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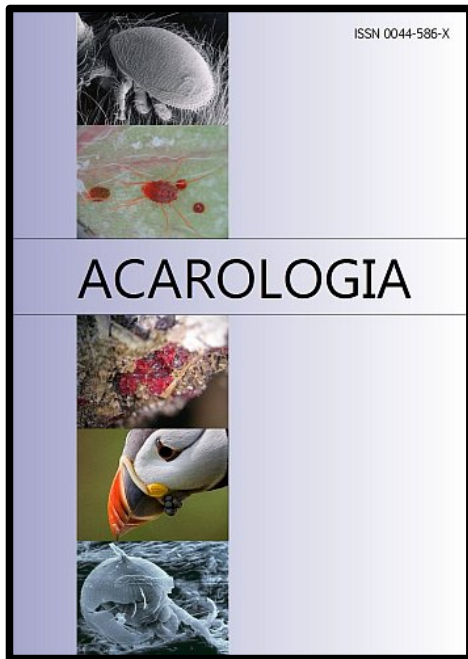
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ORIBATID FAUNA (ACARI, ORIBATIDA) FROM A CAVE IN SOUTH NIPPON (JAPAN), WITH A DESCRIPTION OF A NEW SPECIES

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ABSTRACT — Representatives of six oribatid mite species belonging to the cohort Brachypylina were collected from the upper wall and soil surface at the entrance of Kumaso cave in South Nippon (Japan). Of these, three were known species: *Fissicepheus* (*Fissicepheus*) *takenouchiensis* Fujikawa and Nishi, 2013, *Scheloribates latipes* C. L. Koch, 1841 and *Peloribates* (*Peloribates*) *latus* Fujikawa, 2006. One species of *Humerobates* (*Humerobates*) was described as a new species. Two other individuals did not match any described species and may represent two new species. However, as single individuals, we could not decide with certainty about their specific status. These individuals were respectively assigned to the genera *Protoribates* and *Spatiodamaeus*. Here, we provide only morphological descriptions of these single specimens. No typically cave-dwelling oribatid mites were found in the present investigation.

KEYWORDS — *Fissicepheus*; *Humerobates* (*Humerobates*); Kumaso cave; new species; oribatid mite; *Peloribates*; *Protoribates*; *Scheloribates*; South Japan; *Spatiodamaeus*

INTRODUCTION

Oribatid mite species have been recorded from caves worldwide (e.g. Iturrondobeitia and Arillo, 1997; Ducarme *et al.*, 2004; Lundberg *et al.*, 2010; Skubala *et al.*, 2013).

In the first survey of oribatid fauna living in a cave in Japan, a total of 11 species, all belonging to Brachypylina, was recorded (Nakamura *et al.*, 2010). Brachypylina has are characterized by the following combination of characters: holoïd body type, brachypiline venter, genua of legs I-III shorter than tibiae and presence of Trägårdh's organ (Norton and Behan-Pelletier, 2009). The strongly chi-

tinized cuticle of adult brachypylinid species might have the ability to resist drought as suggested by Ducarme *et al.* (2004).

In order to get an overview of the Oribatid fauna living in another Japanese cave, we sampled soil inside and at the entrance (photic zone) of the Kumaso cave and recorded Oribatid mites found in both types of samples.

This article brings together the survey of Oribatid species found in these samples and the description of some specimens unassigned to any known species, with a designation of *Humerobates* (*Humerobates*) *kumasoï* as a new species.

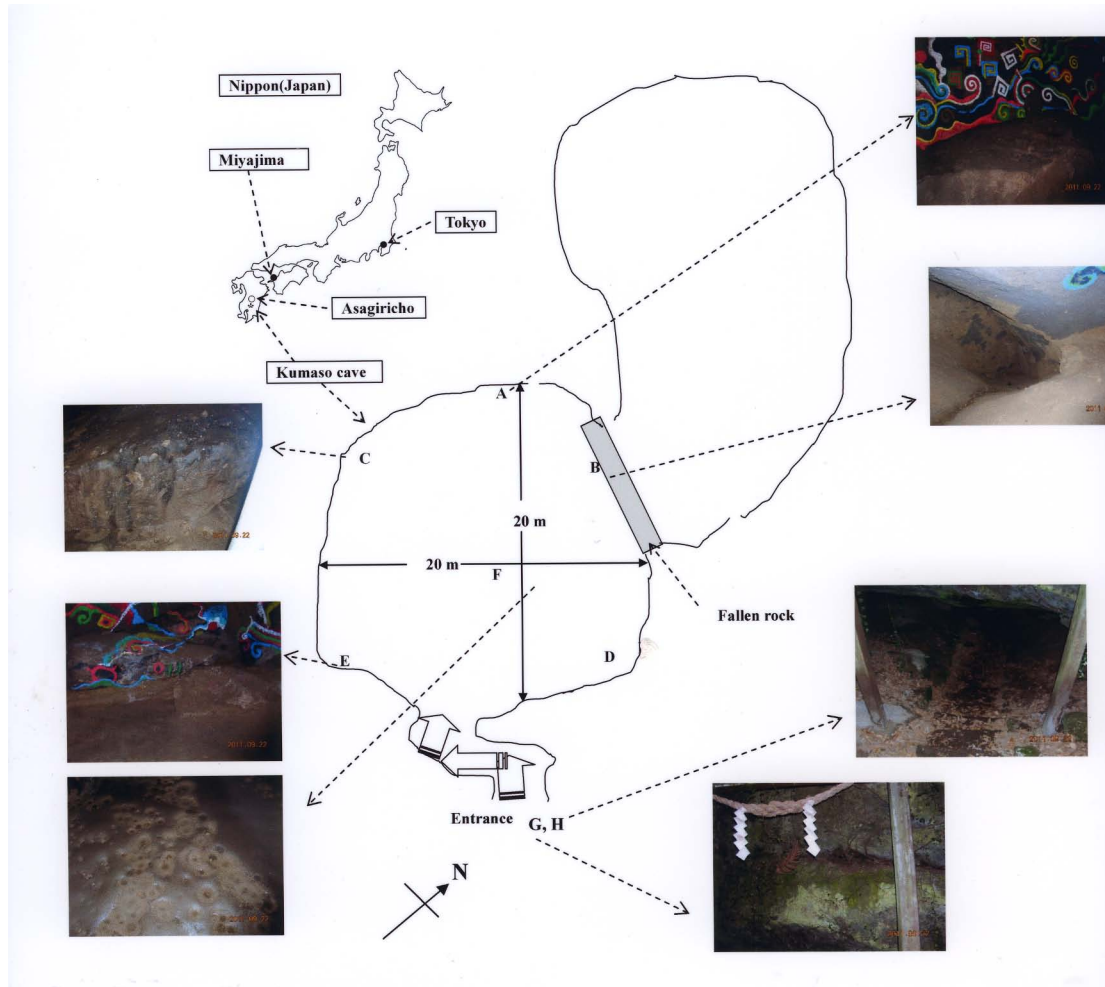


FIGURE 1: Location of sampling.

METHODS

Study site — Kumaso cave (31°48'50"N; 130°45'19"E, about 82 m a.s.l, in the subtropical zone) is located at Hayato-cho, Kirishima-shi, Kagoshima Prefecture, South Japan (Fig. 1). The cave formed in welded tuff 3 million years ago (personal communication from Mr. M. Harada, 2013), and is now situated in a thick forest of *Cryptomeria japonica*, *Castanopsis* spp. and *Quercus* spp. on a hill on a property belonging to President T. Ishihara of Myoken Ishiharaso Co. Ltd. On the day of sampling (22 Sept. 2011), the temperature inside the cave (at 5 p.m.) was 21 °C at the floor surface and 18 °C 1 m above it. The temperature outside the entrance at 5.30 p.m. was 18.5 °C at the soil surface and 19 °C 1 m above it.

Sampling — Eight samples of about 200 cm³ each were collected by hand-picking from sands in the cave and soil materials of top most part and the surface of the ground at the entrance on 22 Sept. 2011, by K. Nakamura. After extraction with a modified Tullgren apparatus, mites were kept in lactic acid for clearing during twenty days, then mounted on glass slides.

Terminology and classification — The notations and morphological terminology are mainly based on Balogh and Mahunka (1983), Grandjean (1952), Hammen (1989), Mahunka and Zombori (1985) and Norton and Behan-Pelletier (2009). Genito-anal setal formula refers to genital, aggenital, anal and adanal setae. The given number of tarsal claws is common to all legs of a species. The setal formula of legs includes the famulus but excludes solenidia. The solenidiotaxy is common to all examined species: I (1-2-2), II (1-1-2), III (1-1-0), IV (0-1-0). [Right-left] refers to the right and left sides of a specimen. Unless indicated, measurements (in µm) in the description relate to the holotype.

RESULTS

The survey of Oribatid fauna from soil sampled inside and at the entrance of the Kumaso cave was carried out on 22 Sept. 2011. The only mite found

inside the cave was a specimen of the mesostigmatid genus *Gamasiphis* (Rhodacaridae). No oribatid mites were found inside the cave. However, representatives of seven oribatid species including one new species, were collected from soil materials of the top most part and the surface of the ground at the entrance, *ie.* from the photic zone. Yet, as found in the Kumaya Cave of Iheya Village (Nakamura *et al.*, 2010), all oribatid species belonged to the cohort Brachypylina. Six oribatid species are detailed in the present study. One specimen of *Drepanoppia* could not be studied because the body was broken.

DESCRIPTION OF NEW SPECIES AND UNASSIGNED INDIVIDUALS

Cohort Brachypylina Hull, 1918

Humerobatidae Grandjean, 1970

Humerobates (*Humerobates*) *kumasoi* n. sp.

