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Research paper

Taxonomic Review of the Cave Dwelling Springtail Tomoceridae (Collembola) in Korea

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Abstract

The family Tomoceridae is the most abundant and diverse group of cave-dwelling Collembola with 8 known species in 5 genera in Korea. In this study, 19 species in 6 genera of the Korean cave-dwelling Tomoceridae are reviewed including two new species, *Tomocerus koreanus* Chang and Bae, sp. n., and *Tomocerus sanho* Chang and Bae, sp. n., and two new Korean records, *Plutomurus riugadoensis* Yosii and *Plutomurus suzukaensis* Yosii.

Key words: Collembola, cave-dwelling springtails, Tomoceridae, *Plutomurus*, *Tomocerus*

Introduction

The cave salamander *Proteus anguinus* Laurenti, 1768, was described for the first time in Europe as the first cave dwelling organism (Choi 2006). In Korea, cave dwelling fauna was investigated during 1960s, and 101 species belonging to 71 genera, 50 families, and 3 classes were reported from Korean caves (Yosii 1966). Korean Collembola fauna was comprehensively studies during 1970–1990s including a report of a new family Gulgastruridae based on *Gulgastrura reticulosa* Yosii, 1966 from the Gossidonggul cave in Gangwon-do (Lee 1974). A list of cave dwelling Collembola including the family Tomoceridae was published by Park and Lee (1995). From the above studies, 8 families of cave dwelling Collembola including 8 species in 5 genera of Tomoceridae are known in Korea.

The purpose of this study is to review known species of cave dwelling Tomoceridae and newly describe the species in Korea.

Materials and methods

Members of the Tomoceridae are the most common and widespread among cave dwelling springtails in Korea. For this study, approximately 40 caves in South Korea were investigated during 2013–2014. The specimens collected since the 1960s in South Korea and deposited in the Korean Institute of Biospeleology and Chonbuk National University were also examined. Springtails were collected using aspirators and brushes and preserved in 80–100% ethanol in 10–20 mL glass vials. Specimens are deposited in the Korean Institute of Biospeleology in Daejeon and Entomological Museum of Korea University in Seoul.

In preparation of permanent slides, KOH, lactic acid or Marc Andre I solutions were used for clearing and body parts such as head, legs and furca were dissected under the stereoscopic microscope (Olympus SZ51, Japan). Abdomen was also dissected and flattened to examine macrochaetae on the body. The specimens were checked every 10 minutes for suitable de-colorization level. Hoyer's solution was used for mounting and mounted specimens were dried at 40–45°C in the dry oven (JISICO drying oven J-300S, Korea). Specimens were examined using a light microscope (Zeiss Lab. A1 AX10, Germany) at 100x, 200x, and 400x magnifications. For pseudopore, sockets of macrochaeate, teeth number of mucro, and other ultrastructure, 1000x magnification was used with oil immersion.

The following abbreviations were used in material examined: GW, Gangwon-do; GG, Gyeonggi-do; SL, Seoul; CN, Chungcheognam-do; CB, Chungcheogbuk-do; JB, Jeollabuk-do; JN, Jeollanam-do; GB, Gyeongsangbuk-do; GN, Gyeongsangnam-do; JJ, Jeju-do.

Systematic accounts

Class Collembola Lubbock, 1870
Order Entomobryomorpha Börner, 1913 sensu Soto-Adames FN *et al*., 2008
Family Tomoceridae (Schäffer, 1896)

Diagnosis. Body color diverse. Antennal length diverse; 3rd antenna much longer than other antennal segments in some species. Labrum setae generally 4 / 5, 5, 4 with large socket and 4 marginal, strong, recurving spines. Trochanteral organ present, up to 60 long or short setae. Lateral macrochaetae on manubrium present or absent. Dental spines shape, number, and teeth of mucro diverse.
Distribution. Worldwide.

Key to the genera and species of cave-dwelling Tomoceridae in Korea

[Modified from F. Janssens (2010), Checklist of the Collembola of the World]

1. Mucro basally with 1 tooth. Third antennal segment 3 or more times as long as fourth ····· genus *Monodontocerus*
   Mucro basally with 2 teeth, sometimes far apart ····· 2
2. Base of dentes with 1 or more large lateral outer macrochaetae ····· 3
   Base of dentes without large lateral outer macrochaetae ····· 4
3. Clear trochanteral organ present only on femur. Tenent hair clavate, 2 + 2 or more outer dental macrochaetae ····· genus *Aphaenomurus*, 6
   Clear trochanteral organ present on femur and trochanter ····· genus *Plutomurus*, 7
4. Eyes absent or vestigial. Trochanteral organ present on trochanter and femur ····· genus *Lethemurus*
   Eyes present and well developed ····· 5
5. Toothlet on basal dental tooth of mucro absent ····· genus *Tomocerina*
   Toothlet on basal dental tooth of mucro present ····· genus *Tomocerus*, 12
6. Distal dental spines arranged as I ····· *Aphaenomurus interpositus*
   Distal dental spines arranged as II ····· *Aphaenomurus vicinus*
7. With 6 eyes on each side of the head ····· *Plutomurus vigintiferispina*
   With fewer than 6 eyes ····· 8
8. With 5 eyes ····· *Plutomurus riugadoensis*
   With fewer than 5 eyes ····· 9
9. With 3 eyes ····· *Plutomurus leei*
   With fewer than 3 eyes ····· 10
10. With 2 eyes ····· *Plutomurus diversispinus*
    Without eyes ····· 11
11. Labral setae as 6 / 5, 5, 4 with 4 recurving spines ····· *Plutomurus gul*
    Labral setae as 4 / 5, 5, 4 with 4 recurving spines ····· *Plutomurus suzukaensis*
12. Spine shape simple ····· 13
    Spine shape complex ····· 14
13. Mucro with curtain shape lamellae ····· *Tomocerus laxalamella*
    Mucro without curtain shape lamellae ····· 16
14. Unguis with more than 3 teeth ····· *Tomocerus ocreatus*
    Unguis with less than 3 teeth ····· 15
15. Dental spines formula as 4 / 4, I, I or 3−5 / 2, I, I ····· *Tomocerus kinoshitai*
    Dental spines formula as 3−5 / 1−2, I, I ····· *Tomocerus sanho*, sp. n
16. Tibiotarsus with 0, 0, 2 spine-like setae ····· 17
    Tibiotarsus with more than 0, 0, 2 spine-like setae ···· 18
17. Dental spines formula as 3−5 / 2−1, I, I ····· *Tomocerus denticulus*
    Dental spines formula as 4−5 / 5−6, I, 1, I ····· *Tomocerus koreanus*, sp. n.
18. Dental spines formula as 7−8 / 8, I ····· *Tomocerus spinistriatus*
    Dental spines formula as 7 / 5, I, 1, I or 6 / I, I, I, 1, I ···· *Tomocerus jesonicus*

(Note: The species of *Monodontocerus*, *Lethemurus*, and *Tomocerina* are not included.)

Genus *Aphaenomurus* Yosii, 1956

Type species. *Aphaenomurus interpositus* Yosii, 1956.
Diagnosis. Eyes 6 + 6. Prelabral setae 2 + 2. Large spine-like setae at the external bases of the dens present. Trochanteral organs on the trochanter reduced but on the base of the femur well developed. Four or fewer intermediate teeth on the mucro and only a single small mucronal lamella on the basal tooth.

