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TWO NEW SPECIES OF *CERATOPHYSELLA* (COLLEMBOLA: HYPOGASTRURIDAE) FROM KOREA

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ABSTRACT

Two new species of the genus *Ceratophysella* from Korea, *Ceratophysella biclavata* **n. sp.** and *Ceratophysella platyna* **n. sp.** are described and illustrated. *Ceratophysella biclavata* differs from the closely related species *Ceratophysella sigillata* (Uzel 1891) by the shape of antennal bulb on antennal segment IV, the number of clavate tenent hairs and the number of granules between p_1 upon abdominal segment V. *Ceratophysella platyna* resembles *Ceratophysella denticulata* (Bagnall 1941) and *Ceratophysella communis* (Folsom 1898), but distinctly differs from the latter by the shape of tenent hairs. A key to the identification of the Korean species of *Ceratophysella* is included. In addition, the known species *Hypogastrura gracilis* (Folsom 1899) is described and recorded for the first time from Korea.

Key Words: *Hypogastrura*, Poduromorpha, Arthropleona, springtail, Apterygota, South Korea

RESUMEN

Dos nuevas especies del género *Ceratophysella* de Korea, *Ceratophysella biclavata* **sp. n.** y *Ceratophysella platyna* **sp. n.** son descritas e ilustradas. *Ceratophysella biclavata* se distingue de la especie cercana *Ceratophysella sigillata* (Uzel, 1891) por la forma del bulbo antenal en el segmento IV de la antena, el número de setas adhesivas clavadas y el número de los gránulos entre p_1 en el segmento V del abdomen. *Ceratophysella platyna* se parece a *Ceratophysella denticulata* (Bagnall, 1941) y *Ceratophysella communis* (Folsom, 1898), pero difiere claramente de estos por la forma de las setas adhesivas. Una clave para la identificación de las especies coreanas de *Ceratophysella* es incluida. También se adjunta la especie conocida *Hypogastrura gracilis* (Folsom, 1899) la cual es descrita y registrada por primera vez en Korea.

The family Hypogastruridae is common, widespread, and has cosmopolitan distribution containing approximately 659 world species in about 40 genera. The genus *Ceratophysella* also with worldwide distribution is one of the largest genera in the family, with more than 108 known species (Bellinger et al. 2006). Their habits were noted by Hopkin (2002), who stated that they often form enormous swarms on roads, glaciers, snow, and on the surfaces of puddles. Individuals in the swarms all leap together in the same direction using the orientation of the sun to navigate. They have small expandable sticky sacs on their antennae that help them adhere to the substrate when they land after a jump to stabilize them (Hopkin 2002).

Eight species of the genus *Ceratophysella* occur in Korea. Yosii & Lee (1963) recorded *C. communis* (Folsom 1897), Lee (1974) added 4 species, *C. liguladorsi* Lee, 1974, *C. sinetertiaseta* Lee, 1974, *C. armata* (Nicolet 1841) and *C. duplicispinosa* Yosii, 1954. Later Thibaud & Lee (1994) added the species, *C. bengtssoni* (Agren 1904), and Lee & Kim (1995, 2000) recorded 2 species, *C. dolsana* Lee & Kim, 1995, *C. denticulata* (Bagnall 1941). We add here 2 new species of the genus *Ceratophysella* and 1 species of the genus *Hypogastrura* as additions to the Korean fauna.

The purpose of this paper is to describe 2 new species and to provide an identification key to the species of *Ceratophysella* from Korea. Lee & Kim (1995) described *C. dolsana* as a new species, but there is no description of the genus in their work. Most authors regarded *dolsana* as belonging in the genus *Hypogastrura* (Bellinger et al. 2006; Thibaud et al. 2004). However, we include it in the key of *Ceratophysella*, primarily on the basis of long p_2 seta on thoracic segments II-III and on the shape of mucro in holotype and paratypes. Morphological abbreviations used in this paper are as follows: Ant. I-IV: antennal segments I-IV; Th. I-III: thoracic segments I-III; Abd. I-VI: abdominal segments I-VI; seta *a* and *b*: seta *a* and *b* among the 7 dorsal sensory setae of Ant. IV; $a_1, 2 \dots$: setae 1, 2 ... of the anterior row counted from the "middle line"; $m_1, 2 \dots$: setae 1, 2 ... of the middle row, counted from the "middle line"; $p_1, 2 \dots$: setae 1, 2 ... of the posterior row, counted from the "middle line".

