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Authors: Karanovic, Ivana, and Lee, Wonchoel

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**On the ostracod genus *Ilyocypris*, with description of one new species from Korea and the first report of males of *I. bradyi* (Crustacea: Ostracoda: Podocopida)**

Ivana Karanovic\* and Wonchoel Lee

(IK, WL) Department of Life Science, College of Natural Science, Hanyang University, Seoul 133-791, Korea, e-mail: ivana.karanovic@utas.edu.au, wlee@hanyang.ac.kr

*Abstract.*—*Ilyocypris* Brady & Norman, 1889 is a globally distributed freshwater ostracod genus, with 27 Recent species described so far. In the present paper we describe *I. hanguk*, new species, collected from a stream in South Korea. This species is very closely related to *I. dentifera* Sars, 1903 and *I. angulata* Sars, 1903, both originally described from China and also reported from Korea and Japan. Due to their limited descriptions, the two species were often synonymized in the past, and *I. angulata* was considered a parthenogenetic form of *I. dentifera*. In order to re-examine morphological characteristics of *I. dentifera* and *I. angulata*, as well as to compare them with the new Korean species, we have studied the type material deposited in the Zoological Museum in Oslo. This revealed that *I. dentifera* Sars, 1903 and *I. angulata* Sars, 1903 are valid species, with clear morphological differences. We have also discovered males of *I. angulata* in the type series. In addition, another form, which we identify as *I. cf. angulata*, is found within the type series of both species. *Ilyocypris cf. angulata* has an intermediate carapace form between *I. angulata* and *I. dentifera*. Dissection of its soft parts, however, indicates unambiguous difference from *I. dentifera*, and a high similarity with *I. angulata*. It was left in the open nomenclature because many species of the genus *Ilyocypris* are still very poorly known and characters of the hemipenis that may define this form as a clear species are missing from many species descriptions. *Ilyocypris hanguk* can be easily distinguished from these two species by the morphology of the hemipenis, and other details of the soft parts. Although a widely distributed species, *Ilyocypris bradyi* Sars, 1890, is recorded from South Korea for the first time. This is also the first record of the bisexual population, and we describe males in detail. In the present paper we also provide a cladistic analysis of the genus *Ilyocypris* based on 20 morphological characters and 21 species.

**Keywords:** cladistic analysis, east Asia, freshwater, Ilyocypridae, taxonomy

The family Ilyocypridae Kaufmann, 1900, together with Notodromadidae Kaufmann, 1900, Candonidae Kaufmann, 1900 and Cyprididae Baird, 1845, belongs to the superfamily Cypridoidea Baird, 1845. Some authors (Martens et al. 1998,

Meisch 2000) consider that Ilyocypridae comprises two subfamilies, Ilyocyprinae and Pelocyprinae, but the most recent view (Martens & Savatentalinton 2011, Karanovic 2012) is that the latter subfamily should be transferred to the family Cyprididae, because the only two known species of the genus *Pelocypris* Klie, 1939

\* Corresponding author.

have a transformed terminal segment of the cleaning leg (the seventh limb) into a so-called “pincer organ”, which is a synapomorphy of Cyprididae. In Ilyocypridinae the terminal segment is small, but otherwise normally developed with three apical setae. Ilyocyprididae share this character with two other Cypridoidea families. It needs to be pointed out that the systematics of Notodromadinae is not completely resolved and that some lineages also bear the “pincer organ” (Karanovic 2012).

Ilyocyprididae comprises six fossil (see Rodríguez-Lázaro & Martín-Rubio 2005) and two Recent genera: *Ilyocypris* Brady & Norman, 1889 and *Indiacypris* Hartmann, 1964. The main differences between the two Recent genera are that the shell of *Ilyocypris* is well-ornamented, always with sulci and often lateral projections, and prehensile palps on the male fifth limb are almost symmetrical, while species of *Indiacypris* do not possess sulci on the shell, and the prehensile palps are asymmetrical. There are also some striking differences between these two genera in the morphology of the hemipenis, which prompted George & Martens (2004) to question the position of *Indiacypris* in Ilyocyprididae. *Indiacypris* is a poorly known freshwater genus, with only three Recent species described from India and Sri Lanka (George & Martens 2004). *Ilyocypris*, on the other hand, is a much more diverse genus, with about 27 Recent and more than 200 fossil species (see Kempf 1980, 1997). Species of *Ilyocypris* commonly occur in Oligocene-Recent deposits (Morkhoven 1963). Taxonomy of the species is based on the types of shell ornamentation and on only several characters of the soft parts, such as the length of the swimming setae on the antenna, the number of setae on the penultimate segment of the cleaning leg (seventh limb), and the division of the penultimate segment of the walking leg (sixth limb). Carapace ornamentation is variable

among the Recent species (see Meisch 2000), and several species have been synonymized because of this. Van Harten (1979) and, later on, Janz (1994) proposed the morphology of marginal ripples as a useful tool for distinguishing between different Recent and fossil species.

*Ilyocypris* is globally distributed, and has been recorded from all continents, except Antarctica. *Ilyocypris bradyi* Sars, 1890 and *I. gibba* (Ramdohr, 1808), have the widest distribution, and are the only species reported from both North and South America (see Martens & Behn 1994, Smith & Delorme 2010). *Ilyocypris decipiens* Masi, 1905, *I. getica* Masi, 1906, *I. inermis* Kaufmann, 1900, and *I. monstrifica* (Norman, 1862) are distributed in the Palearctic. Some species seem to have disjunct distributions, such as *I. australiensis* Sars, 1889 described from Australia (Sars 1889) and recorded from the Middle East (Hartmann 1964), North Africa (Gauthier 1928), Caucasus and Crimea (Bronstein 1947). Another example of a disjunct distribution is *I. salebrosa* Stepanaitys, 1960 described as a fossil from Turkmenistan (Stepanaitys 1960), and found as a Recent species in Japan (Smith et al. 2011), Turkey (Özuluğ 2005), and possibly central Europe (as *I. decipiens*; Karan-Žnidaršič & Petrov 2007), Italy (as *I. decipiens*; Rossetti et al. 2005, 2006), and North America (as *Pelocypris alatabulbosa* Delorme, 1970; see Delorme 1970). Other species have a more restricted distribution, with two species known from Lake Tanganyika and Malawi (*Ilyocypris alta* Sars, 1910 and *I. propinqua* Sars, 1910), four from Europe and Central Asia (*I. lacustris* Kaufmann, 1900; *I. botniensis* Kovalenko, 1972; *I. divisa* Klie, 1926; and *I. carinata* Kovalenko, 1970), three from India and Sri Lanka (*I. mckenzie* Bhatia & Mannikeri, 1974, *I. nagamalaiensis* Victor & Michael, 1975, and *I. taprobanensis* Neale, 1976), three from Turkey and Israel (*I. brehmi* Schäfer, 1952, *I. hartmanni* Lerner-Seggev, 1968, and *I. nitida* Lerner-Seggev,

1968), and two from Australia and New Zealand (*I. perigundi* De Deckker, 1981 and *I. fallax* Brehm, 1928). Five Recent species are known only from East Asia. *Ilyocypris mongolica* Martens, 1991 is endemic to Mongolia (Martens 1991). *Ilyocypris angulata* Sars, 1903 and *I. dentifera* Sars, 1903 were described from China (Sars 1903), and reported from Japan (Okubo 1975, 1990). Japan also has two endemic species, *I. japonica* Okubo, 1990 and *I. haterumensis* Okubo, 1992 (in Okubo & Terauchi 1992). Okubo (2004) considered these two species synonyms, and he also erects *I. nipponica* Okubo, 2004, a name that remains nomen nudum. There are no endemic *Ilyocypris* species in South Korea, and so far only *I. dentifera* has been found in Recent form (Kim & Min 1991), while *I. salebrosa* and *I. subpulchra* Yang, 1982 are known as (sub) fossils (Lee et al. 2000, Chang et al. 2012). The latter species is only known by its shell, and a living population is still to be found. *Ilyocypris dentifera* and *I. angulata* are very closely related species. Some authors consider them synonyms (Victor & Fernando 1981), maintaining the name *I. dentifera*. In order to check this, we have borrowed their type material from the Zoological Museum in Oslo. This proves that two names should be maintained, but that several reports of *I. dentifera* and *I. angulata* are not correct and they represent potentially undescribed species.

A recent study of the Korean fauna has revealed two additional species of *Ilyocypris*. *Ilyocypris bradyi* represents the first record for Korea. Since *I. bradyi* seems to reproduce parthenogenetically elsewhere this is the first finding of males. The other species is described as new, and it is very closely related to both *I. dentifera* and *I. angulata*. The new Korean species and incorrect identifications of some species as *I. dentifera* and/or *I. angulata* question the actual diversity of the genus *Ilyocypris*, and wide distributions of some species. It is

indeed very peculiar that so many fossil species have been described from not so old geological age, while our perception of the Recent diversity is very modest. We believe that the reason lies in the fact that many details of the soft part morphology in this genus are poorly described and undermined. A cladistic analysis is performed in this paper in order to outline the phylogenetic relationships between species. To avoid unresolved clades as much as possible, we decided to exclude seven species from the analysis, because they are poorly described or males are unknown. The number of morphological characters is also limited (20) for the same reason.

#### Materials and Methods

*Taxonomic methods.*—Specimens were dissected and mounted on microscope glass slides in CMC 10 mounting media. The dissected appendages were covered with a coverslip and the valves of each specimen were transferred to a micropaleontological slide. The dissection was done with a Leica L2 stereoscopic microscope, and the appendages were observed with a Leica DM 2500 compound microscope equipped with N-Plan objectives. Line drawings were prepared with the aid of a drawing tube attachment.

Scanning Electron Micrographs (SEM) were taken with a Jeol JSM-6330F at Hanyang University.

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 the female GM claw, while the long one is homologous with the 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 & Danielopol (1982), and for 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 appendages on the ostracod body (so called “furca”) is accepted, and the terminology Uropodal Ramus (UR) is used in the text. Setal classification system follows Garm (2004).

The examined material of *Ilyocypris bradyi* Sars, 1890 and the types of the new species are deposited at the National Institute of Biological Resources (NIBR) in Seoul. Material of *Ilyocypris angulata* Sars, 1903 and *I. dentifera* Sars, 1903 is deposited at the Zoological Museum Oslo (ZMO). Material of *I. gibba* (Ramdohr, 1808) is in the first author’s private collection.

Abbreviations used in text and figures: 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.

*Cladistic methods.*—A total of 21 Recent species of the genus *Ilyocypris* were included in the analysis. One species, *Indiacypris dispar* Hartmann, 1964 was chosen as the outgroup taxon. Twenty characters were scored, based on the study of available material and on the published descriptions of *Ilyocypris* species. The most plesiomorphic character state was given the value “0,” and apomorphic states “1,” “2,” and “3.” The matrix (Appendix 1) was created using WinClada, version 1.00.08 (Nixon 2002), and then analysed using NONA, version 2 (Goloboff 1999). Before running the analysis characters were weighted so that the characters from 0–4 were weighted 0.5, characters 9, 14, and 16 were weighted 0.75, while all other characters were weighted 1. Some of the characters were downweighted because either their state is uncertain in many species, or they are shown to be variable between closely related species. The cladistic analysis was performed using the Ratchet Island Hopper

search with the default parameters: 200 replications; one tree to hold; three characters to sample; 10 random constraint level and amb-poly= (amb- collapses a branch if the ancestor and descendant have different states under same resolutions of multistate characters or of “-”; poly=treats trees as collapsed). The Ratchet Island is a method that searches tree space very efficiently by reducing the search effort spent on generating new starting points and retaining more information from existing results of tree searches. The number of informative characters was limited by the much reduced body plan in the family, as well as the great number of species descriptions that are lacking in detail.

List of characters used in the analysis:

0. Dorsal margin of the shell: flat (0); inclined (1)
1. Lateral allae: present (0); absent (1)
2. Lateral allae: present and pointed (0); present and rounded (1); absent (2)
3. Marginal tubercles/spines: present (0); absent (1)
4. Antero-dorsal margin: rounded (0); sinusoid (1)
5. Swimming setae on A2: reaching and exceeding tip of terminal claws (0); shorter (1)
6. Swimming setae on A2: reaching or exceeding middle of terminal claws (0); not reaching middle of terminal claws (1)
7. Swimming setae on A2: reaching or exceeding middle of second segment (0); shorter (1)
8. Prehensile palps: asymmetrical (0); symmetrical (1)
9. Endopod L5 in females: 3-segmented (0); 2-segmented (1); 1-segmented (2)
10. Seta d2 on basal segment of L6: present (0); absent (1)
11. L6: 5-segmented (0); 4-segmented (1)
12. Number of setae on basal segment of L7: 3(0); 1 (1)
13. Number of setae on the second endopodal segment of L7: 3 (0); 2 (1); 1 (2)



14. Apical hooks distally on penultimate segment of L7: present (0); absent (1)
15. Posterior seta on UR: positioned proximally to half L of ramus (0); below half L of ramus (1)
16. Posterior seta on UR: as long (or almost as long) as posterior claw (0); considerably shorter (1)
17. Inner lobe on the hemipenis: not finger-like (0); finger-like (1)
18. Apical part of the inner lobe of the hemipenis: without a beak-like end (0); with a beak-like end (1)
19. Shape of the distal part of the hemipenis' inner lobe: different than rounded (0); rounded (1)

### Systematics

Order Podocopida Sars, 1866

Suborder Cypridocopina Jones, 1901

Superfamily Cypridoidea Baird, 1845

Family Ilyocyprididae Kaufmann, 1900

*Ilyocypris* Brady & Norman, 1889

*Ilyocypris bradyi* Sars, 1890

Figs. 1–4

*Ilyocypris bradyi* Sars—Sars, 1890:59. —Kaufmann, 1900:353, Pl. 24, Figs. 1, 2, Pl. 25, Figs. 17, 18.—Alm, 1915: 39, Fig. 20.—Klie, 1938: 1890, Figs. 329–333.—Petkovski, 1958:53, Fig. 1.—Meisch, 1988:153, Fig. 5.—Scharf, 1993, Figs. 8–10.—Janz, 1994:5, Pl. 2, Fig. 3.

