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Author(s)	TAMURA, Hiroshi; NAKAMURA, Yoshio; YAMAUCHI, Katsusuke; FUJIKAWA, Tokuko
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An Ecological Survey of Soil Fauna in Hidaka-Mombetsu, Southern Hokkaido[1]

By

Hiroshi Tamura, Yoshio Nakamura, Katsusuke Yamauchi and Tokuko Fujikawa

Biological Institute, Ibaraki University, Institute of Applied Zoology,
Hokkaido University and Zoological Institute, Hokkaido University

(*With 18 Text-figures and 8 Tables*)

Recently the important role played by soil animals in the complicated process of soil formation has gradually been recognized by ecologists, resulting in an accumulation of numerous papers on soil animals carried out at various localities throughout the world, covering a variety of biotopes. However, many of these previous studies, at least those in Japan, have dealt with certain particular groups, apparently reflecting the limit of capacity in sorting and identification by each investigator. Since the establishment of Japan International Biological Programme-Productivity of Terrestrial Communities (JIBP-PT), in 1966, a remarkable advance was achieved concerning the integral analysis of soil fauna by a teamwork of many research workers in various localities in Japan (Kitazawa *et al.*, 1968). On the other hand, virtually no ecological survey of soil fauna has hitherto been undertaken in Hokkaido, except for some preliminary attempts made in relation to the grassland amelioration (Hokkaido Development Bureau, 1965, '66), nevertheless the information upon this subfrigid zone is indispensable for the thorough understanding of soil fauna in Japan.

In 1966–1967, the authors had an opportunity to make, even though still incompletely, a preliminary survey of soil fauna in Hidaka-Mombetsu, Southern Hokkaido. The survey was, as a whole, carried out nearly during one year, covering all seasons, from May 1966 to January 1967. Unfortunately, each author made their sampling independently, both in aims and methods, each dealing with the following animal group: macrofauna with special reference to earthworms (Y. Nakamura), ants (K. Yamauchi) and meseofauna with special reference to collembolans (H. Tamura), oribatid mites (T. Fujikawa). Certainly the later joining together of such independent samplings into a paper could not give results better

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than those obtained by a cooperative sampling well planned since the start. Nevertheless, the authors decided to publish here these imperfect results, mainly to give an impetus for further advance of more precisely planned survey in Hokkaido.

The work was aided by the grant from Kuribayashi Fund to which the authors are much indebted. Further, they wish to express their sincere gratitude to Professor Emeritus Misao Tatewaki, Institute of Plant Ecology, Hokkaido University, Professor Mayumi Yamada and Dr. Shôichi F. Sakagami, Zoological Institute, Hokkaido University, for their valuable advices and helps in the course of the present work. Their heartest thanks are also expressed to Dr. M. Tohyama, Institute of Plant Ecology, Hokkaido University, who offered them an expert guidance as to the vegetational makeup of the area surveyed.

Area surveyed

Hidaka-Mombetsu is located on the Mombetsu Terrace at the east side of the Yufutsu plain, facing the Pacific Ocean (Fig. 1). Geologically, the area is consisted of the Mombetsu Terrace deposits in Pleistocene, the uppermost part of which is mainly of the volcanic ashes, produced about 230 years ago by the eruption of Mt. Tarumae located at about 60 km apart. The area has the climate mildest in Hokkaido, belonging to the Pacific slope climatic province. The annual mean temperature lies between 7 and 8°C and the precipitation is minimum in winter. However the snowfall is so scanty that the maximum depth of snow scarcely exceeds 50 cm, resulting in freezing of soil down to about 50 cm below the surface.

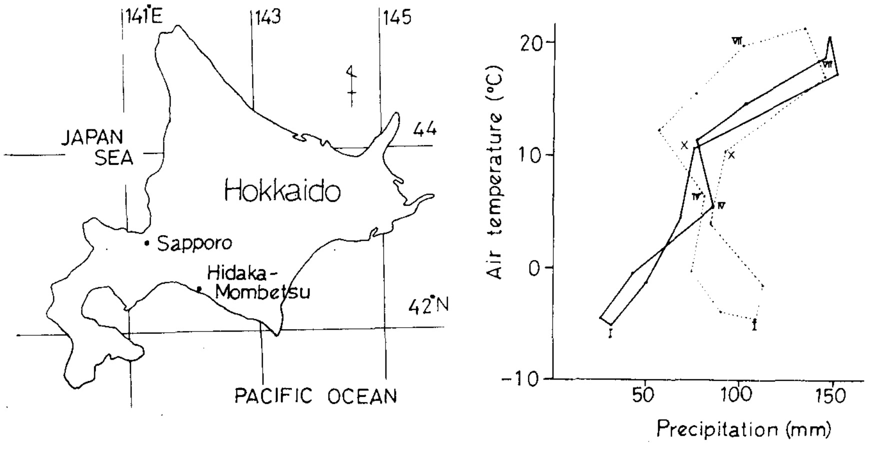

Fig. 1. Location and Climographs (from the data during 1956-'65) of Hidaka-Mombetsu (——) and Sapporo (····).

On the other hand, climate of Sapporo belonging to the Japan Sea slope climatic province, where soil animals have been studied by the authors as later cited for comparison, is characterized, though the annual mean temperature does not markedly differ (ca. 8°C), by the heavy snowfall, which protects soil from freezing. The climographs of these two regions are shown in Figure 1.

The area surveyed, shown in Figure 2, is located at about 1 km apart from the Pacific coast, and about 50 m above the sea level. Originally the whole area was covered by oak forests, but now by various vegetations as follows:

1) *Quercus* forest (*QF*): Still keeping the original state. Dominant trees: *Quercus dentata* Thunb. Under layer: *Lespedeza bicolor* Turcz., *Sasa apoiensis* Nakai, *Virurum opulus* var. *calvescens* Hara, *Rubus idaeus* var. *acculeatissimus* Regel et Tiling, *Aralia elata* Seemann, *Euonymus sievoldiaus* Blume and *Carex lanceolata* Boott.

2) *Larix* forest (*LF*): Reforestation of *Larix leptolepis* Gord. (introduced from Nagano Prefecture, Honshu) made in 1949 after cutting down of *Quercus* forest. Undergrowth is very poor only sparsely represented by *Erigeron annuus* Pers., *Carex lanceolata* Boott. and *Agrimonia pilosa* Ledeb.

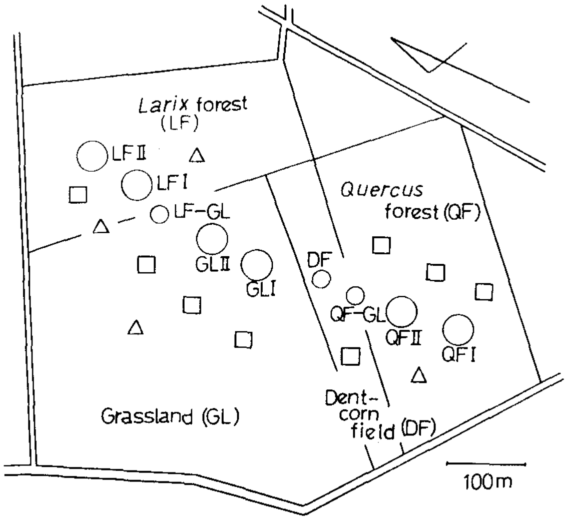

Fig. 2. Map of the area surveyed and the sampling plots.
(○ : mesofauna, □ : macrofauna, △ : ant)

3) Grassland (*GL*): Original *Quercus* forest was replaced by corn and wheat fields in 1942, and again by a meadow in 1956. At the present, this grassland is mainly consisted of *Dactylis glomerata* L. with abundant mixture of *Phleum pratense* L., *Trifolium pratense* L., *T. repens* L., *Medicago sativa* L., *Miscanthus sinensis* Anderss, *Taraxacum officinale* Weber, *Pantago asiatica* L., *Adenocaulon himalaicum* Edgew., *Poa pratensis* L. and *Agrostis alba* L.

Soil profiles are not particularly complicated in all habitats studied (Fig. 3). A_0 layers are thin, in which litter layer is a little thicker in *LF* than in the other vegetations. A_1 and A_2 layers are clearly separable for each other both in *QF* and *LF*, but not in *GL*. B layers are thin, especially in *GL*, underlain by the volcanic ashes layer (VA) of at least more than 20 cm thick. In upper layers (A_1, A_2) ash particles are more or less mixing with soil particles distinctly in *GL*, moderately in *LF*, while little in *QF*, reflecting the difference in the land use among three vegetations. pH value of soil in each habitat was measured as follows:

	QF		*LF*		*GL*		*DF*
A_0	6.25	7.05	6.30	5.91	6.32	6.42	6.57
A_1	6.31	6.80	6.31	6.20	6.31	6.57	6.45
B	6.51	6.90	6.47	6.29	6.70	6.70	6.51

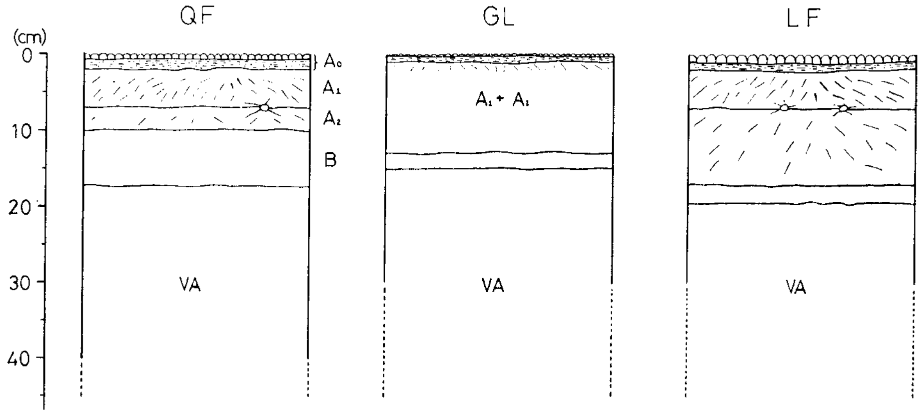

Fig. 3. Soil profiles in various habitats.

