Invertebrate Fauna of Korea

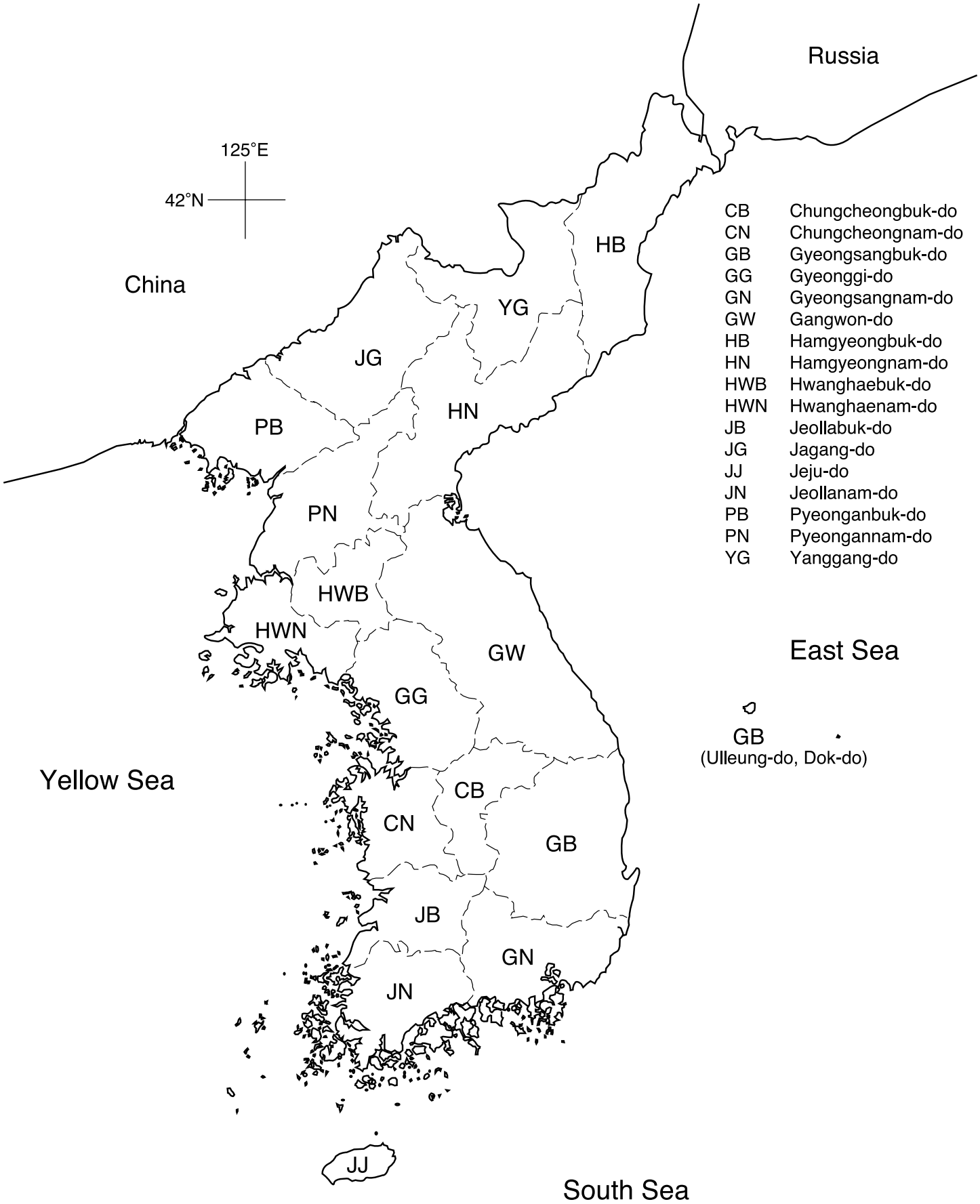
Volume 10, Number 1

Rotifera: Eurotatoria: Bdelloidea: Philodinida:
Habrotrochidae, Philodinidae

Rotifera I

Flora and Fauna of Korea

National Institute of Biological Resources
Ministry of Environment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JB Jeollabuk-do
JG Jagang-do
JJ Jeju-do
JN Jeollanam-do
PB Pyeonganbuk-do
PN Pyeongannam-do
YG Yanggang-do

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The Flora and Fauna of Korea logo was designed to represent six major target groups of the project including vertebrates, invertebrates, insects, algae, fungi, and bacteria. The book cover and the logo were designed by Jee-Yeon Koo.

Preface

The biological resources include all the composition of organisms and genetic resources which possess the practical and potential values essential to human live. Biological resources will be firmed competition of the nation because they will be used as fundamental sources to make highly valued products such as new lines or varieties, new material, and drugs. As the Nagoya Protocol was adopted in 2010 and entered into force in the 12th Conference of Parties of the Convention on Biological Diversity (CBD) in 2014, it is expected that the competition to get biological resources will be much intensive under the rapidly changed circumstance on the access and benefic sharing of the genetic resources (ABS). Therefore, each nation is investigating and clearing information of native species within its territory in order to secure its sovereignty rights over biological resources.

The National Institute of Biological Resources of the Ministry of Environment has been publishing the 'Flora and Fauna of Korea' since 2006 to manage biological resources in comprehensive ways and to enhance national competitiveness by building up the foundation for the sovereignty over biological resources. Professional research groups consisting of professors and related experts of taxonomy examined systematically a total of 12,631 species for the past eight years to publish 151 volumes in both Korean and English versions, and two volumes of World Monograph covering 216 species. This year, 11 volumes of the Flora and Fauna of Korea in both Korean and English versions including 517 species of invertebrates, insects and algae are additionally published. Flora and Fauna of Korea were the first professional records to describe all the species of the nation in a comprehensive way, and they would contribute to level up the taxonomic capacity. Furthermore, publication of flora and fauna through identification of native species and investigation of national biota would be helpful to declare sovereignty rights over our native biological resources, be used as positive proof, and be utilized to provide the basic information of biological resources for industrial application.

The National Institute of Biological Resources of the Ministry of Environment will continue to accelerate the project of the publication of the 'Flora and Fauna of Korea'. Personally I would like to express my sincere appreciation for Professor Min Ok Song of Gangneung-Wonju National University who has continuously made a lot of efforts to publish an excellent version of Korean fauna.

Kim, Sang-Bae
President
National Institute of Biological Resources

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List of Taxa

Class Eurotatoria De Ridder, 1957
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      Family Habrotrochidae Bryce, 1910
        Genus *Habrotrocha* Bryce, 1910
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          Habrotrocha aspera (Bryce, 1892)
          Habrotrocha constricta (Dujardin, 1841)
          Habrotrocha crenata crenata (Murray, 1905)
          Habrotrocha fusca (Bryce, 1894)
          Habrotrocha gracilis gracilis Montet, 1915
          Habrotrocha insignis Bryce, 1915
          Habrotrocha lata lens Donner, 1965
          Habrotrocha parvipes Donner, 1951
          Habrotrocha perforata (Murray, 1906)
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          Habrotrocha spicula Bryce, 1913
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      Family Philodinidae Bryce, 1910
        Genus *Macrotrachela* Milne, 1886
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          Mniobia russeola (Zelinka, 1891)
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        Genus *Philodina* Ehrenberg, 1830
          Philodina acuticornis odiosa Milne, 1916
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          Philodina flaviceps Bryce, 1906
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Rotaria sordida sordida (Western, 1893)
Rotaria sordida fimbriata (Murray, 1906)
Rotaria tardigrada (Ehrenberg, 1832)

Introduction

The phylum Rotifera is a group of aquatic or semiaquatic invertebrates of microscopic size, encompassing about 2200 species of unsegmented and bilaterally symmetrical pseudocoelomates. Although rotifers form a small phylum, they are extremely important in freshwater environments, because they reproduce at the highest rates among metazoans, can populate vacant niches with extreme rapidity, convert primary (algal and bacterial) production into a form usable for secondary consumers (e.g., insect larvae, fish fry, and macroinvertebrates), and achieve this transformation with remarkable efficiency, producing up to 30% of the total plankton biomass (Nogrady et al., 1993). Because of their great adaptibility, rotifers are widely distributed in various freshwater, brackish, marine and terrestrial habitats from the Arctic and Antarctic regions to the tropics.

The phylum Rotifera is divided into two classes, Eurotatoria and Pararotatoria. The class Eurotatoria is composed of two subclasses: the Bdelloidea, having paired ovaries, and the Monogononta with a single ovary. The subclass Bdelloidea consists of 3 orders, Adinetida, Philodinida, and Philodinavida (Nogrady et al., 1993; Melone and Ricci, 1995).

Bdelloids possess a vermiform body with pseudosegmentation that permits telescopic shortening and expansion, and well-developed paired trochal discs, which are used in locomotion and food gathering. All bdelloids possess paired ovaries with vitellaria, more than two pedal glands, and ramate trophi. Their body length ranges from 77 μm, with the shortest known species *Habrotrocha minuta* (Murray, 1908), to 1500 μm, with the longest known species *Rotaria elongata* (Weber, 1888), but most species are 200 μm−500 μm long. In view of their extraordinary tolerances of environmental extremes, bdelloids probably are the most widely dispersed group of rotifers (Koste and Shiel, 1986). They are found in sediments or among plant debris or crawling on the surfaces of aquatic plants. Some forms inhabit capillary water films in soils or in damp mosses and lichens (Donner, 1965; Nogrady et al., 1993). According to Donner (1965), 95% of soil rotifers are bdelloids.

Two biological phenomena distinguish Bdelloidea from the other subclasses of Rotifera: (1) obligatory parthenogenetic reproduction and (2) ability to withstand harsh periods through anhydrobiosis. Both characteristics make them pioneering animals, able to colonize new environments (Ricci, 1987).

About 460 species of bdelloids are known throughout the world (Segers, 2007; Jersabek and Leitner, 2013), but only 56 species/subspecies have been recorded from Korea to date (Song, 2014).

Historical review of studies on bdelloids

Since Anthony van Leeuwenhoek (1632−1723) described a rotifer for the first time, the first major contribution to the study of rotifers was made by O.F. Müller (1730−1784). He described over 50 species and many of his descriptions are still valid today. He classified rotifers as 'ciliates' like his predecessors.

In 1798, Cuvier eventually recognized the status of rotifers as metazoans and placed them in a special order within Infusoria, 'Les Rotiferes' (Harring, 1913). Bory de St. Vincent (1778−1846) was the first systematisist who separated, created and revised many genera.

After these predecessors, rotifers had been studied extensively by some European investigators. Hudson and Gosse's (1886, 1889), 2 volume 'The Rotifera or Wheel Animalcules' were a superb illustrated work in which 600 species were described including numerous new species and augmented the description of the old ones with their own observations. Bryce (1853−1934) was the

first bdelloid specialist. His taxonomic scheme published in 1910 (Bryce, 1910) laid the foundation for the current taxonomy of bdelloids. The Scottish naturalist J. Murray (1805−1914) also had made major contributions to the study of bdelloids. He described a large number of new species from locations around the world he had visited during various expeditions. J. Donner (1909−1989) greatly contributed to the biology and systematics of terrestrial and aquatic bdelloid rotifers by the book, 'Ordnung Bdelloidea' (Donner, 1965), which is the most complete and the only monograph of bdelloids until the present time and includes all bdelloids which had been recorded throughout the world till that time. The Czech zoologist E. Bartoš (1902−1966) described several new species and compiled all the species known from Czech Republic at that time into a 260-page long paper titled 'The Czechoslovak Rotatoria of the order Bdelloidea' (Bartoš, 1951). Later, he published a revised and enlarged edition, Bartoš (1959) as a 1000-page book titled 'Vířníci-Rotatoria. Fauna ČSR', which also contains the compilation of monogononts.

Taxonomic studies on Asian bdelloids also were started by European researchers in India (Murray, 1906b), China (Thorpe, 1893; Bartoš, 1963) and Indonesia (Bartoš, 1963). Currently, descriptive and biogeographic studies on Asian rotifers have been concentrated on monogononts (Segers and Dumont, 1993; Segers and Sanoamuang, 1994; Segers et al., 1994; Koste and Zhuge, 1995, 1996; Sanoamuang et al., 1995; Zhuge and Koste, 1996; Segers and Pholpunthin, 1997; Segers and Wang, 1997; Khoei et al., 2011; Malay et al., 2011; Trinh Dang et al., 2013; Sharma and Sharma, 2014) and small numbers of bdelloids have been reported from China (Wang, 1961; Koste and Zhuge, 1996; Zhuge et al., 1998), Japan (Mizuno and Takahashi, 1991), Myanmar (Koste and Tobias, 1990), Iran (Khoei et al., 2011), India (Sharma and Sharma, 2014), and Thailand (Sa-Ardrit et al., 2013) as parts of results from taxonomic, biogeographic and faunistic studies.

The first record of Korean bdelloid rotifers is the work of Kim and Park (1969). They reported one species, *Rotaria rotatoria* (Pallas, 1766) with other invertebrates from the Han River. An additional bdelloid, *Rotaria neptunia* (Ehrenberg, 1832) was reported by Kim et al. (1987) from the same region (Song, 1989). These two Korean bdelloids were reported without detailed taxonomic accounts. The proper taxonomic study on Korean bdelloids was started very recently by Song and Kim (1996a), which reported 5 species new to Korea. Since then, 50 more bdelloids were added to the Korean fauna by further taxonomic studies such as Song and Kim (1996b, 2000), Song and Jin (2000) and Song (2014).

Materials and Methods

The materials examined in the present study consist of the specimens extracted from mosses, lichens, forest litter, leaf litter from streams, bed sediments of streams and those obtained from a lake. Samples have been collected from 23 localities in Gangwon-do, Gyeongsangbuk-do, Chungcheongbuk-do, Chungcheongnam-do and Jeju-do during the period from November 1994 to September 2014.

For the extraction of bdelloids from mosses, lichens, forest litter and leaf litter from streams, samples were soaked in tap or distilled water for several hours in case of fresh material or about a day for stored and dried material to make the anhydrobiosed individuals recover to the natural state. The samples were agitated to detach any bdelloids from the surfaces of plants or plant debris, and then the plant material was squeezed and removed. The wash water was swirled and set on the bench for a few seconds, and then the supernatant was strained through the sieve of 1.2 mm mesh-size to remove the unnecessary particles and debris. The wash water was then poured through a fine nylon membrane of 60 μm mesh-size. The filtered specimens on the membrane were transferred to a petri dish with a Pasteur pipette and then sorted at $\times 40-100$ magnification on a dissecting microscope stage. Collection of specimens from a lake was made with a plankton net of 60 μm mesh-size.

Bdelloids were identified alive, as preservation induced contraction and other changes, which made the identification impossible. The boiling water fixation method (Pennak, 1978), instead of narcotics, was used to kill the specimens with their head, foot and toes extended. The killed specimens were fixed by 4% buffered formalin solution. After about 1 hr, preserved specimens were placed in 10% glycerine solution, which was then put on a bench for several days to allow water to evaporate from the mixture completely. For preparation of permanent mounts, the method of Stemberger (1979) was used. The specific identification was perfomed at $\times 400-1000$. Unfortunately, specimens were still somewhat deformed even after boiling water fixation and therefore, the photographs, video tape recording and computer-grabbed images were also used for identifications and illustrations. Measurements were made with a micrometer as well as Photoshop CS3. The classification scheme is based on Melone and Ricci (1995).

Morphology and taxonomic characters

1. General morphology of bdelloid rotifers (Fig. 1A)

Bdelloids mostly have vermiform bodies with pseudosegments (segments) which don't have the interior organic correspondence. The ring muscles lining the integument make the pseudosegments and allow the animals the telescopical movements. Their body usually conforms to the following general plan: head with corona, neck, trunk and foot with spurs and toes (Fig. 1A). The head bears a rostrum with rostral lamella distally, and withdrawn corona inside of posterior part. The neck has a dorsal antenna and a trophi inside of posterior part. The trunk usually consists of six pseudosegments. The last two pseudosegments are preanal and anal segments which bear intestine and cloaca and are usually called 'rump', separating it from the other part of the trunk. The foot starts from the segment just posterior to anus and ends in 2–4 toes or an adhesive disc or plate. It bears mostly a pair of spurs on the penultimate pseudoegment (spur segment) dorsally. The pedal glands are well developed.

The taxonomy of bdelloids is based primarily on the morphology of alimentary system, corona,

trophi, spurs, toes and body ornaments such as spines or cuticular knobs.

2. Alimentary system (Fig. 1B)

The stomach is a syncytial mass of protoplasm which is transversed by a tubular lumen in most families except Habrotrochidae. In the family Habrotrochidae, the rotifers lack such a lumen and the food is formed into pellets. The pharyngeal tube is usually short and as long as trophi, but

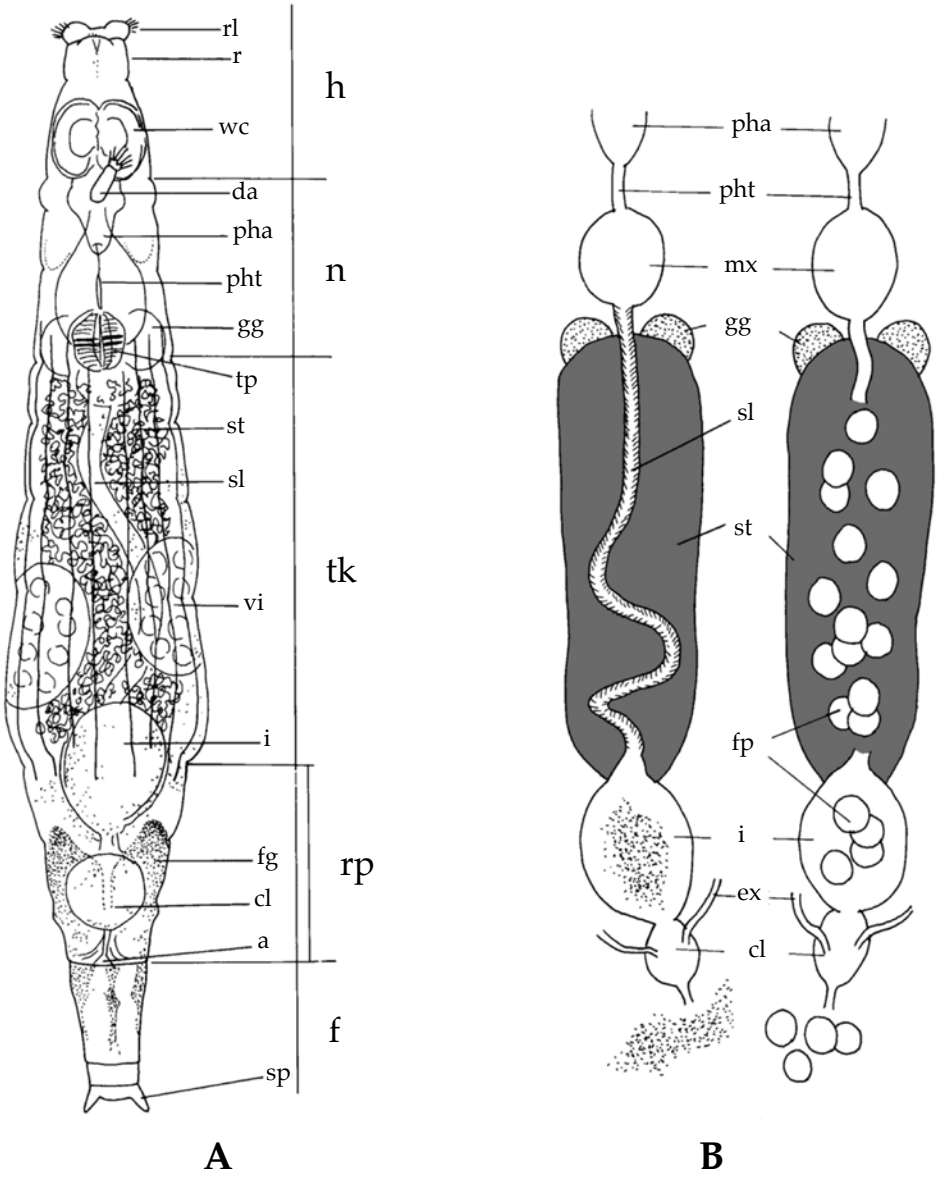

Fig. 1. General morphology and alimentary system of bdelloid rotifers. A. a creeping bdelloid rotifer, *Macrotrachela insulana* in a dorsal view; B. alimentary systems (diagrammatic) of Habrotrochidae (right) and Philodinidae (left) (from Donner, 1965). a. anus; cl. cloaca; da. dorsal antenna; ex. excretory system canal; f. foot; fg. foot gland; fp. food pellet; gg. gastric gland; h. head; i. intestine; mx. mastax; n. neck; pha. pharynx; pht. pharyngeal tube; r. rostrum; rl. rostral lamella; rp. rump; sl. stomach lumen; sp. spurs; st. stomach; tk. trunk; tp. trophi; vi. vitellarium; wc. withdrawn corona.

elongated with or without loops in some species.

3. Corona (Fig. 2)

The corona is a very typical organ of all Rotifera, and it is very well-developed in bdelloids. It usually consists of paired trochal discs on short or long columnar bases, pedicels (*Philodina* type). The pedicels are separated by a sulcus, which may be narrow or wide, deep or shallow, and smooth or ornamented with any processes. The trochal disc usually has a sensory hair on it. The corona is transformed into a ventral ciliary field in the order Adinetida and reduced or rudimentary in the order Philodinavida.

The disc retractor (Fig. 3), although it has been rarely mentioned and recognized only by a few specialists like Bartoš (1951) and Haigh (1966), is various in the extent of development and shape, and sometimes can be used as a diagnostic character.

The cingulum encircles the bases of both pedicels and passes below the mouth. It forms an upper lip dorsally and a lower lip ventrally. The shape of upper lip is rather species-specific and therefore, an important diagnostic character. The cingulum pads are the both lateral parts of feeding head just under cingulum.

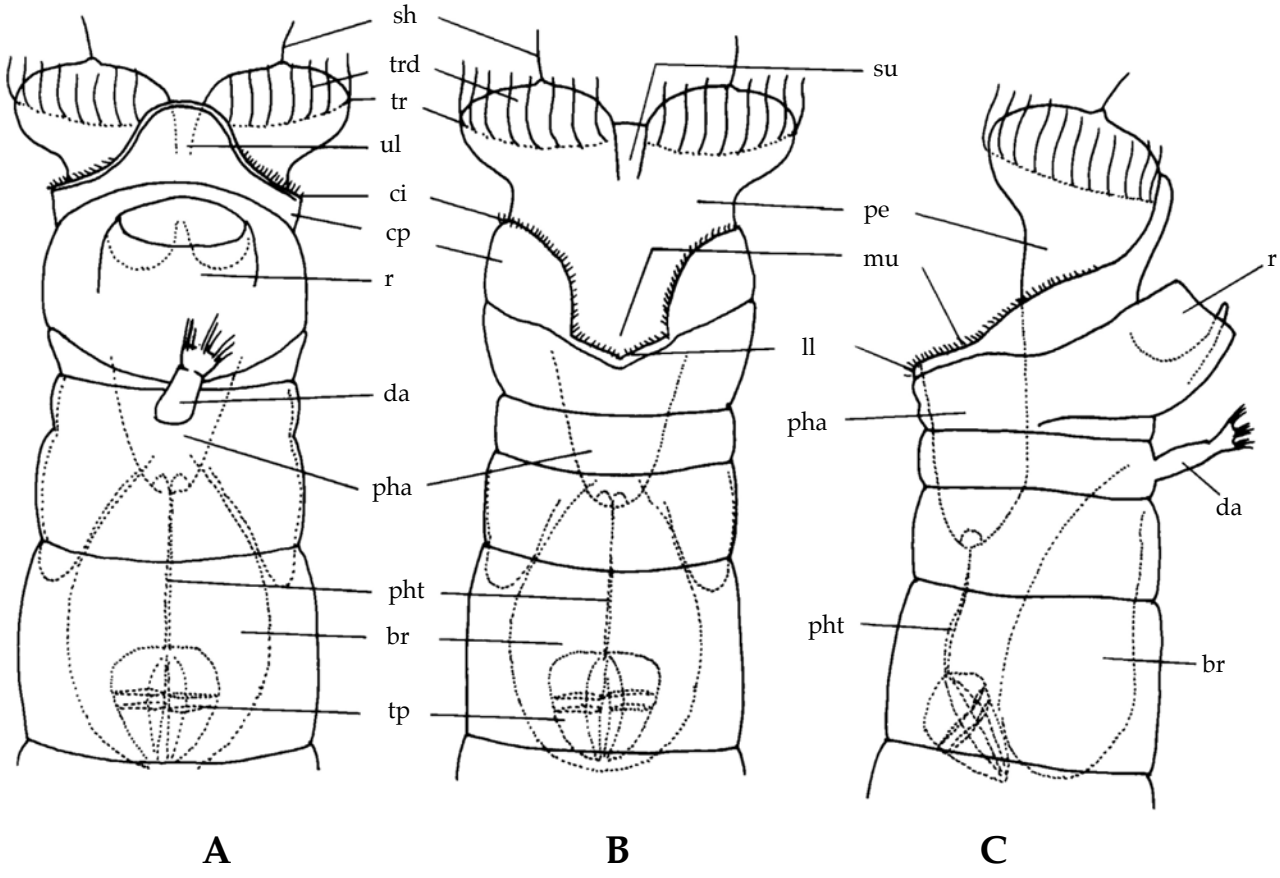

Fig. 2. Corona of a bdelloid rotifer (*Philodina*-type) (from Donner, 1965). A. dorsal view; B. ventral view; C. lateral view. br. brain; ci. cingulum, cp. cingulum pad; da. dorsal antenna; ll. lower lip; mu. mouth; pe. pedicel; pha. pharynx; pht. pharyngeal tube; r. rostrum, sh. sensory hair; su. sulcus; tp. trophi; tr. trochus; trd. trochal disc; ul. upper lip.

4. Trophi (Fig. 4A)

All bdelloids except philodinavids have the ramate trophi which is stout with reduced fulcrum and manubria, and large plate-like unci whose surfaces are provided with numerous parallel ridges. Among these ridges, thick and strong ones are called teeth. The dental formula expresses the number of teeth on each uncus, e.g. 2/3. In this case, the numerator designates two teeth in the left uncus and the denominator three teeth in the right one. The dental formula ranges from 2/2 to 9/9 and can be used as a diagnostic character in some species.

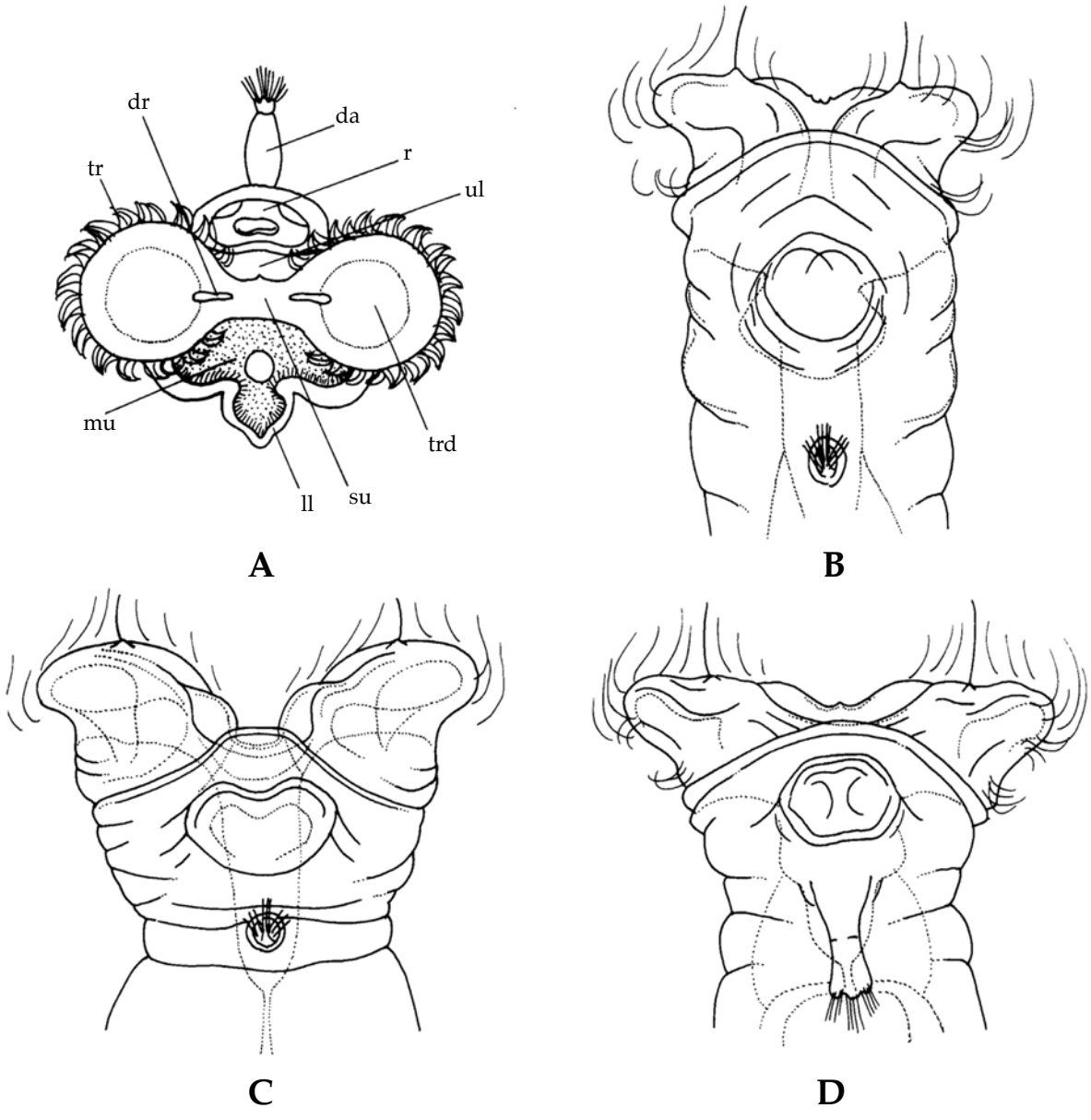

Fig. 3. Disc retractor. A. a front view of feeding head (diagrammatic, modified from Bartoš, 1951); B. feeding head of *Habrotrocha gracilis gracilis*; C. feeding head of *Mniobia scarlatina*; D. feeding head of *Dissotrocha aculeata aculeata*. da. dorsal antenna; dr. disc retractor; mu. mouth; ll. lower lip; r. rostrum, su. sulcus; tr. trochus; trd. trochal disc; ul. upper lip.

5. Spurs and toes (Fig. 4B)

The spurs are highly variable in shape and size, and therefore serve as an important diagnostic character. They are usually paired, with or without interspace, and present on the spur segment dorsally.

The foot ends in 2−4 toes or an adhesive disc, which is diagnostic mainly at the generic level: species of *Philodina*, *Embata*, *Dissotrocha*, *Pleuretra*, *Philodinavus* and *Henoceros* have 4 toes; species of *Habrotrocha*, *Otostephanos*, *Macrotrachela*, *Rotaria*, *Ceratotrocha*, *Adineta* and *Bradyscela* have three toes; species of *Mniobia* have an adhesive disc (Fig. 4B: b, c, e) or plate, which is sometimes split and ends with two stumpy toe-like papillae (Fig. 4B: f). The reduction of toes to an adhesive disc can also be found in genera other than *Mniobia* (Donner, 1953). The toes are also variable in size and shape, and used as a diagnostic character in many species.

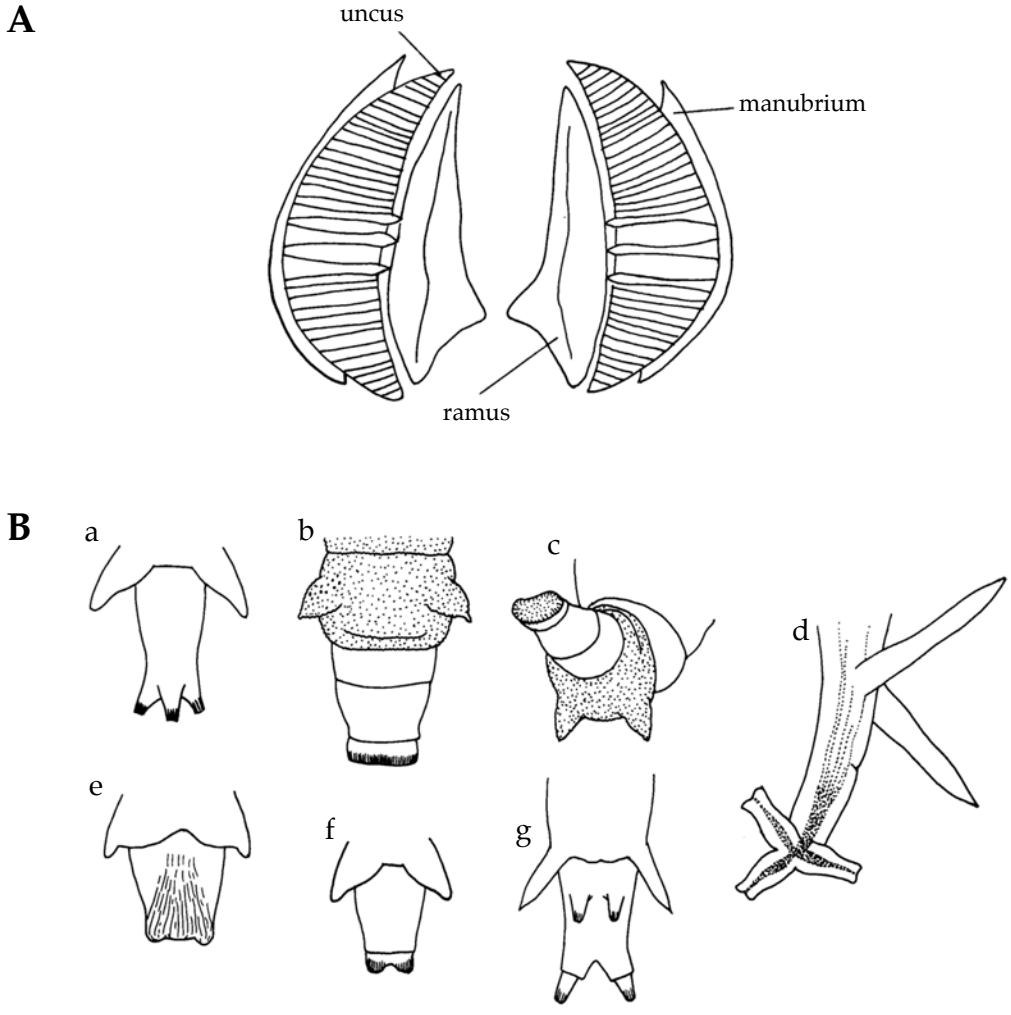

Fig. 4. A. Ramate trophi (from Stemberger, 1979); B. Spurs and toes (from Donner, 1965): a. two spurs and three small toes of many bdelloids; b. two spurs and an adhesive disc; c. ventral view of an adhesive disc; d. two long spurs and three outstretched toes of *Rotaria socialis*; e. broad spurs and another form of an adhesive disc; f. a cleft adhesive plate of a *Mniobia*; g. narrow spurs and four toes of a *Philodina*.

Taxonomic Notes

Class Eurotatoria De Ridder, 1957

Jin-yun-chung-gang (진윤충강)

Subclass Bdelloidea Hudson, 1884

Jil-hyeong-a-gang (질형아강)

Two ovaries with yolk glands (vitellaria). Without male. Body fusiform in fully extended conditions, transversely wrinkled in false segments called pseudosegments. Ciliated rostrum at the end of head. No lateral antenna; single antenna present dorsally at the end of head. Corona consisting of 2 ciliary trochal discs on pedicels or a ventral ciliary area. Foot with 2 spurs and 2–4 toes or an adhesive disc.

