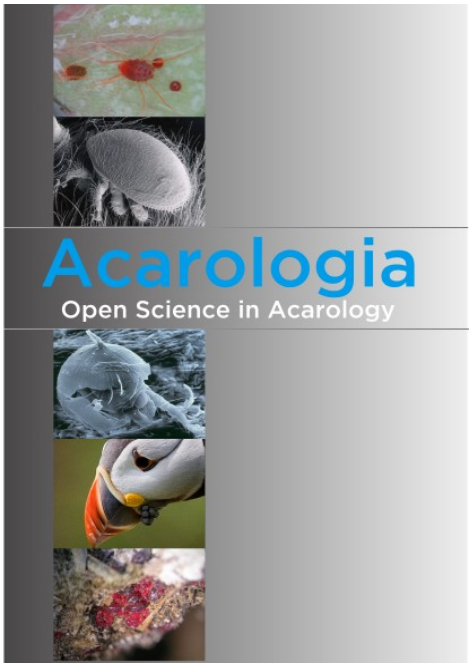

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Two new species of the genus *Trichoribates* (Acari: Oribatida: Ceratozetidae) from Central Japan

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ABSTRACT — The present paper deals with two species of oribatid mites of the genus *Trichoribates* Berlese, 1910 from the subalpine zone of high mountains in Central Japan. *Trichoribates aokii* **n. sp.** and *Trichoribates hirauchiae* **n. sp.** are proposed on the basis of adults. The first species is characterized by narrow lamellar cusps and translamella, and very closely situated notogastral setae h_2 and h_3. The second species is readily distinguishable from other closely related species by the specific structure of porose areas A_1 and A_2, the larger body size, the longer interlamellar and rostral setae, and anteriorly converging lamellae. A key to the Japanese species of *Trichoribates* is provided along with data on their geographical distribution and habitat ecology.

KEYWORDS — Oribatida; Ceratozetidae; *Trichoribates*; new species; distribution; habitat ecology; Japan

INTRODUCTION

The oribatid mite genus *Trichoribates* was established by Berlese (1910) with *Murcia trimaculata* C. L. Koch, 1835 as type species. Weigmann and Norton (2009) discussed recently the validity of this species and interpreted the type of *Trichoribates*. The genus is one of the most common and taxonomically diverse taxa of oribatid mites in the northern hemisphere. According to authors' estimation, the genus now comprises 52 valid species, but only a few of them, such as *T. berlesei* Jacot, 1929, *T. novus* (Sellnick, 1928) and *T. copperminensis* Hammer, 1952 are widely distributed in the Holarctic region. Most other representatives seem to be relatively rare and are found only in restricted areas or are only known from the type localities. Among the biogeographical realms, the Palaearctic region is distinguished from other regions by its high species richness (36 spp.), followed by the Nearctic region (17 spp.). The other biogeographical regions contain less than three species.

Currently, only four species of *Trichoribates* (*T. alpinus* Aoki, 1982, *T. berlesei* Jacot, 1929, *T. novus* (Sellnick, 1928) and *T. rausensis* Aoki, 1982) are known from Japan, and two additional species were found recently, which we describe here as new to science.

The primary goal of this work is to describe two unknown species of *Trichoribates*. Providing additional remarks on the biogeography and habitat

ecology, and constructing an identification key to the Japanese species of *Trichoribates* are the other goals of this work.

This work is based on material collected in the frame of ecological studies on the oribatid mite communities from the subalpine zone of Mt. Naeba, and the first author collected 145 species from litter and soil samples (Maruyama 2003). Among those, several new taxa were found including two species of *Trichoribates* (*T. aokii* **n. sp**. was indicated as *Trichoribates* sp. MC, and *T. hirauchiae* **n. sp.** as *Trichoribates* sp. MA in Maruyama [2003]).

Morphological terminology used in this work is based mostly on that developed over many years by Grandjean (e.g. 1936) as summarized by Norton and Behan-Pelletier (2009). All measurements are given as a range, with the mean in parentheses. Setal formulas of legs are given as numbers per segment for appendages (from trochanter to tarsus), and as number per podosomal segment.

Genus *Trichoribates* Berlese, 1910

Diagnosis of adult — Rostrum rounded; lamellae wide, with well-developed cusps and translamella; lamellar cusps with or without lateral and median dens; bothridia cup-shaped; sensilli with clavate or oval head, rounded or flattened distally; tutoria broad, with cusps pointed or dentate distally; custodia with short to long narrowly pointed cusps; notogaster with large pteromorphs curved ventrally, line of desclerotization absent; lenticulus present or absent; 10 or 11 pairs of notogastral setae, setae *dp* present or absent; four pairs of notogastral porose areas (exception, sacculi in *T. polaris* Hammer, 1953), porose areas *Am* and *Ah* present; six pairs of genital setae; all legs heterotridactylous; tibiae I with dorsodistal apophysis bearing solenidion ϕ_2; seta *l"* of tibiae and genua I, II, and sometimes that of tibiae and genua III, IV thick, heavily barbed (see also Behan-Pelletier 1985; Bayartogtokh and Schatz 2008).

