A preliminary study on oribatid mite communities in the cool temperate forest soils developed on a slope

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冷温帯林斜面におけるササラダニ群集の研究
——予報——

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Résumé

Abundances and species distributions of oribatid mites (Acari: Cryptostigmata) were investigated in a cool temperate forest developed on a slope in the Ashiu Experimental Forest of Kyoto University. Total adult oribatids density was 29,600 per m^2 in the ridge and 14,400 per m^2 in the bottom of the slope respectively. The abundances were higher in the upper than in the lower part of the slope and were related to the amounts of A_0 layer. Distribution of *Epilohmannoides esulcatus* was restricted to the plots where F-H layer was present, while *Archoplophora villosa* and *Eohypochthonius magnus* were found only in the lower part of the slope. The distribution of each species was related to the gradient of soil conditions along the slope.

The species list of oribatid mites in this study area was presented in this paper. Through the study period of 8 months, a total of 88 and 91 species was recorded in the ridge and the bottom plots respectively. Among the total of 108 species, 71 species were common to the both plots.

The species-area relation model proposed by KOBAYASHI (1974) was applied to compare the diversities of different oribatid communities along the slope. The diversity was expressed by a parameter of the species-area relation and was not so different among the communities. The species-area relations model is useful for a comparison of species diversity between different communities sampled with unequal sample numbers.

要　　旨

ササラダニ（ダニ目隠気門類，Acari: Cryptostigmata）の斜面における個体数と種の分布を京都大学芦生演習林の冷温帯林で調査した。ササラダニ成虫の個体数密度は，斜面上部で29,600/m^2，斜面下部で14,400/m^2を示した。A_0層量も斜面上部の方が下部より多く，ササラダニの密

度は A_0 層量と対応していた。優占種のうち *Epilohmannoides esulcatus* は F-H 層のある斜面上部にのみ出現し，*Archoplophora villosa*, *Eohypochthonius magnus* は下部にのみ出現した。ササラダニの種の分布は斜面における土壌の環境条件を反映していた。

この調査地より採集されたササラダニの種リストを作製した。8ケ月の調査期間中，斜面上部からは88種，下部からは91種，あわせて108種が記録され，うち71種が上下に共通して出現した。

Kobayashi (1974) の提案した種数—面積関係を斜面におけるササラダニ群集にあてはめたところ，種数—面積関係による多様性はどの群集でもあまり差はみられなかった。この種数—面積関係は，サンプル数がことなる生物群集の調査データを用いて多様性を比較する際に有効である。

Introduction

Oribatid mites are found in various soil types and are usually abundant in litter and soil layer in forest sites. Their abundances range from 16,400 to 143,700 per m^2 in deciduous temperate forest soils.[7] Feeding habits of oribatid mites are grouped into three categories, i.e. fungivores or microphytophages feeding on fungi and bacteria, macrophytophages feeding on plant litter in soil and panphytophages which are not specialized.[6] Oribatid mites may play an important role in litter decomposition and soil formation because of the abundance and feeding habits in soil.[15]

The composition of soil fauna may vary considerably along the environmental gradients developed on forest slopes, of which soil conditions are important for the soil animals.[9] We have been studying oribatid mite communities in soils developed on a forest slope in a cool temperate forest, where mineral cycling[4], macro-soil animals[13][15], and Collembola[12] have been studied in a framework of biological processes of decomposition.

This is a preliminary report of a study of oribatid mite communities in the soils developed on a forest slope in a cool temperate forest. We describe the changes in abundances and species compositions of oribatid mites along the slope. The community structure of oribatid mites was compared between different plots situated along the forest slope by using a parameter of a species-area relation proposed by Kobayashi.[5]

Study Area

This study was carried out in a forest slope which is covered with a matured deciduous forest dominated by *Fagus crenata* Blume and *Quercus mongolica* var *grosseserrata* (Bl.). The forest is located in the Ashiu Experimantal Forest of Kyoto University (N35°18′ E135°43′) about 40 km north of Kyoto City. Sampling plots were established on a forest slope and location of plots is shown in Fig. 1. Sampling plots were established on the ridge and the bottom parts of the slope and the distance from the ridge to the bottom plots was about 50m long. The ridge and bottom plots are 15×20 and 10×30m in area respectively. Besides the two plots, three plots were placed at 10m intervals along the slope.