***Aphaenomurus interpositus* Yosii, 1956** [Korean name: Teol-ga-si-tok-to-gi]
Tomocerus (*Aphaenomurus*) *interpositus* Yosii, 1956; Nomura, 1957; Yosii, 1967; Yosii, 1969; Park & Lee, 1995.

Korean records. 〈GW〉 Chodang-gul cave, 〈JJ〉 Ssangnyong-gul cave (Park & Lee 1995).
Distribution. Korea, Japan.

***Aphaenomurus vicinus* Yosii, 1956** [Korean name: Oe-teol-ga-si-tok-to-gi]
Tomocerus (*Aphaenomurus*) *vicinus* Yosii, 1956.
Aphaenomurus vicinus Yosii, 1966; Lee, 1974; Lee, 1983.

Korean records. Goyangi-gul cave (unknown), 〈GW〉 Kwang-

cheonseon-gul cave, 〈GB〉 Mosan-gul cave (Yosii 1966).
Material examined. 〈CB〉 1♂, Chungju-si, Salmi-myeon, Gongidonggul cave (cave NO. 57), 6 vi 1966, NamGung J, 〈GW〉 1♂, Yeongwol-gun, Yeongwol-eup, Parun-ri, Parungul cave (cave NO. 144), 12 vi 1999, Choi YG.
Biology. We collected specimens from the twilight zone (about 20−30 m) in soil layer at Gongidonggul cave (cave NO. 57), and from the twilight zone (about 10 m) in guano on flow stone at Parungul cave (cave NO. 144).
Distribution. Korea, Japan.
Remarks. According to Yossi (1966), this species lacks spine-like setae on the tibiotarsus, but we examined two of them on the hindlegs.

Genus *Monodontocerus* Yosii, 1955

Type species: *Monodontocerus modificatus* Yosii, 1955.
Distribution. Korea and Japan.

***Monodontocerus odongyeoensis* Park & Lee, 1995** [Korea name: O-dong-nyeo-gul-ga-si-tok-to-gi]
Tomocerus (*Monodontocerus*) *odongnyeuensis* Park & Lee, 1995 (Holotype: ♀; type locatlity: 〈JN〉 Shinan-gun, Huksan-myeon, Sohuksan-ri, Hnag-ri, Odongnyeogul cave; type deposition: Laboratory of Animal Systematic and Ecology in Jeonbuk University).

Korean records. 〈JN〉 Odongnyeogul cave. (Park & Lee 1995)
Remarks. This species is endemic to Korea.
Distribution. Korea.

Genus *Plutomurus* Yosii, 1956

Type species: *Tritomurus riugadoensis* Yosii, 1939.
Diagnosis. [Modified from Yosii, 1956]. Eyes from 0+0 to 6+6. Prelabral setae from 2+2 to 4+4. Large spine-like setae at the external bases of the dens combined with a well developed multisetaceous trochateral organs on the trochanter and on the base of the femur. There are four or fewer intermediate teeth on the mucro, and there is only a single small mucronal lamella, usually on the basal tooth. Most have some pigment, but eyes are often reduced.
Distribution. Eastern Asia, Western Europe, the Caucasian region, and Western North America.

***Plutomurus vigintiferispina* Lee, 1974** [Korea name: Seumeu-ga-si-tok-to-gi]
Tomocerus (*Plutomurus*) *vigintiferispina* Lee, 1974: 411 (Holotype: ♂?♀?; type deposition: Chunbuk National University; type locality: 〈GW〉 Nampyeongbug-gul cave).

Korean records. 〈GW〉 Nampyeongbuggul cave (Lee 1974).
Remark. This species is endemic to Korea.
Distribution. Korea.

***Plutomurus leei* Yosii, 1966** [Korea name: I-gul-ga-si-tok-to-gi]
Tomocerus (*Plutomurus*) *leei* Yosii, 1966 (Holotype: ♂?♀?; type deposition: Department of Zoology, National Science Museum, Tokyo; type locality: 〈GB〉 Mosan-gul cave).

Korean records. 〈GB〉 Mosangul cave, Yeongchigul cave, Bugoksutgul cave; 〈CB〉 Sillyeonggul cave (Yosii 1966).
Material examined. 〈CB〉 11♂ et ♀, Cheongwon-gun, Miwon-myeon, Unam-ri, Cheongseokgul cave, 6−7 viii 2013, Choi YG, Chang GD (cave NO. 453), 〈GW〉 16♂ et ♀, Taebaek-si, Baeksan-dong, Sillyeonggul cave, 28 viii 2013, Choi YG, Chang GD, Kim JW (cave NO. 462); 2♂ et ♀, Samcheok-gun, Miro-myeon, Musa-ri, Mirogul cave, 8 iii 2002, Choi YG (cave NO. 53), 〈GB〉 53♂ et ♀, Mungyeong-si, Hogye-myeon, Bugongrimaeul, Bugoksutgul cave, 15−16 viii 2013, Choi YG, Chang GD (cave No. 460).
Biology. We collected specimens from the varying temperature zone (about 30−50 m) at clay layer on floor in Mirogul cave (cave NO. 53), from the varying temperature zone (about 70 m) at soil layer in Cheongseokgul cave (cave NO. 453), from the varying temperature zone (about 50 m) at guano with soil (cave NO. 460), and from the varying temperature zone (about 70 m) at soil layer in Sillyeonggul cave (cave NO. 462).
Distribution. Korea.
Remarks. According to Yosii, this species lacks spine-like setae on the tibiotarsus (Yosii 1966), but we examined two of them on the hindlegs.

***Plutomurus diversispinus* Yosii, 1966** [Korea name: Gulga-si-tok-to-gi]
Tomocerus (*Plutomurus*) *diversispinus* Yosii, 1966 [Holotype: ♂?♀?; type deposition: Department of Zoology, National Science Museum, Tokyo; type locality: Daeryonggul (unknown)]; Lee, 1974; Park & Lee, 1995.

Korean records. Daeryonggul cave (unknown), Soryounggul cave (unknown), 〈GW〉 Sinryeong-gul cave, 〈CB〉 Simbog-gul cave (Yosii 1966).
Material examined. 〈CB〉 1♂, Boeun-gun, Hoebuk-myeon, Ssangam-ri, Jangsugul cave, 3 vi 2003, Choi YG (cave NO. 44); 1♂, Cheongwon-gun, Miwon-myeon, Unam-ri, Pyeongsangmo-maeul, Cheongseokdarigul cave, 31 viii 2004, Choi YG (cave NO. 69).
Biology. We collected a specimen from the twilight zone (about 20 m) at soil layer from Cheongseokdarigul cave (cave NO. 44).
Distribution. Korea.
Remarks. According to Yossi, this species lacks spine-like