Trichoribates aokii n. sp.
[Japanese name: Aoki-kobanedani]
(Figures 1-3)

Diagnosis — Medium in size; rostrum widely rounded, with a nose-like protuberance dorsally; rostral, lamellar and interlamellar setae long, barbed; lamellae narrow, with long, but narrow translamella; lamellar cusps with distinct lateral dens, but medial dens minute or sometimes absent; sensilli short, with clavate head; tutoria long and broad, with three to five dentations at the distal end; 10 pairs of short, thin notogastral setae finely barbed; porose areas round to oval, A_2 much smaller than others; epimeral and ano-genital setae minutely barbed.

Measurements — Body length: 504 – 569 (538) μm; width: 338 – 408 (380) μm (n = 14).

Integument — Body colour deep reddish to yellowish brown. Surface of body and leg segments with thick cerotegument, roughened by small granules. Faintly microtuberculate on cuticle of prodorsum, notogaster, ventral plate and leg segments.

Prodorsum — Rostrum widely rounded, with pair of minute lateral dens and nose-like protuberance dorsally (Figure 1B). Lamellae narrow, gradually converging anteriorly, about 2/3 of prodorsal length (Figure 1A). Translamella narrow, but distinctly developed. Length of lamellar cusps about 1/5 length of whole lamellae, with distinct lateral dens, but medial dens minute or sometimes absent (Figure 1D). Prodorsal setae distinctly barbed in their distal half; interlamellar setae slightly extending beyond rostrum, about 1.5 times as long as lamellar setae, almost twice as long as rostral setae. Sensilli short, with clavate head slightly bending medially, its surface roughened. Alveoli of interlamellar setae and bothridia completely concealed under anterior marginal part of notogaster (Figure 1E). Tutoria long and broad, extending beyond alveoli of rostral setae, finely striated along dorsal edge, with three to five dentations at the distal end (Figure 3A, B).

Notogaster — Longer than wide, anterior margin broadly rounded; lenticulus poorly developed. Pteromorphs well developed, curved ventrally,

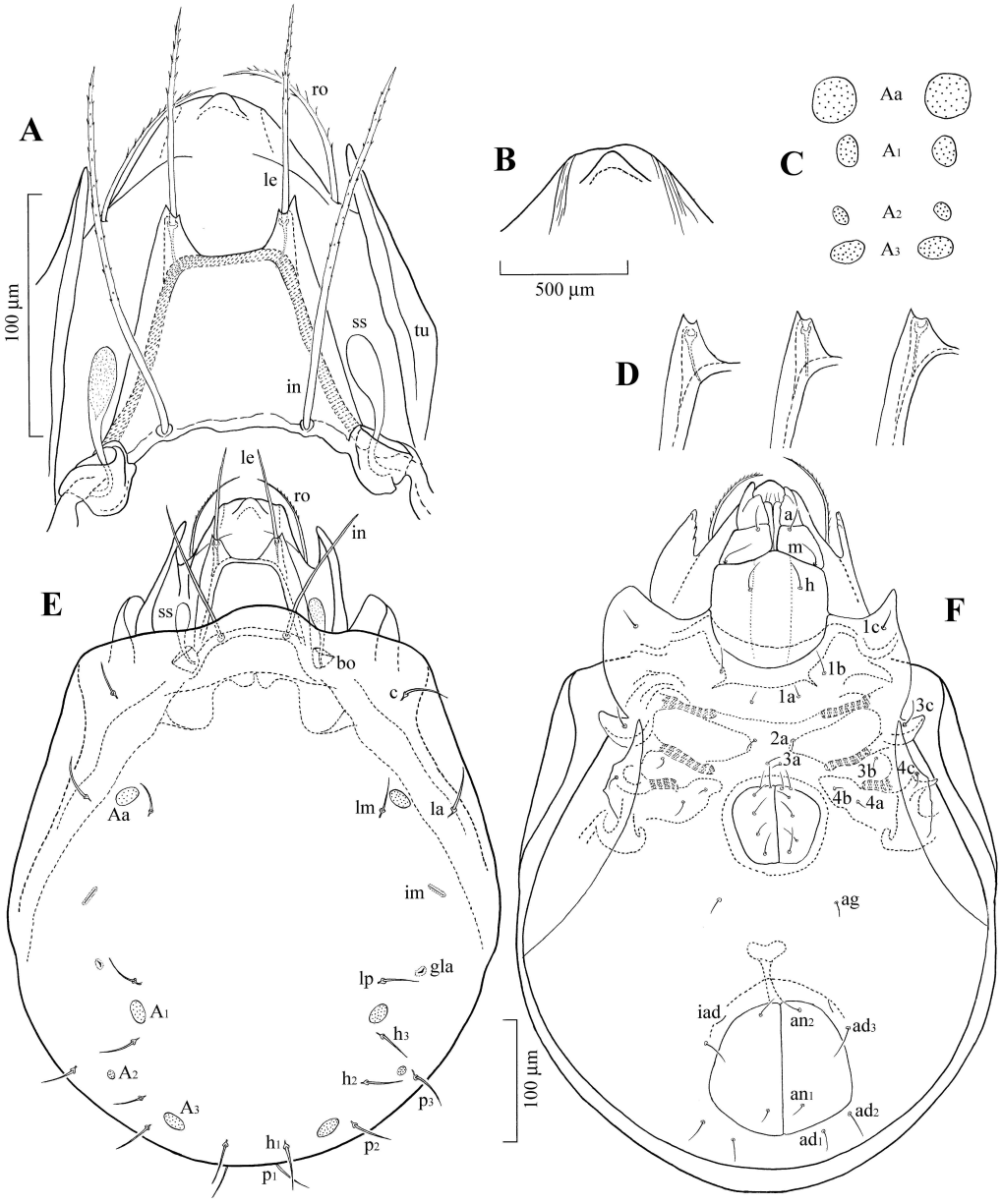

FIGURE 1: *Trichoribates aokii* **n. sp.**: A – prodorsum; B – rosrum; C – notogastral porose areas; D – variation of lamellar cusps; E – dorsal aspect of body, legs omitted; F – ventral aspect of body, legs omitted. B-D and E, F to same scale.