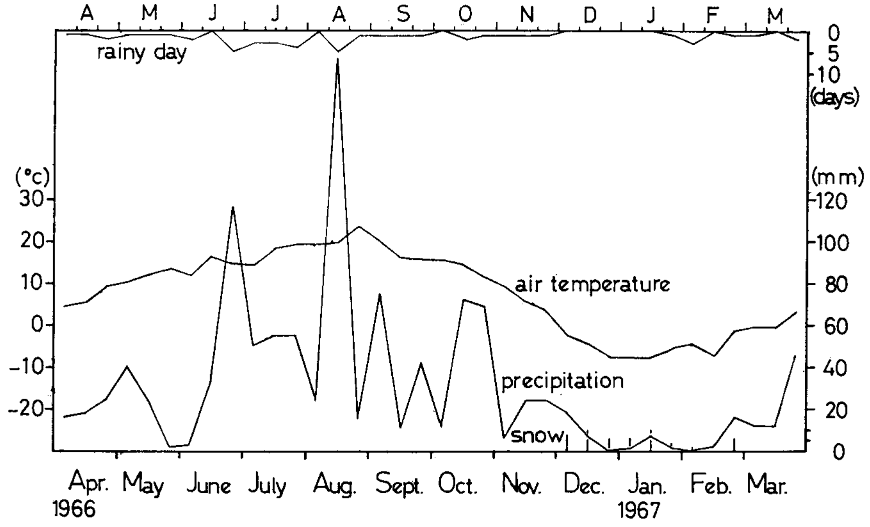

Fig. 4. Climatic conditions of Hidaka-Mombetsu during the period surveyed.

The climatic conditions of the area during the period surveyed is given in Fig. 4 cited from the data by Hidaka-Mombetsu Regional Meteological Station. The maximum mean temperature was about 20°C between early and late August, and the minimum was about -8°C between late December and middle January. The precipitation shows a peak in middle August. Snowfall was seen from early December to late February. In winter soil was frozen down to about 50 cm.

Results and Discussion

As mentioned previously, the sampling of each animal group was made rather independently, both in plots and procedures. Therefore, methods and results are described below for each group separately, with corresponding discussions.

1. *Macrofauna in general* (by Y. Nakamura)

According to Ghilarov (1965), the studies of large invertebrates (earthworms, myriapods, larvae of holometabolous insects, etc.) are quite promising to solve various pedological problems, especially in soil diagnostics and geography. Recently biocoenological studies on soil macrofaunas have been undertaken by many investigations, mainly in Europe and North America (for instance, Huhta, *et al.*, 1967 in coniferous forest soil and Cragg, 1961 in moorland). In Japan, in particular in Hokkaido, a few preliminary surveys were recently carried out (Hokkaido Development Bureau, 1965, '66; Nakamura, 1968b), but the amount of work so far made is still far from satisfaction.

At this lack of information and the increased importance of pedozoology in connection to the reasonable land use, the result obtained in Hidaka-Mombetsu would be, however still preliminary, of some interests for further promotion of similar but more precise work in Hokkaido.

1.1. Methods

Sampling was carried out bimonthly in May, July and September, each choosing the day after one day entirely of fine weather. The stations of 10×10 m. sq. were chosen at random, three in *GL* and *QF*, and one in *DF* and *LF* (Fig. 2). From each of these stations, six sampling plots, each of 25×25 cm. sq. were chosen every time, avoiding ant nests and keeping the distance between plots at least 1 m for each other. At each plot, five vertical layers were distinguished as follows: litter, 0–5, 5–10, 10–15 and 15–20 cm below the surface. From each layer animals larger than 2 mm, excluding Enchytraeidae, Acarina and Collembolans, were taken by hand sorting with pincette (*cf.* Nakamura, 1967).

To know the distribution of animals in the layers deeper than 20 cm, soil boring was once performed in *QF* down to 50 cm in September, with the following result:

Layer (cm)	Litter	0∼5	5∼10	10∼15	15∼20	20∼25	25∼30	30∼35	35∼40	40∼45	45∼50
Individual number per m. sq.	29	15	4	2	—	1	2	1	1	—	—
% ratio	52.7	27.2	7.2	3.6	—	1.8	3.6	1.8	1.8	—	—

As shown above about 90% of the whole sample was collected from litter and top soil layers. Therefore, the sampling down to 20 cm can be regarded reasonable if not perfect.

The animals collected from layers below 20 cm were Chilopoda and larvae of scarabaeid beetles.

1.2. *Faunal makeup*

A list of animal obtained, involving three phyla and eight orders, from four habitats is given in Table 1, together with their individual number per m. sq. at each sampling. In general, the faunal makeup does not markedly differ from the results obtained in and near Kyoto, South Japan (Watanabe and Shidei, 1963; Watanabe, 1968), or in Sapporo, Hokkaido (Nakamura, 1968b). However, it is worth to mention that some groups, such as Isopoda, Cheriferidae and Symphyla were absent in the present sample, nevertheless they were discovered in and near Sapporo (Nakamura, 1968b).

The groups sampled from all four habitats are six in number, Oligochaeta, Diplopoda, Scarabaeidae, Elateridae, Dipteran larvae and Coleopteran larvae, most of which are regarded to be macro-decomposers. Table 1 shows a clear difference among habitats, richer in forests, *QF* and *LF*, than in *GL* and *DF*. The highest number of animal groups was taken at *QF*, reaching 18, whereas the lowest, only 7, in *DF*, where no animal was sampled in September. Such difference was already recorded by Bornebusch (1930) and Birch and Clark (1953) in beetles and Morikawa, *et al.* (1959) in earthworms, ants and beetles. The report by Hokkaido

Table 1. Macrofauna in various habitats

	QF			
Animal groups	May	July	Sept.	May
Oligochaeta	33.8	20.4	23.1	5.3
Hirudinea Gnathobdellae	0.9	—	—	—
Mollusca Gastropoda	—	—	6.2	—
Chrustacea Amphipoda	0.9	7.1	4.4	—
Arachnoidea Aranea	1.8	3.5	7.1	—
Diplopoda	18.6	2.6	13.3	5.3
Chilopoda	—	3.5	0.9	—
Hemiptera				
Delphacidae	0.9	—	—	—
Pentatomidae	—	0.9	—	—
Coleoptera Scarabaeidae	6.2	5.3	—	—
Carabidae	1.8	1.8	0.9	2.6
Staphylinidae	0.9	—	1.8	—
Elateridae	1.8	1.8	0.9	—
Curculionidae	—	—	—	—
Lucanidae	0.9	—	—	—
Hymenoptera Tenthredinidae	0.9	0.9	—	—
Formicidae	6.2	—	4.4	16.0
Lepidopterous pupae	5.3	—	—	5.3
Dipteran larvae	11.5	2.6	—	7.8
Total	92.4	50.4	63.0	42.3

Development Bureau (1965) also mentions the rich macrofauna in forests than in open fields. The coniferous forest, *LF*, is poorer in number of groups obtained, in accordance to the results by Morikawa *et al.* (1959) and Kikuzawa *et al.* (1965), who reported poor and monotonous soil faunas in coniferous stands. The poverty in *DF* is not difficult to explain, when poor floral composition, lack of sufficient litter as principal food stuff for soil animals, and frequent artificial soil agitations characteristic to this habitat are considered together. In conclusion, the result cleary shows a parallelism between floral and faunal richness.

1.3. Population density and Vertical distribution

The relative abundance of soil macrofauna among habitats found in the faunal makeup is also recognized as to the population density, which shows the descending order of *QF*>*LF*>*GL*>*DF*. The discussion given at the end of *1.2.*, concerning the influence of poor plant cover, frequent soil agitation or poverty in dent corn field (*DF*) are applied to this case, too.

Although no sampling was made in winter, the population density shows a seasonal flucutation, which varies, to some degree according to habitat, in spring higher in *QF*, while in autumn in *LF* and *GL*. In *DF* no animal was collected in autumn (*cf.* also Fig. 5).

As shown in Fig. 5, in all four habitats, Oligochaeta occupies an outstanding

(Numerals show individual number per m. sq.)

LF		*GL*			*DF*		
July	Sept.	May	July	Sept.	May	July	Sept.
37.3	48.0	2.6	39.3	37.3	16.0	8.0	—
—	2.6	—	—	—	—	—	—
—	2.6	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	1.3	1.3	—	—	—
2.6	7.8	—	1.3	1.3	—	2.6	—
7.8	7.8	—	—	2.6	—	—	—
—	—	—	3.9	—	—	—	—
—	—	—	—	—	—	—	—
2.6	5.3	1.3	9.3	12.0	2.6	2.6	—
—	—	—	—	—	2.6	5.3	—
2.6	—	—	—	1.3	—	—	—
2.6	2.6	4.0	2.6	3.9	2.6	2.6	—
—	—	—	1.3	—	—	—	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
7.8	—	—	—	3.9	—	—	—
2.6	—	1.3	1.3	—	—	2.6	—
2.6	—	—	1.3	—	—	2.6	—
68.5	76.7	9.2	61.6	62.3	23.8	26.3	—

dominance, especially in *GL* reaching nearly 62% of the total individual number. On the other hand, the subdominant groups vary from habitat to habitat, namely represented by Diplopoda in *QF*, Formicidae in *LF*, Carabidae in *DF* and Scarabaeidae in *GL*.

