Zonation of Oribatid Mite Communities around Sesshogawara of Kusatsu, A Spouting Area of Sulfurous Acid Gas, With Description of Two New Species

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With 2 Tables and 4 Figures

Abstract

Sulfurous acid gas spouting from the ground in living volcanic areas affects the biotopes in its vicinity to produce a distinctive gradual change of vegetation from bareland to woodland. As one of such biotopes, Sesshogawara of Kusatsu, Gumma Prefecture, was selected and an investigation was carried out to examine change of soil fauna, especially oribatid mites, in parallel with the change of vegetation. The result showed that the oribatid community of woodland became more and more simple toward the spouting point of the gas. The oribatid species found there contained two new species, *Allomycobates lichenis* and *Ceratozetes shiranensis*, which are described in the last part of the paper.

Introduction

On the eastern slope of the volcano Mt. Shirane there is a bare rocky place called Sesshogawara. The place is dangerous and kept from sightseers, because poisonous gas of sulfurous acid is spouting from cracks of the ground. Under the influence of the gas, a wide area around the spouting points remains completely naked without any vegetation. However, an initial growth of some plants is observed on the peripheral area, changing its species composition and density toward more distant place. In soil zoological point of view such an area must also be very interesting to know zonation of soil fauna in parallel with that of vegetation.

On September 10 th, 1975, a series of samples was taken at the seven points on the ground along the change of vegetation as shown in Fig. 2. The smples consisted of lichen, litter and soil of various volumes collected at random by hands. The author intended to compare only qualitative data and not quantitative, because sampling of definite surface area or volume was almost impossible in such a rocky area. About eight hours after the smpling, the samples were put in Tullgren apparatuses and animals were extracted at the laboratory of Yokohama National University.

Result and Discussion

Among the soil animls extracted the oribatid mites were identified and counted. In total, 27 species were found, among which 2 species were new to science and are described as new species in the last part of the present paper.

