1996). Abbreviations used in the text are: 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

term acrothek is used to denote the trifold seta complement found apically on the distal antennular segment. Scale bars are in micrometers (μ m).

Type series are deposited in the collections of The Natural Institute of Biological Resources (NIBR), Incheon, Korea.

Description

Order Harpacticoida Sars, 1903

Family Cletopsyllidae Huys and Willems, 1989

Genus *Isocletopsyllus* Huys and Lee, 1999

Isocletopsyllus maximus sp. nov. (Figures 1–7)

Type locality. Moonseom Islet, Jeju Is. South Sea of Korea (31°13'41"N, 126°33'57"E); 37 m depth, sandy bottom.

Type material. Holotype (reg. no. NIBRIV000178485): ovigerous female preserved in alcohol; 8 July 2003, Coll. Jae Wan Choi and Dr Hyun Soo Rho. Paratypes: four males preserved in alcohol (reg. no. NIBRIV0000178486). One female and one male, dissected on 12 and 13 slides respectively, are kept in the personal research collection of the first author (SJS) (reg. no. SACOP3011-3017) – having the same collection data as the holotype.

Additional materials. Two female and one male collected from Ssangjeongcho, Ulleung Is. (37°31'20"N, 130°55'58"E), 20 m depth, sandy bottom, coll. Sung Joon Song, by SCUBA diving, 22 June 2005; three females and one male collected from Do-dong, Ulleung Is. (37°28'52"N, 130°54'34"E), 5 m depth, sandy gravel deposits, coll. Sung Joon Song using a light trap, 29 June 2005; three females collected from Moonseom Isl., Jeju Is., 30 m depth, same as type locality, coll. Sung Joon Song, 6 October 2006.

Female. Total body length 1.980 mm (mean 1.693 mm, $n=6$), measured from the anterior margin of the rostrum to the posterior margin of the caudal rami. Largest width measured at posterior margin of genital-double somite, 0.304 mm. Urosome gradually tapering posteriorly. Cephalothorax bell-shaped, with few integumental sensilla as figured (Figure 1A, B); posterior and posterolateral margin crenulate with several sensilla. Rostrum (Figure 1A, B, 3D) prominent, triangular, directed downward, with trifold tip (very weak), with pair of subapical sensilla. Pedigerous somites with a pair of hairs on dorsal surface, crenulate posteriorly as cephalothorax.

Urosome (Figure 1A, 7A) 5-segmented, comprising P5-bearing somite, genital-double somite and three free