Orders 3 (3 in Korea).

Key to the orders of subclass Bdelloidea

1. Trophi close to mouth opening; can be extruded when the animal is feeding ····· Philodinavida
− Trophi deep in the oesophagus, not extruded when feeding ····· 2
2. Corona modified to a ventral ciliated field with no trochi ····· Adinetida
− Corona with trochi elevated on pedicels ····· Philodinida

Order Philodinida Melone and Ricci, 1995

Seon-yun-chung-mok (선윤충목)

Families 2 (2 in Korea).

Key to the families of order Philodinida

1. Stomach without a visible lumen; foot and feces formed into round pellets within its wall ····· Habrotrochidae
− Stomach with a lumen; foot and feces not formed into round pellets ····· Philodinidae

Family Habrotrochidae Bryce, 1910

Hyeop-gwan-yun-chung-gwa (협관윤충과)

Stomach without a tubular lumen. Food and excreta formed into pellets. Corona *Philodina*-type. Trochal discs rather small. Upper lip mostly without median notch. Short foot ending with 3 toes or an adhesive disc. Oviparous.

Genera 3 (2 in Korea).

Key to genera of family Habrotrochidae

1. A fine band or ring present between corona and cingulum ····· *Otostephanos*
− A fine band or ring absent ····· *Habrotrocha*

Genus *Habrotrocha* Bryce, 1910

Hyeop-gwan-yun-chung-sok (협관윤충속)

Corona mostly narrower than cingulum pad. Food usually formed into pellets. Stomach without a tubular lumen. Eyes uncommon. Mostly moss, leaf-litter and moist soil dwellers. Oviparous.

Species 130 (12 in Korea).

Key to the species of genus *Habrotrocha*

1. Animal in a nest or shell ····· 2
− Animal never in a nest or shell ····· 6
2. Shells self-made ····· 3
− Living in abandoned shells of Rhizopoda; upper lip triangular with obtuse end ····· *H. parvipes*
3. Shells bottle-shaped and made of organic substance secreted from trunk ····· 4
− Shells in irregular shape and made of mucus and foreign particles ····· 5
4. Shell with only 1 opening at end of long and straight neck ····· *H. angusticollis angusticollis*
− Shell with 2 opposite openings; anterior opening on short and wide neck; posterior opening small and leant posterodorsally ····· *H. perforata*
5. Corona a little wider than cingulum pad; triple dorsal thickening between anal and first foot segment ····· *H. gracilis gracilis*
− Corona narrower than cingulum pad; conical process present on both preanal and anal segment dorsally ····· *H. spicula*
6. Trunk heavily granulated ····· 7
− Trunk smooth ····· 9
7. Corona as wide as or narrower than cingulum pad; antenna segment with only 2 protuberances on each side of antenna ····· 8
− Corona a little wider than cingulum pad; antenna segment bearing 5 protuberances all around; trunk covered with mucus and foreign material ····· *H. fusca*

8. Granules on trunk big; dental formula 2/2 ····· *H. aspera*
− Granules on trunk small; dental formula 7/7 ····· *H. crenata crenata*
9. Trunk broad, round and more or less flattened dorsoventrally ····· 10
− Trunk spindle-shaped in creeping ····· 11
10. Dental formula 5/5; disc retractor well-developed and higher than upper lip ····· *H. lata lens*
− Dental formula 2/2; disc retractor much lower than upper lip ····· *H. plana*
11. Dental formula 3/3; neck very long; pharyngeal tube about 3 times as long as trophi; foot ending in two stumpy toe-like papillae instead of 3 toes ····· *H. insignis*
− Dental formula 6/6-8/8; neck short; pharyngeal tube as long as trophi; foot with three toes ····· *H. constricta*

1. *Habrotrocha angusticollis angusticollis* (Murray, 1905) (Fig. 5, Pl. 1)
Ho-ri-byeong-hyeop-gwan-yun-chung (호리병협관윤충)

Callidina angusticollis Murray, 1905, p. 374, pl. 3, fig. 2a−k; Murray, 1906b, p. 640, fig. 11.
Habrotrocha angusticollis: Bartoš, 1951, p. 292, fig. 9A, B, E, F; Bartoš, 1963, p. 31, pl. 2, fig. 1; Koste and Shiel, 1986, p. 770, fig. 5: 1a−f.
Habrotrocha angusticollis angusticollis: Donner, 1965, p. 29, fig. 8a, b; Song and Kim, 2000, p. 96.

Corona slightly wider than cingulum pad. Rostral lamella rather big. Head small in creeping. Trochal discs inclined ventrally. Sulcus narrow and shallow. Upper lip rimmed, inverted trapezoid-shaped with convex anterior margin and as high as, or slightly lower than, trochal discs. Pedicel rather short. Feeding head rather elongate between corona and rostrum. Antenna rather long with 2 segments; distal segment much shorter than proximal one; proximal segment somewhat swollen all around. Pharyngeal tube about 4 times as long as trophi. Dental formula 2/2. Trunk spindle-shaped. Foot short and with 4 segments; first segment swollen anterodorsally. Spurs small, conical with sharp points and rather divergent; interspace narrower than spur base. Shell smooth, thin, semitransparant, dark brown in color, oval ventrally, and with long neck; opening rimmed. Egg oval.

Size (μm): Body length 208−247 in creeping, trunk width 41−43 in creeping, spur length 4, corona width 25, cingulum pad width 22.

Distribution: Cosmopolitan.
Korea: GW.
Specimens examined: 12 specimens (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998).
Remarks: In Asia, this species has been reported from Indonesia (Bartoš, 1963), China (Wang, 1961; Koste and Zhuge, 1996), Myanmar (Koste and Tobias, 1990), and India (Murray, 1906b; Sharma and Sharma, 2014). Song and Kim (2000) reported the present species from South Korea for the first time. Recently another report on this species was added from Thailand (Sa-Ardrit et al., 2013).

With regard to the shell, Murray (1911f) reported the hyaline one of the specimens from South Africa. It seems to have been newly secreted one, because the similar thin and hyaline shell could be observed on the specimen which had been taken out of its shell about a few days before. Bartoš

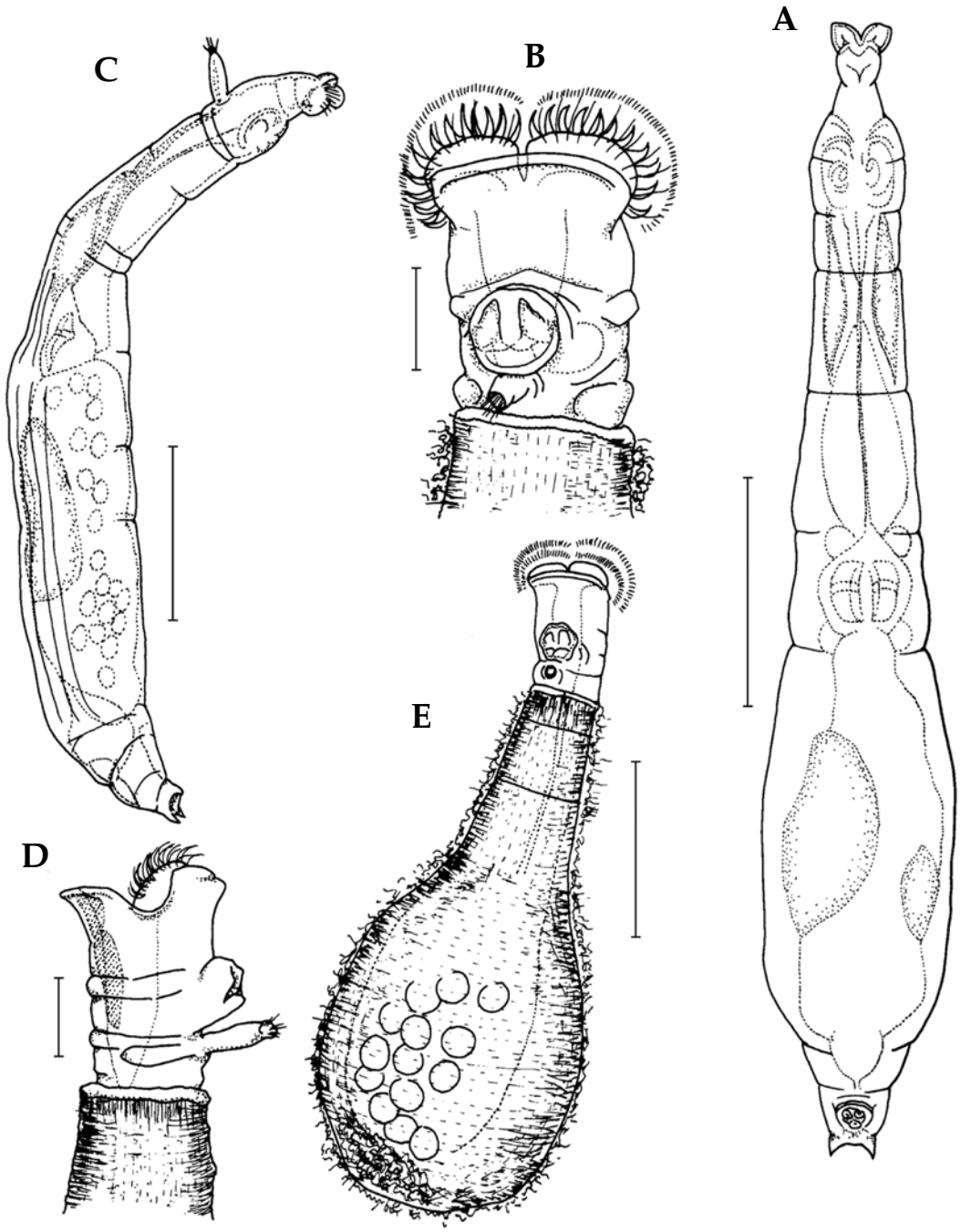

Fig. 5. *Habrotrocha angusticollis angusticollis*. A. creeping, ventral view; B. feeding head, dorsal view; C. creeping, lateral view; D. feeding, lateral view; E. feeding in a shell. Scales: A, C, E=50 μm, B, D=15 μm.

(1951) mentioned that the shell was transparent in the young individuals, later it became clear yellow and finally dark yellow-brown and opaque. Donner (1965: 29) notes that this species may occupy nests of *Nebela* or *Difflugia*.

2. *Habrotrocha aspera* (Bryce, 1892) (Fig. 6A, B, Pl. 2)
U-tul-du-tul-hyeop-gwan-yun-chung (우툴두툴협관윤충)

Callidina aspera Bryce, 1892, p. 23, pl. 2, fig. 4; Janson, 1893, p. 61, pl. 4, fig. 48; Murray, 1906a, p. 176, pl. 4, fig. 16a–d.
Habrotrocha aspera: Bartoš, 1951, p. 333, figs. 5H, 26D–F; Haigh, 1965, p. 9, fig. 1B, C; Donner, 1965, p. 50, fig. 36a, b; Song and Kim, 2000, p. 96.

Rostum small, short and with rather big lamella. Corona as wide as or somewhat narrower than cingulum pad. Sulcus very narrow. Upper lip triangular with an obtuse end and slightly knobby sides. Disc retractor bilobed and with a small spicule on median notch in dorsal view. Antenna about a half as long as antenna segment width and with a protuberance on each side. Pharyngeal tube much longer than trophi length and winding. Dental formula 2/2. Trunk heavily granulated; granules on longitudinal ridges more coarser than others; pseudosegment preceding rump and preanal pseudosegment with angular posterolateral corners. Foot slightly granulated and ending with a U-shaped adhesive plate; first segment with a process dorsally. Spur conical and without interspace.

Size (μm): Body length 211 in creeping or 143 in feeding, trunk width 39 in creeping or 47 in feeding, spur length 7, corona width 22, cingulum pad width 22.

Distribution: Cosmopolitan.
Korea: GW.
Specimens examined: 6 specimens (Taebaeksan, Taebaek-si, Gangwon-do, mosses and lichens: 17.vii.1997); 1 specimen (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee).
Remarks: This species is cosmopolitan and was reported from India by Murray (1906b). Song and Kim (2000) reported this species from Korea for the first time, which was the first record from East Asia as well.

This species is rather similar to *H. crenata crenata* (Murray, 1905) with respect to the granulation of trunk. But the granules on the trunk are much bigger in this species than in *H. crenata crenata*. The Korean specimens of this species have a difference from the other populations in that they have a dorsal process on the first foot segment.

3. *Habrotrocha constricta* (Dujardin, 1841) (Fig. 6C, D, Pl. 3A, B)
Pyeong-beom-hyeop-gwan-yun-chung (평범협관윤충)

Callidina constricta Dujardin, 1841, p. 658, pl. 17, fig. 3 (cited from Harring, 1913).
Habrotrocha constricta: Bryce, 1910, p. 75; Burger, 1948, p. 115, fig. 1; Bartoš, 1951, p. 322, fig. 22E–G; Schulte, 1954, p. 599, figs. 18, 19; Donner, 1965, p. 91, figs. 68, 69; Donner, 1970b, p. 513, fig. 1a–e; Donner, 1972a, p. 103, fig. 11c, d; Donner, 1972b, p. 678, fig. 1a–c; Donner, 1980, p. 129, fig. 1a–f; Haigh, 1966, p. 194, fig. 1c–i; Bateman and Davis, 1980, p. 134, fig. 5; Koste and Shiel, 1986, p. 772, fig. 6: 1a–p, 3; Mizuno and Takahashi, 1991, p. 184, fig. 2; Song and Kim, 2000, p. 96.

Corona much narrower than cingulum pad. Upper lip triangular with obtuse end and much

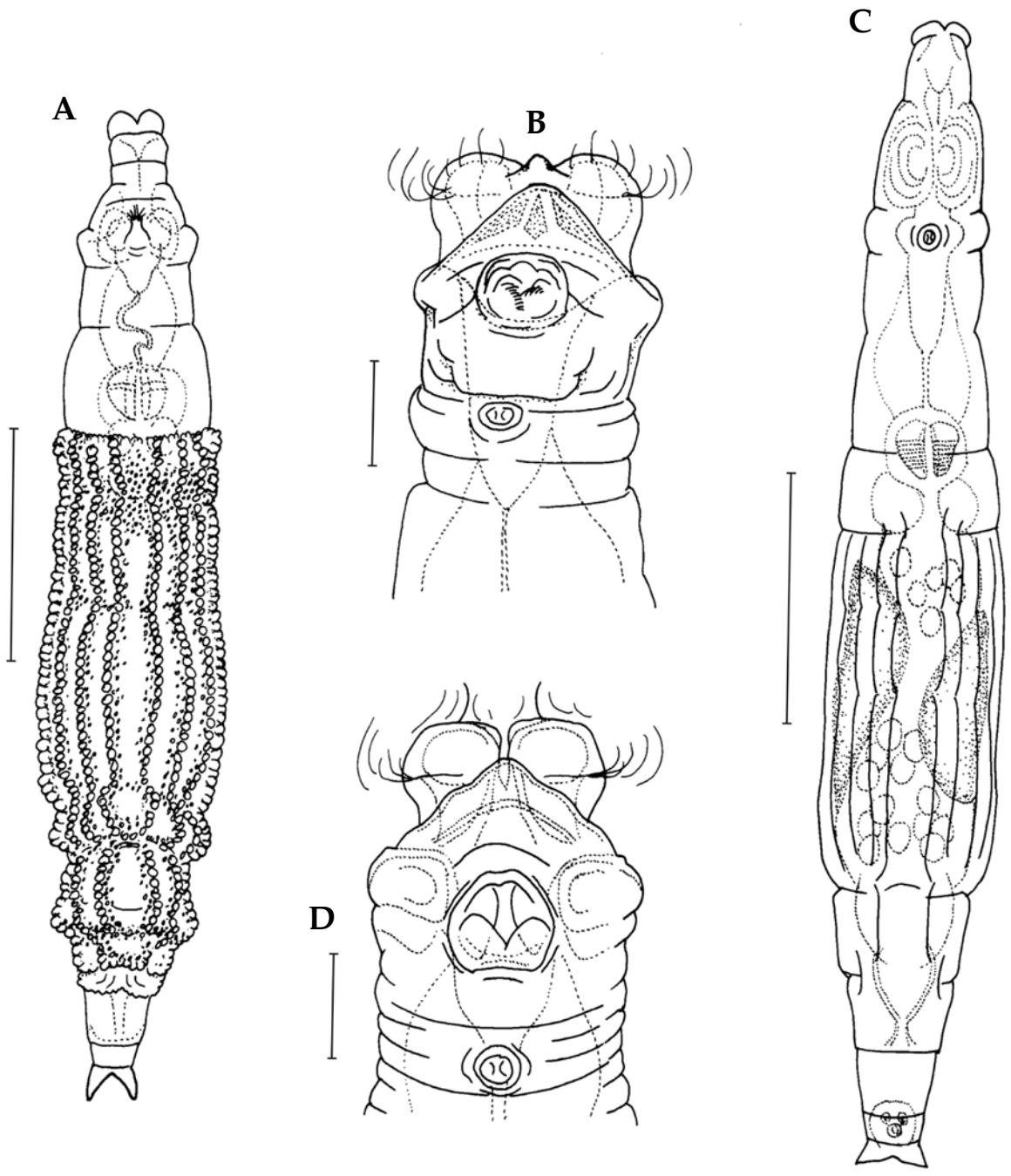

Fig. 6. *Habrotrocha aspera*. A. creeping, dorsal view; B. feeding head, dorsal view. *Habrotrocha constricta*. C. creeping, dorsal view; D. feeding head, dorsal view. Scales: A, C=50 μm, B, D=15 μm.

lower than trochal discs. Rostrum rather short. Rostral lamella bilobed and as wide as rostrum. Antenna segment rather swollen laterally. Antenna short. Dental formula 7/7. Trunk fusiform, smooth, with 2 median longitudinal folds extended to preanal segment dorsally, and slightly constricted before rump; preanal segment rather squarish in dorsal view and slightly constricted medi-

ally; anal segment gradually tapering to foot. Foot with 4 segments and ending with 3 toes. Spurs conical with pointed ends, very divergent and without interspace.

Size (μm): Body length (in creeping) 221−225, corona width 20−21, cingulum pad width 22−27, spur length 4.

Distribution: Cosmopolitan.

Korea: GW, GB.

Specimens examined: 20 specimens (Uljin, Gyeongsangbuk-do, mosses: 21.v.1996, Y.S. Chang and K.Y. Choi); 10 specimens (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, leaf litter from a stream: 25.iii.1998); 2 specimens (Yangyang-gun, Gangwon-do, mosses and forest litter: 27.ix.1998).

Remarks: In Asia, the present species has been reported from Japan (Mizuno and Takahashi, 1991), China (Zhuge et al., 1998), Korea (Song and Kim, 2000), and Iran (Khoei et al., 2011).

H. constricta has been reported to be very variable in the shape of spurs, the width of corona, the height of upper lip and the extent of trunk granulation. The Korean specimens have the corona rather narrow in comparison with other populations reported previously, and their upper lips are low and reach half of the pedicel length.

4. *Habrotrocha crenata crenata* (Murray, 1905) (Fig. 7A, B)

Bang-ul-dol-gi-hyeop-gwan-yun-chung (방울돌기협관윤충)

Callidina crenata Murray, 1905, p. 376, pl. 4, fig. 6a−d; Murray, 1906b, p. 176, pl. 1, fig. 4.
Habrotrocha crenata: de Koning, 1929, p. 72, fig. 13; Bartoš, 1951, p. 331, fig. 27a−c; Schulte, 1954, p. 600, fig. 21; Donner, 1965, p. 83, fig. 60d, e; Song and Kim, 2000, p. 96.

Rostrum short. Rostral lamella bilobed. Corona narrower than cingulum pad. Cingulum pad swollen laterally. Sulcus narrow. Upper lip arched with rather concave and wavy sides, and a little lower than trochal discs. Head and neck smooth. Dental formula 7/7. Trunk granulated; granules crowning longitudinal ridges of trunk somewhat bigger than others; preanal segment with a granulated globular process on each posterolateral corner; anal segment with a transverse crenated fold dorsally. Foot granulated and with 3 segments; first segment with a dorsal process. Spurs granulated, somewhat divergent and conical with sharp ends; without interspace.

Size (μm): Body length (in creeping) 112, corona width 20, cingulum pad width 21; spur length 5.

Distribution: Cosmopolitan.

Korea: GB.

Specimens examined: 1 specimen (Uljin, Gyeongsangbuk-do, mosses: 21.v.1996, Y.S. Chang and K.Y. Choi).

Remarks: This species is cosmopolitan, but Song and Kim (2000) reported this species from Korea for the first time, which was the first record form Asia as well.

This species is very similar to *H. appendiculata* Murray, 1911 with respect to the general body structure. But it is distinguished from the latter by the following characteristics: (1) The posterolateral knobs on the preanal segment are granulated in the present species, while not granulated in *H. appendiculata*, (2) The present species has a dorsal process on the first foot segment, while *H. appen-*

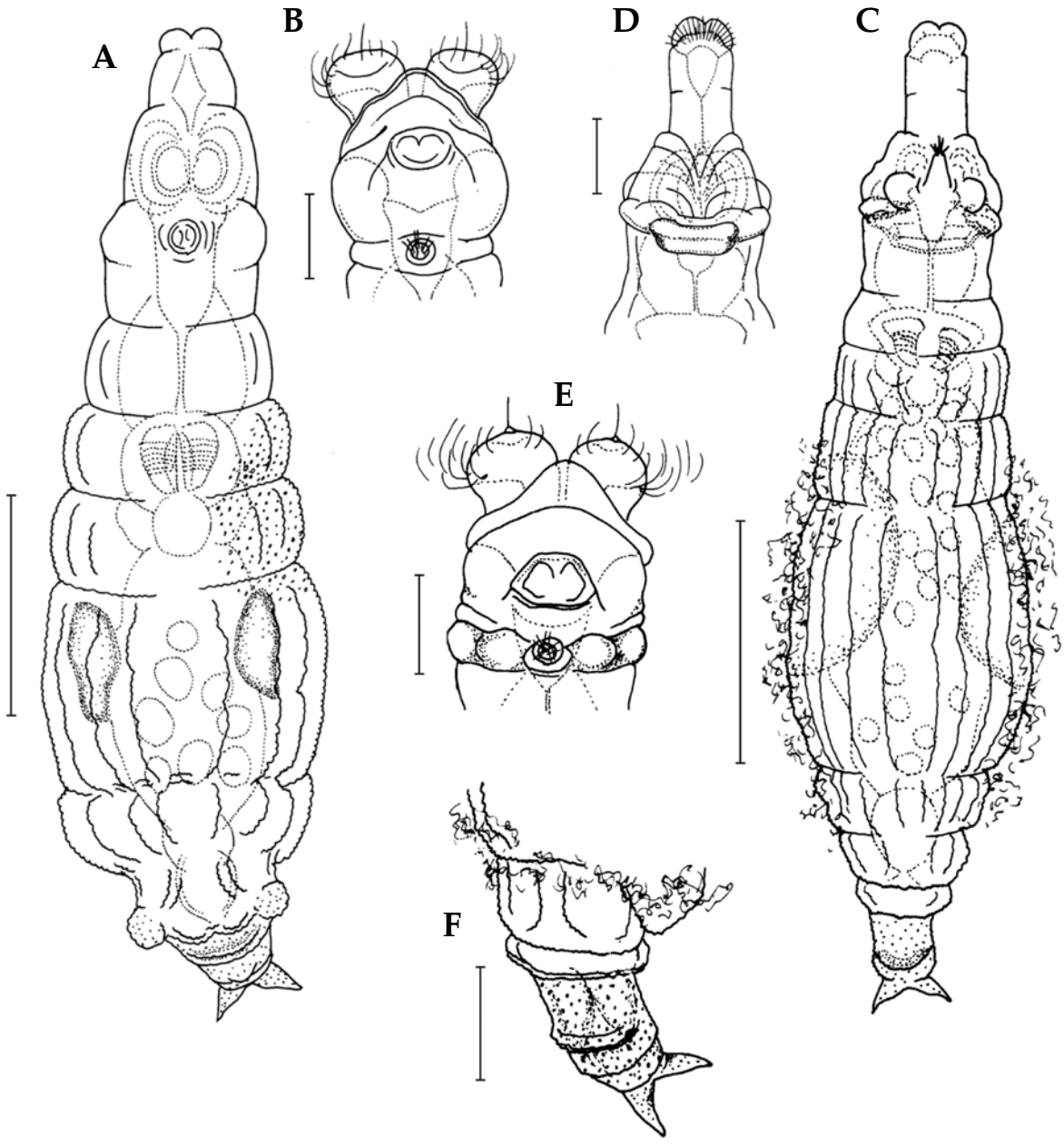

Fig. 7. *Habrotrocha crenata crenata*. A. creeping, dorsal view; B. feeding head, dorsal view. *Habrotrocha fusca*. C. creeping, dorsal view; D. creeping head, ventral view; E. feeding head, dorsal view; F. foot and spurs, dorsolateral view. Scales: A=25 μm, B=10 μm, C=50 μm, D−F=15 μm.

diculata does not, (3) The upper lip of the present species has wavy sides, while that of *H. appendiculata* has smooth sides, and (4) While the foot and spurs are granulated in the present species, those of *H. appendiculata* are smooth.

The Korean specimen of the present species is very small in body length, and only about a third of that of the European populations.

5. *Habrotrocha fusca* (Bryce, 1894) (Fig. 7C–F, Pl. 3C)
Gin-bu-ri-hyeop-gwan-yun-chung (긴부리협관윤충)

Callidina fusca Bryce, 1894, p. 448, pl. 23, fig. 2a–d.
Habrotrocha fusca: Murray, 1913, p. 239, pl. 9, fig. 2a, b; Bartoš, 1951, p. 326, fig. 24a–d; Donner, 1951, p. 618, fig. 4; Donner, 1965, p. 73, fig. 55a–e; Song and Kim, 2000, p. 96.

Rostrum rather long, about double of its width, and much narrower than neck; rostral lamella bilobed and somewhat low; many long cilia present under rostral lamella. Posterior part of head swollen all around like a collar anterior to neck. Corona a little wider than cingulum pad. Pedicel very short. Sulcus narrow. Upper lip arched and with concave sides. Antenna short, thick and with 2 segments; base of proximal segment swollen dorsally. Antenna segment bearing 2 pairs of protuberances dorsally, and three ones ventrally, which making its cross section seven-lobed; a middle one among the ventral protuberances protruded like a lip. Dental formula 5/5. Pharyngeal tube much shorter than trophi length. Trunk covered with detritus, granulated and with about 10 prominent transverse striae ventrally; anal segment a little swollen posterodorsally. Foot highly granulated; first segment with a rather big transverse projection over posterodorsal margin. Three toes obtuse and much shorter than spurs. Spurs granulated, conical and with acute ends; outer margin rather straight and inner margin rather swollen proximally; interspace absent.

Size (μm): Body length (in creeping) 196–205, trunk width (in creeping) 50–52, corona width 48–54, spur length 7.

Distribution: Australia, Brazil, Great Britain, Switzerland, Czech Republic, Germany, Sweden, Austria, Hungary, Rumania, China, Indonesia and Korea.

Korea: GW.

Specimens examined: 2 specimens (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee).

Remarks: The characteristics of the Korean specimens agree well with those of the type specimens and the other populations which have been reported to date. In Asia, this species was recorded from China and Java by Bartoš (1963).

6. *Habrotrocha gracilis gracilis* Montet, 1915 (Fig. 8A–C)
Nal-ssin-hyeop-gwan-yun-chung (날씬협관윤충)

Habrotrocha gracilis gracilis: Donner, 1965, p. 46, figs. 28, 29; Donner, 1970a, p. 235, fig. 19; Donner, 1971, p. 364, fig. 1a, b; Song and Kim, 2000, p. 97, fig. 8.

Inhabiting irregular shaped house of mucus, detritus and extruded food pellets. Rostrum small and rather constricted all around proximally; rostral lamella small and bilobed. Corona a little wider than cingulum pad. Upper lip low, arched and with thick rim. Disc retractor bilobed and with 3 tiny processes on median notch. Sulcus narrow and with base lower than upper lip. Antenna long. Both lateral margins of antenna segment round. Pharyngeal tube as long as trophi. Dental formula 5/6. Lateral margins of trunk rather parallel and as wide as or slightly narrower

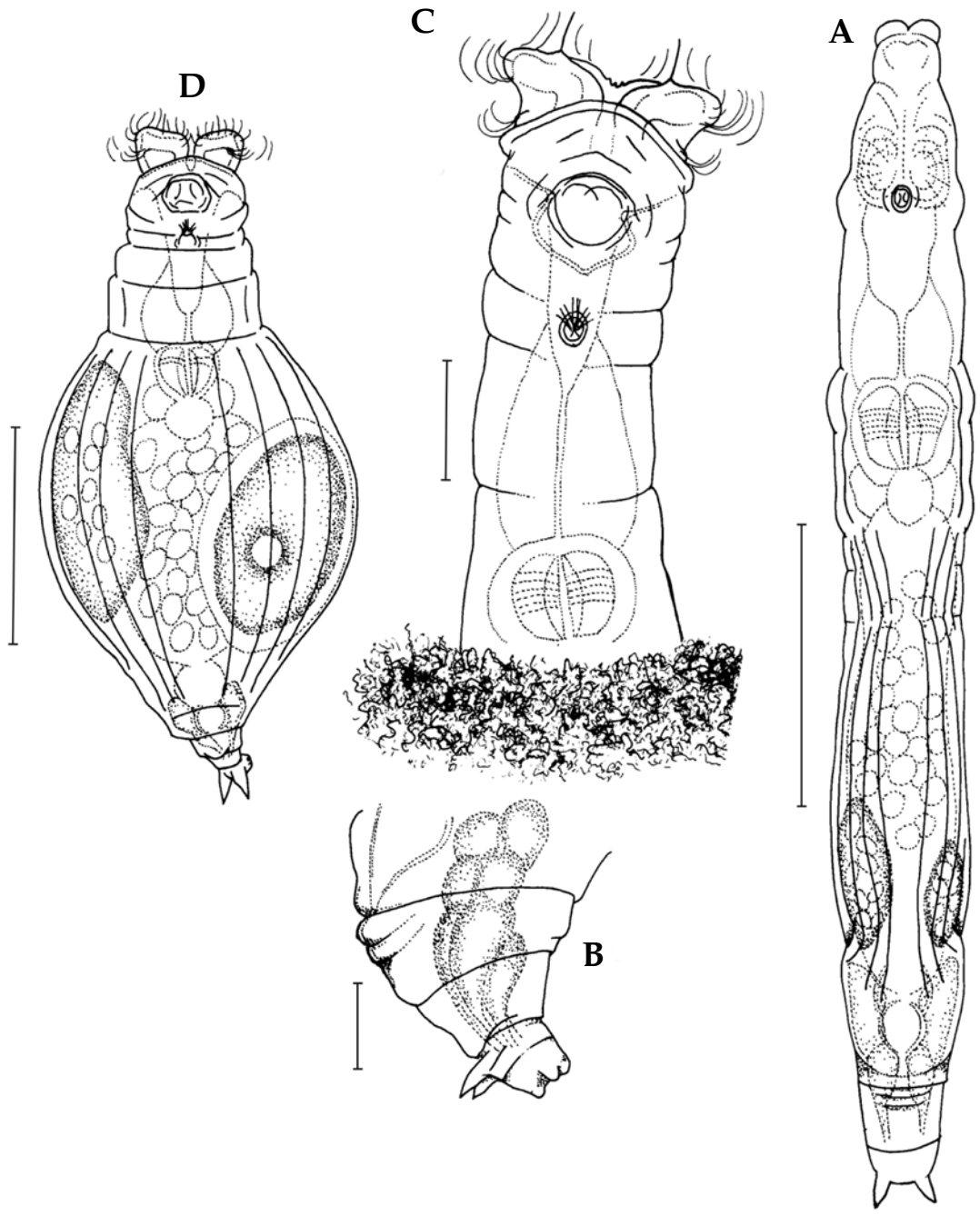

Fig. 8. *Habrotrocha gracilis gracilis*. A. creeping, dorsal view; B. foot and spurs, lateral view; C. feeding head, dorsal view. *Habrotrocha plana*. D. feeding, dorsal view. Scales: A, D=50 μm, B=10 μm, C=15 μm.

than neck. Anal segment with rounded posterior end and posterodorsal thickening. Foot with 4 segments, very short, narrower than anal segment of trunk, inclined ventrally and hardly extended fully; first segment with 2 transverse thickening anterodorsally. Three toes very short and near to toe-like papillae. Spurs conical and narrow; lateral margins of proximal half of spur rather parallel

but tapering in distal half to rather sharp end; interspace somewhat wider than spur base. Egg elliptical and with very thin and flexible shell.

Size (μm): Body length (in creeping) 210−245, trunk width (in creeping) 26−30, corona width 28, cingulum pad width 26; spur length 5−7.

Distribution: Switzerland, Austria, Germany, Czech Republic, Italy, Sweden and Korea.
Korea: GW.
Specimens examined: 2 specimens (Chilseongsan, Gujeong-myeon, Gangneung-si, Gangwon-do, wet leaf litter from a stream: 11.v.1997); 2 specimens (Wangsan-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998).
Remarks: The characteristics of the Korean specimens of this species coincide well with those of the Austrian population (Donner, 1950) except the morphologies of foot and feeding head (Donner, 1965). The shape of foot and feeding head is most similar to that of a variety reported by Donner (1965) with a deviation in the shape of the membraneous bridge between the trochal discs. The Korean specimens have 3 small processes on disc retractor medially, while the Austrian variety has only one.

The present species is very similar to *H. collaris* in the general body structure, but it is distinguished from the latter by the following characteristics: (1) The present species does not have the cerebral eyes which *H. collaris* has, and (2) The present species usually lives in the nest made of detritus while *H. collaris* does not (Donner, 1970a).

This species was reported from Korea for the first time by Song and Kim (2000), which was the first record from the Asian fauna as well.

7. *Habrotrocha insignis* Bryce, 1915 (Fig. 9A−C)
Ga-ro-ju-reum-gin-mok-hyeop-gwan-yun-chung (가로주름긴목협관윤충)

Habrotrocha insignis Bryce, 1915, p. 635, pl. 38, fig. 1; Bartoš, 1951, p. 308, fig. 15E−G; Donner, 1970b, p. 515, fig. 1; Song and Kim, 2000, p. 96.
Habrotrocha tridens var. *proxima* Donner, 1950, p. 305, fig. 9.
Habrotrocha proxima Donner, 1953, p. 346; Donner, 1962, p. 309, fig. 5; Donner, 1965, p. 68, fig. 51.
Mniobia proxima: Bartoš, 1951, p. 466.