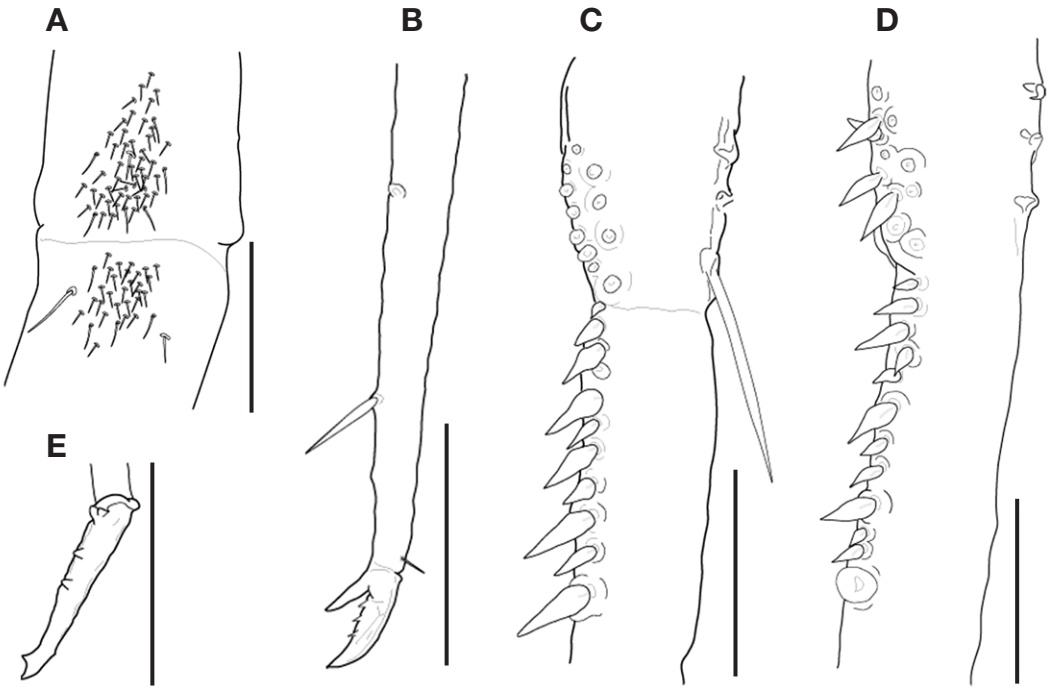

Figure 1. *Plutomurus riugadoensis* (cave NO. 473). (A) trochanteral organ, (B) hindleg tibiotarsus, (C, D) dental spines, (E) mucro. Scale bar = 0.5 mm.

setae on the tibiotarsus (Yosii 1966), but we examined two of them on the hindlegs (Fig. 7D).

***Plutomurus gul* Yosii, 1966** [Korea name: Jang-nim-gul-ga-si-tok-to-gi]

Tomocerus (*Plutomurus*) *gul* Yosii, 1966 [Holotype: ♂?♀?; type deposition: Department of Zoology, National Science Museum, Tokyo; type locality: 〈GW〉 Yongyeongul cave; Lee, 1974.

Korean records. 〈GW〉 Yongyeongul cave, Hwaamgul cave, Kwangcheonseongul cave, Yongdamgul cave, Kosigul cave, Daeyagul cave (Yosii 1966).

Material examined. 2♂ 〈GW〉 Samcheok-si, Singi-myeon, Daei-ri, Hwanseongul cave (at Manmulsang site) (cave NO. 358), 12 ix 2000, Choi YG.

Biology. We collected specimens from the constant temperature zone (about 250 m) at soil with guano in Hwanseongul cave (cave NO. 358).

Distribution. Korea, Japan.

Remarks. This species has distinct 3 + 3 labrum setae, instead of 2 + 2. According to Yossi, this species lacks spine-like setae on the tibiotarsus (Yosii 1966), but we examined two of them on the hindlegs.

***Plutomurus riugadoensis* Yosii, 1939** (Figs 1, 2) [Korean name: U-ro-gul-ga-si-tok-to-gi]

Tritomurus riugadoensis Yosii, 1939 [Holotype: ♂?♀?; type deposition: unknown; type locality: Japan, Sikoku, Prefecture of Koti, Riugado cave]; Yosii, 1956.

Material examined. 〈GB〉 3♂, Mungyeong-si, Hogye-myeon, Gado-ri san 57, Umusilsujikgul cave (cave NO. 473), 14 ii 2014, Choi YG, Chang GD, Kim JW; 2♂ Mungyeong-si, Hogye-myeon, Uro-ri, Urogul cave (cave NO. 368), 28 x 2003, Choi YG.

Redescription. Body length (head to abdomen VI) ca. 3.5 mm. Body segment in ratio as 56 : 29 in thorax, 21 : 21 : 56 : 43 : 16 : 11 in abdomen. Antenna length about 2.5 mm. Antenna segment in ratio as 12 : 41 : 163 : 26. Eyes with 5 + 5. Labral setae as 4 / 5, 5, 4 with 4 recurving spines. Trochantral organ composed of 50−55 short strong setae on trochanter and 30−35 on femur (Figs 1A, 2A). Unguis, unguiculus, tenent hair in ratio as 9 : 6 : 7. Unguis with 3 inner tooth and unguiculus without teeth (Figs 1B, 2B). Tenent hair setae like. Hind-leg tibiotarsus with 2 spine-like setae on inner side (Figs 1B, 2B). Furca in ratio as 75 : 113 : 13. Manubrium with 3 lateral macrochaetae. Dental spines simple, in formula as 11 / 3−5, I, 2, I, 2, I and other side with 11 / 3−4, I, 2, I, 1, I, 1, I (Figs 1C, D, 2C). Mucro with up to 2 intermittent teeth and 2 basal, apical teeth (Figs 1E, 2D).

Biology. We collected specimens from the varying temperature zone (about 20−30 m) at soil with guano and from the constant temperature zone (about 150 m) at guano layer in Urogul cave (cave NO. 368), and from the varying temperature zone (about 10−30 m twilight zone) in Umusilsujikgul

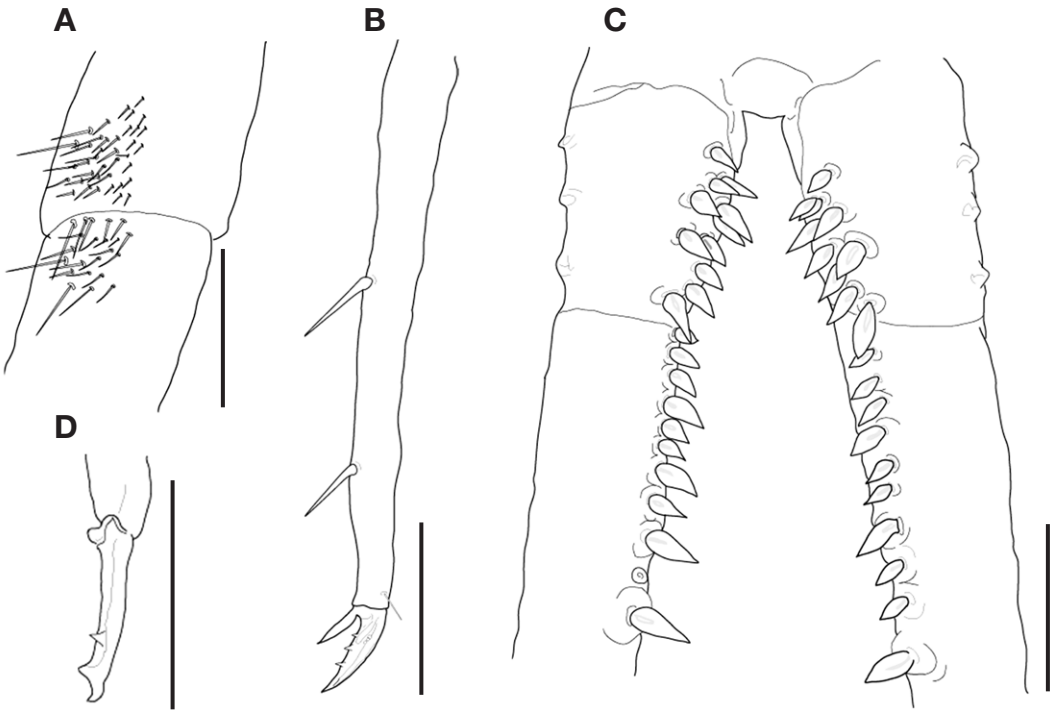

Figure 2. *Plutomurus riugadoensis* (cave NO. 368). (A) trochanteral organ, (B) hindleg tibiotarsus, (C) dental spines, (D) mucro. Scale bar = 0.5 mm.

cave (cave NO. 473).
Distribution. Korea, Japan.
Remarks. This species is new to Korea. Characters are the same as in *Tomocerus riugadoensis* except for dental spines formula. According to Yosii (1967), dental spines formula is 8−10 / 4−5, I, 2, I, 2, I (no data about other side of spine formula). Our specimens has different formula, 11 / 3−5, I, 2, I, 2, I and other side 11 / 3, I, 2, I, 1, I, 1, I.