[Japanese name: Kumaso-hanasujidani]

(Figs. 2 – 4)

Diagnosis — Body size: females, length 286-307 µm, width 229 µm; males, length 286-307 µm, width 214-250 µm. Anterior rostral margin projecting as a point on each side. Setae *ro* and *le* originating from tip of tutorium and lamella, respectively. Sensilli composed of thin, smooth short stem and broad spatulate head, expanded distally without narrower apex, verrucose throughout length. Notogaster bearing 10 pairs of vestigial notogastral setae. Genito-anal setal formula: 6-1-2-3. Epimeral setal formula: 3-1-3-3. Heterotridactylous.

Material examined — Holotype (Adult female) (NSMT-Ac 13788) from the soil surface at the entrance of Kumaso cave; 4 paratypes (2 adult females and 2 adult males) (NSMT-Ac 13789): same data as holotype; 1 additional paratype (adult male) used in scanning electron microscopy: same data as holotype. Type specimens (NSMT-Ac 13788 and 13789) are deposited in the National Museum of Nature and Science, Tokyo. The other type specimen is deposited in the National Agricultural Research Center for Kyushu Okinawa Region, Kumamoto Prefecture.

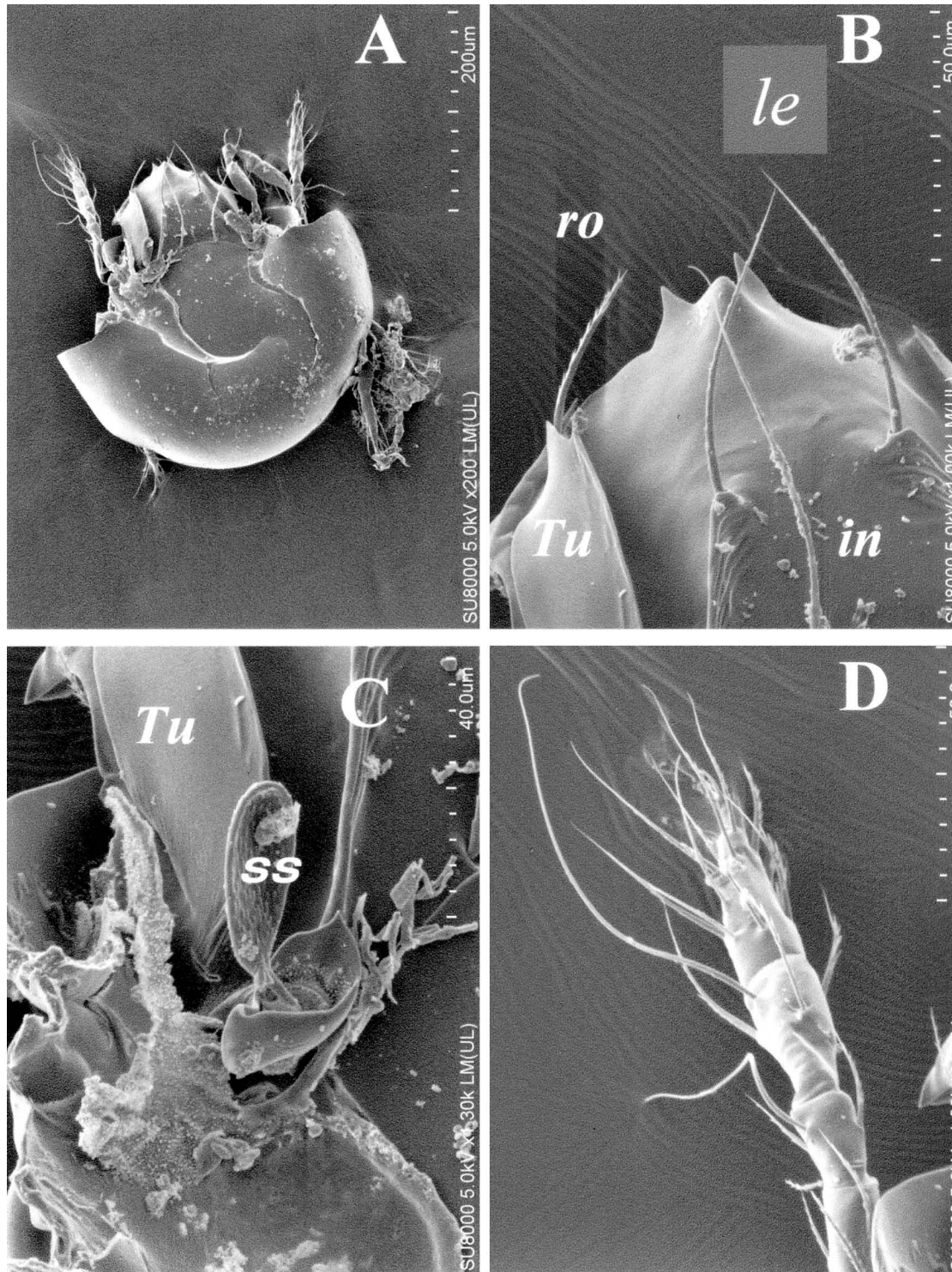


FIGURE 2: *Humerobates (Humerobates) kumasoi* n. sp., scanning electron micrographs (photos by Nakamura Y.-N. and Shirosaki T.). Adult female: A – Dorsal view; B – Rostral region, *in*: interlamellar seta, *le*: lamellar seta, *ro*: rostral seta, *Tu*: tutorium; C – Left bothridial region; D – Left leg I: solenidion of genu broken.

Etymology — Named in honour of Kumaso, one of the former human races in Nippon (Japan).

Measurements and body appearance — Body size: females, length 286-307 μm , width 229 μm ; males, length 286-307 μm , width 214-250 μm . Body colour of live mite dark brown; body surface smooth.

Prodorsum — Anterior rostral margin projecting as a point on each side (Fig. 2B). Setae *ro* and *le* originating from tip of tutorium and lamella respectively, extending anteriorly to rostrum; setae *ro* (Right-left: 56-59 μm) thin, setiform, barbed unilaterally; *le* (54-63 μm) thin, setiform, barbed throughout length. Tutorium with cusp (6-12 μm) extending anterior to tip of lamella (Fig. 3A). Setae *in* (131-120 μm) thin, setiform, roughened throughout length, inserted near anterior notogastral margin, extending beyond rostrum (Fig. 2A). Sensilli (41-47 μm) composed of thin short stem and broad spatulate head, expanded distally without narrower apex, verrucose throughout length (Fig. 2C). Exobothridial setae (*ex*) thin, long (ca. 9 μm) inserted at lateral base of bothridia. Bothridia opening antero-dorsally, with ventrolateral and ventromedial scales; ventromedial scale large, dentate on anterior margin (Fig. 4A).

Notogaster — Nearly as long as wide, anterior margin rounded, bearing 10 pairs of vestigial notogastral setae. Anterior margin of pteromorphae not extending beyond dorsosejugal suture. Porose areas *Aa* (the major axis: ca. 7 μm) located between *la* and *lm*; *A1* between *lp* and *h3*; *A2* antero-lateral to *h3*; *A3* lateral to *h1*. Opisthonotal gland opening (*gla*) situated lateral to *A1*. Lyrifissures *ia*, *im*, *ih* and *ips* aligned obliquely, located posterior to *c2*, anterior to *gla*, antero-lateral to *gla* and anterior to *p3*, respectively. Lyrifissure *ip* aligned perpendicular to notogastral outline, located between *p1* and *p2*.

Ventral region — Genito-anal setal formula: 6-1-2-3. Genital setae (14-19 μm) thin, setiform, roughened throughout length; *g1* longest; *g1*, *g2* inserted at same level near anterior margin of plates. Setae *ag* (ca. 14 μm) thin, smooth setiform, inserted postero-lateral to genital aperture. Setae *an1* (ca. 14 μm), *an2* (ca. 11 μm) thin, smooth setiform, inserted near posterior and anterior margin of plates, respec-

tively. Adanal setae vestigial; *ad1,2* aligned in post-anal position; *ad3* in adanal. Lyrifissures *iad* oriented parallel to outline of aperture, at level of *an2* (Fig. 3B). Genital (34 μm) and anal (55 μm) apertures roughly circular in shape; distance between them (66 μm) about twice length of genital aperture. Sternal ridge indistinct. Epimeral borders 1, 2, *sj* distinct. Epimeral setal formula: 3-1-3-3; setae smooth, short, setiform (18-39 μm); *1c* longest; *1a* shortest; *3c* thickest. Subcapitular setae three pairs; *a* (ca. 13 μm) thin, setiform, roughened throughout length; *m* (ca. 23 μm) thick, setiform, barbed throughout length; *h* (ca. 21 μm) thin, setiform, sparsely barbed throughout length (Fig. 4E). Pedipalpal setal formula: 0-2-1-3-9[1]; solenidion bacilliform (Fig. 4D).

Legs — Heterotridactylous; median claw minutely dentate (24-26 μm) (Fig. 4C); median claw of leg II longest; median claw of IV shortest. Setal formula: I (1-5-3-4-20), II (1-4-3-4-15), III (2-2-1-3-14), IV (1-2-2-3-12). Measurements (μm) of [right-left] segments: I ([26-25]-[61-55]-[26-24]-[40-36]-[61-57]); II ([6-8]-[52-60]-[18-24]-[34-37]-[49-46]); III ([34-41]-[43-48]-[23-23]-[42-40]-[47-50]); IV ([39-39]-[44-41]-[25-31]-[51-46]-[61-59]). On tarsus I, famulus ε (ca. 9 μm) bacilliform, situated anterolateral to ω_2 (ca. 39 μm); ω_2 posterior to *ft'* (ca. 10 μm); *ft'* posterior to ω_1 (ca. 46 μm); ω_1 , ω_2 terminating in fine tip (Fig. 4B). Solenidion φ_1 (ca. 127 μm) inserted near tip of tibia I; φ_2 (ca. 10 μm) lateral to φ_1 . On genu I, solenidion σ (ca. 101 μm) terminating in fine tip (Fig. 4F).

