



## A review of candonid ostracods (Crustacea: Ostracoda: Podocopida) from East Asia, with descriptions of five new species from South Korea\*

IVANA KARANOVIC<sup>1,2,3</sup> & WONCHOEL LEE<sup>1</sup>

<sup>1</sup> Department of Life Science, College of Natural Science, Hanyang University, Seoul 133-791, Korea

<sup>2</sup> Institute of Marine and Antarctic Studies, University of Tasmania, Private Bag 49, 7001, Hobart, Tasmania, Australia

<sup>3</sup> Corresponding author, E-mail: [ivana.karanovic@utas.edu.au](mailto:ivana.karanovic@utas.edu.au)

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### Abstract

Seven species of the family Candonidae Kaufmann, 1900 are reported from South Korea. Five species are described as new, all belonging to the subfamily Candoninae Kaufmann, 1900 and the tribe Candonini Kaufmann, 1900: *Candona quasiakaina* sp. nov., *C. sillae* sp. nov., *Fabaeformiscandona koreana* sp. nov., *Typhlocypris choi* sp. nov., and *Schellencandona tea* sp. nov. A very close resemblance between *Candona sillae* and the European *C. improvisa* Ostermeyer, 1937 prompted a redescription of the latter species based on the type material, and designation of the lectotype. One species of the tribe Candonopsini, *Candonopsis transgrediens* Brehm, 1923, previously known only from China, is reported from Korean freshwater habitats, and its first redescription is provided, along with a key to the world representatives of the genus *Candonopsis* Vávra, 1820. One species of the subfamily Paracypridinae, *Dolerocypris mukaishimensis* Okubo, 1980, previously known only from Japan, is redescribed from Korean brackish water habitats, and some notes on its variability are provided. A checklist of the Candonidae ostracods from East Asia is also provided, but only for those species that have been well-documented and taxonomically described.

**Key words:** Biodiversity, review, new species, taxonomy, Candonidae

### Introduction

The family Candonidae Kaufmann, 1900 counts approximately 500 Recent species (Karanovic, 2012). It is divided into three subfamilies: Candoninae Kaufmann, 1900, Cyclocypridinae Kaufmann, 1900 and Paracypridinae Sars, 1923. The first two subfamilies live exclusively in freshwater ecosystems, while the last one inhabits mostly brackish and marine waters. The subfamily Candoninae is well known for its diversity in subterranean waters around the world (Danielopol 1978, Karanovic 2007) and, at the moment, is divided into eight tribes and 40 genera (Karanovic 2007). Some of the tribes are endemic to certain zoogeographic regions, like, for example Humphreyscandonini Karanovic, 2005, known only from subterranean waters of Western Australia (Karanovic 2005a). With the exception of the genera *Candonopsis*, Vávra, 1820 (of the tribe Candonopsini), *Candona* Baird, 1845, *Fabaeformiscandona* Krstic, 1972, and *Typhlocypris* Vejdovský, 1882 (all belonging to Candonini), which have a wide distribution and are known from more than one continent, all of the other 36 genera are known from one continent only, where they have a very restricted distribution (Karanovic 2012). The Candoninae fauna is well documented only from Europe (Meisch 2000) and to a lesser extent from North America (Karanovic 2006), while it is very poorly known from other continents, and especially from South America (Karanovic & Darty 2009). Systematic research on certain regions always raises the number of known Candoninae taxa dramatically; such are the examples from Japan (Smith & Kamiya 2007, Smith & Janz 2008) and Australia (Karanovic & Marmonier 2002, 2003; Karanovic 2003a, b, 2005a, 2007, Karanovic & Marmonier 2002, 2003). Members of the Candoninae are easily distinguished from other representatives of the family by the complete absence of swimming setae on the second antenna, which are present (but sometimes reduced) in Cyclocypridinae

and Paracypridinae, and by the single-segmented palps on the male prehensile palps (which are two-segmented in the other two subfamilies).

Karanovic (2011) recently revised the subfamily Cycloocypridinae, and proposed two new genera, so that at the moment this subfamily has six genera and 87 Recent species. The subfamily is not especially diverse in subterranean waters, and only occasionally species have been collected from these ecosystems (Wagenleitner 1990); most often they are found in open freshwater bodies. Endemism on the generic level is relatively high, since three out of six genera are known only from one continent or even smaller areas: *Keyserocypria* Karanovic, 2011 is endemic to South and Central America, *Alloocypria* Rome, 1962 to the African rift lakes, and *Kempfcycloocypris* Karanovic, 2011 to subterranean waters of Queensland, Australia. *Cypria* Zenker, 1854, *Physocypria* Vávra, 1897 and *Cycloocypris* Brady & Norman, 1889 have a much wider distribution, and some species, like *Cypria ophthalmica* (Jurine, 1820), are apparently known from almost all over the world (Meisch 2000).

The last subfamily, Paracypridinae, is divided into three tribes (see Maddocks 1992). The position of this subfamily within ostracods have changed during the time and it was considered as a separate family within the Cypridoidea (McKenzie 1979, 1980; Wouters 1984, 1987; Maddocks and Iliffe 1986; Maddocks 1988), subfamily of the family Cyprididae (Maddocks 1992) or, as accepted here, as a subfamily of Candonidae (Martens 1992, Maddocks 2005). The subfamily has many taxonomic problems, and diagnoses of several genera are in urgent need of revision. It is distributed all over the world.

East Asia (China, Korea, Taiwan and Japan) are relatively poorly studied when the Recent freshwater ostracods are concerned. China is well known for the study of fossil ostracods (e.g. Hou & Gou 2007, Hou et al. 2002; Huang 1982, 1984a,b), and many new species have been described from there. Recently, a checklist of the freshwater ostracods from China has been published by Yu et al. (2009), which contains 154 species (both fossil and Recent ones), 38 of them belonging to the family Candonidae. The majority of those 38 species are, however, known only from the fossil record and/or described after carapace characters only. The only Candoninae species recorded from China and described after both soft parts and carapace is *Fabaeformiscandona danielopoli* Jin & Martens, 1997. Japanese Recent freshwater ostracods are much better known and this fauna comprises 99 species (Okubo 1972a-d, 1973a, b, 1974a-c, 1975a, b, 1976, 1990a, b, Matzke-Karasch et al. 2004, Smith 2011, Smith & Hiruta 2004, Smith & Janz 2008, 2009, Smith et al. 2011), 31 of them belonging to the family Candonidae.

The first record of the South Korean Recent freshwater ostracods was published by McKenzie (1972), who described one Candoninae and one Cypridopsinae species (with two subspecies) from a Korean cave. Almost 20 years later, Kim & Min (1991a, b) reported another eight freshwater species (none belonging to Candonidae) from the Korean peninsula. Lee et al. (2000) conducted a study of ostracods from the East coast of Korea as biological indicators of water pollution. In this work the authors did not deal with taxonomy, but nevertheless provided a list of almost 500 species (both marine and freshwater ones) recorded during the study. Most of the species were identified only provisionally, but this impressive number accounts for 32 freshwater species of which only nine were identified to the species level, four of which only in open nomenclature in comparison to known species. This list includes 19 Candonidae, but *Aglaioocypris cf. nipponica* Okubo, 1980, *Dolerocypria mukaishimensis* Okubo, 1980, *Candonopsis cf. transgrediens* Brehm, 1923, and *Physocypria kraepelini* Müller, 1903 are the only ones identified to the species level. Finally, Chang et al. (2012) reported *Cryptocandona brehmi* (Klie, 1934), *C. tsukagoshii* Smith, 2011, *Fabaeformiscandona japonica* (Okubo, 1990), and *Physocypria nipponica* Okubo, 1990 from South Korea.

A recent interest in the biodiversity of the Korean fauna has revealed many ostracod species, both as new to science and as first records for Korea, and those belonging to the family Candoninae are presented here. A total of five new species is described, while *Candonopsis transgrediens* and *Dolerocypria mukaishimensis* are illustrated and redescribed in detail. The first species also provided an opportunity to update the key to species of the genus *Candonopsis* of Karanovic & Marmonier (2002) and Karanovic (2012). One of the new species described here proved to be a very close relative of *Candona improvisa* Ostermeyer, 1937 described from Europe (Ostermeyer 1937, Meisch 2000). To be able to identify the Korean species properly, we had to reexamine the type of its European congener, deposited at the Zoological Museum in Hamburg. Some of its remarkable characters are illustrated here and the species is also redescribed in order to facilitate future comparisons and identifications. Since many of the records of the freshwater ostracods from East Asia concern species that are fossil, or Recent but without any taxonomical notes which would confirm their identity, at the end of this paper we provide a list of well-documented species from this part of the world (Appendix 1).

## Material and Methods

Specimens were dissected and mounted on microscope slides in Faure's medium, which was prepared following the procedure of Stock & Von Vaupel Klein (1996), and dissected appendages were then covered with a coverslip. All drawings were prepared using a drawing tube attached to a Leica DMLS bright-field compound microscope with N-PLAN achromatic objectives. Specimens that were not drawn were examined in a mixture of equal parts of distilled water and glycerol and, after examination, were preserved in 70% ethanol.

Martens (1987) revised the terminology for A2 given originally by Broodbakker & Danielopol (1982). The present paper follows Martens (1987), except that the short claw on the male terminal segment is considered to be homologous with female GM claw, while the long one is homologous with female Gm claw, which is based on the position of these claws on A2, GM claw being the more external one. The terminology for the A1, Md, Mx1, L5 and L6 follows Broodbakker and Danielopol (1982), and for the L7 Meisch (1996). Lobes on the hemipenis are labeled according to Danielopol (1969). Here, the view of Meisch (2007) regarding the terminology and homology of the most posterior appendage on the ostracod body ("furca") is accepted. Setal classification system follows Garm (2004). Holotypes, allotypes and most of the paratypes are deposited at the National Institute for Biological Research, Seoul, while some material was kept for future DNA studies in the senior author's private collection.

Abbreviations used in the text and figure captions are: A1—antennula; A2—antenna; UR—uropodal ramus; H—height; L—length; LV—left valve; Md—mandible; Mx—maxillula; RV—right valve; L5, L6, L7—first, second and third thoracopods; W—width, ZMH — Zoological Museum, Hamburg.

## Systematics

**Class Ostracoda Latreille, 1802**

**Order Podocopida Sars, 1866**

**Suborder Podocopina Sars, 1866**

**Family Candonidae Kaufmann, 1900**

**Subfamily Candoninae Kaufmann, 1900**

**Tribe Candonini Kaufmann, 1900**

**Genus *Candona* Baird, 1845**

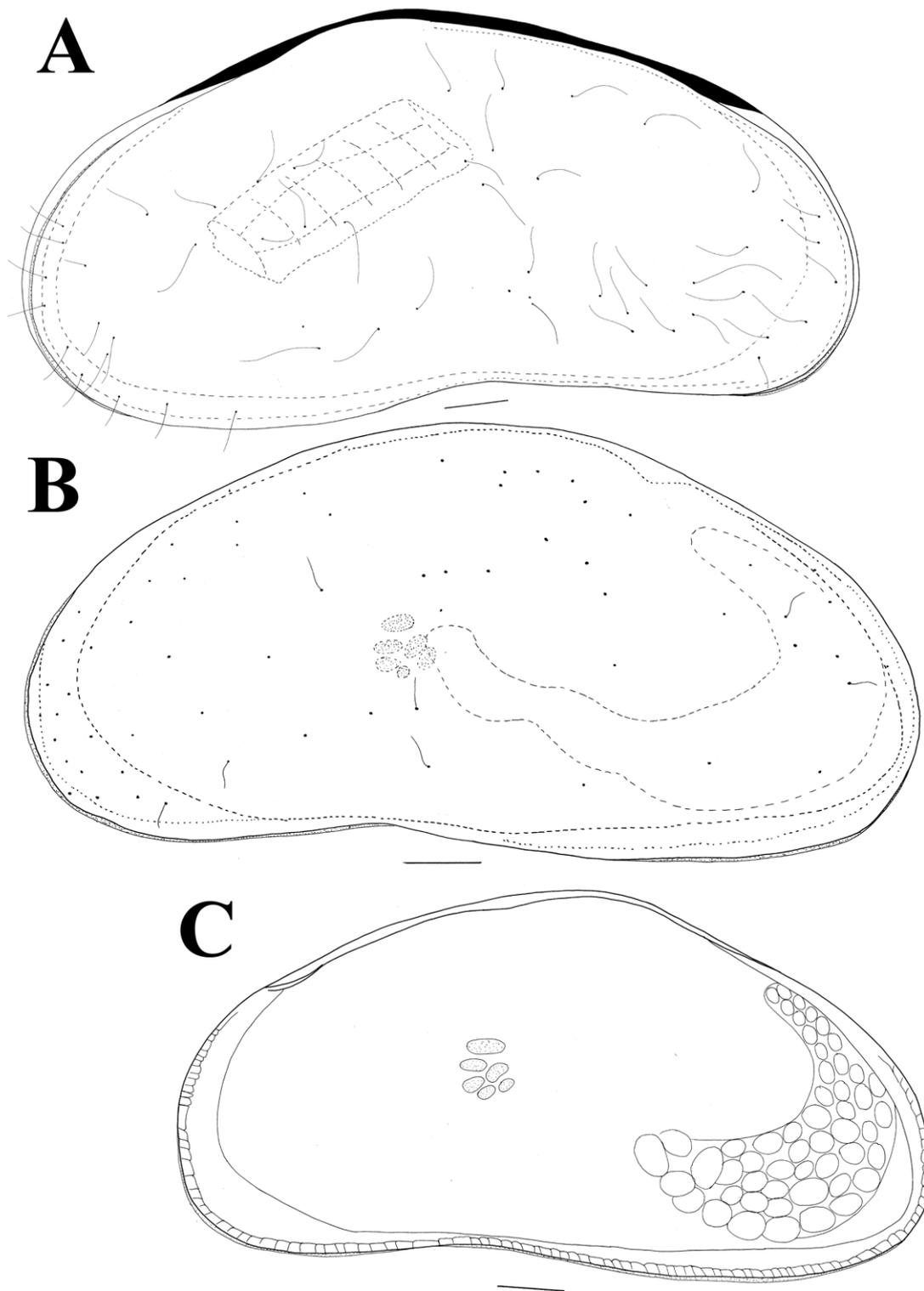
***Candona quasiakaina* sp. nov.**

(Figures 1–4)

**Etymology.** The new species is named after *Fabaeformiscandona akaina* Smith & Janz, 2008, because of their close resemblance. The specific name is composed with the Latin adjective *quasi*, meaning "appearing as if", which was prefixed to the specific name *akaina*. Gender feminine.

**Material examined.** Holotype male (soft parts dissected on one slide, shell not preserved NIBRIV0000245048), allotype female (soft parts dissected on one slide, shell mounted on micropaleontological slide NIBRIV0000245049); 9 paratypes (1 male soft parts dissected on one slide, shell mounted on micropaleontological slide NIBRIV0000245050; 1 female soft parts dissected on one slide, shell not preserved NIBRIV0000245051; 7 females in ethyl alcohol kept for future DNA studies), from (type locality) South Korea, Choenggye Mountain, freshwater stream, 37°25'25"N 127°03'55.2"E; 15/05/2011, collectors Hyunsu Yoo & Ivana Karanovic.

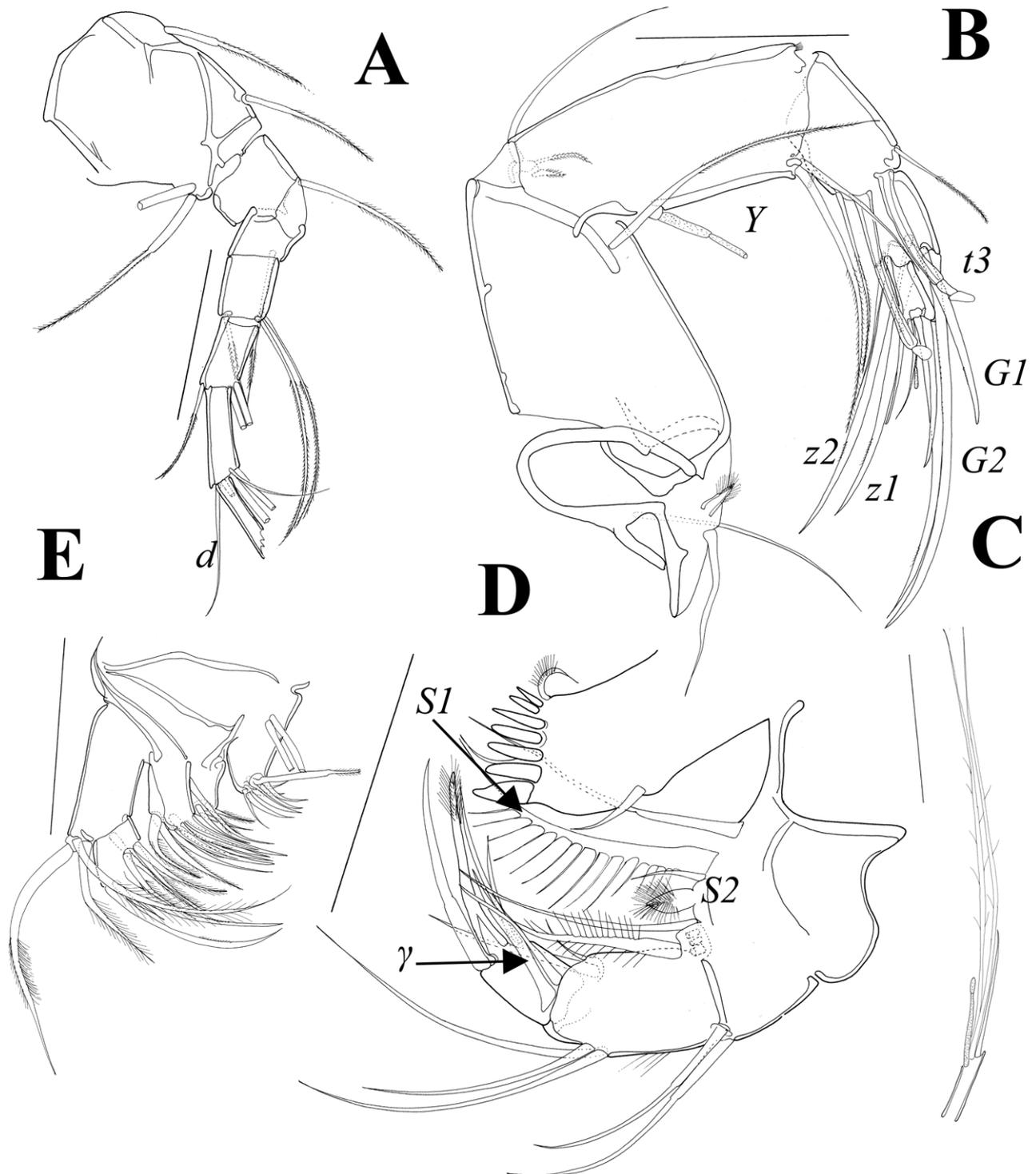
**Description.** Male. Carapace subtriangular in shape (Figure 1A) with the greatest H lying behind middle L, equaling 48% of total L. Size: L=1.3 mm. Dorsal margin highly arched and with slightly sharp angle at point of greatest H, then slightly sinusoid towards posterior and gently sloping towards anterior end. Anterior and posterior margins both broadly rounded and equally wide. Ventral margin concave around mouth region. Calcified inner lamella narrow on both ends, equaling less than 1% of total L. Fused zone also very narrow and marginal pore canals short, straight and denser anteriorly than posteriorly. Surface of shell covered with fine setulae, originating from small, but clear wart-like structures. No other surface ornamentation present. LV overlapping RV on all free margins, dorsally with narrow flange.



**FIGURE 1.** *Candona quasiakaina* sp. nov., A, holotype (male); B, C, allotype (female): A, carapace, lateral exterior view from the right side with Zenker organ indicated; B, LV, exterior view; C, RV, interior view. B and C with ovary indicated. Scales = 0.1 mm.

A1 (Figure 2A). Appendage 7-segmented. First segment with two setae anteriorly and two posteriorly. One anterior seta situated more proximally, the other distally on segment. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, reaching distal end of fourth segment. Third segment with one anterior pappose seta slightly exceeding distal margin of fourth segment. Fourth segment with one short posterior seta (exceeding distal end of the same segment), and two anterior, longer setae

(exceeding distal end of terminal segment); all these setae pappose. Fifth segment with same chaetotaxy as fourth one. Penultimate segment with total of five setae; posteriormost seta “d” present. Alpha seta slightly exceeding distal end of terminal segment. Seventh segment (Figure 2C) with posterior, claw-like seta which is as long as terminal segment, one aesthetasc (ya) of the same L, and two longer pappose setae. L ratio of five distal segments equaling 1 : 1.25 : 1.5 : 2 : 1.9. Rome and Wouters organs not present.



**FIGURE 2.** *Candona quasiakaina* sp. nov., holotype (male): A, A1; B, A2; C, terminal segment of A1; D, Md; E, Mxl. Scales = 0.1mm.