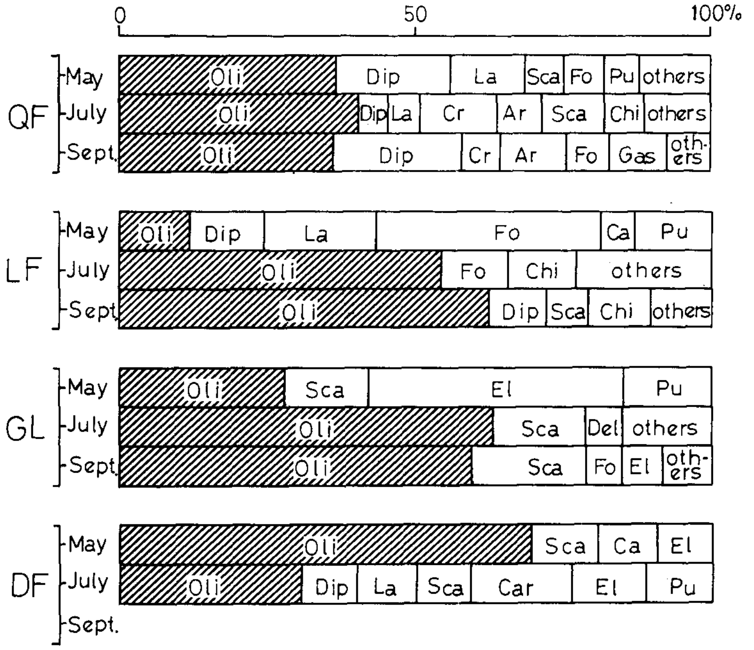

Fig. 5. Relative abundance of individual number of macrofaunal animals in various habitats. Oli: Oligochaeta, Dip: Diptera, La: Dipteran larvae, Sca: Scarabaeidae, Fo: Formicidae, Pu: Lepidopterous pupa Cr: Crustacea Ar: Arachnoidea Ch: Chilopoda Gas: Gastropoda Ca: Carabidae El: Elateridae Del: Delphacidae

Studying the seasonal flucutation of the population trend, Watanabe and Shidei (1963) reported the high density in spring and fall while the poverty in winter or summer. They also mentioned that higher precipitation correlated to higher population density. In the present survey, only the trend in *QF* accorded to the results mentioned above, showing the maximum density in spring probably in part reflecting the climatic difference. It is still premature to discuss the relation between population trend and climatic conditions.

The maximum obtained was observed in May in *QF*, reaching 92.4 per m. sq., though lower than those reported by the other authors, for instance 222 per m. sq. (Mixed broad-leaved forest in Kyoto, Kikuzawa *et al.*, 1965) or 289 per m. sq. (mixed forest in Sapporo, Nakamura, 1968b).

The vertical distribution given in Fig. 6, shows the concentration of macrofauna into uppermost layers, as shown repeatedly by many authors (for instance, Murphy, 1955; Watanabe, 1968). Most animals were collected from the first layer, that is, litter or 0–5 cm, but in July and September in *LF* and in May in *DF*, the density, including that of earthworms, was highest at the second layer.

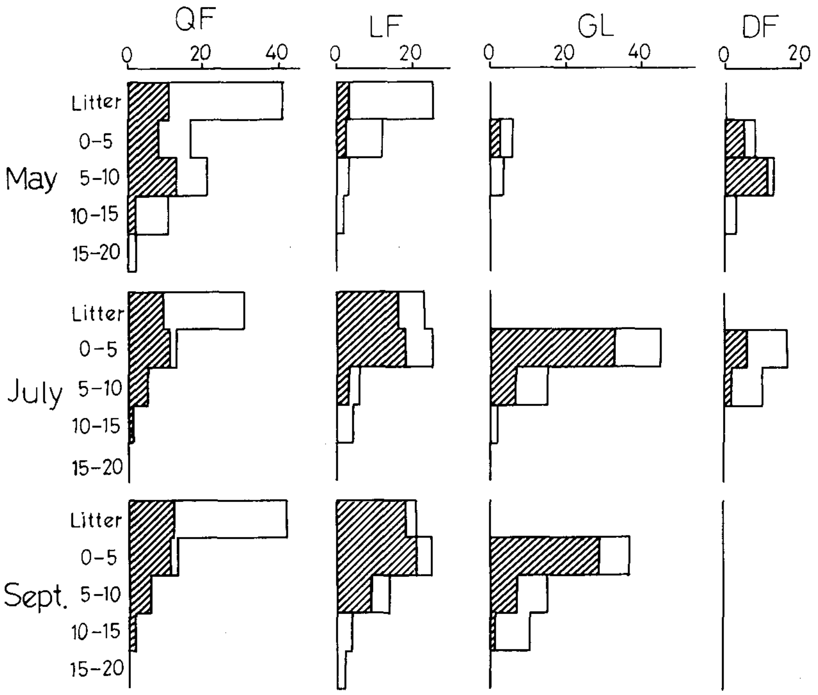

Fig. 6. Vertical distribution of macrofaunal animals (individual number per m. sq.). (Oblique line: Oligochaeta)

Dowdy (1944) obtained a distinct seasonal trend in vertical distribution, mainly depending on soil temperature. In the present survey, however, no marked seasonal trend was confirmed.

2. *Earthworms* (by Y. Nakamura)

Among large soil animals, earthworms occupy the outstanding position by its world-wide distribution, overwhelming abundance and important role in the process of soil formation (Stephenson, 1930; Ghilarov, 1965; Yamaguchi, 1966). In the present survey, too, they are the most dominant group, so that are treated here separately.

2.1. *Faunal makeup*

In total seven speceis of terrestrial earthworms belonging to four genera and two families were obtained in the cource of the present survey, all already recorded from Hokkaido (Yamaguchi, 1966; Nakamura, 1967). The faunal makeup in four habitats is similar for each other, and the species number is in the following: *QF*=*LF*>*GL*>*DF*, as listed in Table 2, together with the individual number obtained, including mature and immature individuals.

Table 2. Earthworms obtained in various habitats

	QF			
Species	May	July	Sept.	May
Allolobophora japonica Michaelsen	25.8	6.2	5.5	5.3
Dendrobaena octaedra Saviney	—	—	—	—
Bimastus tenuis Eisen	—	—	2.6	—
Pheretima yunoshimensis Hatai	—	—	—	—
Pheretima hilgendorfi (Michaelsen)	—	—	2.6	—
Pheretima sp.1	8.0	8.0	9.8	—
Pheretima sp.2	—	6.2	2.6	—
Total	33.8	20.4	23.1	5.3

The dominant species is appearently *Allolobophora japonica* in *QF* and *DF*, *Dendrobaena octaedra* in *LF* and *GL*. *A. japonica*, endemic to Japan (Stephenson, 1930), is common in all habitats. On the other hand, it is noteworthy that *A. caliginosa* (Savigney), another species common throughout Japan, was not found in the present survey, nevertheless this species is common everywhere in Hokkaido.

The percentage ratio of the individual number of the family Lumbricidae or Megascolecidae to the total number, given in Figure 7, shows that the former occupied the majority in open lands such as *GL* and *DF*. In woodlands, *QF* and *LF*, however, the two families were collected nearly in the same ratio.

2.2. *Population density*

The variation of population density was observed among four habitats. No animal was obtained in September in *DF* and the maximum, 48.0 per m. sq. in September in *LF* (Table 2), though lower than those by Hokkaido Development Bureau (1966) and Nakamura (1968a) both in Sapporo, probably caused by the freezing of soil to deeper layers in winter.

Density of earthworms varies in relation to soil types and history of fields (Evans and Guild, 1947; Nakamura, 1967), generally much lower in old arable lands than in grasslands (Satchell, 1958). In the present survey the total individual number was as follows: *LF*>*GL*>*QF*>*DF*. *GL* had few species but high population density, mainly by the occurrence of *D. octaedra* (*cf.* also Hokkaido Development Bureau, 1966; Nakamura, 1967).

Morton (1958, Scotland) and Evans and Guild (1947, England) reported the density high in winter and low in summer. The somewhat same trend was found in the present survey only in *QF*. On the other hand, Nakamura (1968a, Japan) reported the density was high in autumn and low in winter. This probably depends upon the different faunal makeup. *A. japonica*, dominant in the present survey is endemic to Japan, and *Pheretima* also abundant in the present survey is rather rare in European and North America.

(Numerals show individual number per m. sq.)

LF		*GL*			*DF*		
July	Sept.	May	July	Sept.	May	July	Sept.
13.4	—	—	5.3	—	13.4	—	—
2.6	32.0	2.6	31.4	37.3	2.6	8.0	—
—	—	—	1.3	—	—	—	—
—	8.0	—	—	—	—	—	—
—	—	—	—	—	—	—	—
15.7	8.0	—	1.3	—	—	—	—
5.6	—	—	—	—	—	—	—
37.3	48.0	2.6	39.3	37.3	16.0	8.0	—

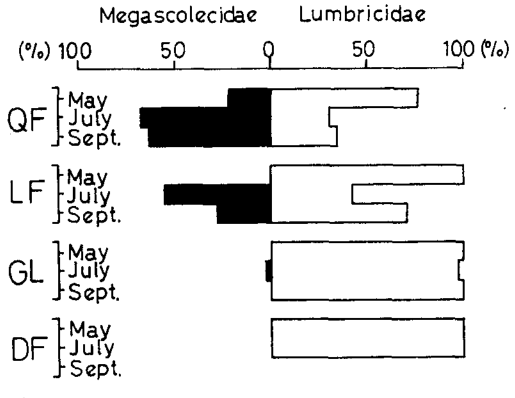

Fig. 7. Percentage ratio between two families of Oligochaeta.

Nakamura (1967) observed the seasonal trends of population density being different among grasslands of different soil types.

The climatic conditions are certainly important factors in population control (Morton, 1958; Murchie, 1958). It is still premature to draw any conclusions on the cases of seasonal flucutation from the result obtained in the present survey.

2.3. *Vertical distribution*

It is well known that earthworms are richest in upper soil layers, gradually decreasing in deeper layers, parallel to the diminution of organic matter. The rate of decrease differs among species (Guild, 1955), as noticed in the present survey, too. More earthworms were observed in the upper layer, litter and 0–5 cm, especially in *GL*, but in the woodland, the more individuals were collected rather from the second layer (Fig. 6). No earthworm was collected from the deepest layer, 15–20 cm.

Grant (1956) and Gerard (1967) reported the vertical distribution of earthworms in the soil changes up and down in response to temperature or moisture gradiens. In England, Stockli (1928) described that, during the hottest summer months, earthworms may escape to deeper soil layers or go into diapause in an earth capusule lined with mucous secretion. In Korea, Kobayashi (1938) found *Pheretima hupeiensis* (Michaelsen) in the upper soil layers from June through September, but to the depth of 80 cm during winter months. In Sapporo, Nakamura (1968a) described that during the period of snowfall, more earthworms were found in 10–20 cm layer. However, in the present survey no regular variation in vertical distribution was noticed.

3. *Ants* (by K. Yamauchi)

Ants are one of the commonest groups among soil animals, obtained abundantly by the standard extracting procedure. But their mode of life differs so remarkably from those of other solitary animals, therefore some additional procedures are required to know their distribution position among soil animals more precisely.