Remarks — According to Subías (2004), 15 species and three subspecies are known as members of the genus *Humerobates* (*Humerobates*) Sellnick, 1928, and a single species of the subgenus *Humerobates* (*Cordylobates*) Luxton, 1995 is known. The new species has some remarkable features in common with known species of *Humerobates* (*Humerobates*) such as narrow lamella without long cusp of translamella, lamellar seta originating from tip of lamella, long tutorium, sensillum with broad head, immovable pteromorph, 10 pairs of notogastral setae, four pairs of porose areas, opisthonotal gland opening, genito-anal setal formula 6-1-2-3, and heterotridactylous legs. However, the new species is

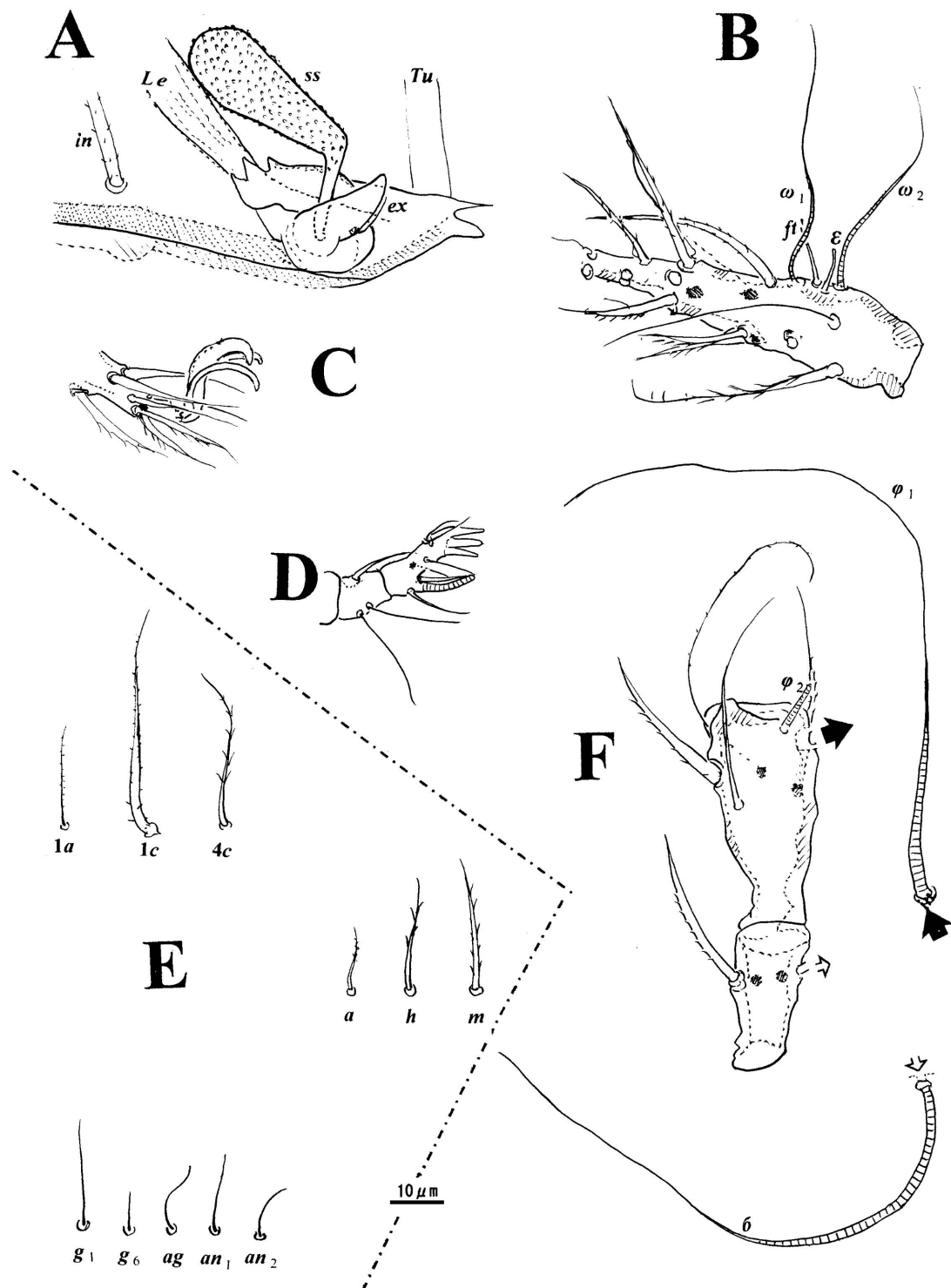


FIGURE 4: *Humeroabates (Humeroabates) kumasoi* n. sp. (Paratype, 13789): A – Right bothridial region; B – Right tarsus I; C – Tip of left tarsus II; D – Right pedipalp; E – Principal setae of ventral region; F – Right tibia I and genu I.

different from congeners in having anterior rostral margin projecting as a point on each side, bothridia with large ventromedial scale dentate on the anterior margin, sensilla composed of thin smooth short stems and broad spatulate heads verrucose throughout length, expanded distally without narrower apex, vestigial notogastral setae, vestigial adanal setae, thick medial subcapitular setae, and small body size (< 310 μm in length). All known members of subgenus *Humerobates* have round or straight anterior rostral margins and adanal setae. Moreover, most have notogastral setae. *Humerobates* (*H.*) *varius* Ohkubo, 1982 recorded from Japan has vestigial notogastral setae like the new species. However, the new species differs from *Humerobates* (*H.*) *varius* by anterior rostral margin projecting as a point on each side and vestigial adanal setae. Females and males of the new species had same range of body lengths and different ranges of widths. The cause of the fact is unknown in the present work.

Damaeidae Berlese, 1896

Spatiodamaeus sp.

(Figs. 5 – 9)

In the present paper, one specimen was described as *Spatiodamaeus* sp. Although it may prove in the future being representatives of new species, it was not designed as new species in the present paper because only a single, damaged specimen was found.

Diagnosis — Body length 536 μm ; width 429 μm . Rostral anterior margin widely rounded. Prodorsal setae *ro*, *le*, *in*, *ss*, *ex*, long, minutely barbed throughout length. Notogaster bearing exuviae with polygonal structure. Spinae adnatae acute. Of 11 pairs of notogastral setae, eight pairs smooth, hypertrophied, widened, blade-like; *p*₁₋₃ setae long, setiform, minutely barbed throughout length. Genito-anal setal formula: 6-1-2-3. Ventral tubercle (*Va*) with long sharply pointed apex, bending to lateral side. Lyrifissures *iad* aligned obliquely. Epimeral setal formula: 3-1-3-3.

Material examined — One adult female (NSMT-Ac 13786) from the soil surface at the entrance of Kumaso cave. The specimen is deposited in the National Museum of Nature and Science, Tokyo.

Measurements and body appearance — Body length 536 μm ; width 429 μm . Body colour of live mite dark brown; body surface smooth. Notogaster bearing concentrically arranged exuviae with polygonal structure (Fig. 5).

Prodorsum — Rostral anterior margin widely rounded. Rostral setae (*ro*) (ca. 129 μm) inserted just behind the border of the underlying rostraphragma (Fig. 3). Lamellar setae (*le*) (Right-left: 157-141 μm) reaching anterior rostral margin. Interlamellar setae (*in*) (159-150 μm) reaching rostral cavity. Sensilla (*ss*) (ca. 195 μm) long spiniform, minutely barbed throughout length. Exobothridial setae (*ex*) (61-77 μm) inserted at lateral side of bothridia. Setae *ro*, *le*, *in* and *ex* long setiform, minutely barbed throughout length. Bothridia opening latero-dorsally with large funnel-like extension of palmate laminated appearance.

Notogaster — concentrically bearing arranged exuviae with polygonal structure (Fig. 5). Spinae adnatae acute (29 μm). Of 11 pairs of notogastral setae; eight pairs (*c*₁₋₂, *la*, *lm*, *lp*, *h*₁₋₃) (68-111 μm) smooth, hypertrophied, widened, blade-like (Fig. 6), arranged in two longitudinal rows; *p*₁₋₃-setae (86-152 μm) long setiform, minutely barbed throughout length; *p*₃ longest; *lp* shortest. Lyrifissures *ia*, *ih*, *ips* aligned parallel to notogastral outline, located lateral to setae *c*₂, *lp* and *h*₃, respectively; *im*, *ip* obliquely aligned, lateral to setae *lm* and *p*₃, respectively. Opisthonotal gland opening (*gla*) situated laterally between setae *lp* and *h*₃.