Rostrum somewhat narrower than neck. Rostral lamella bilobed, circular and big; each lobe a little wider than a half of rostrum end. Corona much narrower than cingulum pad. Pedicel rather long. Sulcus very narrow and about 1/4−1/3 of pedicel width. Upper lip convex, bluntly triangular and reaching to about 1/2 of pedicel height. Both sides of cingulum pad very swollen and round, making this part much wider than corona. Neck very long and about 1/4 of total body length; second and third segment of neck with many irregular transverse wrinkles and thinner than any other neck segments. Dental formula 3/3. Pharyngeal tube very long and about 4 times as long as trophi. Trunk cylindrical in the middle and rather constricted in front of preanal segment; anal segment swollen and rounded posterodorsally; barrel-shaped during feeding and its maximum width about doulble and a half of feeding neck. Foot with 4 segments, very short and with 2 stumpy toe-like papillae terminally. Spur conical, with acute apex, and divergent; inter-

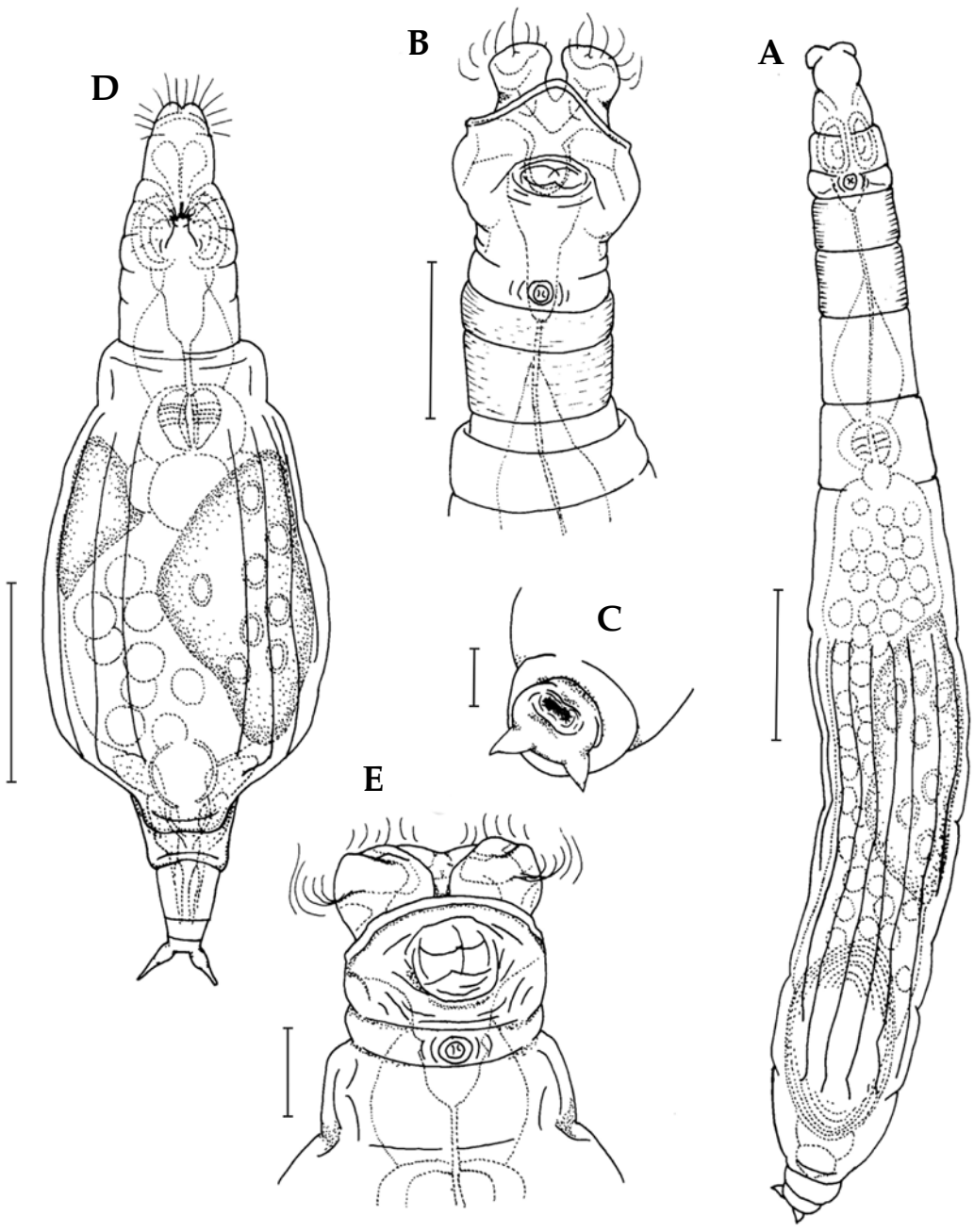

Fig. 9. *Habrotrocha insignis*. A. creeping, dorsal view; B. feeding head, dorsal view; C. spurs, ventral view. *Habrotrocha lata lens*. D. creeping, dorsal view; E. feeding head, dorsal view. Scales: A, D=50 μm, B=25 μm, C=10 μm, E=15 μm.

space somewhat narrower than spur base. Egg oval and with smooth surface.

Size (μm): Body length (in creeping) 274−355, corona width 20−21, cingulum pad width 25−26, spur length 6.

Distribution: Africa, Great Britain, Poland, Switzerland, Czech Republic, the Netherlands, Hun-

gary, Rumania, Germany, Austria, New Zealand and Korea.

Korea: GB.

Specimens examined: 10 specimens (Uljin, Gyeongsangbuk-do, mosses: 21.v.1996, Y.S. Chang and K.Y. Choi).

Remarks: Donner (1950) described a new variety of *Habrotrocha tridens* (Milne) as *Habrotrocha tridens* var. *proxima* from moss samples in Steinauerhohe, Austria. Later, Bartoš (1951) assigned this taxon to the different genus *Mniobia* because it had the adhesive plate instead of three toes, which was censured as erroneous by Donner (1953, 1962). Donner (1953) emphasized that the cases of reduction of three toes to the adhesive disc have been observed often in many genera other than *Mniobia* and changed the status of *H. tridens* var. *proxima* to a complete species, *H. proxima*. Donner (1962) also insisted that *H. tridens* var. *proxima* could not be placed under the genus *Mniobia*, because they have food pellets in their stomach while the congeners of *Mniobia* have a stomach lumen.

H. proxima is very similar to present species except that it does not have the horseshoe-shaped cuticular plates on its upper lip, which the latter has. During his study on the Spanish rotifers, Donner (1970b) came to the conclusion that *H. proxima* was synonymous with *H. insignis*.

The Korean specimens do not have the horseshoe-shaped cuticular plate on their upper lip, either. This species was reported from Korea for the first time by Song and Kim (2000), which was the first record from the Asian fauna as well.

8. ***Habrotrocha lata lens*** Donner, 1965 (Fig. 9D, E, Pl. 4)

Ren-jeu-kong-neolb-jeok-hyeop-gwan-yun-chung (렌즈콩넓적협관윤충)

Habrotrocha lata lens Donner, 1965, p. 77, fig. 56d–f; Song, 1999, pp. 57, 58, Fig. 11d, e.

Rostrum much narrower than neck and rather oval ventrally. Rostral lamella bilobed, very transparant and narrower than rostrum. Rostral cilia with some especially long ones. Upper lip low, arched and rimmed. Trochal discs semicircular ventrally. Corona as wide as cingulum pad. Pedicel rather short. Sulcus narrow. Disc retractor as high as or higher than trochal discs and with median notch in dorsall view. Dorsal antenna shorter than antenna segment width. Dental formula 5/5. Pharyngeal tube as long as trophi. Trunk plump, rather flattened dorsoventrally and abruptly narrowed at preanal segment during feeding; preanal segment inverted trapezoid-shaped in dorsal view and with thick rim posteriorly; anal segment somewhat wider than preanal segment and slightly rimmed posteriorly. Foot with 4 segments; first segment longer than anal segment of trunk; segment before toes longer than spurs. Three toes thin and long, but shorter than spurs. Spurs narrow, long and lanceolate; interspace much narrower than spur base.

Size (μm): Body length (in creeping) 122–169, trunk width (in creeping) 55–57, corona width 23–24, cingulum pad width 26, spur length 7–8.

Distribution: Austria, Italy and Korea.

Korea: GW.

Specimens examined: 4 specimens (Chilseongsan, Gujeong-myeon, Gangneung-si, Gangwon-do, wet leaf litter from a stream: 11.v.1997); 3 specimens (Jeombongsan, Yangyang-gun, Gangwon-do, mosses: 16.xi.1997, K.S. Lee).

Remarks: The present subspecies is distinguished from *H. lata lata* Bryce, 1892 chiefly by the dif-

ferent morphologies of disc retractor, rump and spurs.

Song (1999) was the second report of the present subspecies after the original description by Donner (1965) from Austria. Fontaneto and Melone (2003) later reported this subspecies from Italy.

9. *Habrotrocha parvipes* Donner, 1951 (Fig. 10, Pl. 5)

Jak-eun-bal-hyeop-gwan-yun-chung (작은발협관윤충)

Habrotrocha parvipes Donner, 1951, p. 622, fig. 9a–f; Donner, 1965, p. 53, fig. 38d–f; Song, 1999, pp. 58–61, fig. 12.

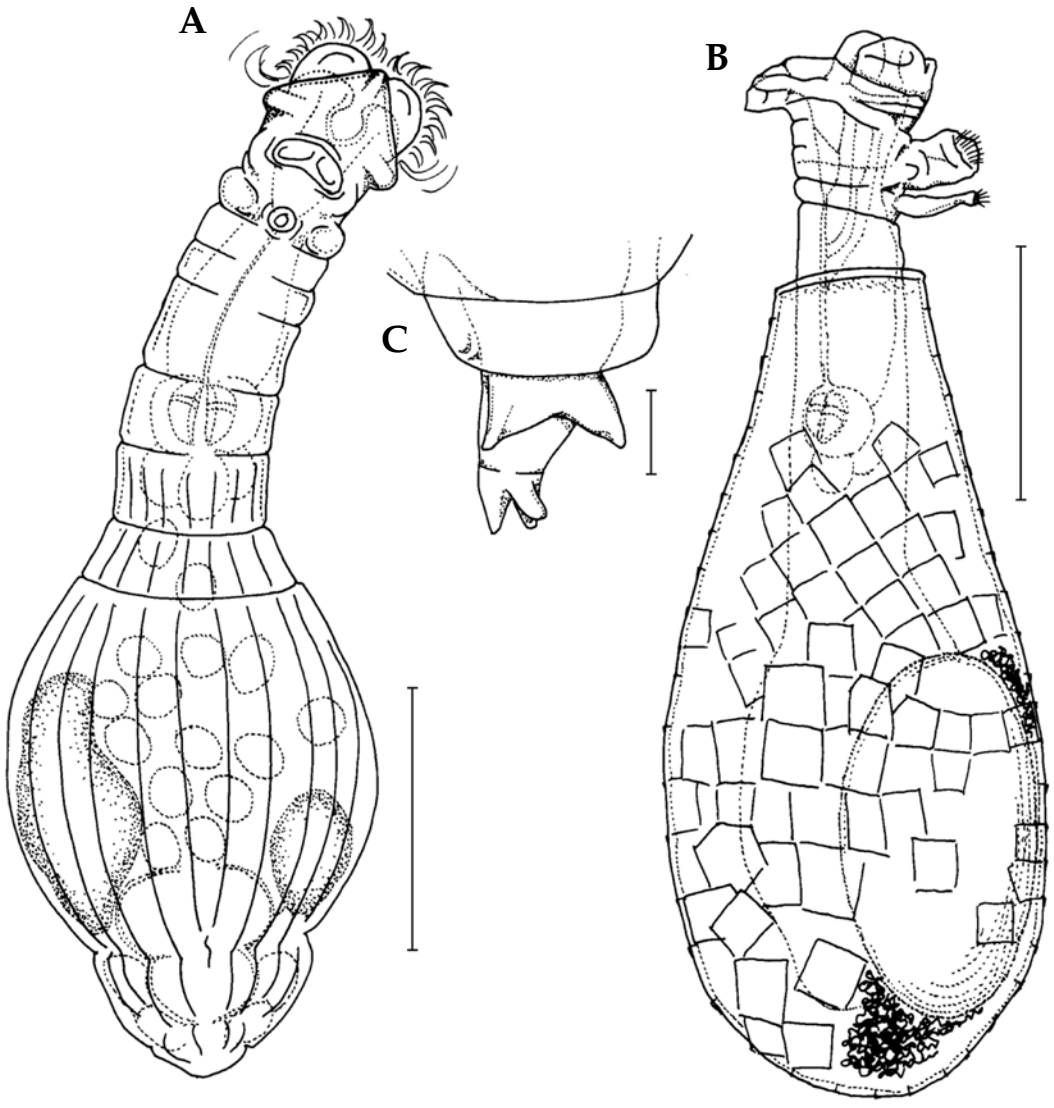

Fig. 10. *Habrotrocha parvipes*. A. feeding, dorsal view; B. feeding in a shell of *Quadrulella* sp., lateral view; C. spurs and toes, dorsal view. Scales: A, B=50 μm, C=5 μm.

Inhabiting shell of *Nebela* or *Quadrulella* spp.. Corona much narrower than cingulum pad and a little narrower than neck; inclined dorsally. Anterior part of cingulum pad bulging laterally. Upper lip triangular with obtuse end and as high as trochal discs. Neck a little wider than feeding head, very long (about one and a half of head length in feeding) and cylindrical. Antenna somewhat longer than a half of neck width. Dental formula 2/2. Pharyngeal tube much longer than twice trophi length. Trunk cylindrical and as wide as neck anteriorly and oval posteriorly; somewhat constricted before rump; rump swollen postero-dorsally. Foot very short, slightly longer than rump, and hardly extended fully. Spurs conical, short and somewhat divergent; interspace very narrow or absent. Egg oval with smooth surface.

Size (μm): Body length (in creeping) 200−258, body length (in feeding) 146−154, trunk width (in feeding) 34−53, corona width 14−17, cingulum pad width 19−23, spur length 4.

Distribution: Austria, Korea.

Korea: GW.

Specimens examined: 10 specimens (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998).

Remarks: Unlike the type specimens, which were not observed in any shells, all the Korean specimens were found inhabiting the shells of *Nebela* sp. or *Quadrulella* sp., but the moments while the individuals changed their shelters have not been observed.

Song (1999) reported the present species from Korea, which was the first record of this species after the original description from Austria by Donner (1951).

10. *Habrotrocha perforata* (Murray, 1906) (Fig. 11A, B, Pl. 6)

Gal-saek-hang-a-ri-hyeop-gwan-yun-chung (갈색항아리협관윤충)

Callidina perforata Murray, 1906b, p. 640, pl. 19, fig. 11a−c; Murray, 1907, p. 97, fig. 1.
Habrotrocha perforata: Murray, 1911c, p. 12; Murray, 1911f, p. 13, pl. 3, fig. 17a−c; Donner, 1965, p. 32, fig. 11; Koste, 1996b, p. 245, fig. 8a, b; Song and Kim, 2000, p. 96.

Living in thin, dark brown and semi-transparent shell, which oval with rather wide neck rimmed anteriorly and small oval opening posteroventrally; longitudinal folds present on surface of shell. Corona much narrower than cingulum pad, and semi-circular dorsoventrally. Sulcus very narrow and shallow. Upper lip low and triangular. Pedicel rather long. Pharyngeal tube a little shorter than trophi length. Dental formula 4/4. Rostrum rather short. Anterior part of trunk narrower than shell opening during feeding; a big and thick process present on anal pseudosegment of trunk dorsally; dorsal process retractile and with tip truncated. Spurs conical, very small; interspace very wide.

Size (μm): Shell length 101−103, shell width 60−67, anterior opening width 30−32, corona width 17−19, cingulum pad width 21−22.

Distribution: Probably cosmopolitan.

Korea: GW.

Specimens examined: 3 specimens (Taebaeksan, Taebaek-si, Gangwon-do, mosses: 17.vii.1997); 2 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee); 2 specimens (Jabyeong-

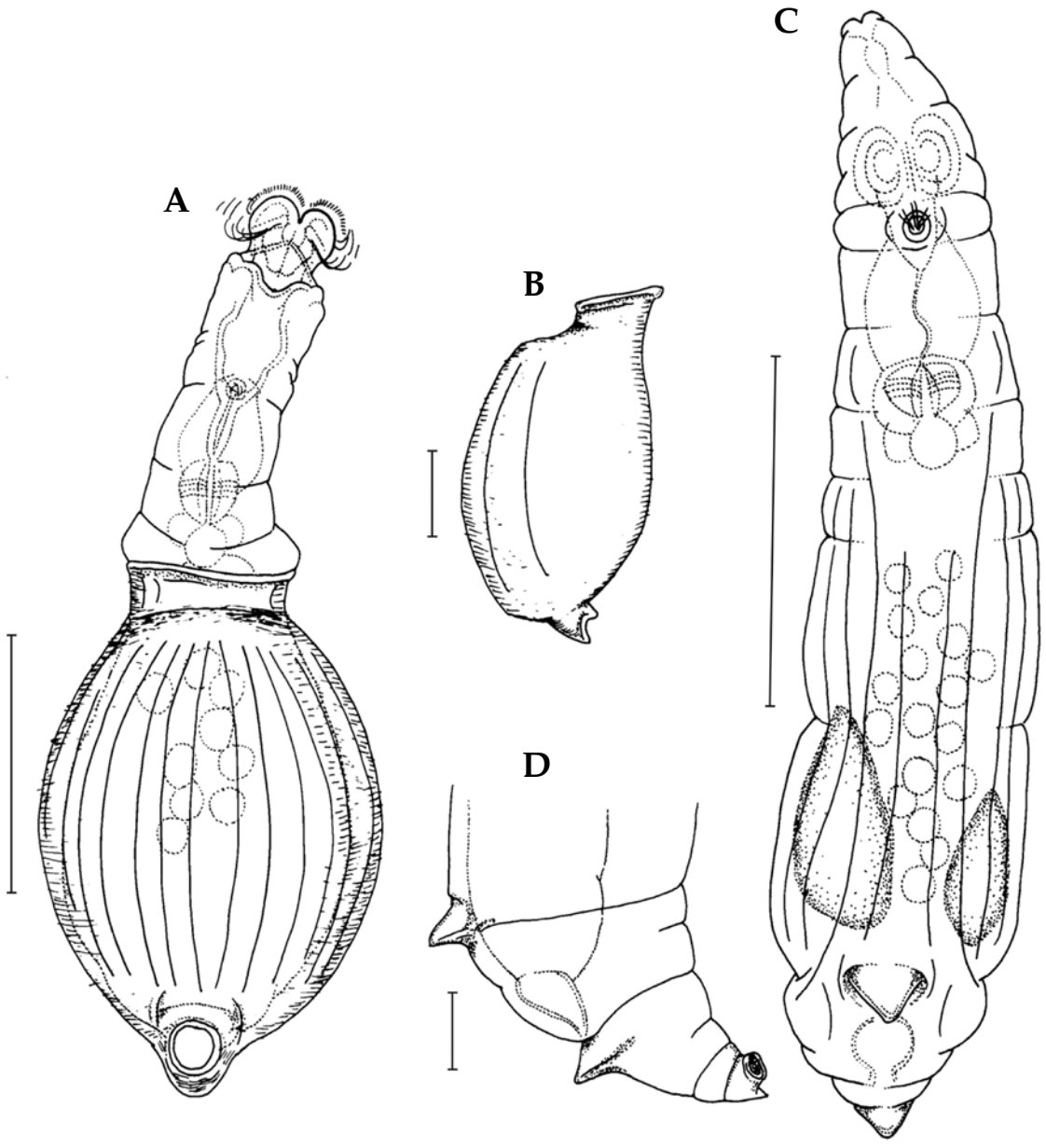

Fig. 11. *Habrotrocha perforata*. A. feeding, ventral view; B. shell, lateral view. *Habrotrocha spicula*. C. creeping, dorsal view; D. rump and foot, lateral view. Scales: A, C=50 μm, B=25 μm, D=10 μm.

san, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee).

Remarks: In Asia, the present species has been reported from India (Murray, 1906b), the type locality, Indonesia (Bartoš, 1963), China (Bartoš, 1963) and Korea (Song and Kim, 2000).

The characteristics of the Korean specimens agree very closely with those of the original specimens and the other populations.

11. *Habrotrocha plana* Milne, 1916 (Fig. 8D)
Dung-geul-nab-jag-hyeop-gwan-yun-chung (둥글납작협관윤충)

Habrotrocha plana Milne, 1916, p. 157, pl. 2, fig. 7; Bartoš, 1959, p. 146, fig. 18D; Donner, 1965, p. 53, fig. 37d; Song and Kim, 2000, p. 97, fig. 5.

Body rather short, stocky and with very small and narrow extremities. Corona somewhat narrower than cingulum pad. Upper lip arched and much lower than trochal discs. Sulcus very narrow. Dental formula 2/2. Trunk very broad, round and more or less flattened dorsoventrally; preanal segment abruptly narrowing posteriorly; anal segment swollen dorsally. Foot short and much narrower than anal segment. Spurs conical, narrow and long (about double of its base width); without interspace between them.

Size (μm): Body length (in feeding) 129–171, corona width 24–26, cingulum pad width 27–29, spur length 6–9, egg length along its long axis 48.

Distribution: South Africa, Korea.

Korea: GB.

Specimens examined: 11 specimens (Uljin, Gyeongsangbuk-do, mosses: 21.v.1996, K.Y. Choi and Y.S. Chang).

Remarks: Song and Kim (2000) was the first record of the present species after its description from South Africa by Milne (1916). The characteristics of the Korean specimens agreed well with those of the type specimens except that the Korean specimens were smaller than the type specimens.

12. *Habrotrocha spicula* Bryce, 1913 (Fig. 11C, D)
Du-gak-chu-dol-gi-hyeop-gwan-yun-chung (두각추돌기협관윤충)

Habrotrocha spicula Bryce, 1913, p. 89, pl. 9, fig. 1; Bartoš, 1951, p. 309, fig. 16A, B; Schulte, 1954, p. 596, fig. 14a–c; Haigh, 1965, p. 13, fig. 2i–l; Donner, 1965, p. 32, fig. 12a–d; Koste, 1996b, p. 247, fig. 9; Song and Kim, 2000, p. 96.

Inhabiting a house of mucus and fine detritus. Rostrum short; rostral lamellae bilobed, very transparent, and narrower than rostrum. Corona narrower than cingulum pad. Pedicel rather long. Upper lip triangular with round end. Sulcus very narrow. Antenna short, a little longer than a half of antenna segment width, thick and with a protuberance on each side. Pharyngeal tube rather long, longer than trophi length and winded. Dental formula 4/4. Preanal segment with big conical process dorsally. Rump gibbous dorsally. Foot short with 4 pseudosegments and ending with 2 stumpy toe-like papillae; first segment with a transversly flat conical process anterodorsally. Spurs very small, conical and with very wide interspace.

Size (μm): Body length (in creeping) 165, trunk width (in creeping) 34, spur length 2.

Distribution: Great Britain, Swiss, Czech Republic, Austria, Hungary, Romania, Sweden, former Soviet Union, Germany, Indonesia, New Zealand and Korea.

Korea: GW.

Specimens examined: 1 specimen (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, mosses, lichens and dry detritus: 13.xii.1995); 1 specimen (Jeombongsan, Yangyang-gun, Gangwon-do, mosses: 11.xi.1997, K.S. Lee).

Remarks: All the Korean specimens were found living in nests made of mucus and fine detritus, and wriggled out of their nests when disturbed. In his original description of the present species, Bryce (1913) did not mention the nest or case. Bartoš (1951) recognized the nest, but regarded it as a thin layer of mucus which covered the individuals and disappeared after moistening of the animals. Schulte (1954) and Donner (1965 noted that *H. spicula* could live both freely and in the nests. The nests may give protection against dessication and harmful mechanical or chemical influences. Bdelloids can leave their nests without harm and do so often of their own 'free will' (Schulte, 1954; Donner, 1966).

The Korean populations have two stumpy toe-like papillae instead of three toes. Bryce (1913), Schulte (1954) and Haigh (1965) did not describe the characteristics of toes. Bartoš (1951) and Donner (1965) did not mention the toes, either, but they illustrated three toes.

In Asia, the present species was reported from Indonesia by Bartoš (1963), and Song and Kim (2000) was the Korean new record of it.

Genus *Otostephanos* Milne, 1916

Go-ri-gwan-yun-chung-sok (고리관윤충속)

A fine band or ring present between corona and cingulum. Food usually formed into pellets. Dental formula 6/6-10/10.

Species 15 (1 in Korea).

13. *Otostephanos torquatus torquatus* (Bryce, 1913) (Fig. 12)

Gin-su-yeom-go-ri-gwan-yun-chung (긴수염고리관윤충)

Habrotrocha torquata Bryce, 1913, p. 87, pl. 8, fig. 2.
Otostephanos torquatus: Milne, 1916, p. 173; Bartoš, 1951, p. 337, fig. 2H; Bartoš, 1959, p. 165, fig. 23D; Schulte, 1954, p. 601.
Otostephanos torquatus torquatus: Donner, 1965, p. 100, fig. 74e, f; Song and Kim, 2000, p. 96.

Body lightly stippled. Many long cilia present under rostrum radially and a long and strong one present on each side at right angles to rostrum. Rostral lamella rather big, bilobed and semicircular ventrally. Corona as wide as or somewhat wider than cingulum pad. Sulcus narrow. Upper lip rimmed and with a convex and narrow lobe medially. Disc retractor with a median notch. A fine ring present between corona and lip and heart-shaped ventrally. Antenna as long as about 2/5 of antenna segment width; lateral margins of antenna segment swollen. Anterior half of the second neck segment rather swollen all around. Pharyngeal tube shorter than trophi length. Dental for-

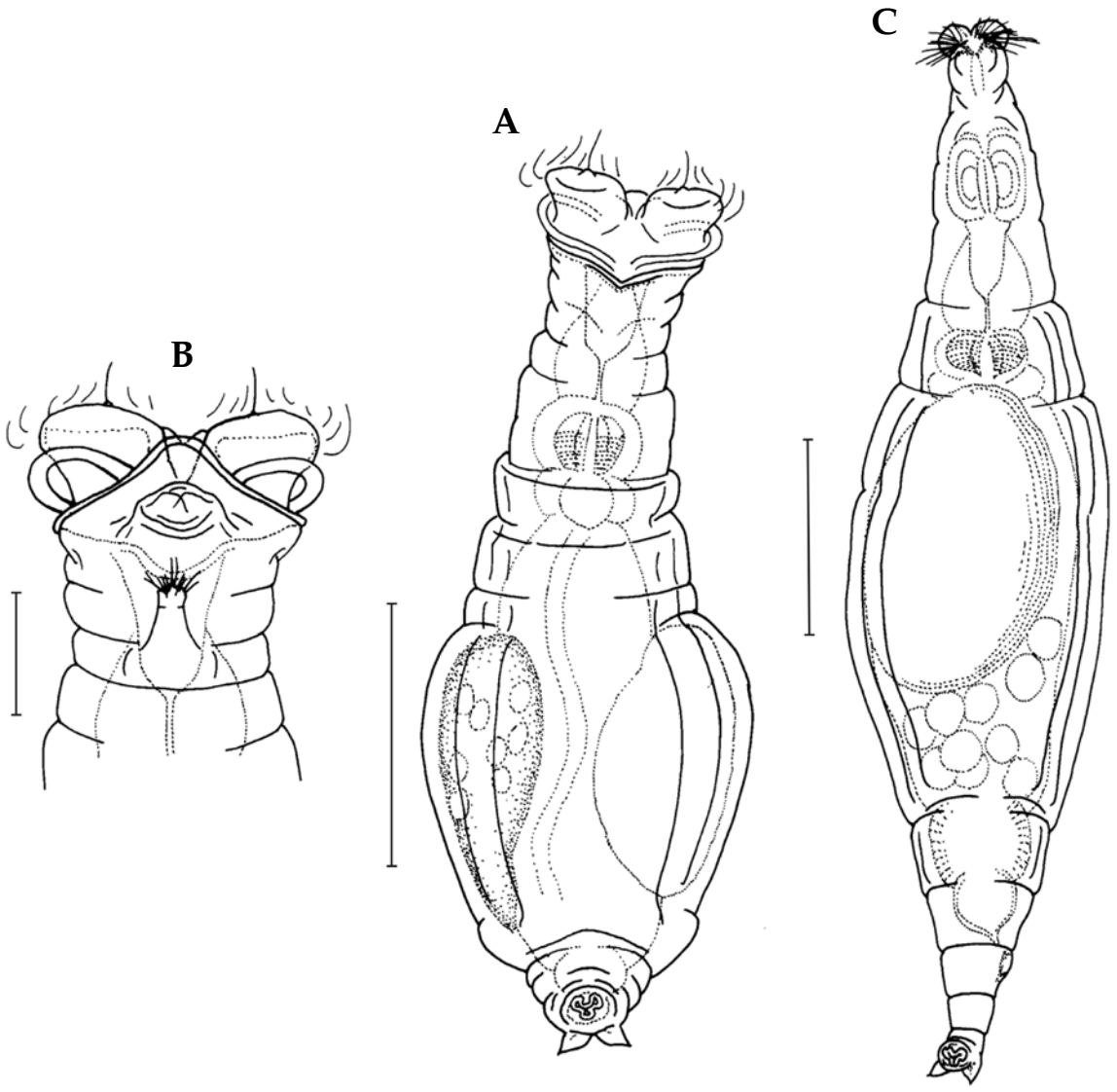

Fig. 12. *Otostephanos torquatus torquatus*. A. feeding, ventral view; B. feeding head, dorsal view; C. creeping, ventral view. Scales: A, C=50 μm, B=15 μm.

mula 7/7. Trunk spindle-shaped and with distinct longitudinal folds, of which two extend to preanal segment; lateral margins of preanal segment rather parallel and slightly constricted medially; anal segment somewhat plump anteriorly and then gradually tapering to foot. Stomach filled with rather big food pellets. Foot short with 4 pseudosegments; first segment a little swollen posterodorsally and with lateral margins slightly convex. Spurs conical and with acute apices; all lateral margins rather convex; without interspace. Three toes shorter than spurs. Egg lemon-shaped and with smooth surface.

Size (μm): Body length (in creeping) 222−260, corona width 34, cingulum pad width 31, spur length 6−7.

Distribution: USA, Great Britain, Swiss, Czech Republic, the Netherlands, Hungary, Austria,

Romania, former Soviet Union, New Zealand and Korea.

Korea: GW, CB, GB.

Specimens examined: 30 specimens (Uljin, Gyeongsangbuk-do, mosses: 21.v.1996, Y.S. Chang and K.Y. Choi); 10 specimens (Taebaeksan, Taebaek-si, Gangwon-do, mosses: 17.vii.1997); 2 specimens (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998); 2 specimens (Danyang, Chungcheongbuk-do, mosses: 17.viii.2014).

Remarks: The present species was found in large numbers from the rehydration of wet mosses together with *Habrotrocha constricta* (Dujardin, 1841) at Uljin. These two species look very alike in the general body structure and can be confused each other unless their feeding heads are observed. The present species has a fine ring between corona and cingulum, which is the diagnostic character of the genus, and of course, can not be observed in the feeding head of *H. constricta*. *Otostephanos torquatus torquatus* (Bryce, 1913) differs from *O. torquatus amoenus* Milne, 1916 mainly in that it does not have any spicules on both the sulcus base and the upper lip, and its first foot segment is swollen posterodorsally.

Song and Kim (2000) was the first Asian record of the present species, and the genus *Otostephanos* was new to the East Asian fauna.

Family Philodinidae Bryce, 1910

Seon-yun-chung-gwa (선윤충과)

Stomach with a tubular lumen. Food not formed into pellets. Corona well-developed with paired trochal discs (*Philodina* type) and mostly wider than cingulum pad. Unci with teeth medially. Upper lip mostly bilobed. Foot ending with 2–4 toes or an adhesive disc.

Genera 11 (5 in Korea).

Key to genera of family Philodinidae

1. Foot with 4 toes ····· 2
− Foot with less than 4 toes or an adhesive disc ····· 3
2. Integument soft and mostly smooth ····· *Philodina*
− Integument stiff, granulated and with cuticular spines and/or knobs ····· *Pleuretra*
3. Foot with 3 toes ····· 4
− Foot with an adhesive disc, possibly with papillae ····· *Mniobia*
4. Viviparous; eyes, when present, on rostrum; foot, spurs, toes, rostrum usually long ····· *Rotaria*
− Oviparous; eyes absent; foot short ····· *Macrotrachela*

Genus *Macrotrachela* Milne, 1886

Keun-gwan-yun-chung-sok (큰관윤충속)

Foot with 3–4 segments and 3 toes; toes usually not transformed to adhesive disc. Oviparous.

Uncus usually with 2−3 teeth. Eyes absent. Cingulum without any protuberances. Inhabiting mosses, *Sphagnum* and humus. Seldom epizoic.

Species 94 (11 in Korea).

Key to the species of genus *Macrotrachela*

1. Trunk smooth ····· 2
− Trunk with cuticular knobs or spines ····· 8
2. Rump and foot without any protuberances ····· 3
− Rump or foot with one or more protuberances ····· 4
3. Upper lip bell-shaped with thick rim; spurs long and lanceolate ····· *M. allani*
− Upper lip bilobed and with a median spicule; spurs conical and highly divergent ····· *M. latior*
4. Two horn-shaped processes present on anal segment posterodorsally ····· *M. plicata hirundinella*
− One or more processes present on first foot segment dorsally ····· 5
5. Two short and conical processes present on first foot segment ····· 6
− One or more hemispherical processes present on first foot segment ····· 7
6. Rump smooth; preanal segment without any protuberances ··· *M. quadricornifera quadricornifera*
− Rump highly granulated; preanal segment extended and forming semicircular plate with thick rim ····· *M. quadricornifera scutellata*
7. One elliptical process present on first foot segment dorsally ····· *M. habita*
− Ten hemispherical proccesses (4 + 5 + 1) present on first foot segment dorsally ····· *M. bullata*
8. Trunk covered with low and hemispherical knobs of uniform size regularly and densely ····· ····· *M. formosa*
− Trunk with many cuticular spines; spine pattern and length variable ····· 9
9. Spines short and mostly with obtuse ends like papillae ····· *M. papillosa*
− Spines sharp with variable length ····· 10
10. Spines mostly short ····· *M. multispinosa brevispinosa*
− Spines long, curved and with wide bases ····· *M. multispinosa crassispinosa*

14. *Macrotrachela allani* (Murray, 1911) (Fig. 13A−C, Pl. 7)
Jong-hyeong-ip-sul-keun-gwan-yun-chung (종형입술큰관윤충)

Callidina allani Murray, 1911c, p. 6, pl. 1, fig. 2a−c.
Macrotrachela allani: Donner, 1965, p. 154, fig. 113e, f; Song, 1999, p. 71, fig. 15a−c.

Rostrum with bilobed and large lamella. Head as long as neck. Corona wider than cingulum pad and as wide as neck segment during feeding. Upper lip bell-shaped with thick rim, and as high as trochal discs. Dental formula 2/2. Pharyngeal tube as long as trophi. Trunk cylindrical. Spurs very long, about 1.7 times as long as spur segment width, tapering gradually from base to tip, more or less abruptly narrowing near ends, slightly bent medially, and with a low shoulder-like bump at each inner proximal margin; without interspace.

Size (μm): Body length 313 (in creeping), trunk width (in creeping) 53, corona width 49, cingulum pad width 40, spur width 3.8, spur length 18, egg length along its long axis 88.