***Plutomurus suzukaensis* Yosii, 1939** (Fig. 3) [Korean name: U-mu-sul-gul-ga-si-tok-to-gi]
Tritomurus suzukaensis Yosii, 1939 (Holotype: ♂?♀?; type deposition: unknown; type locality: Japan, Prefecture of Siga, Inukami-gun, Seritani-mura, Koti, Koti-kazawana cave).
Plutomurus suzukaensis ohminensis Yosii, 1956.
Plutomurus suzukaensis naikaiensis Yosii, 1956.

Material examined. 〈GB〉 3♂, Mungyeong-si, Hogye-myeon, Gado-ri san 57, Umusilsujikgul cave (cave NO. 472), 14 ii 2014, Choi YG, Chang GD, Kim JW.
Redescription. Body length (head to abdomen VI) ca. 3.3 mm. Body segment in ratio as 59 : 25 in thorax, 28 : 30 : 52 : 41 : 22 : 112 in abdomen. Antenna length ca. 2.2 mm. Antenna segment in ratio as 11 : 24 : 162 : 22. Without eyes. Labral setae as 4 / 5, 5, 4 with 4 recurving spines. Hindleg tibiotarsus with 2 spine-like setae on inner side (Fig. 3A). Unguis, unguiculus, tenent hair in ratio as 8 : 5 : 6. Unguis with 3, 3, 3 teeth and unguiculus without teeth. Tenent hair setae-like shape (Fig. 3B). Trochanteral organ composed of 35−40 short strong setae on trochanter and 25−30 on femur (Fig. 3C). Furca in ratio as 63 : 88 : 18. Manubrium with 2 lateral macrochaetae. Dental spines simple, formula as 8−11 / 2−3, I, 2, I, 1−2, I (Fig. 3D). Mucro with 3 intermittent teeth and 2 basal, apical teeth (Fig. 3E).
Distribution. Korea, Japan.
Biology. We collected specimens from the varying temperature zone (about-7 m) at leaf layer in Umusilsujikgul cave (cave NO. 472, vertical cave).
Remarks. This species is new to Korea. This species is similar to *Plutomurus riugadoensis*, but can be distinguished in eyes, unguis, mucro teeth (Fig. 3C).

Genus *Tomocerina* Yosii, 1955

Type species: *Tomocerus minutus* Tullberg, 1876.
Diagnosis. Eyes present. Trochantral organ reduced. Tibiotarsus without spine-like setae on inner side. Mucro with 2 basal and apical teeth usually. Mucro basal teeth without toothlet.
Distribution. Worldwide.
Remarks. This genus is very similar to the genus *Tomocerus*, but lacks spine-like setae on the tibiotarsus.

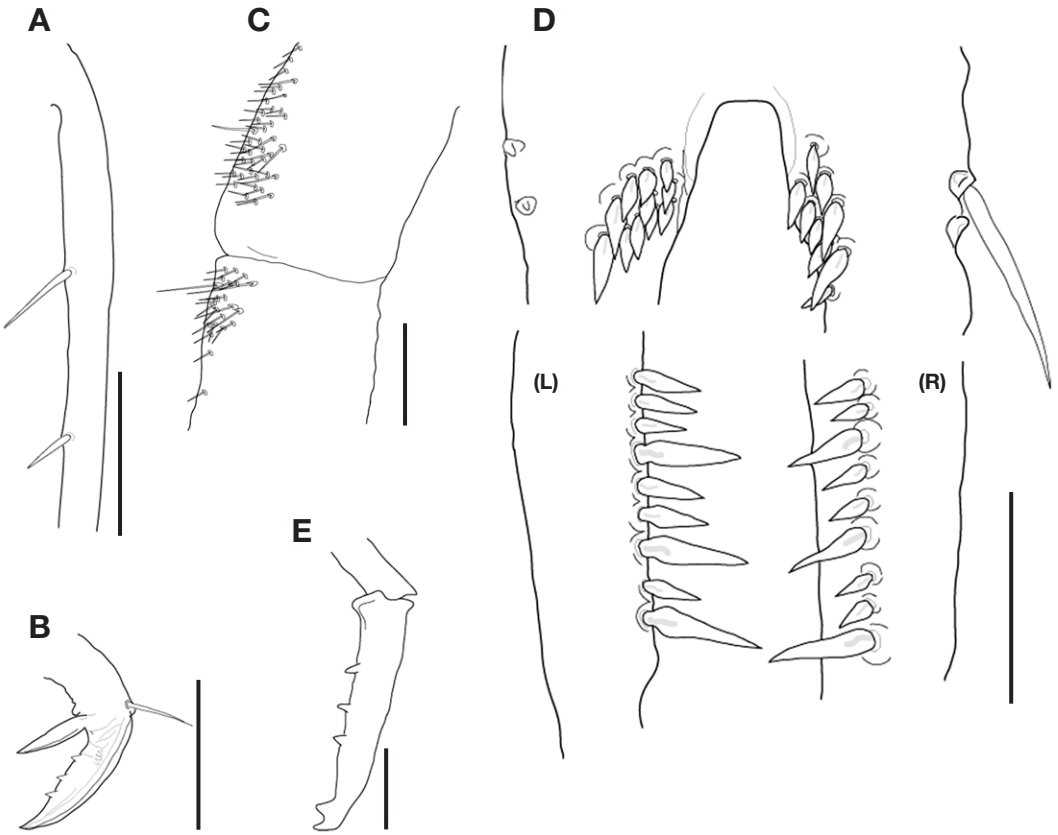

Figure 3. *Plutomurus suzukaensis*. (A) hindleg tibiotarsus, (B) Hindleg claws, (C) trochanteral organ, (D) dental spines, (E) mucro. Scale bar = 0.5 mm. (redrawn using Korean specimen).

***Tomocerina liliputanus* Yosii, 1967** [Korean name: Eo-ri-ga-si-tok-to-gi]

Tomocerus (*Tomocerina*) *liliputanus* Yosii, 1967 [Holotype: 1♂; type deposition: Department of Zoology, National Science Museum, Tokyo; type locality: Hirogawara, Goku-raku-ana, Nagano Pref.]; Yosii, 1967; Lee, 1975; Ma *et al*., 2003.

Tomocerus (s.str) *liliputanus* Yosii, 1967; Lee, 1983; Lee & Park, 1992.

Korean records. 〈GW〉 Sinbuk-myeon, Mt. Seorak-san, 〈GB〉 Gyeongju, 〈SL〉 Seoul, 〈GN〉 Geumsan (Lee 1975).

