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Two new species of Eremellidae and Scheloribatidae (Acari, Oribatida) from the Kuma district of southern Japan

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ABSTRACT — A new oribatid species of Eremellidae was described from litter at the bottom of a hollow Ilex oldhami Miq. tree in Kumamoto Prefecture, in southern Japan in a subtropical area. The new species has long lamellar ridges subpararellly connected by two translamellar ridges, rostral setae longer than lamellar setae, two pairs of adanal setae, and long solenidion ϕ1 about four times as long as the length of the tibia. A key to all species of the genus Eremella is provided. Another new species, Scheloribates yamaeensis n. sp. was described from a chestnut plantation in Kumamoto Prefecture. The new species has a plicate integument, diverged sacculi, immovable pteromorphae with inward curve, a dorsosejugal suture, four pairs of genital setae, minute notogastral setae, adanal setae ad3 inserted in a preanal position, Trägårdh’s organ, three claws of legs, and smooth fastigial setae of tarsus I.

KEYWORDS — Chestnut plantation; Eremella; New species; Oribatida; Scheloribates; Southern Japan

INTRODUCTION

Two new oribatid species were collected from the towns of Asagiri-cho and Yamae-mura in Kuma District, Kumamoto prefecture, which is located in a subtropical zone. Some additional specimens belonging to the genus Eremella Berlese, 1913 were collected in Asagiri-cho from litter at the bottom of a hollow in a withered Ilex oldhami Miq. tree. In addition, Scheloribatid mites belonging to Scheloribates were collected from soil materials of a chestnut plantation in Yamae-mura.

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The Eremellid group has several diagnostic characters such as having two linear, H-shaped costulae, lamellar setae originating near to rostral setae, large, plumose sensillus, rough reticulate notogaster, seven pairs of submarginal and three pairs of postero-marginal notogastral setae, genital and anal apertures separated by a great distance, genito-anal setal formula of 6-1-2-3, palpal eupathidium acm free from the solenidion, legs tri-heterodactyl or monodactyl, without a rostral incision, having a humeral enantiophysis, large dorsodistal tubercle of tibia I, neotrichy of ventral setae, taenidium and minitectum of border of epimere IV (Balogh 1972; Balogh and Balogh 1990; 1992; Norton and Behan-Pelletier 2009). The present specimens of *Eremella* have some unique features and therefore, described as a new species in the present work.

According to Balogh (1962), Enami *et al.* (1996), Fujikawa (2003[2004]; 2011), Nakamura *et al.*, 2013 and Subías (2004), 329 species and 18 subspecies belonging to 20 genera and 4 subgenera have been identified as members of the family Scheloribatidae Grandjean (1933). This family is characterized as having, four pairs of sacculi, immovable pteromorphae, ten pairs of notogastral setae, clavate or fusiform sensilli, arched dorsosejugal suture, four pairs of genital setae, one pair of aggenital setae and three claws (Balogh & Balogh, 1992). The present specimens that were collected from a chestnut plantation in southern Japan have plicate integument near the posterior margin of the notogaster and diverged sacculi, but have numerous character statements which are characteristic for Scheloribatidae.

**Materials and methods**

Study site — Yamae Mura and Asagiri-cho are located in Kuma District, Kumamoto Prefecture, south Japan, in the subtropical zone. Some additional specimens of Scheloribatid species were collected from a chestnut, *Castanea crenata* Sieb. and Zucc. plantation (area of about 10a) belonging to S. Hashimoto (one of the authors) of Yamae Mura (32°14′57″ N; 130 °45′30″ E; about 252 m a.s.l.) in 2007. In 2009, some specimens of Eremellid group were obtained from a big tree, *Ilex oldhami* Miq. being forty years old, withered in 2003 belonging to Y. Nishi (one of the authors) at Ueminami 1299-2 (32′12′5″ N.; 130′54′5″ E.; about 195 m a.s.l.) of Asagiri-cho.