Soil conditions are important for the interpretation of the results and are briefly described. Soil profiles of the study plots are shown in Fig. 1. In the ridge plot, A_0 layer consists of L and F-H layers and F-H layer is about 0.5 to 7.0cm in depth. The soil belongs to brown forest soil (Bb type) (according to 'Classification of Forest Soil in Japan.').[2]

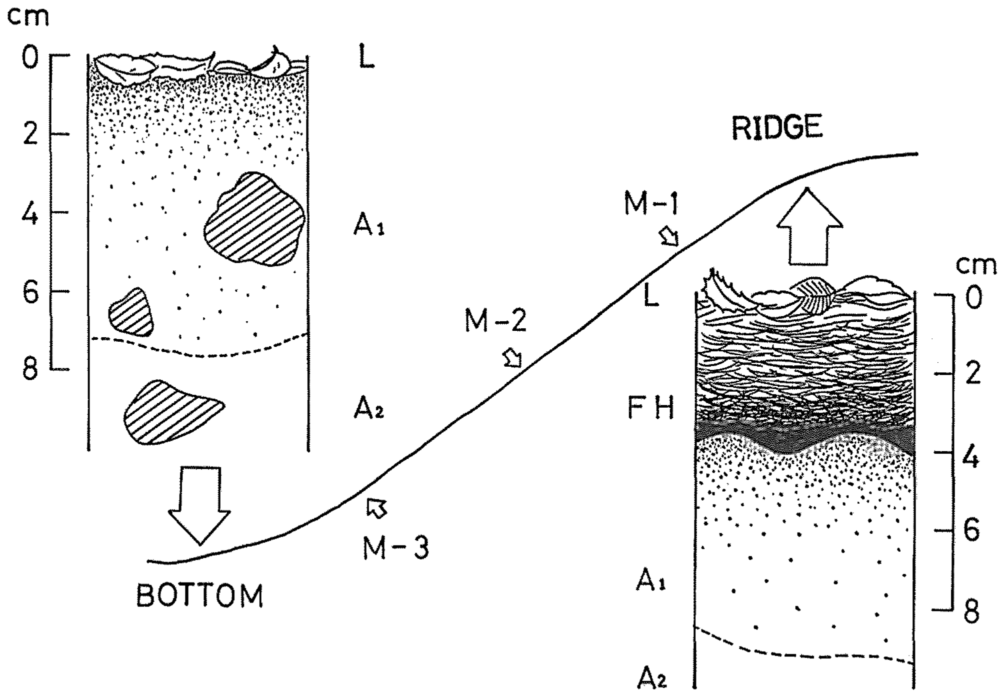

Fig. 1 Location of study plots and soil profiles in Nodahata-dani.

The accumulation of A_0 layer shows a mor type and the boundary between the A_0 layer and A layer is clear in the profile. In the bottom plots, A_0 layer almost consists of L layer and the development of F and H layers are very poor. In the bottom plots, soil belongs to brown forest soil type Bd and L layer immediately contact with the mineral soil layer (A layer). The top of the mineral soil layer contains a lot of gravel and is rich in organic matter.

Methods

Sampling was carried out on 26 April 1982 in the ridge and the bottom plots and on 30 April 1982 in M-1, M-2 and M-3 plots respectively. In each plot, using cylindrical soil sampler, soil samples of each 25cm² in area and 8cm in depth were taken and a numbers of samples were 14, 4, 4, 4 and 14 for the ridge, M-1, M-2, M-3 and the bottom plots respectively. The soil samples were divided into 4 layers each 2 cm in thickness. Besides the April's samples, monthly sampling was carried out in the ridge and the bottom plots during the period from April to December 1982. On each sampling occasion, 15 soil cores were taken from each plot. Samples were 25cm² in area and 8 cm in depth.

Soil animals were extracted by a high gradient canister extractor and extraction process and efficiency of this extractor have been given.[11] The extraction was taken place more than 108 hours with gradually increasing temperature up to 45°c. The extracted animals were collected into a solution of saturated picric acid and then preserved in alcohol. The identification and counting were undertaken under a binocular microscope with a magnification of 100x. Adult individuals of oribatid mites were identified to species and larvae and nymphs of the mites were not identified into species.