*Iliocyprilla bradyi* Sars—Sars, 1923:109, Pl. 50, Fig. 2.

*Ilyocypris gibba* var. *repens* Vávra—Vávra, 1891:60, Fig. 18.

*Iliocyprilla repens* Daday—Daday, 1900:238, Fig. 44.

*Ilyocypris bradyi* var. *compressa* Masi—Masi, 1906:256.

*Material examined*.—Two males (dissected on one slide each NIBRIV0000260613 & NIBRIV0000260614, shell of the second male on SEM stub, shell of first male on micropaleontological slide), three juvenile

females (2 on SEM stub) and 15 juvenile females (in 70% ethyl alcohol, NIBRIV0000260611): from an unnamed stream (depth 15 cm) with sandy and gravelly bottom, Mungyeong, Gyeongsangbuk-do, South Korea, 36°40'07.1"N 128°12'10.7"E, 17 Jun 2011, collectors Choi Y. G & Kim W. R. Altitude = 146 m asl, water temperature = 19.2°C, pH = 8.49.

*Description of male*.—Shell rectangular in lateral view (Figs. 6A, C, 2A). Dorsal margin very gently sloping towards posterior end. Greatest H situated frontally, equaling 47% of total L. Anterior and posterior margins broadly rounded and equally wide. Ventral margin strongly concave near middle. Calcified inner lamella narrow (Fig. 1A, B) on both ends: anteriorly equaling 9%, posteriorly 7% of total L. Central muscle scar consists of four scars grouped together and two additional positioned more anteriorly (Fig. 1F). Line of fusion narrow, marginal pore canals short, denser anteriorly than posteriorly. Marginal ripples (Fig. 1D) very hard to observe but present. Shell with two sulci, positioned close to each other. In dorsal view (Fig. 2B), shell very narrow and without lateral allae, only small constrictions around middle. Central eye very small. Surface of shell roughly ornamented with dense, shallow pits. Surface densely covered with relatively short hair-like setae. L = 960 µm.

A1 (Fig. 3D) 7-segmented: First segment with one antero-distal and two postero-distal setae; postero-distal setae long, reaching tip of A1; antero-distal seta much shorter, reaching distal margin of second segment; both antero- and postero-distal setae serrulate. Second segment articulated with first and third one and carrying one antero-distal, serrulate seta, reaching distal end of fourth segment. Third segment with one anterior and one posterior seta. Both setae smooth: anterior one reaching seventh segment, posterior one only exceeding fourth segment. Fourth segment with two long anterior setae and

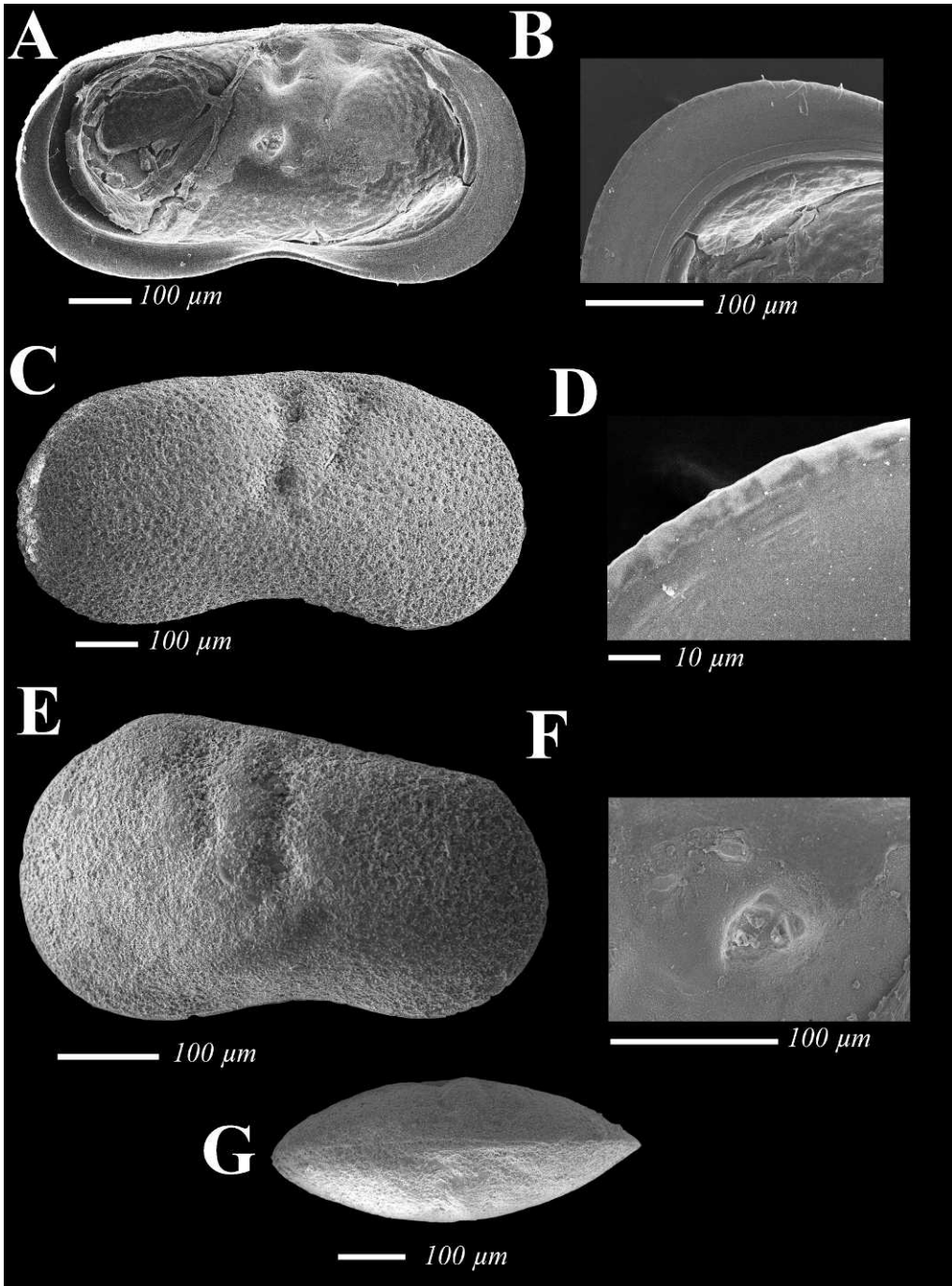


Fig. 1. SEM of *Ilyocypris bradyi* Sars, 1890. A, B, D, F, adult male; C, E, G, juvenile female. A, LV (inside view); B, anterior inner calcified margin of the LV; C, RV (outside view); D, marginal zone of LV; E, LV (outside view); F, muscle scar imprints outside; G, dorsal view.

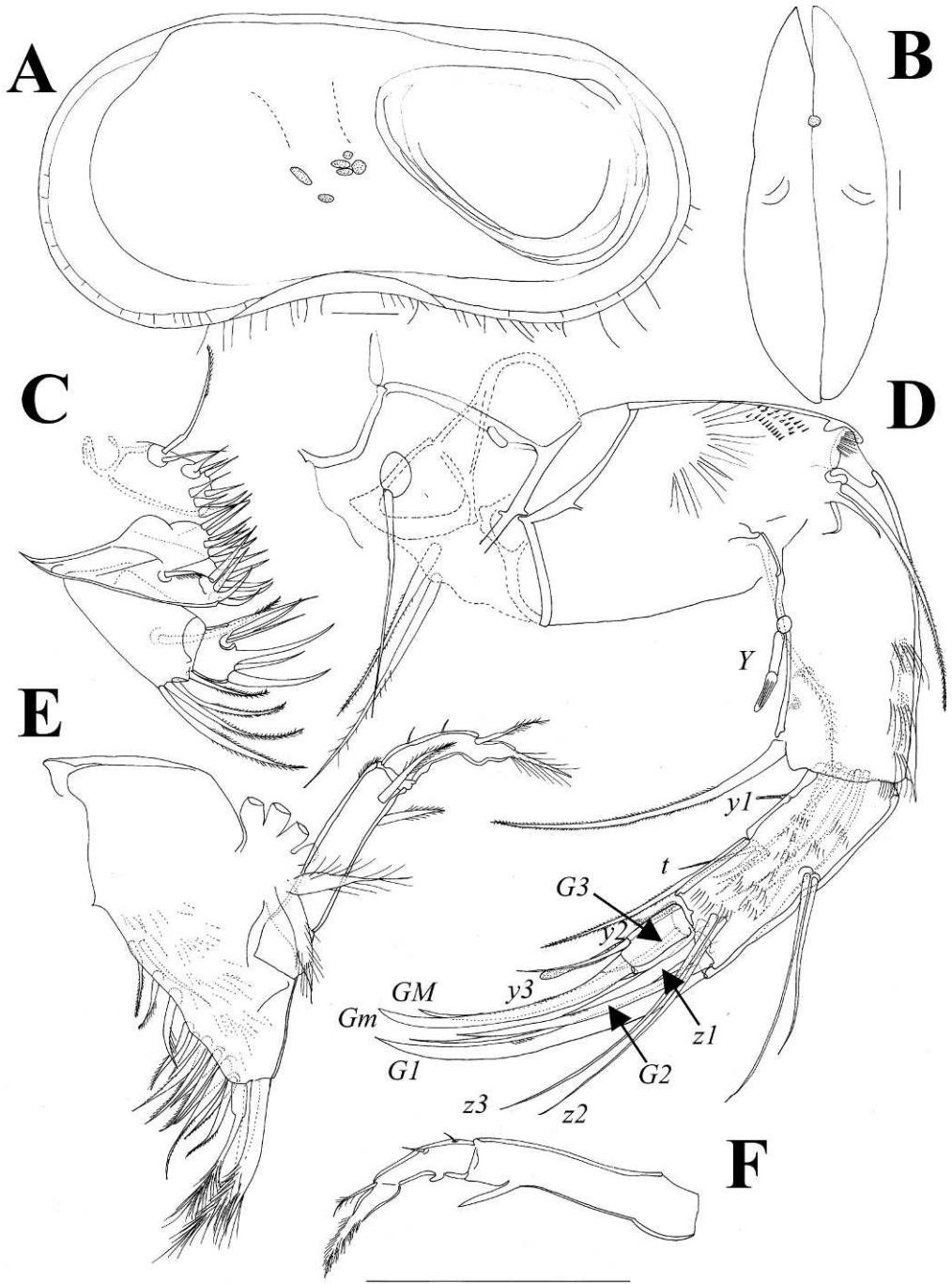


Fig. 2. *Ilyocypris bradyi* Sars, 1890, male: A, RV, internal view; B, dorsal view; C, Mx1, D, A2; E, L5 and prehensile palp; F, prehensile palp. Scales = 0.1 mm.



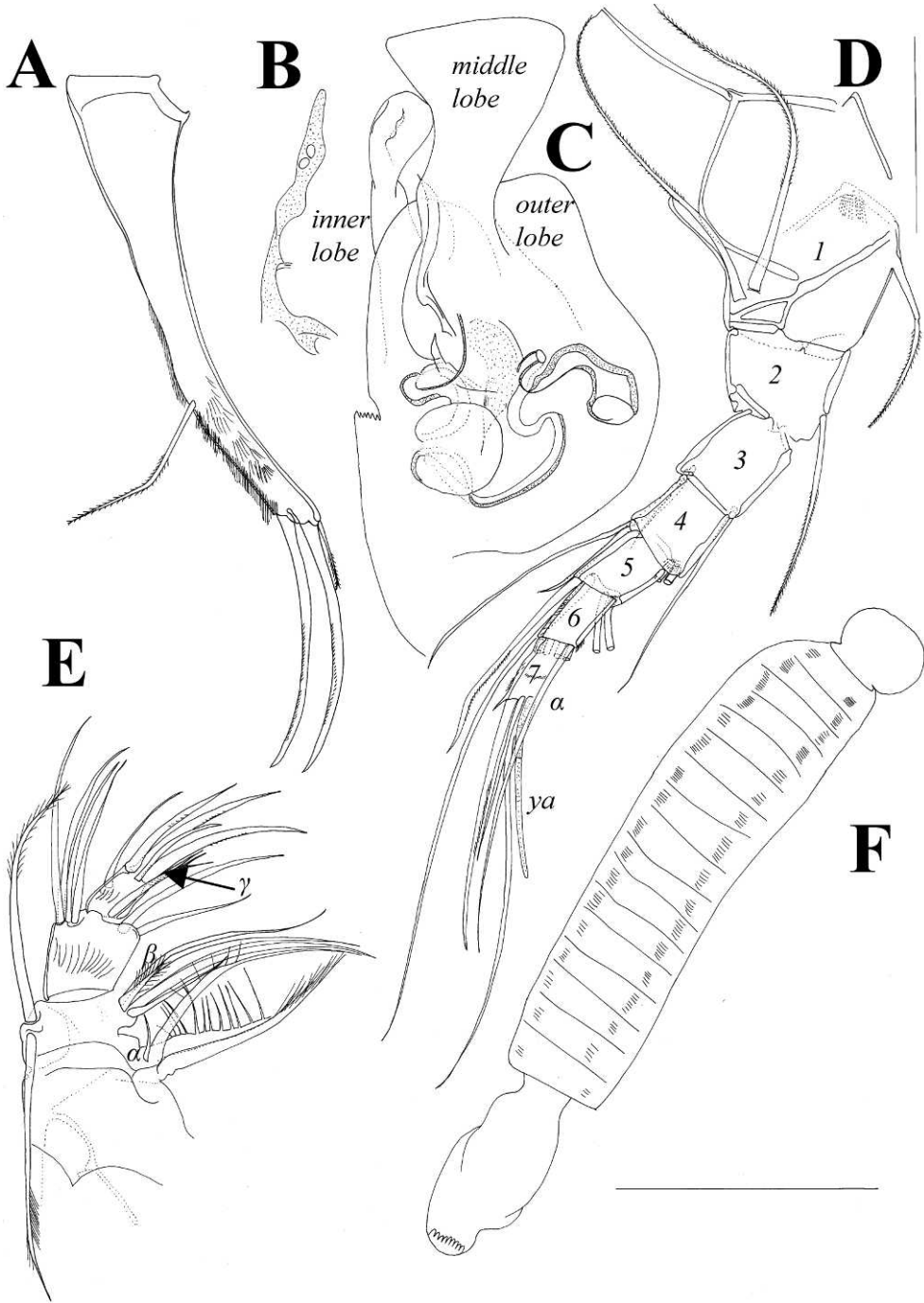


Fig. 3. *Ilyocypris bradyi* Sars, 1890, male: A, UR; B, attachment of UR; C, hemipenis; D, A1; E, Md palp; F, Zenker Organ. Scales = 0.1 mm.