3.1. *Methods*

The collection of as many as possible species inhabiting the area studied was carried out as in usual. Quantitative survey of colonies was made as follows: All colonies within the plot of 2 m × 5 m were searched by digging the ground down to ca. 5 cm deep at distance of ca. 20 cm, noting conditions of their nest sites. Five such plots were studied in *LF-GL* and ten in each of the other habitats (Fig. 2). Nest sites were classified using the system by Hayashida (1960): m; undersides of accumulated litters and other debris, n; interspaces of rootsystems of living trees, r; interspaces of rootsystems of grasses and herbs, d; decayed stumps or fallen logs. Besides these procedures, the specimens sampled by Tullgren funnels (by H.T.) were also studied.

3.2. *Faunal makeup*

As shown in Table 3, 18 species or forms belonging to 10 genera were collected from the area studied. Among them, *Myrmica ruginodis, Pheidole fervida, Lasius niger, L. flavus* and *Paratrechina flavipes* are obviously dominant species in the area. The total number of colonies of these five species occupies 83.4% of all colonies discovered. *Ponera japonica* may also be a dominant species from the data by H.T. as mentioned later. In each habitat, the number of species obtained were as follows: 14 in *QF*; 10 in *LF*; 6 in *LF-GL*; 6 in *GL*. Relatively dominant species in each habitat are as follows:

QF: *Paratrechina flavipes* (30.0%), *Myrmica ruginodis* (26.0%), *Pheidole fervida* (18.0%).
LF: *Myrmica ruginodis* (42.3%), *Pheidole fervida* (17.3%), *Lasius flavus* (15.4%).
LF-GL: *Lasius niger* (36.7%), *L. flavus* (26.6%), *Pheidole fervida* (20.0%).
GL: *Myrmica lobicornis* var. *jessensis* (61.5%), *Lasius niger* (30.8%).

Table 3. List of ants discovered and number of nests per 100 sq. m. in various habitats (Forms obtained only by qualitative sampling are shown by symbol. Actual number is doubled in *LF-GL*)

Forms discovered	Habitat				Total
	LF	*LF-GF*	*GL*	*QF*	
Ponerinae					
Ponera japonica Wheeler	—	—	—	○	
Myrmicinae					
Myrmica ruginodis Nylander	22	2	○	13	37
M. lobicornis var. *jessensis* Forel	1	—	8	—	9
Aphaenogaster smythiensi var. *japonicus* Forel	○	—	1	4	5
Pheidole fervida Smith	9	12	—	9	30
Stenamma nipponense Yasumatsu et Murakami	—	—	—	○	
Leptothorax sp.	—	—	—	○	
Formicinae					
Paratrechina flavipes (F.Smith)	5	4	—	15	24
Lasius umbratus (Nylander)	3	—	—	3	6
L. flavus (Fabricius)	8	16	—	—	24
L. niger (Linnaeus)*	3	22	4	2	31
L. fuliginosus (Latreille)	○	—	—	1	1
L. crispus Wilson	—	—	—	○	
L. sp.	—	—	—	2	2
Camponotus obscuripes Mayr	—	—	—	○	
Formica japonica Motschulsky	—	—	—	1	1
F· truncorum var. *yessensis* Forel	1	4	○	—	5
F. execta fukaii Wheeler	—	—	○	—	
Total	52	60	13	50	175

* Recorded as *L. alienus* in Yamauchi (1968), but actually *L. niger* according to the author's recent study.

As to the faunal makeup in various habitats, the following points are particularly pointed out:

1) The faunal makeup was quite different from each other between forests (*QF* and *LF*) and grassland (*GL*). In *GL*, only six species were collected and in only three of which the nests were confirmed. In *LF* and *QF*, respectively, 10 and 14 species were collected and 8 and 9 ones were confirmed by nests. The dominant

species in *GL*, *Myrmica lobicornis* var. *jessensis* and *Lasius niger*, were rather rare in the forests.

2) The ant fauna in *LF-GL* is intermediate between two habitats, *LF* and *GL*. The dominant species in *LF-GL* are common to those in *LF* or *GL*.

3) The ant faunas are most similar for each other between *LF* and *QF* with the following differences: a) Fauna is richer in *QF* than in *LF*; b) *Lasius flavus* is relatively dominant in *LF*, but not discovered in *QF*.

These relations are confirmed by Renkonen's index (*cf.* Aoki, 1962), as shown in Table 4. The faunal makeup in each habitat is more or less similar to that in Sapporo (Hayashida, 1960; Yamauchi, 1968), except for *Lasius flavus* which inhabits coniferous forests in the area surveyed but not in Sapporo. All vegetations in the area, excluding *QF*, are secondarily formed after removal of the original oak forests. Therefore, the difference in faunal makeup is attributed to the allogenic succession in ant fauna developed at least within 20 years, in parallel with the modification of enviroment.

Table 4. Degree of similarity among various habitats in faunal makeup. Each degree is given by Renkonen's index

LF	*QF*	*LE-GL*	*GL*	
	62.7	50.4	7.7	*LF*
		32.0	11.7	*QF*
			30.8	*LF-GL*
				GL

3.3. *Nest density and nest site preference*

As shown in Table 3, the number of nests per 100 sq. m was 60 (*LF-GL*), 52 (*LF*), 50 (*QF*) and 13 (*GL*) respectively. The extreme poverty in *GL* was probably caused by destruction of nests due to cattle grazing and agitation by the tractor.

These results were compared with those in Sapporo obtained by the same method (Yamauchi, 1968). In deciduous forests in Sapporo, the number of nests

Table 5. Number of soil blocks from which respective species was sampled during

	Habitat	*LF*			*LF-GL*		
	Number of individuals sampled	1	2~4	5~	1	2~4	5~
Species	*Ponera japonica*						
	Myrmica lobicornis var. *jessensis*						
	Aphaenogaster smythiensi var. *japonicus*						
	Stenamma nipponense						
	Paratrechina flavipes	2					
	Lasius flavus	5					

was 82.0 per 100 sq. m, while only 50 in the present area. A high density in Sapporo was mainly caused by the abundance of *Paratrechina flavipes* (33.2). In coniferous forests and forest margins, no remarkable difference between both areas was observed. The most remarkable difference was found in grasslands, namely 39.2 nests in Sapporo against 13 in the present area, caused by the extremely low density in the present area as mentioned above. The data of hypogaeic forms obtained by H.T. are shown in Table 5. Two species, *Ponera japonica* and *Stenamma nipponense*, were not obtained in the sampling procedure mentioned above but in samples extracted by Tullgren funnels. Especially the density of *Ponera japonica* was extremely high in *QF*, sorted from 18 out of 30 soil blocks sampled during May 12–September 18. The same result was also obtained in Sapporo (Yamauchi, 1968), suggesting that *Ponera japonica* is one of the most dominant hypogaeic species in Hokkaido at least in deciduous forests.

In winter no ant specimen was obtained by Tullgren extraction, suggesting the wintering in layers deeper than 15 cm. In Sapporo, at least *Lasius niger* and *L. flavus* are discovered from the top soil in winter. This difference indicates the escape of ants into deeper layers, affected by the freezing of soil in winter.

As shown in Table 6 the nest sites frequently used are m (ca. 50%) follwed by r and d (both about 20%). The general trend does not marked differ form that in Sapporo (Hayashida, 1960) but with the inversion of the relative importance between r and m.

4. *Mesofauna in general* (by H. Tamura)

In the previous work, some observations were made on the ecological distribution of Collembola in Sapporo (Tamura, 1967). Unfortunately, this work involved two defects. One is the use of Para-dichlorobenzol as stimulator, which caused the low efficiency in extraction. The other defect is the ignorance of animals other than Collembola. This was inevitable for the limited facility but made the analysis of the ecological position of Collembola within the whole soil mesofauna impossible. In the present survey, attempts were made to remove these defects so far as possible.

May-Sept. Number of total blocks 30 in *QF*, *LF*, *GL*, and 15 in *LF-GL*, *DF*, *QF-GL*

GL			*DF*			*QF-GL*			*QF*		
1	2~4	5~	1	2~4	5~	1	2~4	5~	1	2~4	5~
									7	6	5
2	4	1									
											1
									1		
									1	1	2

Table 6. Number of nests of each species found at various nest sites

Species	Nest site type				Total
	m	r	d	n	
Myrmica ruginodis	30	3	2	1	36
M. lobicornis var. *jessensis*	1	8			9
Aphaenogaster smythiensi var. *japonicus*	2	1	2		5
Pheidole fervida	8	1	15		24
Paratrechina flavipes	15	3	3	1	22
Lasius umbratus	1			5	6
L. flavus	6	8	1	1	16
L. niger	6	5	8	1	20
L. fuliginosus				1	1
L. sp.				2	2
Formica japonica	1				1
F. truncorum var. yessensis	3				3
Total	73	29	31	12	145

4.1. Methods

Sampling was made from May, 1966 to January, 1967 once per months on the day of fine weather. Actual sampling dates are as follows: May 12, 13; July 22, 23, 24; September 16, 17, 18; November 18, 19, 20; January 18, 19. The stations were settled two by two in each of three habitats, which are henceforth abbreviated as *QFI*, *QFII*, *GLI*, *GLII*, *LFI*, *LFII*, respectively (*cf.* Fig. 2).

QFI was covered with annual plants and sparsely with bush covers; *QFII* was densely covered with a mixture of bamboo grasses and annual plants. Both *GLI* and *GLII* were uniformly covered with dense pasturages, of which *GLII* was rather near to the boundary to *LF*. *LFI* had thick litter layer and no undergrowth while *LFII* was provided with thinner litter and sparse annual plants.

At each sampling, one plot of 10×10 m. sq. was randomly selected in each station, from which five samples were obtained one by one from the center and near each of four corners. The samples are consisted of soil blocks of 10×10 cm. sq. in surface, 5 cm deep in the corner samples and 15 cm deep in the central one. In order to observe the vertical distribution of animals, the latter was vertically subdivided into the following three layers: 0–5 cm (S_1), 5–10 cm (S_2), 10–15 cm (S_3). Further a test sample was taken from each plot at every sampling time for the purpose of determining the species occuring there. No sampling was taken from *QFII*, *GLII* and *LFII* in May for the failure of sampling schedule and in January for the difficulty in digging frozen soil deeply. Soil samples were put separately into polyethylene bags. Each sample was placed in a Tullgren funnel apparatus modified by the author (H.T.)[1] and animals were extracted through a sieve of 2×2 mm. sq. mesh into a stylole vial filled with 70% alcohol.