MATERIALS AND METHODS

Material was collected from 3 localities in Korea. Either an aspirator for direct collection or a Tullgren apparatus for extracting specimens was used. Collembola were fixed in 90% ethanol. Marc André I and II solutions were used to clear and

prepare specimen slides (Massoud 1967). KOH solution (10%) was used for rapid de-coloration. To prepare permanent slides, glycerine was placed along the cover glass edge to prevent the slide medium from drying. All type specimens are deposited in the Insect Collection of Biology Education Department, Chonbuk National University, Jeonju, Korea.

Ceratophysella biclavata,
new species

Description (Fig. 1). Body length 1,110-1,400 μm (1,200 μm long in holotype). Color dark brown or blackish brown on whole body except inter-segmental portions and the ventral side. Body cylindrical, being narrower abruptly at Abd.V (Fig. 1A). Head length 220 μm in holotype. Antenna shorter than head, 0.9 in ratio to head; ratio of length of antennal segments I:II:III:IV is 5:5:6:4. Ant. IV with a simple apical bulb and a closely associated small papilla, a socket seta and some weak setae (Fig. 1B), and with 7 dorsal sensory setae of which seta *a* and *b* thickened. Eversible sac between Ant. III and Ant. IV distinctly developed. Ant. III organ with 2 short sensory and 2 guard sensilla (Fig. 1D). Mandible with 4 apical teeth (Fig. 1F). Eyes 8 + 8, eye patch with 3 setae. Postantennal organ (PAO) consists of 4 peripheral tubercles, about 1.2-1.5 times as long as the diameter of the nearest ocelli, with anterior lobes distinctly larger than posterior and with a small accessory tubercle (Fig. 1C). Tenent hairs 2, 2, 2 with distal end weakly clavate. Unguis elongate, with an inner tooth and a pair of lateral teeth. Unguiculus setaceous and with broad, rounded basal lamella (Figs. 1I-K). Ventral tube with 4 setae on each half. Tenaculum with 4 + 4 barbs without setae (Fig. 1E). Dens dorsally finely granulated and with 7 setae, 4 of them thicker than the others, about twice as long as mucro. Mucro apically rounded and with well developed outer lobe, anterior margin modified to form a tooth-like thickening from which a thin lamella extends basally (Fig. 1H). Abd.V with a granulated medial stripe, granules not modified, but arranged rather regularly. Mostly 11-13 granules lying between the p_1 seta on Abd.V (Fig. 1L). Anal spines 1/2-2/3 as long as inner unguis and about 2-2.5 times as long as papillae. On Abd. VI, a_1 shorter than anal spine including anal papilla (Fig. 1G).

Chaetotaxy. Area verticalis confluent with area occipitalis and with 2 + 2 setae. Th. I with 3 + 3 setae in a row. Th. II and III composed of 3 rows of setae, lacking m_2 , p_2 a macrosetae and p_4 the sensory seta. Abd. I-III with 2 rows of setae, p_2 a macroseta and p_5 the sensory seta. Abd. IV with 3 rows of setae, lacking a_2 , m_2 and m_3 ; p_1 longer than p_2 and p_3 . Abd. IV setae often asymmetric in position. Abd. V with 2 rows of setae, p_1 longer than p_2 , a_2 lacking and p_3 sensory seta (Fig. 1M).