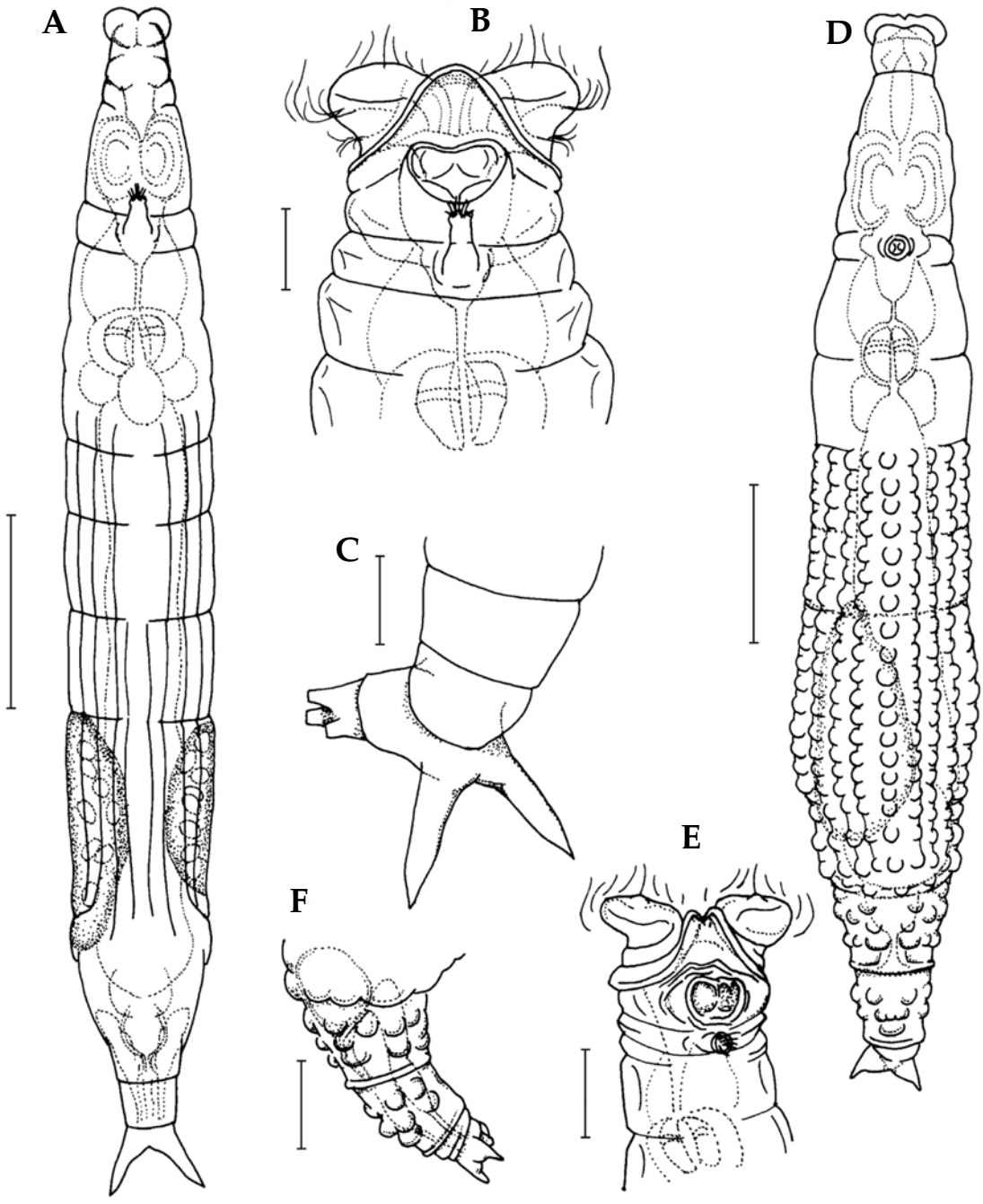

Fig. 13. *Macrotrachela allani*. A. creeping, dorsal view; B. feeding head, dorsal view; C. spurs and toes, dorso-lateral view. *Macrotrachela formosa*. D. creeping, dorsal view; E. feeding head, dorso-lateral view; F. foot and spurs, dorso-lateral view. Scales: A, D=50 μm, B=15 μm, C=10 μm, E, F=25 μm.

Distribution: East Africa, Korea.
Korea: GB.
Specimens examined: 2 specimens (Uljin, Gyeongsangbuk-do, mosses: 21.v.1997, K.Y. Choi and

Y.S. Jang).

Remarks: Numerous specimens were found from moss samples of Uljin eighty six years after Murray (1911c) described this species from a single locality in East Africa. Song (1999) reported this species from Korea, which was the second record of it.

15. *Macrotrachela bullata* (Murray, 1906) (Fig. 14A–D, Pl. 8)
Yeol-hok-keun-gwan-yun-chung (열혹큰관윤충)

Callidina habita var. *bullata* Murray, 1906a, p. 177, pl. 3, fig. 10a–d.
Callidina bullata Murray, 1911f, p. 6, pl. 2, fig. 10a–c.
Macrotrachela bullata: Donner, 1965, p. 125, fig. 92e, f; Song and Kim, 2000, p. 94, fig. 4.

Rostral lamellae wider than rostrum; each rostral lamella bilobed and inner lobes are smaller. Corona much wider than cingulum pad.Upper lip rimmed, bilobed medially and with slightly concave sides. Dental formula 2/2. Pharyngeal tube shorter than trophi. Foot with somewhat heavy and long glands, which pass through the anal segment; first foot segment with 10 prominences in 3 rows; first row of 4 identical hemispherical processes, 2 dorsal and 2 lateral; second row of 2 lateral processes which same as those of first row in shape and size, and 3 dorsal ones which stick to each other tightly and lower than lateral ones; third row of single hemispherical process which very close to median process of second row and transversely elongate a little. Spurs conical, divergent, with swollen margins and tapering rather abruptly to sharp points; without interspace.

Size (μm): Body length (in creeping) 350, corona width 68, cingulum pad width 54, trunk width (in creeping) 65, spur length 11.

Distribution: Great Britain, South Africa, India, China, Tanzania and Korea.
Korea: GW.
Specimens examined: 2 specimens (a stream in Daegwallyeong, Pyeongchang-gun, Gangwon-do, submerged mosses: 8.iii.1997); 10 specimens (Jeombongsan, Yangyang-gun, Gangwon-do, mosses: 16.xi.1997, K.S. Lee); 20 specimens (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee); 5 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee).

Remarks: After Murray (1906b) described this species from India, Wang (1974) reported it from China (Zhuge et al., 1998). Song and Kim (2000) reported this species from Korea, which was the third Asian record of this species. Recently, the present species was recorded from Italy (Fontaneto and Melone, 2003) and Tanzania (Fontaneto et al., 2007).

Murray (1906a) found this species in mosses in Great Britain and described it as an infrasubspecific variant of *Macrotrachela habita* (Bryce, 1894). Later, Murray (1911f) considered it as a complete species, *Macrotrachela bullata*. This species has the general shape shared with *M. habita* except for the number of the process on the first foot segment. According to Murray (1906a), *M. bullata* has 8 processes on the first foot segment while *M. habita* has only one. But, the Korean population has 10 processes because the second row is consisted of 5 processes instead of 3. Among the 5 processes, median 3 processes stick to each other very tightly, which might be the reason why Murray regarded them as a single transversely elliptical one (Song and Kim, 2000).

The populations of the present species were found in Daekwanryeong (wet mosses), Jeombong-

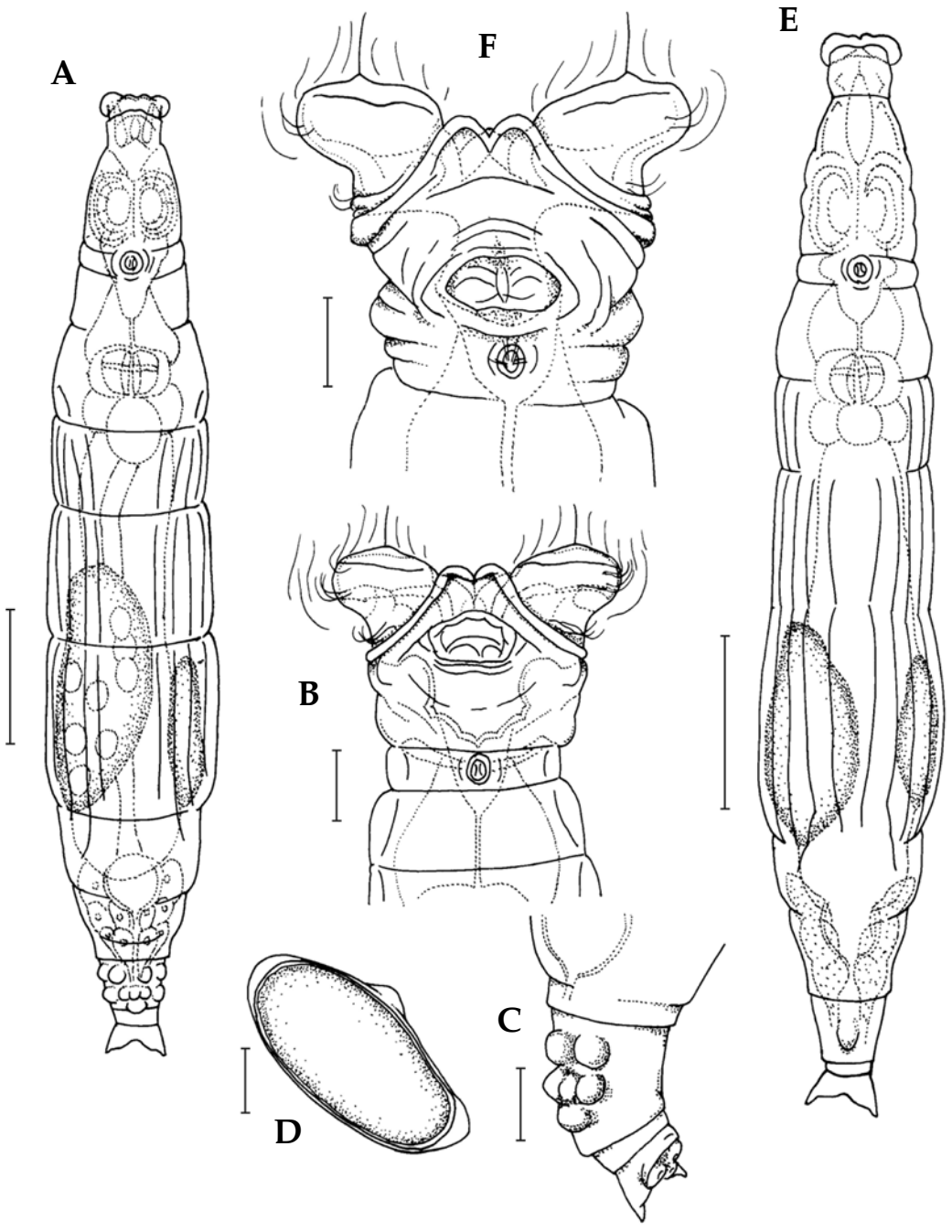

Fig. 14. *Macrotrachela bullata*. A. creeping, dorsal view; B. feeding head, dorsal view; C. foot and spurs, lateral view; D. egg. *Macrotrachela habita*. E. creeping, dorsal view; F. feeding head, dorsal view. Scales: A, E=50 μm, B, C, F=15 μm, D=25 μm.

san (mosses) and Jabyeongsan (mosses). The specimens of Jeombongsan have some characteristics different from those of the other Korean populations: (1) the Jeombongsan population has a small process on the median notch of upper lip; (2) their dental formula is 1+2/2+1 while that of the

other populations 2/2; (3) their anal segment of trunk is very swollen and bilobed posterodorsally in front of the posterior margin. This variant was also found in the mosses of Jabyeongsan together with the typical population.

16. *Macrotrachela formosa* (Murray, 1906) (Fig. 13D–F, Pl. 9A, B)
Hok-tu-seong-i-keun-gwan-yun-chung (혹투성이큰관윤충)

Callidina formosa Murray, 1906b, p. 641, pl. 18, fig. 3a, b; Murray, 1911d, p. 167, pl. 5, fig. 13.
Macrotrachela formosa: Donner, 1965, p. 113, fig. 85d; Song and Kim, 2000, p. 96.

Head and neck with smooth surface. Rostrum rather short. Rostral lamella wider than rostrum, slightly notched medially and somewhat flat terminally; each lobe a little depressed at 1/3 of anterior margin from median notch, making rostral lamella of tetralobed appearance. Upper lip rimmed and with bilobed median lobe higher than sulcus base; with slightly concave sides. Corona wider than cingulum pad. Dental formula 2/2. Antenna length about half antenna segment width. Trunk with low and hemispherical processes of uniform size, regularly and densely arranged on longitudinal ridges; warts on anal segment bigger and more prominent; anal segment tapering rather abruptly to its cuff-like last quarter. Foot with four pseudosegments and three toes; toes shorter than spurs. First foot segment with 10 prominences in three rows; first row of four equal hemispherical processes, two dorsal and two lateral; second row of two lateral processes and three closely spaced dorsal ones (median one most flattest); third row of single semispherical process located very close to median process of second row and slightly elongate transversely. Spurs conical, divergent, with swollen margins and tapering rather abruptly to sharp points; without interspace.

Size (μm): Body length (in creeping) 313–331, trunk width (in creeping) 57–60, corona width 55, spur length 10.

Distribution: Brazil, Bolivia, East and South Africa, India, Java, Australia and Korea.

Korea: GW.

Specimens examined: 4 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee).

Remarks: The characteristics of the Korean population agree well with the original description except the prominences on the first foot segment: type specimens had 11 processes (4+4+3) while the Korean population 10 (4+5+1) like *M. bullata*. The extent of protrusion of warts on trunk seemed to be variable. Some specimens had very low warts, which make these specimens very similar to the Jeombongsan and Jabyeongsan varients of *M. bullata*. The presence of the intermediate form may suggest that *M. formosa* and *M. bullata* are two extreme varieties of one species because the general body structure, shapes of corona, rostral lamella, spurs and egg, and the 10 prominences on the first foot segment of these two species are identical. Further studies should be carried out with these two species to make it clear whether these are distinctly separate species or not, although they are treated as separate species currently.

Murray (1911d, e) suggested that the present species seemed to prefer warm climates because it has been reported from the tropical and subtropical regions like India (Murray, 1906b), Africa (Murray, 1911c, f), and Australia (Murray, 1911d). Murray (1913) also reported this species from Brazil

and Bolivia, and Bartoš (1963) from Java, which seemed to support Murray's opinion. Song and Kim (2000) reported the present species from Korea, which was the first East Asian record. Since Korea is located in the temperate region, it would be necessary to amend Murray's opinion that this species might be warm-stenothermic.

17. *Macrotrachela habita* (Bryce, 1894) (Fig. 14E, F)
Il-hok-keun-gwan-yun-chung (일혹큰관윤충)

Callidina habita Bryce, 1894, p. 451, pl. 24, fig. 5.
Macrotrachela habita: de Koning, 1929, p. 76, fig. 25; Bartoš, 1951, p. 372, fig. 36A, B, E, F, H; Donner, 1965, p. 131, fig. 97a–g; Koste, 1996b, p. 250, fig. 12a, b; Song and Kim, 2000, p. 96.

Rostrum rather short and small. Rostral lamella with median notch, somewhat flat terminally and wide laterally; its width about 1.3 times as wide as rostrum; each lobe a little depressed at 1/3 of anterior margin from median notch, which making rostral lamella look tetralobed. Corona much wider than cingulum pad. Upper lip rimmed, bilobed medially and with slightly concave sides. Creeping head as long as or longer than neck. Antenna short and its length about 1/3 of antenna segment width. Pharyngeal tube as long as or shorter than trophi. Dental formula 2/2. Both lateral parts of trunk very hyaline. Anal segment tapering rather abruptly to its cuff-like last quarter. Foot with 4 pseudosegments, 3 toes and somewhat heavy and long glands; pedal glands passing through anal segment; toes shorter than spurs; first foot segment with a rather big and elliptical process at posterodorsal area. Spurs conical, divergent, with swollen margins and tapering rather abruptly to acute apices; without interspace.

Size (μm): Body length (in creeping) 312, corona width 66, cingulum pad width 51.

Distribution: Cosmopolitan.

Korea: GW.

Specimens examined: 3 specimens (Daegwallyeong, Pyeongchang-gun, Gangwon-do, submerged mosses from a stream: 8.iii.1997); 2 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee); 1 specimen (Gariwangsan, Pyeongchang-gun, Gangwon-do, mosses), 27.v.1998 (K.S. Lee).

Remarks: Despite the many records, the distinction of *M. habita* from *M. insolita* is not clear (Donner, 1965). The most prominent difference between *M. habita* and *M. insolita* is the ratio of corona width to cingulum pad width. In *M. habita*, corona is much wider than cingulum pad, while in *M. insolita*, corona is a little bit wider, or as wide as cingulum pad.

Donner (1970b) recorded some specimens as *M. habita-insolita* in his report of the Spanish rotifers.

The Korean populations were identified as *M. habita* because their coronas were much wider than cingulum pads. Further genetic studies might be necessary with these two species to make it clear whether these are distinctly separate species or not.

Even though the present species is cosmopolitan, it has been reported only from India (Murray, 1906b), Indonesia (Bartoš, 1963) and Korea (Song and Kim, 2000) in Asia.

18. *Macrotrachela latior* Donner, 1951 (Fig. 15A−D, Pl. 9C−E)
Il-chim-ip-sul-keun-gwan-yun-chung (일침입술큰관윤충)

Macrotrachela latior Donner, 1951, p. 625, fig. 11a, b; Donner, 1965, p. 137, fig. 101a−j; Donner, 1971, p. 369, fig. 3d, e; Song and Kim, 2000, p. 94, fig. 3.

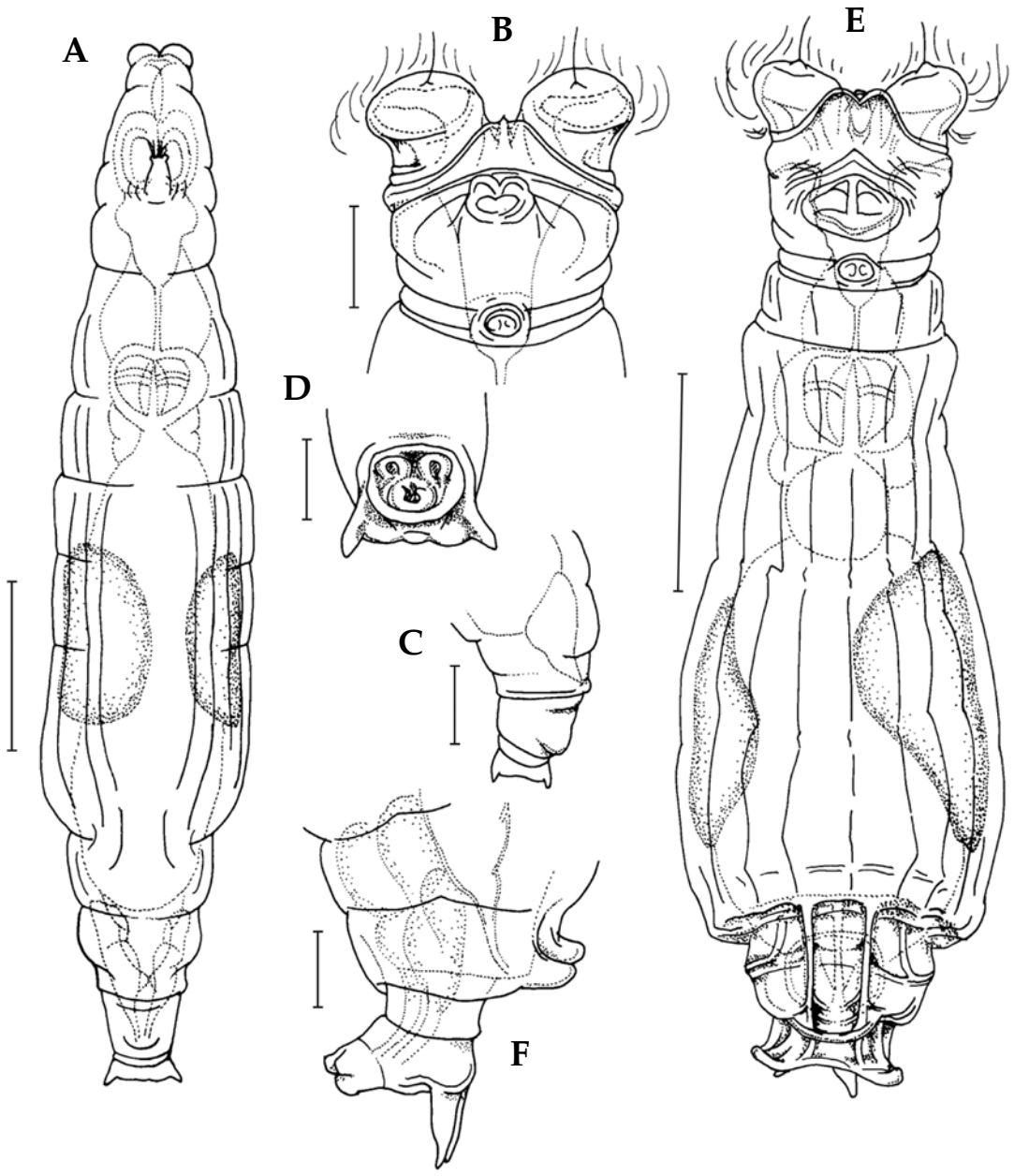

Fig. 15. *Macrotrachela latior*. A. creeping, dorsal view; B. feeding head, dorsal view; C. foot and spurs, dorsolateral view; D. spurs and toes, ventral view. *Macrotrachela plicata hirundinella*. E. feeding, dorsal view; F. foot and spurs, lateral view. Scales: A, E=50 μm, B=15 μm, C=20 μm, D, F=10 μm.

Rostrum rather short. Rostral lamella rather big and bilobed; each lobe semicircular. Corona rather wider than cingulum pad. Sulcus wide and deep. Upper lip with narrow and convex median lobe; anterior margin of median lobe bilobed and with a small and sharp spicule medially. Antenna short. Pharyngeal tube as long as trophi length. Dental formula 3/3. Trunk spindle-shaped in creeping; preanal and anal segment plump laterally and dorsally; posterior part of anal segment cylindrical and much narrower than anterior part. Foot with 3 pseudosegments; first segment with a low hump posterodorsally; ending with 3 short toes. Spurs short and conical; with straight outer margins, convex inner margins and very narrow tips; spurs highly divergent and with rather flat and narrow intrespace, which can be seen like a trilobed interspace with a very small spur at each side.

Size (μm): Body length (in creeping) 258, trunk width (in creeping) 51, corona width 39, cingulum pad width 34, spur length 6.

Distribution: Austria, Hungary, Belgium, Romania, Jordan and Korea.

Korea: GW.

Specimens examined: 1 specimen (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 14.vii.1998).

Remarks: Donner (1951) had described this species from Austria and since then, he reported it from Austria, Hungary, Belgium, Rumania and Jordan (Donner, 1965, 1971). The report of the present species by Song and Kim (2000) was the first one outside Europe and Western Asia.

The general morphology of the Korean specimen conforms with the description of the Austrian population except that it has a low hump on the first foot pseudosegment posterodorsally.

The present species has been found mostly from soils, and in Korea, it was found from a temporary rain pool.

19. *Macrotrachela multispinosa crassispinosa* (Murray, 1907) (Fig. 16A, B, Pl. 10A, B)

Gulg-eun-ga-si-da-geuk-keun-gwan-yun-chung (굵은가시다극큰관윤충)

Callidina multispinosa var. *crassispinosa* Murray, 1907, p. 99, fig. 4.
Macrotrachela multispinosa var. *crassispinosa*: Bartoš, 1951, p. 382, fig. 39D.
Macrotrachela multispinosa crassispinosa: Bartoš, 1959, p. 248, figs. 41D, 57CH; Donner, 1965, p. 113, fig. 84d, e; Song and Kim, 1996b, p. 353, fig. 2d; Song and Kim, 2000, p. 96.

Rostrum small and its width about 1/3 of antenna pseudosegment. Corona narrower than cingulum pad. Dental formula 5/5. Integument stiff and highly granulated. Trunk with many cuticular spines at margins of trunk pseudosegments; spines long, curved and with wide bases; first trunk segment with 2 long spines at each anterolateral corner; second segment with 2 short and 2 long spines laterally; third segment with a transverse row of 10 short spines at anterodorsal area and 4 short ones at each posterolateral margin; fourth segment with 2 short spines at each posterolateral margin and 2–3 short ones on posterodorsal area; preanal segment with 5 short spines at posterodorsal margin and 3 short ones forming a triangle on dorsal area; anal segment with 2 spines at each posterolateral margin and one pair of knobby projection dorsally. Foot with 4 pseudoseg-

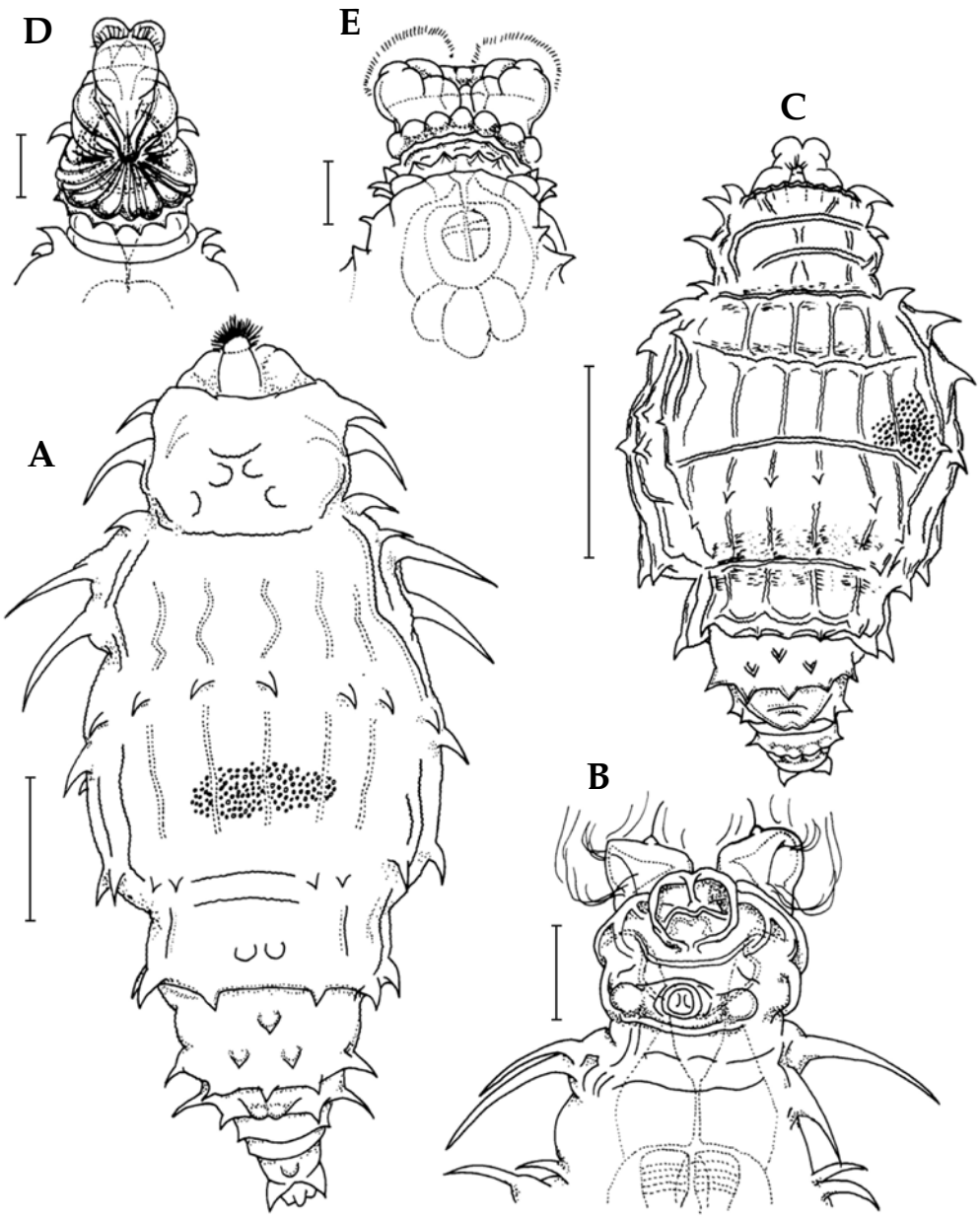

Fig. 16. *Macrotrachela multispinosa crassispinosa*. A. creeping, dorsal view; B. feeding head, dorsal view. *Macrotrachela multispinosa brevispinosa*. C. creeping, dorsal view; D. creeping head and neck, ventral view; E. feeding head, ventral view. Scales: A=25 μm, C=50 μm, B, D, E=15 μm.

ments; posterolateral corners of the first foot pseudosegment acute; one small projection on the third segment dorsally. Spurs conical and acute; margins concave; interspace very narrow.

Size (μm): Body length (in creeping) 212−243, trunk length (in creeping) 125−143, trunk width (in creeping) 63−70, corona width 31, cingulum pad width 34.

Distribution: British Guiana, Czech Republic, Spain, Rhodes (Aegean Sea), Korea.

Korea: GW.

Specimens examined: 10 specimens (Taebaeksan, Taebaek-si, Gangwon-do, mosses: 17.vii.1997); 10 specimens (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee); 4 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee); 1 specimen (Wangsan-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998); 1 specimen (Donghae-si, Gangwon-do, wet mosses: 19.iv.1998, K.S. Chung); 1 specimen (Gariwangsan, Pyeongchang-gun, Gangwon-do, mosses: 27.v.1998, K.S. Lee).

Remarks: Three subspecies are recognized in the species *M. multispinosa*: *brevispinosa* Murray, *crassispinosa* Murray and *flagellata* Bartoš. *M. multispinosa crassispinosa* is distinguished from the other subspecies by its long and rather wide spines with broad bases. Spine pattern is somewhat variable both between and within subspecies (Song and Kim, 1996b). The specimens from the mosses of Jabyeongsan have many ventral transverse striae rather prominent like those of *Pleuretra* species, which have never been reported in previous records.

Song and Kim (1996b) was the first Asian record of the present subspecies.

20. *Macrotrachela multispinosa brevispinosa* (Murray, 1908) (Fig. 16C–E)

Jjalb-eun-ga-si-da-geuk-keun-gwan-yun-chung (짧은가시다극큰관윤충)

Callidina multispinosa var. *brevispinosa* Murray, 1908b, p. 666, pl. 15, figs. 1–4.
Macrotrachela multispinosa var. *brevispinosa*: Bartoš, 1951, p. 382, fig. 39E, F.
Macrotrachela multispinosa brevispinosa: Donner, 1965, p. 113, fig. 84a, b; Song and Kim, 2000, p. 96.

Integument stiff and granulated. Rostrum short and rather circular ventrally. Rostral lamella bilobed and wider than rostrum; each lobe semicircular. Skin folds over withdrawn corona forming a rosette ventrally. Corona wider than cingulum pad. Upper lip rather high and with shallow median notch. Necklet of hemispherical processes present beneath lower lip and second necklet of short spines under antenna segment. Dental formula 2/2. Trunk with short cuticular spines laterally anterior to rump and more than 10 transverse striae ventrally; third segment with a transverse row of 10 short spines dorsally. Rump and foot with many short spines laterally, dorsally and posteriorly in the same pattern as in *M. multispinosa crassispinosa*; anal pseudosegment with a big round, flat, and bilobed projection dorsally. Three toes short. Spurs short, conical, curved inward and with narrow interspace.

Size (μm): Body length (in creeping) 221, trunk width (in creeping) 76, cingulum pad width 41.

Distribution: Probably cosmopolitan.

Korea: GW.

Specimens examined: 5 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee); 1 specimen (Eoseongjeon, Yangyang-gun, Gangwon-do, bed sediment from a stream: 6.ix. 1998).

Remarks: The present subspecies is distinguished from the other subspecies of *M. multispinosa* by its very short spines on trunk. Its spine pattern on trunk is rather similar to that of *M. multispinosa crassispinosa*.

In Asia, this subspecies has been reported from India (Murray, 1906b) and Java (Bartoš, 1963) before Song and Kim (2000), which was the first East Asian record of it.

21. *Macrotrachela papillosa* Thompson, 1892 (Fig. 17A, B, Pl. 10C)
Yu-du-dol-gi-keun-gwan-yun-chung (유두돌기큰관윤충)

Macrotrachela papillosa Thompson, 1892, p. 60, figs. 30–33; de Koning, 1929, p. 102, fig. 29; Bartoš, 1951, p. 377, fig. 38A–C, E–G; Bartoš, 1959, p. 242, fig. 40F–H, K–M; Donner, 1965, p. 115, fig.

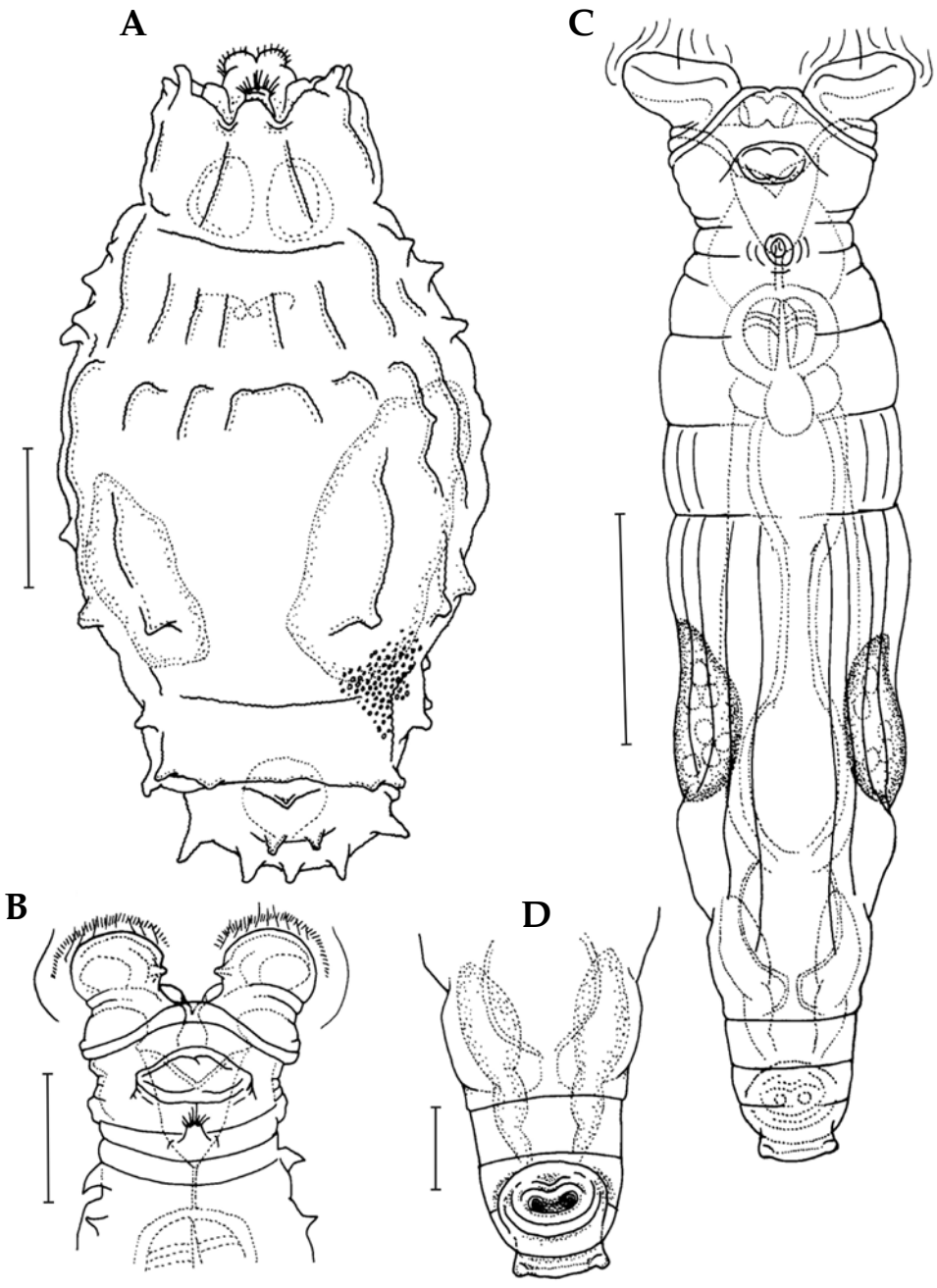

Fig. 17. *Macrotrachela papillosa*. A. creeping trunk, dorsal view; B. feeding head, dorsal view. *Mniobia obtusicornis*. C. feeding, dorsal view; D. foot and spurs, ventral view. Scales: A, B=25 μm, C=50 μm, D=15 μm.