At the sampling in January, the ground was hardly frozen down to deeper layers. The ice clods of soil were dug up with a pickax, chipped with a hammer and divided with

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[1] Each funnel consists fundamentally of a bucket of which the bottom was removed, followed by a long conical cylinder made of a sheet of thick paper as the funnel. A 60-watt nicrome bulb was used as the stimulator. The paper funnel and the nichrome bulb seem to be effective both in absorption of water drops and exclusion of high illumination.

a saw to make the sample of 10×10×5 cc. Then frozen blocks were put in Tullgren funnels and the extraction was made as in other samples.

Possible sources of biases due to procedures

For the unbiased extraction of samples, the procedure adopted is not always immune from criticisms as mentioned below.

A) Limitation in sampling frequency: The periodical sampling of soil mesofauna is usually performed monthly or fortnightly to observe seasonal changes. The bimonthly sampling made in the present survey, which had been adopted by Milne (1962), was inevitable both from financial limit and time schedule, because the area surveyed was remote from the laboratory. It is believed, however, a preliminary estimation for seasonal trend was more or less established.

B) Mortality before extraction: Every time the samples were transported by a rucksack. The total weight of samples usually reached about 30 kg. It is possible that some portion of animals, especially those placed near the bottom of the rucksack, died before extaction due to the pressure. Unfortunately, there is no accurate measure upon the mortality caused by this defect. Judging from the mean number of animals extracted, however, it is assumed that the mortality was not so high as to invalidate the analysis.

C) Sample size insufficient to analyse vertical distribution: Only one tenth of periodical samples from each habitat was used for the analysis of vertical distribution. Therefore, the vertical distribution described later (*cf. 4.3., 5.3.*) might not always reflect the real distribution in every aspect.

In spite of these defects, it is inferred that the results obtained give an approximate estimation for the relative abundance of the mesofauna.

4.2. Faunal makeup

The mesofauna groups sampled cover seven Classes, obviously restricted to those being motile and passable through 2×2 mm. sq. meshes. The faunal makeup does not markedly differ from those by Watanabe and Shidei (1963) sampled in and near Kyoto, and by Morikawa *et al.* (1959) in Matsuyama and its vicinity, except for the absence of any crustaceans (Amphipoda and Isopoda) which are frequent in the two studies mentioned and not rare throughout Hokkaido (Hokkaido Development Bureau, 1965, '66). Table 7 shows the list of animal groups extracted together with their individual numbers in each sampling time. Apparently Collembola (42.3%) and Acarina (52.8%) occupy the majority, reaching 95.1% in combination. Among other groups, those relatively common are Archioligochaeta (1.67%), and Nematoda (1.48%), but their percentages are far less than in the result by direct sorting (Aoki *et al.*, 1968). Other extracting methods must be employed for them (Niijima *et al.*, 1968). Neoligochaeta (0.51%), Formicidae (0.25%) and Coleopteran larvae (0.14%) come to the third and the other groups form quantitatively only a fraction. Judging from the table, most animal groups show the peak in summer to autumn (July to September), decreasing in late autumn (November). The groups sampled from soil in midwinter (January) are only Acarina, Collembola and a limited number of Nematoda and Archioligochaeta. The coleopteran larvae and thysanopteran nymphs abruptly increase in later autumn, but were not extracted from in winter. Probably they pass the winter in the immovale state, eggs or pupae, in the soil.

Table 7. Mesofauna extracted with Tullgren funnel
(s: number of species, n: number of individuals)

Class, Order, Family	1966 May		July		Sept.		Nov.		1967 Jan.		Total	
	s	n	s	n	s	n	s	n	s	n	s	n
Nematoda	?	150	?	285	?	478	?	94	?	33	?	1,040
Oligochaeta												
Archioligochaeta	?	104	?	236	?	733	?	97	?	2	?	1,172
Neoligochaeta	?	35	?	71	?	182	?	75	—	—	?	363
Arachnida												
Pseudoscorpiones	—	—	2	13	2	2	2	3	—	—	3	18
Aranea	2	3	4	5	2	5	5	6	—	—	9	19
Acarina	?	5,374	?	7,885	?	12,182	?	10,235	?	1,295	?	36,971
Symphyla	—	—	1	3	1	1	—	—	—	—	1	4
Diplopoda	1	3	2	2	1	3	2	10	—	—	6	18
Chilopoda												
Geophilomorpha	1	5	1	15	1	5	1	6	—	—	1	13
Lithobiomorpha	1	2	2	7	1	1	1	1	—	—	3	11
Insecta												
Protura	2	8	2	6	1	3	1	4	—	—	1	21
Collembola	24	2,079	28	9,313	29	9,291	27	7,916	17	1,054	34	29,653
Psocoptera	—	—	2	14	2	3	2	3	—	—	2	20
Thysanoptera (nymph)	—	—	2	5	1	1	4	38	—	—	5	44
Hemiptera	1	1	3	4	2	2	—	—	—	—	3	7
Diptera (adult)	—	—	3	4	1	2	1	1	—	—	5	7
(larva)	3	9	5	13	5	17	4	10	—	—	8	49
Coleoptera												
Staphylinidae	3	5	3	4	5	15	9	15	—	—	13	39
Pselaphidae	—	—	—	—	—	—	1	1	—	—	1	1
Scarabaeidae	—	—	—	—	—	—	1	1	—	—	1	1
Carabidae	—	—	—	—	—	—	1	1	—	—	1	1
Coleoptera (larva)	2	5	4	27	7	11	10	61	—	—	13	104
Hymenoptera												
Mutillidae	—	—	1	1	—	—	1	1	—	—	2	2
Formicidae	1	28	4	62	5	79	2	9	—	—	6	178
Unidentified larvae	1	1	3	3	1	4	—	—	—	—	3	8
Total number of individuals	44 + a	7,812	71 + b	17,978	67 + c	23,030	75 + d	18,588	17 + e	2,384	123 + f	69,945

In accordance with most other studies, Acarina and Collembola are the most important constituents, which are dominant throughout the year, obtained even from frozen soils. Figure 8 shows the seasonal trend of relative abundance among Collembola, Acarina and the other animals combined in S_1-layer of each habitat, together with results of some occasional samplings (*DF*, *QF-GL*, *GL-LF*). In *QF*, the part occupied by Acarina is large, showing the distinct minimum in summer (July) and the maximum in winter (January), just contrary to the seasonal trend in Collembola. The other groups occupy a fraction more or less fixed in percentage except for decrease in late autumn to winter. In *GL*, Acarina is overwhelmingly abundant throughout the year. The relative ratio of Acarina and Collembola throughout the year is similar to that in *QF*, but the fluctuation range is far smaller. The other groups show the peak in autumn, mainly due to the increasing populations of Nematoda and Oligochaeta (*cf.* Table 7). In *LF*, Collembola is the top group against the other animals including Acarina. The Collembolan populations grow larger in summer and gradually diminish towards late autum as in *QF* and *GL*, though they are remarkably abundant in the forzen soil in mid-winter. This result seems to be very singular when compared with results in other habitats concerned. Other animals except for Acarina gradually diminish their percentage from spring to winter like as in the case of *QF*.

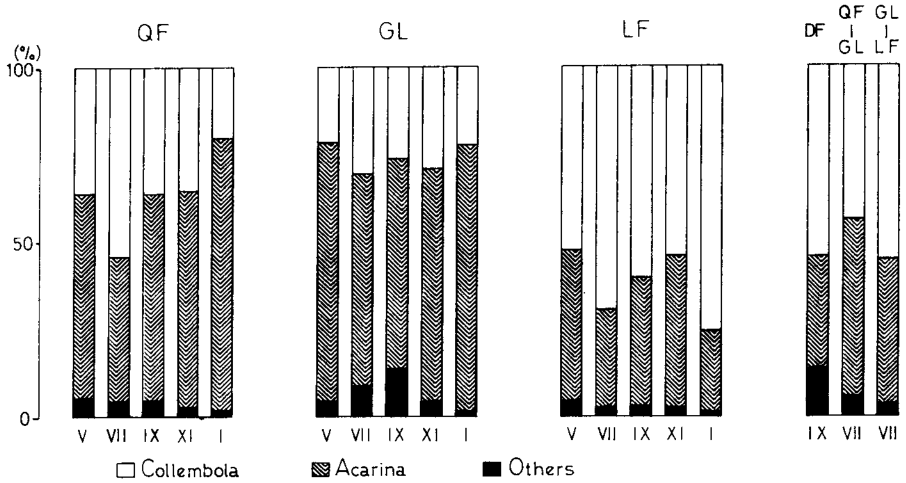

Fig. 8. Relative abundance of three major mesofauna groups and its seasonal change in each habitat with the rsults of occasional samplings (at righthand).

In addition to the periodical sampling, some extraordinary samplings were made from 1) Boundary between *QF* and *GL* (*QF-GL*), 2) Boundary between *GL* and *LF* (*GL-LF*) both in November and 3) A dent-corn field (*DF*) standing closely nearby in September (*cf.* Fig. 2), in all cases using the procedure as in regular sampling. In *DF*, the groups other than Collembola and Acarina are relatively abundant, just like as in *GL* in September, and the percentage of Collembola is larger than that of Acarina as in *LF* in the same season. At that time, the ground surface of *DF* received little insolation by densely overlapping leaves; further the litter is almost absent on the ground. These conditions coincide well with those in *LF* and *GL*. The relative abundance of animals from *QF-GL* in July is just intermediate between *QF* and *GL* at that time, especially in the relative abundance of Acarina and other groups. Same intermediate condition is confirmed in *GL-LF*, too. These tendencies show the strong influence of the vegetation upon mesofauna (Aoki, 1961), indicating the gradual change of soil fauna as a whole in relation to the modification of vegetation.