Ventral region — Ventral tubercles (*Va*) with long sharply pointed apex, bending laterally (Fig. 7). Genito-anal setal formula: 6-1-2-3; all setae thin, setiform, roughened. Genital setae (30-48 μm) aligned in longitudinal row; *g*₁ longest. Setae *ag* (ca. 47 μm) inserting postero-laterally to genital aperture. Setae *an*₁ (ca. 41 μm) inserted almost at mid-distance along plate; *an*₂ (ca. 38 μm) near anterior margin of plate. Setae *ad*₁ (34-34 μm) near postero-lateral corner of anal aperture; *ad*_{2,3} (ca. 45 μm) in adanal position; *ad*₃ inserted at level of *an*₁. Lyrifissures *iad* oriented obliquely, anterior to *ad*₃. Genital (107 μm) and anal (96 μm) apertures almost pentagonal in shape; distance between them (18 μm) about one-sixth as long as anal aperture. Sternal ridge and

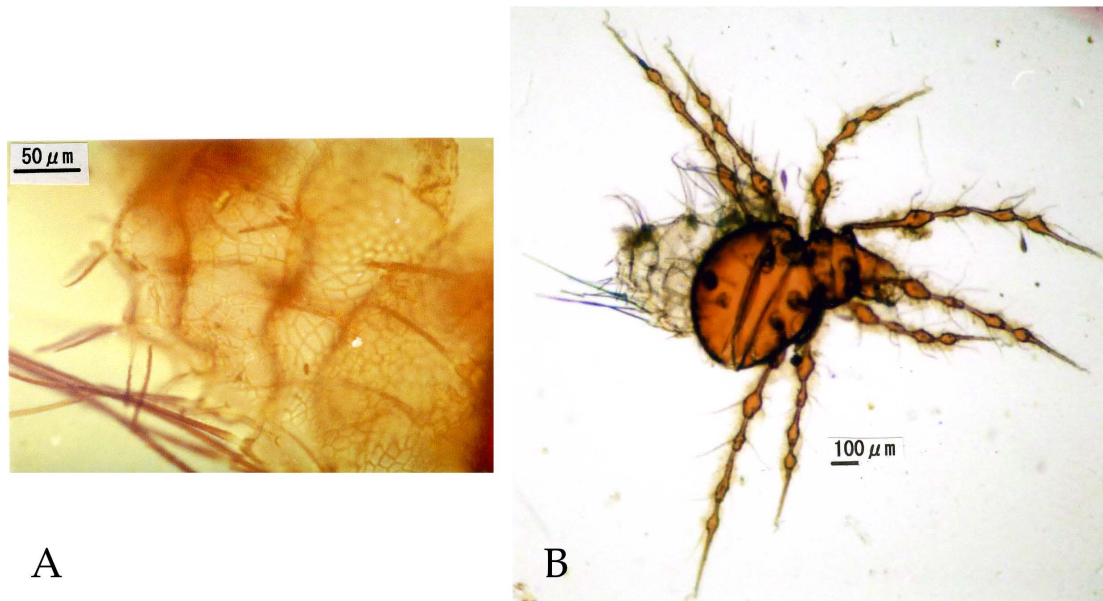


FIGURE 5: *Spatiodamaeus* sp. (photo by Nakamura Y.): A – Exuvial scalps. B – Adult specimen.

epimeral borders 1-4, *sj* indistinct. Epimeral setal formula: 3-1-3-3; setae smooth, short, setiform (14-91 μm); *1b* longest; *4a* shortest. Subcapitular setae 3 pairs, *a* (30-43 μm), *m* (48-43 μm), and *h* (55-57 μm); setae thin setiform; *a*, *m* roughened throughout length; *h* minutely barbed unilaterally. Cheliceral setae *cha* (ca. 38 μm) barbed unilaterally, terminating in fine tips; *chb* (ca. 27 μm) attenuate conspicuously and unilaterally pilose in distal portion (Fig. 8F). Pedipalpal setal formula: 0-2-1-3-9[1]; solenidion spiniform (Fig. 8A).

Legs — Monodactylous; claw smooth (45-61 μm) (Figs. 8D and E); claw of leg IV longest; claw of leg II shortest. Setal formula: I (1-6-4-4-19), II (1-5-4-4-16), III (2-4-4-3-14), IV (1-4-4-3-14). Measurements (μm) of [right-left] segments: I ([39-46]-[248-223]-[?-98]-[?-138]-[?-255]); II ([61-59]-[202-189]-[?-77]-[?-105]-[191-220]); III ([?-130]-[161-163]-[82-?]-[120-?]-[220-?]); IV ([150-186]-[145-186]-[89-?]-[154-?]-[263-275]). Setae long, setiform or bacilliform, verrucose throughout length (Fig. 9). On tarsus I, famulus ε (ca. 30 μm) consisting of fine tip and expanded basal portion, situated posteriorly, contiguously between ω_1 (ca. 45 μm) and ω_2 (ca. 27 μm); ω_1 , ω_2 terminating in fine tip (Fig. 8C). Solenidion φ_1 (ca. 143 μm) originating from small apophysis on tip of tibia

I; φ_2 (ca. 41 μm) originating from smaller apophyses than that of φ_1 , lateral to φ_1 . On genu I, solenidion σ (ca. 36 μm) terminating in fine tip, shorter than seta *d* (Fig. 9A).

Remarks — Bulanova-Zachvatkina (1957) erected new subgenus *Spatiodamaeus*, belonging to the genus *Damaeus*, without original designation for type species, and described three new species, *D. (S.) boreus*, *D. (S.) fagei* and *D. (S.) subverticillipes* as members of the new subgenus. At the same time, she added five known species, *Belba glabriseta* Willmann, 1930, *Damaeus phalangioides* Michael, 1890, *D. tecticola* Michael, 1888, *D. tenuipes* Michael, 1885 and *D. verticillipes* Nicolet, 1855 to the new subgenus, of which *D. phalangioides* was referred to the genus *Metabelbella* Bulanova-Zachvatkina, 1957 (Arillo and Subías, 2006), and *D. tecticola* and *D. tenuipes* to the genus *Epidamaeus* Bulanova-Zachvatkina, 1957 (Luxton, 1989). Since then, Bulanova-Zachvatkina (1967) elevated *Spatiodamaeus* to generic status, designating *D. verticillipes* Nicolet, 1855 as the type. Norton (1977) reviewed it as a subgenus, while Balogh (1972), Balogh and Balogh (1992), Subías (2004) and Weigmann (2006) treated it as a genus. After eight species were listed as members of the genus *Spatiodamaeus* by Subías (2004), one species

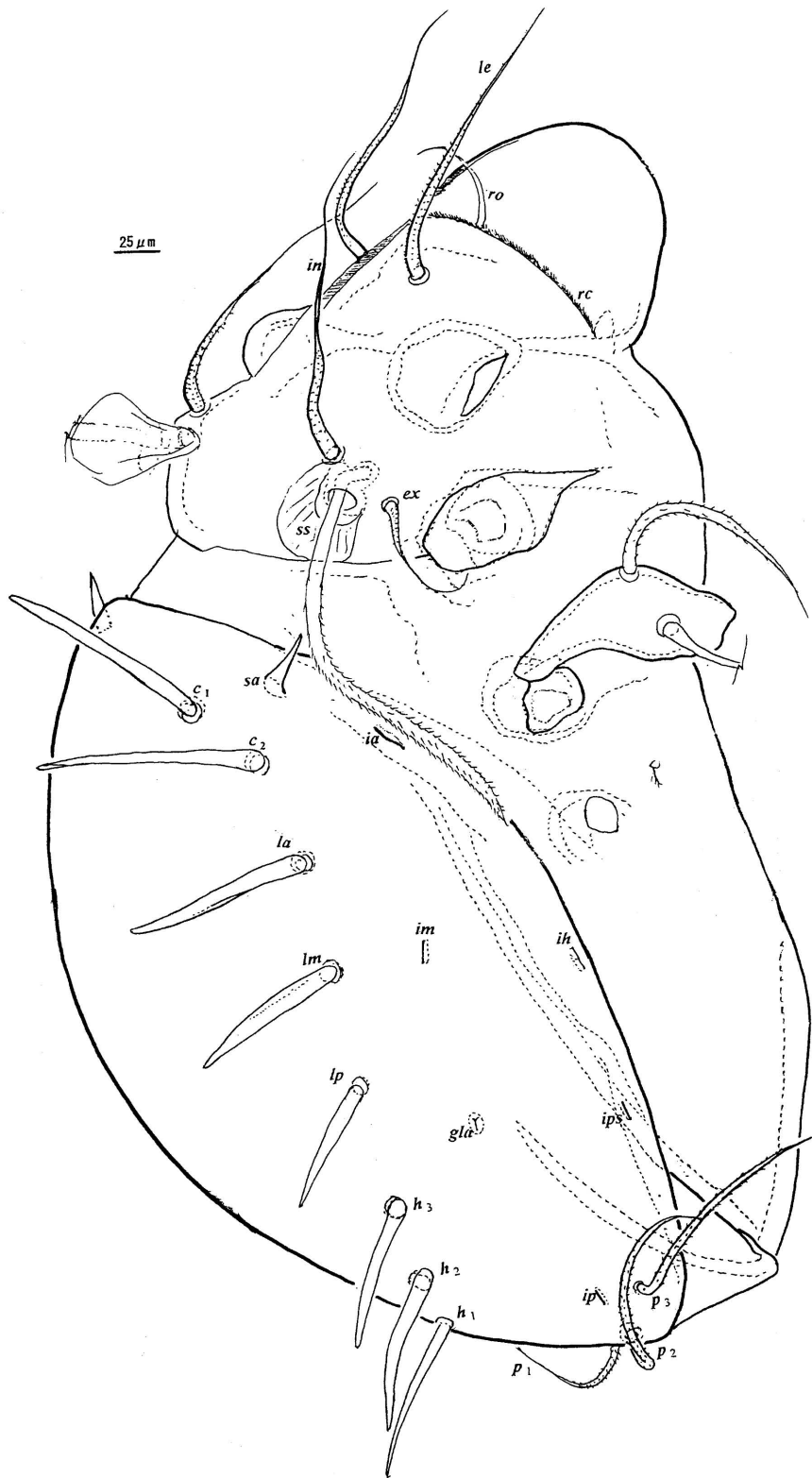


FIGURE 6: *Spatiodamaeus* sp.: Dorsolateral view, legs removed (NSMT-Ac 13786).