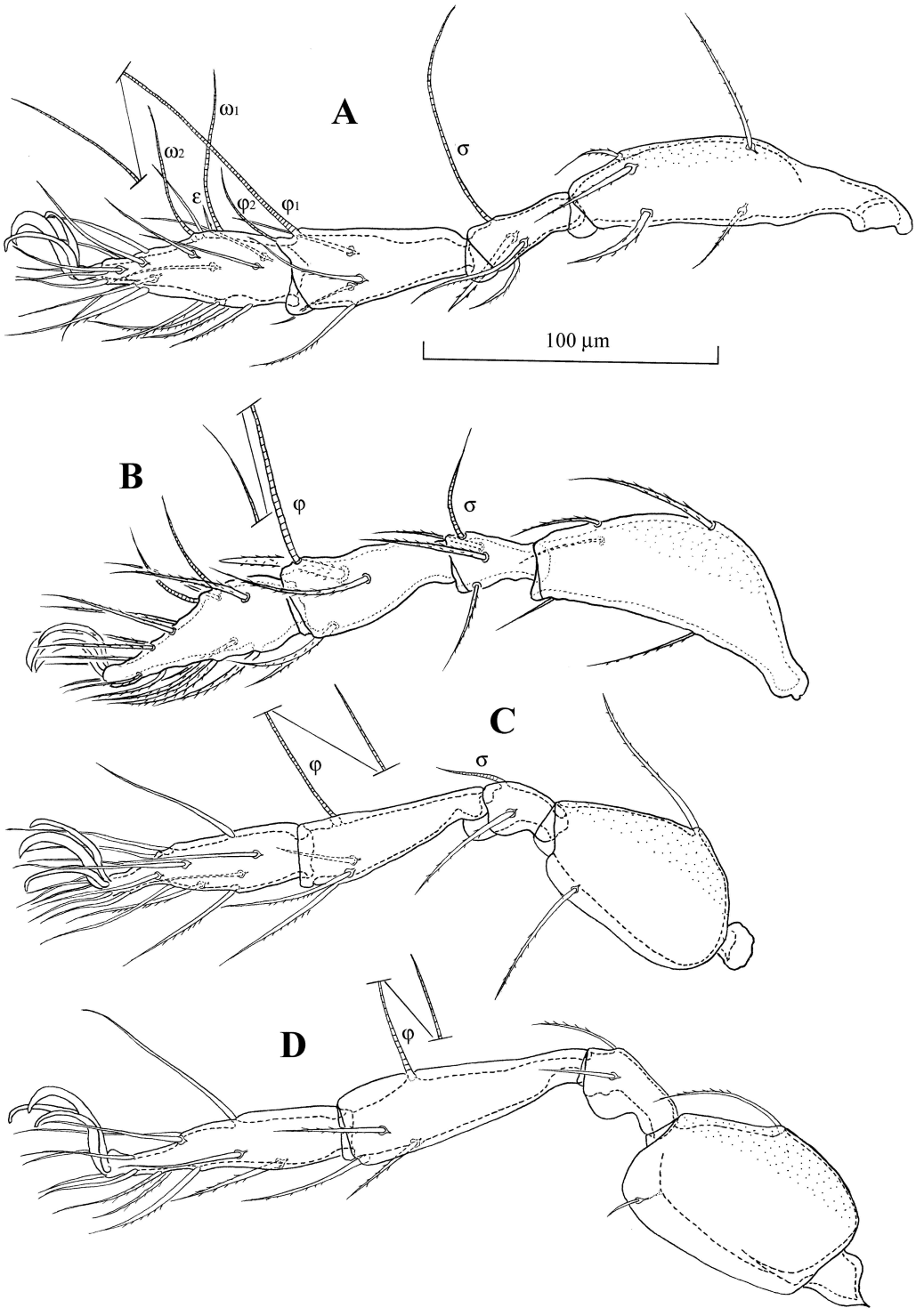

FIGURE 2: *Trichoribates aokii* **n. sp.**: A – leg I (left, antiaxial aspect); B – leg II (left, antiaxial aspect); C – leg III (left, paraxial aspect); D – leg IV (left, paraxial aspect).