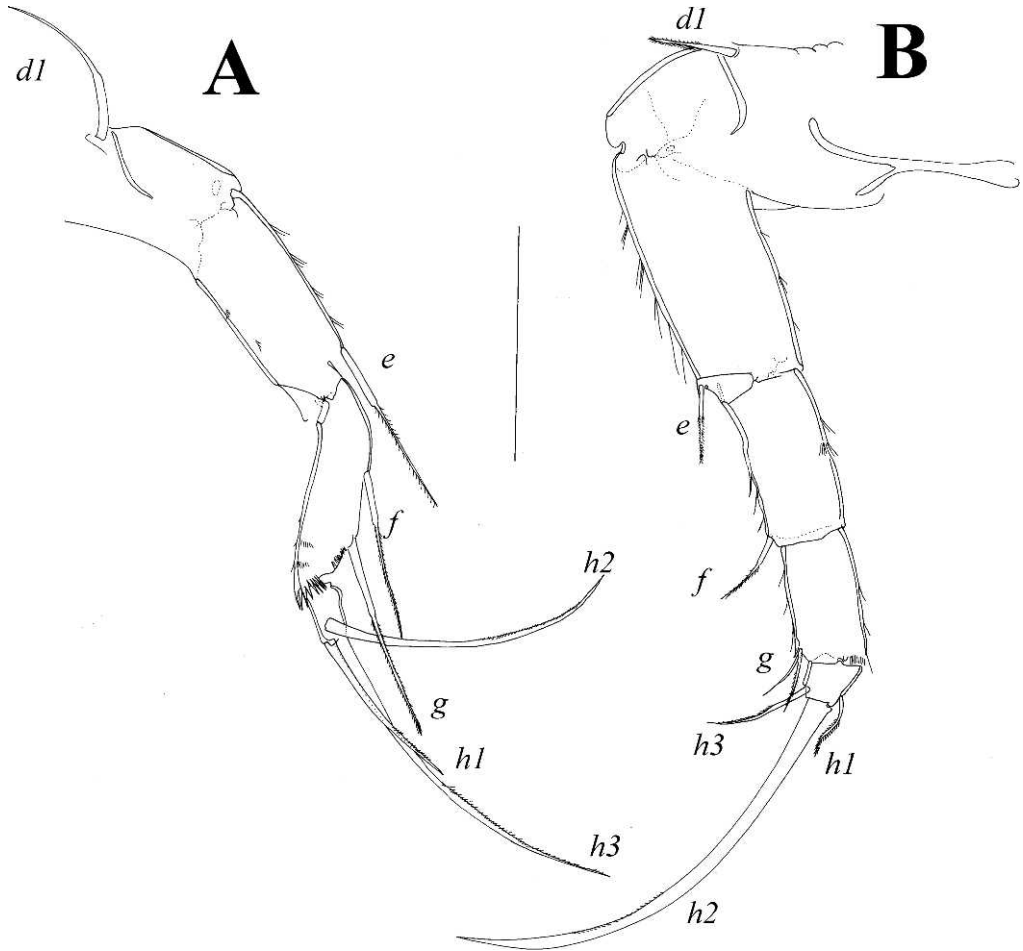


Fig. 4. *Ilyocypris bradyi* Sars, 1890, male: A, L7; B, L6. Scale = 0.1 mm.

two short posterior setae, one of posterior setae reaching tip of A1, other only exceeding distal end of fifth segment. All of these setae smooth. Fifth segment with two long anterior setae, one smooth posterior seta exceeding distal end of terminal setae, and one seta transformed into weak, finely serrated claw. Sixth segment with four long ventral setae and one dorsal ( $\alpha$ ) seta. Seventh segment with weak posterior claw, two smooth setae (one equaling  $2/3$ ) of other. Terminal aesthetasc ( $ya$ ) more than two times longer than terminal segment. All five distal segments more or less equal in size. Segments hirsute on lateral and distal

margins. No Wouters or Rome organs present.

A2 (Fig. 2D) 5-segmented: Coxa with one external smooth seta situated more proximally, and two internal, subequal setae situated distally. Two distal setae one pappose, other serrulate. Basis with one pappose seta situated postero-distally and exceeding distal end of first endopodal segment. Basis covered with bunch of hair-like setae, and small spines. Exopod consisting of one small plate and three apical setae: one serrate, long, exceeding middle of first endopodal segment; other two much shorter and smooth. Endopod 3-segmented. First segment covered with

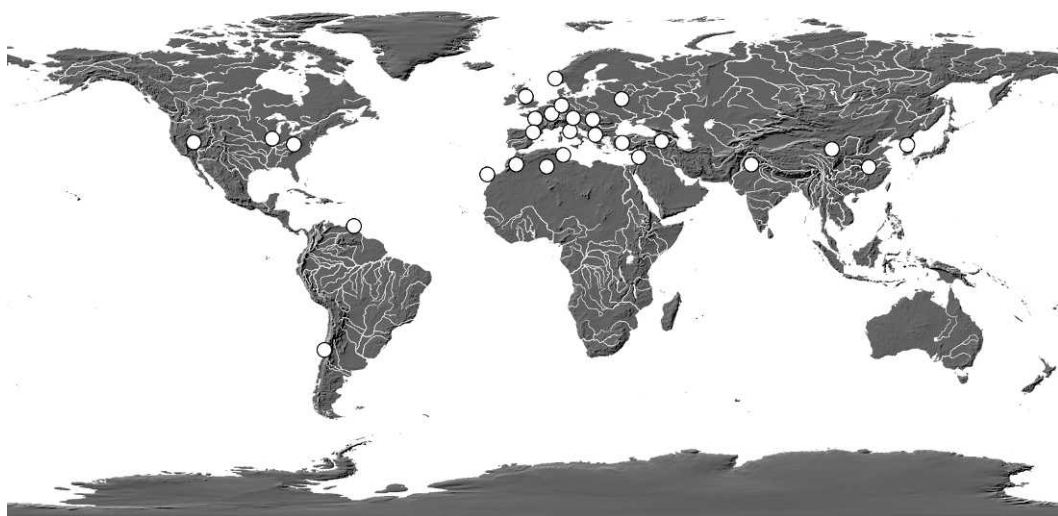


Fig. 5. Distribution of *Ilyocypris bradyi* Sars, 1890 (data from Gauthier 1928, Furtos 1933, Bronstein 1947, Bold 1958, Hartmann 1962, 1964; Cole 1966, Victor & Fernando 1979, Klkylođlu & Vinyard 2000, Meisch 2000).

rows of hair-like setae on its anterior margin; postero-medially first segment with short aesthetasc (Y), while postero-distally with one strong, serrulate seta, reaching distal margin of terminal segment. Swimming setae, situated on distal margin of first segment short, and not reaching distal margin of second endopodal segment. Second endopodal segment also hirsute, carrying two short aesthetasc (y1, y2), two smooth posterior setae (subequally long and smooth) and anteriorly four t-setae. Of these setae, only t1-seta serrulate and exceeding distal end of terminal segment; other t-setae short and not reaching distal margin of second endopodal segment. Second segment on distal margin carrying two z-setae (z2 and Z3), both overpassing middle L of terminal claws, while z1 seta, transferred into claw. G2 claw being as long as z1, and G1 claw being stronger and slightly longer than G2 and z1. Claw G3 reduced into short seta which only slightly exceeding distal end of terminal segment. Terminal segment short and with aesthetasc (y3) accompanied with one seta. Claw GM slightly shorter and

weaker than claw Gm. All claws very finely serrated.

Md palp (Fig. 3E) 4-segmented: First segment internally with four setae. Both S1- and S2-seta plumose,  $\alpha$ -seta very short and smooth and one, unnamed seta which only distally strongly pappose. Second segment externally with two subequally long and distally pappose setae; internally same segment with 3+2 setae; three setae being subequally long and smooth (labeled 1, 2, 3 on the Fig. 3E), one seta being twice as short (arrow pointing on Fig. 3E) and also smooth, and pappose  $\beta$ -seta. Third segment with four extero-distal, smooth, subequal setae, one medio-distal ( $\gamma$ ) seta, and two intero-distal, smooth setae. Terminal segment short with one smooth seta situated extero-medially on segment, three distal claws and three additional small setae: one inserted more externally, two intero-distally on this segment. Third segment covered with long fine hair-like setae.

Mxl (Fig. 2C) with 2-segmented palp and three endites: First segment of palp carrying four serrulate setae distally and serrulate seta medially. Terminal segment

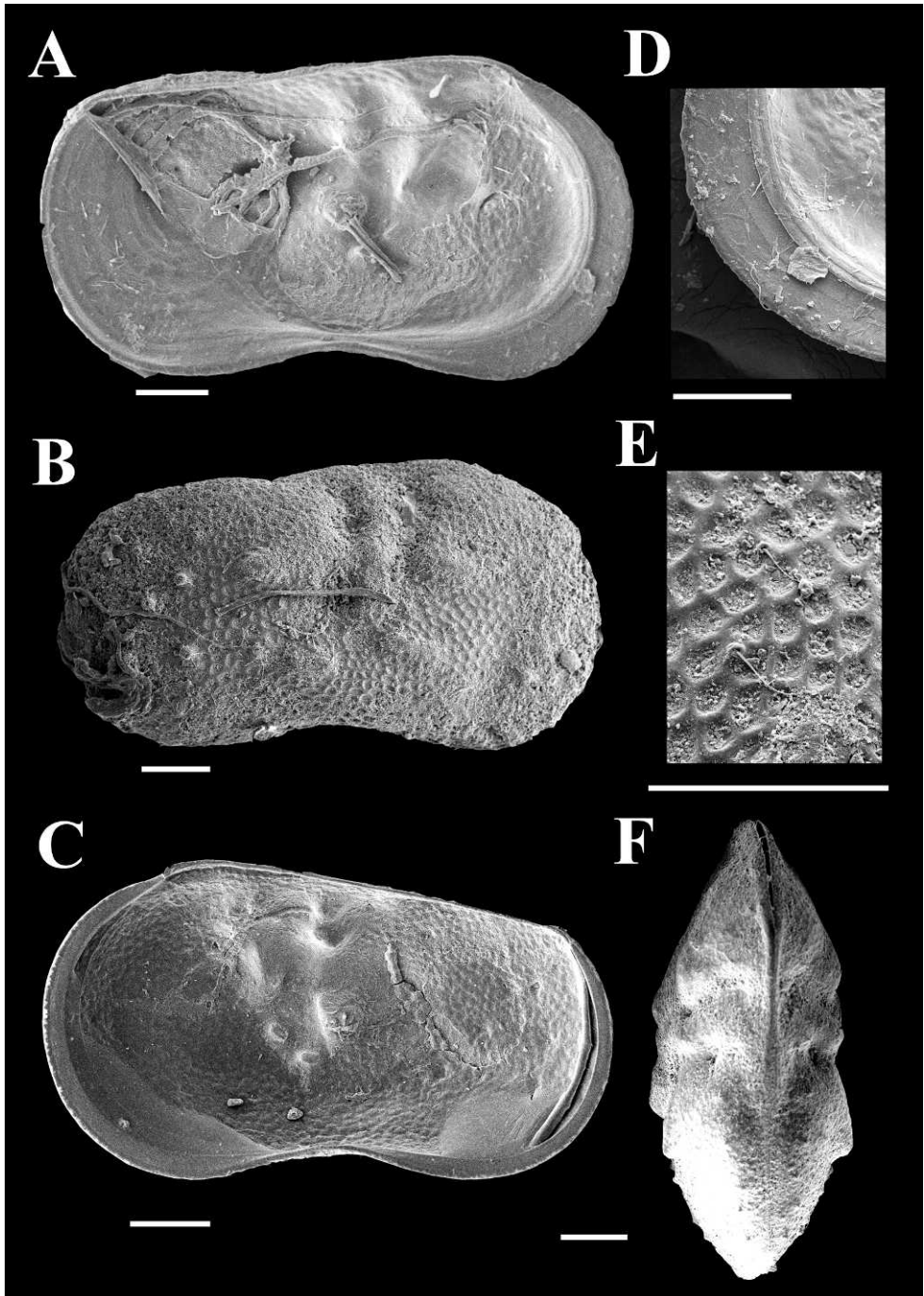


Fig. 6. SEM of *Ilyocypris hanguk*. A, B, D, E, holotype male; C, F, paratype juvenile females. A, LV (inside view); B, RV (outside view); C, RV (inside view); D, anterior marginal zone on LV; E, detail of the carapace ornamentation; F, dorsal view. Scales = 0.1 mm.