A2 (Figure 2B). Basal segment with total of three setae: one short, well-sclerotized and pappose, other two smooth and longer. One of the long setae situated dorsally and one ventrally on segment. Distal segment of

protopod with one, distally pappose seta exceeding distal margin of fourth endopodal segment. Exopod consisting of plate carrying one long (almost reaching distal end of first endopodal segment) and two short, pappose setae. Endopod 4-segmented, penultimate segment being divided, carrying two male sexual bristles. First endopodal segment with aesthetasc "Y" and antero-ventrally with two long setae (almost equally long). Second segment with one medio-dorsal (t4) seta, setae t3 and t2 transformed into sexual bristles (exceeding distal end of terminal segment) and one antero-ventral seta (t1). Same segment medio-ventrally with short aesthetasc y1. Third endopodal segment with claws G1, G2, z1 and z2, and setae G3 and z3. Claw G1 short (60% of first endopodal segment); G2 long (1.3 times longer than first endopodal segment); z1 slightly shorter than z2 and both approximately as long as first endopodal segment; G3 and z3 thin setae and half as long as z2 claw. Terminal segment with one long claw, Gm (approximately as long as first endopodal segment) and one short claw, GM (1.5 times longer than terminal segment). Terminal segment also armed with aesthetasc y3 (as long as terminal segment) and one thin seta accompanying y3. Claws very gently serrated.

Md (Figure 2D). First segment of palp with one plumose seta (S1), one pappose, short seta (S2), a short alpha seta, and one additional seta situated proximally on segment. Second segment dorsally with two setae, reaching distal end of following segment, ventrally with four setae originating from a small plate and one plumose seta; beta seta not observed. Penultimate segment dorsally with three almost equally long setae, gamma seta smooth, and three additional setae of which one originating medially and two ventrally. Terminal segment with two strong, well-sclerotized claws (medial one pappose distally) and two setae more ventrally.

Mxl (Figure 2E). Palp 2-segmented, first segment with four setae: three originating antero-distally, and one medio-distally. All these setae pappose. Terminal segment with two claw-like setae and four setae, one situated between claws, and three situated more posteriorly.

Prehensile palps (Figure 3C, D). Palps slightly asymmetrical, right one with more curved dorsal margin and more strongly pronounced ventral chitinous enlargement situated close to tip of finger. Finger on right palp slightly shorter in comparison to the body than on left palp. Both palps with well-developed subterminal structures.

L6 (Figure 3A). Basal segment with one seta (d1). Endopod 4-segmented (on one leg penultimate segment distally subdivided, creating a 5-segmented endopod). Setae "e", "f", and "g" all relatively short and pappose. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw as long as combined L of three distal segments.

L7 (Figure 3B). Basal segment with "d1" and "dp" setae. Seta "d2" missing. Endopod 4 segmented, and only "g" seta present distally. Terminal segment armed with two long and one short seta. L ratios between three "h" setae equaling: 1 : 1.8 : 1.8.

UR (Figure 3E). Slightly asymmetrical: on one ramus claws almost equally long, on other posterior claw clearly shorter than anterior one. Posterior seta very long and by far exceeding postero-distal margin of the ramus. Anterior seta much shorter and only  $\frac{1}{4}$  L of anterior claw. Both claws faintly serrated. L ratio between anterior margin, anterior claw, posterior claw and posterior seta equaling: 1.75 : 1.2 : 1 : 1.4.

Hemipenis (Figure 4A). Medial lobe well-sclerotized with evenly rounded distal margin. Lobe "h" square-shaped and with sclerotized margins. Lobe "a" with wavy distal margin (Figure 4B) and pointed, elongated outer end. Same lobe also sclerotized, sclerotized structure on inner margin with small septae, giving striate appearance. Inner duct not coiled.

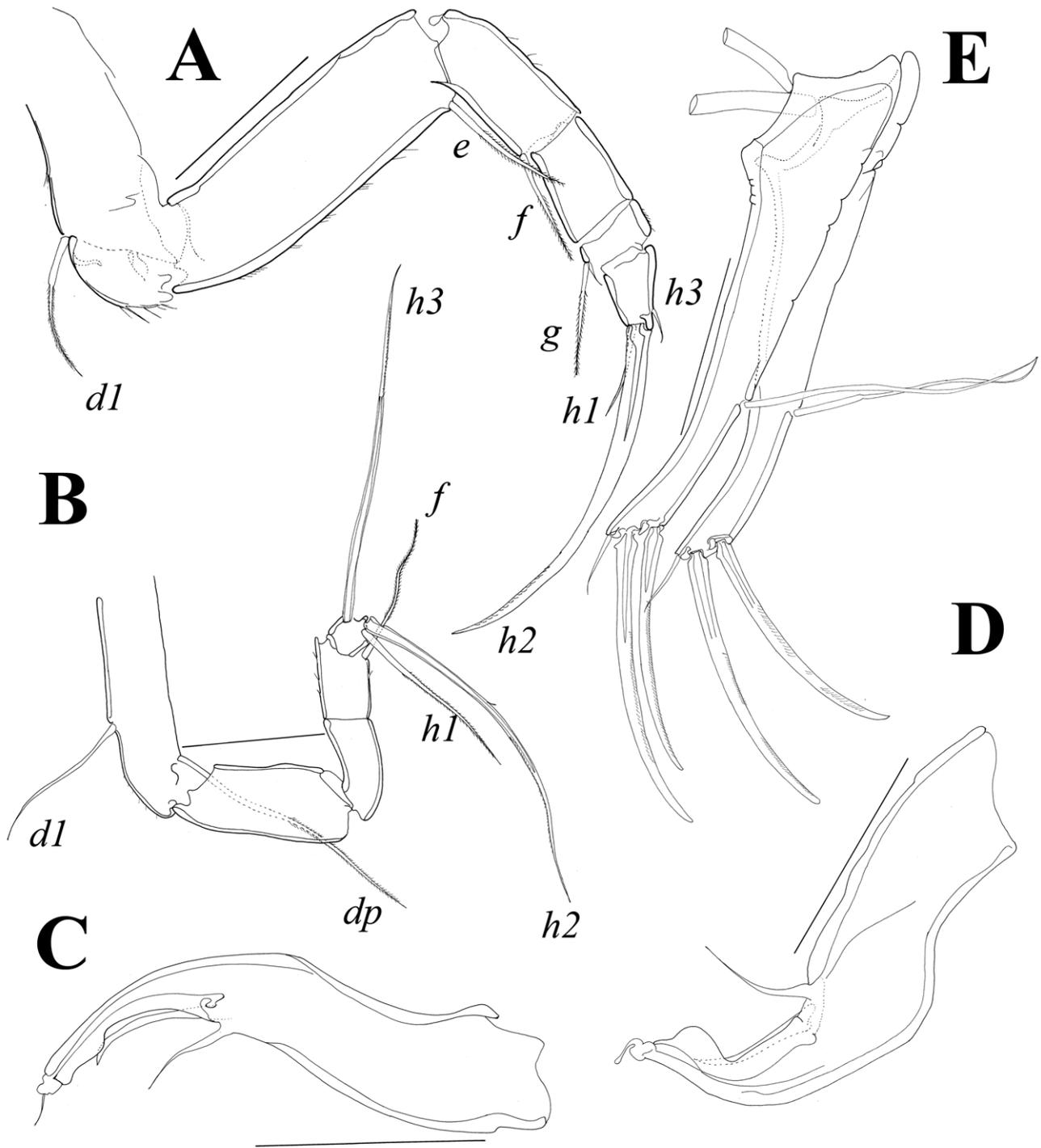
Zenker organ with seven rows of spines.

Female. Slightly smaller than males (Figure 1B, C), L=1.15 mm, otherwise very similar to male. Postero-dorsal margin not as sinusoid as in males, and wider anterior inner calcified lamella than in male.

A2 (Figure 4C). Endopod 3-segmented. All "t" setae on penultimate segment present, subequally long and pappose; exceeding distal end of terminal segment. None of "z" setae transformed into claws, and only two "z" setae visible, slightly exceeding distal end of terminal segment. Claw G2 equaling  $\frac{2}{3}$  of claw G1, which slightly longer than first endopodal segment. Claw G3 same as claw G1. Terminal segment with long claw Gm and short Gm. All claws gently serrated.

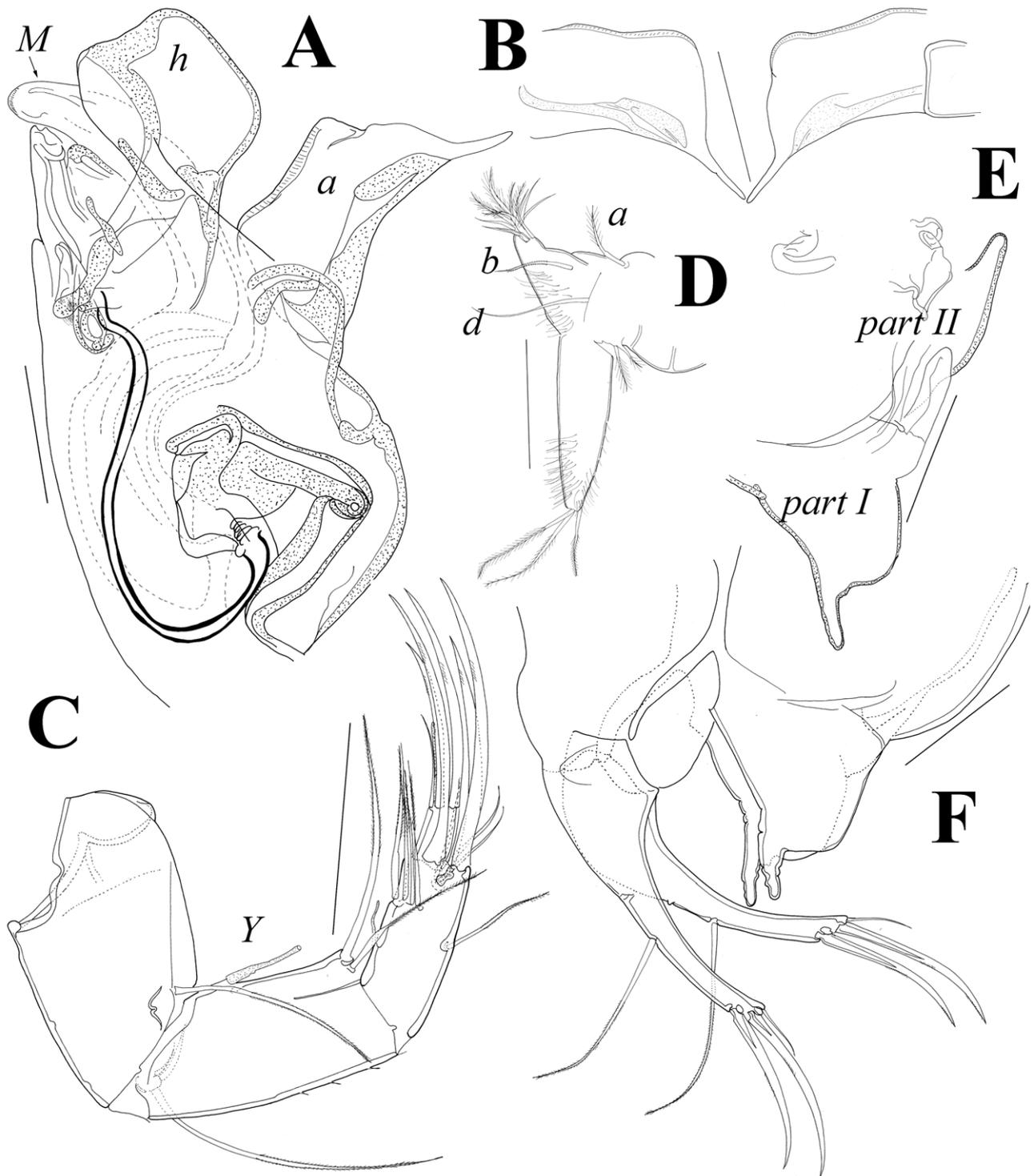
L5 (Figure 4D). Two setae present in exopod, one "a", one "b" and one "d" seta present. Distal setae on endopod relatively short and two subequally long, one half as long.

UR (Figure 4F) Similar to male, two rami slightly asymmetrical: on one, claws almost equally long, on other posterior claw obviously shorter. Posterior seta very long. Ramus also much wider proximally than in males. L ratios between anterior margin, anterior, posterior claw and posterior seta equaling: 1.5 : 1.1 : 1 : 1.3.



**FIGURE 3.** *Candona quasiakaina* sp. nov., holotype (male): A, L6; B, L7; C, left prehensile palp; D, right prehensile palp; E, UR. Scales = 0.1 mm.

Genital field (Figure 4E, F). Well-sclerotized around margins and consisting of anterior and posterior parts. Anterior part with one narrow but rounded end (Figure 4E), posterior part with one large square-like structure which dorsally extends into relatively small, narrow, but rounded process. All other appendages same as in male.



**FIGURE 4.** *Candona quasiakaina* sp. nov., A, B, holotype (male); C–F, allotype (female): A, hemipenis; B, variability of outer lobe of hemipenis; C, A2; D, L5; E, genital field; F, UR. Scales = 0.1 mm.

**Remarks and affinities.** Morphological data suggest that the new species is probably most closely related to *Fabaeformiscandona akaina* Smith & Janz, 2008, described from Lake Biwa, Japan. Smith & Janz (2008) placed the species in the genus *Fabaeformiscandona* Krstic, 1972, accepting the “broad” diagnosis of the genus, which follows Meisch (2000) who includes all species with a smooth “gamma” seta on the penultimate segment of the Md-palp, W/L ratio less than 40% and three (*fabaeformis*-group), four (*acuminata*- and *breuli*-group), and five setae (*balatonica*-group) internally on the second segment of Md-palp, into the genus *Fabaeformiscandona*.

Petkovski & Karanovic (2000, 2004) questioned the validity of the genus *Fabaeformiscandona*, because the type species of the genus *Eucandona* Daday, 1900, *E. balatonica* (Daday, 1900) (poorly known at the time) is placed into the genus *Fabaeformiscandona*, although this species differs in many details (including the carapace shape) from other *Fabaeformiscandona* species. Karanovic (2006) redefined the genus *Fabaeformiscandona*, proposing that it should include only species with a very low carapace in lateral view, without the most posterior (“d”) seta on the fifth segment of the A1, with a group of three setae on the internal margin of the second segment of the Md-palp, and, with a peculiar appearance of the male prehensile palp. The genus at the moment includes 39 Recent species (Karanovic 2012), but not all of those conform to the definition of the genus proposed by Karanovic (2006). The following species currently assigned to the genus should be given a new systematic position (in the genus *Candona* Baird, 1845 or *Eucandona*): *F. acuminata* (Fischer, 1851); *F. akaina* Smith & Janz, 2008; *F. bilobata* (Klie, 1938); *F. bilobatoides* (Löffler, 1961); *F. breuili* (Paris, 1920); *F. brevicornis* (Klie, 1925); *F. caudata* (Kaufmann, 1900); *F. danielopoli* Yin & Martens, 1998; *F. hyalina* (Brady & Robertson, 1870); *F. latens* (Klie, 1940); *F. levanderi* (Hirschmann, 1912); *F. nishinoae* Smith & Janz, 2008; *F. siliquosa* (Brady, 1910). We are here not proposing any new combinations, because the taxonomy and systematic of the genus *Candona* is far from being resolved and the actual relationship among many of the groups is still unknown, therefore the generic position may easily change in the future. On the other hand, we decided not to include *Candona quasiakaina* into the genus *Fabaeformiscandona*, although it is very closely related to some of its current representatives, because the genus *Fabaeformiscandona* should be much narrower (following Karanovic 2006) and all the species *C. quasiakaina* is related to, definitely do not belong there.

*Candona quasiakaina*, *Fabaeformiscandona akaina*, *F. nishinoae* Smith & Janz, 2008, *F. danielopoli* and *F. hyalina* from a group of very closely related species, in which the outer lobe of the hemipenis (lobe “a”) has a tapering/pointed tip. The second and third species are described from Lake Biwa and both differ from the Korean species by the long and finger-like process on the genital field in females; by a shorter posterior seta on the UR, and many details of the hemipenis. *Fabaeformiscandona danielopoli*, described from China (Yin & Martens 1998) also has a finger like genital process, more robust right prehensile palp, a shorter posterior seta on the UR and a quite different hemipenis. The carapace shape is very similar among the four species. *Fabaeformiscandona hyalina* has a supposedly Holarctic distribution (Meisch 2000) but has never been recorded in East Asia. It has a much smaller projection on the genital lobe, but, in contrary to the new species, it is broad and triangular. The posterior seta on the UR is also much shorter in *F. hyalina* and the outer lobe on the hemipenis is not as rectangular as in *C. quasiakaina*. The new species is also lower in lateral view, and the posterior margin is less inclined.

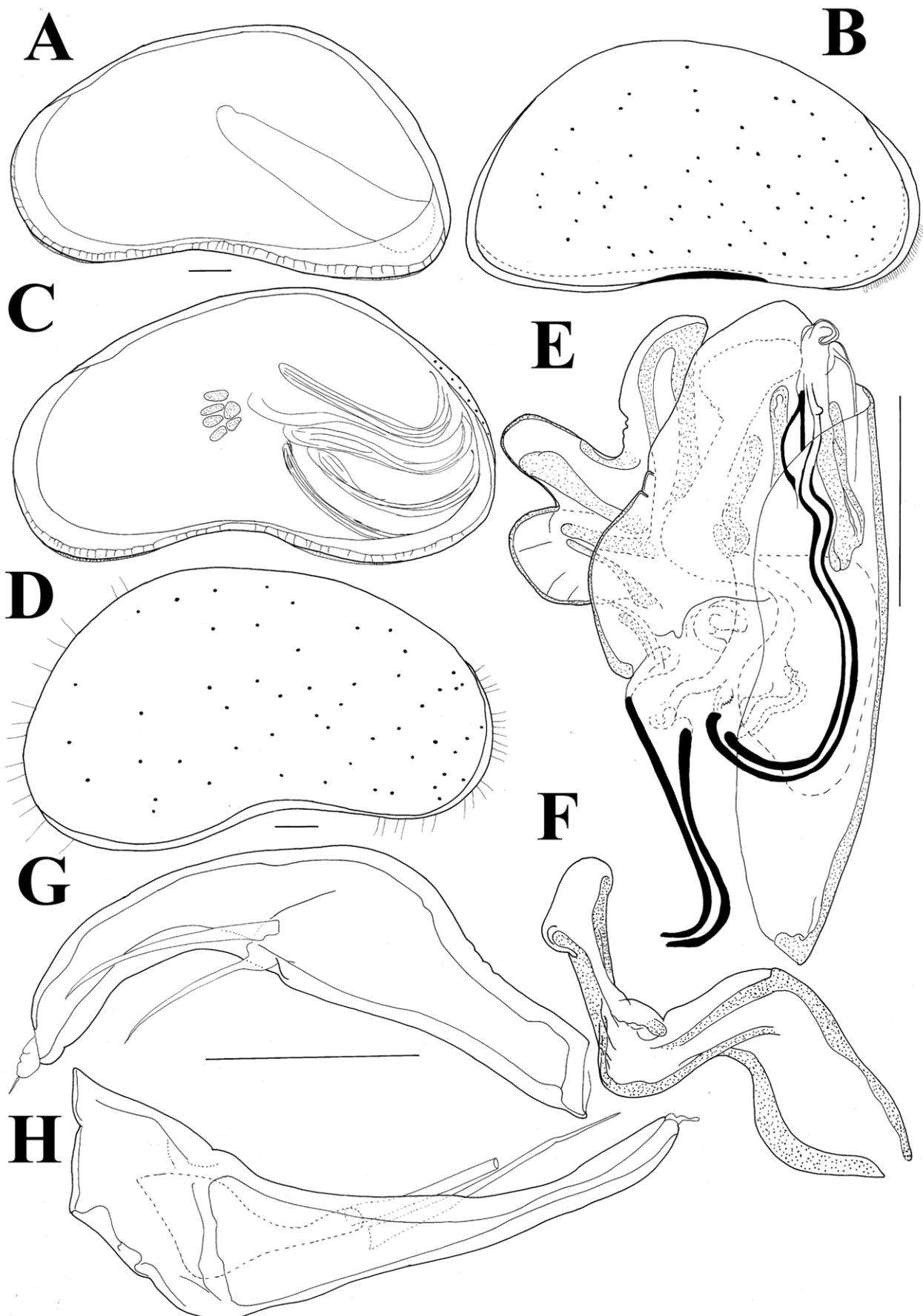
### ***Candona sillae* sp. nov.**

(Figures 5–7)

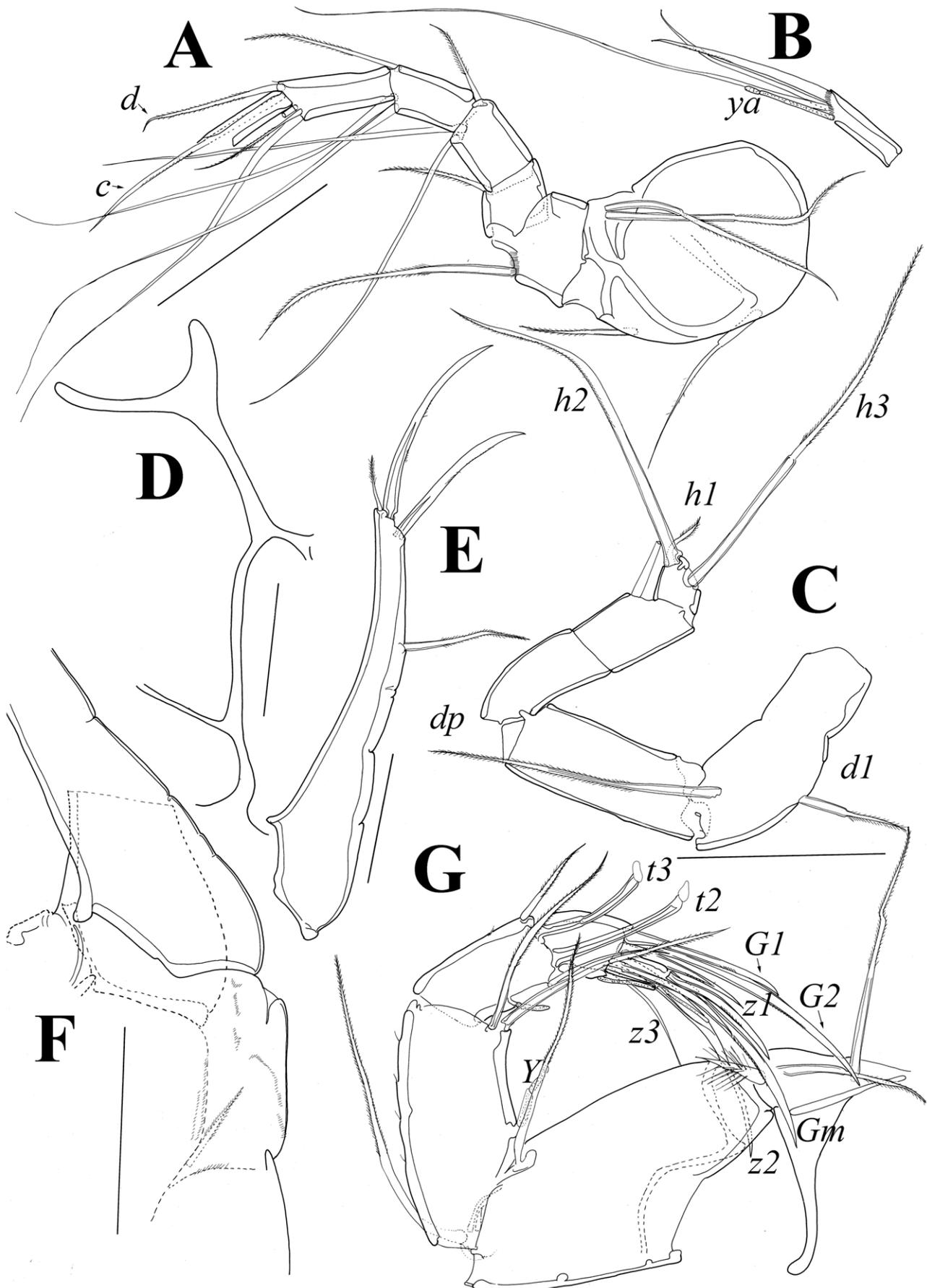
**Etymology.** The species is named after Silla, one of the three ancient kingdoms of Korea (57 BC—935 AD).