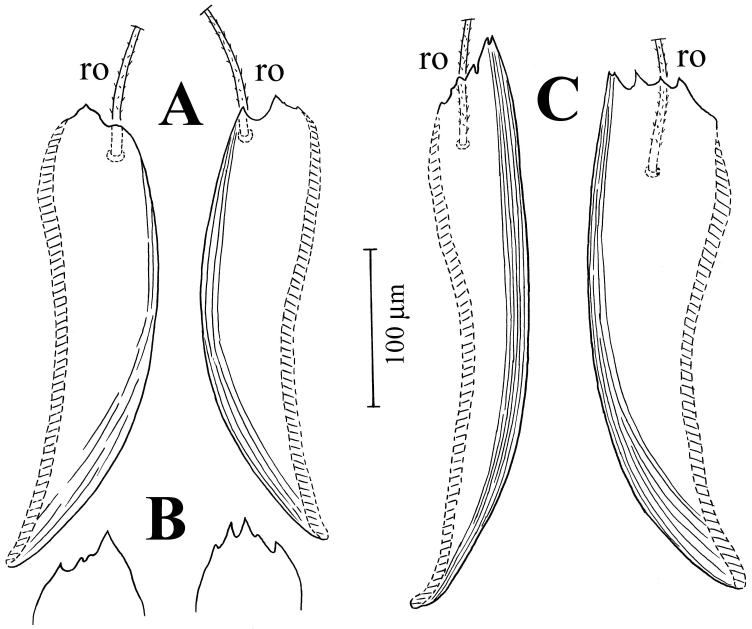

FIGURE 3: Variation of tutoria in two species of *Trichoribates*: A – Left and right tutoria of *Trichoribates aokii* **n. sp.**; B – Variation of tutorial distal dentations of *Trichoribates aokii* **n. sp.**; C – Left and right tutoria of *Trichoribates hirauchiae* **n. sp.**

with rounded margin (Figure 1E). Ten pairs of notogastral setae short, thin, finely barbed. Relative length of posterior notogastral setae: $h_1 > h_2 > h_3$; $p_1 > p_2 > p_3$. Mutual distance of *la*-*la* wider than that of *c*-*c*; distance between h_1-h_1 little wider than that of p_1-p_1. Setae h_2 and h_3 inserted close to each other. Among four pairs of porose areas *Aa* largest, its real shape almost circular or slightly oval; A_2 smallest and sometimes missing; A_1 and A_3 similar in shape and medium in size (Figure 1C). Lyrifissures *im* situated between *la* and *lp*. Openings of opisthosomal glands (*gla*) located anterolateral to setae *lp*.

Gnathosoma — Subcapitular mentum nearly as long as wide, without noticeable microtubercles. Hypostomal setae *m*, *a* and *h* finely barbed (Figure 1F). Chelicerae with strongly sclerotized blunt teeth; setae *cha* and *chb* barbed. Palps typical for family, palpal setation 0-2-1-3-10 including both ventral setae and solenidion ω of tarsi.

Epimeral region — Apodemes *apo.2*, *apo.sj* and *apo.3* well developed, dark-colored. Epimeral setae short, thin, finely barbed, setal formula: 3-1-3-3. Custodia reaching anterior margin of pedotecta II; discidia well developed, conspicuously projected laterally (Figure 1F). Pedotecta I large, surface smooth, without striation.

Ano-genital region — Anal and genital plates smooth, both genital and anal openings slightly wider than long (Figure 1F). All ano-genital setae short, thin, minutely barbed. Relative length of their mutual distance: g_3-$g_3 \approx g_5$-$g_5 \approx g_4$-$g_4 > g_2$-$g_2 > g_6$-$g_6 > g_1$-g_1. Distance between alveoli of aggenital setae slightly shorter than that of adanal setae ad_3-ad_3. Setae ad_3 situated in paranal position, at level posterior to anal setae an_2. Adanal lyrifissures *iad* situated at same level as setae an_2, adjacent to anterolateral margins of anal perture.

Legs — Median claw thicker than lateral claws (Figure 2). Solenidia ω_1 on tarsi I slightly longer than ω_2; solenidia ϕ_1 on tibiae I nearly four times as long as ϕ_2. Legs I and IV subequal in length, leg II shortest. Femora I-IV, tibiae, genua, femora and trochanters of leg IV with narrow ventral blade. Formula of leg setation (including famuli): I (1-5-3-4-20), II (1-5-3-4-15), III (2-2-1-3-15), IV (1-2-2-3-12); formula of solenidia: (Ge-Ti-Ta): I (1-2-2), II (1-1-0),

III (1-1-0), IV (0-1-0).

Type-series — Holotype (NSMT–Ac 11521, male): Southwest from the summit of Mt. Naeba, 36°50′37"N, 138°41′16"E, 2130 m a.s.l., Sakae-mura in Shimominauchi-gun, Nagano Prefecture, from litter and soil of a wetland dominated by *Molinia japonica* Hackel, 26 August 1996, collected by I. Maruyama. Three paratypes (NSMT–Ac 11522–11524, males): same data as holotype; four paratypes (NSMT–Ac 11525–11528, three males and one female): same data as holotype except for altitude, 2040 m. The holotype and paratypes (mounted on slides) will be deposited in the National Science Museum, Tokyo, Japan. Additional non-type specimens (four females and seven males) from the same locality as holotype, are preserved in the collection of S. Shimano.

Remarks — This species is similar to *T. alpinus*, described by Aoki (1982) from Mt. Norikura, Gifu Prefecture, Central Japan, in the very small notogastral porose areas A_2, clavate sensilli and distal structure of lamellar cusps. However, *T. aokii* sp. nov. is distinguishable from *T. alpinus* by the much narrower lamellar cusps and translamella, and closely situated notogastral setae h_2 and h_3. In *T. alpinus*, the lamellae are wide, and becoming broader distally with very broad lamellar cusps and translamella (twice as broad as chitinized median margin of lamellae). Also in *T. alpinus*, the notogastral setae h_2 and h_3 are widely spaced from each other, and the distance between these setae is nearly as long as that between setae p_2 and p_3.