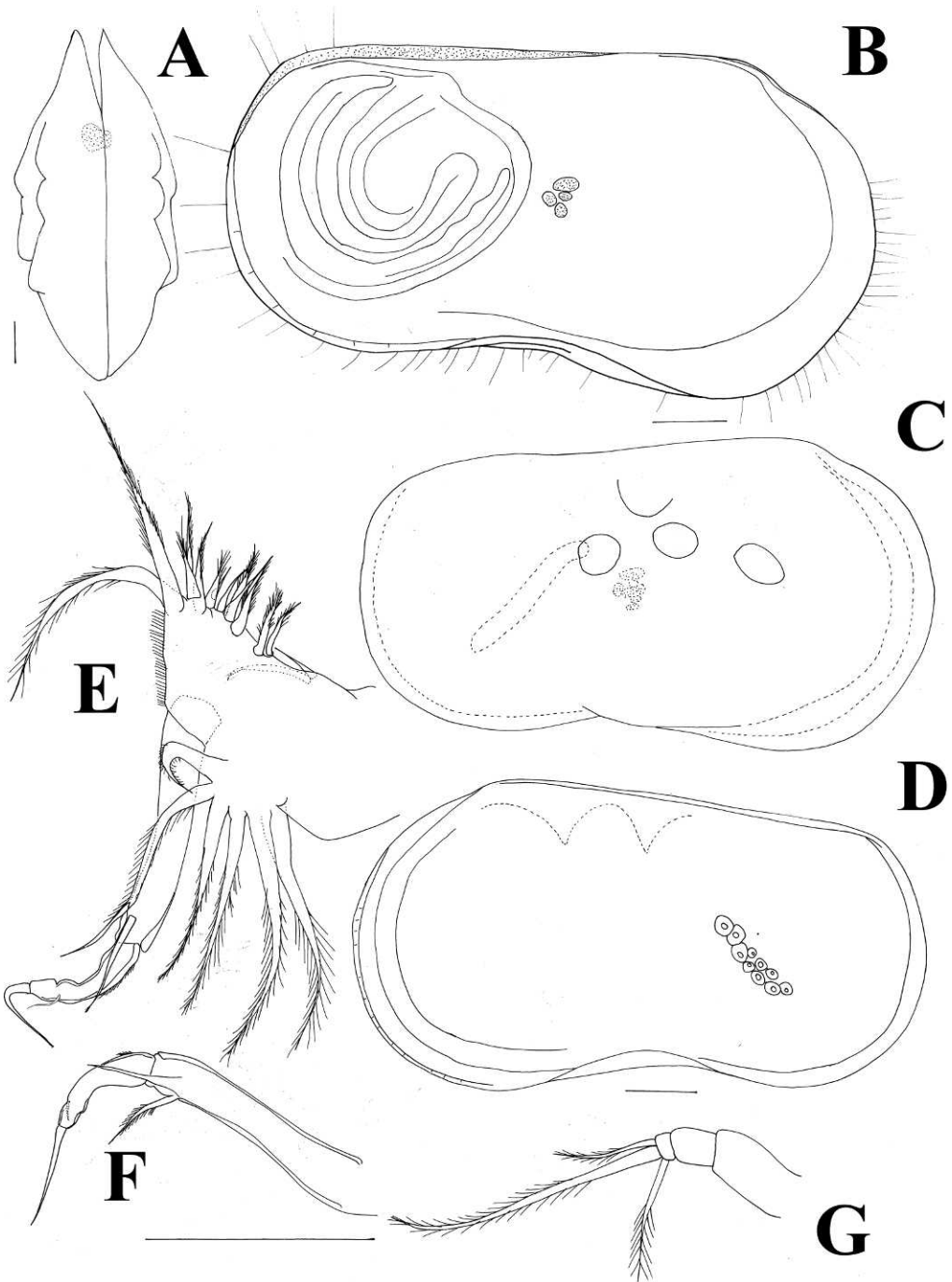


Fig. 7. *Ilyocypris hanguk*. A, C, D, E, paratype juvenile female; B, F, G, holotype male: A, dorsal view; B, LV (inside view); C, RV (outside view); D, RV (inside view); E, L5 with prehensile palp; F, prehensile palp; G, endopod L5. Scales = 0.1 mm.

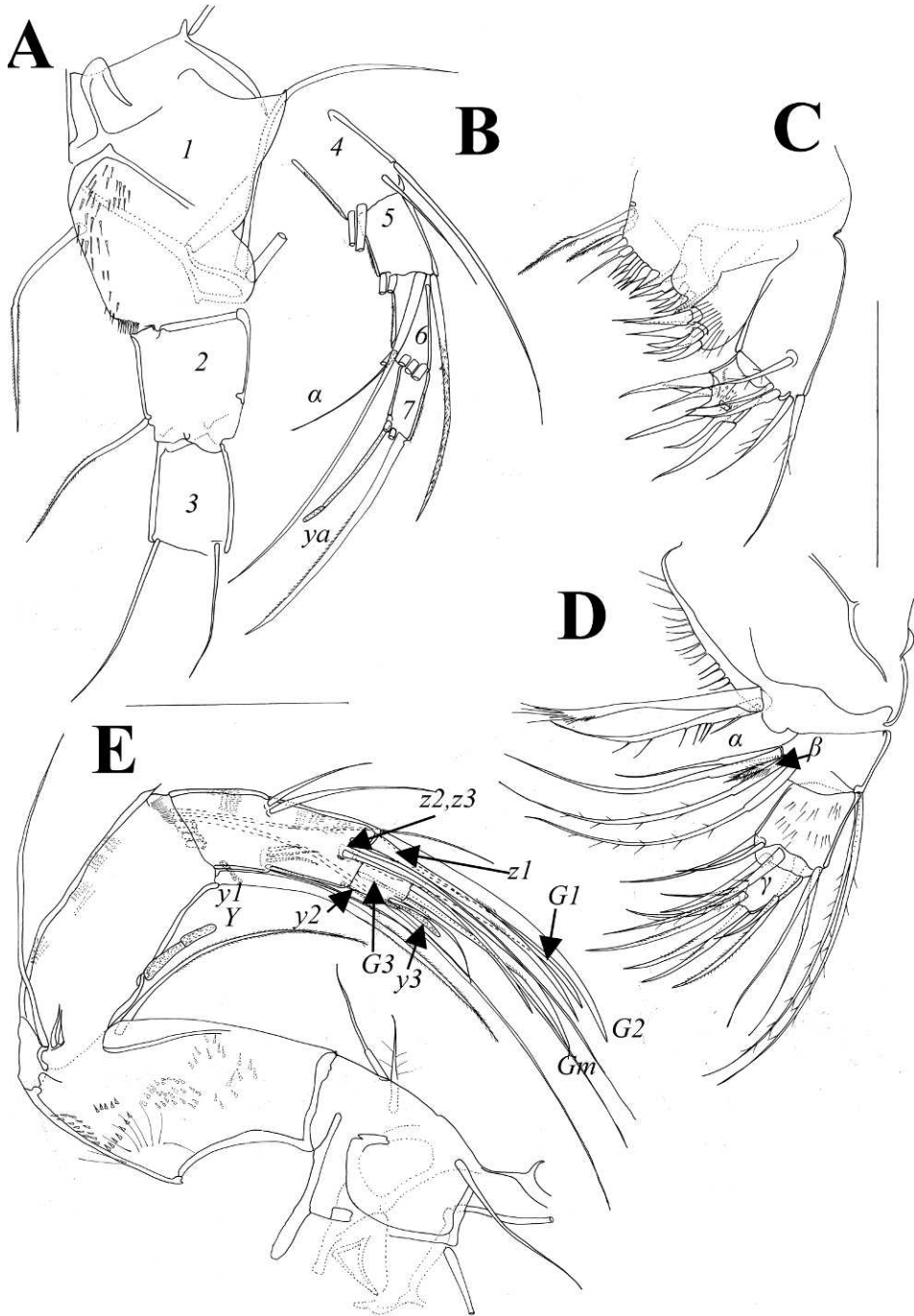


Fig. 8. *Ilyocypris hanguk*. Holotype, male: A, A1 without distal segments; B, A1, distal segments; C, MxI; D, Md palp; E, A2. Scales = 0.1 mm.

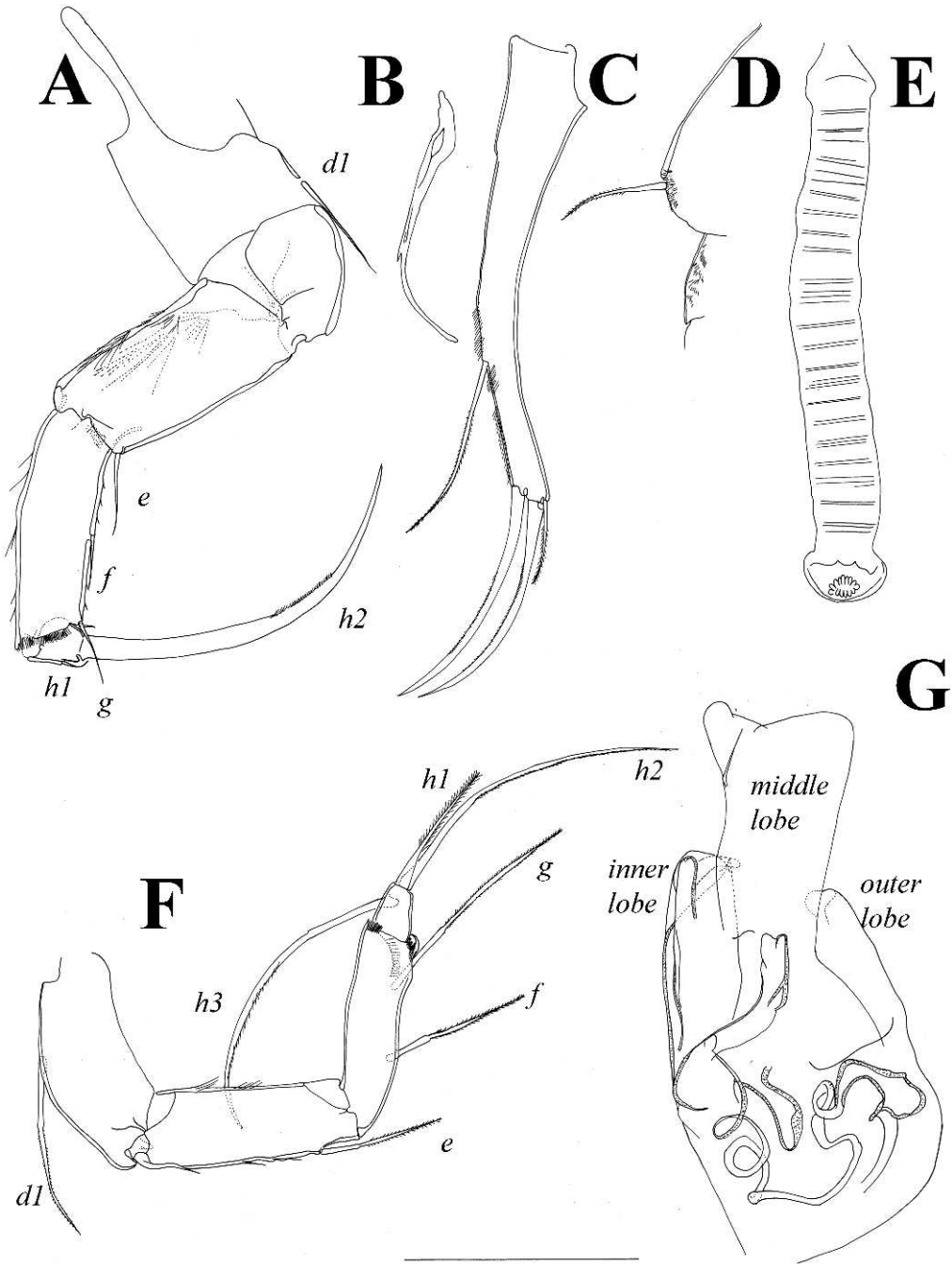


Fig. 9. *Ilyocypris hanguk*. Holotype, male: A, L6; B, attachment of UR; C, UR; D, caudal seta; E, Zenker Organ; F, L7; G, hemipenis. Scale = 0.1 mm.