Sampling — Sample of about 4,000 cm$^3$ was collected by hand-picking from litter, humus and soil materials at the chestnut, *Castanea crenata* Sieb. And Zucc. plantation on 25th Oct. 2007 by S. Hashimoto. Sample of about 1,000 cm$^3$ was collected by hand-picking from deposit at the bottom of a hollow of an *Ilex oldhami* Miq. tree on 19th Dec. 2009 by T. Fujikawa. After extraction with a modified Tullgren apparatus during seven days using 40 W electric bulbs, mites were kept in lactic acid for clearing during about 100 days, and then mounted on glass slides.

Terminology and classification — The notations and morphological terminology are mainly based on Balogh and Mahunka (1983), Grandjean (1952), van der 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. Setal formula of legs is including famulus but excluding solenidia. [Right-left] means right and left sides of body from dorsal view. Measurements (µm) in the description are, for the most part, according to holotype.

**Results**

More than 200 specimens of 34 oribatid species were collected from soil materials of a chestnut plantation of Yamae-mura, and about 50 specimens of
eight species were collected from litter at the bottom of a hollow withered Ilex oldhami Miq. tree. Of them, Scheloribatid and Eremellid specimens are described in detail in the present study.

**Description of new species**

Cohort Brachypylina Hull, 1918 Eremellidae Balogh, 1961

_Eremella funnagasatoensis_ n. sp.

[Japanese name: Funnagasato-fuchikazaridani]

(Figs. 1 - 5)

Diagnosis — 236 (253) 264 µm; width: 121 (139) 150. The whole integument except for anal plates, hypostoma and legs, reticulate. Relative lengths: in > ro > le. Sensilli consisting of conspicuously verrucose, club-shaped head and smooth, thin, long stem. All ten pairs of notogastral setae phylliform. Genito-anal setal formula: 6-1-2-2. Epimeral setal formula: 3-1-3-3; setae (14 16 µm) along mid-ventral line. Setae inserted submarginally. Setae p-series (13 16 µm) narrower than the others (16 - 27 µm); h₃ the shortest, ω₂ the shortest (Fig. 5B). Lyrifissures ia (ca. 6 µm) aligned obliquely in front of setae c; im (ca. 8 µm) obliquely between setae lm and lp; ih (ca. 6 µm) perpendicular to, ips (ca. 6 µm) and ip (ca. 9 µm) along notogastral outline (Fig.2A).

Ventral region — Genital aperture (ca. 42 µm in length) almost square in form; anal aperture (ca. 38 µm in length) rectangular; distance (ca. 34 µm) between them slightly shorter than length of anal aperture (Fig. 2A). Genito-anal setal formula: 6-1-2-2; all setae thin, smooth setiform. Genital setae (ca. 13 µm) g₃ inserted nearer lateral margin of plates than the remainder; setae g₅ inserted at the mid-ventral line. Setae ag (ca. 16 µm) inserted latero-posteriorly to genital aperture. Anal setae (ca.13 µm) an₁ and an₂ inserted near anterior and posterior margins of plate, respectively. Adanal setae (ca. 13 µm) ad₁ aligned in postanal position, ad₂ in analanal, and ad₃ lost (Fig. 5C). Lyrifissures _iad_ located posterolaterally to anterior margin of anal aperture. Sternal ridge indistinct. Epimeral borders II and sejugal distinct. Pedotecta I well developed. Epimeral setal formula: 2-1-3-3; setae (14 16 µm) thin, smooth setiform. Pedipalpal setal formula: 0-2-1-3-9[1]; palpal eupathidium _acm_ (ca.7 µm) free from solenidion _ω_ (ca. 7 µm); _ω_ bacilliform (Fig. 3F). Diarthric subcapitulum bearing 3 pairs of setae, a (ca. 9 µm), m (ca. 17 µm), and h (ca. 13 µm); setae thin, smooth setiform. Cheliceral setae _cha_ (ca. 16 µm) and _chb_ (ca. 7 µm) barbed throughout length; _cha_ longer than _chb_ (Fig. 3E).