Another Japanese species, *T. rausensis*, also has small porose areas A_2 and narrow lamellae. However, *T. rausensis* is different from *T. aokii* sp. nov. in having widely spaced lamellar cusps; the smooth sensilli; the distinctly shorter rostral and interlamellar setae, and very closely situated porose areas A_1 and A_2.

Two other species found in Japan, *T. berlesei* and *T. novus* are distinguishable from *T. aokii* **n. sp.** by having much broader lamellae and lamellar cusps; much larger lateral dens of cusps; far longer notogastral setae with rough barbs; dorso-distally projected tutorial tips; anteriorly protruding pteromorphs, and distinctly larger body size.

Etymology — This species is named after Dr. Jun-ichi Aoki, professor emeritus of the Yokohama National University, Japan. His superb teaching and enthusiasm for soil zoology, acarology, taxonomy and ecology influenced the lives and careers of many students.

Trichoribates hirauchiae n. sp.
[Japanese name: Hirauchi-kobanedani]
(Figures 3-5)

Diagnosis — Large in size; rostrum with pair of minute lateral dens a nose-like protuberance dorsally; rostral, lamellar and interlamellar setae long, barbed; lamellae narrow, translamella very weakly developed, sometimes absent; lamellar cusps with distinct lateral dens, but medial dens minute or absent; sensilli short, with clavate head, its surface roughened; tutoria long and broad, with five or six dentations at the distal end; 10 pairs of short, thin notogastral setae finely barbed; porose areas round to elongate oval, *Aa* largest, A_1 smallest, located very close to A_2, sometimes A_1 joined to A_2; epimeral and ano-genital setae minutely barbed.

Measurements — Body length: 605 – 668 (629) μm; width: 438 – 516 (471) μm (n=7).

Integument — Body color yellowish brown to reddish brown. With thick cerotegument, roughened by minute granules. Faintly microtuberculate on cuticle of prodorsum, notogaster, ventral plate and leg segments.

Prodorsum — Rostrum rounded, with pair of minute lateral dens and nose-like protuberance dorsally (Figure 4B). Rostral setae 93 – 97 μm long, curved inward, conspicuously barbed; distance between alveoli of rostral setae 124 μm. Lamellae narrow, 128 – 134 μm long, gradually converging anteriorly, about 8/10 in length of prodorsum (Figure 4A); distance between alveoli of lamellar setae 48 μm long. Translamella very weakly developed, sometimes absent. Length of lamellar cusps 44 – 47 μm long, with distinct lateral dens of 9 – 12 μm long; inner dens minute or absent (Figure 4D). Lamellar setae barbed, 96 – 102 μm long; interlamellar setae barbed, 177 – 179 μm long, extending beyond tip of rostrum, their insertion pores concealed under anterior marginal part of notogaster (Figure 4E). Rela-