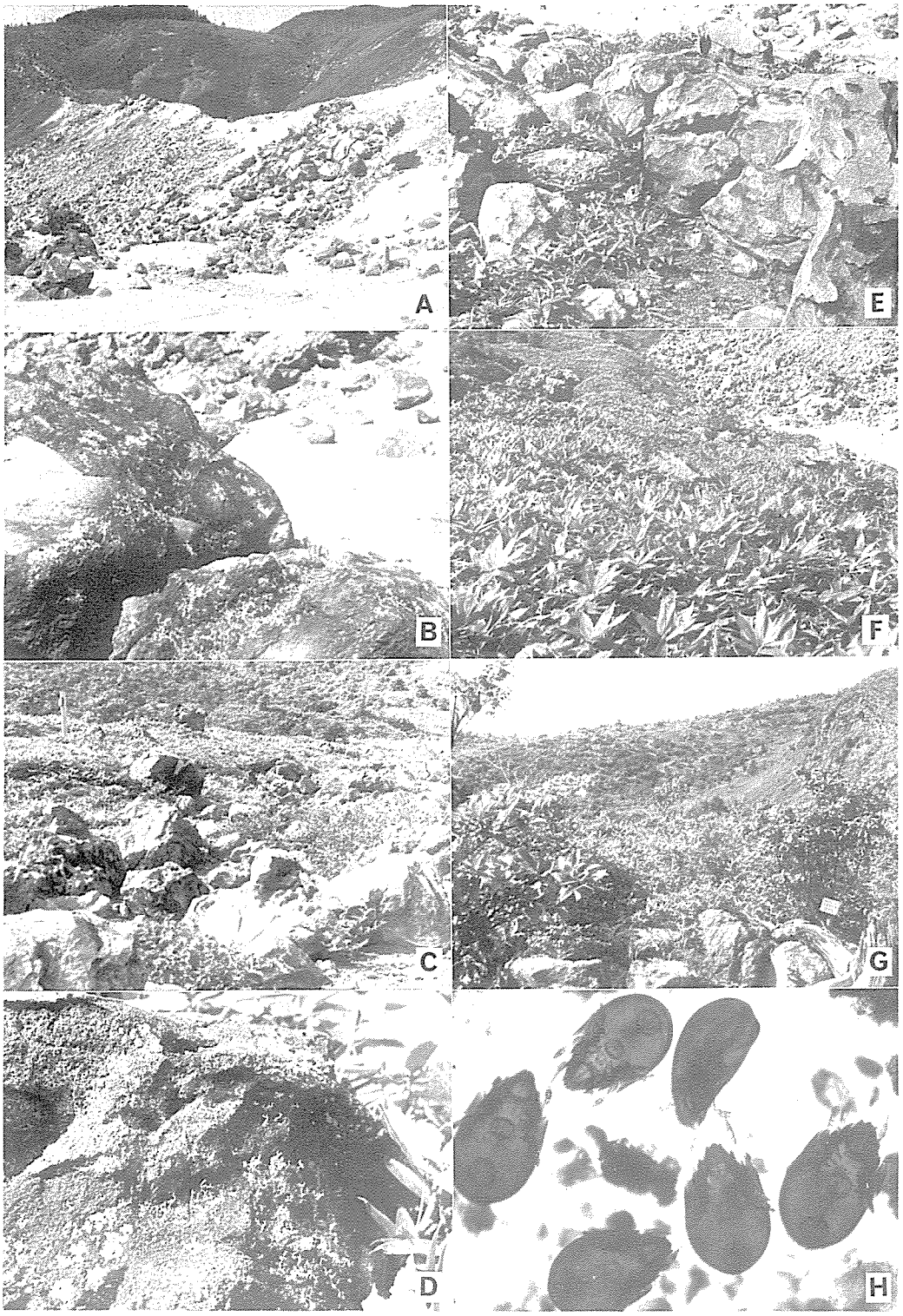

Fig. 1 The pictures of the biotopes where the samples were taken.
A (Point A): Bare land close to the spouting of sulfurous acid gas. —— B (Point B): A lichen, *Cladonia theiophila*, growing on rocks. —— C (Point C): *Polygonum cuspidatum*-community among rocks. —— D (Point D): *Cladonia theiophila* growing on rocks in a poor vegetation of *Sasa kurilensis*. —— E (Point E): Poor vegetation of *Sasa kurilensis*. ——F (Point F): Rich vegetation of *Sasa kurilensis*. ——G(Point G): Edge of woodland. —— H: *Allomycobates lichenis* sp. n. inhabiting *Cladonia theiophila*.

Niphocepheus nivalis (SCHWEIZER) is recorded for the first time from Japan.

1. Species Composition of Oribatids in the Seven Points Investigated

Point A. Rocky place completely without vegetation. Volcanic rocks of various sizes are accumulated. Surface of the rocks are mostly covered by yellow sulfurous adhesion. Neither lichen, nor moss grows on the rocks as well as on the ground. The sample taken here consists of broken rocks and a small amount of plant detritus on the ground. A single species of oribatid was found there:

Oppiella nova (OUDEMANS)……24*

Point B. A species of lichen, *Cladonia theiophila* ASAH., appears as an initial plant in the rocky area. It is well known that this lichen is strongly sulfur-resistant. The sample is composed of this lichen growing on rocks together with a thin layer of soil deposited beneath the plant. Three species of oribatids were found:

Allomycobates lichenis sp. n.……163
Scheloribates latipes (C. L. KOCH)……56
Ceratozetes shiranenis sp. n.……25

Point C. Among the higher plants, *Polygonum cuspidatum* SIEB. et ZUCC. seems to be one of the most resistant species against deterioration of environments and, in the area studied, it appeared in the front line of vegetation. The sample consisted of decaying leaves of the plant and a small amount of soil beneath them. Two species of oribatids were found:

Oppia sp. 11 ……11
Scheloribates sp. E ……11

Point D. The same species of lichen is growing on rocks as in the poin B, but the lichen contains more water and the growth is more intensive, because *Sasa*-plant appears among the rocks, though its density is low. The sample of the lichen and soil beneath it contained a great number of *Allomycobates*-species:

Allomycobates lichenis sp. n.……3936
Melanozetes meridianus SELLNICK……11
Tectocepheus velatus (MICHAEL)… 4
Ceratozetes shiranensis sp. n.…… 2
Oppiella nova (OUDEANS)…… 1

Point E. *Sasa kurilensis* MAKINO et SHIBATA is growing among rocks in a low density. The sample contains thin layers of litter and organic soil. The oribatid community becomes richer in species number than that under *Polygonum cuspidatum* vegetation.