Legs — All tarsi monodactyl; claws without
FIGURE 1: *Eremella fannagashoensis* n. sp. (NSMT-Ac 13580): Dorsal view.
FIGURE 2: *Eremella funagensatoensis* n. sp.: A – Ventral view (NSMT-Ac 13580); B – Lateral view of propodosoma (a depressed specimen) (NSMT-Ac 13581).
Figure 3: *Eremella funnagasatoensis* n. sp. (NSMT-Ac 13581): A – Tarsus I; B – Tibia and genu of leg I; C – Femur I; D – Genu to trochanter of leg III; E – Chelicera; F — Pedipalp.
Figure 5: *Eremella funnagasatoensis* n. sp. scanning electron micrographs (photos by Nakamura Y.-N., Nishi Y. and Nakamura, Y.): A – Rostral region; B – Postro-marginal region of notogaster; C – Anal region; D – Tarsus and tibia of right leg III.
distinct dent or dilated portion (Figs. 3A, 5D); length (µm): [Right-left]: I [24-24], II [22-26], III [23-29] and IV [29-29]. Setal formula of legs including famulus but excluding solenidia: I (1-5-3-4-15), II (1-5-3-4-14), III (2-3-1-3-14), IV (1-2-2-3-12). Measurements (µm) of segments (trochanter to tarsus): [Right-left]: I [8-7]-[66-71]-[14-12]-[29-24]-[36-36], II [10-13]-[60-61]-[11-12]-[29-24]-[39-36], III [7-51]-[43-34]-[16-15]-[29-34]-[36-36], IV [38-31]-[39-45]-[16-14]-[36-41]-[41-43]. Femora I bearing three kinds of formed setae: thin, smooth setiform (v) and spiculate phylliform (Fig. 3C). Genu III and trochanter III bearing carina (Fig. 3D). Solenidioxyt I (1-2-2), II (1-1-2), III (1-1-0), IV (0-1-0). On tarsus I, famulus ε (ca. 3 µm) bacilliform, situated between solenidia ω₁ and ω₂ (Fig. 3A). Solenidion ω₁ (ca. 19 µm) setiform with rounded tip; ω₂ (ca. 37 µm) setiform. Solenidion ω₁ (ca. 99 µm) setiform, originating from apophysis at the anterior margin of segment, about four times longer than the length of tibia (ca. 24 µm); ω₂ setiform (ca. 21 µm) (Figs. 3B). On genu I, solenidion σ (ca. 7 µm) short, bacilliform as long as seta d.

Remarks — Hitherto a single species, *Eremella induta* Berlese, 1913 has been found from Japan in Niigata Prefecture, Kanagawa Prefecture and Ehime Prefecture (Maruyama 1984; Ichisawa and Harada 2001; Yamamoto and Yamamoto 2000). However, the new species differs from *E. induta* according to the original description and redescription by Mahunka and Mahunka-Papp (1995) in having setae ro longer than setae le, phylliform p-series notogastral setae and long solenidion of tibia I. The new species is distinguished from *E. vestita* Berlese, 1913 by smaller body size, basely simple claws of legs, phylliform p-series setae, two transverse ridges between costulae and long solenidion of tibia I, from *E. pulchella* (Balogh, 1959) by phylliform notogastral setae and long costae, from *E. africana* (Balogh, 1966) by smaller body size, phylliform notogastral setae, subparallel costae and notogaster without protuberance, from *E. ensifera* Balogh et Mahunka, 1968 by smaller body size, two pairs of adanal setae, setae ro longer than le, phylliform notogastral setae and long costae with two transverse ridges, and from *E. matildebellae* Mahunka et Palacios-Vargas, 1995 by monodactylous legs, two pairs of adanal setae, subparallel costae and notogaster without crests.