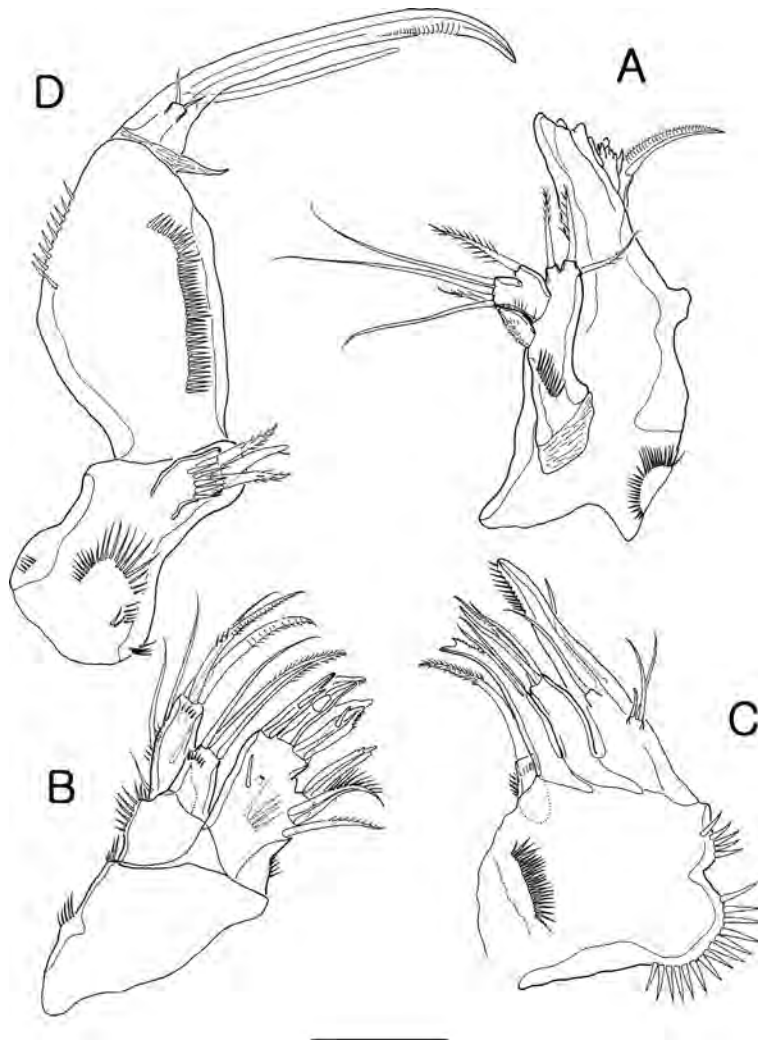


Figure 2. *Isocletopsyllus maximus* sp. nov. Female (paratype): A, mandible; B, maxillule; C, maxilla; D, maxilliped. Scale bar = 30 μ m.

abdominal somites. All urosomites with serrate posterior margin except for anal somite.

Genital-double somite (Figure 7A) as long as wide, with small spinules laterally; urosomites 2 and 3 (genital-double somite) partly fused with transverse serrate surface ridge dorsally and dorsolaterally. P6 (Figure 4A) represented by long outer seta and one small inner seta on small protuberance.

Anal somite (Figure 1A, 7A) with concave medial outer margin; ornamented with tiny spinules ventrally. Anal operculum semicircular, with long setules along posterior margin.

Caudal rami (Figure 7A) with overlapping expanded inner proximal part; about four times as long as wide; each ramus tapering distally, with several spinules on small protuberance laterally. All seven setae located in distal quarter; seta I bare, shortest, setae II–IV bare, and seta VII tri-articulate at base.

Antennule (Figure 3A) 4-segmented; segment 1 smallest, with outer process; segment 2 with two outer processes; distal one about three times as long as proximal one, each one bearing one seta distally; segment 3 longest, with two lobes distally. Armature formula: 1-[1], 2-[8], 3-[8 + ae], 4[11].

Antenna (Figure 3B) 3-segmented, comprising coxa, allobasis and free endopodal segment. Coxa with spinular row. Allobasis as long as endopod, with several spinules on outer margin and tiny abexopodal seta midlength. Endopod ornamented with spinules along outer margin and one transverse hyaline frill subapically. Lateral armature consisting of two spines; distal armature consisting of two spines, three geniculate setae and one slender seta. Exopod represented by one segment, bearing two bare setae.

Mandible (Figure 2A) with well-developed gnathobase bearing several multicuspitate teeth distally and

