Four Freshwater Eutardigrades from Korea with Description of Isohypsibius brevitubulatus n. sp.

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Tardigrada
Freshwater eutardigrada

As a result of examining the specimens collected from various freshwater bodies since 1995, four eutardigrades are added to Korean fauna: Isohypsibius brevitubulatus n. sp., I. baldii (Ramazzotti), I. marcellinoi (Binda and Pilato), and Diphascon (Diphascon) higginsi Binda. I. brevitubulatus n. sp. differs from its congeners by having a combination of the following characteristics: smooth cuticle, rather big body size, short and broad buccal tube, presence of lunules, and pharynx bearing 3 rod-like macroplicoides without microplacoid. All the species are illustrated and briefly commented on their habitats with the associated fauna.

Since Iharos (1971) first reported eight eutardigrade species from North Korea, Dastych (1974) examined 27 species found by "The Expedition of the Institute of Systematic and Experimental Zoology of the Polish Academy of Sciences in Kraków, 1971", and made a checklist on 33 North Korean species including 25 eutardigrade ones.

Thereafter, a series of investigations from South Korea (Moon and Kim, 1988; Moon et al., 1989; Moon and Kim, 1991; Moon et al., 1992) added ten eutardigrades to the Dastych's list. Recently Moon et al. (1994) and Chang and Rho (1996) newly described Doryphonibius koreanus and Isohypsibius granditintinus, respectively.

As a result of examining specimens deposited in Department of Biology, Taegu University, we report four eutardigrades including a new species. Therefore, a total of 41 eutardigrade species of 11 genera in 4 families are now known from the Korean Peninsula.

Materials and Methods

The materials examined in this study were collected from submerged sand bottoms of various freshwater bodies during the period of March 1995 to April 1997. Sands including the specimens were dredged into polyethylene plastic bag, and then the specimens were extracted by the anaesthetization (using MgCl₂)-decan tantion technique (Hulings and Gray, 1971) at the laboratory. The extracted specimens were fixed by 5% formalin.

Specimens were drawn and measured in lactophenol on Cobb's aluminium hole slide, and also observed and photographed under differential interference microscope. Figures were made with the aid of a drawing tube. Specimens for SEM examination was fixed with hot (about 80°C) ethanol immediately after extraction, and fixed again for overnight at 4°C in a 2.5% glutaraldehyde, then followed by postfixation with 1% cold osmium tetroxide. After dehydration through a graded series of ethanol (50%, 60%, 70%, 80%, 90%, 100%, 100%) for 30 minutes each, the material was critical point dried, and coated with gold-palladium in a high evaporator, and then examined in a Hitachi S-520 scanning electron microscope operated at 20 KV.

Systematic Accounts

Class Eutardigrada Marcus, 1927
Order Parachela Schuster, Nelson, Grigarick and Christenberry, 1980
Family Hypsibiidae Pilato, 1969
Subfamily Hypsibiinae Pilato, 1969
Genus Isohypsibius Thulin, 1928

Iohypsibius brevitubulatus Rho, Chang and Kim, n. sp. (Figs. 1, 2A-D)

Material examined: 20 individuals (including 2 exuviae), submerged sand bottom of Sŏmjin River under Kurye Bridge (35° 09' 43'' N, 127° 27' 11'' E), 20 May 1995, H. S. Rho and G. H. Rho. All are mounted in lactophenol. Holotype and three paratypes will be deposited in the Zoologisches Museum, Universität Hamburg, Germany. Other paratypes (16 individuals including 2 exuviae) are kept in the collection of the authors.

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Fig. 1. Isohypsidius brevitubulatus n. sp. A. Habitus, ventro-lateral view. B. Bucco-pharyngeal apparatus, ventral view. C. Bucco-pharyngeal apparatus, lateral view. D. Claws on leg I. E. Claws on leg II. F. Claws on leg III. G-H. Claws on leg IV. Scale bars=0.05 mm (A) and 0.01 mm (B-H).
Fig. 2. *Isohypsibus brevitubulatus* n. sp. A. Habitus. B. Mouth opening with peribuccal area. C. Claws of the second pair of legs. D. Bucco-pharyngeal apparatus, ventral view. E-H. Bucco-pharyngeal apparatus, ventral view. E. *Isohypsibus baldii* (Ramazzotti). F. *Isohypsibus marcellinoi* (Binda and Pilato). G. *Daphacon* (D) nigriti Binda. Scale bars=0.01 μm (E-H), 0.05 μm (D), 7.5 μm (B), 8.6 μm (C), and 120 μm (A).
Table 1. Character measurements (μm)