As already shown in Table 8, Collembola and Acarina (Co+Ac) occupy the most part of mesofauna in all habitats studied, with a slight variation among habitats. In order to clarify this variation of the percentage of Co+Ac to total animal sampled was calculated in each unit sample and frequency distribution was plotted in Figure 9, each habitat separately. The figure clearly shows the difference of *GL* aginst *QF* and *LF*. While in *GL* the frequency distribution disperses

Table 8. Comparison of dominant genera of Collembola in Hidaka-Mombetsu, in and near Sapporo

Locality (Date)	Relative abundance of genera given in descending order
Hidaka-Mombetsu (May,1966-Jan.,'67)	*Onychiurus> Xenyllodes> Folsomia> Tullbegria> Hypogastrura> Isotoma> Isotomiella> Tomocerus>····*
Sapporo (May-Sept.,1965)	*Folsomia> Isotoma> Onychiurus> Isotomiella> Tullbergia>Tomocers-Entomobrya> Hypogastrura>····*
Nopporo (June 3,1966)	*Folsomia>Onychiurus> Isotoma> Isotomiella> Tullbergia> Hypogastrura <Tomocerus>····*
Ishikari (June 6,1967)	*Folsomia> Onychiurus> Hypogastrura> Tullbergia> Isotomiella> Isotoma> Isotomodes>····*

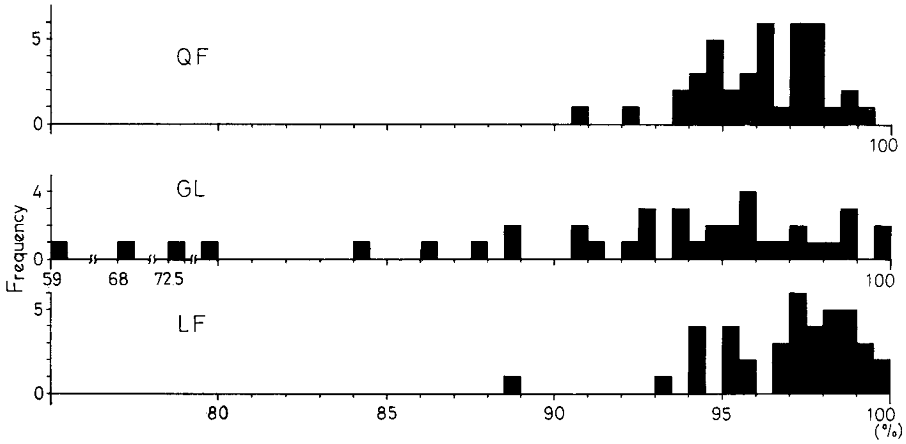

Fig. 9. Frequency distribution of percentage ratio of (Co+Ac) to total animals in each unit sample.

widely, it is more concentrated to the righthand in *QF* and *LF*, falling mostly with 90–100%. Between *QF* and *LF*, the distribution is more biased toward the right in *LF*. The annual mean is 96. 8 and 97.4%, and the bimonthly mean range 94.5–98.5% and 95.5–98.7%, respectively, gradually increasing from spring to winter in both habitats. In *GL* the mean range is 86.2 to 98.5% and the annual mean 91.3%. Consequently, Co+Ac percentage seems to be more or less characteristic to habitat. More important is the ratio of Collembola to Acarina (Co/Ac ratio) reflecting ecological characteristics of habitats (Paclt, 1956). On the basis of the data obtained in Thailand, Imadaté and Kira (1964) noted the difference of this ratio among vegetations. From the survey made in the vicinity of Kyoto, Kikuzawa *et al.* (1965) pointed out that Collembola is in general more abundant in coniferous forests, while Acarina more in broad-leaf forests. Watanabe and Saichuae (1967) noted the higher ratio of Acarina in Thailand than in Japan. In the present study, the Co/Ac ratio was analysed from all samples collected from all three habitats throughout the year, as given in Figure 10 as the frequency distribution. The ratios higher than 1 mean the dominance of Collebomla over Acarina in individual number. In *QF*, more than 70% of Co/Ac plots fall in the range between 1 and 1/6; all bimonthly mean ratios except for January also belong to this range, with annual mean of 63/100. In *GL*, 90% of the plots fall in the range of 1 to 1/11, of which over 70% are within 1 to 1/5; the mean ratios range from 1/2 to 1/4, therefore the variation by sampling time are far smaller than that among samples, keeping relatively stable Co/Ac ratios, with anunal mean of 39/100. In *LF* a little more than 60% of the plots are within 1 to 11, of which 84% between 1 and 3.5; all mean ratios at each time are within

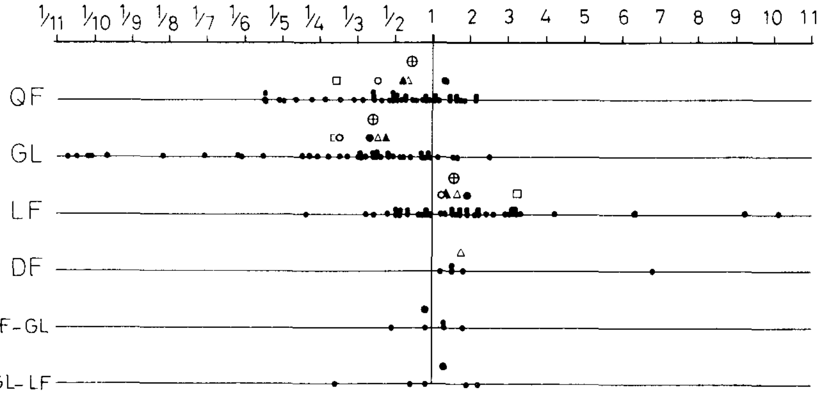

Fig. 10. Distribution of Co/Ac ratio in each sample showing result in each habitat and occasional samplings separately. Mean ratios are expressed by white circle (May), black circle (July), white triangle (September), black triangle (November), white square (January), circle with cross (annual).

1 to 3.5, with the annual mean of 158/100. Consequently Collembola is more dominant than Acarina in the coniferous forest, and *vice versa* in the broad-leaved forest, in accordance with the studies mentioned above. In the grassland, *GL*, the ratio of Acarina is distinctly larger than in *QF*. In spite of the wide variation, both by samples and seasons in all habitats, the Co/Ac ratio is ordered as follows: *LF*>1>*QF*>*GL*. In the dent-corn field sampled in September, the mean Co/Ac ratio based upon five samples is 174/100 namely, with a slight dominance of Collembola over Acarina, as in *LF* in September. In *QF–GL* in July, the mean ratio of five samples is 86/100, with a slight dominance of Acarina, showing intermediate between *QF* and *GL* in the same season. These results show the importance of Co/Ac ratio in pedozoology, especially in analysing the relation between vegetation type and faunal makeup, in accordance with the other studies made in other localities (Paclt, 1956; Imadaté and Kira, 1964; Watanabe and Saichuae, 1967; Kikuzawa *et al.*, 1965).

4.3. Vertical distribution

It is well known that various groups of soil mesofauna make vertical migration according to the seasonal change of environmental factors, temperature, water content, *etc.* But the difference in such migration among various groups has been so far insufficiently studied. In the present survey, the seasonal migration was compared among three groups, Collembola, Acarina and other groups in each habitat, using the subsamples taken from the center of each sampling plot (*cf. 4.1.*).

As shown in Figures 11–13, above, the downward decrease in vertical distribution becomes steeper from May to July, showing a logarithmic linearity. Thereafter the gradient becomes less steep in November and especially very distinct in January. The trend mentioned indicates the concentration of mesofauna in upper layers in summer, and the gradual penetration into deeper layers in autumn and winter, in parallel with the decrease of soil temperature. A remarkable exception to this rule is shown by the gradient in May in *LF*, which is nearly as steep as in July. Although the crucial explanation is impossible, it is mentioned that in *LF* the litter mat was distinctly thicker, consequently the frozen soil layer was relatively thinner than in the other habitats. Probably these conditions accelerate the liberation of animals from freezing earlier than in other habitats, resulting in the vertical distribution seen in Figure 11 in spring. On the other hand, the gradient in *GL* is less steeper than in the other habitats (Fig. 12). This accords to the results by Morikawa *et al.* (1959), who noted that in bare areas such as grasslands, crop-fields and orchard, the mesofuna did not always show the large difference in population density between upper and lower soils. Watanabe and Shidei (1963) described that the seasonal flucutation of vertical distribution of mesofauna was practically absent in Kyoto because upper and lower soil layers exchanged for each other approximately same proportion of biomasses, nevertheless each layer had in itself a clear seasonal trend. Judging from their figure (Fig. 4, p. 240), however, a slight seasonal trend seems to occur as follows: In warm season (June to October) the ratio of Collembola to the whole mesofauna gradually drops while that of Acarina increases in accordance with the soil depth. In cool season (February to April) an opposite relation is traced, especially in a fir stand.

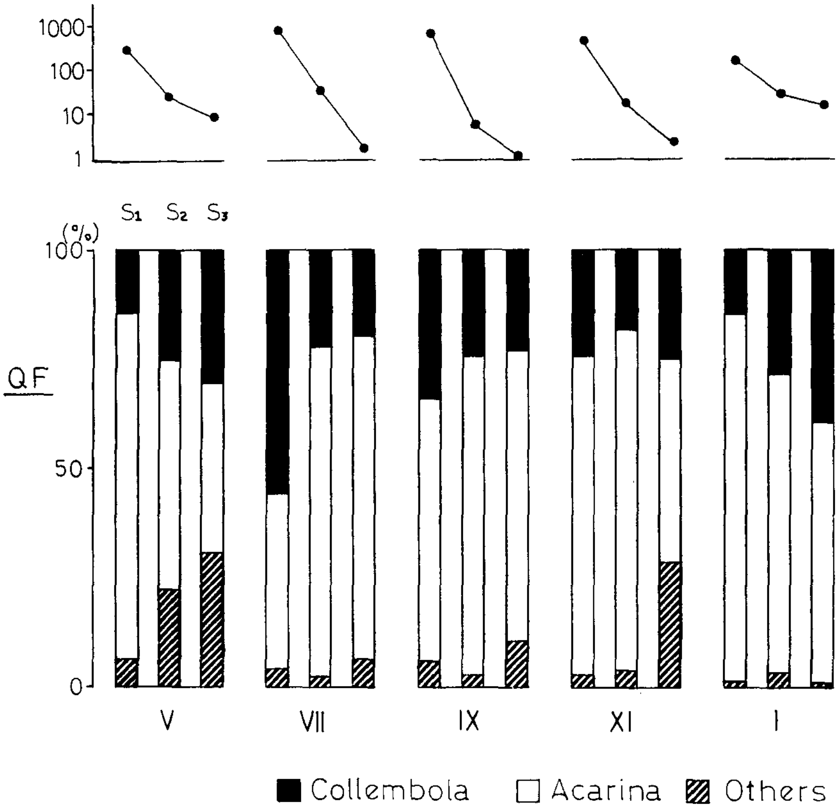

Fig. 11. Vertical distribution of mesofaunal groups in *Quercus* forest (*QF*). Above: seasonal total individual number, with expression using n+1 as the base in three soil layers (from top, S_1, S_2, S_3, *cf.* Fig. 3).