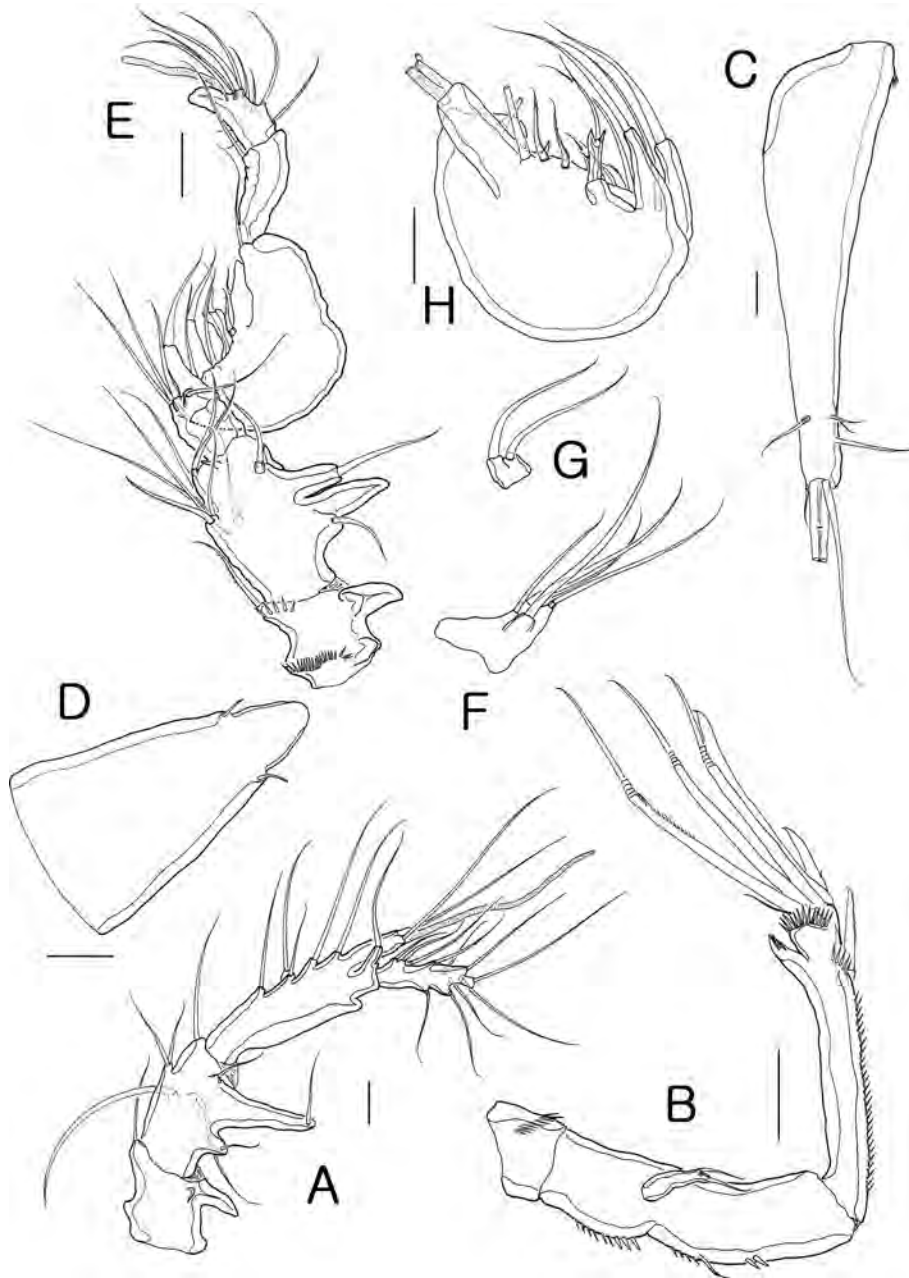


Figure 3. *Isocletopsyllus maximus* sp. nov. Female (paratype): A, antennule; B, antenna; C, caudal ramus, dorsal. Male (paratype): D, rostrum; E, antennule; F, 3rd segment of A1; G, 4th segment of A1; H, 5th segment of A1. Scale bars = 30 μ m.

one pinnate long seta in dorsal corner; with one spinule row on surface. Palp well-developed, biramous; basis ornamented with a surface setule row and three pinnate setae; endopod with one distal seta; exopod bilobed with three distal bare setae and one subdistal pinnate seta.

Maxillule (Figure 2B). Praecoxa with few spinules on outer distal corner and posteriorly. Arthrite strongly developed, with one unipinnate inner seta, one naked surface seta and pore, and five distal spines, and one spine and one unipinnate seta subdistally. Coxal endite

with one bare seta and one bipinnate seta. Palp 1-segmented, elongated with three outer setae, one small posterior seta, and three distal setae.

Maxilla (Figure 2C). Syncoxa with several spinules along bilobed outer margin, and a spinular row on anterior surface; and with three endites. Proximal endite with spinules on surface and one multipinnate spine; middle endite with one modified spine fused to segment and two long setae; distal endite with two bare setae and one pinnate seta. Allobasis drawn out into pectinate