<table>
<thead>
<tr>
<th>Character</th>
<th><em>H</em></th>
<th><strong>P</strong></th>
<th>P2</th>
<th>P3</th>
<th>P4</th>
<th>P5</th>
<th>P6</th>
<th>P7</th>
<th>Mean</th>
<th>l. myrops</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Body length</strong></td>
<td>600</td>
<td>500</td>
<td>501</td>
<td>496</td>
<td>471</td>
<td>893</td>
<td>790</td>
<td>981</td>
<td>652</td>
<td>560</td>
</tr>
<tr>
<td>Macroploids</td>
<td>0.8-0.4:1</td>
<td>0.7:0.5:1</td>
<td>0.8-0.6:1</td>
<td>0.7:0.3:1</td>
<td>0.7:0.45:1</td>
<td>0.7:0.5:0.6:1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(10.5:5.8:13.9)</td>
<td>(5.4:4.1:8.2)</td>
<td>(6.1:4.7:7)</td>
<td>(10.4:6:14.1)</td>
<td>(8.4:7:10.9)</td>
<td>(6.5:6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Length of buccal tube</td>
<td>97%</td>
<td>84%</td>
<td>84%</td>
<td>89%</td>
<td>85%</td>
<td>73%</td>
<td>74%</td>
<td>71%</td>
<td>82%</td>
<td>155%</td>
</tr>
<tr>
<td>/body length</td>
<td>8.3</td>
<td>7</td>
<td>(42/6)</td>
<td>7</td>
<td>(46/6)</td>
<td>7.3</td>
<td>(40/6)</td>
<td>6.7</td>
<td>7.2</td>
<td>7.3</td>
</tr>
<tr>
<td>(58/39)</td>
<td>(40/29)</td>
<td>(38/27)</td>
<td>(40/29)</td>
<td>(38/26)</td>
<td>(63/16)</td>
<td>(50/41)</td>
<td>(55/50)</td>
<td>(5/33)</td>
<td>(46/35)</td>
<td></td>
</tr>
</tbody>
</table>

*H: holotype, **P: paratype.


Diagnosis: cuticle smooth; body very big; buccal tube short and broad; pharynx with 3 rod-shaped macroploids without microplacoid; lunules present.

Holotype: Body length up to 600 μm, and width 137 μm. Body elongated and yellowish. Eye pigments absent. Cuticle completely smooth. Legs also smooth without any kind of humped projection. Mouth opening located in a front-ventral position, with peribuccal lobes and mucrons and without lamellae; buccal armature resembling other species of Macrobiotus type; width of mouth opening 13.2 μm. No apophyses in pharynx; internal diameter of buccal tube 7 μm at stylet support insertion site, extraordinarily wide as against an Isophysipus species; 51 μm long from mouth to point of entry to pharyngeal bulb. Stylet support present. Pharyngeal bulb oval (length 58 μm, width 39 μm, legth to width ratio 1.49), ahead of first leg pair, with 3 large rod-shaped macroploids aligned, which are not constricted in their middle; size arrangement of macroploids III > I > II (I:II:III=10.5 μm : 5.8 μm : 13.9 μm=0.8 : 0.4 : 1). No microplacoid. Paired buccal glands elongated, present outside of pharyngeal bulb.

Legs with claws of "Isophysipus type": Double claws each on legs I-IV, external claw and internal one different in size, with claw sequence 2-1-2-1 (secondary-primary-secondary-primary). Length ratios of primary branch to secondary one on external claw of leg I-IV 1.32, 1.49, 1.08, 1.03, respectively, with 2 accessory points at apical part of lateral margin.

Examined under scanning electron microscope, shapes of accessory points of external claw and internal one resembling each other, as shown in Fig. 2C. Primary branch on external claw of each leg pair diverging from secondary one with an right angle or more. Basal branch expanded. All claws bearing very large lunule, but no cuticular bar.

Measurements and variations: Measurements based on eight specimens (holotype and seven paratypes) are shown in Table 1. Size arrangement of 3 rod-shaped macroploids is (I:II:III=0.75:0.45:1) and the length to width ratio of pharyngeal bulb shows rather high consistency. The width of buccal tube is extraordinarily short and broad [length to width ratio of buccal tube is about 7.1:1, while about 21.75:1 in l. myrops (Bois-Reymond Marcus)]. Any cuticular ornamentation and eyespot were not found in all specimens examined. Exuviae contained 6-7 smooth eggs, diameter of which up to 65 μm.