86a–e; Song and Kim, 1996b, p. 353, fig. 2a–c; Song and Kim, 2000, p. 96.
Callidina papillosa: Janson, 1893, p. 66, pl. 4, figs. 56, 57; Murray, 1911e, p. 289, pl. 6, fig. 5a–c.

Integument rather stiff and highly granulated. Rostrum lamella bilobed, rather big and semicircular. Corona wider than cingulum pad. Trochal disc circular in a dorsal view. Pedicel rather long, about 2 times as high as upper lip, and with plump base. Sulcus wide and with a small projection on each margin. Upper lip arched and rimmed. Dental formula 2/2+1. One posteriorly curved short spine present at each anterolateral corner of last neck pseudosegment. Trunk with 10 prominent longitudinal ridges dorsally and with many small papillae at dorsal and/or lateral margins of trunk pseudosegments; preanal segment with 5 papillae at posterodorsal margin and 3 small ones forming a triangle dorsally; anal segment with a pair of small papilla dorsally. Foot hightly granulated, with 4 pseudosegments and 3 toes. Spurs conical, rather swollen all around, and with sharp tips; interspace flat and as wide as spur base.
Size (μm): Trunk length (in creeping) 108–153, trunk width (in creeping) 50–101, corona width 48–66, spur length 4.

Distribution: Cosmopolitan.
Korea: GW, GB.
Specimens examined: 3 specimens (Taebaeksan, Taebaek-si, Gangwon-do, mosses: 17.vii.1997); 1 specimen (Jeombongsan, Yangyang-gun, Gangwon-do, mosses: 11.xi.1997, K.S. Lee); 15 specimens (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee); 3 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee); 2 specimens (Gariwangsan, Pyeongchang-gun, Gangwon-do, mosses: 27.v.1998, K.S. Lee).
Remarks: In Asia, this species has been reported from India (Murray, 1906b), China (Bartoš, 1963) and Korea (Song and Kim, 1996b, 2000). The population of Jabyeongsan has about 10 prominent transverse striae ventrally. De Ridder (1972) also recognized and illustrated these ventral striae in her report of the Icelandic Rotifera.

22. *Macrotrachela plicata hirundinella* (Murray, 1908) (Fig. 15E, F, Pl. 11)
Je-bi-kko-ri-heo-ri-ju-reum-keun-gwan-yun-chung (제비꼬리허리주름큰관윤충)

Callidina plicata var. *hirundinella* Murray, 1908a, p. 197, pl. 2, figs. 16–18.
Macrotrachela plicata var. *hirundinella*: De Ridder, 1972, p. 8, pl. 1, fig. 2.
Macrotrachela plicata hirundinella: Bartoš, 1951, p. 366, fig. 34G; Donner, 1965, p. 144, fig. 105; Bateman and Davis, 1980, p. 135, fig. 6; Song and Kim, 2000, p. 96.

Corona wider than cingulum pad. Base of sensory hair on trochal disc rather big. Upper lip rimmed and with high median lobe, which bilobed and with a small obtuse process on median notch. Pharyngeal tube shorter than trophi length. Dental formula 2/2. Trunk slightly granulated and with lateral margins rather parallel during creeping; posterodorsal part of anal segment extended to form two horn-shaped processes which protrude dorsally, diverge from each other, with obtuse ends and are somewhat shorter than the spurs. Spurs conical with obtuse ends and plump inner proximal margins; interspace very narrow. Foot with 4 pseudosegments and ending with 3 toes.

Size (μm): Body length (in feeding) 217, trunk width (in feeding) 73, corona width 49, cingulum pad width 43, spur length 11.

Distribution: Canada, Iceland, Great Britain, Ireland, Spitsbergen, Czech Republic, Poland, Germany, Austria, Romania and Korea.

Korea: GW.

Specimens examined: 5 specimens (Taebaeksan, Taebaek-si, Gangwon-do, mosses: 17.vii.1997).

Remarks: This subspecies has the general morphology of *M. plicata* (Bryce, 1892) except for a pair of dorsolateral appendages on anal segment of trunk. Murray (1908a) described that these appendages were sometimes considerably longer than the foot and certainly yielded readily at the bases and assumed many different positions, but he had no evidence that they were movable at will. Those of the Korean population seem to be shorter than those of the type sepcimens. They are a little longer than spurs and have never been observed in different positions. Bateman and Davis (1980) reported the present subspecies from a mesotrophic fen in Newfoundland and discussed on the variations in the shape and size of these processes. The appendages of the Newfoundland population are most similar to those of the Korean population.

Song and Kim (2000) reported the present subspecies for the first time in Asia.

23. *Macrotrachela quadricornifera quadricornifera* Milne, 1886 (Fig. 18A, B, Pl. 10D)

Ne-ppul-keun-gwan-yun-chung (네뿔큰관윤충)

Macrotrachela quadricornifera Milne, 1886, p. 139, pl. 1, fig. 4 (cited from Bartoš, 1959).

Macrotrachela quadricornifera quadricornifera: Bartoš, 1951, p. 362, fig. 33A, B, F, H, J; Bartoš, 1959, p. 228, fig. 38A, B, F, H, I; Donner, 1965, p. 116, fig. 87a–d; Donner, 1970a, p. 244, fig. 22; Donner, 1980, p. 137, fig. 5b, c; Haigh, 1966, p. 199, fig. 2l, m; Song and Kim, 1996a, p. 54, fig. 1e–h; Song and Kim, 2000, p. 96.

Callidina quadricornifera: Hudson and Gosse, 1889, p. 10.

Corona wider than cingulum pad. Upper lip slightly concave laterally and trilobed medially. Sulcus wide, about 1/2 of trochal disc width. Disc retractor U-shaped and with convex sides. Dorsal antenna 2-segmented and long. Dental formula 2+1/1+2. Pharyngeal tube shorter than trophi length. Trunk slightly broader than cingulum pad, yellowish to brown, and with smooth integument. Foot with 3 toes; with 2 short, blunt and conical processes on first pseudosegment dorsally. Spurs longer than the processes on foot; outer margins slightly convex and inner margins plump proximally; interspace narrower than spur base width. Egg lemon-shaped, with a small bump at each pole, and with smooth surface.

Size (μm): Body length (in creeping) 310–443, trunk width (in creeping) 90–114, corona width (in animal 443 μm long) 83, cingulum pad width 71, spur length 12–15.

Distribution: Cosmopolitan.

Korea: GW, JJ.

Specimens examined: 2 specimens (Chilseongsan, Gujeong-myeon, Gangneung-si, Gangwon-

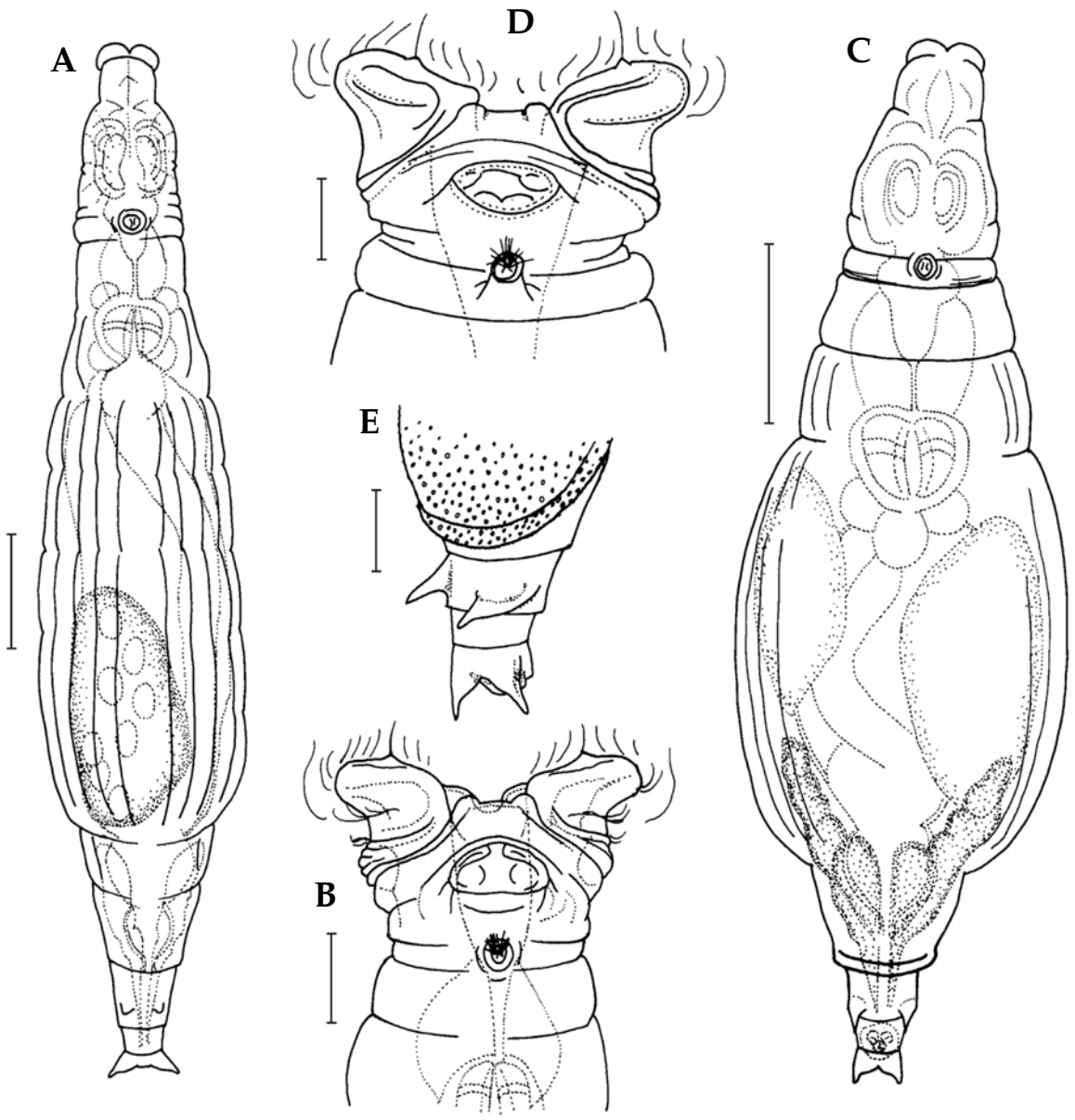

Fig. 18. *Macrotrachela quadricornifera quadricornifera*. A. creeping, dorsal view; B. feeding head, dorsal view. *Macrotrachela quadricornifera scutellata*. C. creeping, dorsal view; D. feeding head, dorsal view; E. foot and spurs, dorso-lateral view. Scales: A, C=50 μm, B=25 μm, D, E=15 μm.

do, wet leaf litter: 11.v.1997); 1 specimen (Jeombongsan, Yangyang-gun, Gangwon-do, mosses: 11. xi.1997, K.S. Lee); 1 specimen (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 13.vii.1998); 1 specimen (Saryeoni forest, mushrooms on a tree trunk: 4.vii.2014).

Remarks: Even though this species is cosmopolitan and has been found from various freshwater and terrestrial habitats, its record from Korea by Song and Kim (1996a) was the first one in Asia. Recently, it was recorded from Iran by Khoei et al. (2011).

24. *Macrotrachela quadricornifera scutellata* Schulte, 1954 (Fig. 18C–E, Pl. 12)

Bang-pae-kko-ri-ne-ppul-keun-gwan-yun-chung (방패꼬리네뿔큰관윤충)

Macrotrachela quadricornifera var. *scutellata* Schulte, 1954, p. 605, fig. 31.
Macrotrachela quadricornifera scutellata: Donner, 1965, p. 119, fig. 88a–d; Song and Kim, 1996a, p. 56, fig. 1a–d; Song and Kim, 2000, p. 96.

Rostrum short. Rostral lamella as wide as rostrum. Corona wider than cingulum pad. Upper lip arched, concave laterally and trilobed medially; lower than trochal discs. Sulcus wide, about 3/5 of trochal disc width. Pharyngeal tube shorter than trophi length. Dorsal antenna 2-segmented and long. Dental formula 2+1/1+2. Trunk finely granulated; posterodorsal part of preanal pseudosegment extended and forming highly granulated semicircular plate with thick rim. Foot with tree toes; with 2 sharp, long and conical processes on first psedosegment dorsally. Outer margins of spurs convex and inner margins swollen proximally; without interspace. Egg elliptical and with smooth surface.

Size (μm): Body length (in creeping) 240–287, trunk width (in creeping) 83–96, corona width (in animal 287 μm long) 64, cingulum pad width (in animal 287 μm long) 56, spur length 10–12.

Distribution: Australia, Brazil, Germany, Spain, New Zealand and Korea.
Korea: GW.
Specimens examined: 1 specimen (Daegwallyeong, Pyeongchang-gun, Gangwon-do, wet mosses: 8.iii.1997); 2 specimens (Chilseongsan, Gujeong-myeon, Gangneung-si, Gangwon-do, wet leaf litter: 11.v.1997); 1 specimen (Wangsan-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998); 2 specimens (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, wet leaf litter from a stream and wet mosses: 25.iii.1998); 5 specimens (Gariwangsan, Pyeongchang-gun, Gangwon-do, mosses: 27.v.1998, K.S. Lee).
Remarks: This subspecies is apparently different from *M. quadricornifera quadricornifera* in many characteristics, such as the state of integument surface, shape and size of spurs and processes on the first foot segment, and egg shape (see each description above). These two subspecies are occasionally found simultaneously. This conflicts with the subspecies definition, but bdelloids reproduce exclusively by parthenogenesis and the standard biological meaning of 'species' cannot be applied. Ricci (1987) recorded the distribution of *M. quadricornifera* and its six subspecies (*M. q. ligulata* Berzins, *M. q. loricata* Donner, *M. q. rigida* Milne, *M. q. quadricorniferoides* Bryce, *M. q. scutellata* Schulte, and *M. q. vanoyei* Schepens). According to her, none of these is limited to any particular region or habitat, except *M. quadricornifera vanoyei* which has been reported only from Belgium. Further studies should be carried out with populations of these subspecies to distinguish them on the parameters other than morphological ones (Song and Kim, 1996a).

Song and Kim (1996a) reported the present subspecies for the first time in Asia.

Genus *Mniobia* Bryce, 1910

Heup-ban-yun-chung-sok (흡반윤충속)

Foot ending with an adhesive disc or 2 stumpy papillae instead of toes. Rostrum mostly short and plump. Eyes absent. Foot short with 3 or 4 pseudosegments. Spurs usually short. Oviparous. Mostly living in mosses and humus.

Species 49 (3 in Korea).

Key to the species of genus *Mniobia*

1. Last foot segment swollen anteriorly like thick circular disc ····· *M. obtusicornis*
− Last foot segment otherwise ····· 2
2. Body except head and neck covered with very large cuticular granules. Dental formula 9/9 ····· ····· *M. scarlatina*
− Body rather smooth and only foot and spurs granulated. Dental formula 7/7 ····· *M. russeola*

25. *Mniobia obtusicornis* Murray, 1911 (Fig. 17C, D, Pl. 13A, B)

Bu-chae-dwit-bal-top-heup-ban-yun-chung (부채뒷발톱흡반윤충)

Mniobia obtusicornis Murray, 1911e, p. 291, pl. 8, fig. 13a–d; Burger, 1948, p. 131, fig. 19e; Bartoš, 1951, p. 454, fig. 61F, H, M; Bartoš, 1959, p. 283, fig. 50C, D, G, H; Schulte, 1954, p. 609; Donner, 1965, p. 238, fig. 176g–i, l, m; Haigh, 1971, p. 21, fig. 3F; Song and Kim, 2000, p. 96.

Corona much wider than cingulum pad. Upper lip arched, bilobed medially and with concave sides. Sulcus very wide; base slightly bilobed and with a small process medially. Cingulum pad much wider than antenna pseudosegment. Rostum very short and circular ventrally. Rostral lamella slightly wider than rostrum, bilobed and with a median notch; each lobe big. Pharyngeal tube shorter than trophi length. Dental formula 3/3. Trunk with lateral margins rather parallel during creeping. Foot with 4 pseudosegments; last segment swollen proximally like thick circular disc and ending with 2 short papillae. Spurs very small and papilla-shaped, very divergent and with wide and convex interspace; spur base present on posterodorsal margin of third foot segment and extended considerably from foot, making spurs look like a trapezoid plate with a trilobed base.

Size (μm): Body length (in creeping) 220, corona width 75, cingulum pad width 54, spur width 19, spur length 8.

Distribution: Canada, USA, Czech Republic, Germany, Austria, New Zealand and Korea.

Korea: GW.

Specimens examined: 1 specimen (Taebaeksan, Taebaek-si, Gangwon-do, mosses and lichens: 17.vii.1997).

Remarks: The present species was rather rare and had been reported from only 6 countries including its type locality before Song and Kim (2000) reported this species for the first time in Asia. Genus *Mniobia* was new to the Korean fauna as well.

The Korean specimen differs from Murray's specimens from Canada as follows: (1) The foot of the Canadian population is ending with an adhesive disc, while that of the Korean specimen with two short papillae; (2) Body length of the Korean specimen is about half of the Canadian population; (3) The sulcus of the Canadian population is rather flat, while that of the Korean specimen has a small process medially. Haigh (1971) recognized a process on the median notch of the upper lip in the specimens of New Zealand and described it as 'a tiny ligule covering the small notch in the upper lip' in his report of a variety of this species.

The present species is most similar to *M. obtusicalcar* de Koning, 1947 except the morphological differences in the upper lip and spurs: (1) The present species has bilobed upper lip while that of *M. obtusicalcar* is arched without median notch, and (2) The spurs of the present species are very small and divergent with very wide interspace, while those of *M. obtusicalcar* are not small, rather parallel each other and with interspace as wide as or narrower than spur base.

This species has been found mostly from mosses and rarely from soil and lichens. The Korean specimen was also found from mosses.

26. *Mniobia russeola* (Zelinka, 1891) (Fig. 19A, B)

Gal-saek-heup-ban-yun-chung (갈색흡반윤충)

Callidina russeola Zelinka, 1891, p. 2, pls. 1–4, figs. 1–72 (cited from Harring, 1913); Bryce, 1894, p. 445.

Mniobia russeola (Zelinka, 1891) Bryce, 1910, p. 77; de Koning, 1929, p. 106, fig. 40; Bartoš, 1951, p. 453, fig. 58E, F, CH; Bartoš, 1959, p. 282, fig. 51CH, J, M; Donner, 1965, p. 256, figs. 1d, 190a–e; Donner, 1970b, p. 529, fig. 9g, h; Haigh, 1968, p. 37, fig. 2A–D; Song and Kim, 2000, p. 96.

Rostrum short. Two rostral lamellae semicircular, far apart each other and located anterolateral corners of rostrum; interspace slightly bilobed. Corona much wider than cingulum pad. Sulcus very wide and as wide as diameter of trochal disc. Pharyngeal tube as long as trophi. Dental formula 8/8. Trunk stout and with smooth or very finely stippled integument; rump rather plump laterally and dorsally. Foot short with 4 pseudosegments, rather smooth and ending with an adhesive disc. Spurs bluntly conical and granulated; interspace as wide as spur base.

Size (μm): Body length (in creeping) 614, trunk width (in creeping) 100, spur length 14.

Distribution: Probably cosmopolitan.

Korea: GW.

Specimens examined: 30 specimens (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, dry detritus: 12.x.1995); 50 specimens (Gariwangsan, Pyeongchang-gun, Gangwon-do, mosses: 27.v.1998, K.S. Lee).

Remarks: Even though the present species is cosmopolitan, it was reported from Asia for the first time by Song and Kim (2000).

This species is rather similar to *M. scarlatina* (Ehrenberg, 1853) in the general body morphology. However, it is distinguished from the latter by the following characteristics: (1) The trunk is not granulated in *M. russeola*, while highly and coarsely granulated in *M. scarlatina*, (2) The dental formula is 8/8 in *M. russeola*, while 9/9 in *M. scarlatina*, and (3) The disc retractor is trilobed in *M. russeola* while bilobed with U-shaped median depression in *M. scarlatina*.

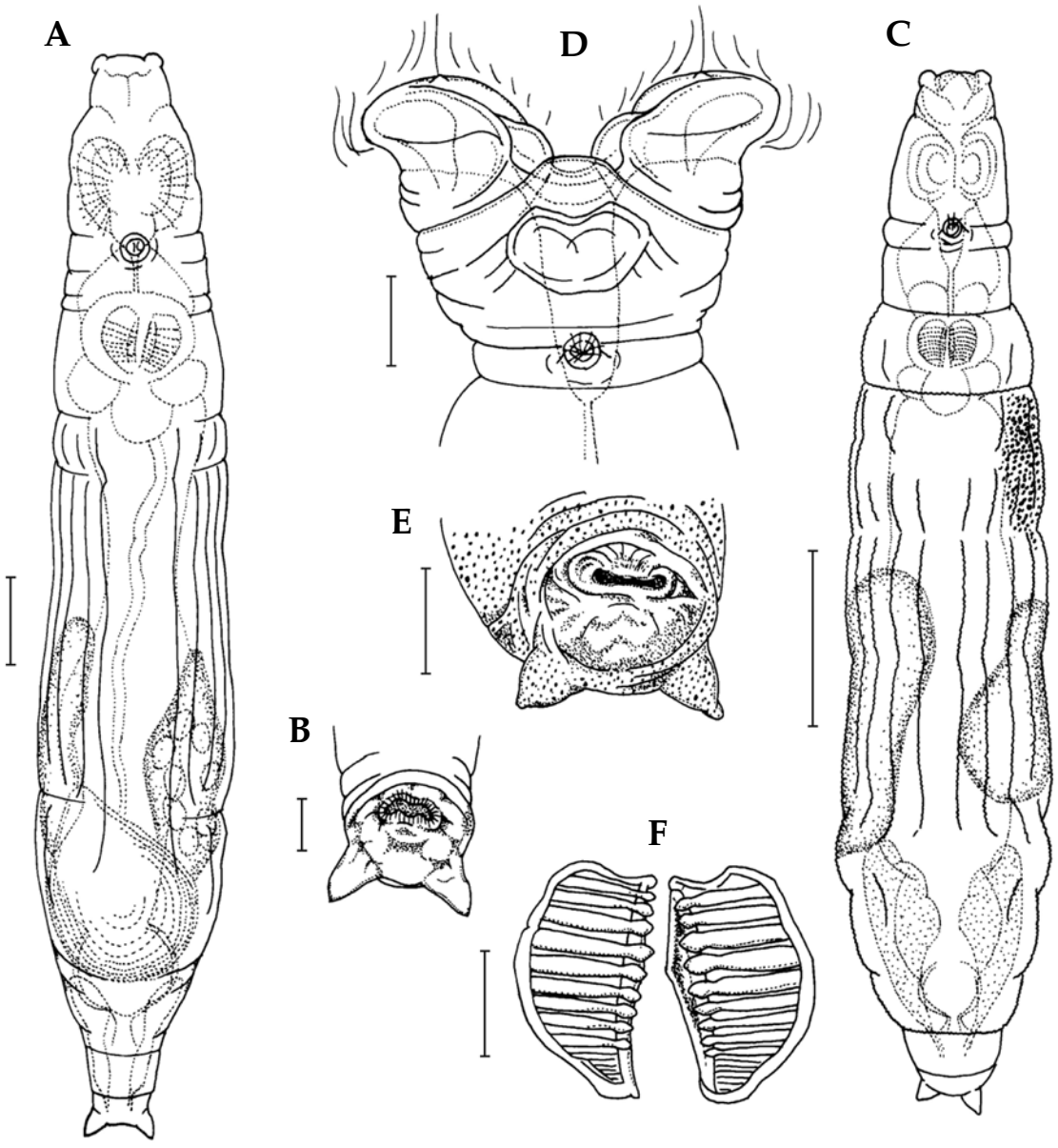

Fig. 19. *Mniobia russeola*. A. creeping, dorsal view; B. spurs and adhesive disc, ventral view. *Mniobia scarlatina*. C. creeping, dorsal view; D. feeding head, dorsal view; E. spurs and adhesive disc, ventral view; F. trophi. Scales: A=100 μm, B=15 μm, C=50 μm, D=25 μm, E=20 μm, F=10 μm.

27. *Mniobia scarlatina* (Ehrenberg, 1853) (Fig. 19C−F, Pl. 13C, D)

Jo-myeon-heup-ban-yun-chung (조면흡반윤충)

Callidina scarlatina Ehrenberg, 1853, p. 529 (cited from Harring, 1913).

Mniobia scarlatina: Bryce, 1910, p. 77; Bartoš, 1951, p. 449, figs. 1C, F, 3L, 5K, 58A; Bartoš, 1959, p. 278, fig. 49A−D; Donner, 1965, p. 256, fig. 189a−f; Schmid-Araya, 1993, p. 96, fig. 51; Song and Kim, 2000, p. 96.

Rostrum very short. Two rostral lamellae small, semicircular and located on anterolateral corners of rostrum; interspace rather flat, very wide and about 2 times as wide as each rostral lamella. Corona wider than cingulum pad. Disc restractor U-shaped with convex sides. Upper lip arched with concave sides; much lower than trochal discs. Pedicel swollen proximolaterally. Pharyngeal tube as long as trophi. Dental formula 9/9. Head and neck smooth. Trunk stout and granulated coarsely and densely; rump plump and dorsally swollen. Foot short with 4 pseudosegments, less granulated than trunk, and ending with an adhesive disc. Spurs granulated, short and conical with sharp points; interspace convex and as wide as spur base.

Size (μm): Body length (in creeping) 586, trunk width (in creeping) 122, spur length 14.

Distribution: Probably cosmopolitan.

Korea: GW.

Specimens examined: Numerous specimens (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee).

Remarks: Even though the present species is considered to be cosmopolitan, it was reported from Asia for the first time by Song and Kim (2000).

This species has been found mostly from mosses and rarely from ponds and lakes. Interestingly, Murray (1902) reported the present species from the pitchers or hollow leaves of *Frullania*, and Schmid-Araya (1993) from the bed sediments of a mountain gravel stream. The Korean specimens were found from mosses.

Genus *Philodina* Ehrenberg, 1830

Seon-yun-chung-sok (선윤충속)

Foot with 4 toes. Integument usually thin and smooth. Oviparous (except *P. gregaria*). Rostrum mostly short. Cerebral eyes rather common. Corona mostly wider than cingulum pad. Dental formula 2/2-5/5. Vitellarium with 8 nuclei in general.

Species 50 (7 in Korea).

Key to the species of genus *Philodina*

1. Trunk highly granulated; rostrum with collar-like protuberances proximoventrally; first Foot segment with transverse ridge dorsally ····· *P. rugosa coriacea*
− Trunk smooth ····· 2
2. Cerebral eyes absent ····· 3
− Cerebral eyes present ····· 5
3. Dorsal toe pair always extended ····· *P. duplicalcar*
− Dorsal toe pair not always extended ····· 4
4. Dental formula 3/3; anal segment swollen medially; interspace of spurs narrower than spur base width ····· *P. rapida*
− Dental formula 2/2; rump gradually tapering to spur segment; interspace of spurs about 2.5 times as wide as spur base ····· *P. vorax*

5. Dorsal toe pair always extended a little or fully; upper lip concave; spurs wedge-shaped and with acute points ····· *P. acuticornis odiosa*
− Dorsal toe pair different ····· 6
6. Upper lip with two bulges flanking median depression; spurs thumb-shaped and with small knob or sharp points at ends ····· *P. flaviceps*
− Upper lip arched and low; spurs conical, long and bent medially ····· *P. roseola*

28. *Philodina acuticornis odiosa* Milne, 1916 (Fig. 20A-C)

Mip-sang-ppyo-jok-dwit-bal-top-seon-yun-chung (밉상뾰족뒷발톱선윤충)

Philodina acuticornis odiosa Milne, 1916, p. 71, pl. 4, fig. 7, 7b; Schulte, 1954, p. 609, fig. 37a−c; Bartoš, 1959, p. 183, fig. 27C, F; Donner, 1964, p. 305, figs. 43−47; Donner, 1965, p. 212, figs. 156−158; Song and Kim, 1996b, p. 351, fig. 1c, d; Song and Kim, 2000, p. 96.

Rostrum short and narrow; radial tufts of long cilia present distally. Rostral lamellae bilobed, small and narrower than rostrum. Corona much broader than cingulum and slightly broader than trunk; base of sensillae rather big. Upper lip low, arched and concave medially. Sulcus width a half of trochal disc width. Antenna 2-segmented and a little longer than a half of antenna pseudosegment width; antenna segment with round lateral margins. Pharyngeal tube very short and only a third of trophi length. Two eyes with dull orange color in posterior part of brain (cerebral eyes). Dental formula 2/2. Trunk cylindrical and gradually tapering to foot posteriorly. Foot rather short, about 2/5 of trunk length, with 4 pseudosegments, and gradually tapering to spur pseudosegment. Spurs wedge-shaped and with acute points; interspace a little narrower than spur length. Four toes; dorsal toes always extended a little even during feeding; ventral toes much longer and thicker than dorsal ones.

Size (μm): Body length (in creeping) 201−346, trunk width (in creeping) 61−93, corona width 70−121, spur length 7.5−11.

Distribution: Austria, Rumania, Poland, South Africa, Jamaica, USA, Germany, Chile, England, Japan and Korea.

Korea: GW, GB.

Specimens examined: 5 specimens (Chilseongsan, Gujeong-myeon, Gangneung-si, Gangwon-do, wet leaf litter: 11.v.1997); 3 specimens (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998).

Remarks: Partially extended dorsal toe pair during both feeding and locomotion is one of the important diagnostic characters of this species and the chief distinction of this species from *P. acuticornis acuticornis* Murray, 1902. When feeding, bdelloids usually fix their body to the bottom on spurs, with all toes and toe segment pulled in and only corona and mastax are working. Donner (1964, 1965, 1970a) had some doubts about validity of extended dorsal toe pair as a diagnostic character, but admitted this subspecies tentatively.

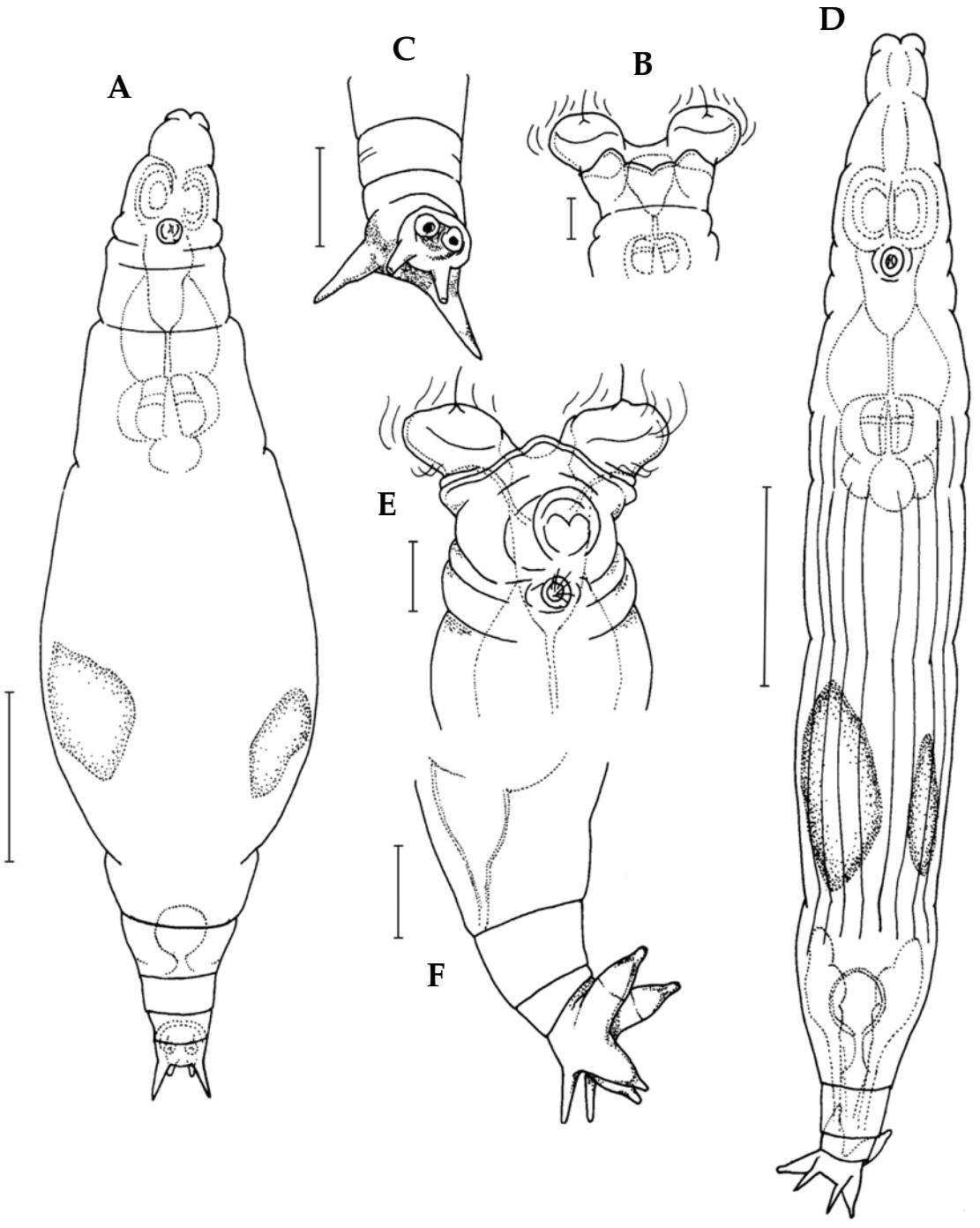

Fig. 20. *Philodina acuticornis odiosa*. A. creeping (fixed specimen), dorsal view; B. feeding head, ventral view; C. spurs and toes, ventral view. *Philodina duplicalcar*. D. creeping, dorsal view; E. feeding head, dorsal view; F. foot, spurs and toes, lateral view. Scales: A, D=50 μm, B=25 μm, C, E, F=15 μm.

29. *Philodina duplicalcar* (de Koning, 1929) (Fig. 20D–F)
Gulg-eun-bal-ga-rak-seon-yun-chung (굵은발가락선윤충)

Didymodactylos sp. de Koning, 1929, p. 105, fig. 38.
Didymodactylos duplicalcar de Koning, 1947, p. 203, pl. 9, fig. 40a–f.
Philodina de Koningi Donner, 1950, p. 327, fig. 20.
Philodina duplicalcar: Bartoš, 1951, p. 440, fig. 6A, B, E; Bartoš, 1959, p. 195, fig. 28G, H, M, O; Donner, 1965, p. 216, fig. 159; Song and Kim, 2000, p. 95, fig. 7.

Rostrum rather small. Rostral lamellae as wide as rostrum and bilobed. Corona wider than cingulum pad. Upper lip with convex median lobe which is slightly trilobed. Sulcus as wide as pedicel width. Pharyngeal tube as long as trophi. Dental formula 2/2. Trunk cylindrical in creeping; rump somewhat abruptly narrowed to foot. Foot with 4 pseudosegments and 4 toes; toes conical, very plump and with acute tips; ventral pair of toes slightly longer than dorsal pair; ventral toes with 2 segments retracting telescopically; dorsal toes kept extended. Spurs wedge-shaped, narrow, and almost as long as dorsal toes; interspace much wider than spur base.