Material examined. 2♂ 〈CB〉 Goesan-gun, Yeonpung-myeon, Galgeum-ri, Simbokgul cave (cave NO. 15①, ②), 18 vi 2010, Choi YG.

Biology. We collected specimens of this species from the varying temperature zone (about 20−40 m) at soil layer in Simbokgul cave (cave NO. 15①, ②).

Distribution. Korea, China, Japan, Russia.

Remarks. According to Yosii (1967), this species has 5 + 5 intensely black eyes. Korean specimens, however, show some variations in eye number, 6 + 6 eyes (Lee & Park 1992).

Genus *Tomocerus* Nicolet, 1842

Type species: *Macrotoma minor* Lubbock, 1862, by subsequent designation.

Diagnosis. Antennal segments III and IV annulated. Dens without large lateral macrochaetae and basal scale-like spine on inner edge; mucro with two basal teeth, outer one with one small toothlet. Trochanteral organ with one seta upon inner side of trochanter and proximal part of femur.

Distribution. Worldwide.

***Tomocerus kinoshitai* Yosii, 1954** [Korea name: Gi-no-si-da-ga-si-tok-to-gi]

Tomocerus kinoshitai Yosii, 1954 (Holotype: ♂?♀?; type deposition: unknown; type locality: 2♂ et ♀, Tanohara, Mt. Ontake Kreis Nagano); Yosii, 1956; Yosii, 1967; Lee, 1974; Lee, 1975; Lee, 1983.

Tomocerus kinoshitai kinoshitai Park & Lee, 1995.

Korean records. 〈GW〉 Beteulgul cave (Lee, 1974); 〈SL〉 Seoul, 〈GG〉 Kanghwado island, 〈GW〉 Sinbuk-myeon, 〈GN〉 Geumsan (Lee 1975).

Material examined. 〈GW〉 2♂, Yeongwol-gun, Gimsatgat-myeon, Jinbyeol-ri, Gossigul cave (cave NO. 173), 10 iii 2001, Choi YG.
Biology. We collected specimens of this species from the twilight zone (about 20−30 m) at bedrock on guano in Gosigul cave (cave NO. 173).
Distribution. Korea, Japan, Russia.
Remarks. Our specimens show some differences from *T. kinoshitai* in mucronal teeth and unguis teeth number described by Yoshii (1954, 1967). *Tomocerus kinoshitai* has one or rarely 2 intermittent tooth dorsally on mucro and 1, 1, 1 teeth with unguis (Yosii 1967), while our specimens show 3 and 2, 2, 2 in these characters, respectively. Dental spines formula is usually 3 / 1, I (Yosii 1967), but some Korean specimens show 4 / 2, I, I in soil and 3 / 2 in cave dwelling ones (Lee 1983). We temporarily identify this species as *Tomocerus kinoshitai*, but additional examination is necessary to verify these Korean specimens.

***Tomocerus denticulus* Lee, 1975** [Korea name: Kkaen-ni-tok-to-gi]
Tomocerus kinoshitai dentuculus Lee, 1975 (Holotype:♂?♀?; type deposition: unknown; type locality:♂?♀? Collection NO. 72-1, 〈GG〉 Yangju-gun, Geumgog-ri, Geumgog-neung royale tomb).

Korean records. 〈GG〉 Geumgog-neung royale tomb (Lee 1975).
Material examined. 〈GW〉 1♂ & 1♀, Jeongseon-gun, Buk-myeon, Yeoryang-ri, Sanhodonggul cave (cave NO. 4①), 4 x 2007, Choi YG.
Biology. We collected specimens from the varying temperature zone (about 150−200 m) at soil organic matter on cave floor in Sanhodonggul cave (cave NO. 4①).
Distribution. Korea.

***Tomocerus jesonicus* Yosii, 1967** [Korea name: Min-ju-reum-ga-si-tok-to-gi]
Tomocerus jesonicus Yosii, 1967 (Holotype:♂?♀?; type deposition: unknown; type locality: 1♂?♀?, Hokkaido).
Tomocerus vulgaris var. *jesonicus* Yosii, 1940.
Tomocerus vulgaris Yosii, 1954.
Tomocerus vulgaris var. *kurilensis* Uchida, 1964.

Korean records. 〈JB〉 Mt. Deogyu (Lee 1975).
Material examined. 2♂ 〈GW〉 Jeongseon-gun, Nam-myeon, Sirubong Balguldeok 50 m vertical inside of cave, Sirubonggul cave1 (cave NO. 165), 17 viii 2000, Choi YG.
Biology. We collected specimens from the twilight zone (about-50 m) at leaf layer in Sirubonggul cave1 (cave NO. 165, vertical cave).
Distribution. Korea, China, Japan, Russia.
Remarks. This species is quite similar to *Tomocerus vulgaris* in spine-like setae on tibiotarsus and number of unguis teeth, but dental spines formula (5−6 / 3−4, I, 2, I) can distinguish this species (Yosii 1967).

***Tomocerus laxalamella* Lee, 1975** [Korea name : Po-jang-ga-si-tok-to-gi]
Tomocerus laxalamella Lee, 1975 [Holotype:♂?♀?; type deposition: unknown; type locality: 〈GG〉 8♂ et ♀, Yangpyeong-gun, Mt. Yongmunsan, collection NO. 71-14-2; 〈GW〉 9♂ et ♀, Mt. Seolagsan, collection NO. 72-3-6].
Tomocerus (*Monolamellus*) *laxalamella* Lee, 1983; Lee & Park, 1992.

Korean records. 〈GG〉 Mt. Yongmun, 〈GW〉 Mt. Seorak (Lee 1975).
Material examined. 〈CB〉 1♂, Goesan-gun, Yeonpung-myeon, Galgeum-ri, Simbokgul cave (cave NO. 19), 23 Mar 1986, NamGung J.
Biology. We collected specimen from the constant temperature zone (about 70−100 m) at bedrock on organic matter layer in Simbokgul cave (cave NO. 9).
Distribution. Korea. China, Japan, Russia.

***Tomocerus ocreatus* Denis, 1948** [Korea name: Deu-ni-ga-si-tok-to-gi]
Tomocerus kawamurai Yosii, 1951; Yosii, 1954.
Tomocerus minor Uchida, 1954.
Tomocerus kawamurai f. *depicta* Yosii, 1955.
Tomocerus ochreatus f. *kawamurai* Yosii, 1956.

Korean records. 〈GB〉 Dae-gu, 〈GG〉 Mt. Yongmun-san, Geumgok, 〈GW〉 Mt. Seorak-san (Lee 1975).
Material examined. 1♂, Hantan Chwisujanggul cave (locality unknown) (cave NO. 191), 6 vi 2001, Yong Geun Choi; 2♂ Dongjeonggul cave (locality unknown) (cave NO. 474), 27 iii 2014, Chang GD, Kim JW.
Biology. We collected specimens from the entrance zone (about 5 m) at soil organic matter layer in Chwisujanggul cave (cave NO. 191), and from the varying temperature zone (about 30−60 m) at soil layer on floor in Dongjeonggul cave (cave NO. 474).
Distribution. Korea, India, Japan, Russia, Vietnam.
Remarks. This species was first collected and described in Vietnam. Blunt spine-like setae of tibiotarsus present up to 5, 5, 6, according to Yosii (Yosii 1967).