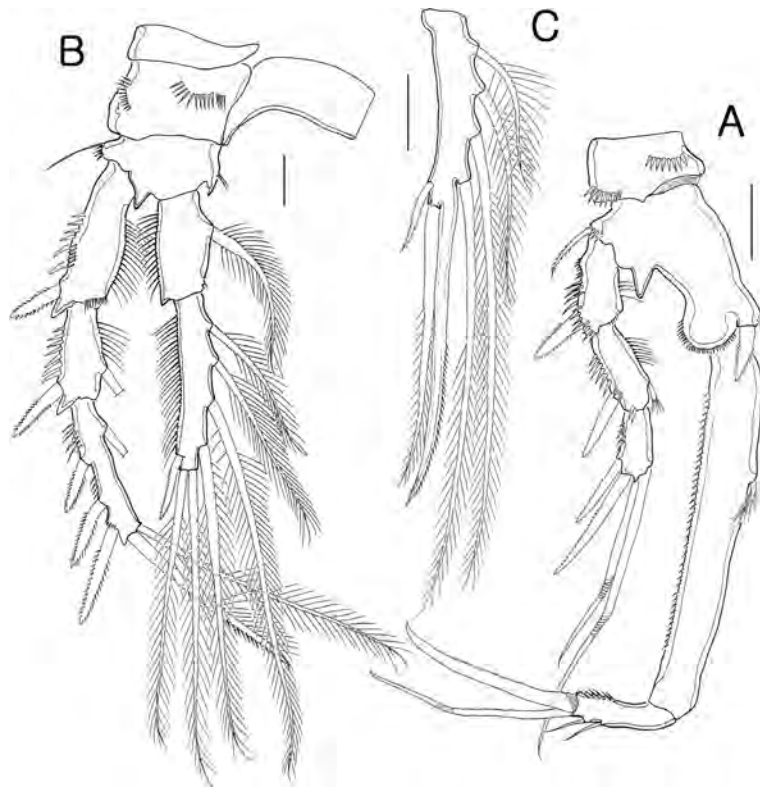


Figure 4. *Isocletopsyllus maximus* sp. nov. Female (paratype): A, P1; B, P2. Male (paratype): C, endopod of P2. Scale bars = 30 μ m.

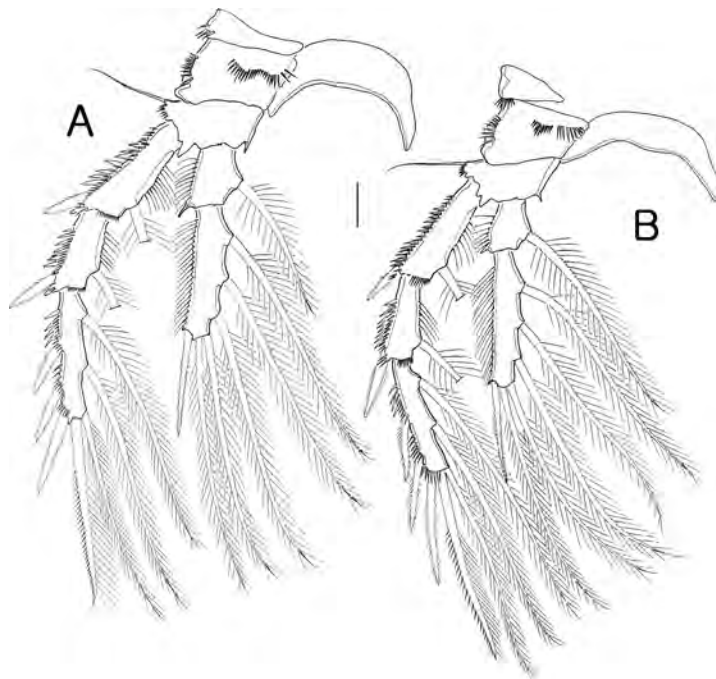


Figure 5. *Isocletopsyllus maximus* sp. nov. Female (paratype): A, P3; B, P4. Scale bar = 30 μ m.