Results and Discussion

1. Distribution and abundance of oribatid mites along the slope.

Distributions of the total adult oribatid mites and the 8 abundant species are shown in Fig. 2. together with the changes in thikness of F-H layer along the slope. Abundances of the total oribatid mites decreased from the ridge to the bottom plots and the population densities are shown in Table 1. The changes in abundances of each species showed the habitat preference of each species.

Distribution of oribatid mites may be related to the environmental gradients developed along the slope. Among the environmental gradients, soil conditions are particularly important for the distribution of the mites. Many studies showed that the amount of organic

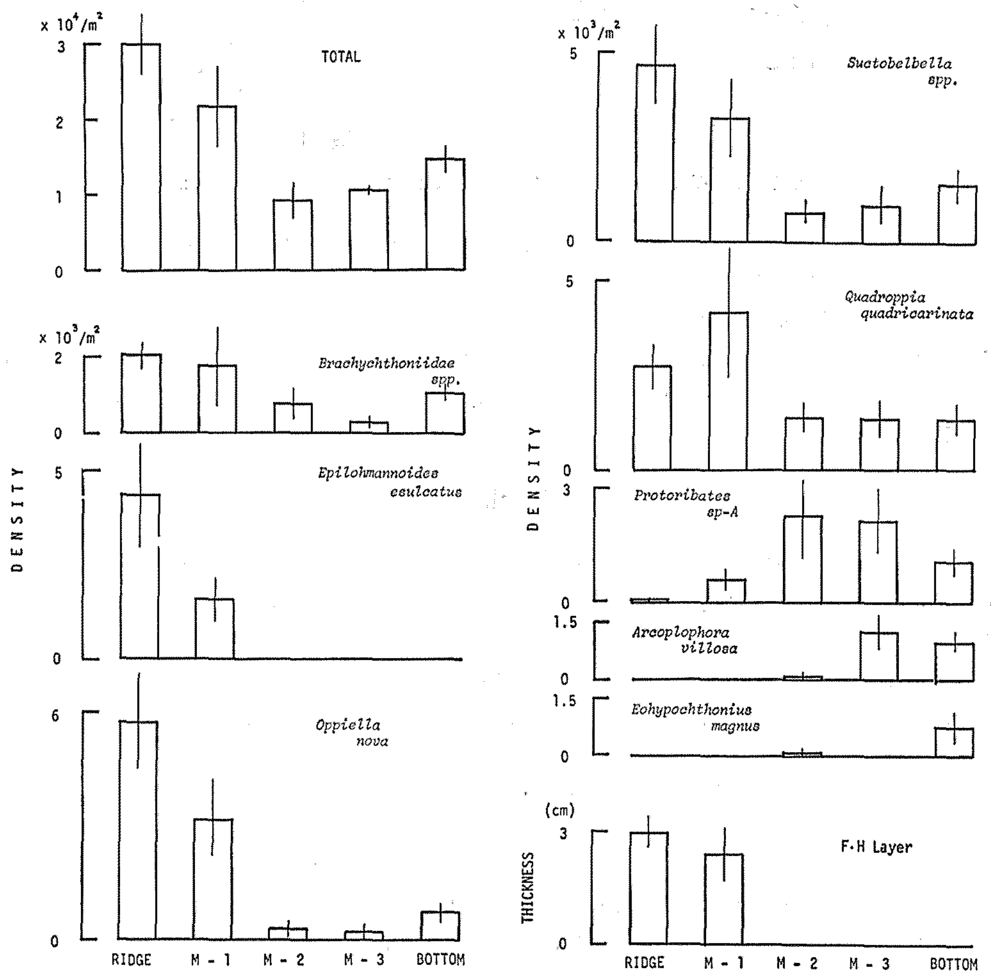

Fig. 2 Distributions and abundances of the total adult oribatid mites and the 8 dominant species and thickness of F-H layer along the slope. Bars indicate the standard errors.

Table 1. Mean population densities of oribatid mites in the slope in Nodahata-dani.