**Material examined.** Holotype male (soft parts dissected on one slide, shell kept on the same slide in a drop of Faure’s medium NIBRIV0000245052), allotype female (soft parts dissected on one slide, shell kept on the same slide in a drop of Faure’s medium NIBRIV0000245053); 2 paratypes (1 female and 1 male in alcohol kept for future DNA studies), from (type locality) South Korea, Choenggye Mountain, freshwater stream, 37°25’25”N 127°03’55.2”E; 15/05/2011, collectors Hyunsu Yoo & Ivana Karanovic.

**Description.** Male. Carapace subtriangular in shape (Figure 5C, D) with the greatest H lying well behind middle L, equaling 52% of total L. Size: L=1.08 mm. Dorsal margin highly arched and with blunt angle at point of greatest H, then inclined towards posterior end and gently sloping towards anterior end. Anterior margin broadly rounded, while posterior one almost straight. Ventral margin concave around mouth region. Calcified inner lamella narrow on both ends, equaling less than 1% of total L. Fused zone also very narrow and marginal pore canals short, straight and denser anteriorly than posteriorly. Surface of shell covered with fine setulae, originating from small, but clear wart-like structures. No other surface ornamentation present. LV overlapping RV on all free margins.



**FIGURE 5.** *Candona sillae* sp. nov., A, B, allotype (female); C–H, holotype (male): A, RV, inside view, with ovary imprints; B, carapace, lateral view from the right side; C, RV, inside view with testes imprints; D, carapace, outside view from the right side; E, hemipenis; F, piece “M” of hemipenis; G, right prehensile palp; H, left prehensile palp. Scales = 0.1 mm.



**FIGURE 6.** *Candona sillae* sp. nov., holotype (male): A, A1; B, terminal segment of A1; C, L7; D, attachment of UR; E, UR; F, proximal part of UR and end of the body, showing caudal seta; G, A2. Scales = 0.1 mm.

A1 (Figure 6A, B). Appendage 7-segmented. First segment with two setae anteriorly and two posteriorly. One anterior seta situated more proximally, the other distally on segment. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, not exceeding distal end of same segment. Third segment with one anterior, long and pappose seta slightly exceeding distal margin of fifth segment. Fourth segment with one short posterior seta (exceeding distal end of the same segment), and two anterior, longer setae (exceeding distal end of terminal segment). Fifth segment with same chaetotaxy as fourth one, except that posterior seta 1.5 times longer than on previous segment. Penultimate segment with total of five setae; posteriormost seta “d” present. Alpha seta slightly exceeding distal end of terminal segment. Seventh segment (Figure 6B) with posterior, claw-like seta twice as long as terminal segment, one aesthetasc (ya) as long as terminal segment, and two other setae, one being slightly longer than claw-like seta, other being much longer. L ratio of five distal segments equaling: 1 : 1.4 : 1.6 : 2 : 1.8. Rome and Wouters organs not present.

A2 (Figure 6G). Basal segment with total of three setae: one short, other two longer. One of the long setae situated dorsally and one ventrally on segment. Distal segment of protopod with one, distally pappose seta exceeding distal margin of fourth endopodal segment. Exopod consisting of plate carrying one long (almost reaching distal end of first endopodal segment) and two short, pappose setae. Endopod 4-segmented, penultimate segment being divided, carrying two male sexual bristles. First endopodal segment with aesthetasc “Y” and antero-ventrally with two long setae (almost equally long). Second segment with one medio-dorsal (t4) seta, setae t3 and t2 transformed into sexual bristles (exceeding distal end of terminal segment) and one antero-ventral seta (t1). Same segment medio-ventrally with short aesthetasc y1. Third endopodal segment with claws G1, G2, G3, z1 and z2, and seta z3. Claws G1 and G3 short (60% of first endopodal segment): G2 long (1.1 times longer than first endopodal segment); z1 equaling 2/3 of z2 and latter approximately as long as first endopodal segment; z3 thin seta and half as long as z2 claw. Terminal segment with one long claw, Gm (approximately as long as first endopodal segment) and one short claw, GM (1.5 times longer than terminal segment). Terminal segment also armed with aesthetasc, y3 (as long as terminal segment) and one thin seta accompanying y3. Claws very gently serrated.

Md (Figure 7A). First segment of palp with one plumose seta (S1), one pappose seta, and short alpha seta. Second segment dorsally with two setae, exceeding distal end of following segment, ventrally with pappose beta seta, five setae originating from a small plate and one plumose seta. Penultimate segment dorsally with three setae of which two are subequally long, and one almost half as long; gamma seta plumose, and three additional setae of which one originating medially and two ventrally. Terminal segment with two strong, well-sclerotized claws and two setae more ventrally.

Mx1 (Figure 7E). Palp 2-segmented, first segment with four setae: three originating antero-distally, and one medio-distally. All these setae pappose. Terminal segment with two claw-like setae and four setae, one situated between claws, and three situated more posteriorly.

Prehensile palps (Figure 5G, H). Palps asymmetrical, right one with more curved dorsal margin and more curved finger. Finger on left palp much longer than body and almost straight. Both palps with well-developed subterminal structures.

L6 (Figure 7C). Basal segment with one seta (d1). Endopod 4-segmented. Seta “e” and “f” reaching distal margins of their corresponding segments, seta “g” exceeding distal end of terminal segment. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw approximately as long as combined L of three distal segments.

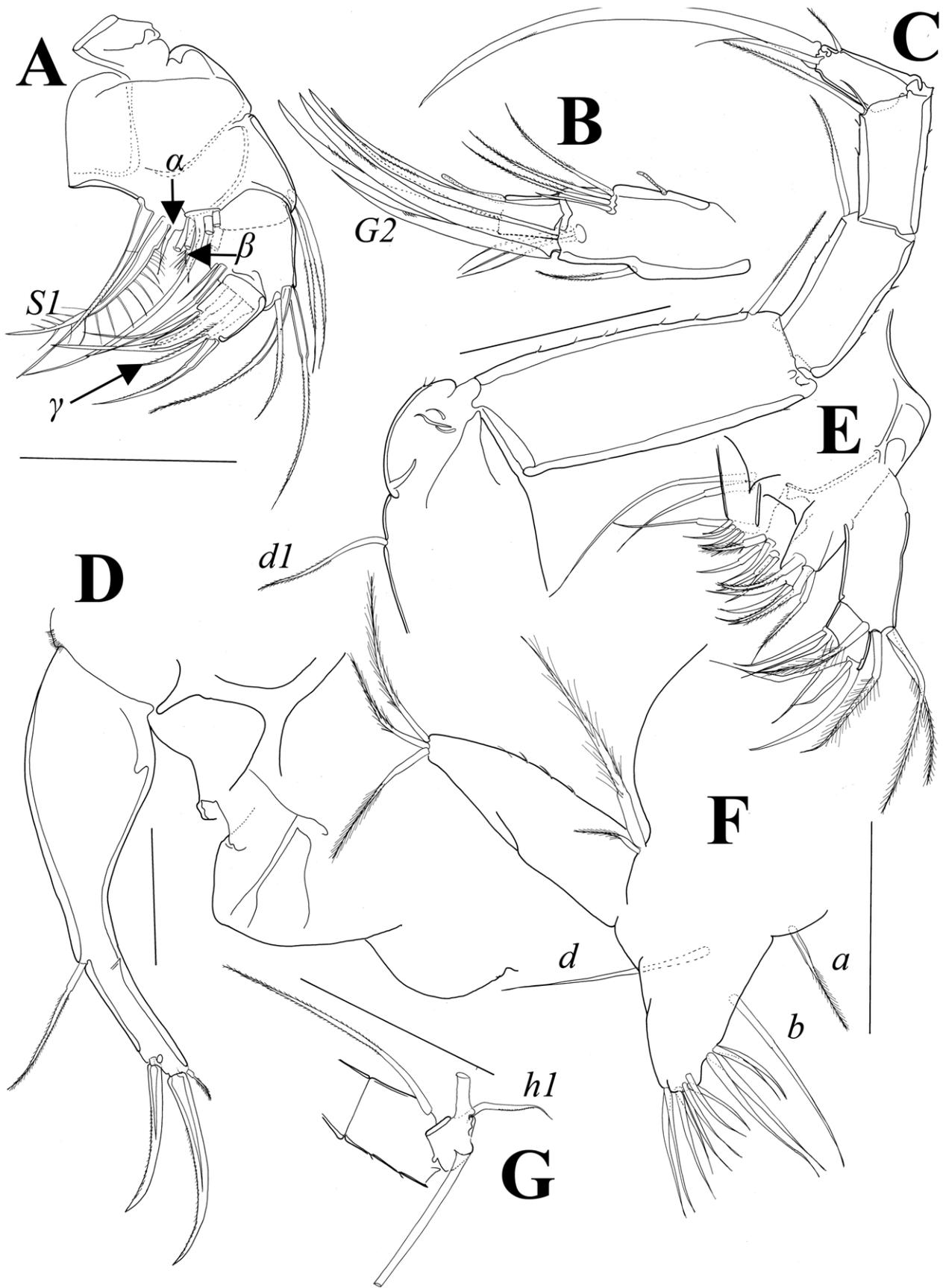
L7 (Figure 6C). Basal segment with “d1” and “dp” setae. Seta “d2” missing. Endopod 4-segmented, and only “g” seta present distally. Terminal segment armed with two long and one very short seta (h1). L ratios between three “h” setae equaling: 1 : 7.5 : 7.5. Seta h1 as long as terminal segment.

UR (Figure 6E, F). Symmetrical; posterior seta not very long and only reaching postero-distal margin of the ramus. Anterior seta much shorter and only ¼ L of anterior claw. Both claws faintly serrated. L ratio between anterior margin, anterior claw, posterior claw and posterior seta equaling: 2.7 : 1.7 : 1.4 : 1. Attachment (Figure 6D) with one dorsal and one ventral branch. Caudal seta present (Figure 6D).

Hemipenis (Figure 5E). Medial lobe (Figure 5F) well-sclerotized with boxer glove-like distal end. Lobe “h” slightly pointed on its distal end. Lobe “a” subdivided into three sub-lobes, more dorsal and medial tongue-like, lower square-shaped. Inner duct not coiled.

Zenker organ with seven rows of spines.

Female. Slightly smaller than males (Figure 5A, B), L=1 mm. Sexual dimorphism clearly pronounced in shape of posterior margin, which is straighter in females than in males. Also, ventral margin not as concave around mouth region as in males.



**FIGURE 7.** *Candonia sillae* sp. nov., A, C, E, holotype (male): B, D, F, G, allotype (female): A, Md; B, terminal part of A2; C, L6; D, UR; E, Mxl; F, L5; G, terminal part of L6. Scales = 0.1 mm.

A2 (Figure 7B). Endopod 3-segmented. All “t” setae on penultimate segment present, subequally long and pappose; three of those exceeding distal end of terminal segment. None of “z” setae transformed into claws exceeding distal end of terminal segment. Claw G2 equaling 2/3 of claw G1 which is slightly longer than first endopodal segment. Claw G3 same as claw G1. Terminal segment with long claw Gm and short Gm. All claws gently serrated.

L5 (Figure 7F). One “a”, “b” and “d” setae present. Terminal setae on endopod short, two subequally long and one slightly longer.

L7 (Figure 7G) with slightly longer h1 seta than in males.

UR (Figure 7D) Similar to male, two rami. Ramus also much wider proximally than in males. L ratios between anterior margin, anterior, posterior claw and posterior seta equaling: 2.5 : 1.3 : 1 : 1.

Genital field (Figure 7D). Projection globular, slightly pointed distally.

All other appendages same as in male.

**Remarks and affinities.** The new species is very closely related to *Candona improvisa* Ostermeyer, 1937. They are the only two species of the genus *Candona* that have a very short, and even peculiarly curved seta “h1” on the L7. In all other *Candona* species this seta is much longer. A short “h1” seta is often encountered in the genus *Typhlocypris*, i.e. in *eremita*- and *rostrata*-groups. *Candona improvisa* was described from Saxony-Anhalt, Germany (Ostermeyer 1937) and is known from Hungary, Poland and Slovakia (Meisch 2000). In both species the outer lobe on the hemipenis is subdivided: in the Korean species it is subdivided in three, while in the European species it is divided in two lobes. The other difference between the two species is the shape of the medial part (piece “M”) on the hemipenis, which is distally more rounded in *C. improvisa*. Genital field is also more acutely pointed in this species than in *C. sillae*. Other minor differences are related to the length of setae on the L6, while the A1, A2, Md, Mx1, L5, L7, and UR are almost identical in both species. A similar appearance of the lobe “a” is present in the North American *Candona inopinata* Furtos, 1933, described from Ohio (Furtos 1933) and redescribed based on the type material by Karanovic (2006). The American species, however, has four setae on the inner side of the second segment of the Md-palp, a different carapace shape (much higher in the lateral view), a different shape of the right prehensile palp, a finger-like projection on the genital field, and a long “h1” seta on the L7.

### ***Candona improvisa* Ostermeyer, 1937**

(Figure 8)

**Synonymy.** *Candona improvisa* Ostermeyer, 1937: p.155, Fig. 1.

*Candona improvisa* Ostermeyer: Meisch (2000), p. 73, Fig. 25.

**Material Examined** . Lectotype (here designated), male (ZMH 421a, soft parts dissected on one slide, shell not preserved); and paralectotype (here designated), female (ZMH 421b, soft parts dissected on one slide, shell not preserved), from (type locality) Germany, Saxony-Anhalt, Passendorfer Wiese, Halle a. S.

**Redescription. Male.** A1. Appendage 7-segmented. First segment with two setae anteriorly and two posteriorly. One anterior seta situated more proximally, the other distally on segment. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, not exceeding distal end of same segment. Third segment with one anterior, long and pappose seta slightly exceeding distal margin of fifth segment. Fourth segment with one short posterior seta (exceeding distal end of the same segment), and two anterior, longer setae (exceeding distal end of terminal segment). Fifth segment with same chaetotaxy as fourth one, except that posterior seta 1.5 times longer than that on previous segment. Penultimate segment with total of five setae; posteriormost seta “d” present. Alpha seta slightly exceeding distal end of terminal segment. Seventh segment with posterior, claw-like seta which is twice as long as terminal segment, one aesthetasc (ya) as long as terminal segment, and two other setae, one being slightly longer than claw-like seta, the other being much longer. L ratio of five distal segments equaling: 1 : 1.4 : 1.6 : 2 : 1.8. Rome and Wouters organs not present.

A2 (Figure 8E). Basal segment (not illustrated) with total of three setae: one short, the other two longer. One of the long setae situated dorsally and one ventrally on segment. Distal segment of protopod with one, distally pappose seta exceeding distal margin of fourth endopodal segment. Exopod consisting of plate carrying one long (almost reaching distal end of first endopodal segment) and two short, pappose setae. Endopod 4-segmented,

penultimate segment being divided, carrying two male sexual bristles. First endopodal segment with aesthetasc "Y" and antero-ventrally with two long setae (almost equally long). Second segment with one medio-dorsal (t4) seta, setae t3 and t2 transformed into sexual bristles (exceeding distal end of terminal segment) and one antero-ventral seta (t1). Same segment medio-ventrally with short aesthetasc y1. Third endopodal segment with claws G1, G2, G3, z1 and z2, and seta z3. Claws G1 and G3 short (60% of first endopodal segment): G2 long (1.1 times longer than first endopodal segment); z1 equaling 2/3 of z2 and latter approximately as long as first endopodal segment; z3 thin seta and half as long as z2 claw. Terminal segment with one long claw, Gm (approximately as long as first endopodal segment) and one short claw, GM (1.5 times longer than terminal segment). Terminal segment also armed with aesthetasc y3 (as long as terminal segment) and one thin seta accompanying y3. Claws very gently serrated.

Md. First segment of palp with one plumose seta (S1) and one pappose seta, and short alpha seta. Second segment dorsally with two setae, exceeding distal end of following segment, ventrally with pappose beta seta, five setae originating from a small plate and one plumose seta. Penultimate segment dorsally with three setae of which two are subequally long, and one almost half as long; gamma seta plumose, and three additional setae of which one originating medially and two ventrally. Terminal segment with two strong, well-sclerotized claws and two setae more ventrally.

Mx1. Palp 2-segmented, first segment with four setae: three originating antero-distally, and one medio-distally. All these setae pappose. Terminal segment with two claw-like setae and four setae, one situated between claws, and three situated more posteriorly.

Prehensile palps (Figure 8C, D). Palps asymmetrical, right one with more curved dorsal margin. Finger on left palp much longer than body. Both palps with well-developed subterminal structures.

L6. Basal segment with one seta (d1). Endopod 4-segmented. Seta "e" and "f" reaching distal margins of their corresponding segments, seta "g" exceeding distal end of terminal segment. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw approximately as long as combined L of three distal segments.

L7. Basal segment with "d1" and "dp" setae. Seta "d2" missing. Endopod 4-segmented, and only "g" seta present distally. Terminal segment armed with two long and one very short seta (h1). L ratios between three "h" setae equaling: 1 : 3.2 : 4. Seta "h1" three times longer than terminal segment.

UR (Figure 8F). Symmetrical; posterior seta not very long and only reaching postero-distal margin of the ramus. Anterior seta much shorter and only 1/4 L of anterior claw. Both claws faintly serrated. L ratio between anterior margin, anterior claw, posterior claw and posterior seta equaling: 2.2 : 1.3 : 1.15 : 1.

Hemipenis (Figure 8A, B). Medial lobe well-sclerotized with boxer glove-like, broadly rounded distal end. Lobe "h" slightly pointed on its distal end. Lobe "a" subdivided into two sub-lobes, more dorsal subquadrate distally and with small protrusion proximally, lower square-shaped. Inner duct not coiled.

Zenker organ with seven rows of spines.

Female. A2. Endopod 3-segmented. All four "t" setae on penultimate segment present, subequally long and pappose; three of those exceeding distal end of terminal segment. None of "z" setae transformed into claws exceeding distal end of terminal segment. Claw G2 equaling 2/3 of claw G1 which is slightly longer than first endopodal segment. Claw G3 same as claw G1. Terminal segment with long claw Gm and short Gm. All claws gently serrated.