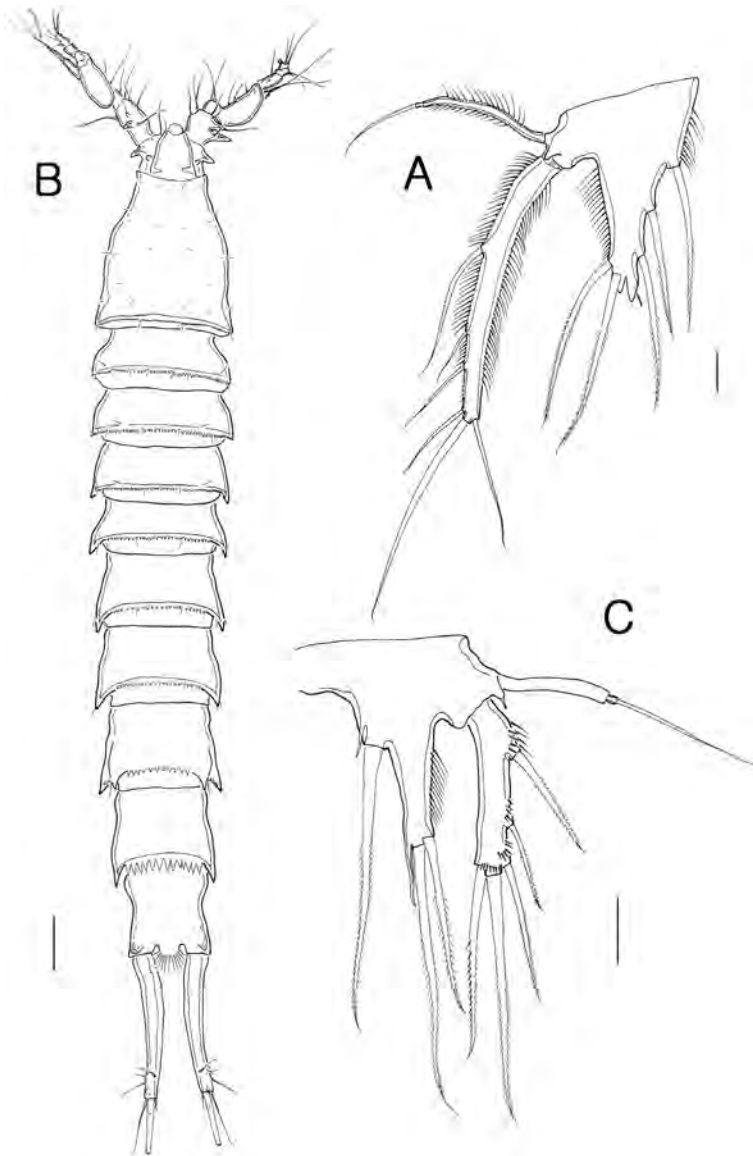


Figure 6. *Isocletopsyllus maximus* sp. nov. Female (paratype): A, P5. Male (paratype): B, habitus, dorsal; C, P5. Scale bars: A, C = 30 μ m; B = 100 μ m.

claw; accessory armature consisting of one anterior seta and one posterior seta. Endopod represented by small protuberance bearing two long and one short setae.

Maxilliped (Figure 2D). Syncoxa with spinular rows as figured, with three pinnate setae distally. Basis with spinular row along palmar margin and few spinules along outer margin. Endopod represented by apically curved claw, minutely pinnate in distal third; accessory armature consisting of one long bare seta and two vestigial elements.

P1 (Figure 4A). Coxa with two rows of spinules on anterior surface. Basis with spinulose process on distal margin between exopod and endopod, with bipinnate seta/spine on inner and outer corners.

Exopod 3-segmented, shorter than endopod; exp-1 with outer spinules, with long inner setules, and one outer bipinnate spine; exp-2 slightly longer than other segments, with one bipinnate outer spine and one small inner spine with long setules at its tip; exp-3 shortest, with two unipinnate long spines and two geniculate setae. Endopod 2-segmented; enp-1 about two times as long as exopod, with spinules along outer margin, with one small bipinnate rod-like seta on proximal third; enp-2 elongate, with outer spinular row, with one pectinate spine and one geniculate seta distally and two small inner setae.

P2-P4 (Figure 4B, 5A,B) with wider intercoxal sclerites lacking ornamentation. Praecoxae with spinu-