Scheloribates sp. E ……56
Oppia sp. 11 ……17
Protoribates sp. B……12
Tectocepheus velatus (MICHAEL)…… 3
Suctobelbella sp. 30…… 3
Oppia sp. 8…… 2
Oppiella nova (OUDEMANS)…… 1
Suctobelbella sp. B …… 1

Point F. Dense growth of *Sasa kurilensis*. The sample was taken from thick layers of litter and decaying organic matter under the vegetation. The mite fauna is more complicated than in the point E with sparse Sasa-vegetation.

Carabodes peniculatus AOKI……90
Tectocepheus velatus (MICHAEL)……54
Scheloribates sp. E ……38
Suctobelbella sp. B ……35
Oppiella nova (OUDEMANS)……18
Suctobelbella sp. 30……16
Oppia sp. 11 ……13
Protokalumma parvisetigerum AOKI…… 1
Ceratozetes shiranensis sp. n. …… 1

Point G. Several tree species appear in this area such as *Hydrangea paniculata* SIEBOLD, *Rhododendron farinae* FRANCHET, *Rh. albrechti* MAXIMOWICZ and *Hugeria japonica* NAKAI accompanied by *Sasa kurilensis*. The mite community is most complicated among the points investigated:

Allomycobates lichenis sp. n. …… 290
Scheloribates sp. E…… 200
Tectocepheus velatus (MICHAEL) ……81
Melanozetes meridianus SELLNICK ……81
Carabodes peniculatus AOKI ……80
Steganacarus striculus (C. L. KOCH) ……57
Suctobelbella sp. B……50
Suctobelbella sp. 30……47
Hermanniella sp. B' ……34

* Actual number of individuals.

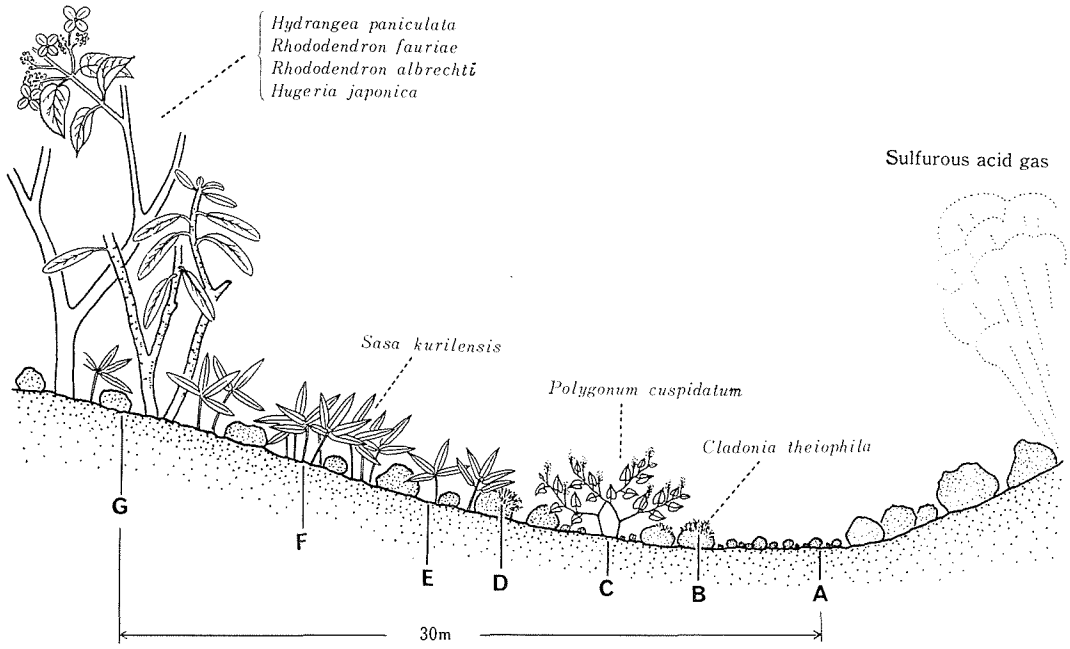

Fig. 2 A profile of the plant zonation around Sesshogawara showing the sampling points (A—G).