Type Materials

Holotype: Female, Temple Jeongamsa, Gacheon-ri Dongmyeong-myeon Chilgok-gun, Gyeongsangbuk-do Province, collected from litter soil layer of the forest near stream. 24-X-2004, collection no. 204-21. **Paratypes:** 2 males and 3 females, same data as holotype.

Etymology. The specific name is derived from the number and shape of tenent hairs in each leg.

Remarks. The present species is very similar to *C. sigillata* (Uzel 1891), and redescribed by Babenko et al. (1994), in chaetotaxy of thorax and abdomen, in shape of mucro and basal lamella of unguiculus and in shape of seta on dens. However, they can be separated easily by differences in the shape of antennal bulb on Ant. IV, the number of tenent hairs on each leg and in the number of granules between p_1 upon Abd.V. Number of granules between p_1 of Abd. V is 20-25 in *C. sigillata* and 11-13 in the present new species. Also, the present species differs from *C. sigillata* by the strongly developed eversible sac (weakly developed in *C. sigillata*) and the absence of hook-like sensilla upon fourth antennal segment (Table 1).

Ceratophysella platyna,
new species

Description (Fig. 2). Body length 1,200-1,400 μm (1,200 μm long in holotype). Body dark brown with blue pigment scattered over dorsum of segments in the form of irregular transverse bands (Fig. 2A). Head length 270 μm in holotype. Antenna shorter than head, 0.8 length of head; ratio of length of antennal segments I:II:III:IV is 3:4:5:6. Fourth antennal segment with a simple apical bulb and a closely associated protective papilla, giving a bilobed appearance to the antennal apex; lacking ventral file, but with 11-13 relatively long straight setae and seven clear blunt setae (Figs. 2B, E). Eversible sac between Ant. III and IV distinctly differentiated. Left mandible with 5 apical teeth and right with 4 apical teeth (Figs. 2D, H). Postantennal organ with 4 peripheral tubercles, a small accessory tubercle, anterior lobes strikingly larger than posterior and about 1.5 times as long as nearest ocelli. Eye patch with 8 ocelli on each side (Fig. 2C). Unguis slender, slightly curving distally, with 1 inner tooth on internal lamella. Unguiculus pointed and with a basal lamella tapering into a filament, almost $\frac{1}{2}$ as longer internal lamella of unguis. Tenent hairs 1, 1, 1 almost as long as outer unguis and truncate to feebly clavate (Fig. 2G). Ventral tube with 3 + 3 setae. Tenaculum with 4 + 4 barbs. Dens about twice as long as mucro, with 7 posterior setae, without basally enlarged angled setae (Fig. 2F). Outer unguis 1.5 times as long as mucro. Mucro 0.8-0.9 times as long as anal spines. Body setae all smooth and slender. Integument