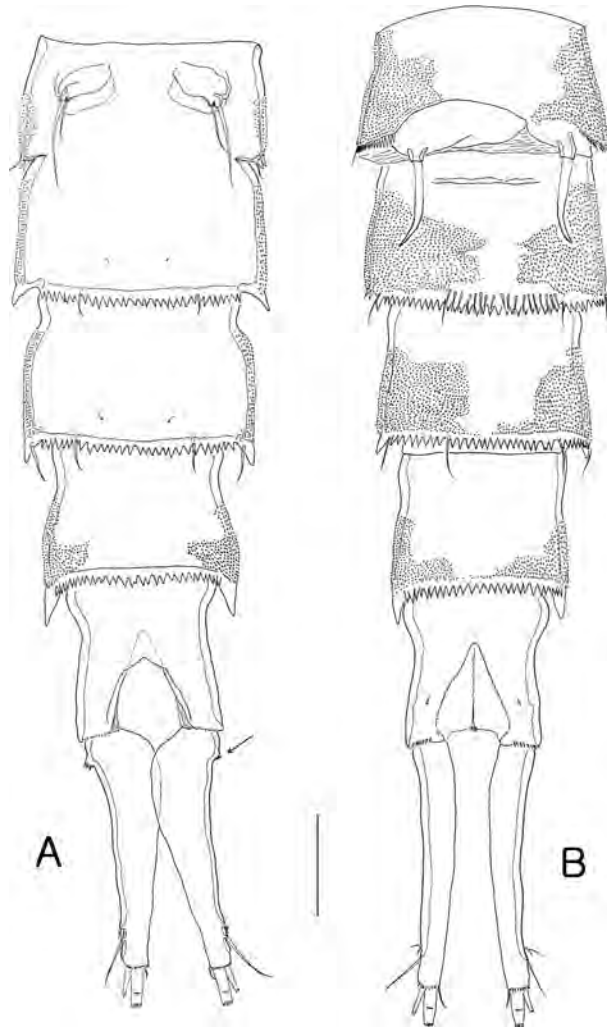


Figure 7. *Isocletopsyllus maximus* sp. nov. Female (paratype): A, urosome (excluding somite bearing P5). Male (paratype): B, urosome (excluding somite bearing P5). Scale = 100 μ m.

lar row anterodistally except P2. Coxae with two spinular rows on anterior surface. Bases wider than long, with spinulose process on distal margin between exopod and endopod; outer distal setae bare, only P2 with a few setules on inner margin. Each rami consisting of 3-segmented exopod and 2-segmented endopod; armature formula of P2-P4 as in Table 1.

P5 (Figure 6A) with separate baseoendopod and exopod, both covered with long setules laterally. Baseoendopod longer than wide, with long outer basal setae arising from triarticulate setophore. Endopodal lobe extending almost to middle of exopod, with a small process distally, with 5 bipinnate setae. Exopod elongated, about 10 times as long as wide, with three bipinnate outer setae and three bare setae apically.

Male. Total body length 1.78 mm (mean 1686 mm, $n = 7$), measured from anterior margin of rostrum to

posterior margin of caudal rami. Largest width measured at posterior margin of cephalic shield, 0.26 mm.

Prosome (Figure 6B) 4-segmented, comprising cephalothorax and three free pedigerous somites. Posterior margin of cephalothorax and pedigerous somites crenulate with few integumental sensillae as figured. Rostrum as in female.

Urosome (Figure 7B) 6-segmented, comprising P5-bearing somite, genital somite and four abdominal somites. Posterior margin of all somites with crunulate

Table 1. Setal formula of swimming legs of *Isocletopsyllus maximus*.

	Exopod	Endopod
P2	0, 1, 123	1, 421
P3	1, 1, 223	1, 321
P4	1, 1, 223	1, 321

line dorsally and ventrally, except for anal somite. Caudal rami (Figure 6B, 7B) sexually dimorphic, without inner expansion, about six times as long as wide, all seven setae similar to that of female.

Antennule (Figure 3E–H) 7-segmented; subchirocer, with geniculation between segment 4 and 5. Segment 1 ornamented with outer spinules, and with outer process. Segment 2 with two outer processes. Segment 5 longest and swollen. Armature formula: 1-[1 unipinnate], 2-[8 bare + 3 pinnate], 3-[5 bare], 4-[2 bare], 5-[7 bare + 3 modified + 3 pinnate + (1 + ae)], 6-[1 bare], 7-[8 bare + acrothek]. Apical acrothek consisting of two long setae and aesthetasc.

Antenna, mouth appendages, and P1, P3, P4 as in female.

P2 (Figure 4C). Exopod as in female. Endopod modified, 2-segmented; enp-2 modified with four plumose inner setae, one short bipinnate outer seta; with one bipinnate seta and one modified styliform spine apically.

Fifth pair of legs (Figure 6C). Rami distinct. Baseoendopodal lobe shorter than exopod, with long triarticulate outer basal seta; endopodal lobe with one long inner seta and two distal setae accompanied by a long tube-pore, outer margin with long setules. Exopod about four times as long as wide, with three outer setae and two distal setae.

Sixth pair of legs (Figure 7B) asymmetric, armature consisting of one curved long spine on cylindrical process.