Size (μm): Body length (in creeping) 300, corona width 58, cingulum pad width 44, spur length 12, dorsal toe length 13, ventral toe length 15.

Distribution: The Netherlands, Austria, Belgium, Romania, Sweden, Turkey, Korea.
Korea: GW.
Specimens examined: 1 specimen (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 18.iii.1996).
Remarks: The present species was rather rare and had been reported only from 6 countries in Europe including its type locality before Song and Kim (2000), which reported it outside Europe for the first time.

This species has been found mostly from soil and moss, while the Korean specimen was found from a temporary rain pool. The characteristics of the Korean specimen agree closely with those of the European populations except that the spurs are almost as long as the dorsal pair of toes, while they are much shorter in the European populations.

30. *Philodina flaviceps* Bryce, 1906 (Fig. 21A, B, Pl. 14A, B)
Hwang-geum-nun-seon-yun-chung (황금눈선윤충)

Philodina flaviceps Bryce, 1906 (In: Murray, 1906a, p. 172, pl. 1, fig. 1a–f); Bartoš, 1959, p. 184, figs. 26A–C, F, G, K, 47G; Schulte, 1959, p. 180, fig. 3a, b; Donner, 1965, p. 203, fig. 147b, c; Song and Kim, 1996b, p. 350, fig. 1e–g; Song and Kim, 2000, p. 96.

Rostrum short; rostral lamellae narrower than rostrum; radial tufts of long cilia present under rostral lamellae. Corona wider than cingulum pad. Sensillae rather apart from center to lateral margins of trochal discs. Sulcus as wide as pedicel width. Upper lip rimmed, arched and much lower than trochal discs; median lobe flat and bilobed. Two orange eyes present at posterior part of brain (cerebral eyes). Antenna 2-segmented and about 3/4 of antenna pseudosegment width

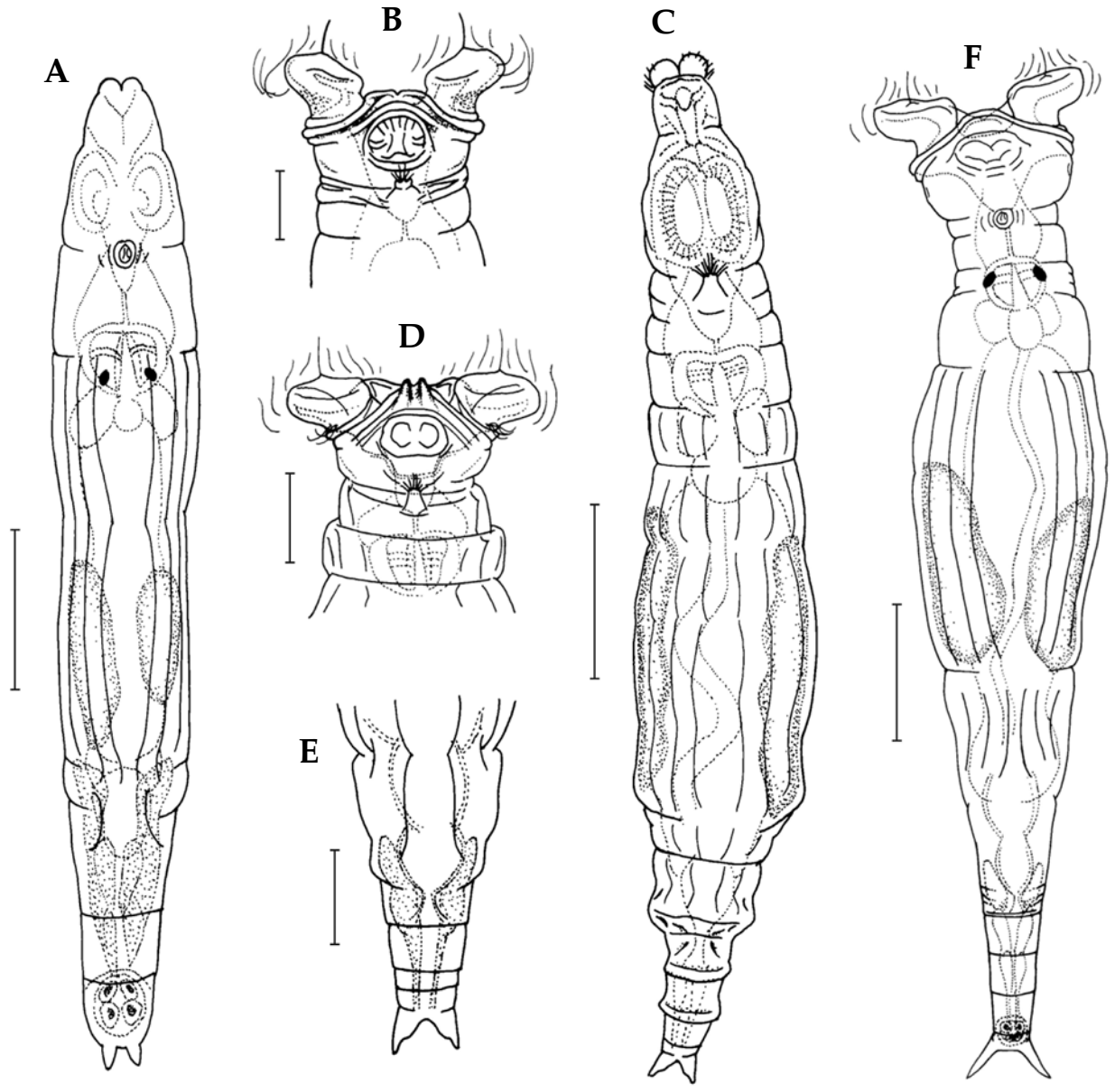

Fig. 21. *Philodina flaviceps*. A. creeping, dorsal view; B, feeding head, dorsal view. *Philodina rapida*. C. creeping, dorsal view; D. feeding head, dorsal view; E. rump, foot and spurs, dorsal view. *Philodina roseola*. F. feeding, dorsal view. Scales: A, C, F=50 μm, B=15 μm, D, E=25 μm.

long. Pharyngeal tube as long as trophi. Dental formula 2/2. Stomach lumen distinct and pinkish. Trunk cylindrical and slimmer than neck in creeping. Foot with 4 pseudosegments, cylindrical, stout, and tapering gradually to toes. Spurs thumb-shaped and often with acute tip, sometimes with small knob at end; interspace as wide as spur base. Egg lemon-shaped and with smooth surface.

Size (μm): Body length (in creeping) 232−525, corona width 43−79, cingulum pad width 40−73, spur length 5−7.

Distribution: Cosmopolitan.

Korea: GW, GB.

Specimens examined: Numerous specimens (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, wet leaf litter from a stream and wet mosses: 25.iii.1998); 1 specimen (Donghae Junior College, Donghae-si, Gangwon-do, wet mosses: 19.iv.1998, K.S. Chung); 1 specimen (Gariwangsan, Pyeongchang-gun, Gangwon-do, mosses: 27.v.1998, K.S. Lee).

Remarks: In Asia, this species had been reported from India (Murray, 1906b) and Japan (Mizuno and Takahashi, 1991) before Song and Kim (1996b) reported it for the first time in Korea.

31. *Philodina rapida* Milne, 1916 (Fig. 21C–E, Pl. 14C, D)

Ppa-reun-seon-yun-chung (빠른선윤충)

Philodina rapida Milne, 1916, p. 74, pl. 4, fig. 8, 8a; Bartoš, 1959, p. 190, fig. 27I; Donner, 1965, p. 223, figs. 164–166; Donner, 1970, p. 530, fig. 9g–t; Donner, 1971, p. 372, figs. 3q–u, 4c; Song and Kim, 2000, p. 96.

Eyes absent. Rostrum short. Rostral lamella bilobed and slightly wider than rostrum; each lobe rather big and circular. Corona much wider than cingulum pad and as wide as trunk in feeding. Sulcus very wide, as wide as trochal disc, and much lower than upper lip. Disc retractor with convex sides and a small sharp process medially. Upper lip arched, with two protuberances medially, and as high as trochal discs. Pedicel short. Antenna length about half antenna pseudosegment width. Pharyngeal tube as long as trophi. Dental formula 3/3. Salivary gland almost as big as mastax. Fourth pseudosegment of trunk abruptly narrowed before preanal segment; anal segment expanded all around medially like a ring with angular lateral margin. Foot short with 4 pseudosegments and tapering gradually to spur segment; second segment much longer than first one; both first and second segments with posterodorsal rim respecitively. Spurs conical with pointed ends, and with rather parallel outer margins and plump inner margins; interspace very narrow.

Size (μm): Body length (in creeping) 287–292, trunk width (in creeping) 51–52, corona width 71–77, cingulum pad width 48–50, spur length 6–8.

Distribution: Brazil, Madeira, Germany, Mallorca, Rhodes, Austria, Spain, South Africa, Turkey and Korea.

Korea: GW, GB.

Specimens examined: 20 specimens (Uljin, Gyeongsangbuk-do, mosses: 21.v.1996); 5 specimens (The vicinity of Chodanggul, Samcheok-si, Gangwon-do, lichens and mosses: 25.viii.1996); 3 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997); 1 specimen (Sagimak, Sacheon-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii1998); 5 specimens (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 13.vii.1998); 2 specimens (Jukheon-dong, Ganwon-do, mushrooms on tree trunks: 22.vi.2014).

Remarks: The rump of this species is more similar to that of *Macrotrachela* species rather than that of the typical *Philodina* species. After Milne (1916) described the upper lip as trilobed or with three small protuberances in his original description, variations in the shape of the upper lip have been reported (Donner, 1965). All the Korean specimens have the upper lip with two protuberances

medially and the specimens from Uljin and the vicinity of Chodanggul have a small process on the disc retractor medially, which is absent in the other Korean specimens. In case of the specimens from Uljin and the vicinity of Chodanggul, their upper lip could be observed to have three processes medially because of the small process on disc retractor.

This species was reported from Asia for the first time by Song and Kim (2000). Recently, it was recorded from Eastern Turkey by Kaya (2013).

32. *Philodina roseola* Ehrenberg, 1832 (Fig. 21F)

Bun-hong-seon-yun-chung (분홍선윤충)

Philodina roseola Ehrenberg, 1832, p. 147, pl. 3, fig. 16 (cited from Harring, 1913); Bryce, 1903, p. 524, fig. 4; Bartoš, 1951, p. 434, fig. 53A, B, F, G; Bartoš, 1959, p. 186, fig. 27D, G, H, K; Donner, 1965, p. 214, fig. 155a–d; de Ridder, 1972, p. 10; Koste and Shiel, 1986, p. 787, figs. 16: 1, 17: 1a–k; Song and Kim, 2000, p. 96.

Rostral lamella very transparent, bilobed, low, narrow, and with many long cilia proximoventrally; each lobe slightly trilobate. Corona wider than head. Sulcus rather wide and as wide as pedicel. Upper lip arched, much lower than trochal discs, with slightly concave sides, and without any extended part. Antenna long, a little shorter than antenna pseudosegment width, and with 2 segments; proximal segment rather longer than distal one. Two cerebral eyes with orange color, elliptical in shape, and overlapping with mastax in ventral view. Dental formula 2/2. Trunk except preanal and anal segments covered with mucus and detritus. Foot with 5 pseudosegments and tapering gradually to spur segment. Spurs conical, thin, longer than spur pseudosegment width, and bent medially with distal half curved outwardly; interspace about 1.5 times as wide as spur base. Four toes present; ventral toes with 2 segments, and thicker and shorter than spurs. Egg lemon-shaped and with smooth surface.

Size (μm): Body length (in creeping) 390, corona width 76, cingulum pad width 62, spur length 17.

Distribution: Cosmopolitan.

Korea: GW.

Specimens examined: 5 specimens (The vicinity of Chodanggul, Samcheok-si, Gangwon-do, mosses and lichens: 25.viii.1996); 5 specimens (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 13.vii.1998).

Remarks: *Philodina* species usually have the foot with 4 pseudosegments, but the present species with 5 pseudosegments. This species is cosmopolitan and inhabits almost all kinds of freshwater and terrestrial habitats, even hot springs (de Ridder, 1972).

In East Asia, this species has been reported from Japan (Mizuno and Takahashi, 1991) and China (Wang, 1961). Song and Kim (2000) was the first Korean record of it. Recently, this species was reported from Iran by Khoei et al. (2011).

33. *Philodina rugosa coriacea* Bryce, 1903 (Fig. 22)

Gwa-rip-ju-reum-seon-yun-chung (과립주름선윤충)

Philodina rugosa var. *coriacea* Bryce, 1903, p. 529, pl. 27, fig. 3, 3a; Bartoš, 1951, p. 427, figs. 1B, 51B.
Philodina rugosa coriacea: Bartoš, 1959, p. 178, fig. 25C, D; Donner, 1965, p. 205, fig. 148b, c; Song and Kim, 2000, pp. 95, 97, fig. 9.

Two cerebral eyes present, with orange color, small and elliptical. Rostral lamella somewhat narrower than rostrum. Corona a little wider than cingulum pad and much narrower than trunk

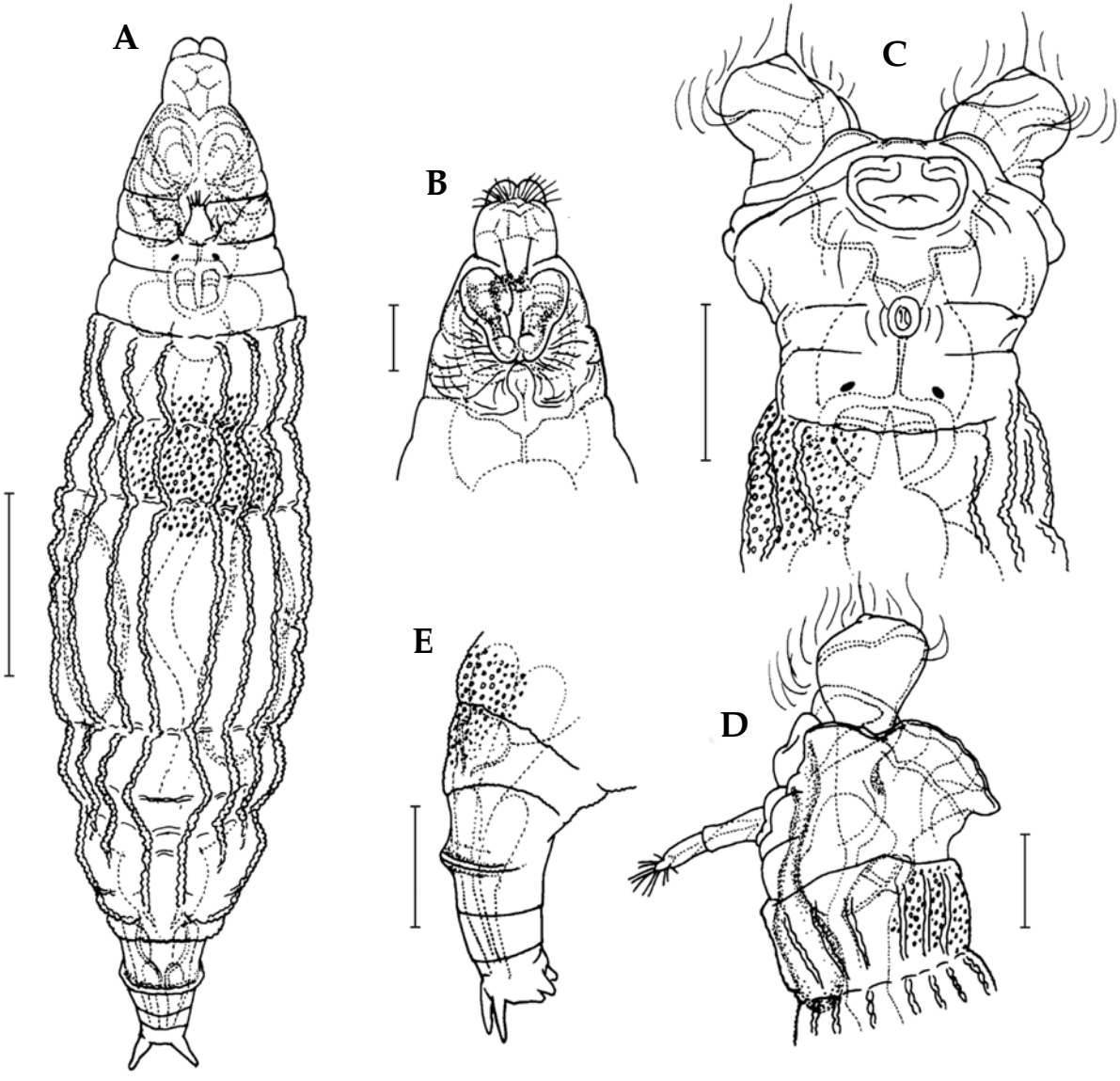

Fig. 22. *Philodina rugosa coriacea*. A. creeping, dorsal view; B. creeping head, ventral view; C. feeding head, dorsal view; D. feeding head, lateral view; E. foot and spurs, lateral view. Scales: A=50 μm, B, D=15 μm, C, E=25 μm.

width in feeding. Trochal discs rather small, inclined inwards and swollen medially; base of sensory hair rather big. Sulcus as wide as pedicel. Upper lip much lower than trochal discs, arched and with 2 bulges flanking flat interspace medially. Antenna rather long and slightly longer than 2/3 of neck width. Collar-like protuberances present under rostrum proximoventrally, just over folded corona. Dental formula 2/2. Trunk strongly granulated and with prominent wavy longitudinal ridges. Foot with rather smooth integument and 4 pseudosegments; transverse ridge with wavy margin present on first pseudosegment dorsomedially. Spurs conical, narrow, with rather obtuse ends and longer than double of spur base width; interspace slightly wider than spur base. Egg oval with one polar hump.

Size (μm): Body length (in creeping) 274, trunk width (in creeping) 66, trunk width (in feeding) 72, dorsal antenna length 28, corona width 56, cingulum pad width 53, spur length 9.

Distribution: Iceland, Great Britain, Czech Republic, Rumania and Korea.

Korea: GW.

Specimens examined: 10 specimens (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee); 2 specimens (Gyo-dong, Gangneung-si, Gangwon-do, mosses: 12.vi. 2014).

Remarks: The Korean specimens of the present subspecies have a pair of collar-like protuberances at proximoventral part of rostrum which are absent in both *rugosa s. str.* and the other variety, *callosa* and had not been mentioned in its original description. The other characteristics except these collar-like protuberances agree well with those of *coriacea*.

The Korean specimens are very similar to Haigh (1965)'s variety in the general body structures, especially in the morphologies of corona and foot, but it differs from Haigh (1965)'s variety in the following characteristics: (1) The dental formula of the Korean specimens is 2/2 while that of Haigh (1965)'s variety 3+1/3+1, (2) The Korean specimens do not have any cuticular transverse ridges on the ventral side of trunk which Haigh (1965)'s variety had, and (3) The foot and spurs of the Korean specimens are not granulated or very finely granulated, while those of Haigh (1965)'s variety heavily granulated like its trunk.

The present subspecies has a transverse ridge on the first foot segment, which Bartoš (1951) did not mention.

The present subspecies had been rather rare and reported from three European countries after description prior to Song and Kim (2000), which reported it outside Europe for the first time.

34. *Philodina vorax* (Janson, 1893) (Fig. 23A, Pl. 14E)

Meok-bo-seon-yun-chung (먹보선윤충)

Callidina vorax Janson, 1893, p. 60, pl. 3, figs. 40−42; Bryce, 1894, p. 446; Brauer, 1912, p. 26, fig. 35a, b.
Philodina vorax: Murray, 1913, p. 235, pl. 9, fig. 1a−d; Bartoš, 1951, p. 437, figs. 5O, 56D, E; Bartoš, 1959, p. 190, figs. 29A, B, E, 42H; Donner, 1965, p. 226, fig. 160a−c; Donner, 1971, p. 374, fig. 4h; Song and Kim, 1996b, p. 350, fig. 1a, b; Song and Kim, 2000, p. 96.

Eye spots absent. Rostral lamellae narrower than rostrum. Corona much wider than trunk. Upper lip arched, much lower than trochal discs, and slightly bilobed medially. Sulcus wide, much lower than upper lip, and as wide as pedicel. Disc retractor V-shaped and with convex sides. Body

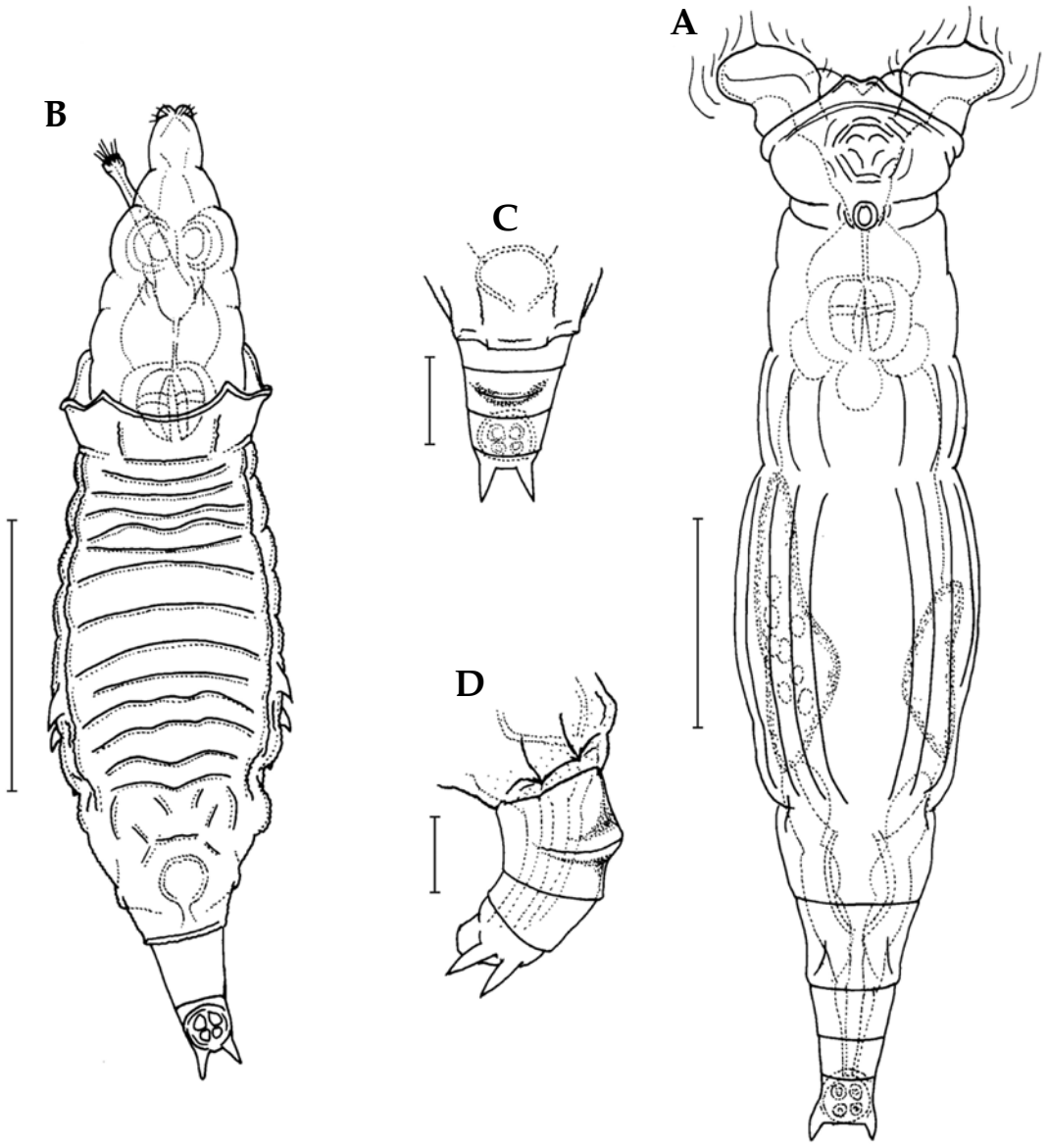

Fig. 23. A. *Philodina vorax* (Janson, 1893), feeding, dorsal view. B–D. *Pleuretra brycei* (Weber, 1898): B. creeping, ventral view; C. foot and spurs, dorsal view; D. foot and spurs, dorsolateral view. Scales: A, B=50 μm, C=10 μm, D=15 μm.

brown and with smooth integument. Lumen of stomach distinct, broad and pink. Dorsal antenna a half of antenna pseudosegment height long. Pharyngeal tube as long as trophi. Dental formula 2/2. Trunk fusiform. Foot with 4 pseudosegments and about 1/4 of total body length long; foot gradually tapering to spur pseudosegment. Spurs small, conical and pointing backwards or divergent; interspace very wide, 2.5–3 times as wide as spur base, and flat or slightly bilobed. Egg oval and with 11 low bumps in lengthwise section.

Size (μm): Body length (in creeping) 272–483, corona width 75–90, cingulum pad width 58–69, spur length 4–10.

Distribution: Probably cosmopolitan.

Korea: GW.

Specimens examined: 5 specimens (The vicinity of Chodanggul, Samcheok-si, Gangwon-do, mosses: 25.viii.1997); 1 specimen (Daegwallyeong, Pyeongchang-gun, Gangwon-do, submerged mosses: 8.iii.1997); 2 specimens (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii. 1997, K.S. Lee); 10 specimens (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temprary rain pool: 13.vii.1998); 2 specimens (Yangyang-gun, Gangwon-do, mosses and forest litter: 27.ix.1998).

Remarks: This species is easily recognized by its wide corona and interspace between spurs. The interspace tends to be flat if spurs pointing backwards and slightly bilobed if spurs divergent (Song and Kim, 1996b). The present species has been found from various habitats like mosses, temporary rain pools, forest litters and lichens in Korea.

Even though this species seems to be cosmopolitan, it has been reported only from India (Murray, 1906b), China (Zhuge et al., 1998), and Korea (Song and Kim, 1996b) in Asia.

Genus *Pleuretra* Bryce, 1910

Gap-ju-yun-chung-sok (갑주윤충속)

Foot with 4 toes. Eyes absent. Integument rather rigid, granulated and with cuticular knobs and/or spines. Dental formula mostly 2/2. Many ventral striae present on trunk. Oviparous.

Species 14 (2 in Korea).

Key to the species of genus *Pleuretra*

1. Trunk with sharp spines dorsally; rostrum without proximal granulation; corona much broader than cingulum pad ..... *P. brycei*
− Trunk without spines; rostrum coarsely granulated proximally; corona as wide as cingulum pad ..... *P. humerosa*

35. *Pleuretra brycei* (Weber, 1898) (Figs 23B–D, 24, Pl. 15)

Beu-ra-i-seu-gap-ju-yun-chung (브라이스갑주윤충)

Callidina brycei Weber, 1898, pp. 347–349, pl. 15, figs. 8–12.
Callidina cataracta Lord, 1898, p. 76, pl. 7, fig. 2a, b.
Philodina brycei: Murray, 1905, p. 383; Murray, 1908a, p. 191, pl. 1, fig. 13.
Pleuretra brycei: Bryce, 1910, p. 76; Murray and Wailes, 1913, p. 22, fig. 7; Bartoš, 1951, p. 411, fig. 47G, H; Song and Kim, 2000, p. 96.

Dorsal antenna very long, 1.5 times longer than rostrum and with 2 segments; distal segment with 5 radial tufts of long cilia terminally; proximal segment with a small protuberance on each

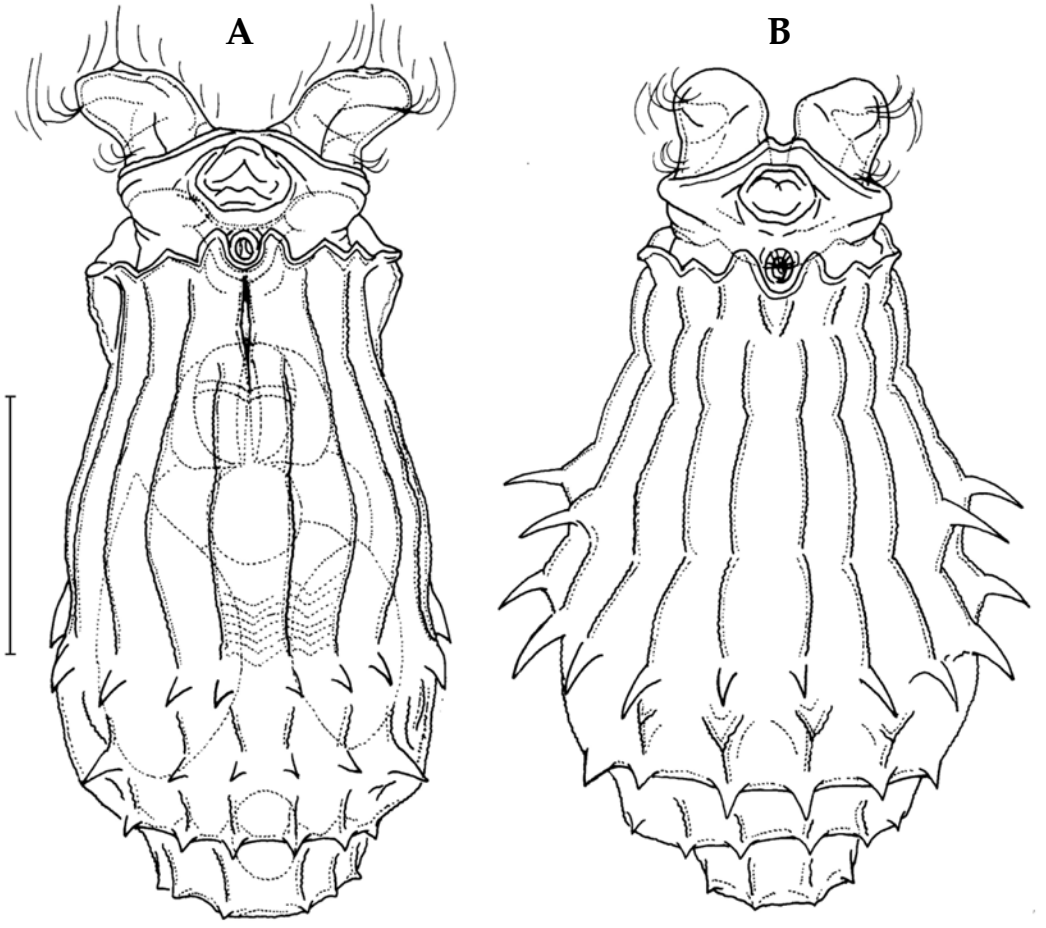

Fig. 24. *Pleuretra brycei*. A. feeding, dorsal view; B. feeding, dorsal view (a specimen from Taebaeksan). Scales: A, B=50 μm.

sides. Corona very wide and much broader than cingulum pad. Sulcus as wide as pedicel. Upper lip arched and much lower than trochal discs. Rostral lamella bilobed and narrower than rostrum. Rostral cilia long and radial. Trophi very large and as wide as 1/3 of trunk width. Dental formula 2/2. Trunk integument rather stiff and highly granulated. Trunk with 10 prominent longitudinal ridges dorsally; with about 14 ventral transverse striae which are sometimes indistinct. Anterior margin of first trunk pseudosegment with different forms of projections; anterodorsal margin with 2 pairs of angular projections and middle pair much longer than next pair; anterolateral corners expanded like teapot spouts; anteroventral margin with 2 triangular projections separated by a wide U-shaped median margin. Third trunk pseudosegment with 2 transverse rows of spines dorsally; first row bearing 5 pairs of short spines as prolongations of 10 longitudinal ridges, of these, median pair shortest; second row bearing 4 pairs of short spines, of these, submedian pair longest. Posterodorsal margin of forth trunk pseudosegment with 4 pairs of small spines and/or angular protuberances. Posterodorsal margin of fifth trunk segment angular laterally and drooping dorsally. Foot with 4 pseudosegments and 4 toes; first foot segment with a transverse projection mediodorsally. Spurs granulated, conical, 1.5−1.8 times as long as its base and with blunt ends; interspace rather narrower than spur base. Egg smooth and oval with a polar bump.

Size (μm): Corona width 56−64, cingulum pad width 39−48, dorsal antenna length about 29, trunk width 42−63 (in creeping), trunk length 154−162 (in creeping), spur length 6−7, egg 34.5 × 60.

Distribution: Cosmopolitan.
Korea: GW.
Specimens examined: 1 specimen (a stream in Daegwallyeong, Pyeongchang-gun, Gangwon-do, submerged mosses: 8.iii.1997; 1 specimen (Wangsan-myeon, Gangneung-si, Gangwon-do, wet mosses: 25.iii.1998); 3 specimens (Bicheon-valley, Donghae-si, Gangwon-do, wet mosses: 19.iv.1998, K.S. Chung).
Remarks: Since Weber (1898)'s description of *P. brycei*, many researchers have reported this species and described its local varieties from a lot of countries (Murray, 1908, 1911a, 1911b, 1911d, 1911f, 1913; Murray and Wailes, 1913; Bartoš, 1959; Donner, 1965). Murray and Wailes (1913) reported two new varieties from Bolivia. The morphology of Korean population of this species is most similar to that of the first variety of Bolivian populations. But Korean specimens differ from Bolivian population by the following characteristics: (1) Korean specimens have a pair of small submedian projections on anterodorsal margin of the first trunk pseudosegment, which Bolivian populations lack, (2) Korean specimens have another row of eight spines under the main row of ten spines on dorsal area of the third trunk pseudosegment, while Bolivian populations have the main row only, and (3) Korean specimens have four pairs of small spines and/or angular protuberances on posterodorsal margin of the forth trunk segment, which Bolivian populations lack.

Even though this species is cosmopolitan, it was reported from Asia for the first time by Song and Kim (2000).

36. *Pleuretra humerosa* (Murray, 1905) (Fig. 25)
Gom-bo-gap-ju-yun-chung (곰보갑주윤충)

Philodina humerosa Murray, 1905, p. 382, pl. 4, fig. 4a−g.
Pleuretra humerosa: Bryce, 1910, p. 76; Donner, 1965, p. 189, fig. 138a−d; Song and Kim, 2000, p. 96.

Rostrum rather short, round, slightly constricted proximally, coarsely granulated proximally, and with granulated collar-shaped protuberances proximoventrally. Rostral lamellae short and narrower than rostrum. Corona as wide as cingulum pad. Pedicel with plump base. Upper lip arched, rimmed, and much lower than trochal discs. Cingulum pad granulated and swollen laterally. Sulcus about 1/3 of pedicel width and with convex base. Dental formula 2/2. Antenna rather longer than rostrum and with a protuberance on each side. Trunk rough, slightly granulated, sometimes covered with detritus, and with distinctively crinkled longitudinal ridges and about 14 ventral striae; anterior margin of first pseudosegment wavy and without distinct projections; preanal segment with 4 short angular projections dorsally as prologations of longitudinal ridges. Foot more stippled than trunk and with 4 pseudosegments; first segment with a transverse dorsal projection. Four toes present; ventral toes as long as spurs and much thicker than spurs. Spurs conical and granulated; interspace as wide as or slightly narrower than spur base.
Size (μm): Body length (in creeping) 200, corona width 33, cingulum pad width 34, spur length 8.

Distribution: Probably cosmopolitan.