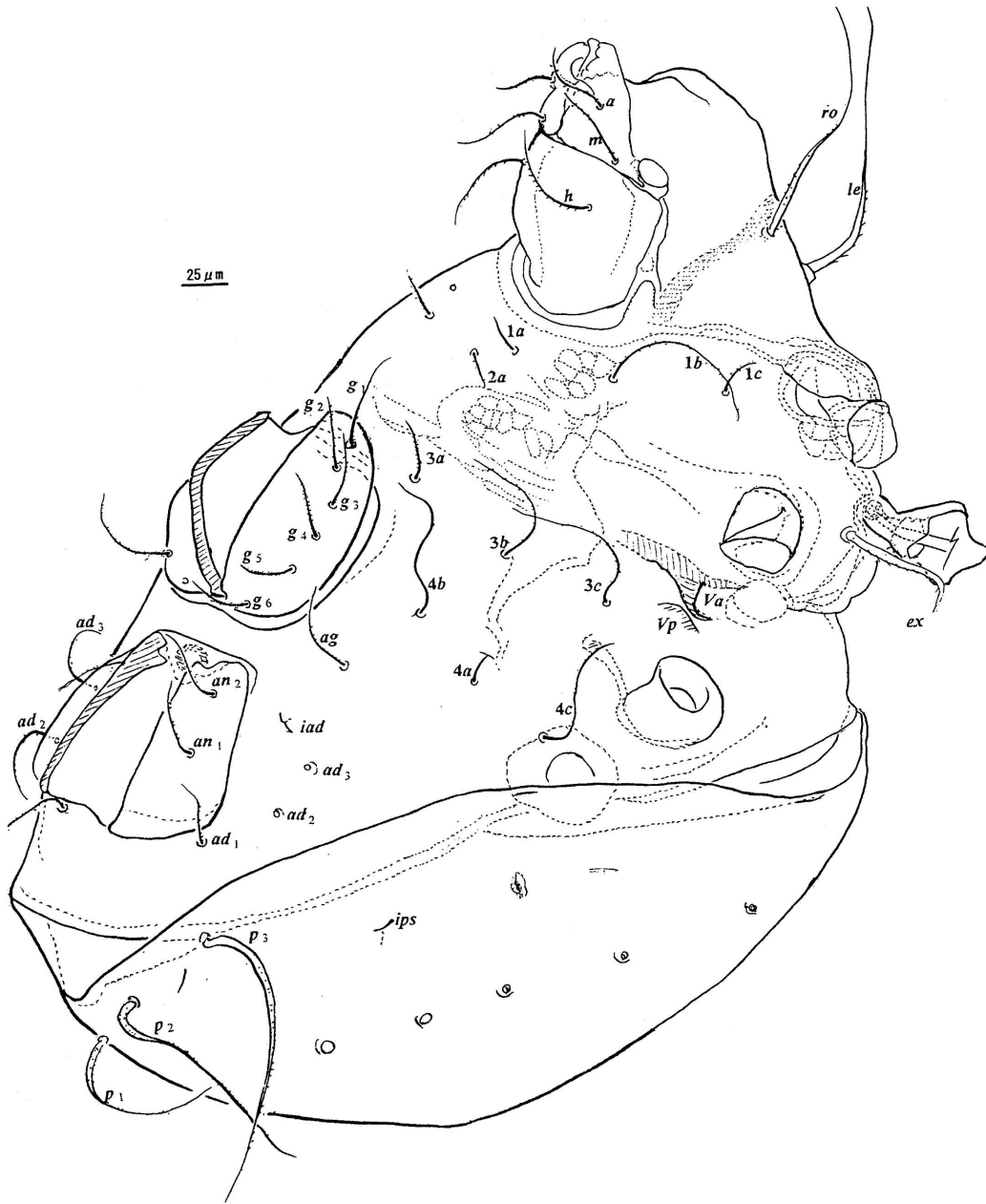


FIGURE 7: *Spatiodamaeus* sp.: Ventrolateral view, legs and pedipalps removed (NSMT-Ac, 13786).

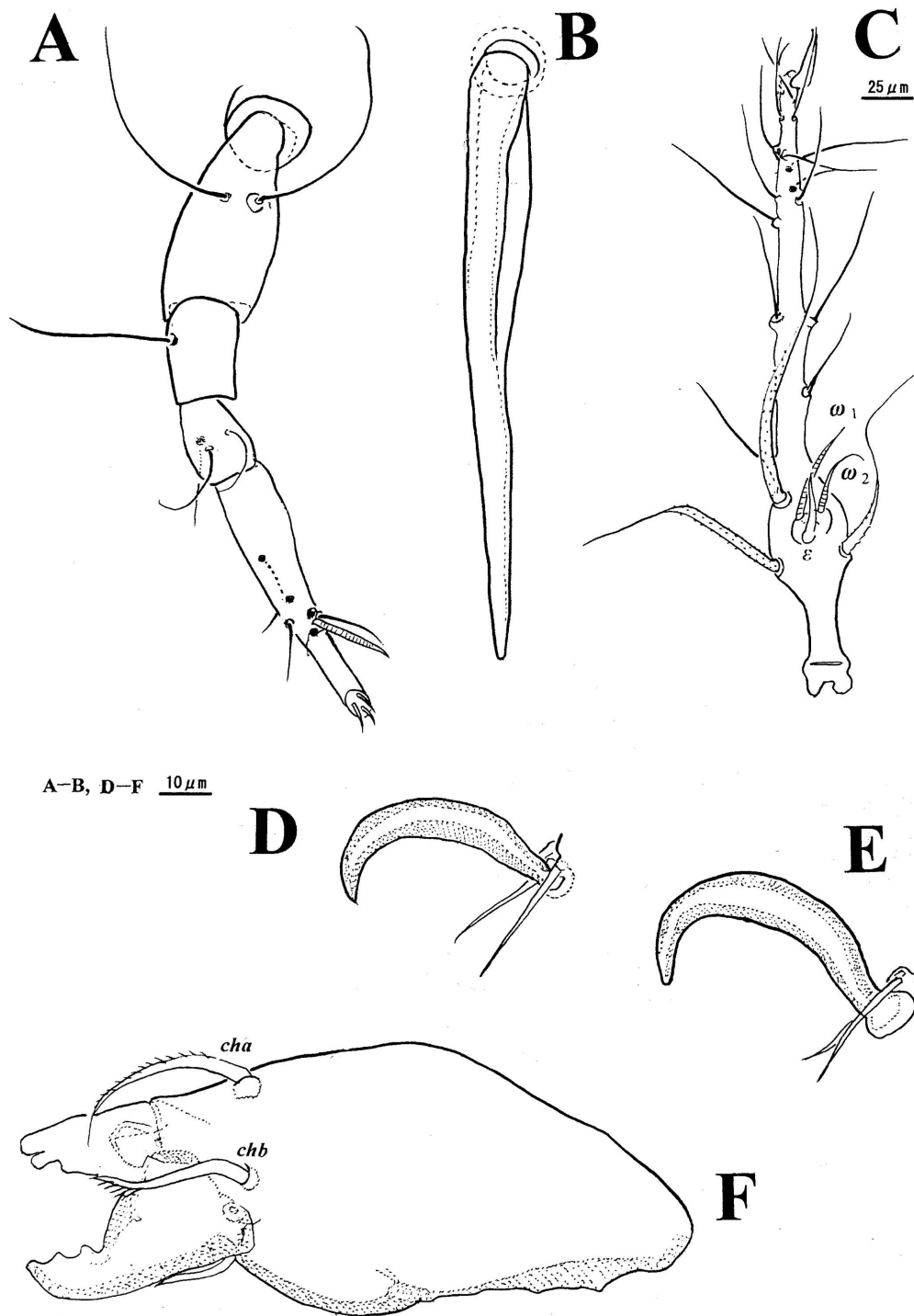


FIGURE 8: *Spatiodamaeus* sp. (NSMT-Ac 13786): A – Left pedipalp; B – Right seta c_1 ; C – Right tarsus I; D – Claw and distal setae of left leg I; E – Claw and distal setae of left leg IV; F – Left chelicera.