Protoribates sp. B ·····26
Carabodes rimosus AOKI ·····22
Oppiella nova (OUDEMANS) ·····19
Others (9 species) ·····38

2. Zonation of Oribatid Fauna

As shown in Tab. 2 the oribatid communities change their species compositions in paralell with the plant zonation from the bare area (A) to the area with dense vegetation (G). The species number of the mites gradually increase from the point A to G. The points B, C, D, E and F are represented each by a single species of plant, but the species number of the oribatids in these points are 3, 2, 5, 8 and 11, respectively, increasing in accordance with distances from the bare area (A).

It is an astonishing fact that there are living animals in rigorous environments such as A and B. A single species of oribatid found in A, *Oppiella nova*, is a cosmopolitic species which has a wide geographical distribution and a large ecological valency. The lichen, *Cladonia theiophila*, growing on rocks in B is in extremely dry condition, being exposed to direct irradiation of sunshine. It was, therefore, also unexpected that there lived considerable number of oribatids. The oribatid community in B consisted of only 3 species (72% of them is *Allomycobates lichenis*), but their number was far numerous than expected. *Polygonum cuspidatum* is a well known plant growing in rigorous environments in Japan. In the soil under this plant (C) only two species of oribatids were found, which are different from those found in A and B, and their individual numbers were very small. On the point D, *Sasa kurilensis* appears just behind *Polygonum cuspidatum* and protects the ground from sunshine to some extent, and the lichen growing on rocks is more vivid and soft, containing more water than in the point B. This may be the reason for that the lichen holds a great number of oribatids. However, the oribatid community there mostly consisted of a single species, *Allomycobates lichenis*, occupying 99.5% of total oribatids. On the contrary, *Allomycobates lichenis* disappeared in the soil (E) under the same vegetation of sparse *Sasa* growth and the dominant species are replaced by three

Table 1 Zonation of the oribatid communities in parallel with the plant zonation as shown in Fig. 2. Relative abundance of each species is expressed as percentage in individual number in each habitat (+: <5%).

Oribatid Mite Species \ Sampling Point	G	F	E	D	C	B	A
Oppiella nova (OUDEMANS)	+	6.5	+	+			100.0
Allomycobates lichenis sp. n.	28.2			99.5		72.8	
Scheloribates latipes (C. L. KOCH)						23.0	
Ceratozetes shiranensis sp. n.		+		+		11.2	
Scheloribates sp. E	19.5	13.8	58.9		50.0		
Oppia sp. 11	+	4.7	17.9		50.0		
Protoribates sp. B	+		12.6				
Tectocepheus velatus (MICHAEL)	7.9	19.6	+	+			
Melanozetes meridianus SELLNICK	7.9			+			
Suctobelbella sp. B	+	12.7	+				
Suctobelbella sp. 30			+				
Oppia sp. 8			+				
Protoribotritia aberrans ensifer AOKI		+					
Pterochthonius angelus BERLESE		+					
Carabodes peniculatus AOKI	7.8	32.7					
Suctobelbella sp. K	+	5.8					
Protokalumma parvisetigerum AOKI	+	+					
Nothrus biciliatus C. L. KOCH	+						
Liochthonius sp.	+						
Parhypochthonius aphidinus BERLESE	+						
Carabodes rimosus AOKI	+						
Niphocepheus nivalis (SCHWEIZER)	+						
Hermanniella sp. B'	+						
Podopterotegaeus tectus AOKI	+						
Ceratoppia bipilis (HERMANN)	+						
Hafenrefferia acuta AOKI	+						
Steganacarus striculus (C. L. KOCH)	+						
Number of Species	21	11	8	5	2	3	1

species, among which two are in common with those under *Polygonum cuspidatum* vegetation (C). In the soil under the dense vegetation of *Sasa* (F), the oribatid community becomes far complicated, containing seven dominant species. The most dominant species in the point E, *Scheloribates* sp. E, is replaced by *Carabodes peniculatus* which was never found in the points from A to E. In the last point (G) covered by several tree species the oribatid community becomes further complicated, containing twenty-one species, but losing the species which stand out conspicuously.

3. Mites Other than Oribatids

The mites belonging to Mesostigmata, Prostigmata and Astigmata were also extracted from the samples. Their individual number in total and percentage are shown in Table 2.

The bare area (A) without vegetation and the lichen growing on rocks (B and D) must not be biotopes adaptable for the non-oribatid mites. Percentages in the number of these mites

Table 2 The numbers of oribatid and non-oribatid mites in each habitat.