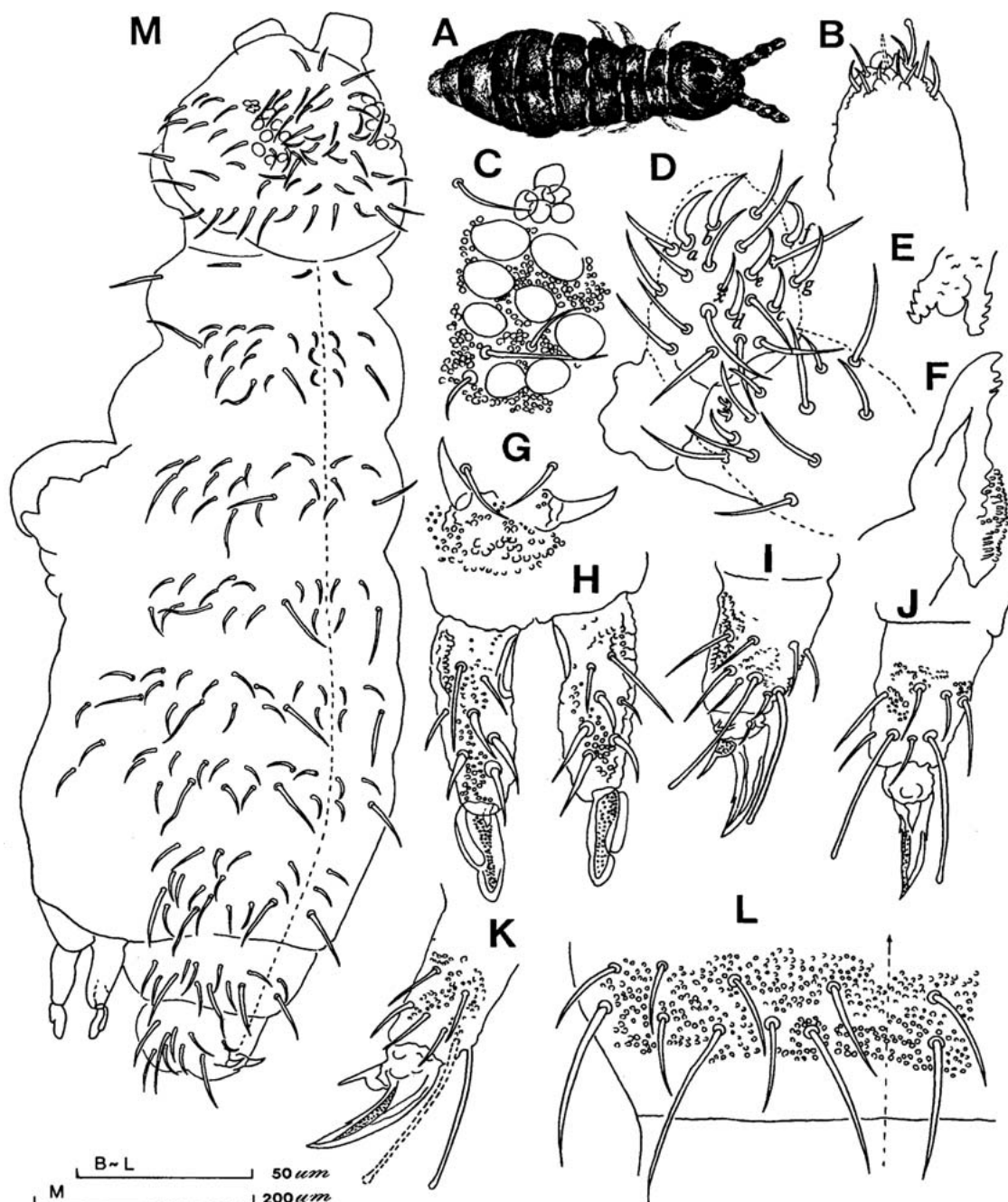


Fig. 1. *Ceratophysella biclavata* n. sp. A. Habitus. B. Apical view of antenna IV segment. C. Postantennal organ (PAO) and 8 ocelli. D. Dorsal view of antenna III, IV segments and the expandable sac between antennal segment III and IV. E. Tenaculum. F. Mandible. G. Anal spine. H. Dorsal view of mucro and dens. I. First leg. J. Second leg. K. Third leg. L. Abdomen V segment. M. Dorsal chaetotaxy of body.

moderately granular. Granular stripe on Abd. V arranged regularly, 9-12 granules lying between the p_1 setae on Abd. V (Fig. 2I). Fovea lying between the p_1 . Anal spines slender, on unusually

large contiguous papillae. On Abd. VI, a, nearly as long as anal spine including anal papilla (Fig. 2J).

Chaetotaxy. Area verticalis confluent with area occipitalis and with 2 + 2 setae. Th. I with 3

TABLE 1. DIAGNOSTIC CHARACTERS FOR *CERATOPHYSELLA SIGILLATA* AND *CERATOPHYSELLA BICLAVATA* N. SP.