The seasonal trend was recognized more emphatically in the present survey as already mentioned. Moreover, the percentage ratios of Collembola, Acarina and other groups also varied according to season, (*cf.* Figs. 11–13, below). In *QF* in summer (July) Collembola increases strikingly in S_1, gradually decreasing in lower layers, while Acarina behaves oppositely. In cool season (September to November) the collembolan ratio is more or less similar among three layers. In frozen soil in winter the collembolan ratio becomes small in S_1, gradually increasing in lower layers, and Acarina behaves *vice versa*. The relative increase of the other animals in May may be attributed to the outburst of free-living forms such as earthworms, ants, dipterans, all passing winter in immobile states. The relative increase of these groups in S_3 in November is probably caused by Thysanoptera and Coleoptera which penetrated in deeper layers in order to hibernate or to lay eggs. In *GL* (Fig. 12), the collembolan ratios in different layers does not markedly deviate each other in July, September and November, but increase remarkably in S_2 in frozen soil in January. Collembola is also abundant in S_3 in May for unknown reason. In *LF* (Fig. 13) in July Collembola shows a marked concentration in top soil, while Acarina monopolized in S_3. Their proportions among layers are approximately simialr in September thereafter, Collembola relatively increases in deeper layers in November. Nevertheless they again concentrate in S_1-layer in January. Probably the same state is maintained throughout May and July, for unknown reason.

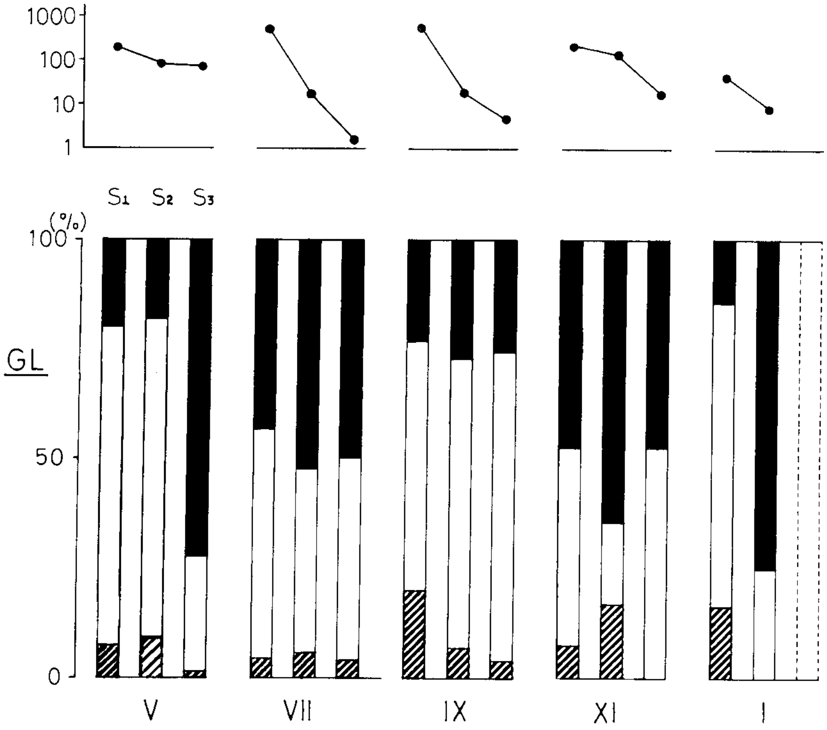

Fig. 12. Vertical distribution of mesofaunal groups in grassland (*GL*). Explanations see in Fig. 11.

Summarizing, Collembola prefers upper soil layers than Acarina in favorable seasons, while deeper layers in winter.

Wallwork (1959) studied the population shift of Acarina and Collembola in litter, humus and mineral layers of a hemlock-yellow birch mor in Michigan. He reported that at the onset of winter the mesofauna sharply decreased in number in litter, but humus populations doubled or even more than that in summer. The winter increase in humus was due to the marked increase of juvenile mites and collembolans, hatching out during the late summer or early winter in humus layer, but adults of some species of oribatid mites apparently moved down into humus as the litter became frozen. Although his observation did not touch on the percentage ratios among mesofaunal groups, the results of the present survey well agree to his results, except for his opinion on the winter increase in humus due to the appearance of newly born individuals, which will be discussed in *5.3*.

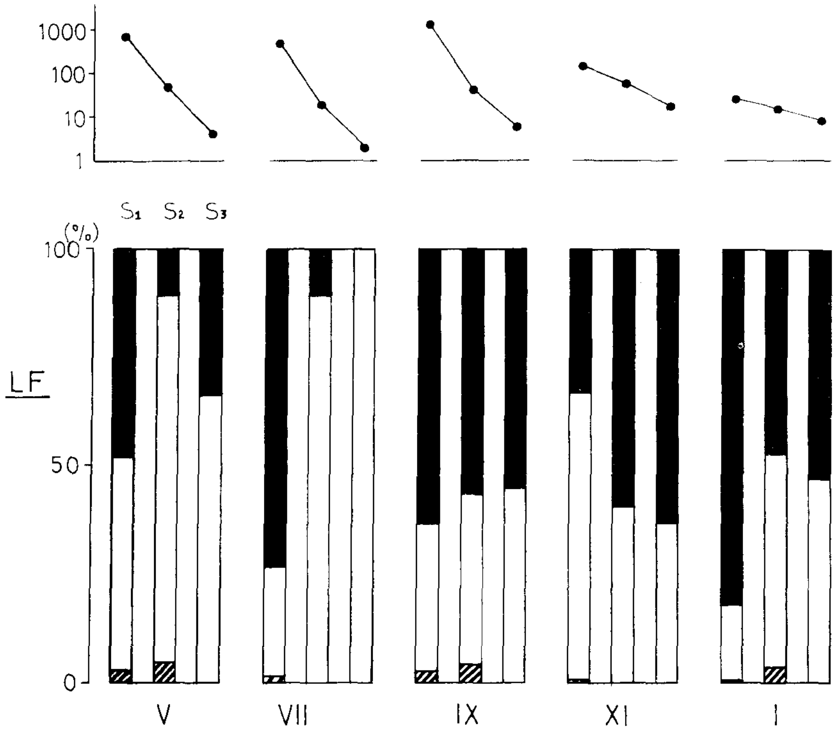

Fig. 13. Vertical distribution of mesofaunal groups in *Larix* forest (*LF*). Explanations see in Fig. 11.

5. *Collembola* (by H. Tamura)

As given in the preceeding section, Collembola is one of the two dominant mesofaunal groups. Biocoenological studies on this group have hitherto been made by many investigators in the world. Some recent studies are those by Bellinger (1954), Poole (1961, '64), and Cassagau and Rouguet (1962). Most of them deal, however, with European or North American faunas. In Japan, especially in Hokkaido, this topic has been neglected until recently, in spite of their numerical abundance, apparently limited by the lack of reliable taxonomic studies (Uchida and Tamura, 1967). Following the previous survey made in Sapporo (Tamura, 1967), the analysis of Collembolan assemblage sampled in the present survey are given in this section.

5.1. Faunal makeup

In total 34 species of Collembola belonging to 20 genera and 8 families were obtained in the present survey. The species number is fewer than that in the vicinity of Sapporo (Tamura, 1967) where wider areas covered with various vegetations were studied. But it is remarkable that not neglegible number of species new to science or to Japan were obtained from the present study made at a relatively restricted area (Uchida and Tamura, 1968 a, b). The list of species obtained in the study is shown in Figure 14, together with seasonal change in relative abundance and total individual number for each species at each habitat. The genera with relatively abundant species are *Onychiurus* (4 species), *Folsomia* (4) and *Hypogastrura* (3)[1], as in the fauna in and near Sapporo.

Dominant species with individual number more than 10% of total in each habitat (Davis, 1963) are as follows:

QF: *Onychiurus sibiricus* (=*O. watanabei*, *cf.* Salmon, 1964) (18.7%) and *Folsomia fimetaria* (16.8%);
GL: *Tullbergia krausbaueri* (56.2%) and *O. octopunctatus* (14.0%);
LF: *Xenyllodes armatus* (43.8%) and *O. sibiricus* (11.3%).