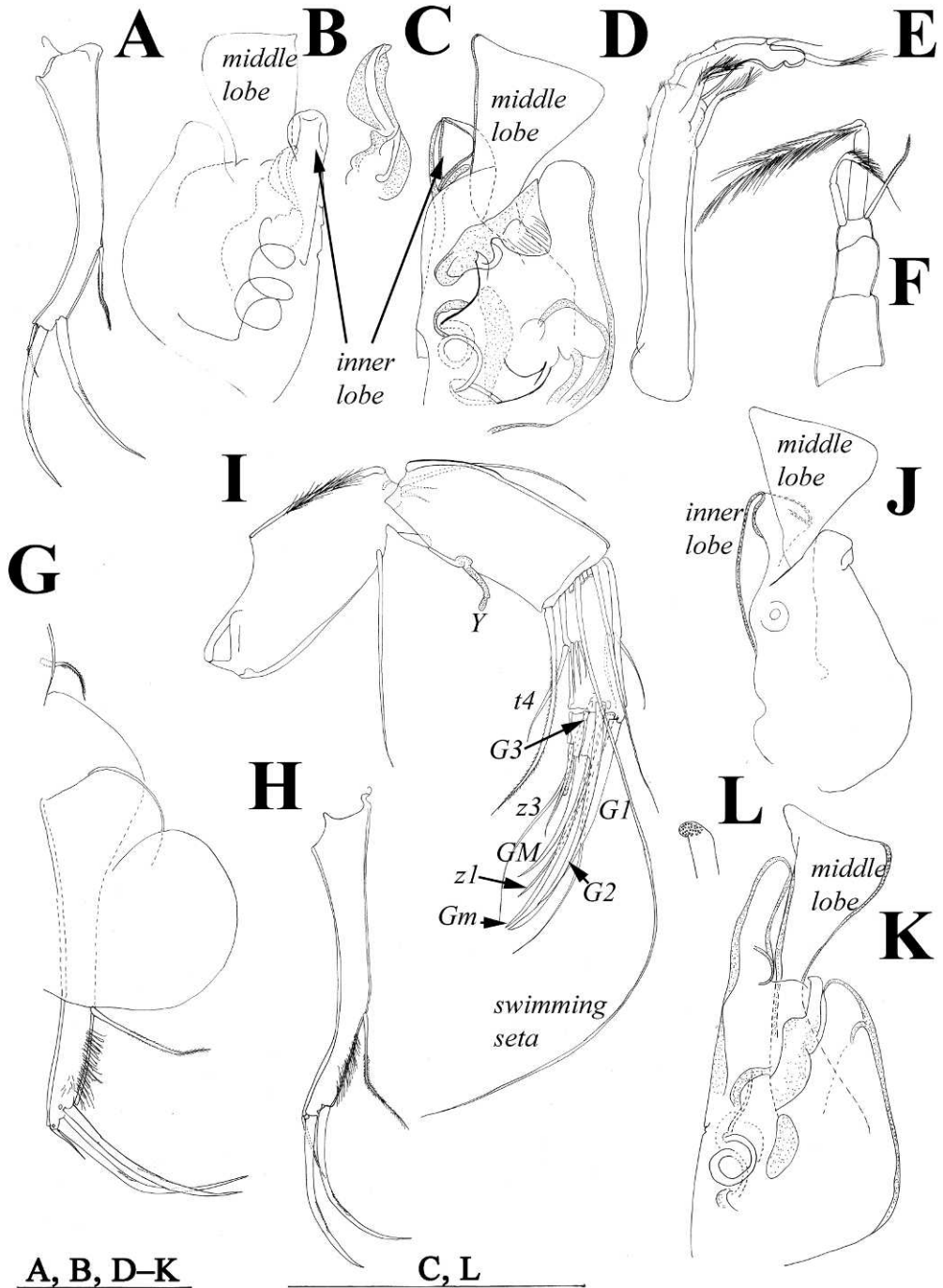


Fig. 10. A, B, *Ilyocypris gibba* (Ramdohr, 1808), male; C–J, *I. dentifera* Sars, 1903; D, E, male, paralectotype, ZMO F12245e-2; F, G, female, paralectotype, ZMO F12245e-1; H–J, male, paralectotype, ZMO F12245C); K, L, *I. cf. angulata*, male, ZMO F12245e-3. A, H, UR; B, D, J, K, hemipenis; C, medial sclerotized part of hemipenis; E, prehensile palp; F, endopod of L5; G, UR with genital filed; I, A2; L, tip of the medial sclerotized part of hemipenis. Scales = 0.1 mm.



distinctly distally enlarged and rectangular, with three claws (medial one being fused with segment) and three setae: one inserted between first two claws, two after medial and most posterior claw. Each of endites with about nine small spine-like setae, first endite in addition with one medial pappose seta, last endite with two postero-medial setae (one longer and pappose, other smooth and half as long).

L5 (Fig. 2E, F) with 2-segmented, almost symmetrical prehensile palps: First segment with two distal pappose setae (on one palp, one of these setae absent on one male, but present on other male). Second segment with two very small setae inserted medio-dorsally and one longer, pappose seta inserted more distally to them. Distal part of both palps terminating in pappose elongated tip. Ventral side of second segment with small claw situated proximally on segment. Two a-setae present on protopod, followed by two setae one of which may represent c-seta, and bunch of approximately 15 pappose/serrulate setae. Protopod highly hirsute. Exopod with six rays, two much shorter. All rays pappose.

L6 (Fig. 4B) 5-segmented: Basal segment with short, serrulate d1-seta. Endopod 4-segmented. Setae e-, f-, and g- all present, short and serrulate. Seta g- accompanied with one slightly shorter, smooth setae. Separation between second and third segment clear. Terminal segment short and with one long, finally serrated claw, and two serrulate, short setae (h1, and h3). Terminal claw 1.3 times longer than three segments combined. All segments on L6 hirsute.

L7 (Fig. 4A) 4-segmented: Basal segment with only d1-seta present. Endopod 3-segmented and with e-, f-, and g-seta present. All these setae being serrulate and equally long. Antero-distally penultimate segment with about 9 spine-like extensions. Terminal segment with three setae, h2- and h3-seta being subequally long, while h1-seta less than half as long. All of these setae finely serrated.

UR (Fig. 3A) with elongated, slightly curved shaft, two setae and two claws: Claw thin, equally long, slightly curved and finely serrated. Posterior seta long, and serrulate (exceeding distal margin of shaft), anterior seta short and serrulate. L ratios between anterior margin of shaft and claws equal 2 : 1. Attachment (Fig. 3B) strong with one small hole proximally, recurved dorsally and with very short dorsal branch. Attachment also bumpy.

Hemipenis (Fig. 3C) with all three lobes well defined: Outer lobe with flat distal margin, medial lobe dilated distally and with dorsal margin rounded and ventral margin slightly triangular. Inner lobe thumb-like and slightly constricted medially. Spermiducts with four coils. Ejaculatory process simple, pointed.

Zenker organ (Fig. 3F) with 18 rows of spines.

*Female.* —Only juvenile females present in samples (Fig. 1E, G). L = 520  $\mu$ m.

*Remarks.* —*Ilyocypris bradyi* Sars, 1890 is one of the three Recent species of this genus in which the swimming setae on the second antenna do not overpass the distal end of the penultimate segment. The other two are *I. inermis* Kaufmann, 1900 and *I. nitida* Lerner-Seggev, 1968. In the latter two species, however, the setae are barely visible (except for the most anterior one), while in *I. bradyi* all setae are longer, at most reaching the distal end of the penultimate segment (except for the most posterior one, which can reach the basis of the claws). All three species also have a 5-segmented L6.

Although we had only juvenile females available for this study, they are positively identified as *I. bradyi*, based on, among other characters, the characteristic reduction of the swimming setae. Other characters that support this are the absence of the lateral allae on the shell with only two medial sulci present, morphology of the L6, L7, etc. Some authors report variability in the presence of the marginal tubercles, these being found only in juveniles

(see Meisch 2000). In the Korean population, tubercles are absent in both adult males and juvenile females. The Korean specimens were identified as juveniles based on their very small size (compared to adults), wide anterior margin, calcified inner lamella narrower than in the adults, setae on the L5 and L6 with bulbous base, and undeveloped oviducts (for general juvenile characteristics in ostracods see Meisch 2000, Karanovic 2012). Although morphology of A1, Mx1 and Md may hold valuable taxonomic information (such as in Candonidae; see Meisch 2000, Karanovic 2012), it is hard to compare this because many reports of *I. bradyi* do not provide these details. The only exception is illustrations in Karanovic (2012), and they are identical to those in the Korean male.

Morphology of the hemipenis of *I. bradyi* conforms to the general appearance of this appendage in other species of the genus, consisting of a large, distally enlarged medial lobe, and lower inner and outer lobes. Unfortunately, little attention has been paid in describing the antenna of males, so it is hard to compare this appendage with other known males. It is worth noting that there is a significant sexual dimorphism in the structure of this appendage in *I. bradyi*. In males the claw G3 is reduced, while the seta z1 is transformed into a claw, a similar situation found in several Candonidae lineages. The only comparable description is that of *I. salebrosa* Stepanaitys, 1960 from Japan (Smith et al. 2011), in which the chaetotaxy is similar to *I. bradyi*, with a difference that the G1 claw is longer in *I. salebrosa*. Martens (1991) described a claw like z3 seta for *I. mongolica* Martens, 1991, but did not provide any information regarding the G1–G3 claws. Lerner-Seggev (1968) provided relatively accurate drawings of this appendage for *I. hartmanni* Lerner-Seggev, 1968 and *I. nitida*, with a similar chaetotaxy of the antenna as in *I. bradyi*. Sari et al. (2012) recently published the first finding of males of *I. inermis*, but it is

hard to distinguish between different claws and setae on the antenna, because all these structures are illustrated as if originating from the same side of the appendage, while it is known that the z-setae are external, while the G1–3 are positioned internally on the antenna. Finally, one can suspect from the drawings of males of *I. angulata* Sars, 1903 by Okubo (1975) that the G3 claw is long, but, on the other hand, not all setae and claws were drawn.

*Ilyocypris bradyi* is a species commonly found in springs and streams, or water bodies closely connected to these but sometimes also in slightly saline waters (for details on its ecology see Meisch 2000). This is a widely distributed species, so far found throughout the Holarctic (Fig. 5). Some findings may be questionable. For example, Cole (1966) reported a population from Tennessee, in which the palp of the female L5 is 3-segmented and the L ratio between three setae on L7 (h1, h2, and h3) is unusual, i.e. two setae are shorter than the third one, while there should be two long and one shorter seta. The reports of this species from South America by Bold (1958) and Hartmann (1962) are very brief, without any description or drawings, and should be rechecked, because they also may represent a different species. Similarly, Martens & Behen (1994) list the record of *I. gibba* (Ramdohr, 1808) by Ramirez (1967) from South America. Ramirez (1967), however, presented drawings of *I. gibba* var. *repens* Vávra, 1891, the name synonymized with *I. bradyi* (see Meisch 2000:253). This species is definitely not *I. bradyi* because it has a 4-segmented penultimate segment of L6.

***Ilyocypris hanguk*, new species**  
Figs. 6–9

*Type locality*.—Stream with clay and water plants on the bottom, Goseori Sinan-gun Bigeum-myeon, Jeollanam-do, South Korea, 34°45'24.4"N, 125°54'35.8"E,

31 May 2011, collected by Choi Y. G. & Kim W. R. Altitude = 12 m asl, water temperature = 17.3°C, pH = 7.34.

*Type material.*—Holotype male (dissected on one slide, shell on SEM stub, NIBRIV0000260612), paratype male (dissected on one slide, shell in alcohol; NIBRIV0000260610), four paratype juvenile females (1 in alcohol, NIBRIV0000260610a; 2 dissected and shell of one female, NIBRIV0000260610b; on SEM stub, shell of the other female, NIBRIV0000260610c; on micropaleontological slide, one female not dissected, shell on SEM stub, dorsal view).

*Description of male.*—Shell rectangular in lateral view (Figs. 1A, B, 7B). Dorsal margin straight along its entire L, with small depression anteriorly extending to anterior margin, while forming almost right angle with posterior margin. Greatest H situated frontally, equaling 51% of total L. Anterior and posterior margins broadly rounded and equally wide. Ventral margin strongly concave near middle. Calcified inner lamella narrow on both ends (Fig. 6D): anteriorly equaling 8%, posteriorly less than 2% of total L. Central muscle scar consists of four scars grouped together. Line of fusion narrow, marginal pore canals short, and hard to observe anteriorly, while clear but sparse posteriorly. Shell with three sulci, positioned close to each other. In dorsal view (Fig. 7A), shell with lateral extensions each with dull/rounded margins, most distal one strongest and triangular. Surface of shell roughly ornamented with dense, shallow pits (Fig. 6E). Surface densely covered with relatively short hair-like setae. L = 930  $\mu$ m.

A1 (Fig. 8A, B) 7-segmented: First segment with one antero-distal and two postero-distal setae; postero-distal setae long; antero-distal seta much shorter, reaching distal margin of second segment; both antero- and postero-distal setae serrulate. First segment with small spines. Second segment articulated with first and

third one and carrying one antero-distal, serrulate seta, not reaching distal end of fourth segment. Third segment with one anterior and one posterior seta. Both of these setae smooth and subequally long. Fourth segment with two long anterior setae and two short posterior setae, one of posterior setae reaching tip of A1, other only exceeding distal end of fifth segment. All of these setae smooth. Fifth segment with two long anterior setae, one smooth posterior seta exceeding distal end of terminal setae, and one seta transformed into weak, finely serrated claw. Sixth segment with four long ventral setae and one dorsal ( $\alpha$ ) seta. Seventh segment with posterior claw, and two smooth, long setae. Terminal aesthetasc (ya) more than two times longer than terminal segment. All five distal segment more or less equal. Segments hirsute on lateral and distal margins. No Wouters or Rome organs present.

A2 (Fig. 8E) 5-segmented: Coxa with one external smooth seta situated more proximally, and two internal, subequal setae situated distally. Of two distal setae one pappose, other serrulate. Basis with one pappose seta situated postero-distally and exceeding distal end of first endopodal segment. Basis covered with bunch of hair-like setae, and numerous small spines. Exopod consisting of one small plate and three apical setae: one long, exceeding middle of first endopodal segment; other two much shorter and smooth. Endopod 3-segmented. First segment on its anterior margin covered with rows of hair-like setae; postero-medially first segment with short aesthetasc (Y), while postero-distally with one strong, serrulate seta, exceeding distal margin of terminal segment. Swimming setae, situated on distal margin of first segment slightly exceeding tips of terminal claws, except for the most anterior one, shorter and reaching middle of terminal claws. Second endopodal segment also hirsute, carrying two short aesthetasc (y1, y2), two smooth posterior setae (both

smooth, one being slightly shorter) and anteriorly four t-setae. Of these setae, only t1-seta exceeding distal end of terminal segment; other t-setae short and not reaching distal margin of second endopodal segment. Second segment on distal margin carrying two z-setae, both overpassing middle L of terminal claws, z1 seta, transferred into claw, G2 claw being as long as z1, and G2 claw being stronger and slightly longer than G1 and z1. Claw G3 reduced into short seta which only slightly exceeding distal end of terminal segment. Terminal segment short and with aesthetasc (y3) accompanied with one seta. Claw GM slightly shorter and weaker than claw Gm. All claws very finely serrated.

Md palp (Fig. 8D) same as in the previous species.

Mxl (Fig. 8C) same as in the previous species.

L5 (Fig. 4E, F) with 2-segmented, almost symmetrical prehensile palps: First segment with two distal setae (only one of these setae pappose). Second segment with one smooth seta inserted distally. Distal part of both palps terminating in smooth elongated tip. Two a-setae present on protopod, followed by two setae one of which may represent c-seta, and bunch of approximately 15 pappose/serrulate setae. Protopod highly hirsute. Exopod with six rays, two much shorter. All rays pappose.

L6 (Fig. 9A) 4-segmented: Basal segment with short, serrulate d1-seta. Endopod 3-segmented, penultimate segment completely fused. Setae e-, f-, and g- all present, short and smooth. Seta g- accompanied with one slightly shorter, smooth seta. Terminal segment short and with one long, finally serrated claw, and one short seta (h1). Terminal claw 1.3 times longer than three segments combined. All segments on L6 hirsute.