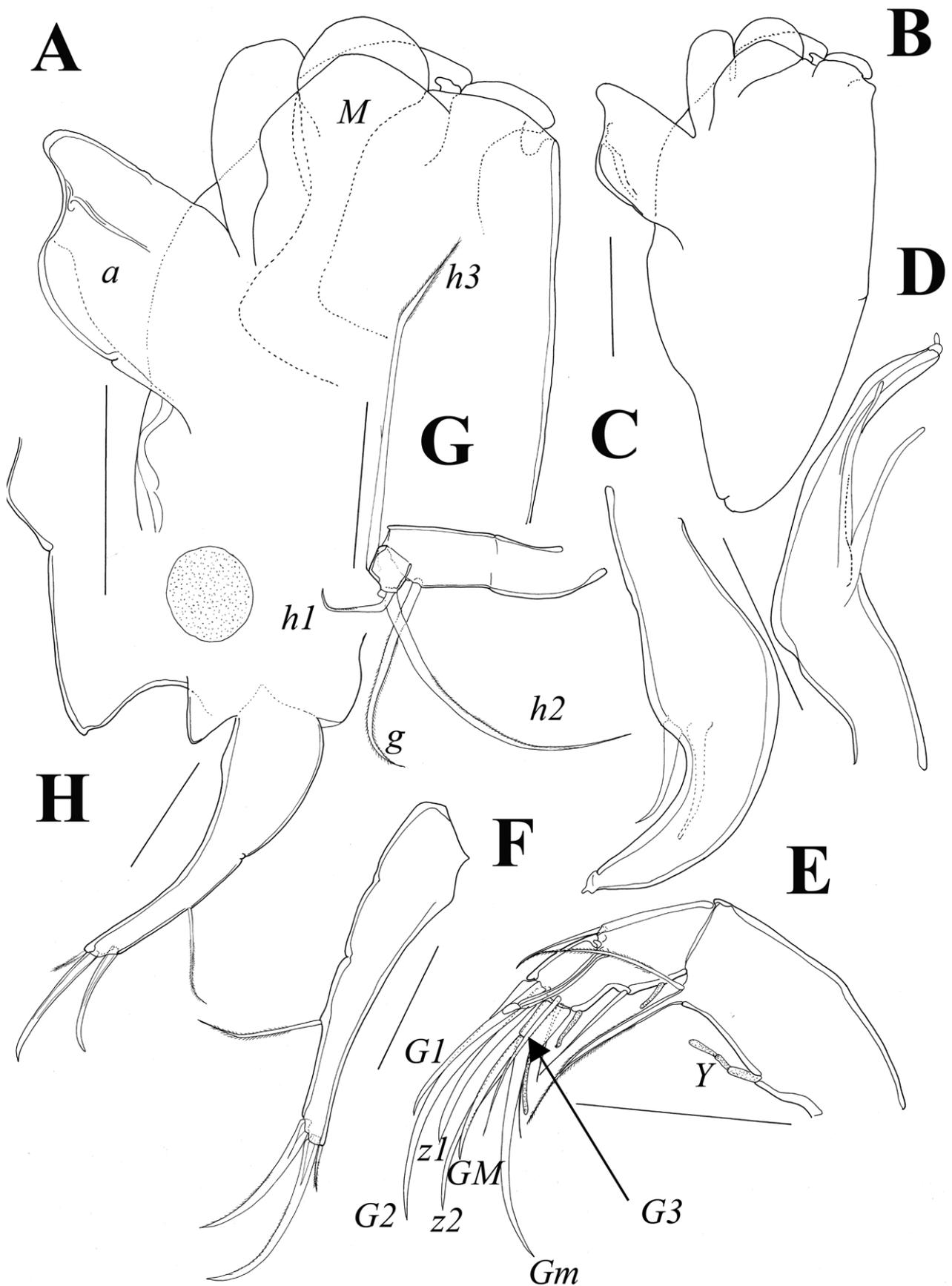
L5. One "a", "b" and "d" setae present. Terminal setae on endopod short, two subequally long, one slightly longer.

L7 (Figure 8G) same as in male.

UR (Figure 8H) Similar to male. Ramus much wider proximally than in males. L ratios between anterior margin, anterior, posterior claw and posterior seta equaling: 2.9 : 1.35 : 1 : 1.

Genital field (Figure 8H). On one field two projections present, both triangular in shape, on other field the projection closer to ramus apparently missing (maybe destroyed during dissection), the other same as on previous field.

All other appendages same as in male.



**FIGURE 8.** *Candona improvisa* Ostermeyer, 1937, A–F lectotype (male) (ZMH421a); G, H paralectotype (female) (ZMH421b): A, details of the hemipenis; B, hemipenis, general view; C, right prehensile palp; D, left prehensile palp; E, A2; F, UR; G, distal part of L7; H, UR with genital field. Scales = 0.1 mm.

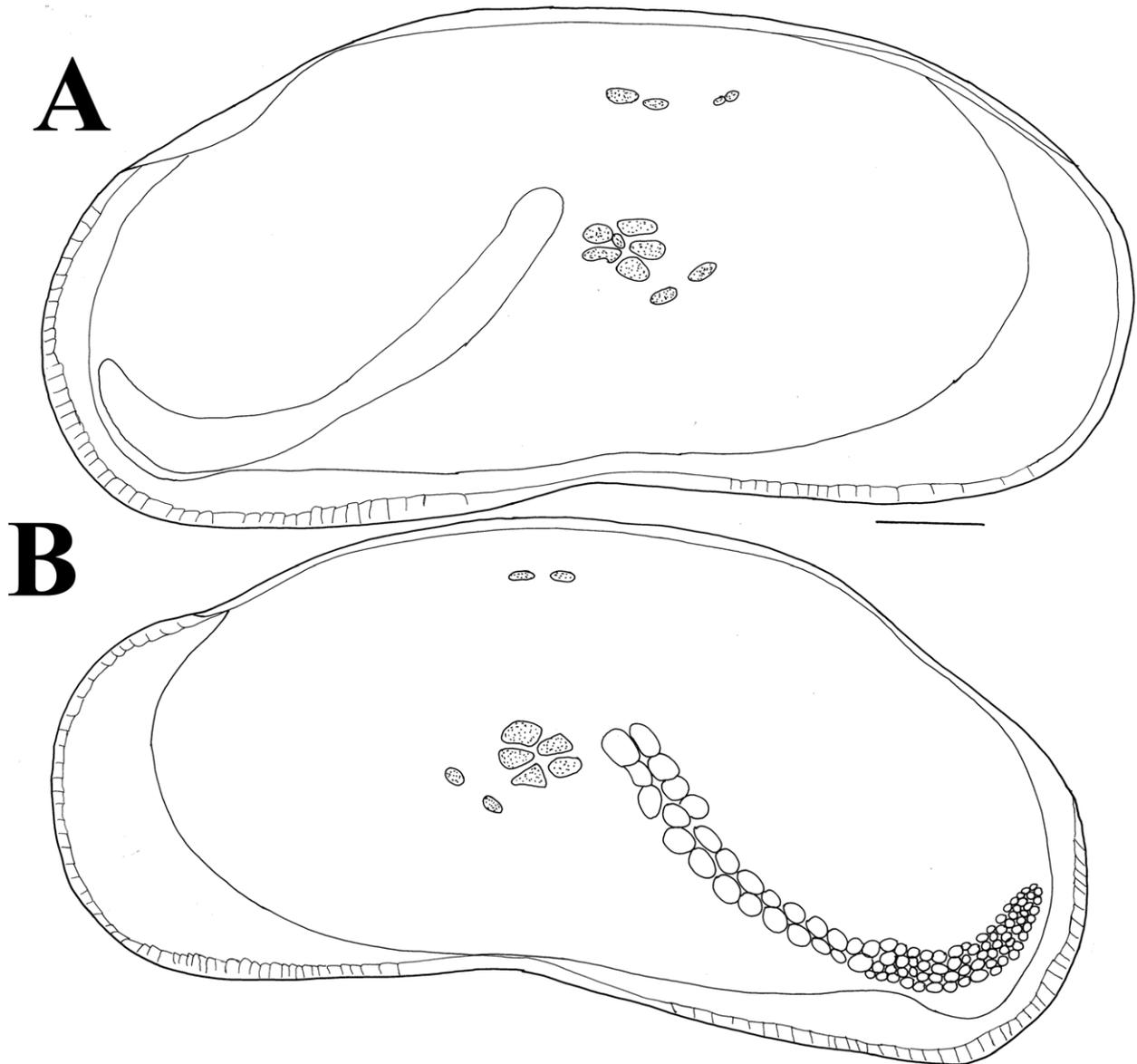
Genus *Fabaeformiscandona* Krstic, 1972

*Fabaeformiscandona koreana* sp. nov.

(Figures 9–11)

**Etymology.** The species is named after Korea. The name is in genitive singular.

Material examined. Holotype female (soft parts dissected on one slide, shell kept in ethyl alcohol NIBRIV0000245054a), paratypes (juvenile female in ethyl alcohol NIBRIV0000245054b), from (type locality) South Korea, Jilmoeneup, freshwater swamp, 37°47'49"N 128°40'41"E, 20/05/2006, collector Dongju Lee.



**FIGURE 9.** *Fabaeformiscandona koreana* sp. nov., holotype (female): A, LV, inside view; B, RV, inside view. Scales = 0.1 mm.

Description. Female: Carapace subrectangular in lateral view (Figures 9A, B; 10A, B) with the greatest H lying around middle L, equaling 47% of total L. Size: L=1 mm. Dorsal margin very gently curved medially, rounded toward anterior end and sinusoid on postero-dorsal part. Anterior and posterior margins both broadly rounded and almost equally wide, posterior being slightly narrower than anterior one. Ventral margin concave

around mouth region. Calcified inner lamella narrower posteriorly than anteriorly. Anteriorly equaling 10%, posteriorly less than 1% of total L. Lamella sinusoid in postero-ventral region, otherwise following contour of shell. Fused zone also very narrow and marginal pore canals short, straight and denser anteriorly than posteriorly. Surface of shell covered with fine setulae, originating from small, but clear wart-like structures. No other surface ornamentation present. LV overlapping RV on all free margins, with one keel-like flange postero-dorsally.

A1 (Figure 11E). Appendage 7-segmented. First segment with two setae anteriorly and two posteriorly. One anterior seta situated more proximally, other distally on segment. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, not reaching distal end of fourth segment. Third segment with one anterior seta reaching distal margin of sixth segment. Fourth segment with one short posterior seta (reaching middle L of following segment), and two anterior, longer setae (exceeding distal end of terminal segment). Fifth segment with same chaetotaxy as fourth one, except that most posterior seta is much stiffer. Penultimate segment with total of four setae; posteriormost seta "d" absent (see arrow on figure 11E). Alpha seta exceeding distal end of terminal segment. Seventh segment (Figure 11F) with posterior, claw-like seta which is 2.4 times as long as terminal segment, one aesthetasc (ya), 1.6 times longer than terminal segment, and two longer setae. L ratio of five distal segments equaling: 1 : 1.5 : 1.2 : 1.5 : 1.7. Rome and Wouters organs not present.

A2 (Figure 11G). Basal segment (not illustrated) with total of three setae: one short, well-sclerotized and pappose, other two smooth and longer. One of the long setae situated dorsally and one ventrally on segment. Distal segment of protopod with one, distal pappose seta exceeding distal margin of first endopodal segment. Exopod consisting of plate carrying one long (exceeding distal end of first endopodal segment) and two short, pappose setae. Endopod 3-segmented. First endopodal segment with aesthetasc "Y" and antero-ventrally with two long setae (one half as long as the other). Second segment with one medio-dorsal seta and four "t" setae ventrally. Same segment medio-ventrally with short aesthetasc y1. Claws G1, G2 and G3 all well developed, G2 reaching 2/3 of G1 and G3. Long claws as long as first endopodal segment. Only two "z" setae observed. Terminal segment with one long claw, GM (slightly shorter than first endopodal segment) and one short claw, Gm (2.3 times longer than terminal segment). Terminal segment also armed with aesthetasc y3 (longer than terminal segment) and one thin seta accompanying y3. Claws very gently serrated.

Md (Figure 10D). First segment of palp with one plumose seta (S1), one pappose, short seta (S2), alpha seta (short and smooth) and one additional pappose seta. Second segment dorsally with two setae, exceeding distal end of following segment, ventrally with beta seta, three plumose setae originating from a small plate, and one pappose seta. Penultimate segment dorsally with three almost equally long setae, gamma seta faintly pappose, and three additional setae of which one originating medially and two ventrally. Terminal segment with two strong, well-sclerotized claws and three setae more ventrally.

Mx1 (Figure 10C). Palp 2-segmented, first segment with four setae: three originating antero-distally, and one medio-distally. All these setae pappose. Terminal segment with two claw-like setae and four setae, one situated between claws, and three situated more posteriorly.

L5 (Figure 10E). Exopod with two rays. One "a", one "b" and one "d" seta present. Endopod distally with three short, subequal setae.

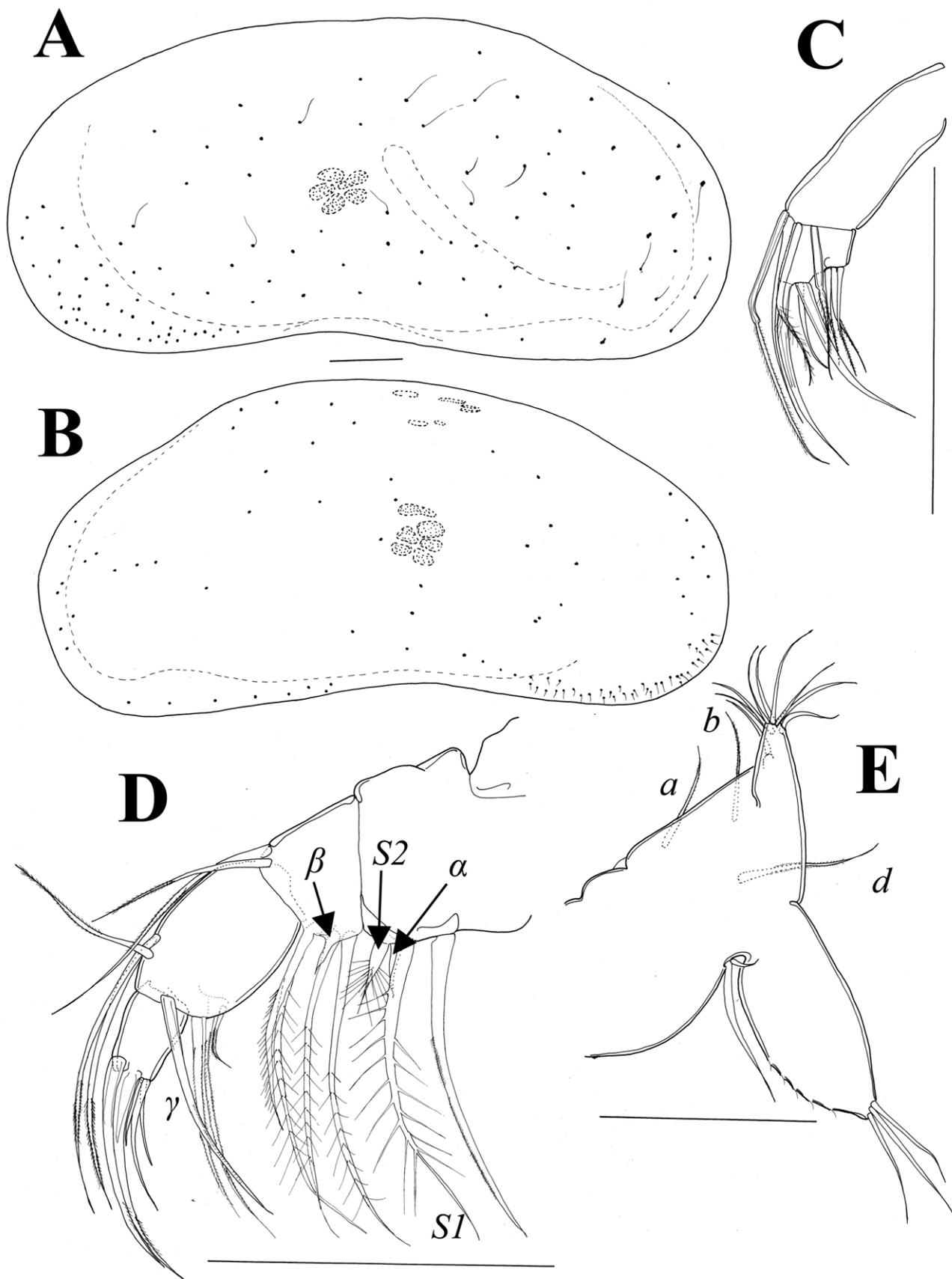
L6 (Figure 11A, B). Basal segment with one seta (d1). Endopod 4-segmented. Setae "e", "f", and "g" all relatively short and pappose. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw as long as combined L of three distal segments.

L7 (Figure 11C). Basal segment with "d1" and "dp" setae. Seta "d2" missing. Endopod 4-segmented, and only "g" seta present distally. Terminal segment armed with two long and one short seta. L ratios between three "h" setae equaling: 1 : 2.9 : 3.5.

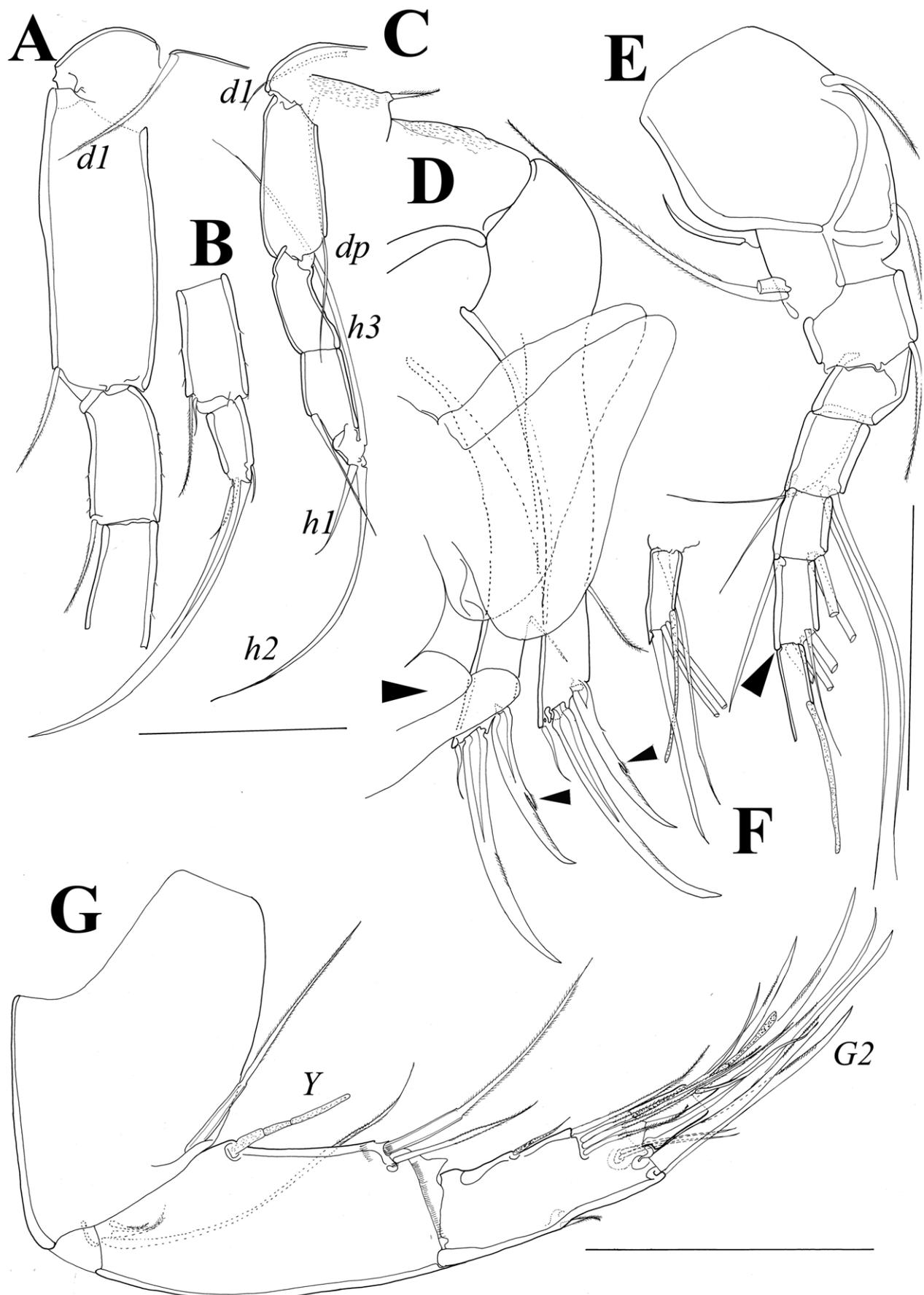
UR (Figure 11D). Symmetrical, with posterior claw 2/3 of anterior one. Posterior seta not very long and only reaching postero-distal margin of the ramus. Anterior seta much shorter and only 1/4 L of anterior claw. Posterior claw with clear spine medially (SEE ARROW ON FIGURE 11D), and both claws also serrated. L ratios between anterior margin, anterior claw, posterior claw and posterior seta equaling: 4.7 : 2.6 : 1.7 : 1

Genital field (Figure 11D). Two processes present, one more anterior, cylindrical with rounded distal end (see arrow on figure 11D), the other more prominent and subtriangular.