Key to the species of *Eremella* Berlese, 1913. Body length and width (in µm) are shown with type locality according to the original description

1. Costae not parallel..............................2
   — Costae subparallel..........................4

2. Interlamellar setae simple....................E. africana (Balogh, 1966) (Tshad); 280 × 150
   — Interlamellar setae phylliform, spinose or speculate ........................................3

3. Notogaster with longitudinal and transversal crests..........E. matildebellae Mahunka and Palacios-Vargas, 1995 (Mexico); 213-258 × 110-132
   — Notogaster without longitudinal and transversal crests ......E. induta Berlese, 1913 (Jaba); 240 × 130

4. Lamellar setae originate far from the tip of lamellar costae .........E. pulchella (Balogh, 1959) (Hungary); 240-275 × 125-146
   — Lamellar setae originate at the end of the tip of, or on the lamellar costae .....................6

5. Rostral setae longer than lamellar setae............E. vestita Berlese, 1913 (Giava); 300 × 180
   — Rostral setae shorter than lamellar setae...............E. ensifera Balogh and Mahunka, 1968 (Argentina); 279-311 × 136-168

6. Costae with one transversal ridge; claws of legs dilated basally (According to Mahunka and Mahunka-Papp 1995)............................E. vestita Berlese, 1913 (Giava); 300 × 180
   — Costae with two transversal ridges; claws not dilated basally............ *Eremella funnagasatoensis* n. sp. (Japan); 236-264 × 121-150
Scheloribatidae Grandjean, 1933

Scheloribates yamaeensis n. sp.

[Japanese name: Yamae-shiwadani]

(Figs. 6 - 10)

Diagnosis — Prodorsum triangular. Rostrum rounded. Lamellae narrower situated laterally, with prolambellae, without cusps and translamella. Sensillus barbed fusiform. Anterior margin of immovable pteromorphae not extending anteriorly beyond level of dorsosejugal scissure; pteromorphae with inward curve. Notogaster elongate with ten pairs of setae and four pairs of saclci; each sacculi diverged. Notogastral integument plicate near level of dorsosejugal scissure; pteromorphae with ability pteromorphae not extending anteriorly beyond level of anterior notogastral margin for a distance equal to almost two-third length of the propodosoma (ca. 125 μm) (Fig. 9A). Lamellar setae le sparsely barbed throughout length, inserted at the end of lamellae (Fig. 8B), extending anterior to rostral setae. Interlamellar setae in sparsely spiculate throughout length (Fig. 6C), inserted anterior to the level of bothridia. Bothridial basal part covered by anterior margin of notogaster, opening anteriorly (Fig. 9D). Sensilli ss fusiform, ciliate (Fig. 7A). Exobothridial setae ex smooth, minute. Relative lengths and distances of prodorsal setae: ro : le : in : ss : ex = 1 : 1.68 : 1.68 : 0.05; (ro-ro) : (le-le) : (in-in) : (ro-le) : (le-in) = 1 : 1 : 1 : 0.3 : 0.8.

Notogaster — Elongate, with broadly rounded anterior margin (Fig. 9C). Anterior margin of immovable pteromorphae not extending anteriorly beyond level of anterior notogastral margin; pteromorphae curved inward (Figs. 6D, 10D). Notogastr bearer of light spots throughout length (Fig. 6). Sensilli ss cylindrical, ciliate. Lamellar setae in central part of notogaster, opening anteriorly to level of bothridia. Bothridial basal part covered by anterior margin of notogaster, opening anteriorly (Fig. 9D). Sensilli ss fusiform, ciliate (Fig. 7A). Exobothridial setae ex smooth, minute. Relative lengths and distances of prodorsal setae: ro : le : in : ss : ex = 1 : 1.68 : 1.68 : 0.05; (ro-ro) : (le-le) : (in-in) : (ro-le) : (le-in) = 1 : 1 : 1 : 0.3 : 0.8.