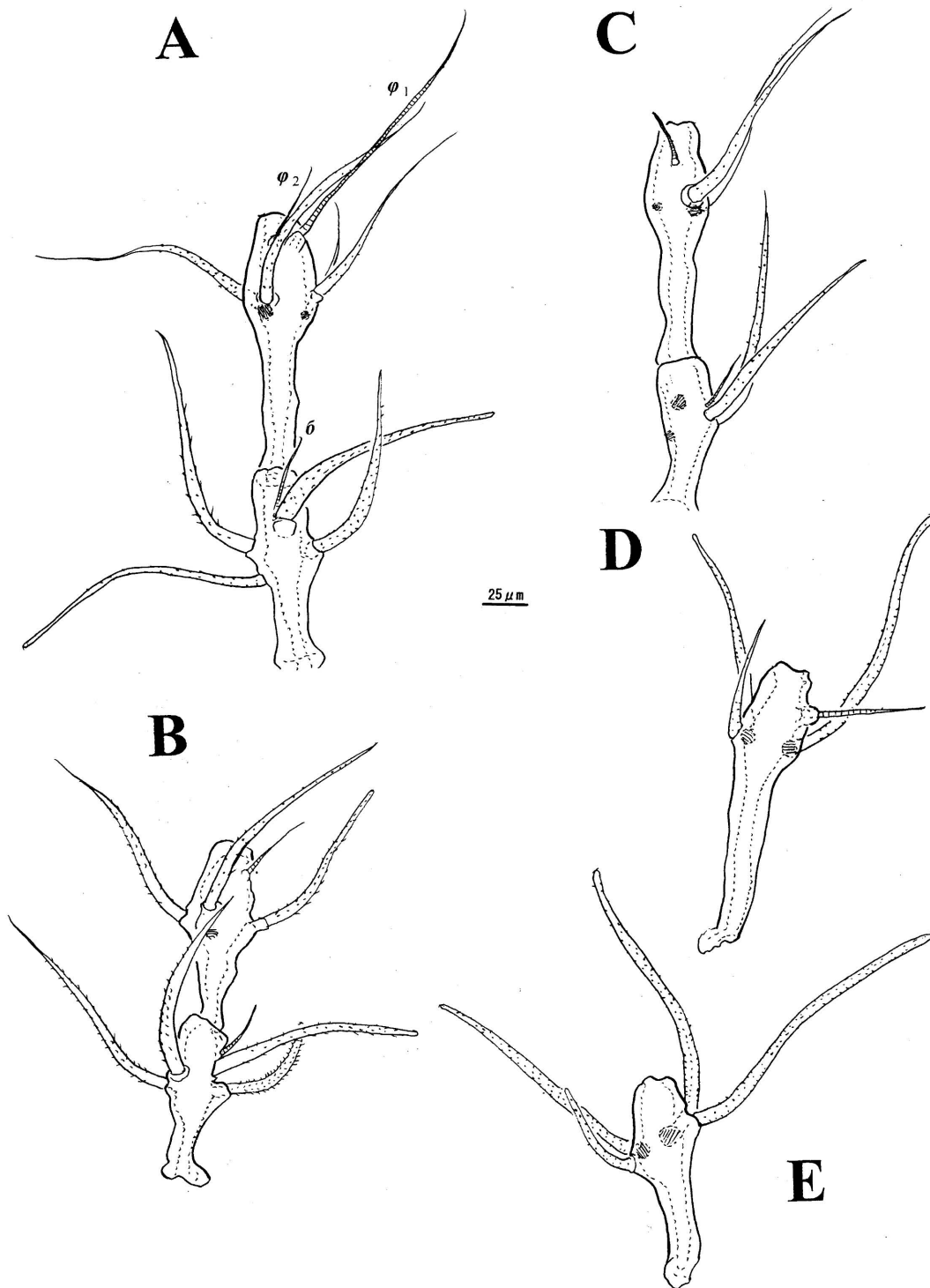


FIGURE 9: *Spatiodamaeus* sp. (NSMT-Ac 13786): A – Right tibia I and genu I; B – Right tibia II and genu II; C – Left tibia III and genu III; D – Left tibia IV; E – Left genu IV.

was added (Xie *et al.*, 2012). *D. (S.) verticillipes* is microphytophagous (Schuster, 1956) and diplodiploid (Norton, 1993). No member of this genus has been recorded from Japan to date. The present specimen was distinguished from congeners by (1) small body size (length 536 μm , width 429 μm); (2) spinae adnatae acute, (3) 11 pairs of notogastral setae, p_{1-3} setae long setiform, minutely barbed throughout length, and the other setae smooth hypertrophied, widened, blade-like, and (4) ventral tubercle (*Va*) with long sharply pointed apex, bending to lateral side.

Key to the species. Largest body length and width (in μm) are shown according to the original description.

1. Notogastral setae h_1, h_2 and h_3 longer than setae, c_1, c_2, la, lm, lp *Spatiodamaeus subverticillipes* Bulanova-Zachvatkina, 1957; 840 \times 640 μm
— Notogastral setae h_1, h_2 and h_3 not longer than setae, c_1, c_2, la, lm, lp 2
2. Notogastral setae la, lm shorter than other setae. *S. fageti* Bulanova-Zachvatkina, 1957; 860 \times 580 μm
— Length of notogastral setae variable 3
3. Interlamellar setae *in* longer or as long as sensilli. 4
— Setae *in* shorter than sensilli 6
4. Genual setation: 5-5-4-4.
..... *S. verticillipes* (Nicolet, 1855); 740 \times ? μm
— Genual setation: 4-4-4-4 5
5. Setae c_1, c_2 thick, smooth as long as thin smooth h_1 *S. boreus* Bulanova-Zachvatkina, 1957; 680 \times 480 μm
— Setae c_1 thick, barbed longer than thin, smooth h_{1-3} *S. crassispinosus* Mihelčič, 1964; 850 \times 520 μm
6. Ventral tubercles (*Va*) tuberculate 7
— Ventral tubercles (*Va*) with long sharply pointed apex, bending laterally.

- *Spatiodamaeus* sp.; 536 \times 429 μm
7. Setae, c_1, c_2, la, lm, lp thick, long, barbed; other setae h_{1-3} and p_{1-3} thin, short, smooth.
..... *S. similes* (Willmann, 1954); ? \times ? μm
— Setae, c_1, c_2, la, lm thin, smooth 8
 8. Setae, c_1, c_2, la, lm, lp shorter than setae h_{1-3}
..... *S. glabriseta* (Willmann, 1930); 740 \times 495 μm
— Setae, c_1, c_2, la, lm, lp longer than setae h_{1-3}
..... *S. diversipilis* (Willmann, 1951); 600 \times 360 μm
— Setae, c_1 slightly longer than other setae.
..... *S. bomeensis* Xie *et al.*, 2012; 910 \times 670 μm

Protoribatidae Balogh and Balogh, 1984

Protoribates (Protoribates) sp.

(Figs. 10 – 12)

In the present paper, one specimen was described as *Protoribates* sp. Although it may prove in the future being representatives of new species, it were not designed as new species in the present paper because only a single, damaged specimen was found.

Diagnosis — Body length 557 μm ; width 329 μm . Rostrum rounded. Anterior notogastral margin straight. Setae *ro* inserted laterally. Tutorium absent. Setae *le* originating from tip of lamella. Sensilli composed of long stem and fusiform head, barbed throughout length. Notogaster bearing 10 pairs of minute notogastral setae. Genito-anal setal formula: 5-1-2-3; genital and aggenital setae variable in number. Epimeral setal formula: 3-1-3-3. Monodactylous.

Material examined — One adult female (NSMT-Ac 13790) from the soil surface at the entrance of Kumaso cave. Specimen is deposited in the National Museum of Nature and Science, Tokyo.

Measurements and body appearance — Body length, 557 μm ; width, 329 μm . Body colour light brown; body surface smooth.

Prodorsum — Anterior rostral margin rounded (Fig. 10). Setae *ro* (59-55 μm) inserted laterally on rostrum. Lamellae thin, about 0.7 \times length of prodorsum. Setae *le* (91-88 μm) originating from tip of lamella. Setae *ro* and *le* extending anterior to