Male. Unknown.



**FIGURE 10.** *Fabaeformiscandona koreana* sp. nov., holotype (female): A, LV, outside view; B, RV, outside view; C, Mx1 palp; D, Md-palp; E, L5. Scales = 0.1 mm.



**FIGURE 11.** *Fabaeformiscandona koreana* sp. nov., holotype (female): A, proximal part of L6; B, distal part of L6; C, L7; D, UR with genital field, arrows showing second projection on the genital field and the prominent spines on the claws; E, A1, arrows pointing the absence of “d” seta; F, terminal segment of A1; G, A2. Scales = 0.1 mm.

**Remarks and affinities.** The new species clearly belongs to the genus *Fabaeformiscandona* because of the carapace shape, the presence of three setae on the internal side of the second segment of the Md-palp, and because of the absence of the most posterior (“d”) seta on the penultimate segment of the A1. As discussed under *Candona quasiakaina* **sp. nov.**, the genus *Fabaeformiscandona* currently comprises many species which do not conform with the narrow definition of the genus proposed by Karanovic (2006). The genus comprises four groups of species: *fabaeformiscandona*– *acuminata* – *balatonica* –, and *breuli* – group. Species belonging to the first group have three setae on the second segment of the Md-palp, in *acuminata* – and *breuli* – groups, this segment is armed with four setae, while in *balatonica* – group there are five setae (Meisch 2000, Smith & Kamiya 2007, Smith & Janz 2008). The following species belong to the *fabaeformis* – group: *F. aemonae* (Klie, 1935); *F. alexandri* (Sywula, 1981); *F. angusta* (Ostermeyer, 1937), *F. brisiaca* (Klie, 1938), *F. condylea* Smith & Janz, 2008; *F. dolabella* Smith & Janz, 2008; *F. fabaeformis* (Fischer, 1851); *F. fragilis* (Hartwig, 1898); *F. holtzkampfi* (Hartwig, 1900); *F. japonica* (Okubo, 1990); *F. krstici* (Petkovski, 1969); *F. myllaina* Smith & Kamiya, 2007; *F. okuboi* Smith & Janz, 2008; *F. paterea* Smith & Janz, 2008; *F. pedana* Smith & Janz, 2008; *F. svetožari* (Petkovski & Karanovic, 2004); *F. tora* Smith & Kamiya, 2007; *F. velifera* Smith & Janz, 2008, and *F. yajimae* Smith & Janz, 2008.

*Fabaeformiscandona aemonae* (Klie, 1935), described from a cave in Slovenia, has a completely atypical appearance of the hemipenis, closely resembling *Schellencandona* Meisch, 1998 and/or *Typhlocypris* Vejdovský, 1882 and should be transferred to one of these genera. It is a similar case with *F. brisiaca*, another stygobiont species, described from wells in the Rhine valley (Klie 1938). *Fabaeformiscandona angusta* is known only after females (Ostermeyer 1937, Meisch 2000), but the carapace shape and the genital field do not conform to the other representatives of *Fabaeformiscandona*, and this species is more likely to belong to *Candona* Baird, 1845 or *Schellencandona*.

The following species, described from Lake Biwa (Smith & Janz 2008), have an isolated position within the genus: *F. okuboi*, *F. condylea*, and *F. dolabella*. The first species has a peculiar appearance of the hemipenis with the piece “M” missing, the prehensile palps do not have a typical *fabaeformis* appearance, but are less asymmetrical and simpler, and the genital field in females does not have any projections. The shape of the carapace is also with a less (if at all) pronounced sexual dimorphism, typical for the genus *Fabaeformiscandona*, and without a steep postero-dorsal margin in females. *Fabaeformiscandona condylea* was found in the interstitial of Lake Biwa, and, like *F. okuboi*, does not have a strong sexual dimorphism in the carapace shape, has simple, not hook-like fingers on the prehensile palp, and lacks piece “M” on the hemipenis. Additionally, the seta “z2” on the male A2 is not claw-like but is a simple seta. In all other *Fabaeformiscandona* both “z1” and “z2” are transformed into claws. The last species, *F. dolabella*, has a distinct “M” piece on the hemipenis, but the genital field lacks any projections, prehensile palps are simple and, like in *F. condylea*, “z2” is seta like. This species is more closely related to the *breuli* – group of the genus, having a similar carapace shape, morphology of hemipenis and prehensile palps. The *breuli* – group, on the other hand, has four setae on the Md-palp second segment internally. *Fabaeformiscandona dolabella* is probably more closely related to a group of North American Candoninae, such as *C. crogmaniana* Turner, 1985, *C. inopinata* Furtos, 1933 and *C. intermedia* Furtos, 1933 with which it shares almost the same morphology of the prehensile palps and a similar hemipenis. Nevertheless, all those North American species have four setae on the Md-palp, and both “z1” and “z2” setae on the male’s A2 transformed into claws. It is interesting to note here that a “true” *Fabaeformiscandona* species has never been recorded from North America.

All other species listed above are closely related to the type species of the genus, *F. fabaeformis*, and without any doubt form a clear phylogenetic lineage. The new Korean species is, unfortunately, known only after females, but the peculiar morphology of the genital field (two projections) and a strong spine on the posterior claw of the UR, clearly separate it from other congeners.

## Genus *Typhlocypris* Vejdovský, 1882

### *Typhlocypris choi* **sp. nov.**

(Figures 12–14)

**Etymology.** The species name is dedicated to Dr. Joo-Lae Cho (National Institute of Biological Resources, Korea), as a recognition of his outstanding contribution towards the knowledge of interstitial fauna of Korea.

**Material examined.** Holotype female (soft parts dissected on one slide, shell kept on micropaleontological slide NIBR0000245055), from (type locality) South Korea, Gangwondo, Wonju, Jijeong, River interstitial, 37°23'30"N, 127°51'08"E; 24/06/2010, collector Joo-Lae Cho.

One female (in ethyl alcohol NIBRIV0000245056), from South Korea, Gangwondo, Pyeongchang, Jinbu, Namhan river (freshwater), interstitial, 37°36'56"N, 128°32'23"E; 12/06/2010, collector Joo-Lae Cho.

One juvenile female (in ethyl alcohol NIBRIV0000245057), from South Korea, Gangwondo, Pyeongchang, Jinbu, Odae river, interstitial, 37°36'43"N, 128°33'09"E; 24/04/2010, collector Joo-Lae Cho.

**Description.** Female. Carapace reniform in shape (Figure 12A, B) with the greatest H lying slightly behind middle L, equaling 50% of total L. Size: L=0.7 mm. Dorsal margin almost evenly rounded and slightly more curved towards posterior and inclined towards anterior end. Anterior and posterior margins both broadly rounded, posterior being slightly narrower than anterior one. Ventral margin almost straight along entire L. Calcified inner lamella narrow on both ends, anteriorly equaling 12%, posteriorly less than 1% of total L. Fused zone also very narrow and marginal pore canals short, straight and denser anteriorly than posteriorly. Surface of shell covered with fine setulae, originating from small, but clear wart-like structures. No other surface ornamentation present. LV overlapping RV on all free margins.

A1 (Figure 14B). Appendage 7-segmented. First segment with two setae anteriorly and two posteriorly. One anterior seta situated more proximally, the other distally on segment. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, almost reaching distal end of fourth segment. Third segment with one anterior pappose seta not reaching distal margin of fifth segment. Fourth segment with one short posterior seta (not exceeding distal end of fifth segment), and two anterior, longer setae (exceeding distal end of terminal segment); all these setae pappose. Fifth segment with same chaetotaxy as fourth one. Penultimate segment with total of four setae; posteriormost seta "d" absent. Alpha seta not reaching distal end of terminal segment. Seventh segment with posterior, claw-like seta 1.5 times longer than terminal segment, one aesthetasc (ya) of the same length, and two longer pappose setae. L ratio of five distal segments equaling: 1 : 1 : 1.3 : 1.3 : 1.4. Rome and Wouters organs not present.

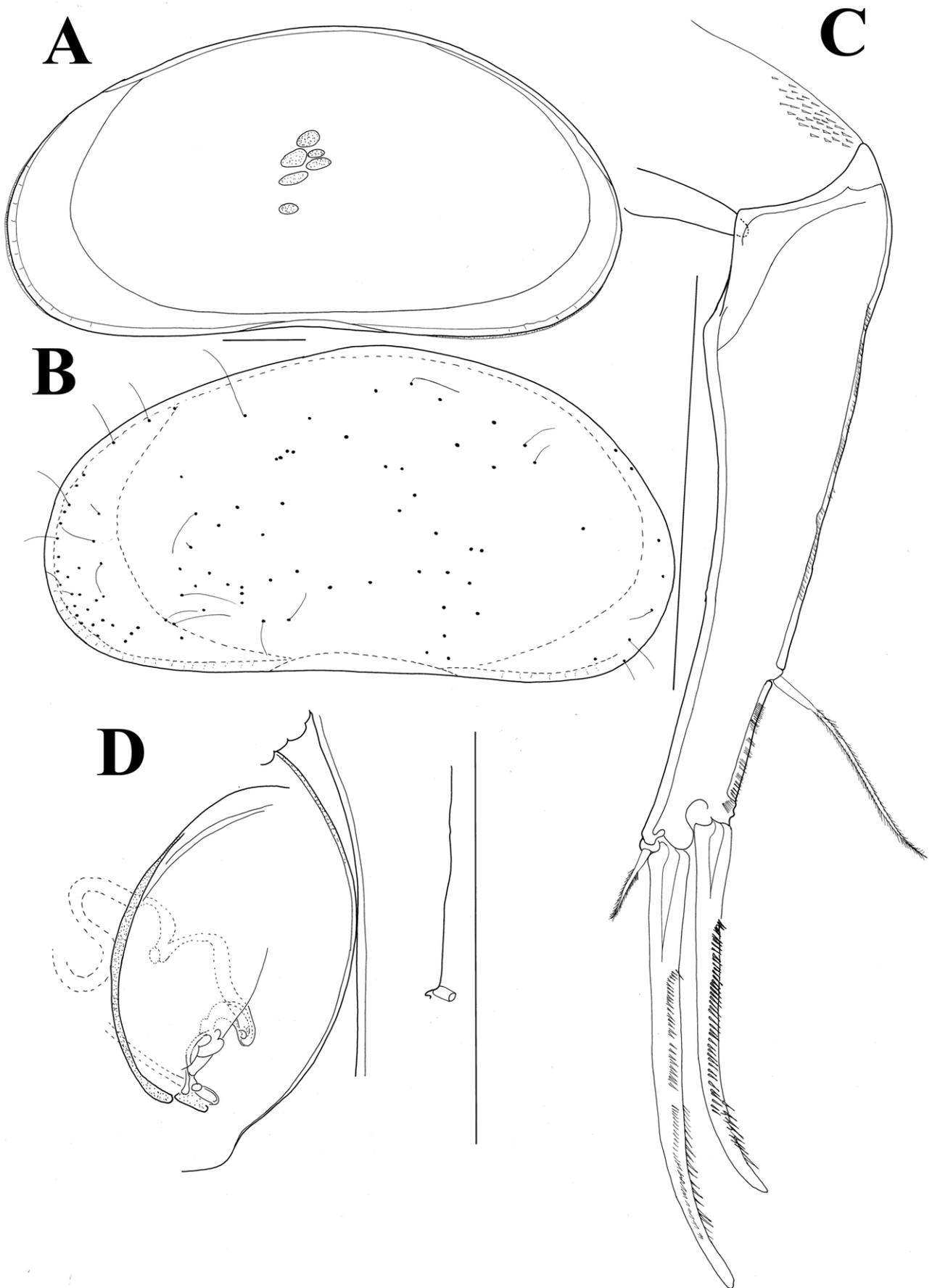
A2 (Figure 13B, E). Basal segment with total of three setae of subequal L, one situated dorsally and two ventrally on segment. Protopod with one, distally pappose seta exceeding distal margin of second endopodal segment. Exopod consisting of plate carrying one long (almost reaching distal end of first endopodal segment) and two short, pappose setae. Endopod 3-segmented. First endopodal segment with aesthetasc "Y" and antero-ventrally with two setae. Second segment with one medio-dorsal seta, only two "t" setae visible (exceeding distal end of terminal segment). Same segment medio-ventrally with short aesthetasc y1. Third endopodal segment with claws G1, G2 and G3; G2 being less than half as long as G1. Seta z1 transformed in short claw, slightly exceeding distal end of terminal segment, other two seta-like and of same L. Third segment distally with aesthetasc y2. Terminal segment with one long claw, GM and one short claw, Gm (twice as long as terminal segment). Terminal segment also armed with aesthetasc y3 (1.5 times as long as terminal segment) and one thin seta accompanying y3. Claws very gently serrated.

Md (Figure 14A). First segment of palp with one plumose seta (S1), one pappose, one short seta (S2), the short alpha seta, and one additional seta situated proximally on segment. Second segment dorsally with two setae, reaching distal end of following segment, ventrally with three setae originating from a small plate and one plumose seta; beta seta short and smooth. Penultimate segment dorsally with three almost equally long setae, gamma seta faintly pappose, and three additional setae of which one originating medially and two ventrally. Terminal segment with two strong, well-sclerotized claws (lateral one pappose distally, medial claw serrated) and two setae more ventrally. Exopod Md (Figure 13D) with seven rays.

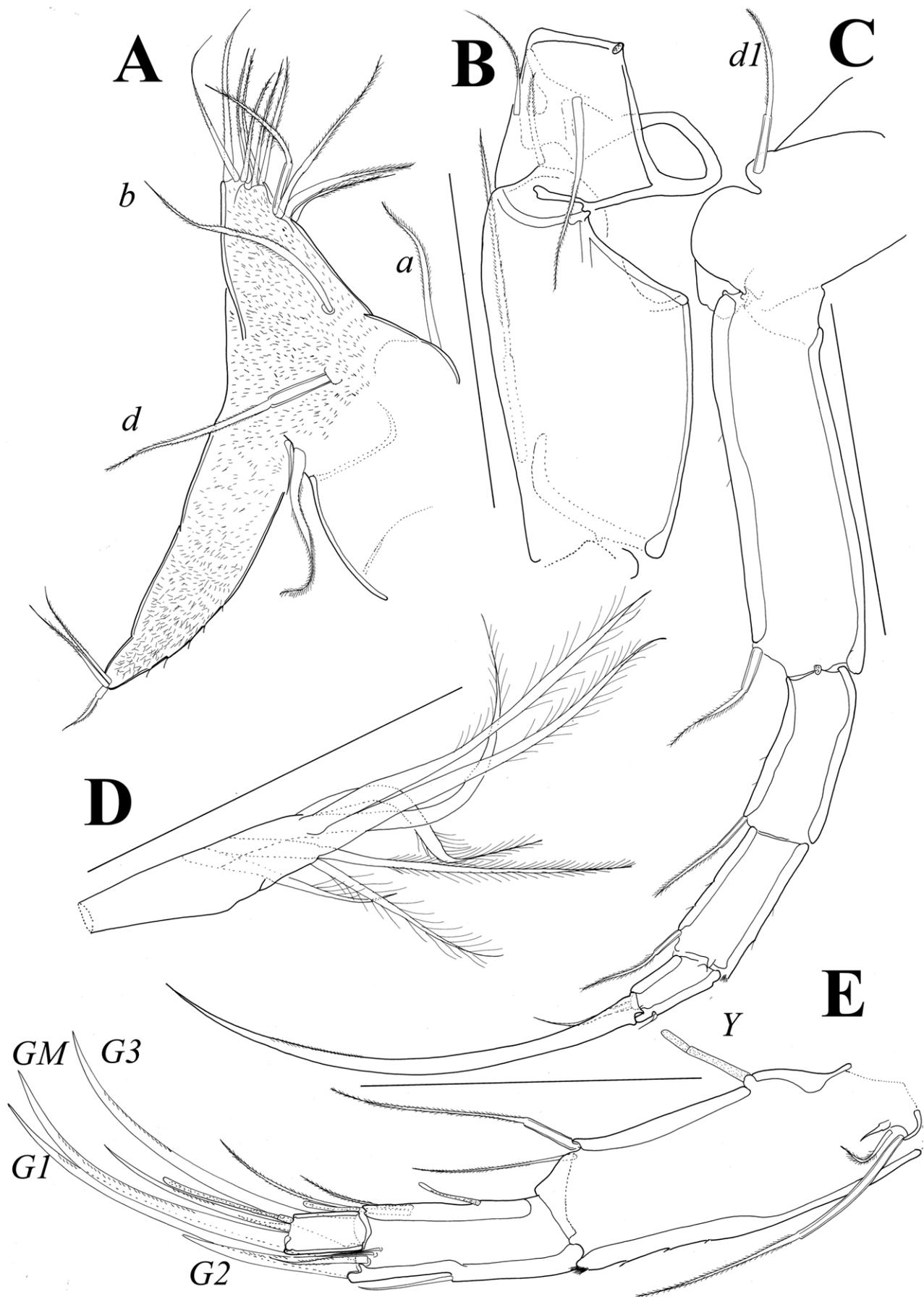
Mx1 (Figure 14C). Palp 2-segmented, first segment with four setae: three originating antero-distally, and one medio-distally. All these setae pappose. Terminal segment with two claw-like setae and four setae, one situated between claws, and three situated more posteriorly.

L5 (Figure 13A). With two rays in exopod, one each "a", "b", and "d" seta. Protopod with three short setae distally.

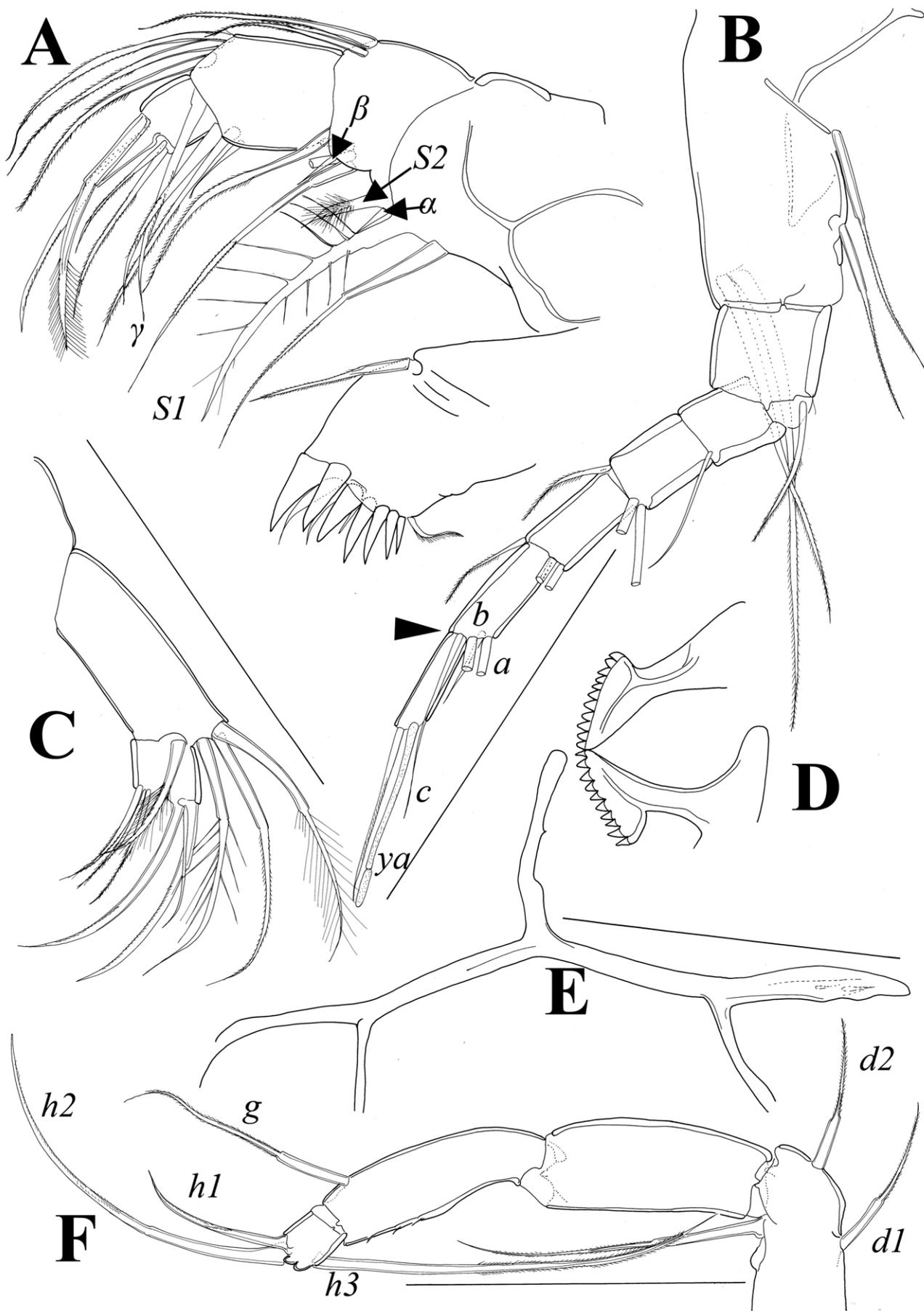
L6 (Figure 13C). Basal segment with one seta (d1). Endopod 4-segmented. Setae "e", "f", and "g") all relatively short and pappose. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw 1.3 times longer than combined L of three distal segments.