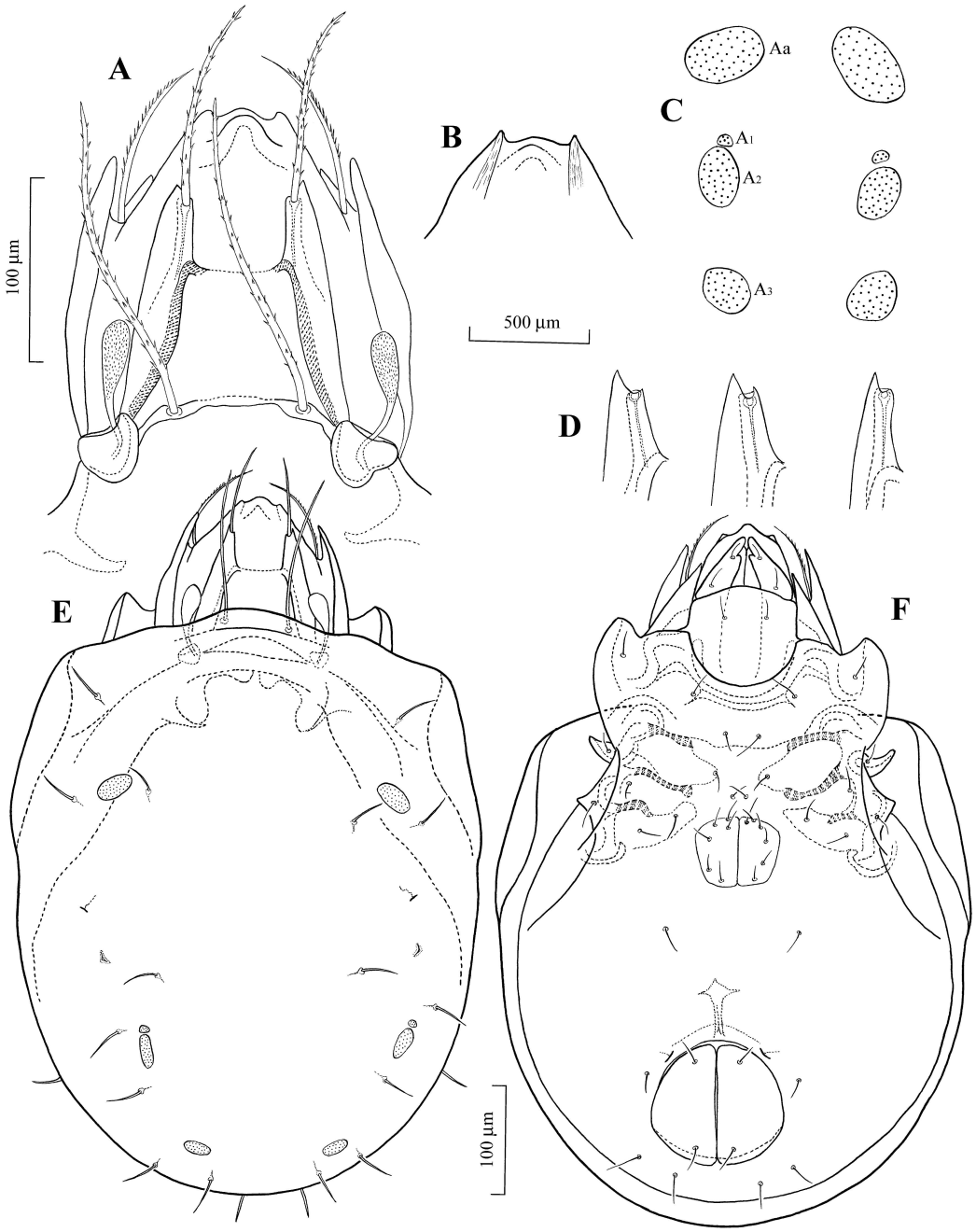

FIGURE 4: *Trichoribates hirauchiae* **n. sp.**: A – prodorsum; B – rostrum; C – notogastral porose areas; D – variation of lamellar cusps; E – dorsal aspect of body, legs omitted; F – ventral aspect of body, legs omitted. B-D and E, F to same scale.

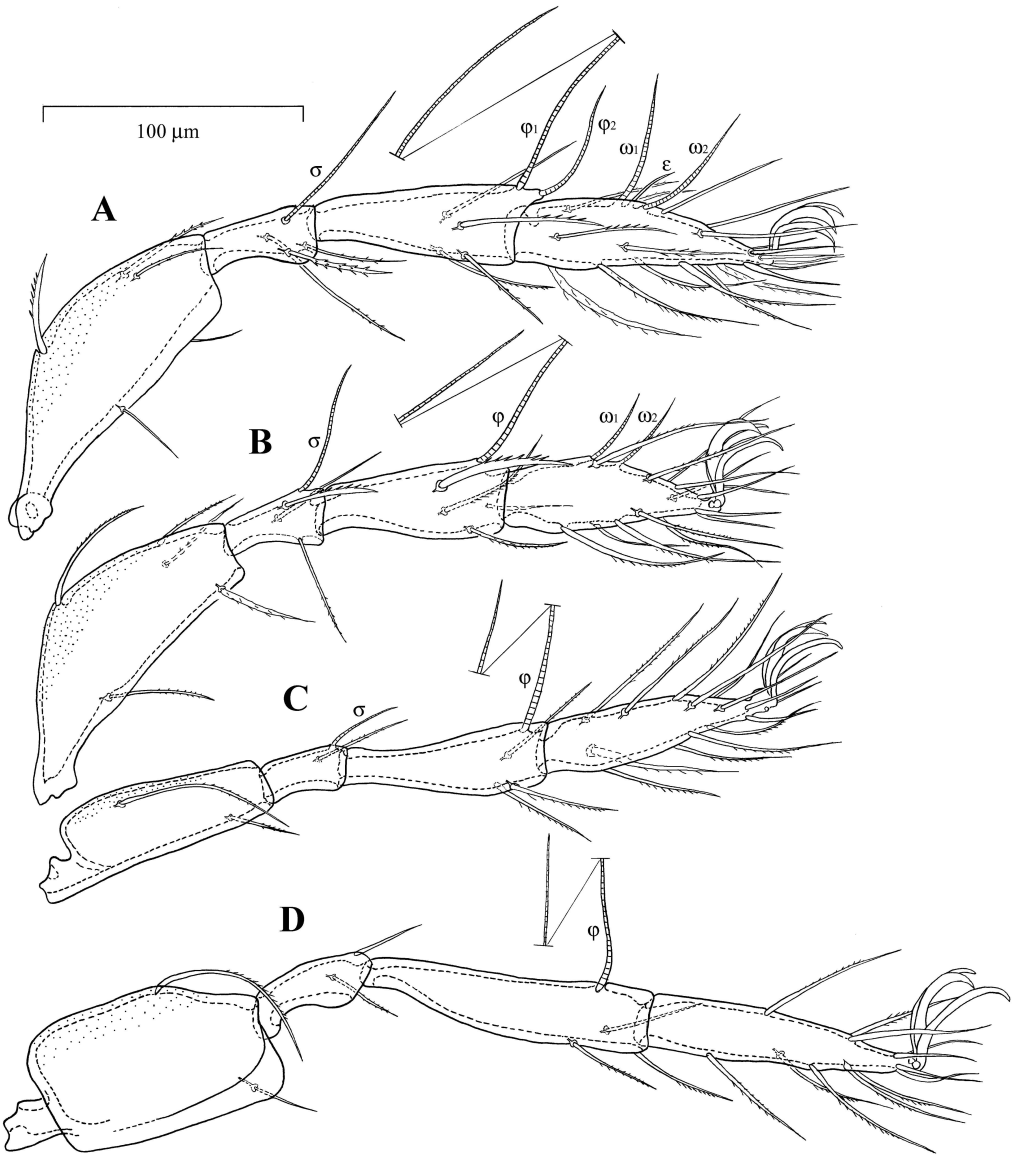

FIGURE 5: *Trichoribates hirauchiae* **n. sp.**: A – leg I (right, antiaxial aspect); B – leg II (right, antiaxial aspect); C – leg III (right, paraxial aspect, tibia and genu slightly twisted); D – leg IV (right, paraxial aspect).