Species/Character	<i>C. sigillata</i>	<i>C. biclavata</i> n. sp.
The number of clavate tenent hairs	1, 1, 1	2, 2, 2
Ant. IV antennal bulb	a simple apical bulb	a simple apical bulb and a closely associated small papilla
The number of granules between p ₁ upon Abd. V	20-25 grains	11-13 grains
Eversible sac	weakly developed	strongly developed
hook-like sensilla upon Ant. IV	Present	absent

+ 3 setae in a row. Th. II and III with 3 rows of setae, m₂ and m₃ absent, p₂ a macroseta and p₄ the sensory seta. Abd. I-III with 2 rows of setae, without m-seta, with a₂', p₂ a macroseta and p₅ the sensory seta. Abd. IV with 3 rows of setae, a₁ slightly laterally dislocated, a₂, m₂ and m₃ absent, p₂ longer than p₁ and p₅ the sensory seta. Abd. V with 2 rows of setae, without a₂', p₁ longer than p₂, a₂ lacking and p₃ the sensory seta (Fig. 2K).

Type Materials

Holotype: Male, 700 m a.s.l., Mt. Moacksan, Gui-myeon, Wanju-gun, Jeollabuk-do Province, collected from the leaf litter under snow, 14 Feb 2004, collection no. 204-01-1. Paratypes: 2 males and 2 females, same data as holotype.

Etymology: The specific name, *platyna*, refers to the shape of body in this species.

Remarks: This species is characterized by the presence of an antennal bulb and the shape of tenent hairs. In many respects this species resembles *C. pratorum* of *C. boletivora*-group from North America (Christiansen & Bellinger 1998), but they differ in chaetotaxy. The present species is a member of Gisin's A type (Gisin 1947) with p₂ seta longer than p₁ seta on Abd. IV (p₁ > p₂ in *C. pratorum*). The antennal bulb clearly separates *C. platyna* n. sp. from *C. boletivora* and *C. biloba* of *C. boletivora*-group. Also, the present species is closely related to palaearctic species *C. annae* described by Babenko (1994), but is distinguished by the darker body colour, the presence of eversible sac and having 7 dorsal sensilla setae on Ant. IV (*C. annae* has 6). Chaetotaxy of the present species is similar to *C. communis* (Folsom) from Korea (Lee 1974; Lee & Thibaud 1975) by the presences of the a₂' seta on Abd. I-III, the absence of the a₂' seta on Abd. V, but it is separated from the latter in the shape of tenent hairs and the number of granules between p₁ upon Abd. V. It also has the same number of granules between p₁ upon Abd. V with cosmopolitan *C. denticulata* (Bagnall 1941) (Yosii 1962; Lee & Kim 2000). However, this new species is distinctly different from *C. denticulata* and *C. communis* in the shape of tenent hairs (Table 2).

Hypogastrura gracilis (Folsom, 1899),
new record

Diagnosis (Fig. 3). Body length 1,500-1,900 µm (1,700 µm long in holotype). Color grey or blackish brown on whole body except only inter-segmental portions and the ventral side. Body laterally swollen at Abd. II and III, being gradually narrower toward posterior end (Fig. 3A). Head length 310 µm in holotype. Antenna longer than head, ratio 1.1 to head length; ratio of length of antennal segments I:II:III:IV is 12:13:18:30. Fourth antennal segment with a distal, slightly trilobed end-bulb and a number of socket setae, with 3 weak setae each on a slightly differentiated, small subapical papillae (Figs. 3C, E). Third antennal segment organ of 2 small rods in a shallow groove accompanied by 2 curved setae. Labrum with 4/5, 5, 4 setae, their distal row very weak. Labral margin with 4 rounded tubercles (Fig. 3H). Postantennal organ of 4 peripheral tubercles, with or without a small accessory tubercle, subequal to nearest ocelli (Figs. 3B, D). Eyes 8 + 8, on black patches. Unguis of all legs subequal, relatively small, dorsally carinate and with 1 inner tooth near the distal end. Unguiculus setaceous and reaching three-quarters of the distance from base to apex of unguis. Basal half with lamella on the inner side apically arcuate. Tenent hairs 2, 3, 3 rather thick and conspicuously swollen at apex. Median tenent hairs larger than others and above the level of others on the second and third legs (Fig. 3F). Ventral tube with 4+4 setae. Tenaculum with 3 + 3 barbs. Dens almost smooth dorsally with 7 setae, about 4 times as long as mucro. Mucro strongly compressed bilaterally and somewhat blade-shaped (Fig. 3G). Mucro 3.7-5.5 (mostly 4) times as long as anal spines. Outer unguis 1.3-1.8 times as long as mucro. Anal spines 0.25 times as long as inner unguis and subequal to anal papillae. All body setae short and fine.