**FIGURE 12.** *Typhlocypris choi* sp. nov., holotype (female): A, RV, inside view; B, LV, outside view; C, UR; D, genital field. Scales = 0.1 mm.



**FIGURE 13.** *Typhlocypris choi* sp. nov., holotype (female): A, L5; B, basis and protopod of A2; C, L6; D, vibratory plate on Md; E, A2. Scales = 0.1 mm.



**FIGURE 14.** *Typhlocypris choi* sp. nov., holotype (female): A, Md; B, A1, arrow pointing the absence of seta “d”; C, Mx1 palp; D, rake-like organ; E, UR attachment; F, L7. Scales = 0.1 mm.

L7 (Figure 14F). Basal segment with “d1”, “d2” and “dp” setae. Endopod 3-segmented, and only “g” seta present distally. Terminal segment armed with two long and one short seta. L ratios between three “h” setae equaling: 1 : 2.2 : 2.7.

UR (Figure 12C). Relatively short and stout ramus, symmetrical rami. Posterior seta long and exceeding postero-distal margin of the ramus. Anterior seta much shorter and only ¼ L of anterior claw. Both claws strongly serrated. L ratio between anterior margin, anterior claw, posterior claw and posterior seta equaling: 2.3 : 1.9 : 1.6 : 1.

Genital field (Figure 12D) rounded and without any projections.

Male. Unknown.

**Remarks and affinities.** The genus *Typhlocypris* Vejdovský, 1882 is at the moment subdivided into two subgenera: *Typhlocypris s.str.* and *Pseudocandona* Kaufmann, 1900. The nominal subgenus is divided in *eremita* –, *caribbeana* –, *rostrata* –, and *prespica* –group (Karanovic 2005b). The new Korean species belongs to the *caribbeana* – group of species. This group is defined by a relatively long “h1” seta on the L7 in comparison to the terminal segment, by a 4-segmented L7 and by the presence of three setae internally on the second segment of the Md-palp. It comprises approximately 20 species (see Karanovic 2006). *Typhlocypris choi* sp. nov. has a relatively low carapace, with an evenly rounded dorsal margin and by this characters it is closely related to several species. *Typhlocypris arcuata* (Klie, 1932), described from east Java (Klie 1932), is a bit higher in lateral view and the UR is much shorter than in the new species. *Typhlocypris annae* (Méhés, 1913), described from Columbia (Méhés 1913) and also found in Florida (Furtos 1936), has a much shorter seta “h3” on the terminal segment of L7. *Typhlocypris geratsi* (Broodbakker, 1983) from Venezuela (Broodbakker 1983) and *T. parvula* (Sars, 1926) from Canada (Sars 1926) both have a shorter “h3” seta and also a shorter UR, as well as dorsal margin of the carapace not so evenly rounded. The Korean species is most closely related to *Pseudocandona abei* Smith & Janz, 2008, known from the southern basin of Lake Biwa (Smith & Janz 2008). This species is retained by the authors in the genus *Pseudocandona*, which is in fact a junior synonym of *Typhlocypris* (see discussion in Karanovic 2005b). The carapace shape of the Japanese and Korean species is almost the same as are many details of the morphology. They differ in the following details: *P. abei* has a much shorter most distal seta situated anteriorly on the first segment of the A1; posterior setae on the third, fourth and fifth segments in *T. choi* are longer than in *P. abei*; and posterior seta on the UR is much longer in *P. abei* than in the new species. Unfortunately, both species are known only after females and their similarity may indicate a very close relationship. However, we think that these differences are sufficient enough when dealing with allopatric subterranean taxa with restricted distributions. Further studies and possible finding of males will clarify this issue, and hopefully bring new characters.

## Genus *Schellencandona* Meisch, 1996

### *Schellencandona tea* sp. nov.

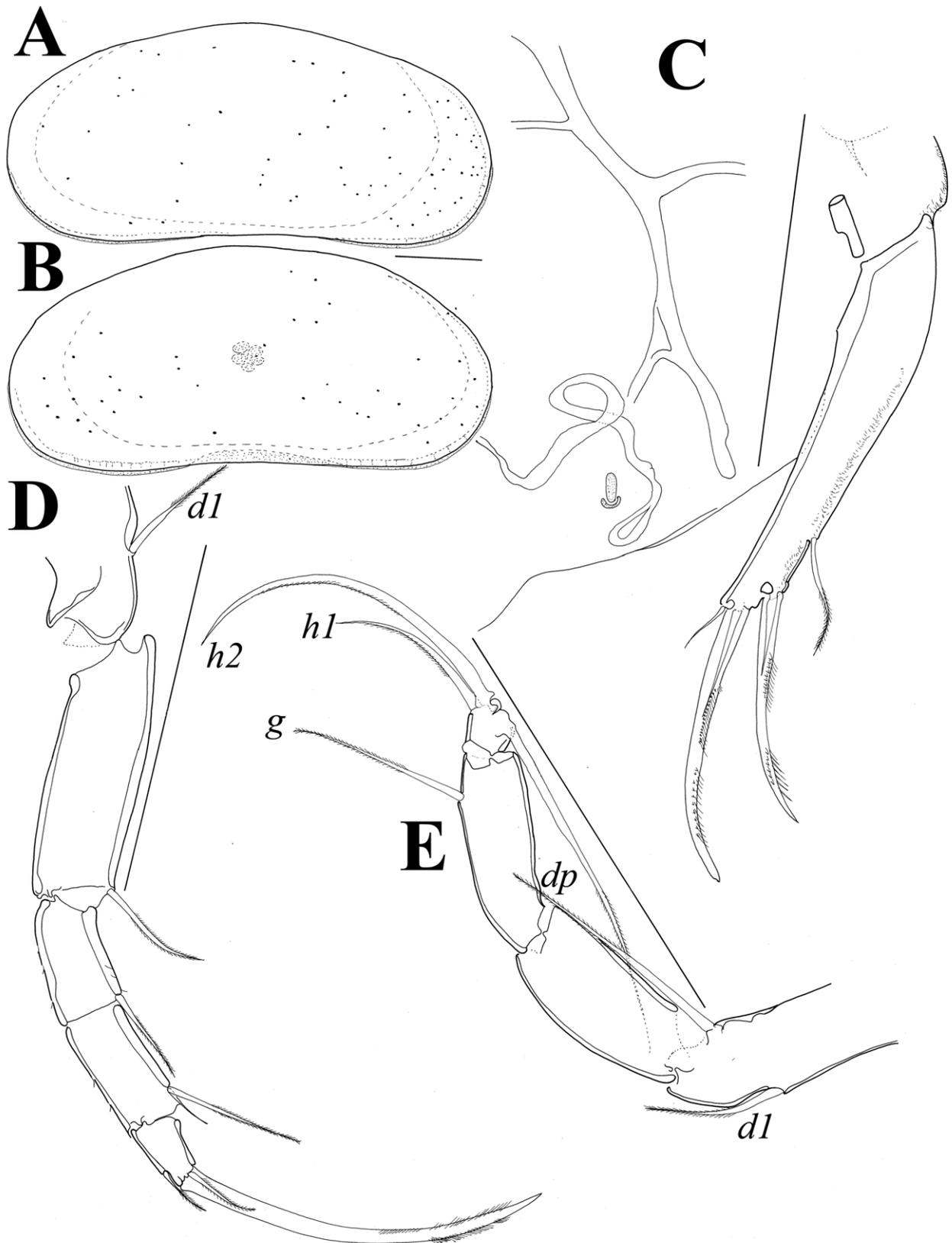
(Figures 15–16)

**Etymology.** The species is named after the Chinese word “tea”, later on Latinized and incorporated into the plant genus name *Thea* Linnaeus, 1753 (now a junior synonym of the genus *Camellia* Linnaeus, 1753), a genus of the tea family Theaceae D. Don, 1825.

**Material examined.** Holotype female (soft parts dissected on one slide, shell kept on micropaleontological slide NIBRIV0000245058), from (type locality) South Korea, Gyungsangbukdo, Sanggu, Young river (freshwater), interstitial, 36°31'42"N, 128°14'02"E; 01/07/2010, collector Joo-Lae Cho. One female (soft parts dissected on one slide, shell not preserved NIBRIV0000245059), from South Korea, Gyungsangbukdo, Uljin, Geunnam river, interstitial, 36°57'52"N, 129°22'52"E; 03/08/2010, collector Joo-Lae Cho.

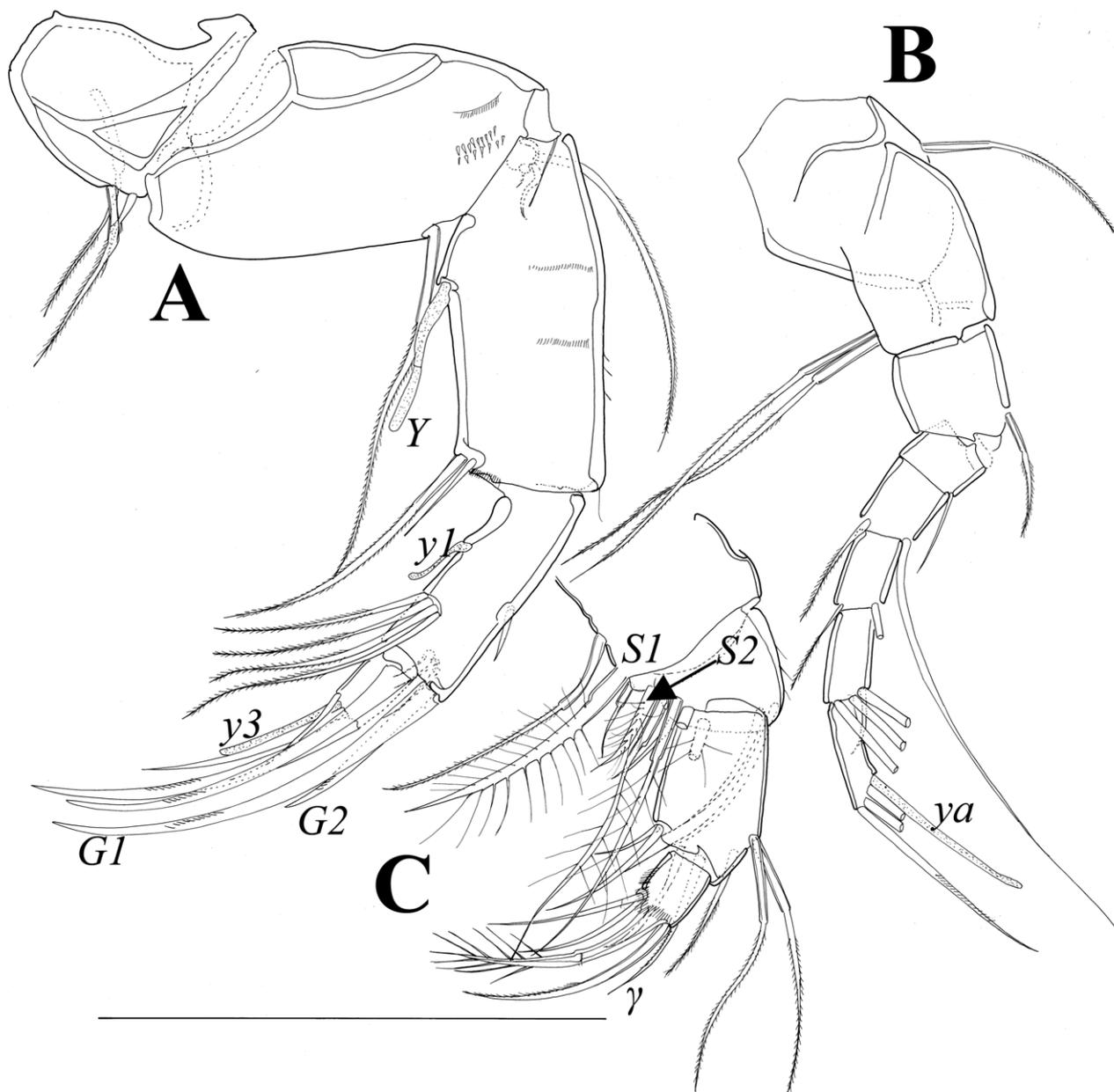
**Description.** Female: Carapace reniform in shape (Figure 15A, B) with the greatest H lying slightly behind middle L, equaling 44% of total L. Size: L=0.56 mm. Dorsal margin almost evenly rounded and slightly more curved towards posterior and inclined towards anterior end. Anterior and posterior margins both broadly rounded and equally wide. Ventral margin almost straight along entire L. Calcified inner lamella narrow on both ends, anteriorly equaling 13%, posteriorly less than 1% of total L. Fused zone also very narrow and marginal pore canals short, straight and denser anteriorly than posteriorly. Surface of shell covered

with fine setulae, originating from small, but clear wart-like structures. No other surface ornamentation present. LV overlapping RV on all free margins. Selvage thin and peripheral.



**FIGURE 15.** *Schellencandona tea* sp. nov., holotype (female): A, RV, outside view; B, LV, outside view; C, UR; D, L6; E, L7. Scales = 0.1 mm.

A1 (Figure 16B). Appendage 7-segmented. First segment with only one seta anteriorly and two posteriorly. Anterior seta situated more proximally, distal one missing. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, not reaching distal end of fourth segment. Third segment with one anterior pappose seta not reaching distal margin of fifth segment. Fourth segment with one short posterior seta (slightly exceeding distal end of fifth segment), and one anterior, longer seta (exceeding distal end of terminal segment); all these setae pappose. Fifth segment with same chaetotaxy as fourth one. Penultimate segment with total of four setae; posteriormost seta “d” absent. Alpha seta not reaching distal end of terminal segment. Seventh segment with posterior, claw-like seta twice as long as terminal segment, one aesthetasc (ya) of the same L, and two longer pappose setae. L ratio of five distal segments equaling: 1 : 1.25 : 1.4 : 1.75 : 2. Rome and Wouters organs not present.



**FIGURE 16.** *Schellencandona tea* sp. nov., holotype (female): A, A2; B, A1; C, Md-palp. Scales = 0.1 mm.

A2 (Figure 16A). Basal segment with total of three setae of subequal L, one situated dorsally and two ventrally on segment. Protopod with a distally pappose seta, not exceeding distal margin of second endopodal segment. Protopod with rows of spines posteriorly. Exopod consisting of plate carrying one long (almost reaching distal end of first endopodal segment) and two short, pappose setae. Endopod 3-segmented. First endopodal segment with

long aesthetasc “Y” and antero-ventrally with two setae. Second segment with one medio-dorsal seta, all “t” setae visible (exceeding distal end of terminal segment). Same segment medio-ventrally with short aesthetasc y1. Third endopodal segment with claws G1, G2 and G3; G2 being half as long as G1. Seta z1 not transformed in claw, slightly exceeding distal end of terminal segment, the other two also seta-like and of same L. Terminal segment with one long claw, GM and one short claw, Gm (3 times longer than terminal segment). Terminal segment also armed with aesthetasc y3 (2.5 times as long as terminal segment) and one thin seta accompanying y3. Claws very gently serrated.

Md (Figure 16C). First segment of palp with one plumose seta (S1), one pappose, short seta (S2), a short alpha seta, and one additional seta situated proximally on segment. Second segment dorsally with two setae, reaching distal end of following segment, ventrally with three plumose setae originating from a small plate and one plumose seta; beta seta short and smooth. Penultimate segment dorsally with three almost equally long setae, gamma seta faintly pappose, and three additional setae, one of which originates medially and two ventrally. Terminal segment with two strong, well-sclerotized claws (lateral one serrated distally, medial plumose) and two setae more ventrally.

Mx1 and L5. Same as in previous species.

L6 (Figure 15D). Basal segment with one seta (d1). Endopod 4-segmented. Setae “e”, “f”, and “g” all relatively short and pappose. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw 1.2 times longer than combined L of three distal segments.

L7 (Figure 15E). Basal segment with “d1” and “dp” setae, “d2” missing. Endopod 3-segmented, and only “g” seta present distally. Terminal segment armed with two long and one short seta. L ratios between three “h” setae equaling: 1 : 2.4 : 2.8.

UR (Figure 15C). Relatively short and stout, symmetrical rami. Posterior seta not long but exceeding postero-distal margin of the ramus. Anterior seta much shorter and only  $\frac{1}{4}$  L of anterior claw. Both claws strongly serrated. L ratio between anterior margin, anterior claw, posterior claw and posterior seta equaling: 3.25 : 2.4 : 2 : 1.

Genital field (Figure 15C) rounded and without any projections.

Male. Unknown.

**Remarks and affinities.** The genus *Schellencandona* was erected to accommodate *Candona*-like species with seta “d2” missing on the L7, a hemipenis with flat (not strongly sclerotized) “M”-piece, three setae on the second segment of Md-palp internally and with two long and one short seta on the terminal segment of the L7, and 4+2 rows of spines on the Zenker organ (Meisch 1996). At the moment, the genus comprises six Recent species: *S. belgica* (Klie, 1937), *S. insueta* (Klie, 1938), *S. schellenbergi* (Klie, 1934); *S. simililampadis* (Danielopol, 1978), *S. triquetra* (Klie, 1936), and *S. yakushimaensis* Smith & Kamiya, 2006. Most of the species have been found in subterranean waters of Europe (Klie 1934, 1936, 1937, 1938; Danielopol 1978; Meisch 1996, 2000), while *S. yakushimaensis* Smith & Kamiya, 2006 was described from a temporary water body in Japan (Smith & Kamiya 2006). With the exception of the Japanese species, all others are known from both male and female specimens. Of the new Korean species we also collected only female specimens. Despite the lack of males, we decided to place it in the genus *Schellencandona*, based of its small size and the chaetotaxy of the L7. It differs from the European species by the carapace shape, which is trapezoidal to subtrapezoidal in lateral view in the European species, while the dorsal margin in the new species is rounded and the carapace is more bean-shaped. *Schellencandona tea* **sp. nov.** is very closely related to *S. yakushimaensis*, but differs in the chaetotaxy of the A1 (antero-distal seta on the first segment of A1 is missing in the Korean species and there is only one seta on the fourth and fifth segments), as well as in seta “g” on the L6 and seta “h1” on the L7, which are both shorter in the Japanese species. Furthermore, the calcified inner lamella is wider in *S. yakushimaensis* than in *S. tea*.

### **Tribe Candonopsini Karanovic, 2004**

#### **Genus *Candonopsis* (*Candonopsis*) Vávra, 1891**

#### ***Candonopsis* (*C.*) *transgrediens* Brehm, 1923**

(Figures 17–19)

Synonymy. *Candonopsis transgrediens* Brehm, 1923: p. 340, Figs. 3 & 10–14.

**Material examined.** One male and one female (soft parts dissected on slides, shell kept on micropaleontological slides NIBRIV245060, NIBRIV0000245061), 5 females and 5 males in ethyl alcohol (kept for future DNA studies), from South Korea, Daepyeong wetland, 35°20'24.1"N 128°20'06.06"E; 28/04/2011, collector Hyunsu Yoo.

One female (soft parts dissected on slides, shell not preserved NIBRIV0000245062) from South Korea, Daepyeong wetland, 35°20'24.1"N 128°20'06.06"E; 15/05/2010, collector Hyungi Jeong; temperature = 18.6°C; pH = 7.57; salinity = 0.12‰.

**Redescription.** Male. Carapace reniform in lateral view (Figure 17C, D) with the greatest H lying behind middle L, equaling 53% of total L. Size: L = 0.79 mm. Dorsal margin highly rounded in posterior part and gently inclined towards anterior. Anterior and posterior margins both broadly rounded, but posterior margin wider than anterior. Ventral margin slightly concave around mouth region. Calcified inner lamella narrow on both ends, anteriorly equaling 13% of total L, posteriorly equaling less than 1% of total L. Fused zone also very narrow and marginal pore canals short, straight and denser anteriorly than posteriorly. Surface of shell covered with fine setulae, originating from small, but clear wart-like structures. No other surface ornamentation present. LV overlapping RV on all free margins.

A1 (Figure 18D). Appendage 7-segmented. First segment with two setae anteriorly and two posteriorly. One anterior seta situated more proximally, other distally on segment. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, reaching distal end of fourth segment. Third segment with one posterior seta slightly, reaching only half L of following segment. Fourth segment with two anterior, long setae (exceeding distal end of terminal segment). Fifth segment with two longer anterior setae (one half as long as other) and one short posterior seta, not reaching distal margin of following segment. Penultimate segment with total of four setae; posteriormost seta "d" seta present. Alpha seta absent. Seventh segment with posterior, claw-like seta which is 1.8 times as long as terminal segment, one aesthetasc (ya) of the same L as terminal segment, and two pappose setae, of which one is half as long as other. L ratio of five distal segments equaling: 1.4 : 1 : 1.3 : 1.3 : 1.3. Rome and Wouters organs not present.