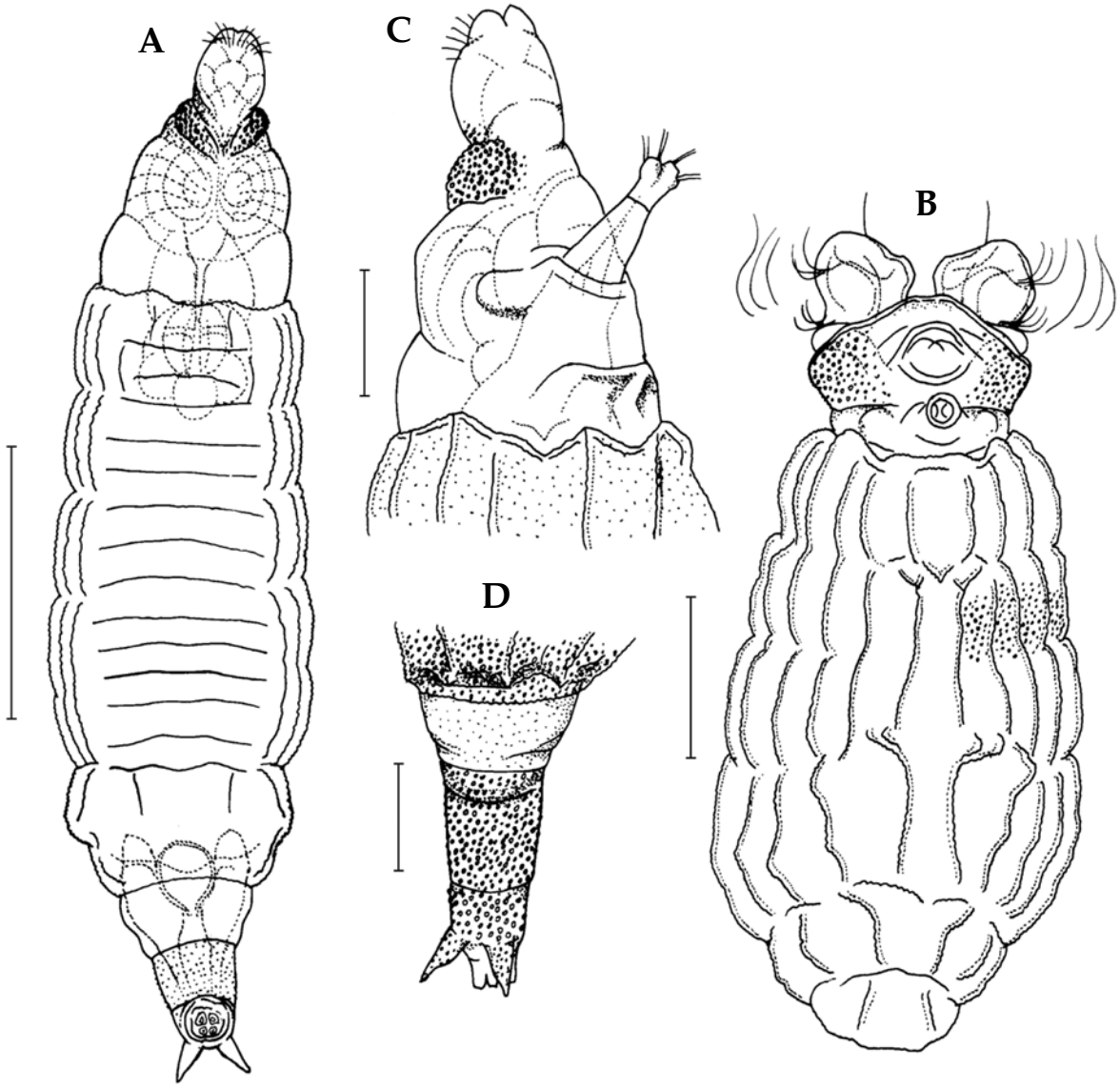

Fig. 25. *Pleuretra humerosa* (Murray, 1905). A. creeping, ventral view; B. feeding, dorsal view; C. head and antenna, dorsolateral view; D. foot and spurs, dorsal view. Scales: A=50 μm, B=25 μm, C, D=15 μm.

Korea: GW.

Specimens examined: 20 specimens (Yongyeonsa, Gangneung-si, Gangwon-do, mosses: 2.viii. 1998).

Remarks: The characteristics of the Korean specimens coincide closely with the original description except the granulated collar-shaped protuberances on proximoventral part of rostrum and the transverse dorsal projection on the first foot pseudosegment.

The present species has been found mostly from mosses and all the Korean specimens have been also found from mosses.

Even though it is cosmopolitan, Song and Kim (2000) was the first Asian record of it.

Genus *Rotaria* Scopoli, 1777

Cham-yun-chung-sok (참윤충속)

Foot, spurs, toes, rostrum and antenna usually long. Foot with 3 toes. Eyes, when present, on rostrum. Rostrum usually extended in feeding. All viviparous.

Species 27 (4 in Korea).

Key to the species of genus *Rotaria*

1. Eyes present on rostrum; foot and spurs smooth ····· 2
− Eyes absent; foot and spurs granulated ····· 3
2. Ventral toes much longer than spurs; rostrum much longer than its width ····· *R. tardigrada*
− Toes shorter than spurs and all of equal length; rostrum slightly longer than its width ····· *R. rotatoria rotatoria*
3. Coarse granules on longitudinal ridges of trunk rather uniform in size ····· *R. sordida sordida*
− Coarse granules on longitudinal ridges of trunk getting longer and stiffer toward posterior part of each segment ····· *R. sordida fimbriata*

37. *Rotaria rotatoria rotatoria* (Pallas, 1766) (Fig. 26A)

Hoe-jeon-cham-yun-chung (회전참윤충)

Brachionus rotatorius Pallas, 1766, p. 94 (cited from Harring, 1913).
Rotaria rotatoria: Harring, 1913, p. 92; de Koning, 1929, p. 74, fig. 18; Bartoš, 1951, p. 391, figs. 3B, 5J, 42A–E, I–L.
Rotaria rotatoria rotatoria: Bartoš, 1959, p. 260, figs. 44C–CH, K, 45G; Donner, 1965, p. 180, fig. 131a–d; Koste and Shiel, 1986, p. 781, figs. 11: 2, 12: 4; Song and Kim, 2000, p. 96.

Rostrum rather small and with 2 red eyes; eyes bean-shaped. Rostral lamella as wide as rostrum end. Corona wider than cingulum pad. Sulcus wide and bilobed. Upper lip low and arched. Dental formula 2/2. Body with smooth integument and slender with long foot. Trunk longer than foot. Foot cylindrical and with 6 pseudosegments. Spurs long, thin, conical and tapering to sharp points; interspace wider than spur base. Three toes of equal length and shorter than spurs.
Size (μm): Body length (in creeping) 376–379, spur length 17–19.

Distribution: Cosmopolitan.
Korea: GW.
Specimens examined: 10 specimens (Daegwallyeong, Pyeongchang-gun, Gangwon-do, submerged mosses from a stream: 8.iii.1997); 3 specimens (Sageunjin, Gangneung-si, Gangwon-do, lake: 25.iii.1998).
Remarks: The present species is the commonest species of the genus *Rotaria* in plankton samples, sometimes occurring at great depths and inhabits almost all freshwater and terrestrial habitats (Koste and Shiel, 1986).

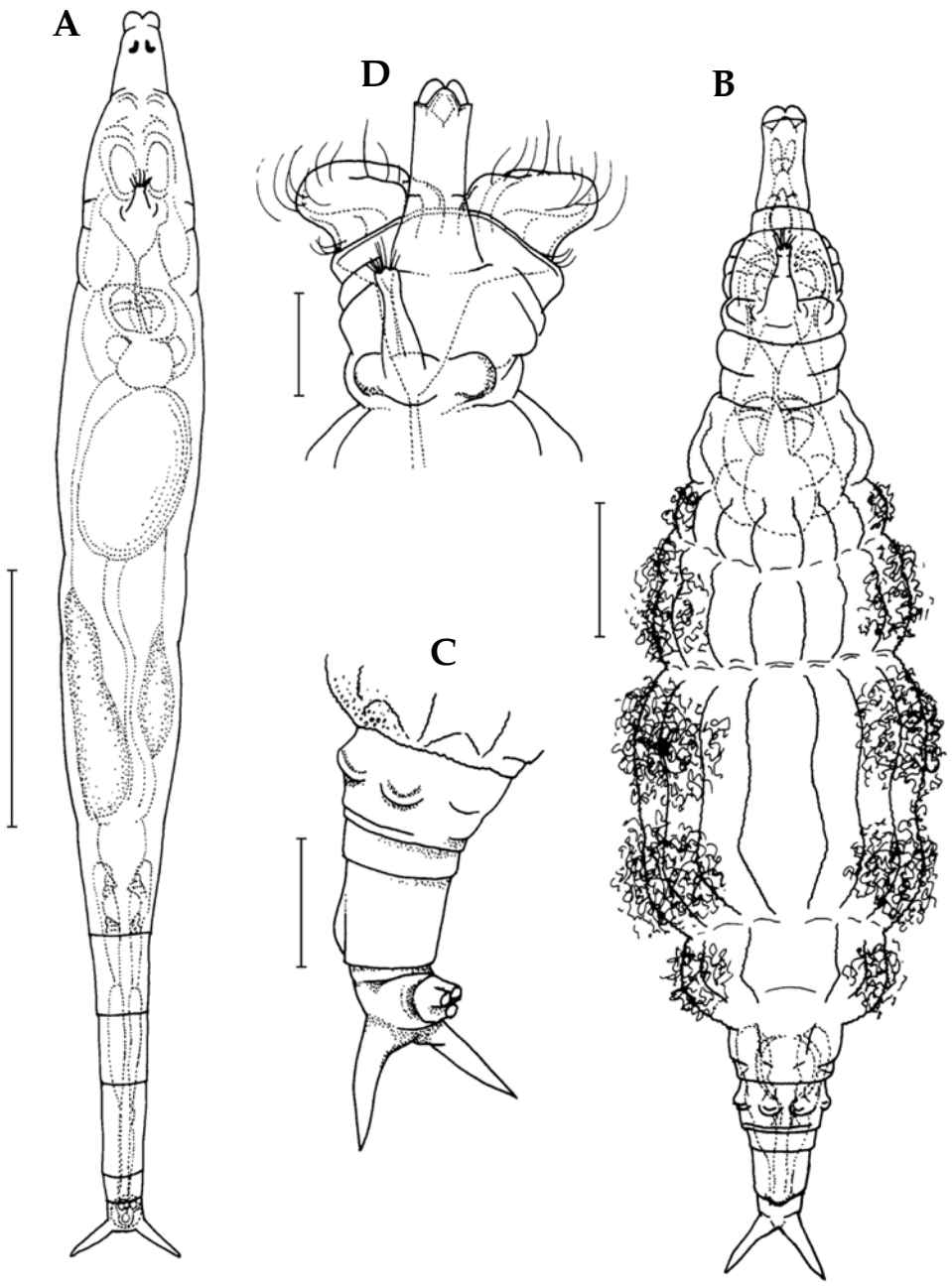

Fig. 26. *Rotaria rotatoria rotatoria*. A. creeping, dorsal view. *Rotaria sordida sordida*. B. creeping, dorsal view; C. foot and spurs, ventrolateral view; D. feeding head, dorsal view. Scales: A=100 μm, B=50 μm, C=15 μm, D=25 μm.

Kim and Park (1969) reported the present species from the Hangang River for the first time in Korea as a part of species list resulted from an ecological study. Song and Kim (2000) was the first taxonomic study on this species in Korea. In Asia, this species has been reported from China (Wang, 1961), India (Murray, 1906b; Sharma and Sharma, 2014), Iran (Khoei et al., 2011), Japan (Mizuno and Takahashi, 1991), Myanmar (Koste and Tobias, 1990), and Sri Lanka (Bartoš, 1951).

38. *Rotaria sordida sordida* (Western, 1893) (Fig. 26B–D)
Ne-dol-gi-cham-yun-chung (네돌기참윤충)

Callidina sordida Western, 1893, p. 159, pl. 9, fig. 1.
Callidina longirostris Janson, 1893, p. 57, pl. 3, figs. 33, 34.
Rotifer longirostris: Murray, 1906b, p. 642.
Rotaria sordida (Western, 1893) Harring, 1913, p. 92; de Koning, 1929, p. 74, fig. 19; Bartoš, 1951, p. 399, fig. 44B, C, G; Donner, 1971, p. 371, fig. 4a, b; Mizuno and Takahashi, 1991, p. 187, fig. 15.
Rotaria sordida sordida: Bartoš, 1959, p. 270, fig. 46D, H; Donner, 1965, p. 170, fig. 126a, b; Koste and Shiel, 1986, p. 781, figs. 12: 6, 13: 2a–c; Song and Kim, 2000, p. 96.

Corona much wider than cingulum pad. Upper lip arched and slightly bilobed medially. Pedicel short. Rostrum kept extended during feeding and rather expanded distally; rostrum end much higher than trochal discs. Rostral lamella bilobed and rather narrower than rostrum; each lobe somewhat elliptical and very transparant. Eyes absent. Head and neck with smooth surface. Antenna rather short, thick and with very prominent process on each side; each protuberance with slightly angular side. Dental formula 2/2. Trunk highly granulated, with prominent longitudinal ridges crowned with coarse granules, and covered with mucus and detritus; preanal segment without granulation and with ring-like swelling around it medially; anal segment with 4 U-shaped processes dorsally. Foot slightly granulated and with 4 pseudosegments; second pseudosegment much longer than first one and slightly swollen posterodorsally. Spurs blade-shaped, long, about 1.5 times longer than spur pseudosegment width, lightly granulated, and without interspace. Three toes shorter than spurs.

Size (μm): Body length (in creeping) 449, corona width 73, cingulum pad width 56, spur length 24.

Distribution: Cosmopolitan.
Korea: GW.
Specimens examined: 7 specimens (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 18 March, 1996); 5 specimens (The vicinity of Chodang-gul, Samcheok-si, Gangwon-do, mosses: 25.viii.1996).
Remarks: In the present species, two subspecies, *R. sordida fimbriata* (Murray, 1906b) and *R. sordida bitorquata* (Murray, 1908b) were described and of them, *R. sordida fimbriata* was found from Korea. The present subspecies was reported from Korea for the first time by Song and Kim (2000). In Asia, it has been reported from China (Bartoš, 1963), India (Murray, 1906b), Indonesia (Bartoš, 1963), and Japan (Mizuno and Takahashi, 1991).

39. *Rotaria sordida fimbriata* (Murray, 1906) (Fig. 27A, B, Pl. 16)
Peu-ril-ne-dol-gi-cham-yun-chung (프릴네돌기참윤충)

Rotifer longirostris var. *fimbriata* Murray, 1906b, p. 643, pl. 19, fig. 7a–c; Murray, 1911a, p. 433, pl. 15, fig. 7.
Rotaria sordida var. *fimbriata*: Bartoš, 1951, p. 401, fig. 44D, H; Bartoš, 1963, p. 41, pl. 3, fig. D.
Rotaria sordida fimbriata: Donner, 1965, p. 172, fig. 126c, d; Donner, 1970b, p. 531, fig. 10; Song and

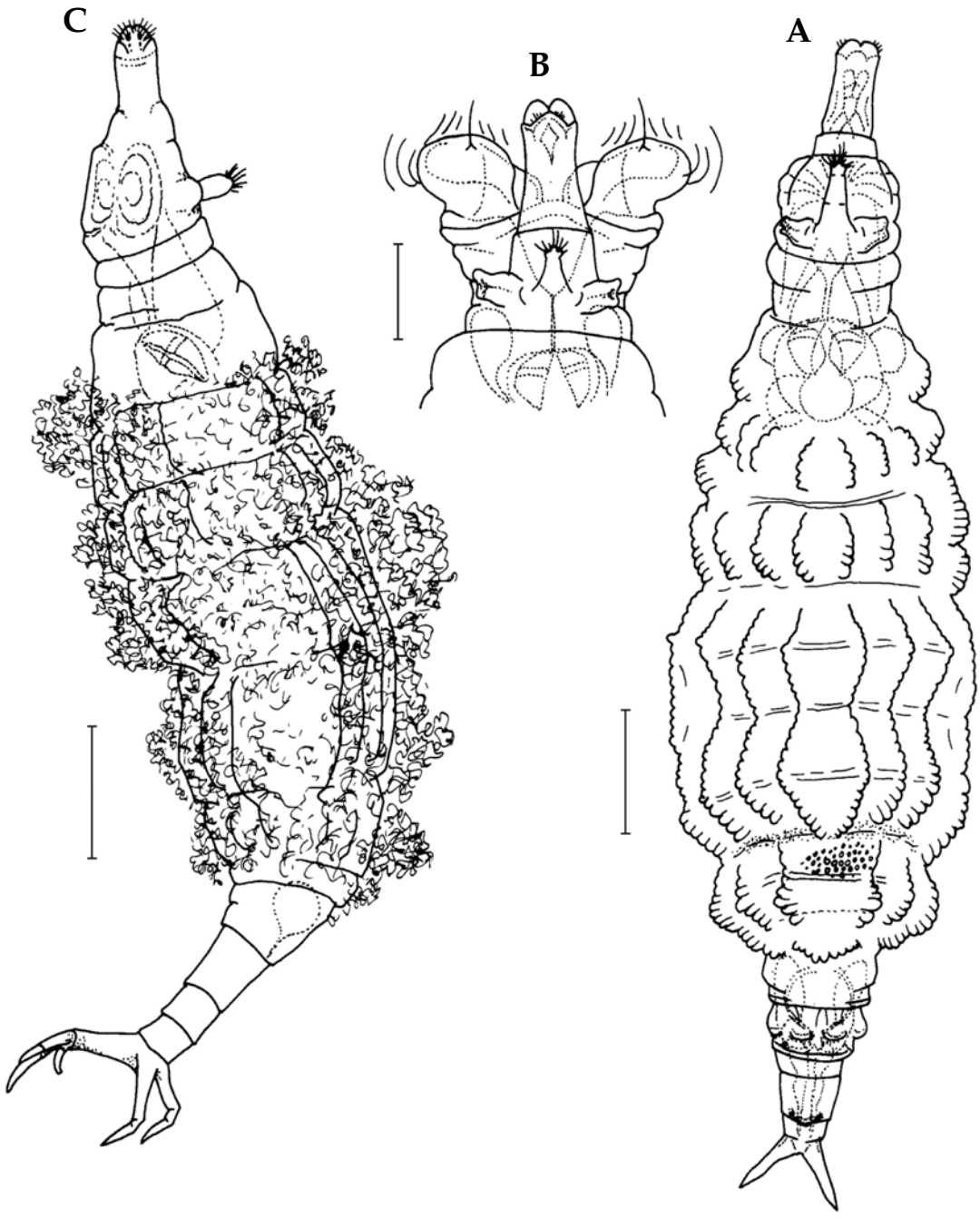

Fig. 27. *Rotaria sordida fimbriata*. A. creeping, dorsal view; B. feeding head, dorsal view. *Rotaria tardigrada*. C. creeping, ventrolateral view (modified from Song and Kim, 1996a). Scales: A, C=50 μm, B=25 μm.

Kim, 2000, p. 96.

Corona much wider than cingulum pad. Upper lip arched, much lower than trochal discs, slightly bilobed medially, and with concave sides. Sulcus as wide as pedicel. Pedicel short. Rostrum

kept extended during feeding and rather expanded distally; rostrum end higher than trochal discs. Rostral lamella bilobed and rather narrower than rostrum; each lobe somewhat elliptical and very transparant. Eyes absent. Head and neck with smooth surface. Antenna rather short, thick, and with very prominent process on each side; each protuberance with slightly bifid and angular side. Dental formula 2/2. Trunk highly granulated and with prominent longitudinal ridges crowned with coarse granules; granules getting bigger toward posterior part of each pseudosegment and set closely like ruffle; preanal pseudosegment without granulation and with ring-like swelling around it medially; anal pseudosegment with 4 U-shaped protuberances dorsally. Foot slightly granulated and with 4 pseudosegments; second segment longer than first one; second segment swollen posterodorsally. Spurs blade-shaped, long, about 1.5 times longer than spur segment width, lightly granulated, and without interspace. Three toes shorter than spurs.

Size (μm): Body length (in creeping) 300−398, corona width 52−69, cingulum pad width 43−56, spur length 18−24.

Distribution: Portuguese Madeira (Northwest Africa), Czech Republic, Uganda, South Africa, India, Java, New Zealand, Hawaii and Korea.

Korea: GW.

Specimens examined: 5 specimens (Garibong, Inje-gun, Gangwon-do, mosses: 28.ix.1997, K.S. Lee); 1 specimen (Jabyeongsan, Okgye-myeon, Gangneung-si, Gangwon-do, mosses: 1.xii.1997, K.S. Lee); 1 specimen (Sageunjin, Gangneung-si, Gangwon-do, lake: 25.iii.1998); 3 specimens (Gariwang-san, Pyeongchang-gun, Gangwon-do, mosses: 27.v.1998, K.S. Lee); 1 specimen (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 13.vii.1998).

Remarks: The present subspecies differs from *R. sordida sordida* in the following characteristics: (1) The two processes on each side of antenna are bifid distally in the present subspecies, while not bifid in *R. sordida sordida* and (2) The granules on the longitudinal ridges of trunk are getting bigger and stiffer toward the posterior part of each trunk pseudosegment in the present subspecies, while uniform in size in *R. sordida sordida*.

The present subspecies was reported from Korea for the first time by Song and Kim (2000). In Asia, this subspecies has been reported from India (Murray, 1906b) and Indonesia (Bartoš, 1963).

40. *Rotaria tardigrada* (Ehrenberg, 1832) (Fig. 27C)

Wan-bo-cham-yun-chung (완보참윤충)

Rotifer tardigradus Ehrenberg, 1832, p. 145 (cited from Koste and Shiel, 1986).

Rotifer tardus Ehrenberg, 1838, p. 490, pl. 1x, fig. 8 (cited from Hudson and Gosse, 1886); Hudson and Gosse, 1886, vol. 1, p. 105, pl. 10, fig. 1.

Rotaria tardigrada: Donner, 1965, p. 170, fig. 125a−d; Bartoš, 1959, p. 264, fig. 45D, H; Koste and Shiel, 1986, p. 780, figs. 12: 1a, b, 13: 1a−d; Song and Kim, 1996a, p. 54, fig. 1m; Song and Kim, 2000, p. 96.

Rostrum long, about 2 times longer than its width, and with 2 red eyes distally. Corona much wider than cingulum pad. Dorsal antenna 2-segmented and long. Dental formula 2/2. Trunk yellowish brown, with smooth integument, and covered with detritus. Foot with 5 pseudosegments and 3 toes; ventral toes 2−2.5 times longer than dorsal ones, and all 2-segmented. Spurs thin, blade-

shaped, longer than ventral toes and can be bent medially.

Size (μm): Body length (in creeping) 495−550, trunk width (in creeping) 101−114, ventral toe length 34−35, dorsal toe length 14−16, spur length 39−45.

Distribution: Cosmopolitan.

Korea: GW.

Specimens examined: 22 specimens (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, temporary rain pool: 18.iii.1996); 20 specimens (Campus of Gangneung-Wonju National University, Gangneung-si, Gangwon-do, mosses, lichens and: 23.iv.1996).

Remarks: This species is easily recognized by its trunk heavily covered with detritus. Spurs and ventral toes are long and bent toward each other, which makes grasping motion when the animal crawls (Song and Kim, 1996a).

This species is xerophilous and has been found in the various habitats like soil, lake, pond, sphagnum, marsh, moss, lichen, activated sludge and even on the surface of other animal. Some populations of this species cannot live without their host, a kind of crayfish, *Astacus fluviatilis* (Bartoš, 1951). Some Korean specimens were found in a temporary rain pools.

Even though the present species has a worldwide distribution, it has been reported only from China (Thorpe, 1893; Wang, 1961; Koste and Zhuge, 1996), Japan (Mizuno and Takahashi, 1991), Korea (Song and Kim, 1996a), and India (Sharma and Sharma, 2014) in Asia.

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Plates

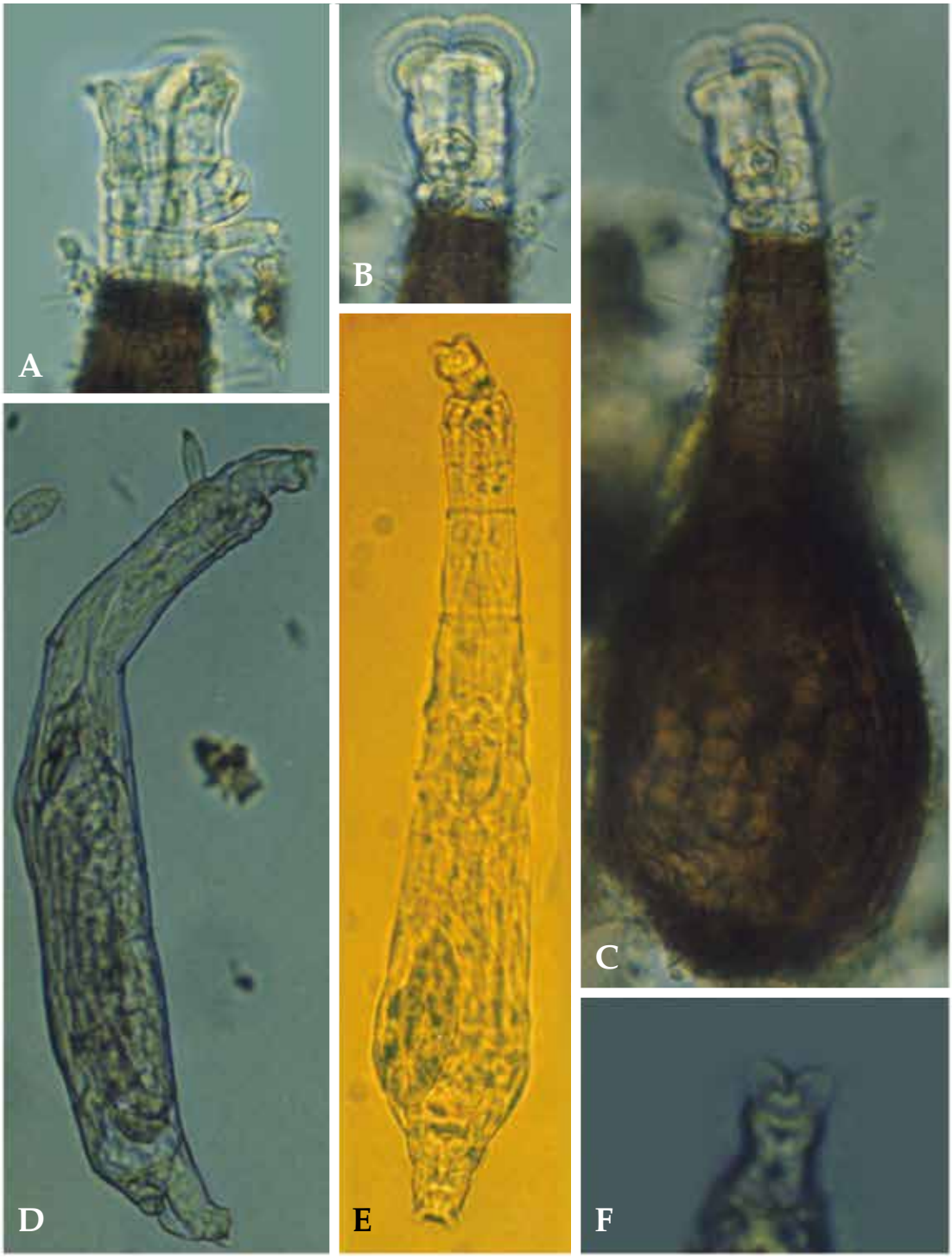


Plate 1. *Habrotrocha angusticollis angusticollis*. A. feeding head and neck, lateral view; B. feeding head, dorsal view; C. feeding in a shell, dorsal view; D. creeping, lateral view; E. creeping, ventral view; F. head and neck, ventral view.

Plate 2. *Habrotrocha aspera*. A. feeding, dorsal view; B. creeping, dorsal view; C. foot and spurs, ventral view.

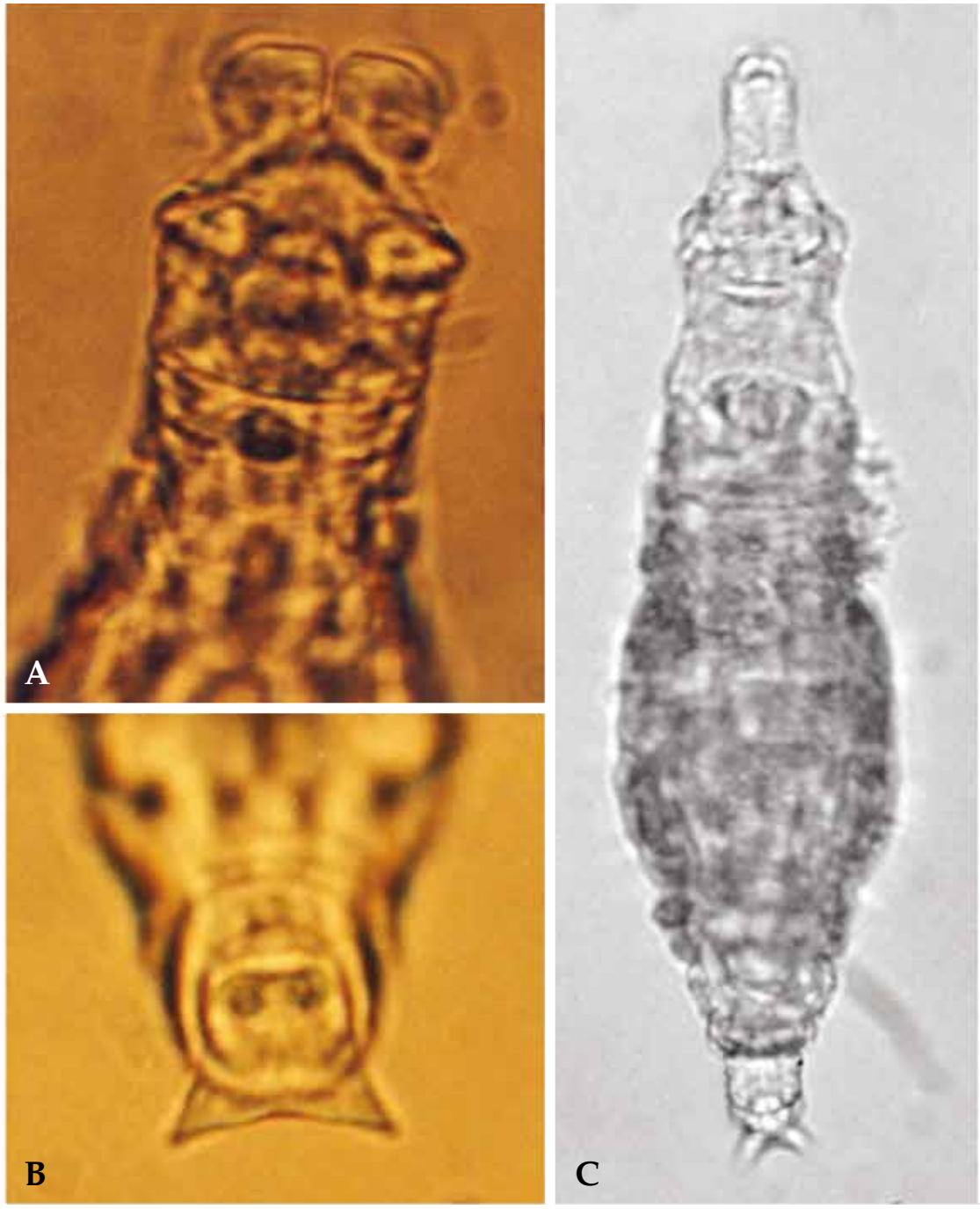


Plate 3. *Habrotrocha constricta*. A. feeding head and neck, dorsal view; B. foot, spurs and toes, ventral view. *Habrotrocha fusca*. C. creeping, dorsal view.

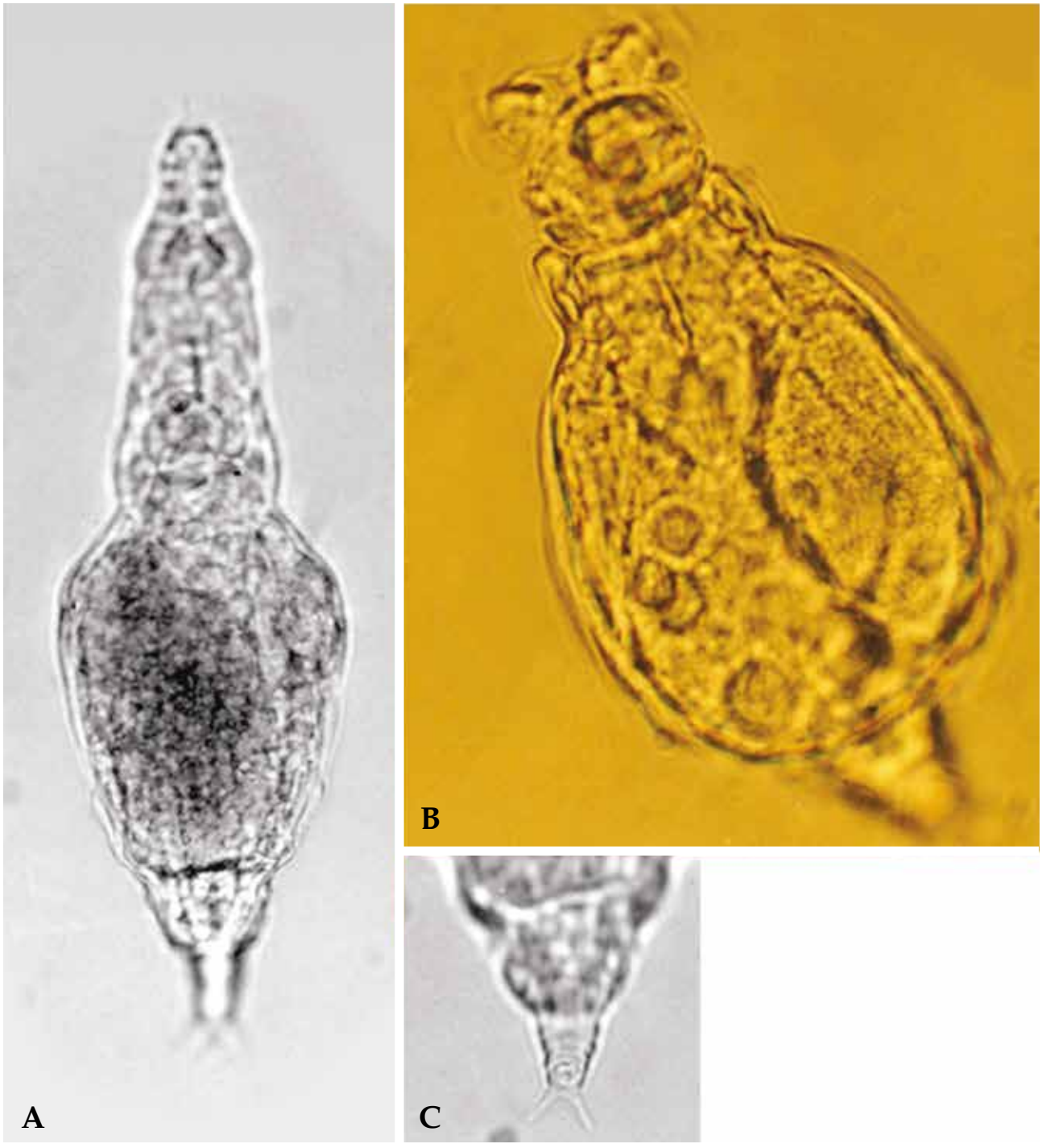


Plate 4. *Habrotrocha lata lens*. A. creeping, dorsal view; B. feeding, dorsal view; C. foot, spurs and toes, ventral view.