Chaetotaxy. Th. I with 3+3 setae in a row. Th. II and III composed of 3 rows of setae, p₄ a little longer than others, sensory seta on Th. II without m₃ seta and Th. III without m₂, m₃, a₃ setae. Abd.



Fig. 2. *Ceratophysella platyna* n. sp. A. Habitus. B. Ventral view of antenna IV segment. C. Postantennal organ (PAO) and 8 ocelli. D. Left mandible. E. Dorsal view of antenna IV segment. F. Dorsal view of mucro and dens. G. First leg. H. Right mandible. I. Abdomen V segment. J. Anal spine. K. Dorsal chaetotaxy of body.

TABLE 2. DIAGNOSTIC CHARACTERS FOR *CERATOPHYSELLA PLATYNA* N. SP.

Species/Character	<i>C. denticulata</i>	<i>C. communis</i>	<i>C. platyna</i> n. sp.
Shape of tenent hair	acuminate	acuminate	clavate
The number of granules between p ₁ upon Abd. V	9-12 grains	20 grains	9-12 grains
a ₂ ' seta on Abd. V	present	absent	absent

I-III bearing two rows of setae, p₂ a macroseta and p₅ the sensory seta. Abd. IV with three rows of setae and p₄ sensory seta. Abd. V bearing 2 rows of setae, p₁ longer than p₂, and p₃ the sensory seta (Fig. 3D).

Material Examined. Numerous specimens collected from soil samples taken from mixed forest floor at Bisugumi, Dongchon, Hwacheon-eup, Hwacheon-gun, Gangwon-do Province. 15 Nov 2003, collection no. 203-27. Numerous specimens collected from litter of natural mixed forest consisting of coniferous and broad-leaved trees 300 m a.s.l., at the foot of Mt. Obongsan Gui-myeon Wanju-gun Jeollabuk-do Province. 10 Dec 2005, collection no. 205-33.

Remarks. This specimen generally correlates with the descriptions by Yosii (1960) from Japan. Some minor differences are observed, however, in the fourth antennal segment setae, in the presence or absence of accessory tubercle, in the position of the median tenent hair on the second and third legs. In addition, the present material is shown to have some local variation as compared to the original description. More extensive collections must be examined to determine whether this is a geographically variable species or a group of several similar species. The present species resembles *H. bulba* Christiansen & Bellinger 1980 of the *viatica* group in the trilobed antennal bulb. But it differs somewhat from *H. bulba* in the length ratio of mucro and dens, the number of tenent hairs on each leg (2, 3, 3 or 3, 3, 3 in *H. bulba*), and relative length of anal spine to anal papilla. Also, this species is similar to *H. tullbergi* (Schäffer 1900), but differs in the absence of spine-like setae on the apex of the third antennal segment.

Distribution. Japan, Korea (new record).

DISCUSSION

The species of *Ceratophysella* are characterized by having a well developed unguiculus and a spoon-shaped mucro with a lateral lamella. Posterior arms of postantennal organ are large, and seta m₂ on thoracic segment II is absent. In Japan, about 12 species are recorded (Furuno et al. 2000; Tamura 2001). Three species are known to occur in China (Zhao et al. 1997).