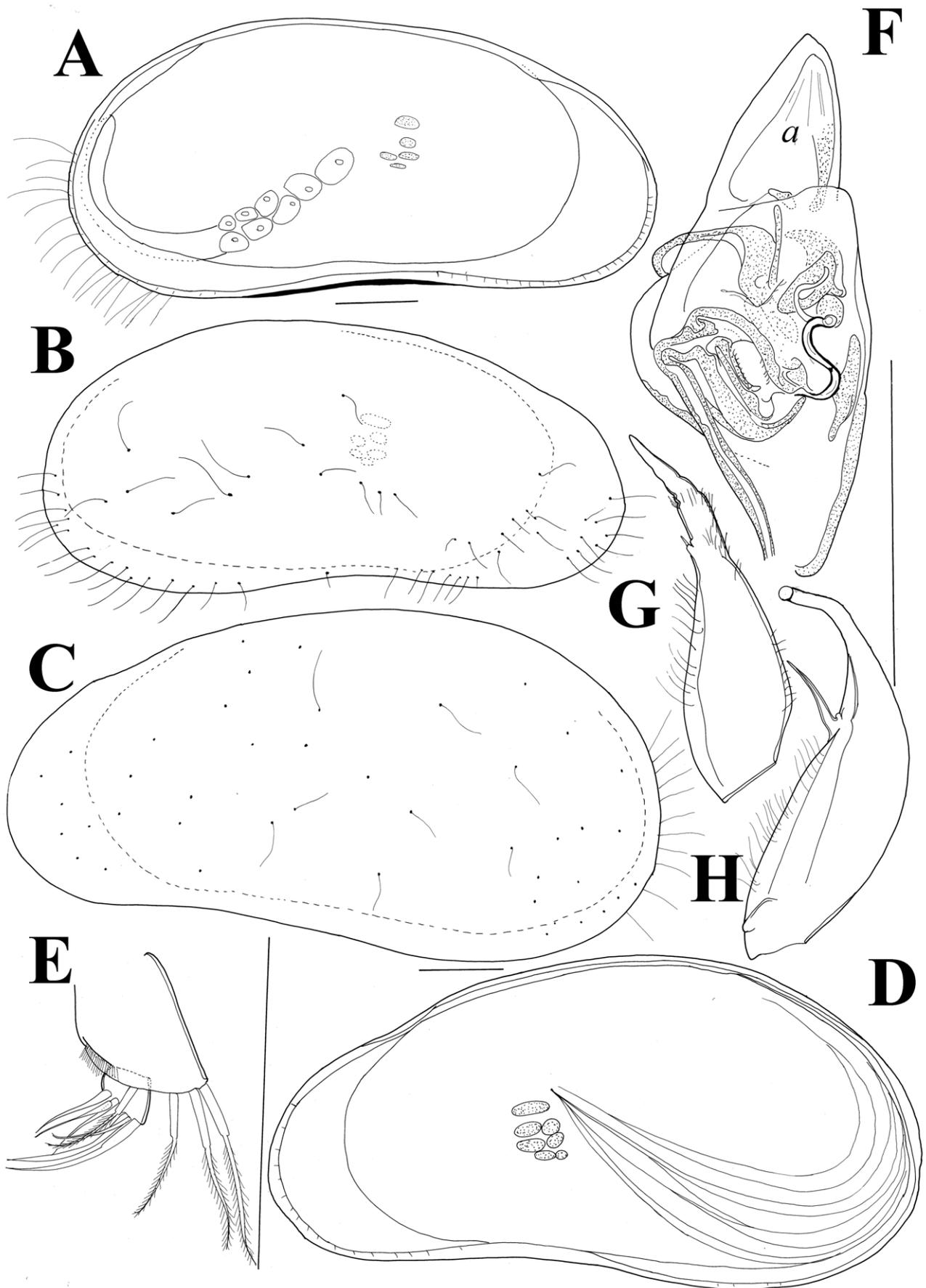
A2 (Figure 19D). Basal segment with one seta. Protopod with one, distally pappose seta exceeding distal margin of fourth endopodal segment, same segment with spines dorsally. Exopod consisting of plate carrying one long (almost reaching distal end of first endopodal segment) and two short, pappose setae. Endopod 4-segmented, penultimate segment divided with two male sexual bristles. First endopodal segment with one relatively long aesthetasc "Y" and antero-ventrally with two setae (one very long, other short). Second segment with two medio-dorsal setae (one being "t4" seta); setae t3 and t2 transformed into sexual bristles (exceeding distal end of terminal segment) and one antero-ventral seta (t1). Same segment medio-ventrally with short aesthetasc y1, y2 also short. Third endopodal segment with claws G1, G2, z1 and z2, and setae G3 and z3. Claw G1 short (50% of first endopodal segment); G2 long (1.2 times longer than first endopodal segment); z1 much shorter than z2 and later as long as G2. G3 and z3 thin setae and half as long as G1 claw. Terminal segment with one long claw, Gm (approximately as long as first endopodal segment) and one short claw, GM (1.5 times shorter than Gm). Terminal segment also armed with aesthetasc y3 (as long as terminal segment) and one thin seta accompanying y3.

Md (Figure 19A). First segment of palp with one plumose seta (S1), one pappose, short seta (S2), a short alpha seta, and one additional seta situated proximally on segment. Second segment dorsally with two setae, reaching distal end of following segment, ventrally with three plumose setae originating from a small plate, one plumose shorter seta and beta seta. Penultimate segment dorsally with two almost equally long setae, gamma seta pappose, and four additional setae of which one originates medially and three ventrally. Terminal segment elongated with one strong, central claw and one seta on each side. Width : L ratio of terminal segment equaling 1 : 6.

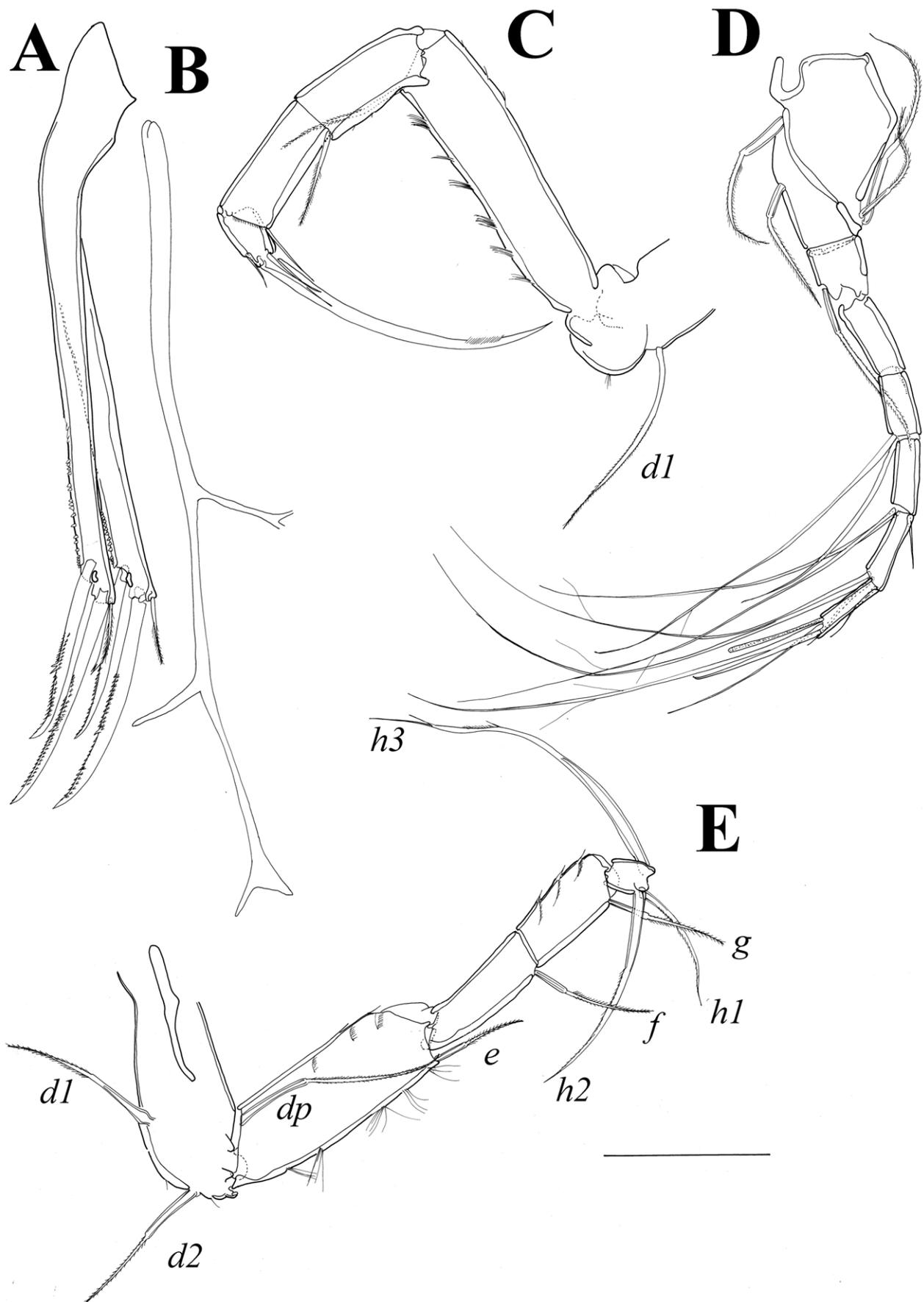
Mxl (Figure 17E). Palp 2-segmented, first segment dilated and with four setae: three originating antero-distally, and one medio-distally. All these setae pappose. Terminal segment with two claw-like setae and four setae, one situated between claws, and three situated more posteriorly.

Prehensile palps (Figure 17G, H). Palps strongly asymmetrical, right one with more curved dorsal margin, and curved finger, while left one with more straight dorsal margin and straight finger. Subterminal structures more developed on right palp.

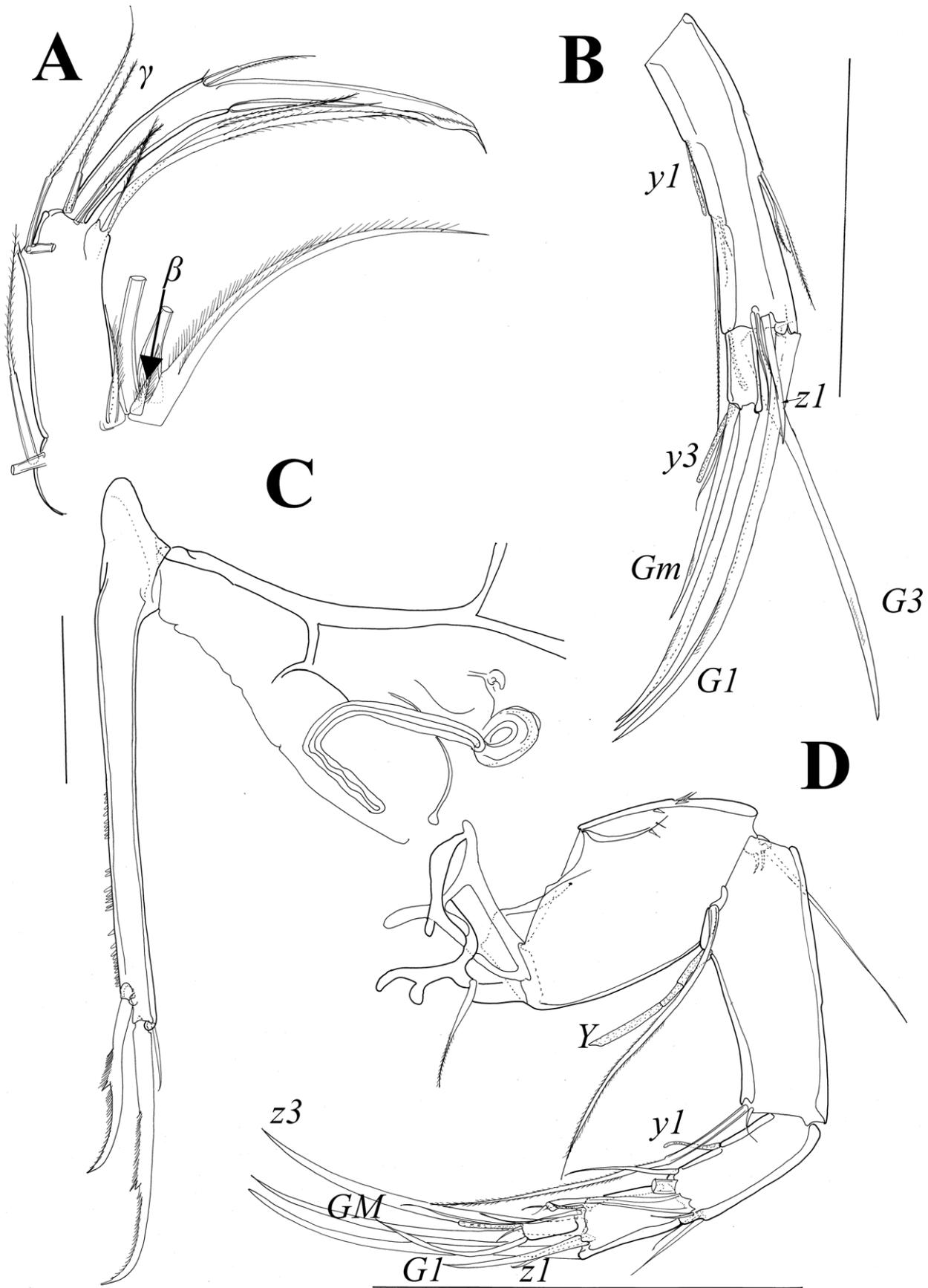
L6 (Figure 18C). Basal segment with one seta (d1). Endopod 4-segmented (on one leg penultimate segment distally subdivided, creating a 5-segmented endopod). Setae "e", "f", and "g" all relatively short and pappose. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw as long as combined L of three distal segments.



**FIGURE 17.** *Candonopsis (C.) transgrediens* Brehm, 1923, A, B, female; C–H, male: A, LV, inside view; B, RV, outside view; C, LV, outside view; D, RV, inside view; E, Mx1-palp; F, hemipenis; G, right prehensile palp; H, left prehensile palp. Scale = 0.1 mm.



**FIGURE 18.** *Candonopsis (C.) transgrediens* Brehm, 1923, male: A, UR; B, UR attachment; C, L6; D, A1; E, L7. Scales = 0.1 mm.



**FIGURE 19.** *Candonopsis (C.) transgrediens* Brehm, 1923, A, D, male; B, C, female: A, Md palp; B, terminal part of A2; C, UR with genital field; D, A2. Scales = 0.1 mm.

L7 (Figure 18E). Basal segment with “d1”, “d2” and “dp” setae. Endopod 4-segmented, with all setae present. Terminal segment armed with two long and one short seta. L ratios between three “h” setae equaling: 1 : 1.7 : 2.4. UR (Figure 18A). Symmetrical, missing posterior seta and with strong denticles along posterior margin. Both claws strongly serrated. Posterior claw shorter than anterior one and with prominent teeth medially, while these teeth on anterior claw less pronounced. L ratio between anterior margin, anterior claw and posterior claw equaling: 2.8 : 1.3 : 1. Attachment (Figure 17B) with one dorsal and one ventral branch.

Hemipenis (Figure 17F). Lobe “a” triangular but with rounded tip. Other lobes low. Inner duct coiled.

Zenker organ with seven rows of spines.

Female. Slightly smaller than males (Figure 16A, B), L=0.71 mm, otherwise very similar to male, except that dorsal margin posteriorly less wide.

A2 (Figure 19B). Endopod 3-segmented. Three “t” setae on penultimate segment present, and second endopodal segment postero-medially with two setae. Seta “z1” transformed into claws, slightly longer than terminal segment. Claws G1–G3 equally long. Terminal segment with long claw GM and short Gm. All claws gently serrated.

L5. Three setae present in exopod.

UR (Figure 19C) Similar to male, symmetrical. L ratios between anterior margin, anterior, and posterior claws equaling: 2.2 : 1.4 : 1. Medial teeth on anterior claw more developed than in males.

Genital field (Figure 19C). Rounded and without projections.

All other appendages same as in male.

**Remarks and affinities.** This species was originally described from a marsh in Canton, China. Brehm (1923) provided only a couple of drawings and a brief description. Based on this, it was difficult to give it a proper generic position, and consequently it was omitted from the key to the genus provided by Karanovic & Marmonier (2002) and Karanovic (2012). This species is also mentioned by Lee et al. (2000) as *C. cf. transgrediens* collected from around Ulsan, Korea. The authors, however, provide no other details of their record. The species collected for this study is here identified as *Candonopsis transgrediens* based on a very peculiar ornament on the posterior margin of the UR, i.e. a row of relatively thick teeth. This feature is indeed illustrated by Brehm (1923), but its relevance and correctness was unclear, because all other drawings provided in the same paper are of a low quality. With our Korean material, we can now establish this specific ornament of the UR as a unique feature of *C. transgrediens*, distinguishing it from all other representatives of the genus. *Candonopsis transgrediens* belongs to the nominal subgenus because it has a basal seta on the L6 (see Karanovic 2004). It is very closely related to the group of species where the posterior claw on the UR carries a distinctive spine, a grouping that was proposed by Klie (1932). Namely, this author divided the genus into three species groups: 1. both claws carry one prominent spine; 2. both claws without a spine; 3. only the posterior claw has a prominent spine. In Klie's time groups even had separate geographic distribution, i.e. species from the first and the last groups were known only from Africa and Australia, while species from the second group were restricted to Europe and the Americas. Along with the discovery of more species and genera within the tribe Candonopsini (Karanovic & Marmonier 2002; Karanovic 2004, 2007, 2008), Klie's biogeographic delimitation of species groups could no longer be sustained.

The redescription of *Candonopsis transgrediens* provides an opportunity to place this species into the key to the *Candonopsis* (*Candonopsis*) species of the world. This key is modified after Karanovic (2012).

### Key to the *Candonopsis* (*Candonopsis*) species of the world

1.	Posterior UR claw reduced . . . . .	2
–	Both UR claws developed, and well sclerotized . . . . .	3
2.	Posterior UR claw reduced into thin, long seta (more than 1/2 L of anterior claw) . . . . .	<i>C. thienemanni</i> Schäfer, 1945
–	Posterior claw on the UR reduced into swollen, pappose and short seta (less than 1/3 L of anterior) . . . . .	<i>C. westaustraliensis</i> Karanovic & Marmonier, 2002
3.	Seta “F” missing . . . . .	<i>C. kimberleyi</i> Karanovic & Marmonier, 2002
–	Seta “F” present . . . . .	4
4.	Anterior claw on UR shorter than ramus . . . . .	5
–	Anterior claw on UR clearly longer than ramus . . . . .	<i>C. urmilae</i> Gupta, 1988
5.	Valves strongly asymmetrical: RV overlaps LV with flange dorsally . . . . .	6
–	RV equally high, or lower than LV . . . . .	7

6. Claws on UR of subequal L, or anterior claw slightly longer than posterior one (at the most 1.2 times) ..... *C. murchisoni* Karanovic & Marmonier, 2002  
 – Anterior claw on UR always markedly longer than posterior one (at least 1.4 times) ... *C. dani* Karanovic & Marmonier, 2002
7. L: W ratio of terminal segment of Md-palp 7:1 or less. .... 8  
 – L: W ratio of terminal segment of Md-palp 9:1 ..... *C. anteroacuta* Rome, 1962
8. Setae “e” and “f” on L7 extremely short ..... *C. navicula* Daday, 1910a  
 – Same setae each at least reaching  $\frac{1}{3}$  of following segments ..... 9
9. Neither of UR claws carries spine ..... 10  
 – At least one of the UR claws with distinct spine. .... 14
10. Carapace subtriangular ..... 11  
 – Carapace reniform to subreniform, elongated. .... 12
11. Anterior and posterior ends of carapace covered with long, stiff, spine-like setae, posterior and anterior UR claws equally long ..... *C. trichota* Schäfer, 1945  
 – Anterior and posterior ends of carapace with fine setae, posterior UR claw shorter .. *C. marezza* Karanovic & Petkovski, 1999
12. L: W ratio of terminal segment of Md-palp less than 4:1 ..... 13  
 – L: W ratio of terminal segment of Md-palp 5:1 up to 6:1 ..... *C. kingsleii* (Brady & Robertson, 1870)
13. Outer lobe of hemipenis more triangular and pointed ..... *C. boui* Danielopol, 1978  
 – Same lobe more squarish and oblong ..... *C. scourfieldi* Brady, 1910
14. Anterior UR seta missing ..... *C. putealis* Klie, 1932  
 – Anterior UR seta present ..... 15
15. L of carapace between 0.55 mm and 0.65 mm ..... *C. solitaria* Vávra, 1895  
 – L. of carapace always more than 0.75 mm ..... 16
16. Anterior UR claw with strong spine, while on posterior claw spine sometimes weaker ..... 17  
 – Posterior claws always with strong spine, while spine on anterior claw very weak ..... 19
17. All four t-setae in female on A2 developed ..... 18  
 – Just two t-setae present ..... *C. tenuis* (Brady, 1886)
18. L of carapace more than 0.85 mm, L:W ratio of terminal segment of Md-palp 6:1 ..... *C. africana* Klie, 1944  
 – L of carapace less than 0.7 mm and L:W ratio of terminal segment of Md-palp 7:1 ..... *C. hummelincki* Broodbakker, 1983
19. In lateral view, dorsal margin equally rounded, with greatest H around middle ..... 20  
 – In lateral view greatest H on the posterior third, from where margin rounded towards posterior end, and inclined towards anterior end ..... *C. sumatrana*, 1932
20. Seta “h2” of L7 1.5 times longer than “h1” ..... 21  
 – Seta “h2” more than 2.5 times longer than “h1” ..... *C. bujukuensis* Löffler, 1968
21. Posterior margin of UR ramus without prominent teeth ..... *C. nama* Daday, 1913  
 – Posterior margin of UR ramus with prominent, thick teeth ..... *C. transgrediens*, 1923

### Subfamily Paracypridinae Sars, 1923

#### Tribe Thalassocypridini Hartmann & Puri, 1974

#### Genus *Dolerocypria* Tressler, 1937

#### *Dolerocypria mukaishimensis* Okubo, 1980

(Figures 20, 21)

Synonymy. *Dolerocypria mukaishimensis* Okubo, 1980: p. 20, Fig. 2, Pl. 1g, h.