Plot	Density (per m² with standerd errors)
Ridge*	29, 600±3, 840
M-1**	22, 000±5, 160
M-2**	9, 200±2, 280
M-3**	10, 520± 380
Bottom*	14, 400±1, 640

* collected on 26 April 1982 (n=14)
** collected on 30 April 1982 (n= 4)

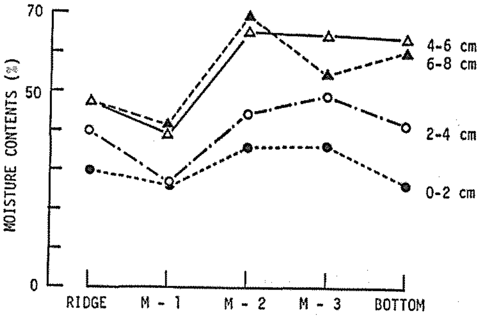

Fig. 3 Soil moisture contents for April's samples. (Values are expressed by water percent per valume.)

matter in the soil affected the abundance of oribatid mites[3)10)], while species distribution was influenced by various factors.[8)9)]

The depth of F-H layer along the slope is shown in Fig. 1. and soil moisture contents along the slope are also shown in Fig. 3. The amount of F-H layer and soil moisture contents are important among the environmental gradients along this slope. The abundances of total oribatid mites were apparently related to the amount of F-H layer and were two times higher in the ridge than in the bottom plots. While the distribution of each species are not fully explained by the amount of A_0 layer. Distribution of *Epilohmannoides esulcatus* was apparently restricted to the plots where F-H layers were present, while *Archoplophora villosa* and *Eohypochthonius magnus* were only found in the lower part of the slope. The distribution of each species may be related to various environmental factors including the amount of F-H Layer and soil moisture contents.

2. Comparison of oribatid mite communities between the ridge and the bottom plots.

A_0 layer accumulation shows a different type between the ridge and the bottom part of the slope and the A_0 layer shows a mull and mor type in the ridge and the botom plots respectively. It is shown that there is a difference of decomposition rate between the upper part and a lower part of a slope.[15)] The comparison of oribatid mites communities between the ridge and the bottom plots provides a crue for the understanding the relations between the decomposition process and oribatid mite species, while the climatical conditions are similar on the slope.

Basing on the monthly samples in the ridge and the bottom plots, species composition of oribatid mites in both plots is summarized in Table 2. During the study period (from April to December 1982), a total of 108 species was recorded in the both plots. Numbers of species in the ridge and bottom plots were 88 and 91 respectively, and 71 species were common to the both plots. The following species are mainly occurred in the ridge plot; *Epilohmannoides esulcatus, Phthiracarus clemens, Apolohmannia gigantea, Heminothrus minor, Phyllhermannia kanoi, Carabodes rimosus, Dometrina* sp., *Oribatula sakamorii, Scheloribates* sp-B and *Chamobates* sp.. The bottom preffered species are as follows; *Archoplophora villosa, Mesoplophora japonica, Malaphthiracarus bacillatus, Eohypochthonius magnus, Cyrthermannia parallera, Fosseremus quadripertitus, Ceratoppia* sp-B, *Protoribates* sp-A,

Table 2. Species list for oribatid mites collected from Nodahata-dani, Ashiu.