L7 (Fig. 9F) 4-segmented: Basal segment with only d1-seta present. Endopod 3-segmented and with e-, f-, and g-seta present. All these setae being serrulate and equally long. Antero-distally penultimate

segment without spine-like extensions, only bunch of fine hair-like setae. Terminal segment with three setae, h2- and h3-seta being subequally long, while h1-seta less than half as long.

UR (Fig. 9B) with elongated, slightly curved shaft, two setae and two claws: Claw thin, equally long, slightly curved and finely serrated. Posterior seta long, and serrulate (exceeding distal margin of shaft), anterior seta short and serrulate. L ratio between anterior margin of shaft and claws equal 2 : 1. Attachment (Fig. 9B) strong with one hole proximally, recurved dorsally and without dorsal branch. Attachment also bumpy. Caudal seta (Fig. 9D) serrulate.

Hemipenis (Fig. 9G) with all three lobes well defined: Outer lobe with flat distal margin, medial lobe dilated distally and with dorsal margin rounded, while ventral margin extended with rounded bulging. Inner lobe strongly sclerotized, curved towards medial lobe and beak. Spermiducts with four coils. Ejaculatory process wide, distally with concave margin and small subdivision.

Zenker organ (Fig. 9E) number of rosettes hard to count, but approximately 25 rows present.

*Female*.—Only juvenile females present in samples (Figs. 6C, F, 7C, D), with carapace shape very similar to male, only dorsal margin sloping toward posterior end. L5 (Fig. 7G) 3-segmented with three distal setae, all pappose, two being shorter.

*Variability*.—The holotype male lacks h2-seta on the L6, while this seta is present in the paratype male. In addition the swimming setae on the A2 of the paratype male are longer than in the holotype male, and they exceed the tips of terminal claws at least by half length of the claws.

*Etymology*.—The species name is a Korean word “Hanguk,” meaning Korea.

*Remarks*.—*Ilyocypris hanguk* belongs to a group of *Ilyocypris* species in which the swimming setae on A2 reach and/or overpass the tips of terminal claws, and



the L6 is 4-segmented. The following 11 species can be confidently assigned to this group: *I. angulata* Sars, 1903; *I. australiensis* Sars, 1889; *I. brehmi* Schäfer, 1952; *I. dentifera* Sars, 1903; *I. fallax* Brehm, 1928; *I. gibba* (Ramdohr, 1808); *I. haterumensis* Okubo, 1992; *I. japonica* Okubo, 1990; *I. lacustris* Kaufmann, 1900; *I. nagamalaiensis* Victor & Michael, 1975; and *I. perigundi* De Deckker, 1981. While the new species has two setae on the penultimate segment of L7, *Ilyocypris lacustris* has three, *I. brehmi* has only one seta, and *I. nagamalaiensis* lacks any setae. *Ilyocypris perigundi* has a 1-segmented palp on the female L5, while *I. gibba* has a 2-segmented palp, and the new species has a 3-segmented palp. Like the majority of Recent species, *I. hanguk* has only one seta on the basal segment of L7, contrary to *I. australiensis*, which has two setae. With the exception of *I. angulata* all other species are generally considered to lack lateral projections on the shell. The presence/absence of these shell extensions or nodding is often thought to be an intraspecific variability. The most drastic examples are those in *I. gibba* and *I. biplicata* Koch, 1838. Most authors (see Meisch 2000:246) consider these two only as forms of a single species: *I. gibba* having the lateral allae, and *I. biplicata* lacking. Petkovski (1958) and Martens (1984) are of a different opinion and they retain both names as valid species. The carapace variability within one species is a well-documented phenomenon in some ostracods, such as *Cyprideis torosa* (Jones, 1850) (see Frenzel 1991, Wouters 2002, Keyser & Aladin 2004). Unfortunately, at least in the case of *Ilyocypris*, the morphology of the soft parts is rarely studied in detail, so it is often hard to tell if the variability in the shell structure is accompanied by some variability in soft parts. If we compare Martens' (1984) drawings of *I. biplicata* found in Sudan, we can see significant difference in the morphology of the hemipenis between the Sudanese

populations of *I. biplicata* and the European populations of *I. gibba*. Another two problematic species are *I. dentifera* and *I. angulata*, which are the most closely related to the new Korean species. Discussion on their taxonomy is given below. The new species can be distinguished from *I. dentifera* because it does not have marginal tubercles on the shell, and from *I. angulata* because of the lack of the lateral projections on the shell. Other, more striking differences are: the middle lobe of the hemipenis is less conical in *I. hanguk* than in the other two species; the inner lobe of the hemipenis has a beak-like, well-sclerified part in *I. angulata*; and the posterior seta on the UR is longer in the latter species as well.

*Ilyocypris dentifera* Sars, 1903

Figs. 10C–L & 11

*Ilyocypris dentifera* Sars—Sars, 1903:38, Plate 4, Fig. 8a–c.—Victor & Fernando, 1981:1106, Figs. 1–3.—Okubo, 1990:40, Fig. 1a–e.

*Ilyocypris dentifera* form *angulata* Sars—Victor & Fernando, 1981, Fig. 28.

[non] *Ilyocypris dentifera* Sars — Kim & Min, 1991:317, Figs. 8–9.

*Material from the lectotype series examined and identified as I. dentifera.*—Lectotype female (dissected on one slide, shells in 70% alcohol, ZMO F12245a); Paralectotypes (one female dissected on one slide, shell on SEM stub, ZMO F12245e-1; one female of SEM stub, ZMO F12245e-4; one male dissected on one slide, shell on SEM slide, F12245e-2; one male dissected on one slide, shell in 70% ethyl alcohol; ZMO F12245c; 54 females, 61 males, 1 juvenile in 70% ethyl alcohol, ZMO F12245e); from Putsching, China.

For the examined material identified either as *I. angulata* or *I. cf. angulata*, see below.

*Ilyocypris angulata* Sars, 1903  
Figs. 12, 13

*Ilyocypris angulata* Sars—Sars, 1903:38, Plate 4, Fig. 8a–c.—Chen, 1990:235, Fig. 1.

*Ilyocypris dentifera* form *angulata* Sars—Victor & Fernando, 1981:1106, Figs. 23–27, 29–38.

[non] *Ilyocypris angulata* Sars—Okubo, 1975:46, Fig. 1.

*Material from the lectotype series examined and identified as I. angulata.*—Lectotype female (dissected on one slide, shells in alcohol, ZMO F12244a); Paralectotypes (one female dissected on one slide, shell on SEM stub, ZMO F12244c-4; one female on SEM stubs, ZMO F12244c-6; one male dissected on one slide, shell on SEM, ZMO F12244c-5; six females, one male, six valves in 70% ethyl alcohol, ZMO F12244c): from Putsching, China.

For the examined material identified as *I. cf. angulata*, see below.

*Remarks on the taxonomic status of the I. dentifera-angulata species complex.*—Sars (1903) described *Ilyocypris dentifera* and *I. angulata* from a dried mud sample he received from China and raised in Norway. In a very brief description Sars expressed a possibility that the two species may be synonyms, because of some variability in the level of development of lateral allae on the shell. Beside the drawings of the shell, Sars provided only drawings of the UR of *I. dentifera*. Victor & Fernando (1981) examined the type series of both species, provided a brief redescription, designated lectotype and paralectotypes, and finally concluded that the two species are indeed synonyms, and that *I. angulata* is a parthenogenetic form of *I. dentifera*. As support for this hypothesis, Victor & Fernando (1981) stated that in the *I. angulata* population there are some specimens with a very strongly developed lateral allae, some without allae, and some with very weakly

developed ones. The complete absence of allae is a character of *I. dentifera*. Although, they also did not find males of *I. angulata*, they compared the males reported from Japan (Okubo 1975) and said that they are the same as males of *I. dentifera*. The authors decided to retain the name *I. dentifera*. The drawings of Victor & Fernando (1981) are quite simple and sketchy but represent a completely different hemipenis from the one given by Okubo (1975). There are also some other differences between the Japanese population and the Chinese one. For example, the lateral allae in the Japanese specimens are much more pointed. Unaware of descriptions of Okubo, Chen (1990) reported the first finding of males of *I. angulata* from China (Fig. 14), a species also different when compared with the drawings of male *I. dentifera* of Victor & Fernando (1981), and from the drawing of *I. angulata* reported by Okubo (1975). Kim & Min (1991) reported a bisexual population of *I. dentifera* from numerous localities in Korea, but their finding is, again, questionable. First, the hemipenis is quite different from the one in Victor & Fernando (1981), the inner lobe seems to be thick and worm-like in the Korean populations, and there are some differences in the appearance of the male prehensile palps. Some additional peculiarities question the identity of the Korean *I. dentifera* as well. Namely, the claws on the L6 and the UR are very strongly serrated, not noticed in any *Ilyocypris* species described so far (but, again, many descriptions are rather limited), and also this species seems to have two bristles on the basal segment of L7. The last character is only present in *I. australiensis*. Finally, Okubo (1990) reported bisexual populations of *I. dentifera* from Japan (Fig. 14) and correctly concluded that this species differs from *I. angulata* by the hemipenis and the prehensile palps morphology. The Korean population of *I. dentifera* is also different

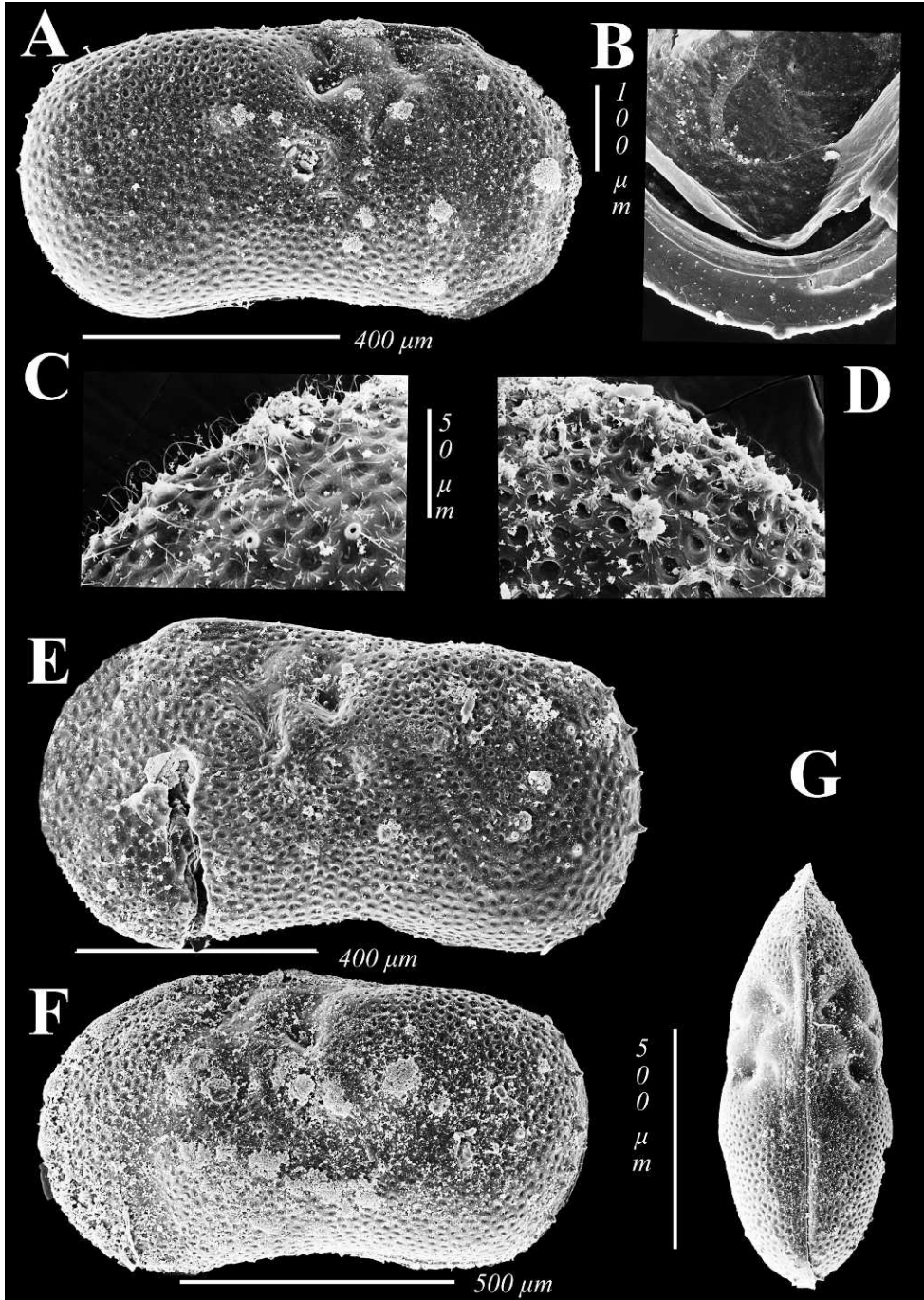


Fig. 11. SEM. A, C, F, G, *Ilyocypris dentifera* Sars, 1903: A, C, male, paralectotype, ZMO F12245e-2; F, female, paralectotype F12245e-1; G, female, paralectotype F12245e-4; B, D, E, *Ilyocypris cf. angulata*, male, ZMOF12245e-3. A, RV, lateral view (outside view); B, anterior margin (inside view); C, anterior margin (outside view); D, anterior margin (outside view); E, F, LV, (outside view); G, dorsal view.