Etyymology: The specific name, brevitubulatus (brevis, L.: short; tubulatus, L.: tube; -atus, provided with) is taken from the short buccal tube, which is the most characteristic feature of this species.

Remarks: The present new species, l. brevitubulatus, may be easily distinguished from the other species of genus Isophysipus, for it has a very large body and wide buccal aperture, as shown in many species of Macrobiotus. In general shape of body and buccal apparatus, this species is most similar to l. myrops (Bois-Reymond Marcus), which was recorded only from Brazil (Bois-Reymond Marcus, 1944) and Mexico (Nelson and Schuster, 1982). However, as shown in Table 1, the present new species is clearly discernible from l. myrops in having the following combinations of characteristics: (1) body rather longer, up to mean 652 μm (ranging 471-961 μm), (2) presence of lunules, (3) the percentage of width of buccal tube to length of pharyngeal bulb 14.6%, while 8.69% in l. myrops, (4) length to width ratio of buccal tube 7.1, while 21.75 in l. myrops, (5) size arrangement of three macroploids (I:II:III) is 8 μm:4.7 μm:10.9 μm (0.75:0.45:1), while 6 μm:5 μm:8 μm (0.75:0.6:1) in l. myrops.
Habitat and associated fauna: This species was collected from submerged sand bottom with rich organic detritus of Sömjin River, and co-occurred with the following aquatic invertebrates mostly known as indexing β- to α-mesosaprobic waters in Korea: Oladocera - *Chydorus sphaericus* (O. F. Müller); Coepoda - *Ephiothelida grandiclari* (Guene et Richard), *Parastenocaris sp., Eucyclops serrulatus* (Fischer), *Paracyclops limniratus* (Fischer), *Microcyclops varicos* (Sars).

*Isohypsius baldii* (Ramazzotti, 1945)  
(Figs. 2E, 3)

*Hypsius* (*Isohypsius*) *baldii* 1945 (cited from Bertolani and Balsamo, 1989); Ramazzotti, 1972 (p. 483, fig. 270).

*Isohypsius baldii*: Bertolani, 1982 (p. 65, fig. 35); Ramazzotti and Maucci, 1983 (p. 589, fig. 355); Bertolani and Balsamo, 1989 (p. 85, figs. 1-7).


Remarks: This is the first record since Bertolani and Balsamo (1989) redescribed the present species after reconfirmation from the type locality to compensate the poor original description. Our specimens fit well with Bertolani and Balsamo’s redescription except some minor discrepancies in the absences of eyespot and the size of cuticular granules, but these do not nevertheless represent the genuine species or subspecies distinction but may be attributed to the improper preparation or intraspecific deviation, and so are recognized as the same species with *I. baldii* (Ramazzotti).

Habitat and associated fauna: our specimens were collected from the submerged sand bottom covered with some fallen leaves and snows around a fall in Sônginbong Mt., Uljung I., the East Sea of Korea. The associated fauna co-occurred were: Gastrotrocha - *Chaetonaus laroides* (Marcolongo), *C. maximus* (Ehrenberg); Coepoda - *Canthocamptus sp., Maraenibiotus rucei* (Richard), *Diacyclops tenuidontis* (Liljeberg), which are the representative species from cold and oligotrophic waters, especially frequent in mountain waters in early spring of Korea. This species is considered to be rare, and to be restricted to cool mountain waters.

Distribution: Italy and Korea.

*Isohypsius marcellinii* (Binda and Pilato, 1971)  
(Figs. 2F, 4)

*Hypsius* (*Isohypsius*) *marcellinii* Binda and Pilato, 1971 (p. 906, fig. 50).

*Isohypsius marcellinii*: Pilato, 1974 (p. 242); Bertolani, 1982 (p. 77, fig. 42); Ramazzotti and Maucci, 1983 (p. 636, fig. 396); Pilato and Binda, 1988 (p. 52, fig. 2a-c); Biserov, 1991 (p. 203); McInnes, 1994 (p. 308).


Remarks: we could not find any morphological differences between the specimens from a spring at hilltop of Tŏkyu Mt. and ones from an estuary, and both of them were fully coincided to the original description of Binda and Pilato (1971).