Sampling Point (Dry Weight of Sample)	Nos. of Non-oribatid Mites	Nos. of Oribatid Mites	% of Non-oribatid Mites
A (394.0 g)	1	24	1.0
B (153.0 g)	14	358	3.8
C (65.5 g)	35	24	59.9
D (75.0 g)	51	4,016	1.3
E (39.0 g)	130	168	43.6
F (99.5 g)	244	352	40.9
G (98.5 g)	485	2,108	18.7

are very low (less than 4 %) in these three biotopes. However, in the areas covered with *Polygonum cuspidatum* (C) or *Sasa kurilensis* (E and F), the number of oribatids and that of non-oribatid mites become nearly equal to each other. In the soil under the tree vegetation(G) percentage of the non-oribatid mites is again lowered to 18.7%.

Conclusion

The present study revealed that there was a distinctive zonation of oribatid mite communities along with plant zonation around Sesshogawara. According to deterioration of biotopes toward the center of Sesshogawara, the oribatid communities lose their richness in the species number, gradually omitting the species not resistant against rigorous environments. However, it was also found that a peculiar species, *Allomycobates lichenis*, inhabited in a great abundance the lichen growing on rocks near the marginal area of vegetation, where other mite species can hardly live. Thus, the lichen (*Cladonia theiophila*) and the oribatid (*Allomycobates lichenis*) in combination characterize the critical biotope around Sesshogawara.

Such zonation of the oribatid communities must be mainly caused secondarily by the plant zonation which was formed under the strong affection of sulfurous acid gas. A direct effect of the gas on the oribatid communities is also supposed to exist, but no evidence in this regard was obtained by the present study. The only evident fact is that *Allomycobates lichenis* has a great resistance against exposure to the gas.

Description of New Genus and Species

Allomycobates gen. nov.

Very similar in appeaarance to the genus *Mycobates*, but no areae porosae are found on notogaster. More than 70 specimens of the type-species were carefully examined to find out areae porosae or sacculi, but notogaster of every specimen bears no such structures, except for 3 pairs of lyrifissures and 1 pair of latero-abdominal gland openings. The number of setae —— ntg: 10—10, g: 6—6, ag: 1—1, an: 2—2, ad: 3—3. Anal opening rounded. All the legs monodactyle.

Type-species: *Allomycobates lichenis* sp. nov.

Allomycobates lichenis sp. nov.

(Figs. 1-H and 3)

Measurement. Body length: 325 (357) 392 μ; width: 200 (231) 225 μ.

Prodorsum. Lamellar cusp bending downward along the curvature of prodorsum, so that in dorsal aspect it appears to be shorter than it is; in the lateral aspect, the cusp is about 1/1.17 as long as the basal portion of lamella; tip of the cusp bearing a short upper tooth, beneath which lamellar seta is inserted. Translamella ribbon-like, weakly arched, connecting the lamellae at the level somewhat anterior to the posterior end of cusps. Interlamellar seta only slightly roughened, extending a little beyond the anterior margin of translamella in dissected specimens (Fig. 3-C) and 1.77-2.27× as long as their mutual distance. Lamellar seta weakly barbed unilaterally, bending inward and downward, being a little shorter than lamellar

Fig. 3 *Allomycobates lichenis* gen. nov. et sp. nov. A: Leg I. —— B: Leg II. ——C: Prodorsum of a dissected specimen. —— D: Dorsal. —— E: Ventral.

cusp. Rostral seta somewhat longer than lamellar one, being distinctly barbed on the outside. Pedotectum I provided with several apical teeth, small and irregular (Fig. 3-C). Rostral margin seems to be smooth, but when examined in dissected specimens, it has a small median indentation (Fig. 3-C). A triangular projection exists on rostrum between lamellar cusps. Sensillus with a short, thick peduncle and a fusiform head directed anteromediad.