tive length of prodorsal setae: *ro* : *le* : *in* = 0.96 : 1.0 : 1.8, respectively. Sensilli 68 – 70 μm long, with clavate head slightly bending medialy, its surface roughened. Bothridia completely concealed under anterior marginal part of notogaster. Tutoria long and broad, extending beyond alveoli of rostral setae, finely striated along its dorsal edge, with five or six dentations at the distal end (Figure 3C).

Notogaster — Longer than wide, anterior margin broadly rounded; lenticulus poorly developed. Pteromorphs well developed, curved ventrally, with rounded margin (Figure 4E). Ten pairs of notogastral setae short, weakly barbed; relative length of the setae: $c > la > lm$, $p_1 > p_2 > p_3$, $h_3 \geq h_1 > h_2$. Relative mutual distance between pairs of setae: p_3-$p_3 > la$-$la > h_3$-$h_3 > c$-$c > h_2$-$h_2 > lm$-$lm > lp$-$lp \approx p_2$-$p_2 > h_1$-$h_1 > p_1$-p_1. Among four pairs of porose areas, *Aa* largest, oval; A_1 smallest, round to oval, located very close to A_2; A_2 and A_3 of medium size, elliptical or oval (Figure 4C); sometimes A_1 joined to A_2, but in one specimen A_2 divided into two parts. Lyrifissures *im* situated at level midway between setae *la* and *lp*. Openings of opisthosomal glands (*gla*) located anterior to setae h_3.

Gnathosoma — Subcapitular mentum nearly as long as wide, without noticeable microtubercles. Hypostomal setae *m*, *a* and *h* minutely barbed (Figure 4F). Chelicerae with strongly sclerotized blunt teeth; setae *cha* and *chb* barbed. Palps typical for family, palpal setation 0-2-1-3-10 including both ventral setae and solenidion ω of tarsi.

Epimeral region — Apodemes *apo.2*, *apo.sj* and *apo.3* well developed, dark-colored. Epimeral setae short, thin, finely barbed, setal formula: 3-1-3-3. Custodia reaching anterior margin of pedotecta II; discidia well developed, conspicuously projecting laterally (Figure 4F). Pedotecta I large, surface smooth, without striation.

Ano-genital region — Anal and genital plates smooth; both genital and anal openings slightly wider than long (Figure 4F). Genital and aggenital setae thin, minutely barbed; relative length of distance between pairs of setae: g_4-$g_4 > g_5$-$g_5 > g_3$-$g_3 > g_6$-$g_6 > g_2$-$g_2 \approx g_1$-g_1. Anal and adanal setae thin, minutely barbed; relative length of their mutual distance an_2-$an_2 > an_1$-an_1. Setae ad_3 situated in paranal position, at level posterior to anal setae an_2. Adanal lyrifissure (*iad*) aligned obliquely, situated slightly anterior to level of setae an_2, adjacent to anterolateral margins of anal aperture.

Legs — Median claw thicker than lateral claws (Figure 5). Solenidia ω_1 and ω_2 on tarsi I subequal in length; solenidia ϕ_1 on tibiae I nearly three times as long as ϕ_2; solenidia σ on genua I slightly longer than that on genua II. Solenidia ω_1 and ω_2 on tarsi II subequal in length. Leg II shortest and leg IV longest. Femora I–IV, trochanters IV with ventral blade. Formula of leg setation (including famulus): I (1-5-3-4-20); II (1-5-3-4-15); III (2-2-1-3-15); IV (1-2-2-3-12); formula of solenidia: I (1-2-2), II (1-1-2), III (1-1-0), IV (0-1-0).

Type-series — Holotype (NSMT–Ac 11518, male): Near summit of Mt. Naeba, 36°50′28"N, 138°41′15"E, 2110 m a.s.l., Sakae-mura in Shimominauchi-gun, Nagano Prefecture; from litter and soil of a wetland dominated by *Veratrum stamineum* Maxim, 26 August 1996, collected by I. Maruyama. Two paratypes (NSMT–Ac 11519–11520, males): the same data as holotype. The holotype and paratypes (mounted on slides) will be deposited in the National Science Museum, Tokyo, Japan. Additional non-type specimens (three females and four males) from the same locality as holotype are preserved in the collection of S. Shimano.