The taxonomic status of the members of genus *Ceratophysella* have been described by several researchers world-wide (Yosii 1960, 1962; Bourgeois & Cassagnau 1972; Bonet et al. 1973; Christiansen & Bellinger 1998; Babenko et al. 1994; Thibaud 2004). According to Yosii (1960, 1962), 3 species-groups are recognized in the genus *Ceratophysella*: *communis*, *armata*, and *denisana*-groups. The *communis*-group has the chaetotaxy of Gisin's A type (1947), which seta p₂ on Abd. IV larger than p₁ and is represented by *C. denticulata* Bagnall 1941 in Europe. The chaetotaxy of *armata*-group represents Gisin's B type (1947), which seta p₂ on Abd. IV smaller than p₁. Chaetal arrangement of *Ceratophysella biclavata* **n. sp.** is typical for the *armata*-group in the chaetotaxy of Abd. IV. *Ceratophysella platyna* **n. sp.** is clearly different from *armata*-group in the chaetotaxy of Abd. IV, where seta p₂ is longer than p₁ and p₃. Microsetae and macrosetae of the species weakly differentiated, but some setae as p₂ on Th. II and III, p₂ on Abd. I-IV and p₁ on Abd. V are longer than others, thus indicating the *communis*-group of chaetotaxy, that is Gisin's A type. *Ceratophysella platyna* **n. sp.**, commonly forms enormous swarms under leaves covered with snow.

In the present study, 2 new species and 1 newly recorded species are recognized in Korea. As result of this study, the Korean faunal list of Hypogastruridae consists of 28 species in 6 genera.

KEY TO 10 SPECIES OF *CERATOPHYSELLA* FROM KOREA

- 1. Fourth abdominal segment with seta p₁ longer than seta p₂ 2
- . Fourth abdominal segment with seta p₁ shorter than seta p₂ 8
- 2. Fourth abdominal segment with seta p₂ and seta p₃ short, sensory seta p₅ 3
- . Fourth abdominal segment with seta p₂ short and seta p₃ long, sensory seta p₄ 7
- 3. Fifth abdominal segment, an integumentary process "languette" present *liguladorsi*
- . Fifth abdominal segment, an integumentary process "languette" absent 4
- 4. Dens with bladder-like swelling *bengtssoni*