Etymology

The species name is derived from the Latin *maximus*, meaning biggest or longest, and refers to the longest body length within the family.

Discussion

Characteristic of the genus Isocletospyllus

The new species herein described from Jeju and Ulleung Islands was attributed to *Isocletospyllus* Huys and Lee, 1999 by the presence of a crenulated posterior margin of body somites, female 4-segmented antennules, third segment of the female antennule without any posterior modification, male P5 exp with five setae/spines, and sexually dimorphic caudal rami (with a larger length:width ratio than in females). *Isocletospyllus maximus* sp. nov. differs from other species of the genus in the male P2 enp-2 with a modified apical spine fused to the distal segment, instead of unilaterally pectinate spines on p4 exp-3. In addition the female of the new species has a caudal ramus with a widened inner expansion, and has a raised spinulose patch on

outer margin proximally, while other species in the genus has the patch on the inner proximal margin.

Sexual dimorphism of swimming legs

Huys and Lee (1999) suggested allocating genera *Bathycletospyllus* [*B. hexarthra*] and the genus *Cletospyllus* in the family Cletospyllidae, being composed of three genera: *Cletospyllus* Willey, 1935 [*C. papillifer* Willey, 1935; *C. bacescui* Marcus, 1976; *C. rotundifera* Fiers, 1986], *Retrocalcar* Huys and Lee, 1999 [*R. brattstoemi* (Geddes 1981); *R. secundus* (Nicholls 1945); *R. sagamiensis* (Itô 1971)] and *Isocletospyllus* Huys and Lee, 1999 [*I. tertius* (Por 1964); *I. quartus* (Soyer 1966)]. The species of the family are rarely found worldwide and still unknown are the males of *R. secundus*, *I. quartus* and *C. papillifera*. It would be also notable that only one male of the genus *Isocletospyllus* was known to science. Thus detailed description of the sexual dimorphism of *I. maximus* sp. nov. would help us better understand the taxonomy of the family, especially for the genus *Isocletospyllus*. As shown in Table 2 for the modification of male swimming legs, the third outer seta of p2 enp-2 is transformed to a styliform spine in five species, *B. hexarthra*, *C. rotundifera*, *C. bacescui*, *R. brattstoemi*, and *I. maximus* sp. nov. Of these species *C. rotundifera* has a curved spine and *C. bacescui* has a similar spine that is not fused at base. In p4 exp of the male three species (*B. hexarthra*, *R. brattstoemi* and *I. tertius*) have modified outer spines, while specimens of the new species from Jeju and Ulleung Islands do not show these modifications (Table 2).

Remarks on Isocletospyllus species

Representatives of the genus *Isocletospyllus* have been recorded only from the Mediterranean. Por (1964) described both sexes of *I. tertius* from off the Israel Mediterranean coast (on gravel bottom, 35 m deep). *Isocletospyllus tertius* is different from the new species in: (1) having a setule row on the inner expansion of caudal rami proximally, (2) antennules without process anteriorly, (3) P1 exo-1 and -2 with long and thin outer spines as in *I. quartus* (thick spine in *I. maximus*), (4) male P4 exp-3 with three unipectinate spines, (5) male and female basal seta of p5 baseoendopod without a setule line along the margins, and (6) male P5 baseoendopod with few spinules along the inner margin.

Isocletospyllus quartus (Soyer 1966) was recorded from Banyuls-sur-Mer, France by Søyer (1966). The male and female of *I. tertius* are known, but only the female of *I. quartus* is known. The latter could not show the sexual dimorphism of the male, which is unexplored as yet. *Isocletospyllus quartus* is different

Table 2. Modified leg, body length and their recorded localities of cletopsyllid species.