Species	Abundance* Ridge	Abundance* Bottom
ARCHENOTHRIDAE		
Zachvatkinella nipponica Aoki	33	29
PALAEACARIDAE		
Palaeacarus hystricinus Trägårdh	43	22
ARCHOPLOPHORIDAE		
Archoplophora villosa Aoki	0	357
MESOPLOPHORIDAE		
Mesoplophora japonica Aoki	0	12
PHTHIRACARIDAE		
Atropacarus striculus (Koch)	335	85
Phthiracarus clemens Aoki	60	0
Phthiracarus japonicus Aoki	7	1
Phthiracarus sp-A	3	0
EUPHTHIRACARIDAE		
Euphthiracarus sp.	0	2
Metaphthiracarus bacillatus Aoki	0	13
Microtritia minima (Berlese)	206	3
Rhysotritia ardua (Koch)	109	47
HYPOCHTHONIIDAE		
Eohypochthonius magnus Aoki	1	585
Hypocthonius rufulus Koch	3	5
HAPLOCHTHONIIDAE		
Haplochthonius simplex Willmann	1	0
BRACHYCHTHONIIDAE		
Brachychthoniidae spp.	561	319
PTEROCHTHONIIDAE		
Pterochthonius angelus Berlese	99	25
LOHMANIIDAE		
Vepracarus hirsutus (Aoki)	8	4
PERLOHMANNIIDAE		
Apolohmannia gigantea Aoki	26	1
Perlohmannia coiffaiti Grandjean	1	0
EPILOHMANNIIDAE		
Epilohmannia sp-D	6	0
Epilohmannoides esulcatus Ohkubo	1594	6
NOTHRIDAE		
Nothrus biciliatus Koch	0	4
Nothrus borussicus Sellnick	3	0
Nothrus palustris Koch	0	1
Nothrus silvestris Nicoiet	17	4
CAMISIIDAE		
Camisia biurus (Koch)	0	1
Camisia lapponica (Trägårdh)	9	0
Heminothrus longisetosus Willmann	16	1
Heminothrus minor Aoki	108	0
Platynothrus yamasakii (Aoki)	0	7
TRHYPOCHTHONIIDAE		
Trhypochthonius japonicus Aoki	4	4
MALACONOTHRIDAE		
Malaconothrus japonicus Aoki	105	115
Malaconothrus pygmaeus Aoki	161	137
NANHERMANNIIDAE		
Cyrthermannia parallela (Aoki)	0	10
Masthermannia hirsuta (Hartman)	0	5
Nanhermannia nana (Nicolet)	97	16
HERMANNIIDAE		
Phyllhermannia kanoi (Aoki)	29	0
HERMANNIELLIDAE		
Hermanniella punctulata Berlese	19	20
DAMAEIDAE		
Damaeidae sp-As1	18	80
Damaeidae sp-As2	2	1
Damaeidae sp-As3	9	56
Damaeidae sp-As4	0	1
Damaeidae sp-As6	43	12
Damaeidae sp-As7	13	37
Damaeidae sp-As8	5	10
CHARASSOBATIDAE		
Ameroproctus sp.	1	0
MICROZETIDAE		
Microzetidae sp-A	29	59
DAMAEOLIDAE		
Costeremus ornatus Aoki	2	0
Fosseremus quadripertitus Grandjean	0	66
EREMOBELBIDAE		
Eremobelba japonica Aoki	6	21
AMERIDAE		
Defectamerus crassisetiger Aoki	20	13
HETEROBELBIDAE		
Hetrobelba stellifera Okayama	67	18
EREMAEIDAE		
Eremaeus tenuisetiger Aoki	4	0
Eremaeus sp.	0	1
LIACARIDAE		
Liacarus acutidens Aoki	8	7
Liacarus contiguus Aoki	6	0
Liacarus sp-G	6	3
XENILLIDAE		
Xenillus tegeocranus (Hermann)	0	2
ASTEGISTIDAE		
Cultroribula lata Aoki	196	87
Cultroribula tridentata Aoki	12	1

Species	Abundance* Ridge	Bottom	Species	Abundance* Ridge	Bottom
METRIOPPIIDAE			*Oppia* sp-AsR	33	141
Ceratoppia bipilis (Hermann)	1	1	*Oppiella nova* (Oudemans)	1901	155
Ceratoppia incisa Kaneko et Aoki	9	0	*Quadroppia quadricarinata* (Michael)		
Ceratoppia quadridentata (Haller)	6	1		596	382
Ceratoppia sexpilosa (Willmann)	0	2	SUCTOBELBIDAE		
Ceratoppia sp-B	0	21	*Suctobelbella* spp.	2048	629
Metrioppia sp.	6	5	*Suctobelbila tuberculata* Aoki	225	16
Metrioppiidae sp.	7	61	ORIBATULIDAE		
GUSTAVIIDAE			*Dometrina* sp.	115	3
Gustavia microcephala (Nicolet)	4	2	*Incabates major* Aoki	3	1
CARABODIDAE			*Oribatula sakamorii* Aoki	30	0
Carabodes peniculatus (Aoki)	0	1	*Scheloribates* sp-B	99	9
Carabodes rimosus rimosus Aoki	84	7	HAPLOZETIDAE		
TECTOCEPHEIDAE			*Protoribates lophotrichus* (Berlese)		
Tectocepheus spp.	676	143		160	29
OTOCEPHEIDAE			*Protoribates* sp-A	14	435
Dolicheremaeus elongatus Aoki	5	33	*Protoribates* sp-As3	8	30
Fissicepheus clavatus (Aoki)	0	8	*Rostrozetes foveolatus* Sellnick	2	1
Fissicepheus coronarius Aoki	1	0	CHAMOBATIDAE		
Megalotocepheus japonicus Aoki	9	1	*Chamobates* sp.	22	2
OPPIIDAE			CERATOZETIDAE		
Lasiobelba remota Aoki	0	4	*Ceratozetes* sp-C	0	46
Operculoppia restata (Aoki)	7	9	PELOPIDAE		
Oppia arcualis (Berlese)	48	17	*Eupelops* sp.	11	9
Oppia sp-3	54	7	ORIBATELLIDAE		
Oppia sp-17	83	120	*Ophidiotrichus ussuricus* Krivolutsky	2	8
Oppia sp-67	30	2	*Prionoribatella impar* Aoki	6	0
Oppia sp-95	65	15	PARAKALUMMIDAE		
Oppia sp-As3	483	250	*Neoribates roubali* (Berlese)	10	9
Oppia sp-As5	3	6	GALUMNIDAE		
Oppia sp-As6	17	1	*Pergalumna intermedia* Aoki	1	2
Oppia sp-As8	9	5	*Trichogalumna nipponica* (Aoki)	2	26