*Dolerocypria mukaishimensis* Okubo—Nakao & Tsukagoshi, 2002: p. 71, Figs 2E–J, 3,4.

**Material examined.** Two males and one female (soft parts dissected on slides, shell of 1 male and of 1 female kept on micropaleontological slides NIBRIV0000245063, NIBRIV0000245064, NIBRIV0000245065), 2 females (in ethyl alcohol NIBRIV0000245066), from South Korea, Yigidae rocky shore, near Busan, rock pool, 35°07'27.30"N 129°07'25.50"E; 25/04/2011, collector Hyunsu Yoo; temperature = 24.10°C, salinity = 35.2‰.

Two females (soft parts dissected on slides, shell kept in ethyl alcohol NIBRIV0000245067, NIBRIV0000245068) from South Korea, Hwapyeonggyo, 37°49'46"N 128°51'40"E; 06/08/2008, collector Dongju Lee.

**Redescription.** Male. Carapace subtriangular in lateral view (Figure 20A, B) with the greatest H lying in front of middle L, equaling 40% of total L. Size: L= 0.62 mm. Dorsal margin highly arched on point of greatest H, with sinusoid margin towards anterior and gently inclined (almost rounded) towards posterior margin. Posterior margin much narrower than anterior one. Ventral margin slightly concave around mouth

region. Calcified inner lamella narrow on both ends, anteriorly equaling 16% of total L, posteriorly equaling less than 1% of total L. Fused zone also very narrow and marginal pore canals short, straight and denser anteriorly than posteriorly. Surface of shell covered with fine setulae, originating from small, but clear wart-like structures. No other surface ornamentation present. LV overlapping RV on all free margins.

A1 (Figure 21A-C). Appendage 7-segmented. First segment with one seta anteriorly and two posteriorly. One anterior seta situated more proximally. Posterior setae originate from same (or very close) spot. All setae pappose. Second segment with one anterior pappose seta, reaching middle of following segment. Rome organ well-developed (Figure 21C), Wouters organ not observed. Third segment with one posterior short seta, and one anterior longer seta. Fourth and fifth segments with two anterior, long setae (exceeding distal end of terminal segment), and one short posteriorly. Penultimate segment with total of four setae; posteriormost seta "d" present. Alpha seta absent. Seventh segment with aesthetasc (ya) twice as long as terminal segment. L ratio of five distal segments equaling: 2.2 : 1.7 : 1 : 1 : 1.45.

A2 (Figure 21H, I). Protopod with one, distally pappose seta exceeding distal margin of fourth endopodal segment. Exopod consisting of plate carrying one long (almost reaching distal end of first endopodal segment) and two short, pappose setae. Endopod 4-segmented, penultimate segment being divided, carrying two male sexual bristles. First endopodal segment with one relatively long aesthetasc "Y" and antero-ventrally with one strong seta. Swimming setae longer than claw, except for first and sixth ones, which are much shorter. Sixth swimming seta at some distance from the group. Second segment with two medio-dorsal setae (one being "t4" seta); setae t3 and t2 transformed into sexual bristles (exceeding distal end of terminal segment) and one antero-ventral seta (t1). Same segment medio-ventrally with short aesthetasc y1, y2 also short. Third endopodal segment with claws G1, G2, z1 and z2, and setae G3 and z3. Claw G1 short (less than 50% of G2); G2 long (1.2 times longer than first endopodal segment); z1 slightly shorter than z2 and both slightly shorter than G2. G3 and z3 thin setae and as long as G1 claw. Terminal segment with one long claw, Gm (approximately as long as first endopodal segment) and one short claw, GM (1.5 times shorter than Gm). Terminal segment also armed with aesthetasc y3 (1.5 times as long as terminal segment) and one thin seta accompanying y3.

Md (Figure 21E). First segment of palp with two plumose setae (S1 and S2), and one pappose seta; alpha seta not observed. S2 seta bent. Second segment dorsally with two setae, reaching distal end of following segment (one apparently smooth other plumose), ventrally with three smooth setae originating from a small plate, one plumose shorter seta and beta seta. Penultimate segment dorsally with four almost equally long setae, gamma seta pappose, and five additional setae, one of which originates medially and four ventrally. Terminal segment short with two claws and two setae.

Prehensile palps (Figure 20H, I). Palps 2-segmented and finger on right palp more robust. Each palp bearing ventrally on body three long, pappose setae. More than two "a" setae present on protopod, exopod with five long and pappose setae and one very small. Distally to exopod one additional seta present.

L6 (Figure 20G). Basal segment with three setae (d1, d2, dx). Endopod 4-segmented. Setae "e", "f", and "g" all relatively short and pappose. Terminal segment with distal claw and two lateral, short setae (h1 and h3). Distal claw as long as combined L of three distal segments. Appendage very hirsute, some setulae very strong and exiting from their own canals.

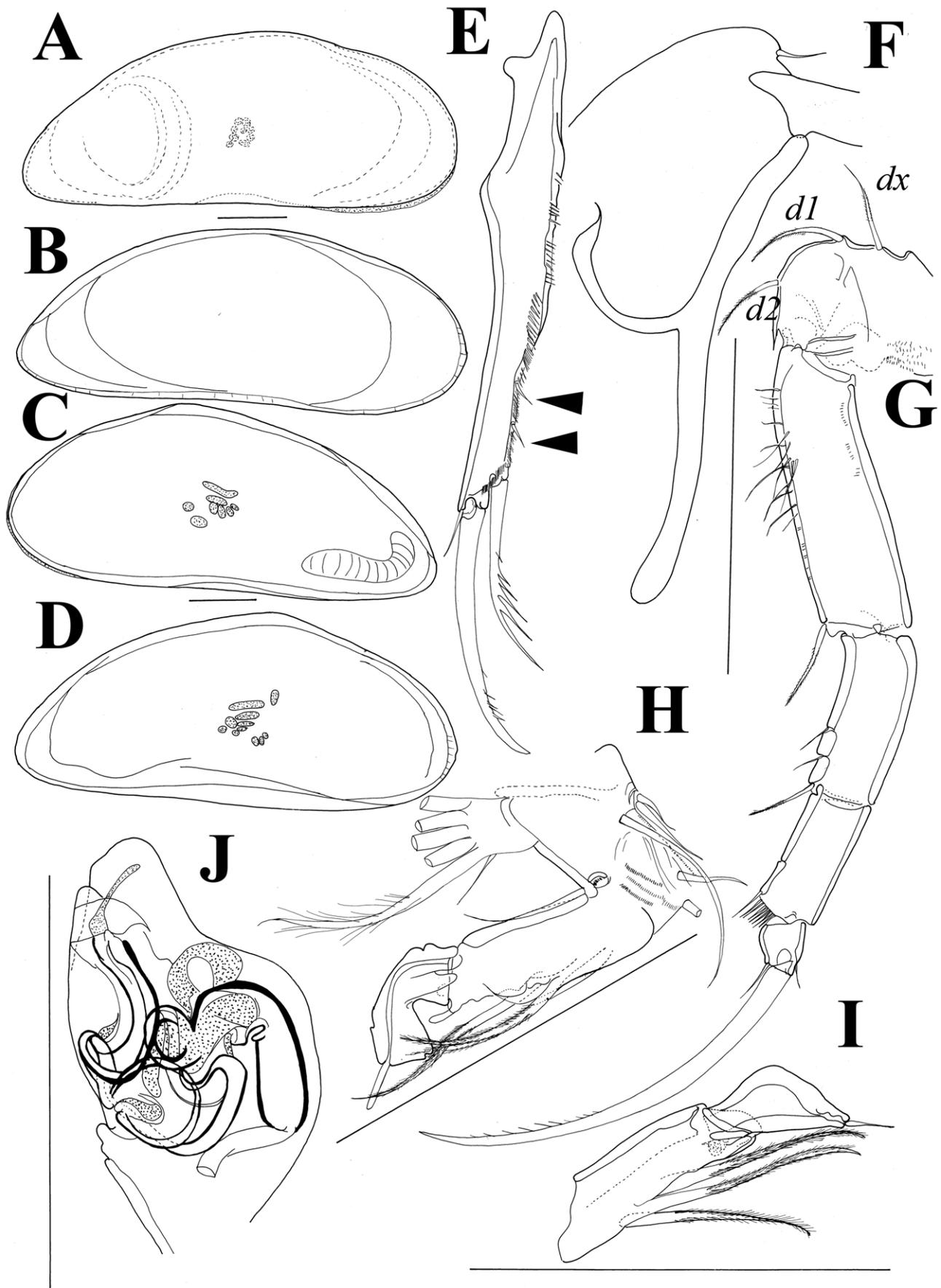
L7 (Figure 21F). Basal segment with three setae. Endopod 4-segmented, with all setae present, "g" being very short and accompanied by four small setulae. Terminal segment armed with two very short and one long seta. Long seta covered with setulae which are very strong and long distally. Terminal segment elongated. Appendage very hirsute.

UR (Figure 20D). Symmetrical, with two distinct posterior setae and with stiff setulae along posterior margin. Posterior claw with strong teeth, while anterior one with fines setulae. L ratio between anterior margin, anterior claw and posterior claw equaling: 1.7 : 1.4 : 1. Attachment (Figure 20F) with one dorsal branch. One caudal seta present.

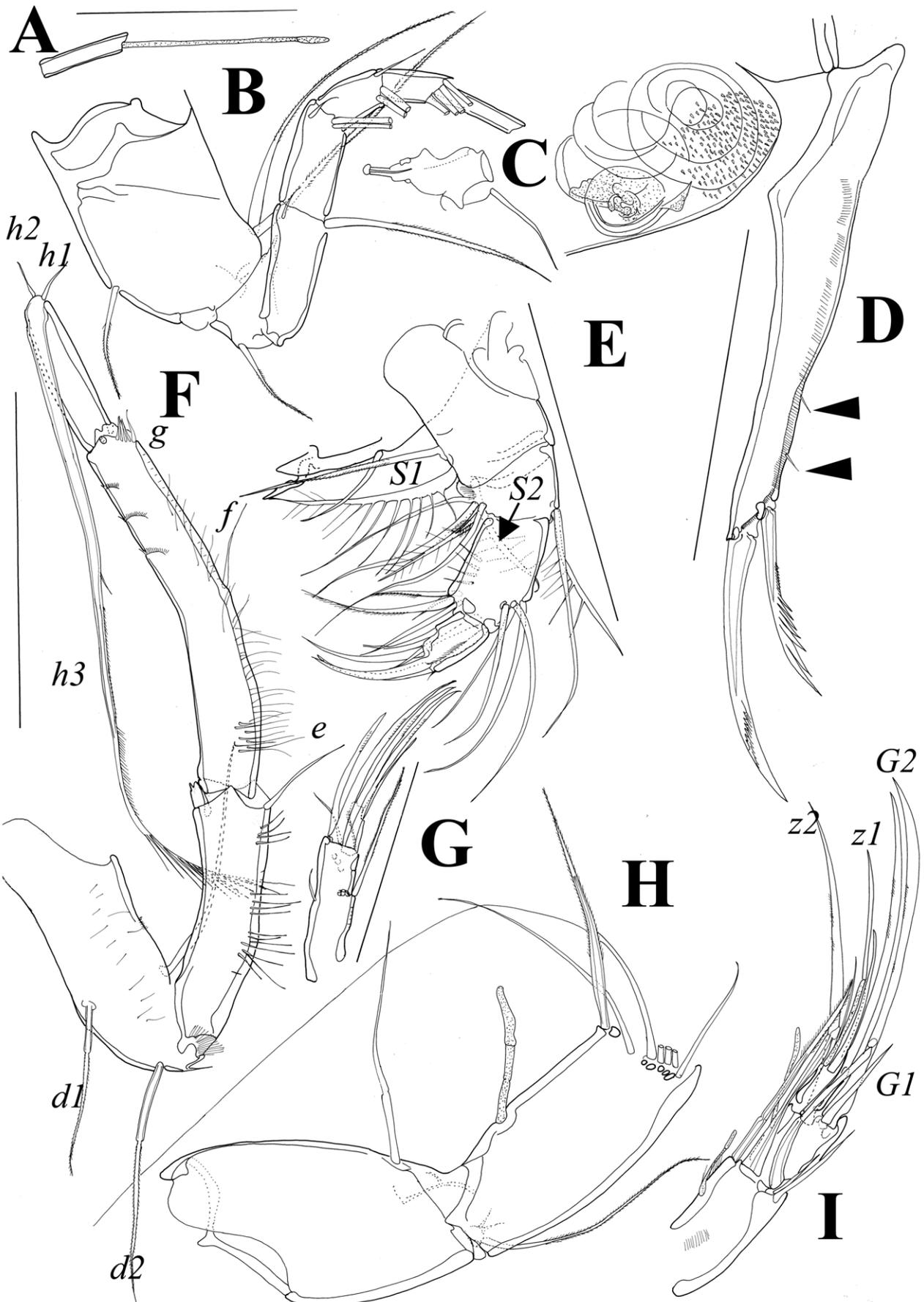
Hemipenis (Figure 20J). Lobe "a" (outer lobe) almost square shaped, lobe "b" triangular. Inner duct coiled. The presence of three setae on the basal segment of the L6 (Fig. 20G) is only an abnormality found on one leg of a male.

Female. Carapace (Figure 20C, D) very similar to male. L=0.65 mm.

A2 (Figure 21G). Endopod 3-segmented. All four "t" setae on penultimate segment present, and second endopodal segment postero-medially with one seta. All "z" setae seta-like, second segment with one additional seta medio-distally positioned on dorsal side of appendage. Claw G2 2/3 of other claws.



**FIGURE 20.** *Dolerocypris mukaishimensis* Okubo, 1980, A, B, E-I, male; C, D, female: A, RV, outside view; B, LV, inside view; C, RV, inside view; D, LV, inside view; E, UR; F, end of the body showing caudal seta and UR attachment; G, L6; H, right prehensile palp; I, left prehensile palp; J, hemipenis. Scales = 0.1 mm.



**FIGURE 21.** *Dolerocypris mukaishimensis* Okubo, 1980, A, B, C, E, F, H, I, male; D, G, female: A, terminal segment of A1; B, A1; C, Rome organ; D, UR, arrows pointing on two posterior setae; E, Md palp; F, L7; G, terminal part of A2; H, proximal part of A2; I, distal part of A2. Scales = 0.1 mm.

UR (Figure 21D) Similar to male, symmetrical.

Genital field (Figure 21D). Rounded and without projections but densely covered with spines.

All other appendages same as in male.

**Remarks and affinities.** The genus *Dolerocypria* at the moment comprises 12 species (Maddocks 2005), and they occur in the tropical Pacific and Atlantic Oceans, but also in the subtropical and moderate regions of Japan (Wouters 2001). *Dolerocypria mukaishimensis* Okubo, 1980 was described only after females (Okubo 1980), but the males were later on collected and described by Nakao & Tsukagoshi (2002). The species is relatively common in Japan living from marine to brackish waters, reaching the highest abundance in brackish environment (Smith & Kamiya 2003). The male upon which Nakao & Tsukagoshi (2002) based their description was probably subadult, because the chitinous rows on the Zenker organ are not fully developed and some additional soft tissue (like a small flap) accompanies the hemipenis on the internal side. Unfortunately, the authors never described both prehensile palps, so only the appearance of the right one is known and it looks very much like the one found in males of the Korean population. Since our males were fully developed, they had a normal Zenker organ and the flap on the hemipenis was not observed. There are, however, several differences between the Japanese and the Korean populations. The first, probably the most important one, is the number of posterior setae on the UR. While on the drawings of Okubo (1980) and Nakao & Tsukagoshi (2002), there is only one (more distal seta), we have found one more seta situated more proximally. However, because the posterior margin of the UR is densely covered with spines, the second, very short seta could be easily overlooked. In the entire genus *Dolerocypria* the number of posterior setae on the ramus varies from none to two and they are always very short, like in *D. mukaishimensis*. Similar miscalculations of the number of posterior setae on the UR have already occurred in this genus (see McKenzie 1979). The other difference is related to the fact that the L6 and L7 are covered with conspicuous setulae, not illustrated in Nakao & Tsukagoshi (2002) for neither of these legs, but in Okubo (1980) the L7 has also some sort of long setulae along the margins of the appendage, but not the L6. In addition, the genital field in the Korean population is covered with tiny spinules, not described for the Japanese species. Despite these differences we believe that the investigated Korean population is conspecific with the Japanese one and thus belong to *D. mukaishimensis*. It is most probable that they represent interspecific variability. Other than that, the carapace shape and structure, as well as the appearance and the chaetotaxy of all other appendages are the same in these two populations.

The systematics of the entire subfamily Paracypridinae is in an urgent need of revision, and although several attempts of improvement were made (see Maddocks 1992, 2005), none has resolved the current problems, such as many overlapping morphological characters between different genera and no clear synapomorphies.

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**APPENDIX 1.** List of the Recent Candonidae species recorded from East Asia (reference sources other than the original descriptions are between square brackets). The list includes only species which have been well-documented and taxonomically described

Subfamily Candoninae

Tribe Candonini

1. *Candona quasiakaina* **sp. nov.** [this paper]—Korea
2. *Fabaeformiscandona akaina* Smith & Janz, 2008—Japan
3. *F. condylea* Smith & Janz, 2008—Japan
4. *F. danielopoli* Yin & Martens, 1997—China
5. *F. dolabella* Smith & Janz, 2008—Japan
6. *F. fabaeformis* (Fischer, 1851) [Okubo 2004]—Japan
7. *F. holzkampfi* (Hartwig, 1900) [Okubo 2004]—Japan
8. *F. japonica* Okubo, 1990a [Smith & Janz 2008]—Japan
9. *F. myllaina* Smith & Kamiya, 2007—Japan
10. *F. nishinoae* Smith & Janz, 2008—Japan
11. *F. okuboi* Smith & Janz, 2008 [Smith & Janz 2008, Chang et al. 2012] —Japan , Korea
12. *F. paterea* Smith & Janz, 2008—Japan
13. *F. pedana* Smith & Janz, 2008—Japan
14. *F. siberica* (Müller, 1912) [Okubo 2004]—Japan
15. *F. tora* Smith & Kamiya, 2007—Japan
16. *F. velifera* Smith & Janz, 2008—Japan
17. *F. yajimae* Smith & Janz, 2008—Japan
18. *Pseudocandona abei* Smith & Janz, 2008—Japan
19. *Schellencandona tea* **sp. nov.** [this paper]—Korea
20. *S. yakushimaensis* Smith & Kamiya, 2006—Japan
21. *Typhlocypris choi* **sp. nov.** [this paper]—Korea
22. *T. morimotoi* (McKenzie, 1972a) [Karanovic 2005b]—Korea

Tribe Candonopsini

23. *Candonopsis tenuis* (Brady, 1886) [Sars 1903]—China
24. *C. transgrediens* Brehm, 1923 [and the present publication]—China and Korea

Tribe Cryptocandonini

25. *Cryptocandona brehmi* (Klie, 1934) [Namiotko & Danielopol 2002, Smith 2011, Chang et al. 2012]—Japan, Korea
26. *Cryptocandona tsukagoshii* Smith, 2011 [Smith 2011, Chang et al. 2012]—Japan, Korea

Tribe Mixtacandonini

27. *Undulacandona spinula* Smith, 2011—Japan

Subfamily Cyclocypridi

28. *Cyclocypris diebeli* Absolon, 1973 [Matzke-Karasz et al. 2004]—Japan
29. *Cypria biwaensis* Okubo, 1990b [Smith & Janz 2008]—Japan
30. *C. crenulata* Sars, 1903—China
31. *C. konishii* Smith & Kamiya, 2006—Japan
32. *C. kraepelini* Müller, 1903 [Yu et al. 2005, 2010]—China
33. *C. matzkeae* Smith & Janz, 2008—Japan
34. *C. nipponica* (Okubo, 1990b) [Smith & Janz 2008; Chang et al. 2012]—Japan, Korea

Subfamily Paracypridinae

35. *Aglaiocypris nipponica* Okubo, 1980—Japan
36. *Dolerocypria mukaishimensis* Okubo, 1980 [Nakao & Tsukagoshi 2002; Smith & Kamiya 2003; this paper]—Japan & Korea
37. *Paracypria injuimensis* (Okubo, 1980) [Smith & Kamiya 2003]—Japan
38. *P. adnata* Smith & Kamiya, 2006—Japan