Species	Modified leg	Body length (scale: µm)	Localities
<i>Bathycletopsyllus hexarthra</i>	p2 enp-2 (s.s.) p4 enp-2 & -3	♀: 1210–1250, ♂: 1010–1030	Indian Ocean, off La Reunion (muddy sand, 460 m)
<i>Cletopsyllus rotundifera</i>	p2 enp-2 (curved s.s.)	♀: 1000, ♂: 950	West Indian Islands (coarse coral sand, 4 m)
<i>C. papillifera</i>	Unknown*	♀: 960	Bermuda, off northeast end of Agar's Island
<i>C. bacescui</i>	p2 enp-2 (s.s.)**	♀: 1300, ♂: 900	Indian Ocean, off Tanzania, East Mbvakumi coral bottom
<i>Isocletopsyllus tertius</i>	p4 exp-3 (u.s.)	♀: 1520, ♂: 1300	off the Israeli mediterranean coast
<i>I. quartus</i>	Unknown*	♀: 1150	Mediterranean, Banyuls-sur-mer (France)
<i>I. maximus</i>	p2 enp-2 (s.s.)	♀: 1980, ♂: 1780	Present study
<i>Retrocalcar secundus</i>	Unknown*	♀: 980	Nicholls (1945), Huys and Lee (1999)
<i>R. brattstroemi</i>	p2 enp-2 (s.s.) p3 exp-1 to -3*** p4 exp-3 (u.s.)	♀: 1280, ♂: 1130	Bahamas, lagoon, Great Egg Island, 0.5 m, mud
<i>R. sagamiensis</i>	Not modified	♀: 1600, ♂: 1300	Sagami Bay, Japan, 80 m

s.s.: styliform spine, u.s.: unipectinate spine.

* not described for male.

** not fused at base.

*** heavily chitinized spines.

from the new species, *I. maximus*, in (1) caudal ramus with several setules on the inner expansion proximally in *I. quartus*, while with setules on the outer proximal margin in *I. maximus* sp. nov, (2) third antennular segment with 10 + ae in the female of *I. quartus*, while 8 + ae in *I. maximus*, (3) endopodal segment of antenna with long setules on the outer margin in *I. quartus*, while with short setules along the outer margin in *I. maximus* sp. nov., (4) syncoxa of maxilliped with two setae, while with three setae in *I. maximus*, (5) basis of mandible with two setae *I. quartus*, while with three setae in *I. maximus*, and (6) proximal endite of maxilla with three setae in *I. quartus*, but one seta in *I. maximus* sp. nov.

Differential diagnosis

Isocletopsyllus maximus sp. nov. can be separated from its congeners on the basis of the following aspects that are differential characters of the species: (1) elongated body in female (1.98 mm) and male (1.78 mm) (compared to 1.15 mm in female of *I. quartus*; 1.52 mm in female and 1.30 mm in male of *I. tertius*), (2) caudal ramus with a spinular field on a small outer protuberance proximally, (3) well-developed outer setule line on syncoxa of the maxilla, (4) P1 exp-2 with a short rod-like inner seta, (5) P2 enp-2 with a short outermost spine, P2 enp-2 of male with a styliform spine derived from a transformed distal inner seta, (6) male P4 exopod without modified outer spines, (7) P5 exp very long and narrow with a very

short second outer seta, and (8) male baseoendopod with well-developed tube-pores, especially distally.

Biogeography

Representatives of the genus *Isocletopsyllus* have a comparatively elongated body and live on shallow subtidal gravel or in sandy bottoms, from 10 to 45 m depth. So far only two species of the genus collected from the Mediterranean Sea, *I. quartus*, have been collected along the coasts of Banyuls-sur-mer, France, and *I. tertius* have been collected from off the Israeli coast. The discovery of *I. maximus* sp. nov. in Korean waters (eastern and southern islands) would expand the range of the hitherto known biogeography for representatives of the genus *Isocletopsyllus*, from the Mediterranean to the Far East of Asia.

Additionally, as shown in Table 2, *R. sagamiensis* was also reported from the Pacific Ocean (collected from the Sagami Bay, 80 m depth) as *I. maximus*. *Bathycletopsyllus hexarthra*, *C. bacescui*, *C. rotundifera* and *R. secundus* were reported from the Indian Ocean; especially *B. hexarthra* were collected from the deepest bottom (460 m). *Cletopsyllus papillifer* and *R. brattstroemi* were reported from the Atlantic Ocean.

Key to the female species of the genus Isocletopsyllus

1. First antennular segment with outer process 2
- First antennular segment without outer process; caudal ramus about six times as long as wide *I. tertius* (Por 1964)

2. Caudal ramus without expanded inner board; about 10 times as long as wide.....
*I. quartus* (Soyer 1966)
 Caudal ramus with expanded inner board; about four times as long as wide
*I. maximus* sp. nov.

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