***Tomocerus spinistriatus* Lee, 1975** [Korea name: Ju-reum-ga-si-tok-to-gi]
Tomocerus spinistriatus Lee, 1975 [Holotype:♂?♀?; type deposition: unknown; type locality: 〈GG〉 8♂ et ♀, Yangpyeong-gun, Mt. Yongmunsan, collection NO. 71-14-2].

Korean records. 〈GG〉 Mt. Yongmun-san (Lee 1975).

Material examined. 〈CB〉 2♂, Boeun-gun, Songnisan-myeon, Mt. Songnisan, Talgoramgul cave (cave NO. 470), 8 viii 1965, Namgung J.
Biology. We collected specimens from the entrance zone (about 3−5 m) at leaf layer in Talgoramgul cave (cave NO. 470).
Distribution. Korea, China, Japan, Russia.
Remarks. According to Lee (1975), this species lacks any tibiotarsal spine-like setae, but in our specimens possess 5, 5, 6 tibiotarsal spine-like setae on each leg.

Tomocerus koreanus **Chang and Bae, sp. n.** [Korean name: Han-guk-ga-si-tok-to-gi] (Figs 4−6)

Type material examined. Holotype ♀: 〈GW〉 Jeongseon-gun, Buk-myeon, Yeoryang-ri, Sanhodonggul cave (cave NO. 462), 28 viii 2013, Choi YG, Chang GD, Kim JW.
Other material examined. 1♀ (same data as holotype).
Description (Holotype). Body length (head to abdomen VI) ca. 6.2 mm; color dark yellow in dorsal part. Body segment in ratio as 19 : 13 in thorax, 50 : 44 : 85 : 75 : 28 : 25 in abdomen. Antennal length ca. 5.6 mm; color dark brown (Fig. 4A). Antennal segment in ratio as 40 : 71 : 451. Head chaetotaxy with 3 + 3 / 2 + 2 / 3 + 2 large setae and a row of small setae along antennal and posterior boarder (Fig. 4B). Eyes 5 + 5 with dark pigments. Labral setae 4 / 5, 5, 4 and 4 spinules in margin of labrum (Fig. 5A). Leg segment in ratio (tibiotarsus : femur : trochanter : coxa) as 82 : 69 : 26 : 69. Trochanter and femur with one each setae of trochanteral organ in hindleg

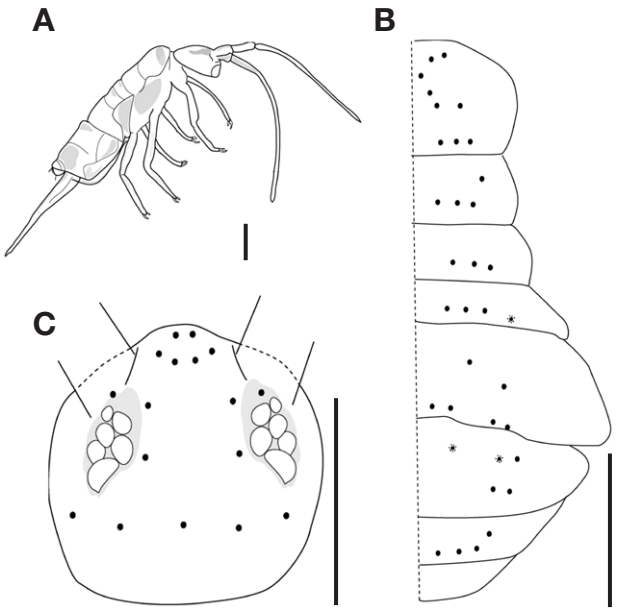

Figure 4. *Tomocerus koreanus* sp. n. (A) habitus, (B) head, (C) body cheatotaxy. Scale bar = 1 mm (A), 0.15 mm (B), 0.3 mm (C).

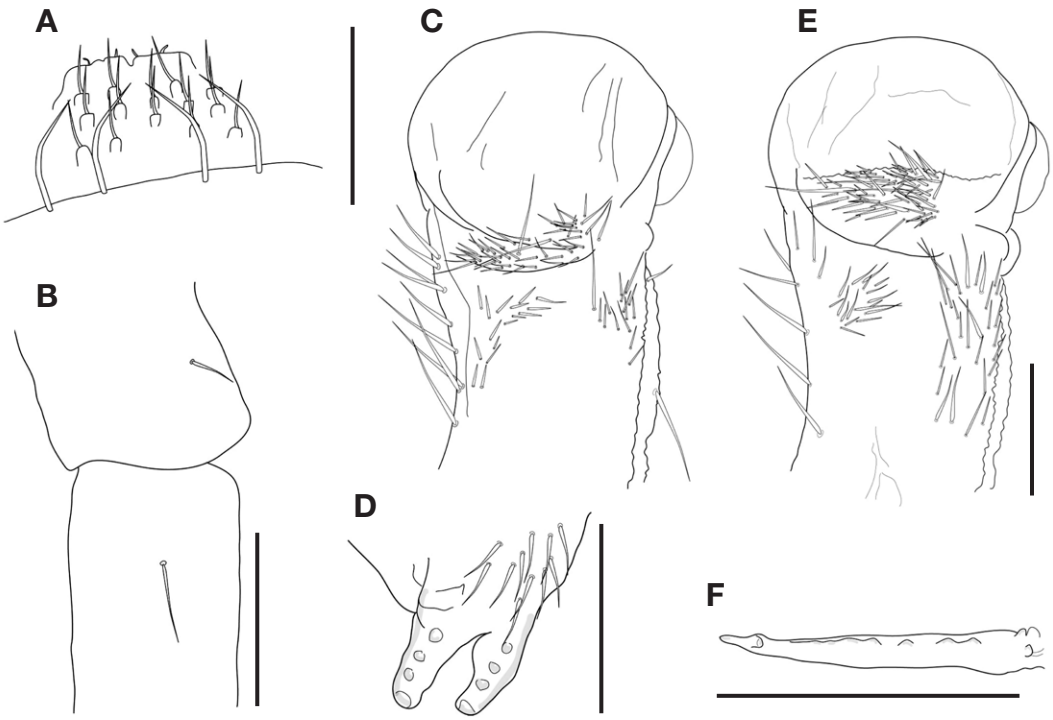

Figure 5. *Tomocerus koreanus* sp. n. (A) labrum setae, (B) trochanteral setae, (C) ventral tube, (D) tenaculum, (E) dental spines, (F) mucro. Scale bar = 0.5 mm (A–D), 0.3 mm (E, F).