Habitat and associated fauna: This species was originally recorded from mosses in Sicily, Italy and later in the Simento River, Sicily (Pilato, 1974). Our specimens were collected from a mountainous spring, and from about 50 m upstream from a mouth of small stream draining into the East Sea of Korea. The former was cool and clear, and surrounded by mossy rocks with coarse sand bottom, and inhabited by the copepod *Acanthocyclops sp.* and *Canthocamptus sp.*, while the latter was brackish water with fine sands submerged, and flourishing by β- to α-mesosaprobic cladocerans (*Chydorus sphaericus* (O. F. Müller), *Simocyclus vetulus* (O. F. Müller)) and copepods (*E. serrulatus*, *Megacyclops viridis* (Jurine), *Mesocyclops sp.*) between littoral macrophytes. So, this species seems to adapt to wide range of water bodies including brackish waters with low salinity.

Distribution: Italy (Sicily), Russia, U.S.A. (East Tennessee), and Korea.

Subfamily Diphasconinae Dastych, 1992  
Genus *Diphascon* Plate, 1889  
Subgenus *Diphascon* Pilato, 1987

*Diphascon* (*Diphascon*) *higginsi* Binda, 1971  
(Figs. 2G, 5)

*Diphascon* *higginsi* Binda, 1971 (p. 761, figs. A-C); Pilato, 1974 (p. 76, figs. 1, 2); Pilato, 1975 (p. 285, fig. 2); Binda and Guglielmino, 1982 (p. 209); Weglarz and Korecka, 1983 (p. 89); Ramazzotti and Maucci, 1983 (p. 283, fig. 119); Maucci, 1987 (p. 205); Dastych, 1988 (p. 188, figs. 125 D-G).


*Diphascon* (*Diphascon*) *higginsi*: Pilato, 1987 (p. 350); Ito, 1995 (p. 23, fig. 3).

Material examined: 1 specimen, a bog beside Yulsansŏn, Kyŏngsan city, June 8, 1995 (C. Y. Chang, J. M. Lee, and H. S. Rho); 12 specimens, same locality (water temperature 12.0°C, pH 8.2), Apr. 15, 1997 (C.
Fig. 3. *Isohypsaibius baltii* (Ramazzotti). A. Habitus, ventral view. B. Bucco-pharyngeal apparatus, ventral view. C. Bucco-pharyngeal apparatus, lateral view. D. Claws on leg I. E. Claws on leg II. F. Claws on leg III. G. Claws on leg IV. Scale bar=0.01 mm.
Fig. 4. *Isohypsius marcellinoi* (Binda and Pilato). A. Habitus, ventral view. B. Bucco-pharyngeal apparatus, ventral view. C. Bucco-pharyngeal apparatus, lateral view. D. Claws on leg I. E. Claws on leg II. F. Claws on leg III. G-H. Claws on leg IV. Scale bars=0.01 mm.
Fig. 5. Diphascon (Diphascon) higginsi Binda. A. Habitus, ventral view. B. Bucco-pharyngeal apparatus, ventral view. C. Claws on leg I. D. Claws on leg II. E. Claws on leg III. F-G. Claws on leg IV. Scale bars=0.01 mm.
Y. Chang, and H. S. Rho).

Remarks: The appearance of drop-like thickening on the wall of buccal tube was not mentioned in the description of Binda (1971), and also in Pilato (1975). Later, the observation of the type specimens, Pilato (1987) confirmed its presence and attributed it to the subgenus Diphascon (Ito, 1995). Our specimens bear also the same structure as shown in Fig. 5B. Other characteristics are also quite well fitted to the original description as well as Dastych's (1988) and Ito's (1995).

Habitat and associated fauna: This species has been reported worldwide usually from terrestrial or aquatic masses. Our specimens were collected from a stagnant bog with plentiful of organic detritus, and co-occurred with the aquatic invertebrates which usually frequent in the eutrophicated swamps or transient pools in Korea: Rotifera - Polyarthra major (Burckhardt); Gastrotricha - Polymorurus sp.; Cladocera - Chydorus sphaericus (O. F. Müller); Copepoda - Macrocyclops albidus (Jurine), Eucyclops serrulatus (Fischer), Diacyclops thomasi (Forbes), Megacyclops viridis (Jurine).

Distribution: Morocco, Poland, Italy, Finland, Russia, New Zealand, U.S.A. (Tennessee), Japan and Korea.

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References


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