* total number of adults collected from the monthly samples

Ceratozetes sp-C and *Trichogalumna nipponica.*

3. The species-area relations for oribatid mite communities.

The species-area relation, as well as the species abundance relation, may provide a quantitative evaluation of community structure. The species-area relation was estimated for the oribatid mite communities in the study plots. KOBAYASHI[5] proposed a new method for describing the species-area ralation for the biotic communities. When discrete samples (here soil cores) of a given unit size are taken successively in a homogenous sampling area, the species-area relation is expressed by the following equation;

$$Sn = \lambda(1 + 1/2 + 1/3 + \cdots\cdots + 1/n) \qquad \cdots\cdots\cdots(1)$$

where n is the number of sample units, Sn is the number of species occurring in n sample units, and λ is a costant which may be regarded as an index of species diversity. The formula (1) holds only for a particular size of sampling unit (i. e. the characteristic area), and a general form is applicable to any unit size. A more general form of the formula (1) is as follows;

$$Sn \approx u + v\sum(1/n) \qquad \cdots\cdots\cdots(2)$$

where u and v are constant and v is nearly equal to λ.

Regression of Sn to $1/n$ based on sampling data may be influenced by the order of the samples. A smoothed regression will be obtained by the following equation;

$$\bar{S}n = \sum_{j=1}^{s}\left\{1 - \binom{Q-Ai}{n} \Big/ \binom{Q}{n}\right\} \qquad \cdots\cdots\cdots(3)$$

where Ai is the number of samples in which ith species occurs and s is the total number of species occuring in Q samples.

The species-area relation was calculated by using the equation (2) and (3). The results for the ridge and the bottom communities sampled on April are shown in Fig. 4. Fit to the equation (2) is good for every cases examined and the correlation coefficients ranged from 0. 997 to 0. 999 in the ridge and from 0. 998 to 0. 999 in the bottom communities respectively. In every cases, the value u are negative or positive around the zero and showing that the sampling unit is not so different from the characteristic area of the equation (1). The values of v showed no clear seasonal changes in the both communities, suggesting that the community structure was rather stable over the study period in the both plots. The mean values of v were 16. 25 and 15. 70 for the ridge and the bottom communities respestively. The both communities were similar in their community structure in terms of species-area relation.

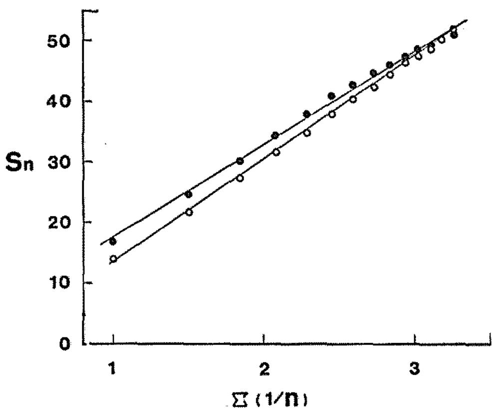

Fig. 4 Examples of the species-area relations for the ridge (filled circles) and the bottom communities (open circles) for April's samples.

Community structure may be characteri-

Table 3. Estimated values of species-area relations ($Sn = u + v\sum 1/n$) and species numbers for the oribatid mite communities in Nodahata-dani.