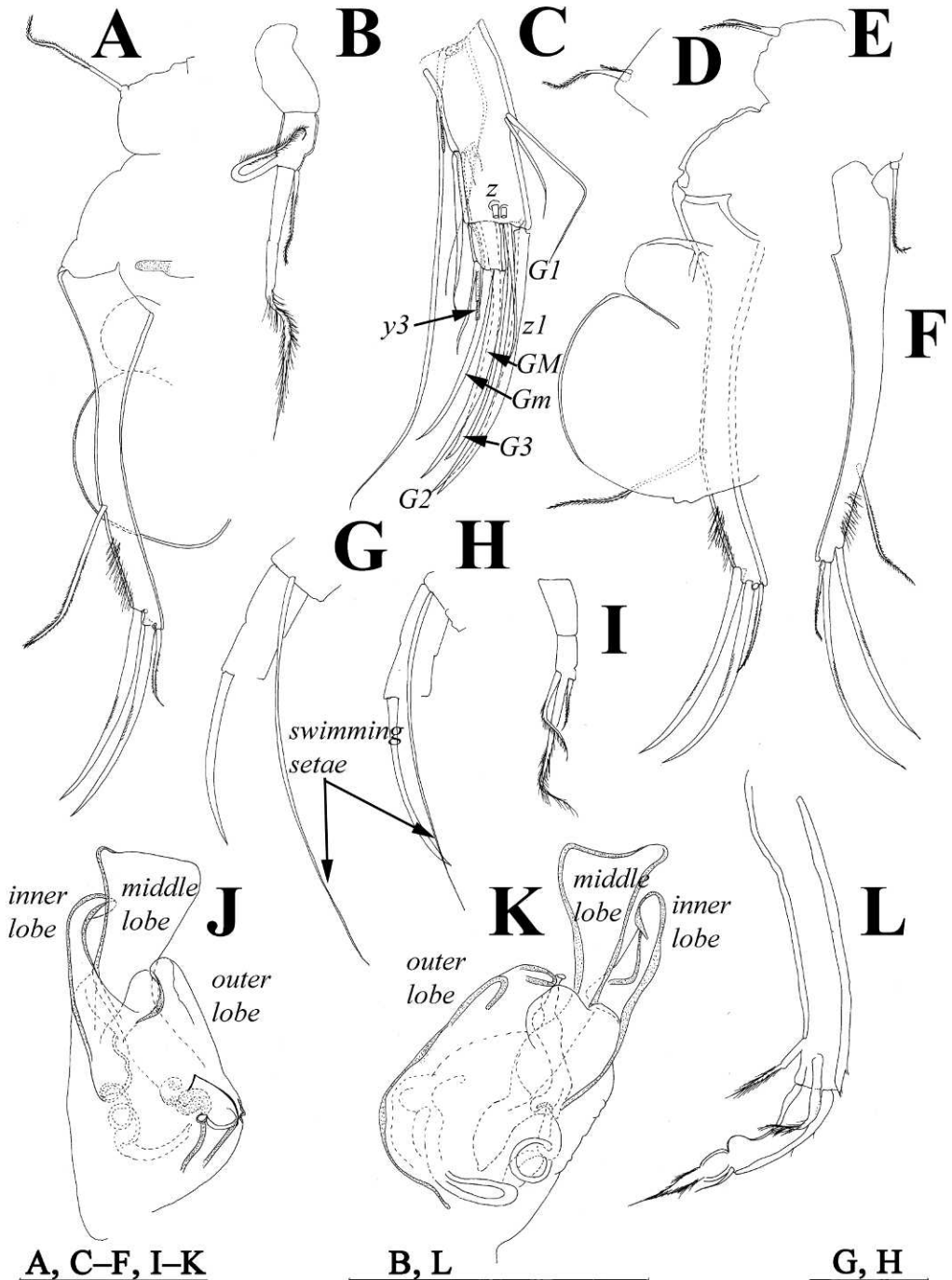


Fig. 12. A–C, J, *Ilyocypris angulata* Sars, 1903: A, B, female, paralectotype, ZMO F12244c-4; C, female, lectotype, ZMO F12244a; J, male, paralectotype, ZMO F12244c-5; D–I, K, L, *I. cf. angulata*: D, H, I, female, paralectotype, ZMO F12244c-2; E, G, female, paralectotype, ZMO F12244c-1; F, K, L, male, paralectotype, ZMO12244c-3. A, D, UR with genital filed; B, I, endopod of L5; C, swimming setae and last two segments of A2; C, caudal seta; F, UR; G, H, unarmed last two segments of A2 with one swimming seta, indicating length of swimming setae; J, K, hemipenis; L, prehensile palp. Scales = 0.1 mm.



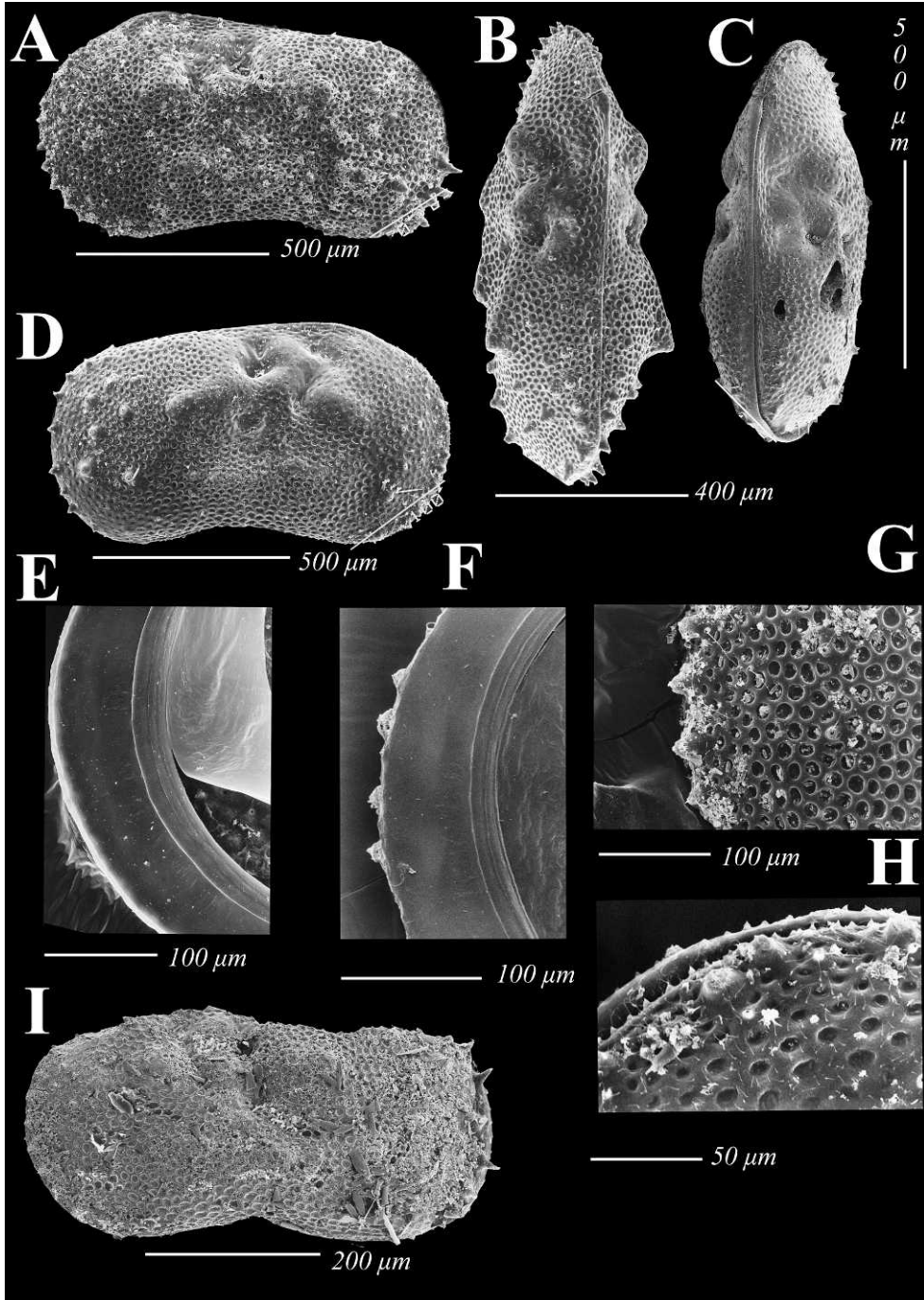


Fig. 13. SEM. A, B, F, G, I, *Ilyocypris angulata* Sars, 1903: A, F, G, female, paralectotype, F12244c-4; B, female, paralectotype F12244c-6; I, male paralectotype, F12244c-5; C, D, E, H, *Ilyocypris cf. angulata*: D, E, H, female, paralectotype, F12244c-1; C, female, paralectotype, F12244c-7. A, LV, (outside view); B, C, dorsal view; D, RV (outside view); E, F, anterior margin from the inside; G, H, anterior margin from the outside; I, LV (outside view).



Fig. 14. Known distributions of three East Asian *Ilyocypris* Brady & Norman, 1889 species: *Ilyocypris angulata* Sars, 1903 (circles); *I. dentifera* (stars), and *I. hanguk* (triangle). Data from Sars 1903, Okubo 1975, 1990; Chen 1991, Kim & Min 1991, and original report.

from the Japanese one, because of the strong serration of the claws on the UR, shorter posterior seta on the same appendage, hemipenis outline, and the absence of the dorsal seta on the second segment of the prehensile palps. Lead by this confusion regarding the two species, we have decided to examine the type series and resolve the issue. Material deposited in the Zoological Museum in Oslo contained microscope slides of a lectotype female and a paralectotype male of *I. dentifera* and a slide of an *I. angulata* lectotype female. Their valves are kept separately in glass vials in alcohol. No other dissection was kept, and all other material of the two species is contained in glass vials in alcohol. The vial labeled as paralectotypes of *I. dentifera* contained some typical specimens (Figs. 10C–J, 11A, C, F, G) but also some atypical ones (Figs. 10K, L, 11B, D, E). They differ from typical *I. dentifera* by the absence of marginal tubercles (Fig. 11B), a slightly

stronger surface ornamentation (Fig. 11D), and a different valve shape, so that the postero-dorsal margin is more angular and the ventral margin is more concave (Fig. 11E). In dorsal view lateral allae are very poorly developed. When dissected these atypical specimens revealed a completely different hemipenis (Fig. 10K, L), which has a finger-like inner lobe and an elongated distal part of the internal hemipenis structure, which may be part of ejaculatory apparatus. In this atypical form, its tip is also ornamented with tiny spine-like structures (Fig. 10L). The shell of a typical *I. dentifera* has a more rounded postero-dorsal margin (Fig. 11A, F), slightly less prominent surface pits (Fig. 11C), a completely different shape of the hemipenis inner lobe (Fig. 10C, J), and a much wider internal part close to the ejaculatory apparatus (Fig. 10C). Beside this atypical form, the paralectotype series of *I. dentifera* also contained some typical *I. angulata* speci-

mens (see the material examined). When we examined the paralectotypes of *I. angulata* we also found some typical forms with prominent lateral allae (Fig. 13B) but also some that are the same as the atypical form found within the *I. dentifera* paralectotypes (Fig. 13C–E, H). Dissection also revealed that the males of *I. angulata* were actually present in the sample (Fig. 12J) and that the hemipenis has a finger-like inner lobe, completely different to *I. dentifera*. The hemipenises of *I. angulata* and *I. cf. angulata* are similar, with the exception that the inner lobe of the former one is more pointed distally and always turned towards the middle lobe. In addition, the inner part of the ejaculatory apparatus is boxer-glove like. There are some other differences between a typical *I. angulata*, typical *I. dentifera*, and the intermediate form found in both type series, such as the appearance of the middle lobe of the hemipenis. We have decided to provisionally identify this atypical form as *I. cf. angulata* because we have found some inconsistency in the morphology of other soft parts. Namely, the swimming setae on A2 are sometimes as long as in *I. angulata* (compare Fig. 12C and Fig. 12H) and sometimes longer (Fig. 12G). Dissected *I. angulata* specimens have only one caudal seta (Fig. 12A), dissected females of *I. cf. angulata* have two (Fig. 12C) or bifurcate seta (Fig. 12E), while the corresponding males have one seta (Fig. 12F). In both forms the endopod of female L5 is 2-segmented (Fig. 12B, I). This last character is another clear distinguishing feature between *I. angulata* and *I. dentifera*, in the later the female endopod L5 is 3-segmented (Fig. 10F). Differences between the two species are even clear in the lateral view of the shell: dorsal margin in *I. angulata* is more posteriorly inclined (Fig. 13A, D) and generally lower compared to *I. dentifera* (Fig. 11F). Uropodal ramus and prehensile palps are almost identical between the two species (Figs. 10D, G, H, 12A, D, E,

L). This is more obvious if one compares their UR with *I. gibba* (Ramdohr, 1808), which is a closely related species. Here, the posterior seta is much shorter (Fig. 10A). In this species the inner lobe of the hemipenis is also rounded distally, but it does not extend as high as in *Ilyocypris angulata* and *I. dentifera* (Fig. 10B). Detailed comparison of the *I. dentifera* and *I. angulata* types allows us to reconsider other records of the two species. Namely, *I. angulata* reported from Japan (Okubo 1975) does not belong to this species. Its hemipenis is more similar to *I. dentifera* from Korea (Kim & Min 1991). However, the Korean population does not have lateral allae and has some peculiar serrations on different appendages (see above) and it may represent a third, undescribed, species. The record from China of *I. angulata* by Chen (1990) and that of *I. dentifera* from Japan (Okubo 1990), in our opinion, represent good identifications. It must be noted that the species *I. japonica* Okubo, 1990, described from Japan (Okubo 1990) has an almost identical hemipenis as *I. angulata* but apparently does not have lateral projections on the carapace. Okubo (2004) suggested that *I. japonica* is a synonym of another Japanese species, *I. haterumensis* Okubo, 1992 (in Okubo & Terauchi 1992), but this has to be taken with caution, because this species has a much shorter posterior seta on the UR.

*Material from the lectotype series of I. dentifera examined and identified as I. cf. angulata.*—One male dissected, shell on SEM stub, ZMO F12245e-3; five males, 12 females, one empty shell in 70% alcohol ZMO F12245e-5: from Putsching, China.