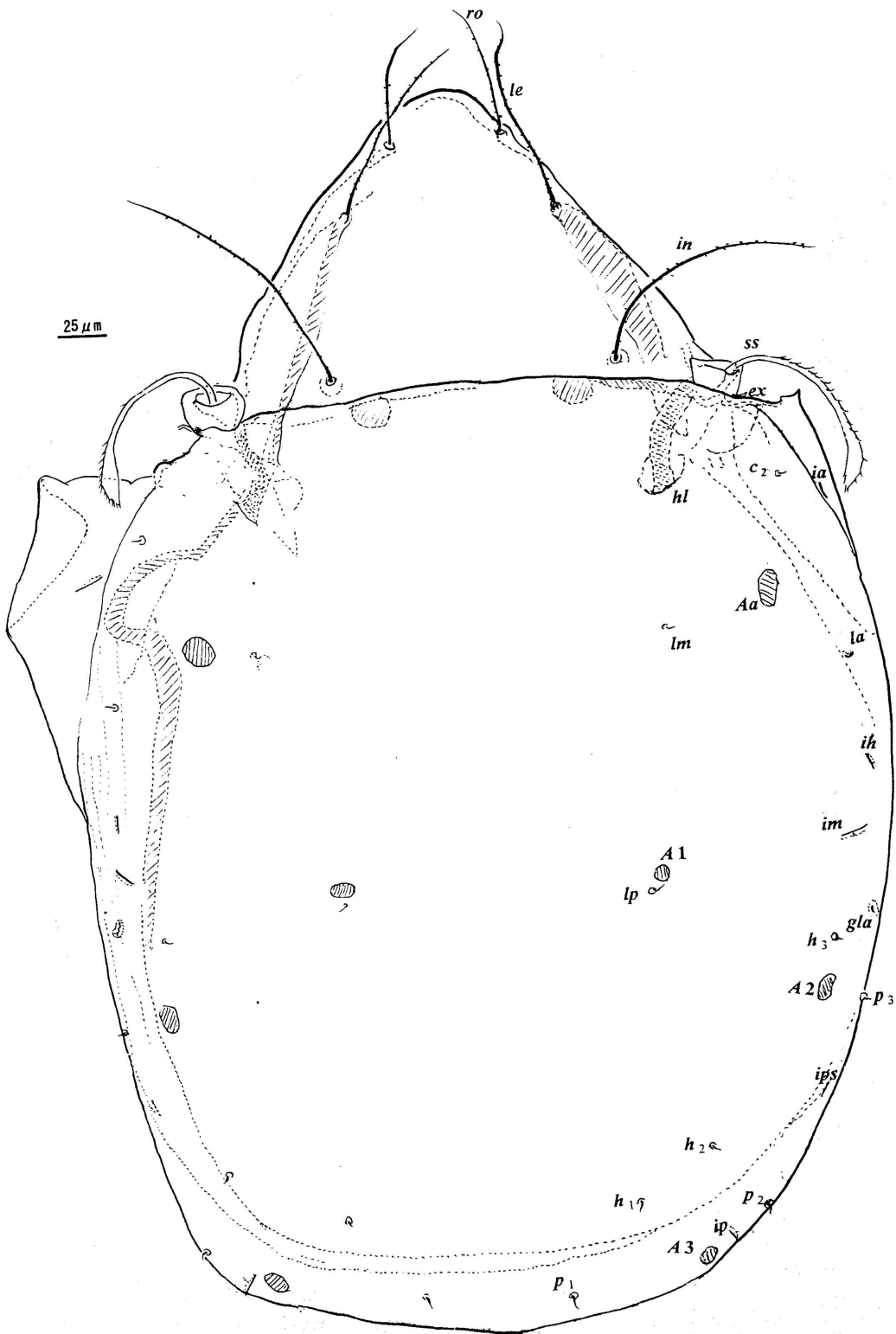


FIGURE 10: *Protoribates* sp. (NSMT-Ac 13790): Dorsal view, legs removed.

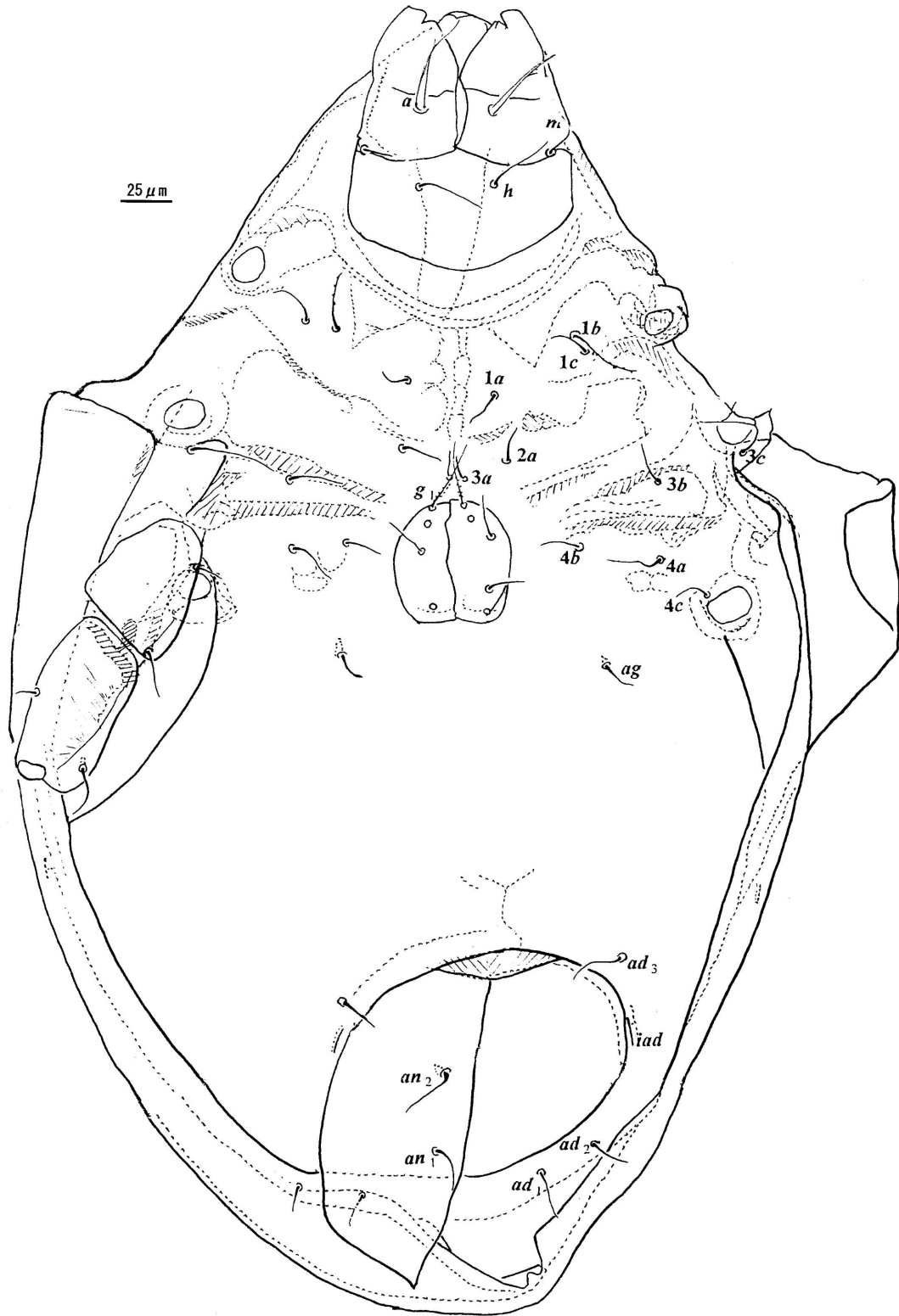


FIGURE 11: *Protoribates* sp. (NSMT-Ac 13790): Ventral view, legs removed.

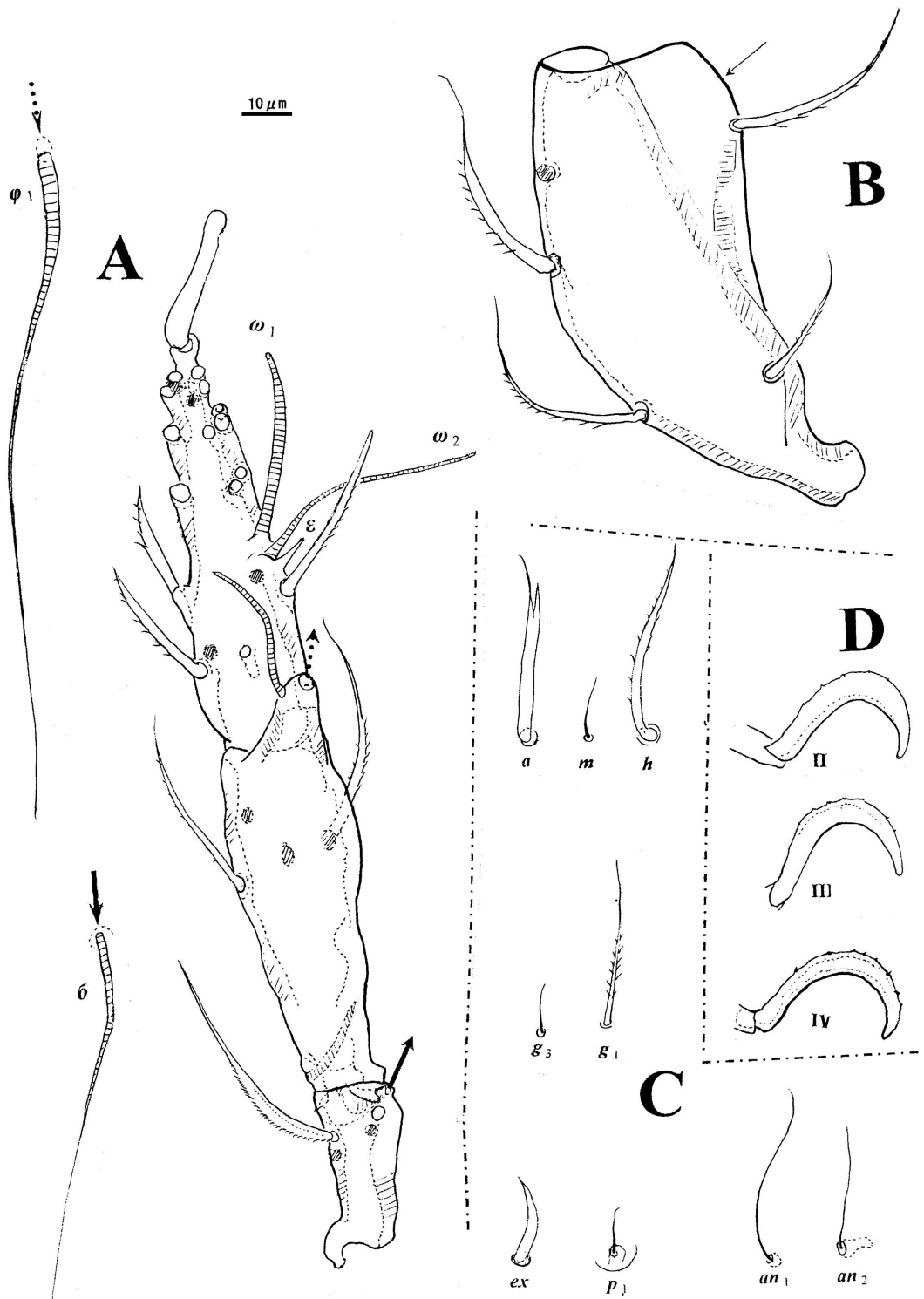


FIGURE 12: *Protoribates* sp. (NSMT-Ac, 13790): A – Right leg I; B – Right femur II (arrow leg-fin); C – Principal setae of ventral region; D – Claws of right leg II, left leg III and right leg IV.

rostrum. Setae *in* (116-134 μm) reaching insertions of setae *ro*. Setae *ro*, *le*, *in* thin setiform, minutely, sparsely barbed throughout length. Sensilla (105-105 μm) composed of thin long stem and fusiform head, unilaterally barbed throughout length. Setae *ex* thick, smooth, spiniform (ca. 16 μm) inserted at lateral base of bothridia (Fig. 12C). Bothridia opening antero-dorsally. Relative length: (*in-in*) > (*le-le*) > (*le-in*) > (*ro-ro*) > (*ro-le*).