Material examined — Holotype (Male) (NSMT-Ac 13034) from litter, humus and soil materials at the chestnut Castanea crenata Sieb. et Zucc. plantation of Yamae Mura in Kumamoto Prefecture on 25th Oct. 2007, by S. Hashimoto; 24 paratypes (NSMT-Ac 13035: female): the same data as holotype. The type series with number of NSMT-Ac 13034 & 13035 is deposited in the National Museum of Nature and Science, Tokyo. The remainder of paratypes are deposited in the National Agricultural Research Center for Kyushu Okinawa Region, Kumamoto Prefecture.

Etymology — After the name of sampling locality.

Measurements and body appearance — Female (n = 13): Body length: 471 (508) 564 μm; width: 300 (345) 400 μm, male (n = 12) : Body length: 457 (486) 514 μm; width: 293 (320) 379 μm. Body color light brown. The whole integument without granulation except for exobothridial region. Description of features in common of male and female: Prodorsum — Triangular (Fig. 6A). Rostrum rounded. Rostral setae ro sparsely barbed, inserted at lateral sides, extending in front of the rostrum for a distance equal to about two-third of their length. Lamellar ridges narrower, situated at the lateral sides, with prolambellae but without cusps nor translamella, extending forward from underneath of anterior notogastral margin for a distance equal to almost two-third length of the propodosoma (ca. 125 μm) (Fig. 9A). Lamellar setae le sparsely barbed throughout length, inserted at the end of lamellae (Fig. 8B), extending anterior to rostral setae. Interlamellar setae in sparsely spiculate throughout length (Fig. 6C), inserted anterior to the level of bothridia. Bothridial basal part covered by anterior margin of notogaster, opening anteriorly (Fig. 9D). Sensilli ss fusiform, ciliate (Fig. 7A). Exobothridial setae ex smooth, minute. Relative lengths and distances of prodorsal setae: ro : le : in : ss : ex = 1 : 1.68 : 1.68 : 0.05; (ro-ro) : (le-le) : (in-in) : (ro-le) : (le-in) = 1 : 1 : 1 : 0.3 : 0.8.
**Figure 6:** *Scheloribates yamaeensis* n. sp.: A – Dorsal view; B – Ventral view; C – A part of interlamellar seta; D – Left pteromorpha of a depressed specimen; E – Genito-anal region of female. Posterior anal locking-pieces (black arrow). A, B: (NSMT-Ac 13034; male); C – E: (NSMT-Ac 13035; female).
Figure 7: Scheloribates yamaensis n. sp. (NSMT-Ac 13035; female). A – Sensillus (ss) and exobothridial seta (ex); B – Setae: ag, an, ad: aggenital, anal and adanal setae, respectively; 4a, 4c: Epimeral setae; C – Gnathosoma. a, m, h: Anterior, medial and posterior subcapitular setae, respectively; D – Solenidial region of tarsus-tibia of leg I. c: Famulus; ω1,2, ϕ1,2: Solenidia; ft*: fastigial seta; E – Femur IV; F – Pedipalp; G – Chelicera. cha, chb: cheliceral setae, Tg: Trägårdh’s organ.
FIGURE 8: Scheloribates yameensis n. sp.: A – Tip of left lamella (NSMT-Ac 13034); B – Left sacculi Sa (NSMT-Ac 13035); C – Right trochanter II–IV region (NSMT-Ac 13034).
FIGURE 9: Scheloribates yamaeensis n. sp. scanning electron micrographs (photos by Nakamura Y.-N., Hashimoto S.): A – Lateral view; B – Camerostomal region; C – Dorsal view; D – Left bothridial region; E – Sacculus S2 and notogastral seta h3; F – Plications near posterior margin of notogaster.
FIGURE 10: *Scheloribates yamaeensis* n. sp. scanning electron micrographs (photos by Nakamura Y.-N., Hashimoto S.): A – Ventral view; B – Anal aperture; C – Sacculi S2, S3; D – Left pteromophal region.
roughly circular in outline (Figs. 6B, 6E, 10A); the latter about 1.5 × as long as the former; distance between them appreciably 1.5 × as long as anal aperture. Genito-anal setae: 4(3, 5)-1(2)-2-3; setae thin, smooth setiform (Fig. 7B); genital g and aggenital ag setae variable in number, but generally (4-4) and (1-1), respectively. Genital setae g1 and g2 remote from g3 and g4. Setae ag inserted postero-laterally remote from genital aperture. Adanal setae ad1 inserted in postanal position; ad2 postero-laterally; ad3 preanal. Lyrifissures iad aligned in the paraanal position, between the level of anterior margin of anal aperture and insertion of setae in. Posterial anal locking-pieces remarkable (Fig. 10B). Sternal ridge and epimeral border IV indistinct. Custodium extending at the level of trochanter II; discidium small (Fig. 8C). Epimeral setal formula: 3-1-3-3; setae thin, smooth setiform (Fig. 7B), variable in length. Diarthric subcapitulum bearing 3 pairs of setae; setae thin, smooth setiform (Fig. 7C). Mentum without remarkable transverse slit connected with inner pharynx. Chelicera bearing short Trägårdh’s organ (Fig. 7G). Two setae, cha and chb pilose; cha long, chb short. Pedipalpal chaetotaxy: 0-2-1-3-9[1]; tarsus with a short solenidion (ca. 9 µm) not extending forwards from tip of tarsus (Figs. 7E, 9B). Relative lengths of some of the ventral setae: 4c > 4a > g > ad > ag > an.