Plate 5. *Habrotrocha parvipes*. A. feeding, ventral view; B. feeding in a shell, dorsal view.

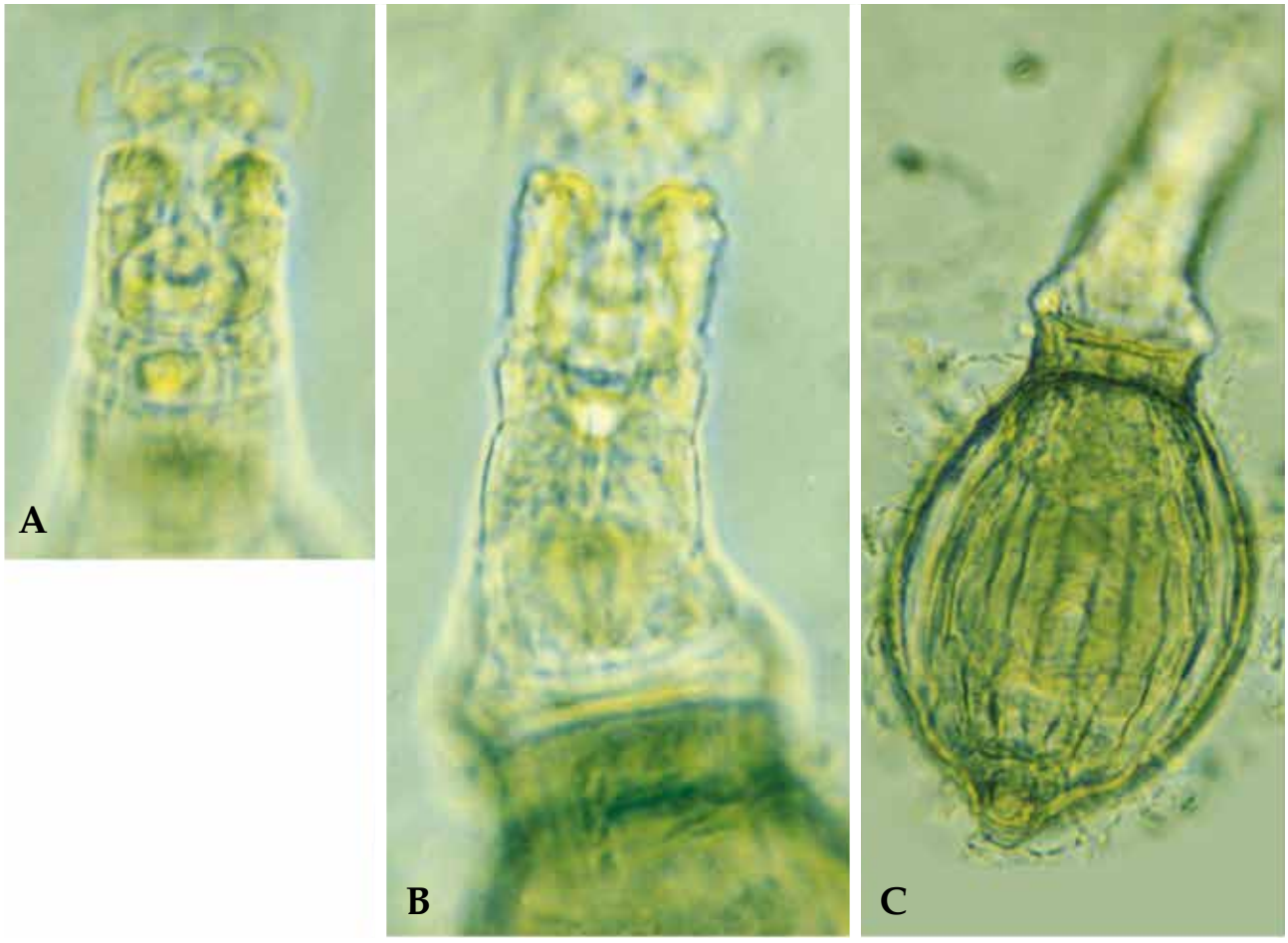


Plate 6. *Habrotrocha perforata*. A. feeding head and neck, dorsal view; B. feeding head and neck, ventral view; C. shell, dorsal view.

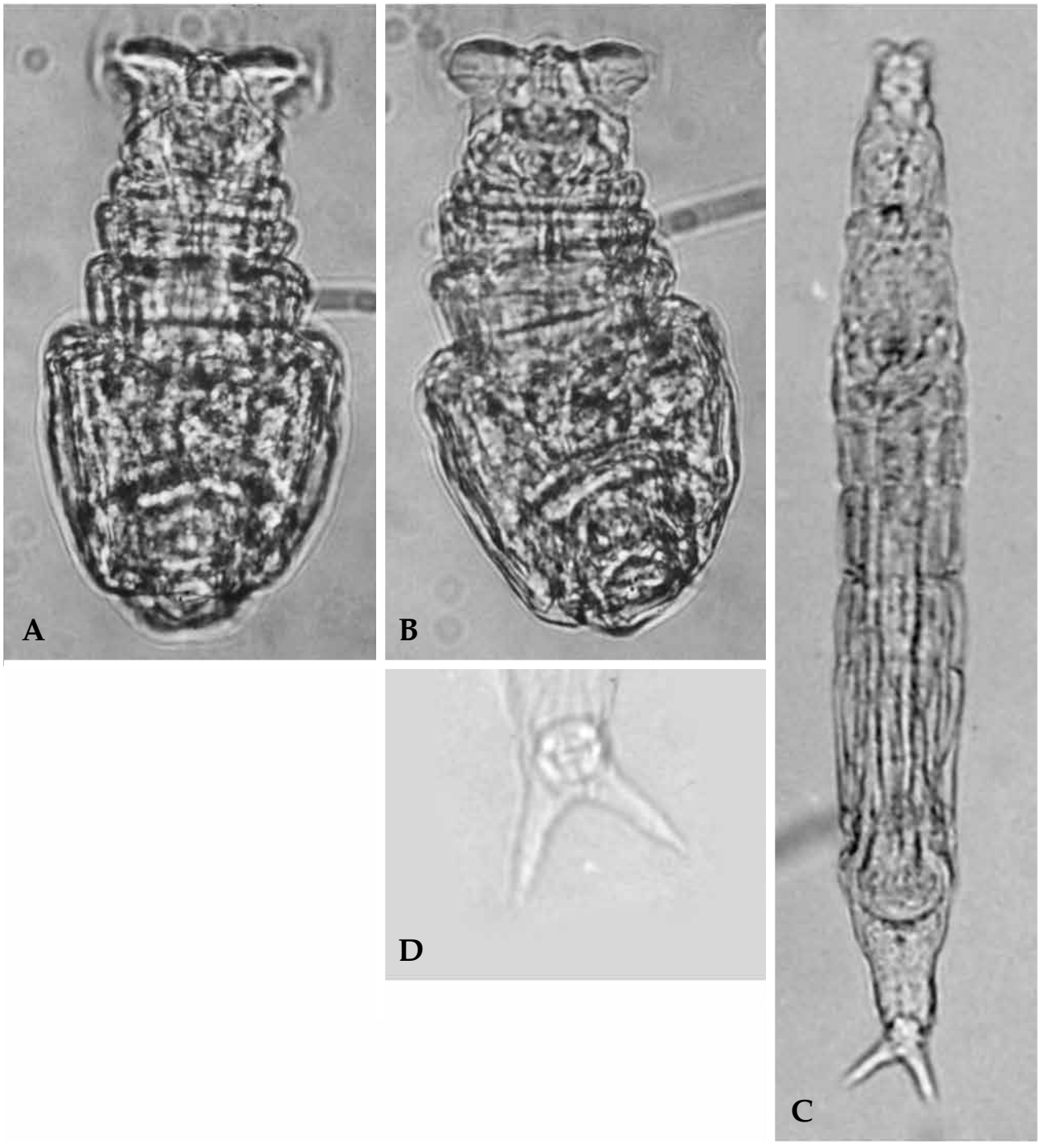


Plate 7. *Macrotrachela allani*. A, B. feeding, dorsal view; C. creeping, dorsal view; D. spurs and toes, ventral view.

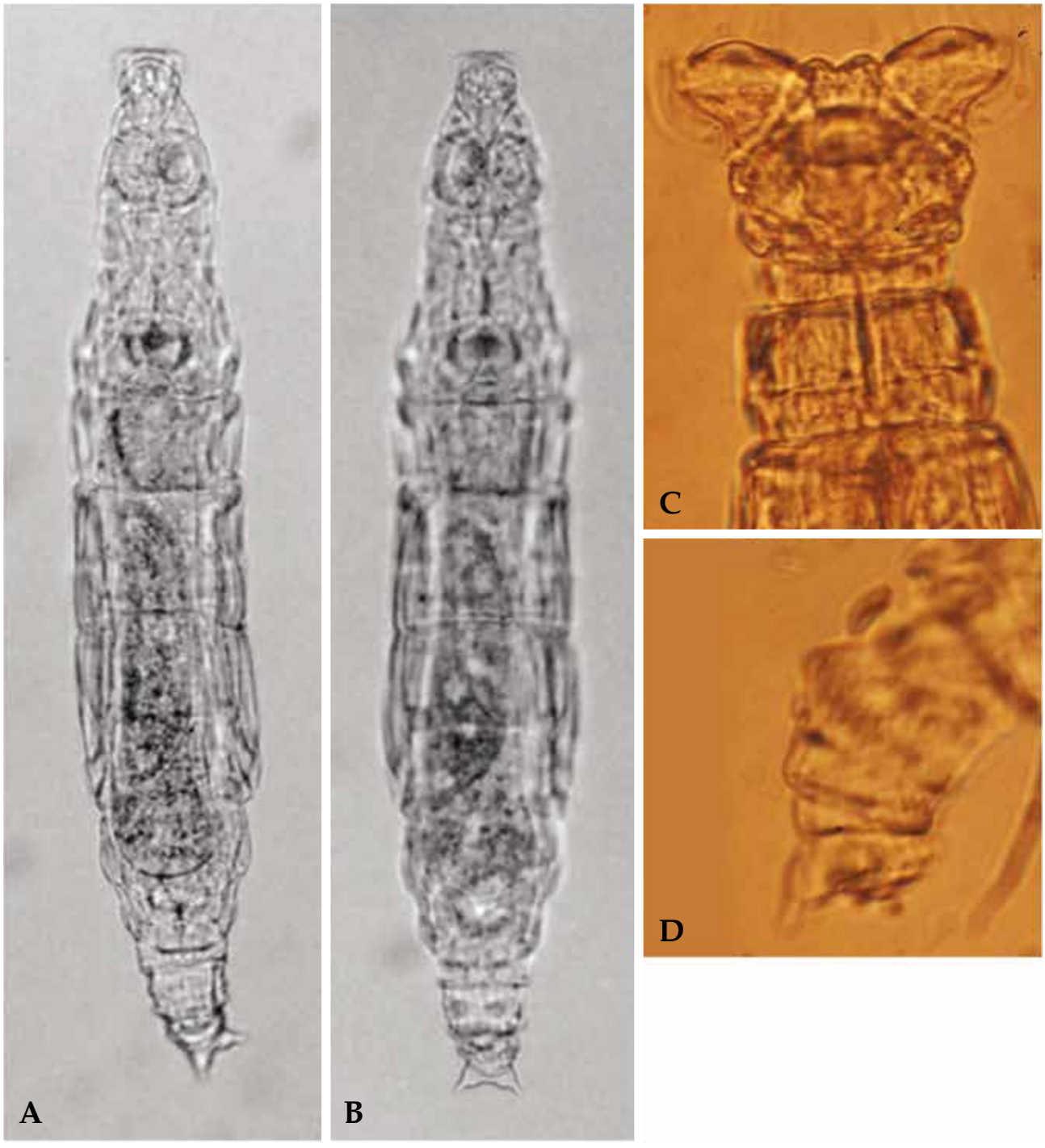


Plate 8. *Macrotrachela bullata*. A, B. creeping, dorsal view; C. feeding head and neck, dorsal view; D. foot and spurs, ventrolateral view.

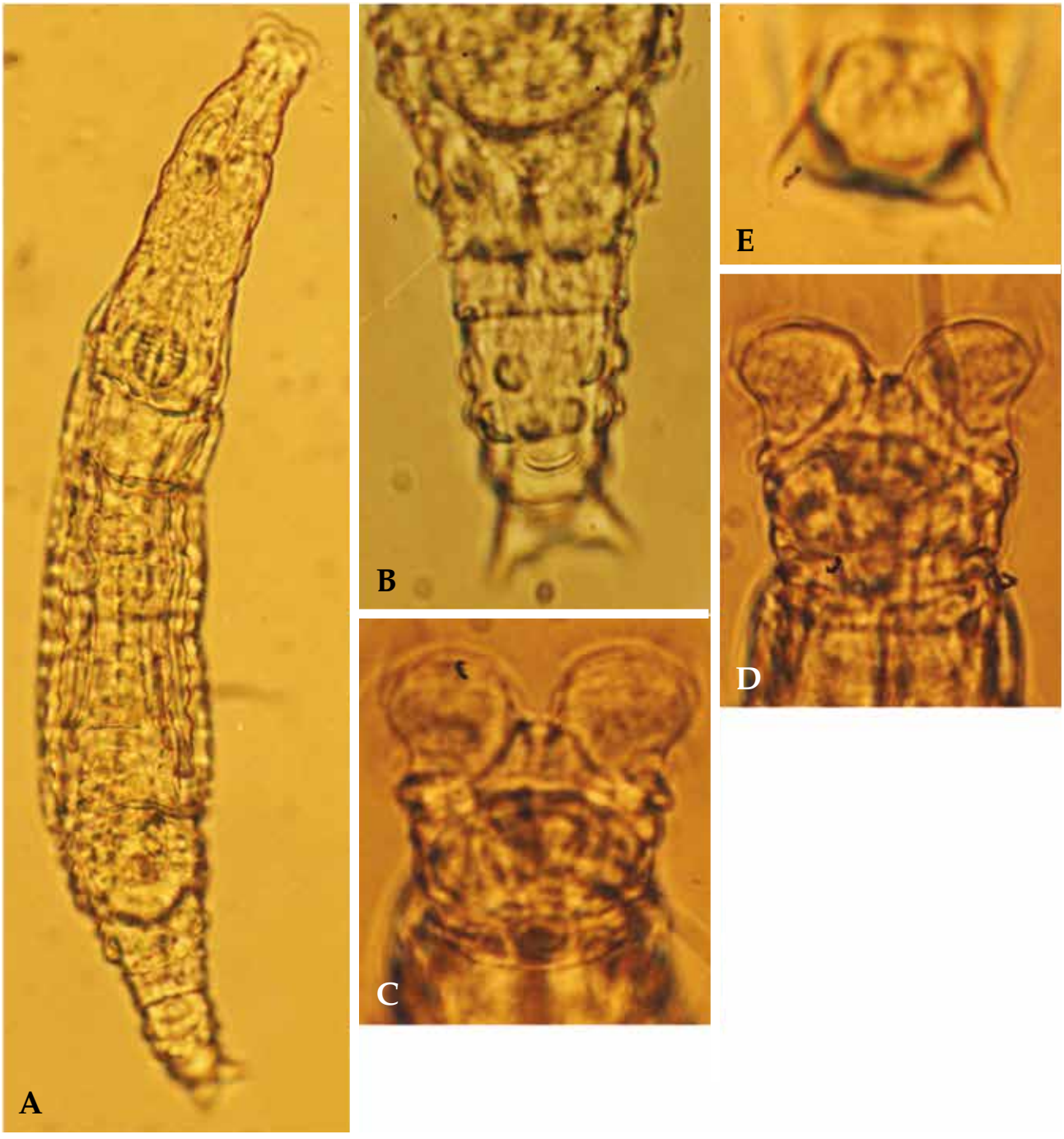
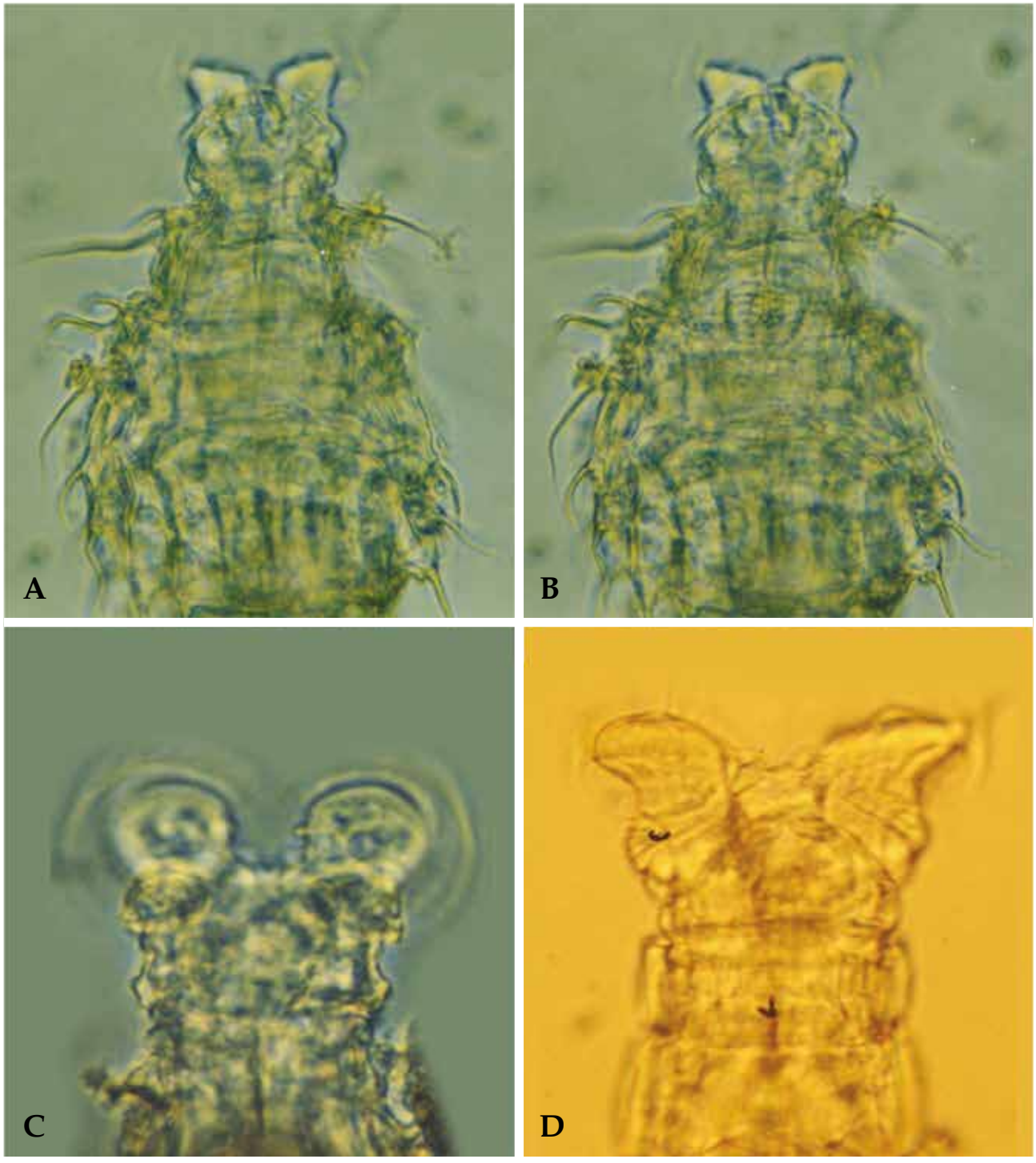


Plate 9. *Macrotrachela formosa*. A. creeping, dorsal view; B. creeping rump and foot, dorsal view. *Macrotrachela latior*. C, D. feeding head and neck, dorsal view; E. spurs and toes, ventral view.



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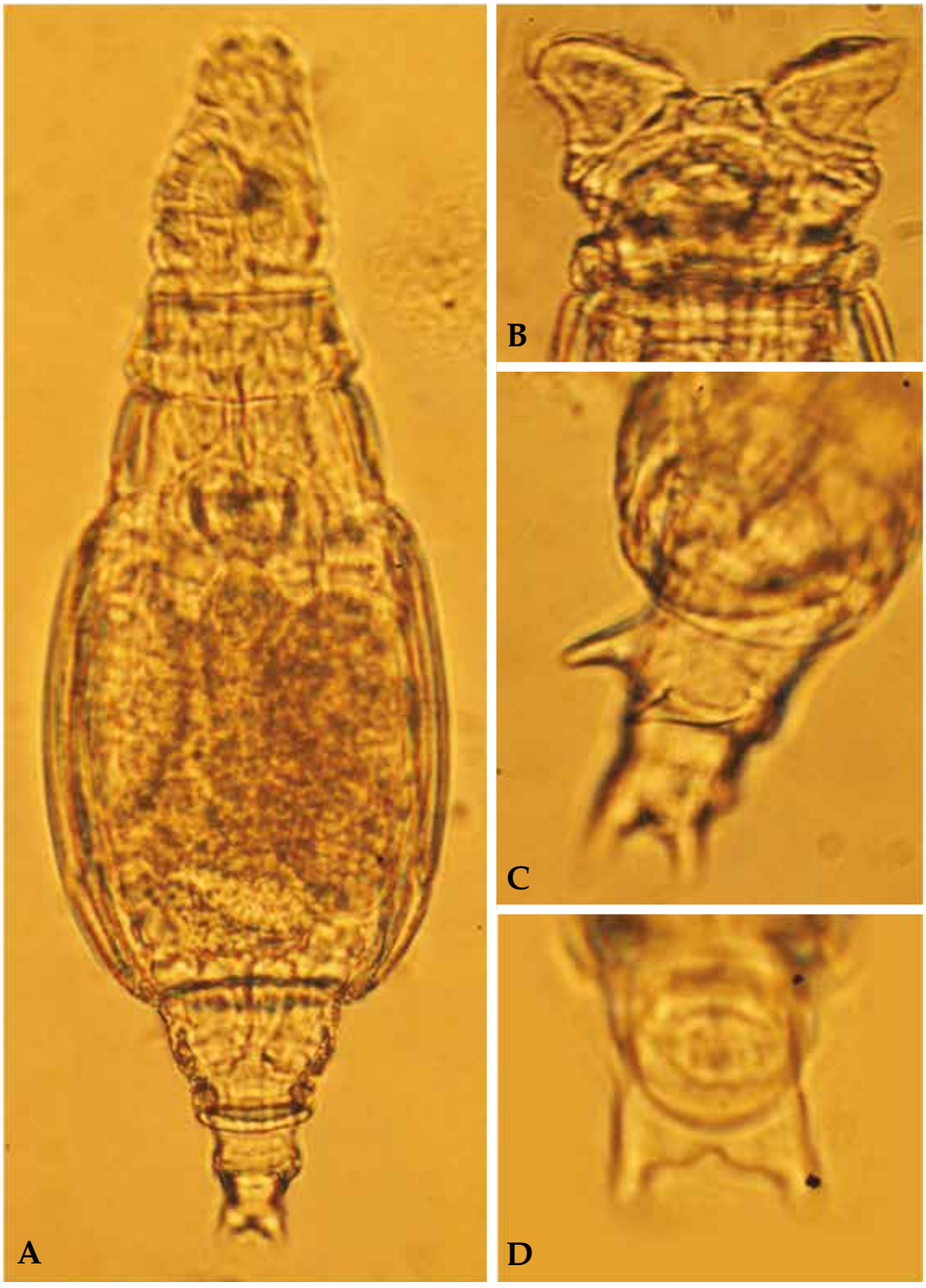

Plate 12. *Macrotrachela quadricornifera scutellata*. A. creeping, dorsal view; B. feeding head, dorsal view; C. rump, foot and spurs, dorsolateral view; D. spurs and toes, ventral view.

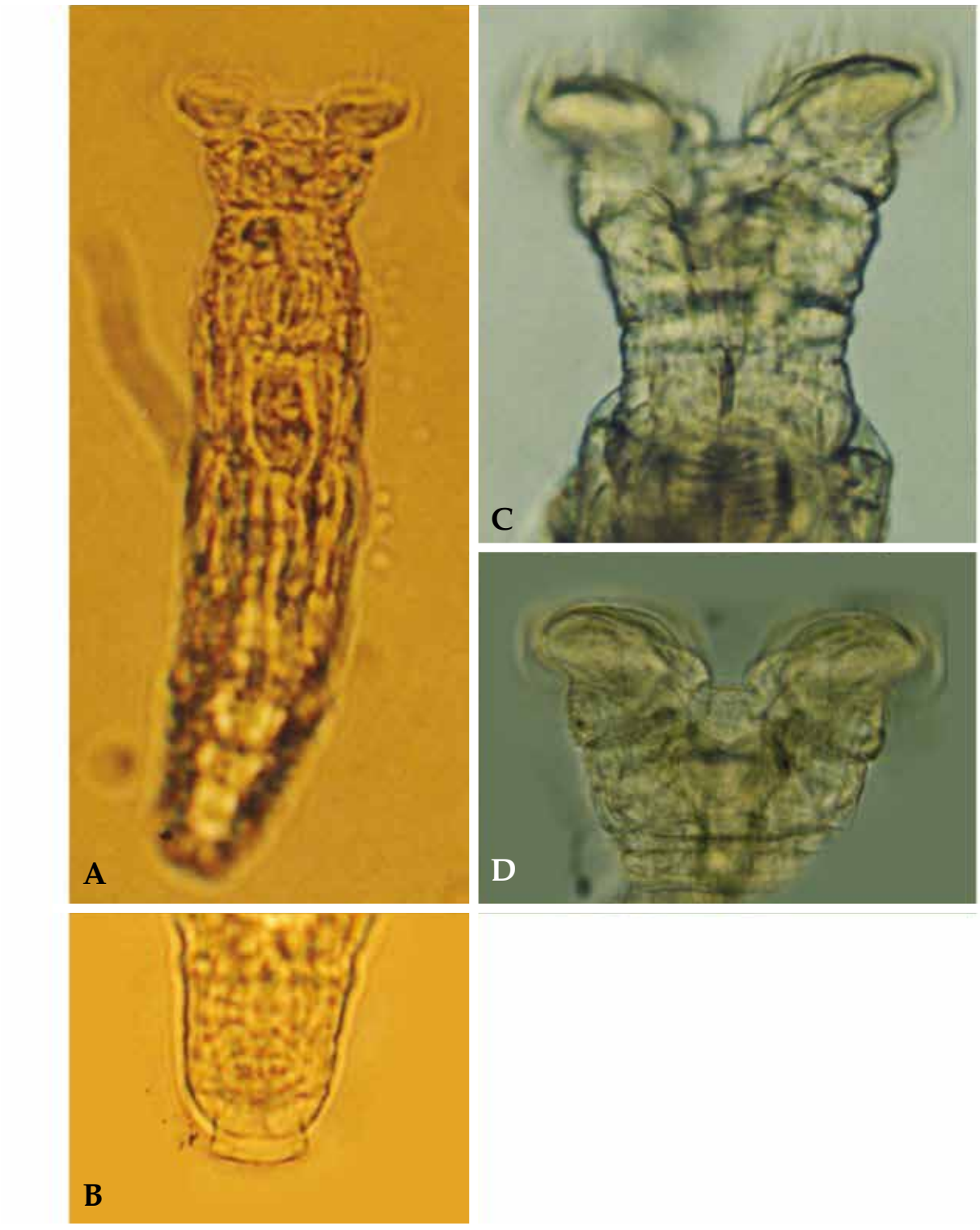

Plate 13. *Mniobia obtusicornis*. A. feeding, ventral view; B. spurs and adhesive disc, ventral view. *M. scarlatina*. C. feeding head, ventral view; D. feeding head, dorsal view.

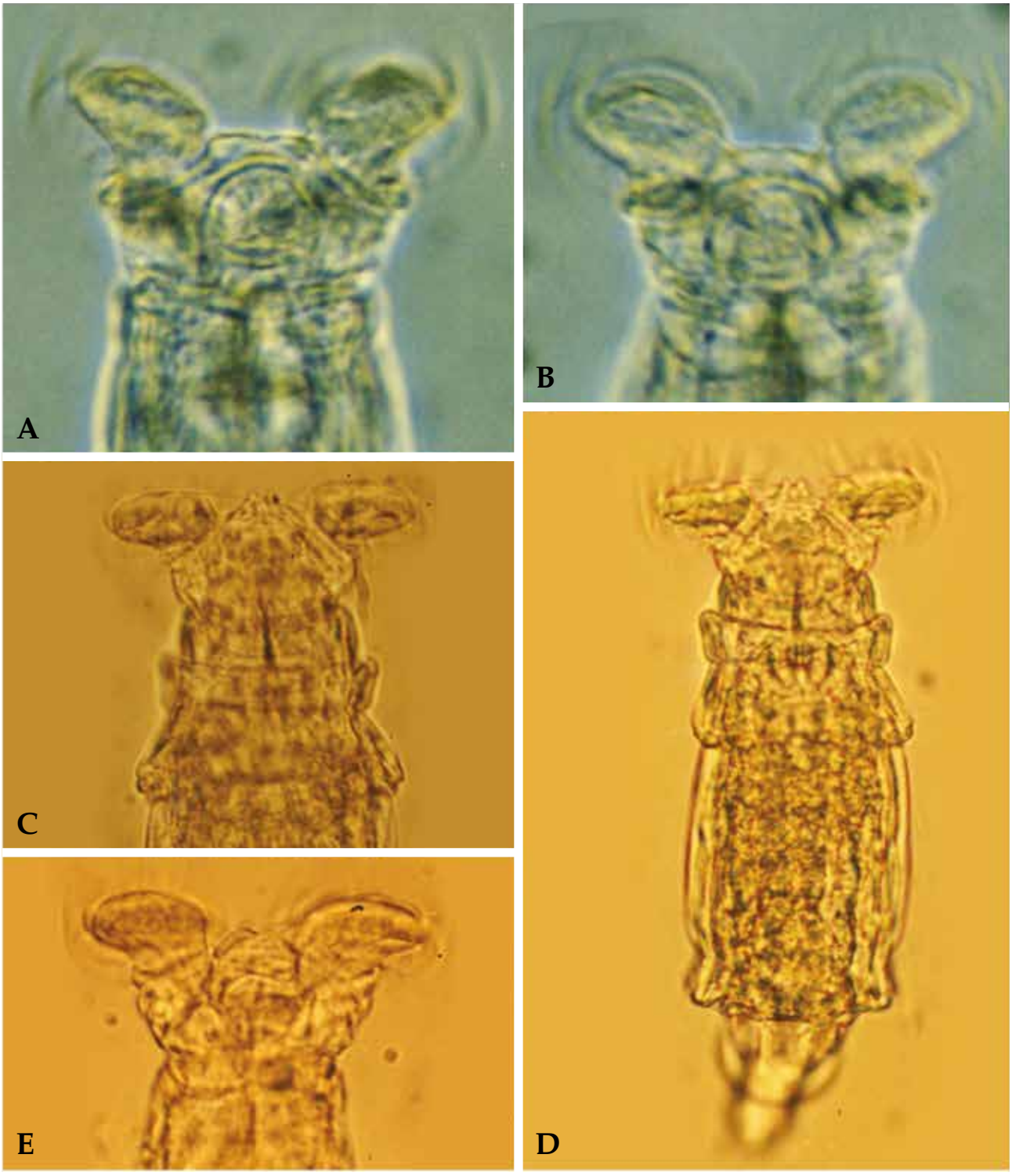

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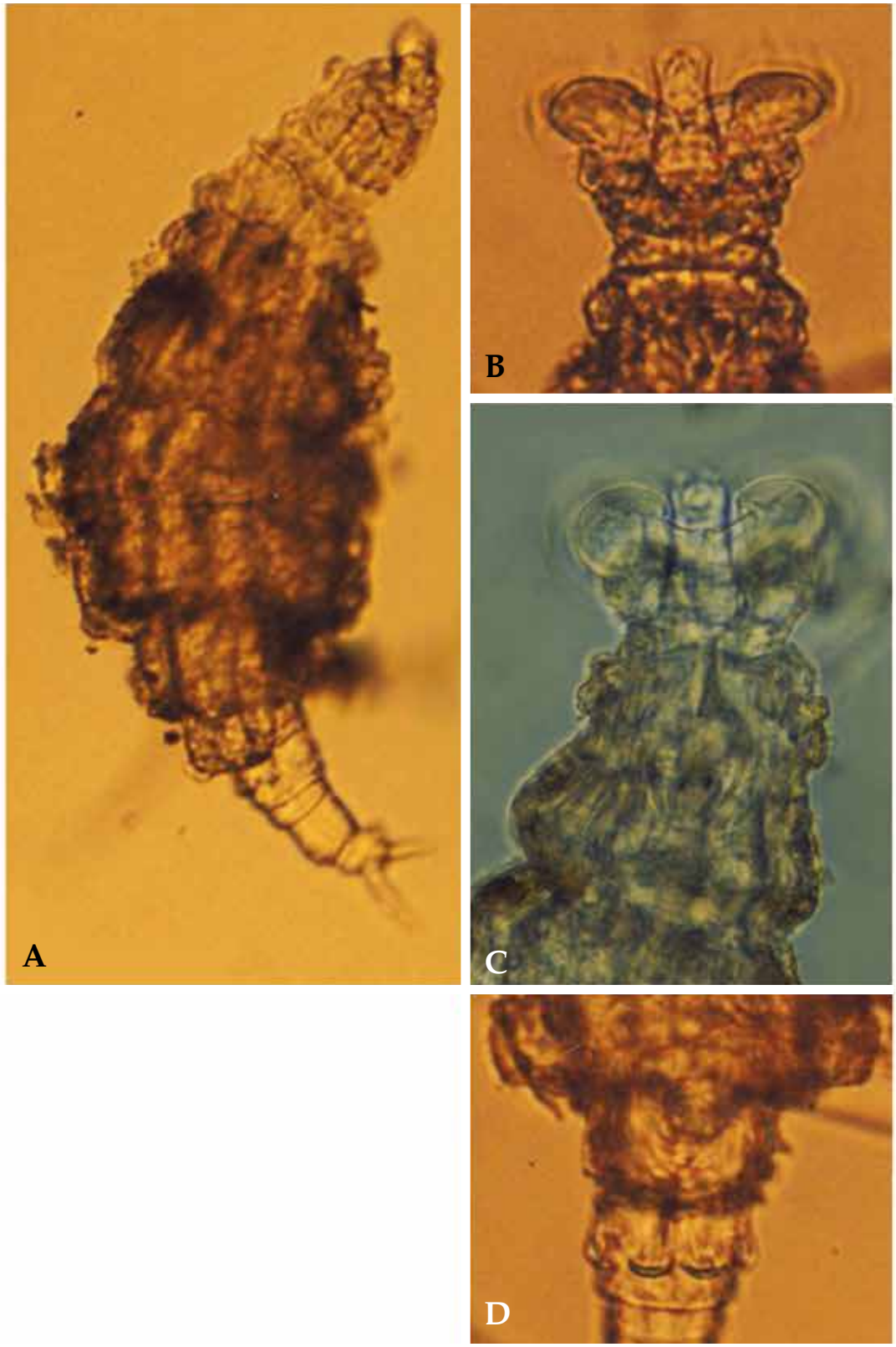
Plate 15. *Pleuretra brycei*. A. feeding, dorsal view; B. feeding, ventral view.



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National Institute of Biological Resources
Ministry of Environment