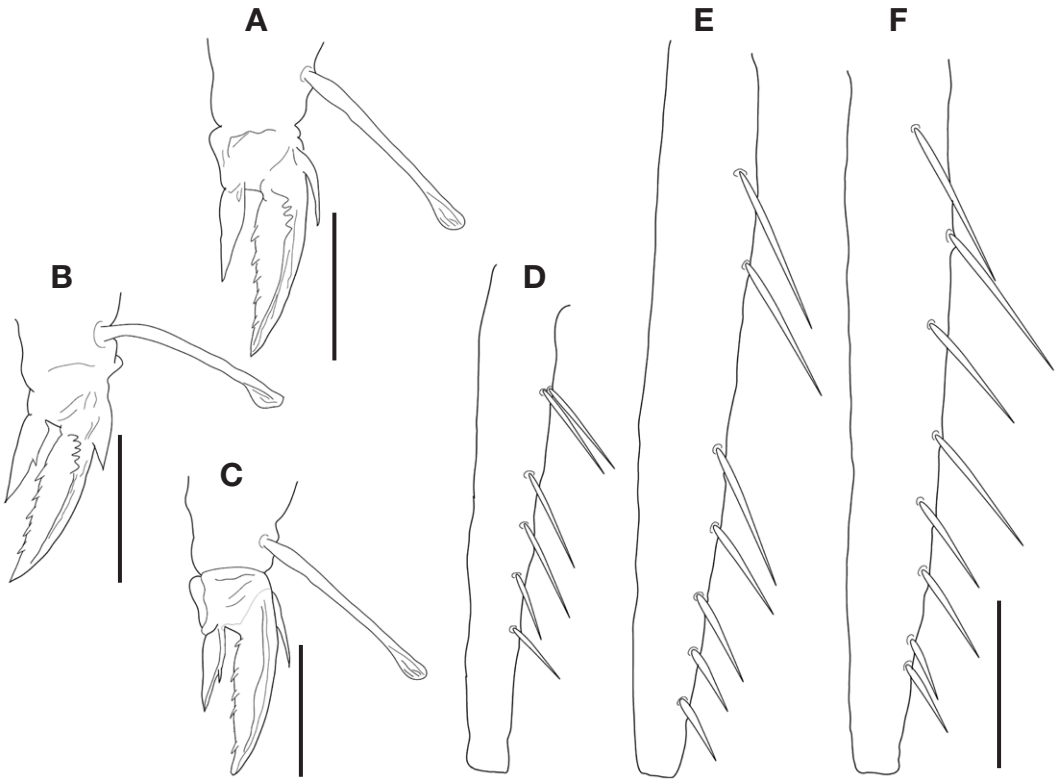

Figure 6. *Tomocerus koreanus* sp. n. (A) fore-claw, (B) mid-claw, (C) hind-claw, (D) foreleg tibiotarsus, (E) midleg tibiotarsus, (F) hindleg tibiotarsus. Scale bar = 0.5 mm.

Table 1. Comparison of diagnostic characters between *Tomocerus koreanus*, sp. n., *Tomocerus sanho*, sp. n., and other related species

Species	Dental spines	Ung.teeth	Ung.	Eyes	Prelab.	Troch/ Fem	Mucro (B/S/A)	Tenent hair	Spin.tib
Tomocerus kawamurai Yosii, 1954	3 / 1–2, II	1, 1, 1	none	none	2+2	1, 1	2, 1, 2	P-like	none
Tomocerus ocreatus Denis, 1948	4 / 3–4, II	3, 3, 3 (up to 4, 4, 4)	none	6+6	2+2	1, 1	2, 5, 2	P-like	5, 5, 6
Tomocerus vulgaris Brook, 1883	5–6 / 3–4, I, 2, I	Usually 5, 5, 5 (up to 8, 9, 9)	none	6+6	2+2	1, 1	2, 5–9, 2	P-like	4, 4, 4–5
Tomocerus kinoshitai Yosii, 1954	3–4 / 1–2, I–II (compound form)	1, 1, 1	none	6+6	2+2	1, 1	2, 1–3, 2	P-like	0, 0, 2
Tomocerus deogyuensis Lee, 1975	5 / 4–6, II	4, 4, 4 (up to 5, 5, 5)	None	6+6	2+2	1, 1	2, 5–6, 2	P-like	none
Tomocerus jesonicus Yosii, 1967	4–8 / 4–5, I, 1, I	4, 5, 5	1, 1, 1	6+6	2+2	1, 1	2, 3–7, 2	P-like	2, 2, 4
Tomocerus ishibashii Yosii, 1954	4–5 / 3–5, II (4 / 4, I, 1, I in Korea)	6, 6, 6	None	6+6	2+2	1, 1	2, 5–8, 2	P-like	2, 2, 6
Tomocerus koreanus Chang & Bae, sp. n.	4–5 / 5–6, I, 1, I	2, 2, 5–6	none	5+5	2+2	1, 1	2, 5–6, 2	P-like	6, 7, 8
Tomocerus sanho Chang & Bae, sp. n.	3–5 / 3–4, II (compound form)	2, 2, 2	none	6+6	2+2	1, 1	2, 3, 2	P-like	0, 0, 2

(Fig. 5B). Claw well developed with psueodonychium. Unguis, unguiculus, tenent hair in ratio as 5 : 3 : 7. Unguis with 2 / 2 / 5–6 teeth and unguiculus with proximal single inner tooth. Setae-like, tapering, acuminate tenent hair in tibiotarsus (Figs 6A–C). Tibiotarsus with 6 / 7 / 8 spine-like setae inner side (Figs 6D–F). Ventral tube with many setae

(Fig. 5C). Tenaculum has four quardridentate with 1−2 setae on coupus (Fig. 5D). Furca in ratio as 103 : 139 : 22. Dens without large lateral macrocheate and dental spines formula 4−5 / 5−6, 1, 1, I (Fig. 5E). Mucro long and slender with 2 apical, 5−6 subapical, 2 basal teeth and toothlet in the basal teeth and also have numerous setae (Fig. 5F).

Diagnosis. Labral setae 4 / 5, 5, 4 and 4 spinules. Dental spines formula 4−5 / 5−6, 1, 1, I. Trochanteral organ with each one setae on trochanter and femur. Mucro teeth 2 / 5−6 / 2 with many setae. Basal teeth with toothlet.

Etymology. The species epithet "*koreanus*" is from "Korea".

Biology. We collected this species from the entrance zone (about 10−15 m) under leaf litters and piles of small rocks.

Remarks. This species is similar to *Tomocerus ocreatus* Denis, 1948 and *Tomocerus kawamurai* Yosii, 1954 in general morphology, but the dental spine formula and mucro teeth can distinguish this species from them (Table 1).

***Tomocerus sanho* Chang and Bae, sp. n.** [Korean name: San-ho-ga-si-tok-to-gi] (Figs 7−9)

Type material examined. Holotype ♂. 〈GW〉 Jeongseon-gun, Buk-myeon, Yeoryang-ri, Sanhodonggul cave (cave NO. 464), 28 viii 2013, Choi YG, Chang GD, Kim JW.

Other material examined. 6♂ (same data as holotype).

Description (Holotype). Body length (head to abdomen VI) about 4.9 mm and color brown to dark brown (Fig. 7A). Body segment in ratio as 81 : 47 in thorax, 35 : 47 : 72 : 54 : 37 : 16 in abdomen. Body chaetotaxy as in Fig. 7B. Antenna length

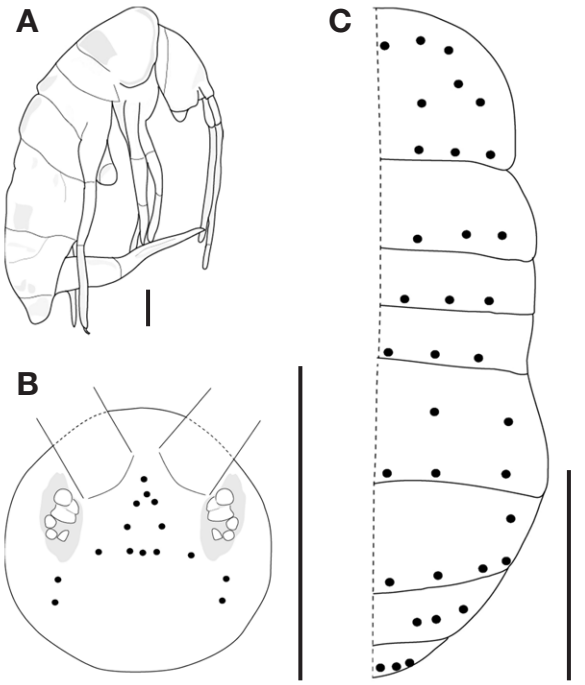

Figure 7. *Tomocerus sanho* sp. n. (A) habitus, (B) body cheatotaxy, (C) head cheatotaxy. Scale bar = 0.5 mm (A), 0.3 mm (B), 0.15 mm (C).