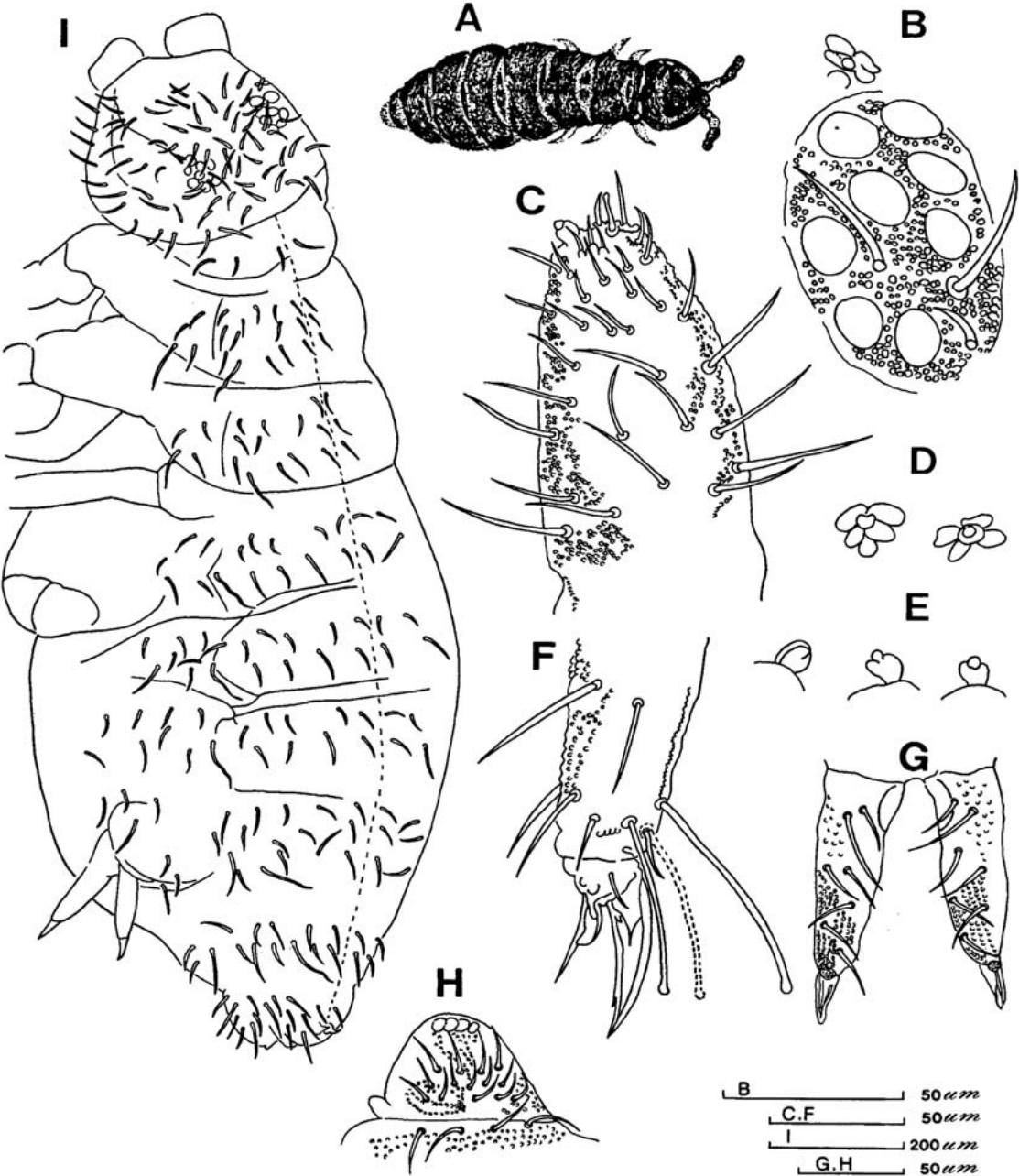


Fig. 3. *Hypogastrura gracilis*. A. Habitus. B. Postantennal organ (PAO) and 8 ocelli. C. Dorsal view of antenna IV segment. D. Various types of postantennal organ (PAO). E. Various types of fourth antennal segment apical bulb. F. Second leg. G. Dorsal view of mucro and dens. H. Labrum. I. Dorsal chaetotaxy of body.

- Dens without bladder-like swelling 5
- 5. Fourth antennal segment with conspicuous ventral “file”, tenent hair acuminate *armata*
- Fourth antennal segment without conspicuous ventral “file”, tenent hair clavate or truncate 6
- 6. p_6 , p_5 and p_4 sensory setae upon Abd. I-III, Abd. IV and Abd. V, respectively. Tenent hairs 1, 1, 1 and apical bulb of fourth antennal segment trilobed *dolsana*

- p_5 , p_6 and p_7 sensory setae upon Abd. I-III, Abd. IV and Abd. V, respectively. Tenent hairs 2, 2, 2 and apical bulb of fourth antennal segment unilobed. *biclavata* **n. sp.**
- 7. Two spines present in the position of p_1 setae on Abd. V. *duplicispinosa*
- Two spines absent in the position of p_1 setae on Abd. V *sinetertiaseta*
- 8. Abd. V with a_2' setae; tenent hair acuminate; 9-12 granules between p_1 upon fifth abdominal segment *denticulata*
- Abd. V without a_2' setae. 9
- 9. Tenent hair acuminate; 20 granules between p_1 upon fifth abdominal segment. *communis*
- Tenent hair clavate or truncate; 9-12 granules between p_1 upon fifth abdominal segment *platyna* **n. sp.**

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