Remarks — *Trichoribates hirauchiae* sp. nov. is similar to *T. rausensis* described by Aoki (1982) from Hokkaido, Ishikawa, Yamanashi and Nagano Prefectures (northern and central Japan) in the narrow lamellae, the weakly-developed translamella, and the clavate sensilli. However, *T. hirauchiae* sp. nov. is readily distinguishable from *T. rausensis* by the different structure of porose areas A_1 and A_2 (A_1 is larger than A_2 in *T. rausensis*); the much larger body size (body length: 524 – 564 μm width: 332 – 420 μm in *T. rausensis*); the far longer interlamellar and rostral setae, extending beyond the rostral tip (setae *in* and *ro* of *T. rausensis* not reaching tip of rostrum); the lamellae gradually converging anteriorly (lamellae of *T. rausensis* nearly parallel to each other).

Etymology — This species is named in memory of our colleague, late acarologist, Mrs. Yoshiko Hi-

rauchi for her generous contribution to the knowledge of oribatid mites of the Toyama Prefecture, Central Japan.

DISCUSSION

As mentioned above, only four species of *Trichoribates* have been recorded from Japan, and are mainly known from moist, warm soil and litter on the temperate habitats.

Two of those species, *T. novus* and *T. berlesei* (formerly reported as *T. trimaculatus*; see also Weigmann and Norton 2009) are widely distributed in the Holarctic region. In North America, both these species are known from USA and Canada (Marshall *et al.* 1987). In Europe, these two species can be found almost everywhere (Schatz 1983; Karppinen *et al.* 1987, 1992; Bernini *et al*. 1995; Luxton 1996; Niedbała and Olszanowski 1997; Niemi *et al.* 1997; Subías and Gil-Martín 1997; Shtanchaeva 2001; Bayartogtokh and Schatz 2008). In Asia, both these species are widely distributed in Turkey, Russian Far East, Caucasus, Siberia, Kazakhstan, Kyrgyzstan, Mongolia and Japan (Aoki 1964; Golosova *et al*. 1983; Karppinen *et al.* 1986; Fujikawa *et al.* 1993; Rahimbaeva 1995; Ryabinin and Pankov 1997; Bayartogtokh and Aoki 1998; Shtanchaeva 2001; Erman *et al*. 2007; Bayartogtokh 2010).

Two other species, *T. alpinus* and *T. rausensis* have been known only from Japan until recent time, but later the former species was recorded from the Kunashir Island of the Russian Far East (Ryabinin 2015), whereas the second species was found in northern India (Mondal and Kundu 1999).

In Japan, these species are basically distributed in the mountainous areas. Aoki (1964) recorded *T. novus* from Zizoudaira, Tanzawa Mountains, Kanagawa Prefecture, at about 1600 m a.s.l., however, Ohkubo *et al.* (2015) excluded this species from the revised Japanese faunistic list of oribatid mites, because they suspected the previous record was made by misidentified.

Another species, *T. rausensis* was found from mountainous areas of the Hokkaido, Ishikawa, Yamanashi, Nagano, Aomori, Iwate, Akita, Yamagata and Miyagi Prefectures of Central and Northern Japan, at elevations of 1140-2850 m a.s.l. (Harada 1993, 1994).

The third species, *T. alpinus* also occurs in high altitudes, and found at elevations about 1360-2835 m a.s.l. This species is currently known from Yamagata, Niigata, Miyagi, Fukushima, Iwate, Akita, Yamanashi, Nagano Prefectures (Aoki and Harada 1983; Harada 1988, 1993, 1994, 1999).

The above-mentioned two species, *T. rausensis* and *T. alpinus* were also considered as two of the most common species below the alpine zone (Aoki and Harada 1983; Harada 1994).

The fourth species, *T. berlesei* was found only from moss cushion on city construction in Kushiro, Hokkaido Prefecture (Aoki 2000).

Concerning the habitat ecology, in Japan, these species are litter inhabitants in various types of forests (*i.e.* Harada 1993, 1994, 1999), but also occur in moss cushion in urban area (Aoki 2000).

Finally, the following key can be used to identify adults of *Trichoribates* species in Japan.

Key to adults of the Japanese species of *Trichoribates*

1. Lamellae broadened anteriorly, lamellar cusps and translamella thick 2
— Lamellae not broadened anteriorly, lamellar cusps and translamella thin 4

2. Tutoria distally pointed, without dentation; body length larger than 560 μm; notogastral setae roughly barbed; pteromorphs protruding anteriorly 3
— Tutoria distally bears five or six dentations; body length less than 540 μm; notogastral setae minutely barbed; pteromorphs not protruding anteriorly. . . . . *T. alpinus* Aoki, 1982

3. Sensilli with very short stalk; medial dens of lamellar cusps distinctly developed; body size relatively small (body length less than 616 μm). . . . . *T. berlesei* Jacot, 1929
— Sensilli with relatively long stalk; medial dens of lamellar cusps minute or absent; body size relatively large (body length more than 616

μm).....*T. novus* (Sellnick, 1928)

4. Notogastral porose areas A_1 relatively large, A_2 very small; body size relatively small (body length less than 570 μm).....5
— Notogastral porose areas A_1 very small, A_2 relatively large; body size relatively large (body length more than 600 μm) ..... *T. hirauchiae* **n. sp.**

5. Lamellae gradually converging to each other; rostral and interlamellar setae long, extending beyond anterior margin of rostrum; sensilli roughened; porose areas A_1 and A_2 removed from each other ..... *T. aokii* **n. sp.**
— Lamellae nearly parallel to each other; rostral and interlamellar setae short, not reaching anterior margin of rostrum; sensilli smooth; porose areas A_1 and A_2 very closely situated..... *T. rausensis* Aoki, 1982

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