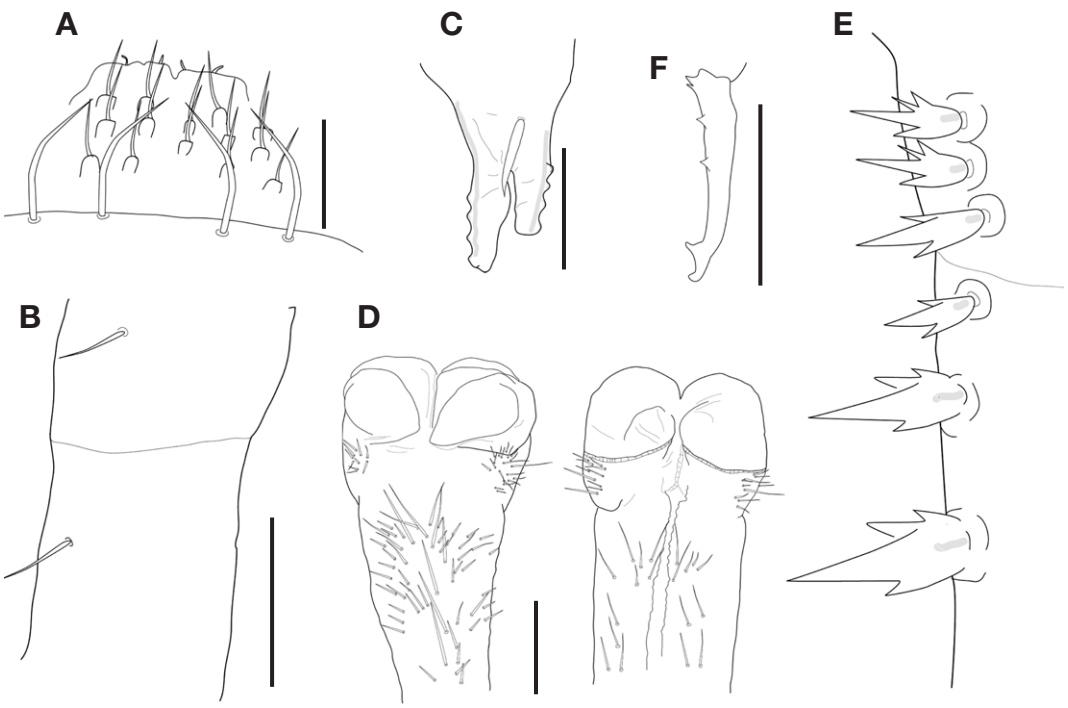

Figure 8. *Tomocerus sanho* sp. n. (A) labral setae, (B) trochanteral organ, (C) tenaculum, (D) ventral tube, (E) dental spines, (F) mucro. Scale bar = 0.5 mm (A−D), 0.3 mm (E, F).

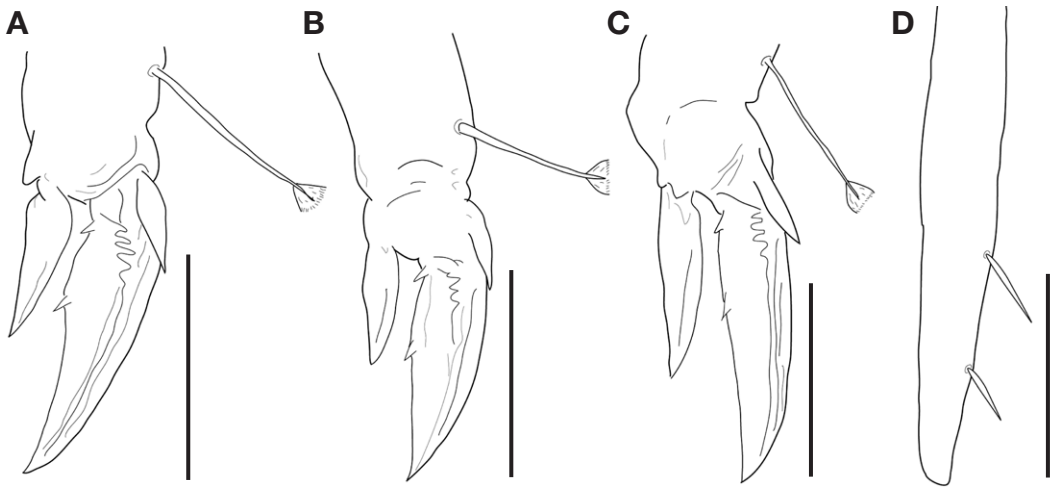

Figure 9. *Tomocerus sanho* sp. n. (A) foreleg teeth, (B) midleg teeth, (C) hindleg teeth, (D) hindleg tibiotarsus. Scale bar = 0.5 mm.

ca. 2.1 mm and color same to body color. Antennal segment in ratio as 21 : 33 : 118 : 34. Head chaetotaxy with 1, 1, 1 + 1 / 1 + 1, 3 + 2 / 2 + 2 large setae and a row of small setae along antennal boarder (Fig. 7C). Eyes 6 + 6 with dark pigments patch. Labral setae 4 / 5, 5, 4 and 4 spinules in margin of labrum (Fig. 8A). Leg segment in ratio (tibiotarsus : femur : trochanter : coxa) as 85 : 62 : 25 : 39. Trochanter and femur with one each setae of trochanteral organ in hindleg (Fig. 8B). Claw well developed with psueodonychium. Unguis, unguiculus, tenent hair in ratio as 11 : 8 : 7. Unguis with one tooth and unguiculus without teeth. Clubbed like tenent hair (Figs 9A-C). Hind-tibiotarsus with 2 spine-like setae in inner side only (Fig. 9D). Tenaculum with four quardridentate, with one setae on coupus (Fig. 8C). Ventral tube with many setae (Fig. 8D). Furca in ratio as 63 : 110 : 30. Dens without large lateral macrocheatae and dental spines shape complex with small teeth attached. Dental spines formula 3−5 / 1−2, I, I (Fig. 8E). Mucro long and slender with 2 apical, 3 subapical, 2 basal teeth and toothlet in basal teeth and also with numerous setae (Fig. 8F).

Diagnosis. Labral setae with 4 / 5, 5, 4 and 4 spinules in margin of labrum. Dental spines formula 3−5 / 1−2, I, I. Mucro with numerous setae and 2 / 3 / 2 and toothlet in basal teeth.

Etymology. The species epithet "*sanho*" [Korean, noun] is from the holotype locality "Sanhodonggul" or "Sanho cave" meaning "coral cave".

Biology. Specimens were collected from the entrance of the cave, within 10 m distance. Cave entrance was covered with abundant leaf litters and small rocks.

Remarks. This species is similar to *Tomocerus kawamurai* Yosii, 1954 in general morphology, but but can be distinguished by the dental spines formula and unguis teeth (Table 1).

Acknowledgments

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