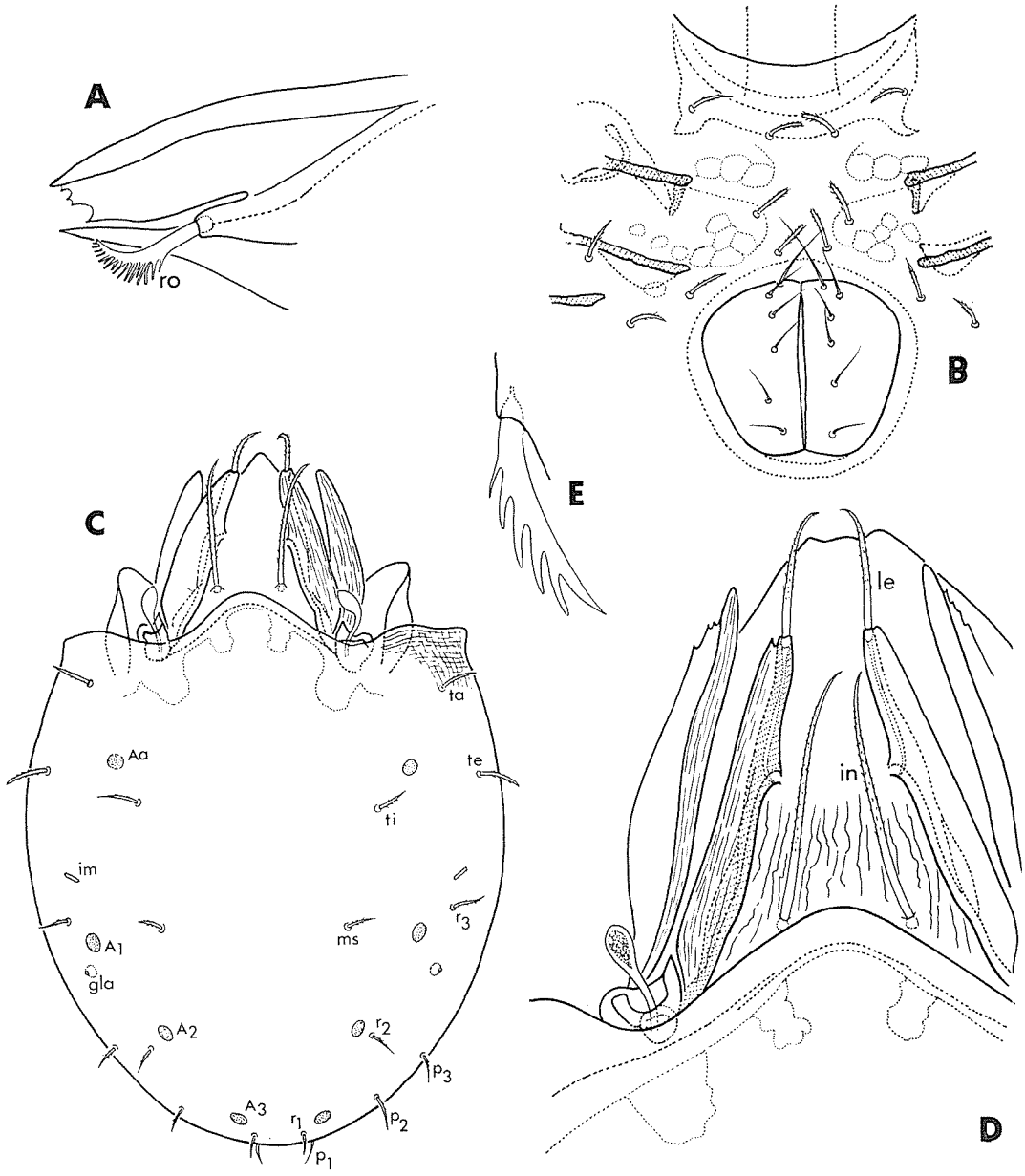

Fig. 4 *Ceratozetes shiranensis* sp. nov. A: Rostral seta and pedotectum I in lateral view. —— B: Genital and epimeral region. —— C: Dorsal. —— D: Prodorsum of a dissected specimen. —— E: A strong seta on the ventral side of tarsus II.

Notogaster. Front part of notogaster arched, covering insertion pores for interlamellar setae. Ten pairs of notogastral setae distinct and curled. Mutual distances (average in 10 examples): $ti-ti=87.5\mu$, $ms-ms=87.0\mu$, $r_2-r_2=108\mu$ $r_1-r_1=27\ \mu$; *ti*−*ti* sometimes longer, sometimes shorter than *ms*−*ms*, but they are nearly equal on the average; r_2-r_2 is 5/4 as long as *ti*−*ti* or *ms*−*ms*. Lateroabdominal gland opening located near and posterolateral to seta r_3. Three pairs of lyrifissures found in front of r_3, lateral to *gla* and lateral to r_1. Neither areae porosae nor sacculi exist on notogaster.