*Material from the lectotype series of I. dentifera examined and identified as I. angulata.*—One male and three females in 70% alcohol, ZMO F12245e-6: from Putsching, China.

*Material from the lectotype series of I. angulata examined and identified as I. cf. angulata.*—One female dissected, shell on



SEM slide, ZMO F12244c-1; one female dissected, shell on SEM stub, ZMO F12244c-2; one female on SEM stub, ZMO F12244c-7; one male dissected on one slide, shell on SEM stub, ZMO F12244c-3; 15 females, 3 empty shells, and 7 valves in 70% ZMO F12244c-8: from Putsching, China.

### Discussion

*Ilyocypris* Brady & Norman, 1880 currently contains 28 Recent species, of which 21 are included in our cladistic analysis. The cladistic analysis resulted in a single tree, 35 steps long, with the consistency index of 56 and the retention index of 75 (Fig. 15). *Ilyocypris alta* Sars, 1910; *I. brehmi* Schäfer, 1952; *I. carinata* Kovalenko, 1970; *I. mckenzie* (Bhatia & Mannikeri, 1974); *I. nagamalaiensis* Victor & Michael, 1975; *I. propinqua* Sars, 1910; and *I. taprobanensis* Neale, 1976 are left out from the analysis, because they are either poorly described and/or the males are not known. The genus is defined by several characters: presence of sulci on the carapace, symmetrical prehensile palps, one basal seta (d1) on L6, less than three setae on the basal segment of the L7, and the position of the posterior seta on the UR (bellow half length of the posterior margin). The first character is shared with other fossil genera of the family Ilyocyprididae (see Rodríguez-Lázaro & Martín-Rubio 2005) and a fossil Candoninae genus, *Septacandona* Cabral & Colin, 2002. The latter is especially interesting because this Upper Jurassic candonid (Cabral & Colin 2002) may be a support that, among the four families of the superfamily Cypridoidea, Ilyocyprididae, and Candonidae, are the most closely related. When the prehensile palps are considered, it is hard to say if their symmetry is a plesiomorphic or apomorphic feature, because in most other Cypridoidea they are asymmetrical, but

to a different extent in different lineages. The lack of some setae on the basal segments of L6 and L7 is often encountered in Cypridoidea, and it usually indicates a separate lineage. One example is the subfamily Candoninae, where the lack of both d1- and d2-setae may be a character on the tribe level (Karanovic 2007), and the chaetotaxy of L7 is a very useful tool in distinguishing between different Candoninae genera (see Meisch 1996). Similar examples can be found in other Cypridoidea lineages. The position of the posterior seta on UR, as found in the genus *Ilyocypris*, is common among Cypridoidea, and a proximally inserted seta found in the outgroup taxon is shared with some Paracypridinae and some terrestrial Candoninae (both Candonidae subfamilies).

*Ilyocypris bradyi* Sars, 1860, *I. inermis* Kaufmann, 1900, and *I. nitida* Lerner-Seggev, 1968 form one of the basal clades, supported by short swimming setae on the A1 and a 6-segmented L6. *Ilyocypris getica* Masi, 1906 and *I. salebrosa* Stepanaitys, 1960 form another group. However, these two species, as well to all the other species on the tree, have much longer swimming setae. The genus can be roughly divided in two groups of species: the ones with the 6-segmented L6 (the more basal clade) and the one with a 5-segmented L5 (the more terminal clade). It is interesting to note that, with the exception of *I. gibba* and *I. lacustris*, all the other species on the terminal clade are distributed in Asia or Australia/New Zealand. *Ilyocypris mongolica* Martens, 1991, another Asian species (Martens 1991), has a 6-segmented L6, and on the tree is a sister taxon of the terminal clade. The species that form the basal clade are either widely distributed or are known from Europe or the Middle East.

Although *Ilyocypris* has a global distribution, and many species have been reported from a wide area, here we have to point out some other incongruence

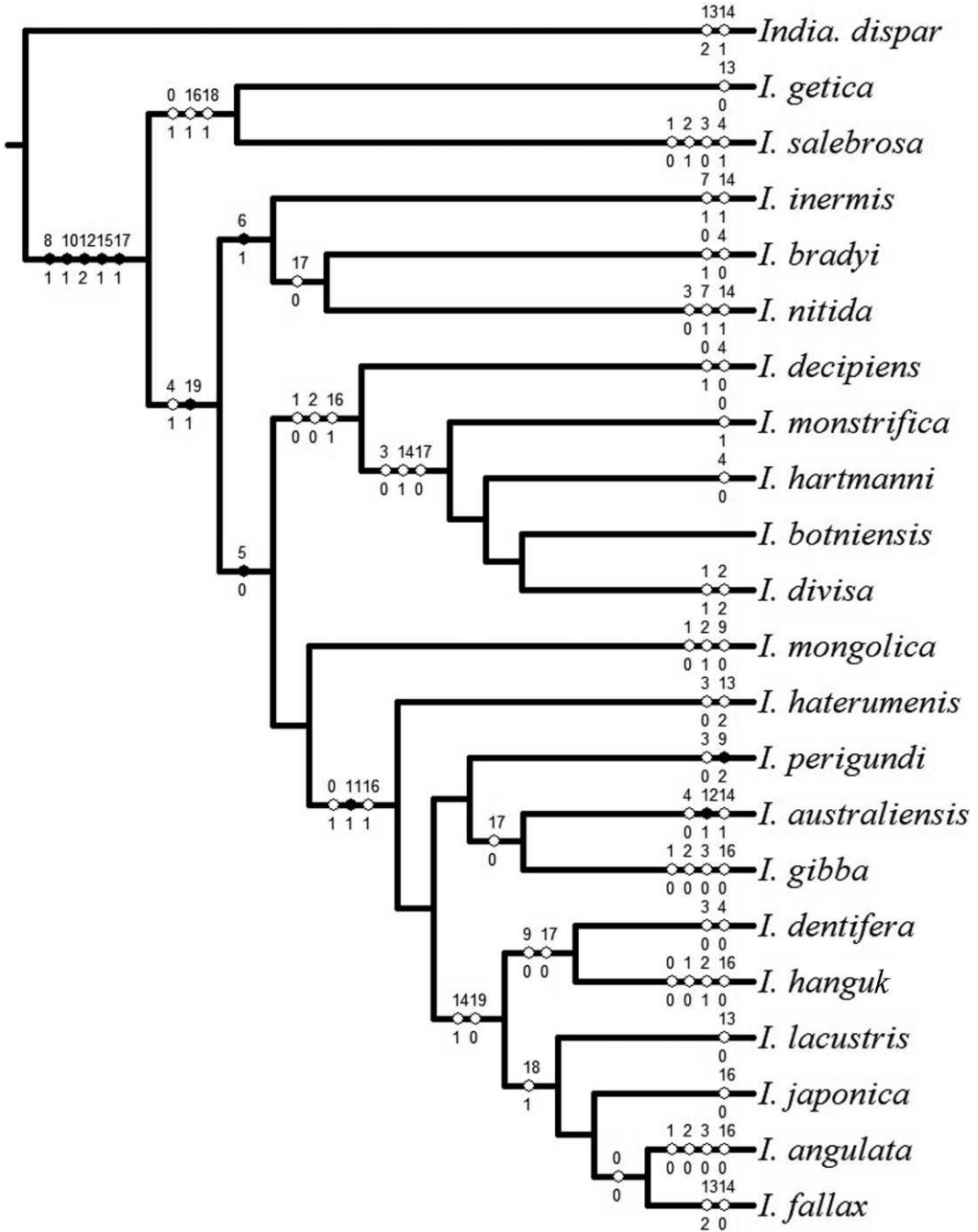


Fig. 15. Cladistic tree of the genus *Ilyocypris* Brady & Norman, 1889. Black circles, probable synapomorphies; white circles, probable plesiomorphies or homoplasies; numbers above branches, characters; numbers below branches, character states.



between different reports of certain species, which may support a more restricted distribution and a higher diversity in the genus. Examples of *I. dentifera*, *I. angulata* and *I. bradyi* have already been discussed in this paper. *Ilyocypris australiensis* was described from Queensland (Sars 1889). In contrary to many other descriptions of ostracods by Sars, which contain only shell characters and often UR, this one is very detailed and contains descriptions/drawings of almost all soft parts. It is, therefore, very peculiar that in the description of *I. fallax* from New Zealand, Brehm (1928:798–799) wrote: “In 1899 [wrong year] Sars recorded a species of the genus (*Ilyocypris*) from Queensland, under the name *I. austliensis*; but unfortunately, the description of the species is so imperfect that Mueller, in his monograph in the “Tierreich,” considered it to be only a nomen nudum. Until further material from the same locality can be examined in order to revise the description, one can hardly arrive at a working-idea of the nature of the species.” Gauthier (1928) reports *I. australiensis* from North Africa and postulates that it is very similar to *I. biplicata* (Koch, 1838) and should be its synonym. *Ilyocypris biplicata* is accepted as a junior synonym of *I. gibba* (see Meisch 2000), and it is considered only a form without lateral allae on the shell. Comparison of the hemipenis morphology of *I. australiensis* and *I. gibba/biplicata* shows some clear differences: ventro-distal margin of the middle lobe is elongated, with a sharply pointed end in *I. australiensis*, while it is almost blunt and not elongated in the other species. Bronstein (1947) reported *I. australiensis* from the Crimea and the Caucasus but reproduced drawings of Sars and provided no additional remarks. De Deckker (1981) reported *I. australiensis* from two distant localities in Western Australia, one in Victoria and one in New South Wales. The author compares morphology of the hemipenis of

*I. australiensis* with drawings of *I. decipiens* presented in Petkovski (1958), and suggests that these two species may be synonyms. The hemipenis may exhibit some similarities, but *I. decipiens* has lateral projections on the shell (no projections in *I. australiensis*), much shorter swimming setae on the A2, and divided penultimate segment of the L6 (undivided in *I. australiensis*). Meisch (1988) also suggested the same possibility, which we believe cannot be supported. We also have to express our view that not all of the De Deckker’s (1981) findings of *I. australiensis* belong to the same species. Although the author provides only SEM photographs of different populations, the dorsal view indicates some clear and important differences: some populations have square shaped anterior and posterior ends, others cuneiform; some populations have parallel lateral margins, in other the margins are clearly narrowing toward both anterior and posterior ends. It is hard to be exact in this case because of the lack of other details, but we believe that there are at least two different species in western Australia, and a third in Victoria and New South Wales. Which one of these (if any) is conspecific with *I. australiensis* requires further study. All of these clearly suggest that *I. australiensis* is probably not as widely distributed as suspected.

*Ilyocypris australiensis*, *I. bradyi*, *I. gibba*, *I. dentifera*, and *I. angulata* are not the only examples of the confusing taxonomy due to brief descriptions and inaccurate drawings. We believe that there are many more species, and that the genus needs a revision that has to be based on a more thorough study of morphology, accompanied with molecular data.

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Appendix

Matrix for 20 characters and 21 species used for the cladistic analysis. ?, unknown character state; \*, ambiguous character state; 0, presumably plesiomorphic character state; 1, 2, presumably apomorphic character states.

Taxon	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
<i>Indiacypris dispar</i>	0	1	2	1	0	1	0	0	0	1	0	0	0	2	1	0	0	0	0	0
<i>I. angulata</i>	0	0	0	0	1	0	0	0	1	1	1	1	2	1	1	1	0	1	1	0
<i>I. australiensis</i>	1	1	2	1	0	0	0	0	1	1	1	1	1	1	1	1	1	0	0	1
<i>I. botniensis</i>	0	0	?	0	1	0	0	0	1	1	1	0	2	1	1	1	1	0	0	1
<i>I. bradyi</i>	1	1	2	*	0	1	1	0	1	1	1	0	2	1	0	1	0	0	0	1
<i>I. decipiens</i>	1	0	0	1	0	0	0	0	1	1	1	0	2	1	0	1	1	1	0	1
<i>I. dentifera</i>	1	1	2	0	0	0	0	0	1	0	1	1	2	1	1	1	1	0	0	0
<i>I. divisa</i>	?	1	2	?	?	0	0	0	1	?	1	0	2	1	?	1	1	0	0	1
<i>I. fallanx</i>	0	?	?	?	1	0	0	0	1	?	1	1	2	2	0	1	1	1	1	0
<i>I. getica</i>	1	1	2	1	0	1	0	0	1	1	1	0	2	0	0	1	1	1	1	0
<i>I. gibba</i>	1	0	0	0	1	0	0	0	1	1	1	1	2	1	0	1	0	0	0	1
<i>I. hangul</i>	0	0	1	1	1	0	0	0	1	0	1	1	2	1	1	1	0	0	0	0
<i>I. hartmanni</i>	0	0	0	0	0	0	0	0	1	1	1	0	2	1	1	1	1	0	0	1
<i>I. haterumenis</i>	1	1	2	0	1	0	0	0	1	?	1	1	2	2	0	1	1	1	0	1
<i>I. inermis</i>	0	1	2	1	1	1	1	1	1	?	1	0	2	1	1	1	0	1	0	1
<i>I. japonica</i>	1	1	2	1	1	0	0	0	1	?	1	1	2	1	1	1	0	1	1	0
<i>I. lacustris</i>	1	1	2	1	1	0	0	0	1	?	1	1	2	0	1	1	1	1	1	0
<i>I. mongolica</i>	0	0	1	1	1	0	0	0	1	0	1	0	2	1	0	1	0	1	0	1
<i>I. monstrefica</i>	1	0	0	0	1	0	0	0	1	1	1	0	2	1	1	1	1	0	0	1
<i>I. nitida</i>	0	1	2	0	1	1	1	1	1	1	1	0	2	1	1	1	0	0	0	1
<i>I. perigundi</i>	1	1	2	0	1	0	0	0	1	2	1	1	2	1	0	1	1	1	0	1
<i>I. salebrosa</i>	1	0	1	0	1	1	0	0	1	1	1	0	2	1	0	1	1	1	1	0