Legs — All tarsi heterotridactylous; claws dorsally serrate. Setal formula of legs including famulus but excluding solenidia: I (1-5-3-4-18), II (1-5-2-4-16), III (2-3-1-3-14), IV (1-2-2-3-12). Femora of leg II, III and IV bearing small carina (Fig. 7E). Solenidiotaxy I (1-2-2), II (1-1-2), III (1-1-0), IV (0-1-0). Famulus on tarsus I short, spiniform, situated between ω2 and fastigial seta ft; solenidion ω1 and ω2 short bacilliform; ω2 longer than ω1, inserted posteriorly to ω1; ω1, ω2, famulus and ft aligned almost in a line (Fig. 7D).

Description of different characters between male and female: Female with genital aperture and distance between genital and anal apertures longer than those of male.

Remarks — The new species has dorsal aspect similar to those of Scheloribates maoriensis Hammer (1968) and S. gunini Bayartogtokh (2000). However, the plications of posterial margin of notogaster and diverged sacculi are particular characters of the new species.

**DISCUSSION**

Chestnut, Castanea crenata Sieb. and Zucc. is native to Japan, and is widely cultivated all across the country. It would be interesting to know whether Scheloribates yamaeensis n. sp. depends on chestnut plantations or the subtropical region. Of six known species of Eremella, four species, E. africana, E. induta, E. matildebellae and E. vestita occur in the tropics, and two species, E. ensifera and E. pulchella in the temperate zone. However, in Japan E. induta has been recorded from both the temperate (Maruyama 1984, Ichisawa and Harada 2001) and the subtropical zones (Yamamoto and Yamamoto 2000). The new species, Eremella funnagasatoensis n. sp. was found in litter at the bottom of a hollow of an Illex oldhami Miq. tree in the subtropical zone. The specimens of E. induta were collected from litter at the bottom of a hollow in a Quercus tree at 1.5 m above the ground (Yamamoto and Yamamoto 2000), from the canopy of Castanopsis cuspidate var. sieboldii (Makr.) Nakai at 1.5 - 10 m above the ground (Ichisawa and Harada 2001), and from soil materials on the ground surface of Fagus forests (Maruyama 1984). Eremella matildebellae has also been found from the canopy level and other species have been collected from litter, humus, mosses and soil materials.

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