Plot	u	v	r*	Number of species	Number of samples
Ridge	2. 28	15. 36	0. 998	51	14
M-1	−2. 87	16. 36	0. 999	31	4
M-2	−3. 51	13. 61	0. 999	25	4
M-3	−8. 06	17. 21	0. 998	28	4
Bottom	−3. 27	19. 91	0. 999	52	14

* regression coefficient.

zed by the three components, i. e. diversity, evenness and species richness. Species richness is often used to compare different communities and is simply expressed as the number of species found in the limited number of samples from a given community. But the number of species has a limitation because of the dependency on the number of samples. An example is shown for the different communities in this study area in Table 3. This limitaion can be avoided by measuring the rate at which species increase with sample area. The rate was expressed by the constant of the species–area relation (λ or v). Comparison of v values between April's samples revealed that community structures of the oribatid mite communities along the slope are similar in terms of species-area relation. When the same number of samples are taken, one can expect a similar number of oribatid mite species.

In the study of soil arthropods, samples generally consist of a constant volume and area by means of a cylindrical soil cores and the area of the samples range from 10 to 20cm^2 in area.(1) The parameter (λ) of the species-area relation is appropriate for comparison of diversity between different communities sampled with unequal number of samples, while the area of sample unit remains the same for the different samples. The species-area relation may be useful for the study of soil arthropods, especially for the comparison of diversity of different communities sampled with unequal number of samples.

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References

1) Berthet, P: MITES. in J. Phillipson ed. 'Methods of study in quantitative soil ecology: population, production and energy flow.' IBP Handbook **18**, 186–208, Blackwell (1971)
2) Forest soil division: Classification of Forest Soil in Japan. Bull. Gov. For. Exp. Sta., **280**, 1–28, (1976)
3) Holt, J. A: The vertical distribution of cryptostigmatic mites, soil organic matter and macroporosity in three North Queensland rainforest soils. Pedobiologia, **22**, 202–209, (1981)
4) Katagiri, N & T. Tsutsumi: The relationship between site condition and circulation of nutrients in forest ecosystem. (V) The difference in nutrient circulation between stands located on upper part of slope and lower part of slope. J. Jap. For. Soc., **60**, 195–202, (1978)*
5) Kobayashi, S: The species-area relation. I. A model for discrete sampling. Res. Popul. Ecol., **15**, 223–237, (1974)
6) Luxton, M: Studies on the oribatid mites of a Danish beech wood soil. I. Nutritional biology. Pedobiologia, **12**, 434–463, (1972)
7) ———: Studies on the oribatid mites of a Danish beech wood soil. III. Introduction to the field populations. Pedobiologia, **24**, 301–311, (1981)
8) Plowman, K. Inter-relation between environmental factors and Cryptostigmata and Mesostigmata (Acari) in the litter and soil of two Australian subtropical forests. J. Anim. Ecol., **50**, 533–542,

(1981)
9) Popp, E: Communities of moss mites (Oribatei) in a gradient area. OIKOS, **21**, 236-240, (1970)
10) Seastedt, T. R. & D. A. Crossley, Jr.: Microarthropod response following cable logging and clear-cutting in the Southern Appalachians. Ecology, **62**(1), 126-135, (1981)
11) Takeda, H: On the extraction process and efficiency of MacFadyen's high gradient extractor. Pedobiologia, **19**, 106-112, (1979)
12) ———: A preliminary study on Collembolan communities in a deciduous forest slope. Bulletin of the Kyoto University Forests **53**, 1-7, (1981)
13) Tsukamoto, J: Soil macro-animals on a slope in a deciduous broad leaved forest. 1. Two species of terrestrial Isopoda *Ligidium japonicum* and *L. paulum*. Jap. J. Ecol., **26**, 201-206, (1977)
14) Tsutsumi, T. & N. Katagiri: The relationship between site condition and circulation of nutrients in forest ecosystem. (II) Moisture index as a means of evaluation of site condition. J. Jap. For. Soc., **56**,(12), 434-440, (1974)*
15) Wallwork, J. A: Oribatids in forest ecosystems. Ann. Rev. Entomol., **28**, 109-130, (1983)
16) Watanabe, H: Studies on the breakdown of leaf litter and ploughing by soil macro animals in forest ecosystems. I. Individual numbers, biomasses and environmental factors. Bulletin of the Kyoto University Forests, **44**, 1-19, (1972)*
* in Japanese with English summary