Notogaster — Anterior margin straight, bearing 10 pairs of minute, smooth notogastral setae. Pleurophragmata (*hl*) distinct. Porose areas *Aa* (the major axis: 16 μm) located anteriorly between *la* and *lm*; *A1* anterior to *lp*; *A2* posterior to *h3*; *A3* lateral to *ip*. Opisthonotal gland opening (*gla*) situated latero-anteriorly to *h3*. Lyrifissures *ia* (9-14 μm), *im* (14-9 μm), *ih* (ca. 16 μm) and *ips* (9-9 μm) aligned obliquely, located lateral to *c2*, posterior to *la*, antero-lateral to *im* and posterior to *A2*, respectively. Lyrifissure *ip* (9-9 μm) aligned perpendicular to notogastral outline, located between *p1* (ca. 9 μm) and *p2*.

Ventral region — Genito-anal setal formula: 4[5]-1[0]-2-3; genital and aggenital setae variable in number, indicated by brackets. Genital setae (10-31 μm) setiform; *g1* longest, thick, barbed throughout length; other setae thin, bearing sparse barbs. Setae *ag* (ca. 16 μm) thin, smooth setiform, inserted postero-laterally far from genital aperture. Setae *an1* (ca. 32 μm), *an2* (ca. 22 μm) thin, smooth setiform, inserted near mid-distance along plates. Adanal setae thin, smooth, setiform; *ad1,2* (ca. 31 μm) aligned in post-anal position; *ad3* (18-26 μm) in adanal, near anterior margin of aperture. Lyrifissures *iad* (ca. 14 μm) located parallel to outline of aperture, anterior to level of *an2*, posterior to *ad3* (Fig. 11). Genital (54 μm) and anal (141 μm) apertures roughly circular in shape; distance between them (154 μm) about one-third genital aperture length. Sternal ridge observable. Epimeral borders 1-3, *sj* distinct. Epimeral setal formula: 3-1-3-3; setae setiform (15-33 μm); *3c* longest; *1a* shortest; *1b* thickest, sparsely barbed; other setae smooth. Subcapitular setae 3 pairs; *a* (ca. 35 μm) thick setiform, bearing few barbs; *m* (ca. 6 μm) thin, smooth setiform; *h* (ca. 36 μm) thick setiform, barbed throughout length (Fig. 12C).

Legs — Monodactylous; claw minutely dentate (40 μm) (Fig. 12D). Setal formula: I (1-5-3-4-20), II (1-5-2-4-14), III (2-3-1-3-14), IV (1-2-2-3-14). Measurements (μm) of [right-left] segments: I ([?-16]-[91-96]-[?-31]-[?-80]-[?-71]); II ([9-?]-[?-91]-[24-19]-[66-56]-[62-64]); III ([?-49]-[?-72]-[?-27]-[55-59]-[55-53]); IV ([68-66]-[69-67]-[33-39]-[72-78]-[72-69]). On tarsus I, famulus ε (ca. 7 μm) consisting of obtuse tip and expanded basal portion, situated posterior to ω_2 ; ω_2 (ca. 44 μm) posterior to ω_1 (ca. 36 μm); *ft'* (ca. 37 μm) posterior to ε ; ω_1 , ω_2 terminating in obtuse tip (Fig. 12A). Solenidion φ_1 (ca. 122 μm) inserted on apophyses (ca. 17 μm) protruding at the tip of tibia I; φ_2 (ca. 27 μm) lateral to φ_1 on the same apophyses. On genu I, solenidion σ (ca. 64 μm) terminating in a fine tip. Femora II, IV and trochantera IV bearing ventral keel (Fig. 12B).

Remarks — The genus *Protoribates* (*Protoribates*) contains 40 known species and three known subspecies worldwide, of which two species bear a superficial resemblance to the present specimen. *P. (P.) mollicoma* (Hammer, 1973) and *P. (P.) yezoensis* (Fujikawa, 1983) have straight anterior notogastral margin, long lamellar and interlamellar setae, and *ad1,2* aligned in post-anal position as seen in the present specimen. However, the present specimen is different from *P. (P.) mollicoma* in length of *ad1* and *ad2*, and insertion of *ad3*. The former has adanal setae *ad1,3* of the same length, and *ad3* inserted the anterior margin of the anal aperture, while the latter had adanal setae *ad1,2* longer than *ad3* and *ad3* inserted in front of anterior margin of the anal aperture. The present specimen is different from *P. (P.) yezoensis* in the form of rostrum and insertion of *an1,2*. The former has a round rostrum, and setae *an1,2* inserted near midway along the plates, while the latter has a rostrum with a median elevation, and seta *an1* inserted near the posterior margin of the anal plate.

RECORD OF KNOWN SPECIES

Tetracondylidae Aoki, 1961

Fissicepheus(*Fissicepheus*) *takenouchiensis* Fujikawa and Nishi, 2013

Fissicepheus(*Fissicepheus*) *takenouchiensis* Fujikawa

and Nishi, 2013, *Edaphologia*, (92): 17-23, figs. 1-3.

Material examined — One adult female (NSMT-Ac 13787): from the soil surface at the entrance of Kumaso cave. Specimen is deposited in the National Museum of Nature and Science, Tokyo.

Measurements — Body length 786 μm ; width 429 μm . Body colour light brown.

Known record — Litter, humus, and soil from inside of old cut bamboo joint at a bamboo plantation of *Phyllostachys pubescens* Mazel (32°12'5"N, 130°54'5"E, 195 m a.s.l.), Asagiri-cho, Kumamoto Prefecture.

Remarks — The present specimen differs from the holotype in position of the cuticle hardened and darkened transverse band situated nearer to (*lm-lm*) than to (*h₂-h₂*).

Schelorbitidae Jacot, 1935

Schelorbites latipes C. L. Koch, 1841

Zetes latipes C. L. Koch, 1841, *Deu. Crust. Myr. Aradhn.*, fa. 38, t.14.

Schelorbites latipes: Sellnick, 1928, p.16, fig. 30; Oudemans, 1937 *Kritisch Historisch Overzicht der Acarologie*, III (E & F), pp. 2662-2663; Fujikawa, 1983, *Edaphologia*, (29), pp. 3-4, figs. 4 & 5.

Material examined — One adult female (NSMT-Ac 13789), from the soil surface at the entrance of Kumaso cave, mounted together with *Humerobates kumaso* sp. nov. Specimen is deposited in the National Museum of Nature and Science, Tokyo.

Measurements — Body length 307 μm ; width 229 μm . Body colour light brown.

Distribution — Cosmopolitan.

Haplozetidae Grandjean, 1936

Peloribates (Peloribates) latus Fujikawa, 2006

Peloribates (Peloribates) latus Fujikawa, 2006, *Edaphologia*, (80), pp.18 & 19, fig. 17.

Material examined — Two adult females (NSMT-Ac 13791 & 13792): from the upper wall at the entrance of Kumaso cave; four adult females (NSMT-Ac 13793 to 13796): from the soil surface at the entrance of Kumaso cave. Specimens are

deposited in the National Museum of Nature and Science, Tokyo.

Measurements — Body length 307-379 μm ; width 264-357 μm . Body colour light brown.

Known record — Litter and humus, and soil from the bank of the intertidal zone of Miyajima, Hiroshima prefecture (34°17'50"N, 132°19'13"E, 0 m a.s.l.).

Remarks — The present specimens differ from the holotype in relative distances of two setal pairs: (*in-in*) < (*le-le*).

DISCUSSION

Whilst many oribatid species have been recorded from inside caves worldwide (e.g. Iturrondobeitia and Arillo, 1997; Ducarme *et al.*, 2004; Lundberg *et al.*, 2010; Skubała *et al.*, 2013) and even in a Japanese cave (Nakamura *et al.*, 2010), no oribatid mites were found in samples collected inside the Kumaso cave and seven genera were found at the entrance of the Kumaso cave only (*Drepanoppia*, *Fissicepheus*, *Humerobates (Humerobates)*, *Peloribates*, *Protoribates*, *Schelorbites*, *Spatiodamaeus*). Congeners of one of the entrance-sampled genera, namely *Protoribates*, were previously recorded from caves (Mahunka, 2009a; Nakamura *et al.*, 2010) and members of *Damaeus*, in the same family (Damaeidae) as *Spatiodamaeus*, have been recorded from many caves (Skubała *et al.*, 2013). In contrast, congeners of the species belonging to the six remaining genera are not specifically known from caves. Some of them were even found in arboreal habitats: a congener of *Fissicepheus* and a congener of *Schelorbites* were collected from the canopy (Aoki, 1971; Behan-Pelletier and Winchester, 1998, resp.). As a result, although two species in the present samples might be true cave-dwellers, the presence of others at the cave's entrance was likely fortuitous and unlinked to the cave habitat. The absence of oribatid mites from caves is not so uncommon: for example, 12 of 30 caves in Belgium lacked any oribatids (Skubała *et al.*, 2013). In the present case, maybe the nature of the cave floor (covered with rocks that were pitted by water dripping from the ceiling, and with no organic materials available, such as litter, soil, bat

guano deposits or nests) was unsuitable for oribatid mites.

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