Ventral side. Six pairs of genital, one pair of aggenital, two pairs of anal and three pairs of adanal setae are present. Anal fissure located

close to anal margin, a little posterior to the level of an_2. Adanal seta ad_3 located nearly on the level of *iad*; ad_2 inserted closer to ad_1 than to ad_3. Setal formula on epimerata: 3—1—2—2. Along the anterior margin of epimerata I numerous granules (40–70) of irregular sizes are arranged transversely.

Legs. All the legs monodactyle. A strong tooth-like projection ("tooth" by HAMMER, 1952; "Zahn" by WILLMANN, 1931; "apophysis" by STRENZKE, 1954) exists each on genu I, genu II and tibia II (Fig. 3-A and 3-B).

Material examined. Holotype (in spirit) and 70 paratopotypes (35 in spirit and 35 on slides): Sesshogawara, Kusatsu, Gumma Prefecture, Central Japan, 10-IX-1975, J. AOKI. From a lichen, *Cladonia theiophila* ASAH., growing on rocks, The type-series is deposited in the collection of Yokohama National University, Yokohama.

Ceratozetes shiranensis sp. nov.

(Fig. 4)

Measurement. Body length: 495 (510) 520 μ; width: 340 (347) 350 μ.

Prodorsum. Rostral margin with a wide incision; the median bottom of the incision sometimes very slightly, sometimes considerably projecting anteriad. Lamella nearly straight, its cusp slightly curving inward. Lamellar cusp 2/3 as long as basal portion of lamella. Lamellar seta rather thick, weakly barbed, almost as long as cusp of lamella. Interlamellar seta as thick as lamellar one, but 1.8—1.9× as long as the latter. Rostral seta (Fig. 4—A) provided with strong barbs on the outside, being a little shorter than lamellar seta. Sensillus with a short peduncle and a clavate head usually directed anteromedially. Distinct longitudinal striae found on lamellae and indistinct ones on the prodorsal surface. Pedotectum I with 5—6 apical teeth.

Notogaster. Ten pairs of notogastral setae gently curved and not sharply pointed at tip and weakly barbed on their apical half; setae *ta* and *te* appear to be somewhat longer than the remaining notogastral setae. Areae porosae *Aa*, A_1, A_2 and A_3 circular, nearly epual in size to one another. Pteromorpha finely striated in transverse as well as longitudinal directions.

Ventral side. Genital plate with 6 setae arranged almost in a straignt line, though g_5 is located somewhat outside the line. Anal plate with 2 setae, which are equally distant from the median margin of the plate; distance an_1—an_2 slightly wider than the maximum width of the plate; an_2 located closer to the anterior margin, while an_1 fairly distant from the posterior margin. Adanal seta ad_3 inserted on the level about mid-distance between an_1 and an_2. Distance ad_1—ad_2 nearly equal to that between ad_3 and *iad*. Setal formula of epimerata: 3—1—3—2; all the epimeral setae rather thick, being barbed on their apical half; epimeral setae on the anterior half of epimeral region appreciably thicker than those on the posterior half; seta 1*c* especially long and thick; mutual distance 2*a*—2*a* wider than 1*a*—1*a* as well as 3*a*—3*a*.

Legs. All the legs tridactyle, with a strong median claw and slender lateral claws. One of the ventral setae on tarsus II becomes very strong, being provided with 5 thick ventral branches (Fig. 4 E).

Meterial examined. Holotype (in spirit) and 5 paratopotypes (2 in spirit and 3 on slides): Sesshogawara, Kusatsu, Gumma Prefecture, Central Japan, 10-IX-1975, J. AOKI. From a lichen, *Cladonia theiophila* ASAH., growing on rocks. The type-series is deposited in the collection of Yokohama National University, Yokohama.

Remarks. The present new species is distinguishable from any other species of the genus *Ceratozetes* by the combination of the following characters: (1) long lamellar cusps, (2) rostral margin with a wide incision, (3) notogastral areae porosae circular in shape and equal in size to one another, (4) rostral setae not visible in dorsal aspect, (5) clavate sensilli, and (6) comparatively thick notogastral and epimeral setae.

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