It is supposed that the faunal makeup more or less differs at least quantitatively among habitats. The species numbers collected from each habitat are: 28 (*QF*), 28 (*LF*), 20 (*GL*). *GL* is very poor as compared with *QF* and *LF*, both of which are equal in species number though with some minor difference in faunal makeup. The qualitative and quantitative similarities of the collembolan fauna between each pair of six stations were analysed in Figure 15, using Renkonen's index (*cf.* Aoki *et al.*, 1962). As obviously understood, the relations *QFI-QFII* and *GLI-GLII* show each a strong similarity, respectively 77.8 and 79.4% with the ratio of common species number (csn) to the total number of species; 25/28, 13/20. But it is worth to mention that *LFI* and *LFII* are moderately dissimilar (39.2%, csn: 20/28), though both in the same vegetation, mainly caused by the difference in the density of *Xenyllodes armatus*, which occupies 59.0% of the total individuals in *LFI*, while only 0.4% in *LFII*, resulting in the value of similarity 58.6% by this species alone. Both pairs of *LFII-QFI* and *LFII-QFII* are moderately similar (59.5%, csn: 22/27; 58.9%, csn: 22/28), and *LFI-QFI*, *LFI-QFII*, *LFII-GLI* and *LFII-GLII* are all moderately dissimilar. The similarity values are respectively

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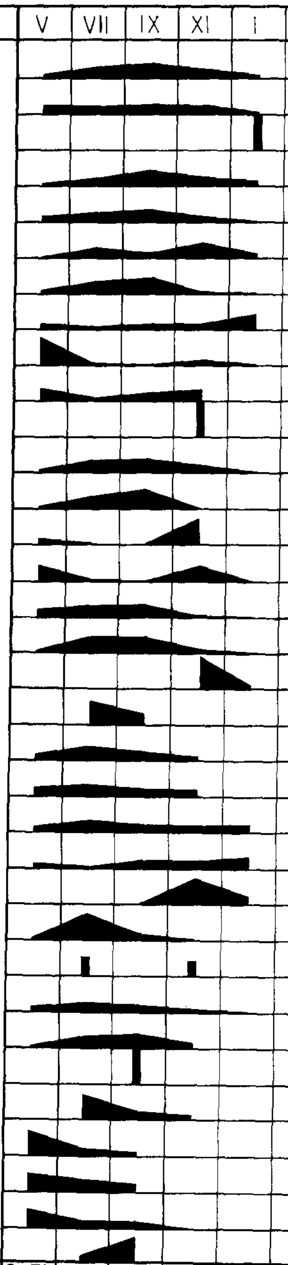
[1] Cited as *Neogastrura* (Stach, 1949) in the previous paper.



Species	V	VII	IX	XI	I	Total indiv.	QF	GL	LF
1 Onychiurus octopunctatus						1685 (1845)	591	695	401
2 sibiricus						3818 (4471)	1815	395	1528
3 sp.1						15 (30)	0	0	15
4 spp.						1826 (1966)	671	253	902
5 Tullbergia krausbaueri						4341 (4840)	415	2783	1143
6 Xenyllodes armatus						6537 (6971)	83	0	6454
7 Hypogastrura wrayia						1646 (1722)	928	56	662
8 sp.1						63 (89)	63	0	0
9 spp.						271 (455)	175	69	27
10 Phyllomeria sp.						34 (41)	15	7	2
11 Anachorutes sp.						5 (5)	5	0	0
12 Folsomia octoculata						1275 (1355)	427	183	665
13 fimetaria						1899 (1913)	1680	26	193
14 ezoensis						848 (911)	845	0	3
15 hidakana						955 (1219)	831	0	125
16 Isotomodes sp.						131 (149)	3	124	4
17 Isotomiella minor						531 (553)	275	1	255
18 Appendisotoma mitra						57 (58)	0	57	0
19 Spinisotoma pectinata						456 (456)	374	0	82
20 Isotoma trispinata						1181 (1302)	130	24	1027
21 notabilis						153 (176)	89	0	64
22 Pteronychella spatiosa						1016 (1231)	205	0	811
23 Entomobrya corticalis						36 (48)	16	6	14
24 sp.						32 (36)	20	0	12
25 Sinella coeca						91 (93)	61	1	29
26 Tomocerus minutus						9 (9)	6	0	3
27 lamelliferus						206 (243)	97	0	109
28 Megalothorax minimus						165 (167)	48	0	117
29 Bourletiella hortensis						2 (2)	0	2	0
30 Ptenothrix sp.						18 (18)	13	2	3
31 SMINTHURIDAE sp.1						10 (15)	2	7	1
32 sp.2						24 (30)	23	0	1
33 sp.3						140 (191)	0	85	55
34 sp.4						176 (176)	0	176	0
Total	2079 (4158)	9313	9296	7916	1054 (2108)	29653 (32786)	9986	4950	14717

Fig. 14. Collembolan species collected in Hidaka-Mombetsu, together with their seasonal trend in % individual number and absolute individual number in total (in parentheses, corrected total number, *cf.* in text) and collected in each habitat.

33.4%, csn: 24/27; 33.4%, csn: 23/27; 34.0%, csn: 17/26; 32.4%, csn: 14/28. Strongly dissimilar relations are found in *GLI-QFI* and *GLI-QFII* (29.9%, csn: 16/28; 29.2%, csn: 17/28, respectively), *GLII-QFI* and *GLII-QFII* (27.2%, csn: 14/30; 27.5%, csn: 14/29, respectively), and *LFI-GLI* and *LFI-GLII* (25.3%, csn: 15/26; 25.5%, csn: 14/27, respectively). Summarizing, the faunal makeup is more or less similar between the samples taken from the same habitat, and the similarity between *Quercus* and *Larix* forests is larger than that between forests and grassland.

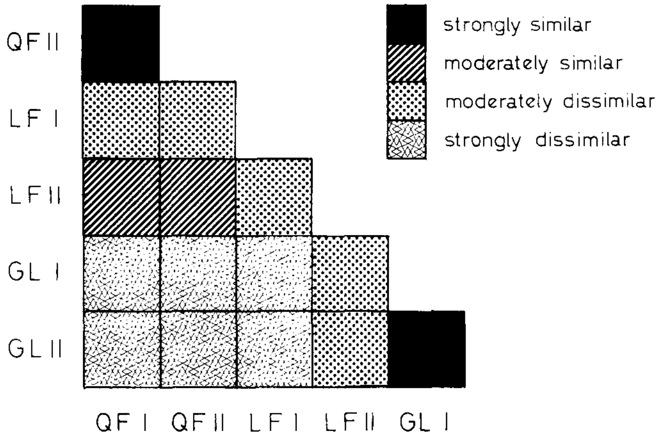


Fig. 15. Qualitative and quantitative similarities of collembolan fauna at specific level between each pair of six stations, by using Renkonen's index.

5.2. Seasonal trend and relative abundance

The seasonal trend of each species is shown in Figure 14, by using the percentage abundance at each sampling time to the annual total. The percentage ratios in May and January were calculated based upon the doubled individual number, because the sample size in these months was one half in the other months. Correspondingly the total individual number of each species is given in Figure 14 in two ways, as actual and, in parentheses, corrected ones. It is recognized that many species have the peak in hot or warm seasons (July-September) and diminish in cool or cold seasons (November-January). But there are some species showing their peaks rather in cool or cold season: *Hypogastrura* sp. 1 with the maximum in winter and *Phylliomeria* sp., *Folsomia ezoensis* and *F. hidakana* all in late autumn. Further the following species were sampled only in particular seasons: *Spinisotoma pectinata*, *Sinella coeca* and all species of Sminthuridae only in warm season, while *Appendisotoma mitra*, *Entomobrya* sp. only in cold season. *Onychiurus* sp. 1, *Anachorutes* sp., *Tomocerus minutus* and *Bourletiella hortensis* were collected only sporadically, so that population trends could not be ascertained.

To know the relative abundance of each species in each station (Fig. 16), the classification by Brockmann-Jerosch (*cf.* Aoki 1962) was used as follows; dominant (more than 5% of the total individuals in each habitat for each sampling time); subdominant (5–2%); rare (2–0%); and absent (0%).

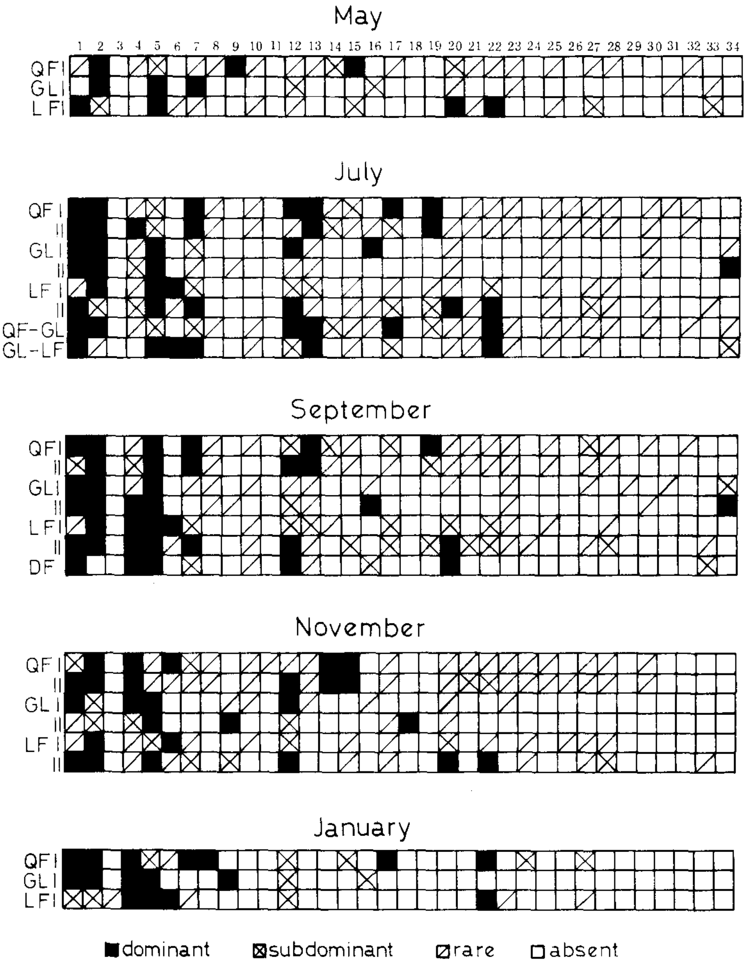


Fig. 16. Relative abundance of the collembolan species in each station at each sampling time, expressed by using the class by Brockmann-Jerosch. The specific names are replaced by numerals given in Fig. 14.

From Figures 14 and 16, seasonal change of the community structure is outlined as follows:

1. May: Twenty-five species were sampled. The abundant species common to three habitats are *Onychiurus sibiricus* (numbered in Fig. 14 as 2) and *Tullbergia krausbaueri* (5), followed by *Hypogastrura wrayia* (7), *Folsomia octoculata* (12) and *Isotoma trispinata* (20). But the number of species varied considerably among habitats: 20 (*QF*), 9 (*GL*) and 15 (*LF*) respectively, probably in part affected by the difference in frost-melting.

2. July: Species obtained were 29 in number. The abundant species common to three habitats are *O. octopunctatus* (1), *O. sibiricus* (2), *Tullbergia krausbaueri* (5), *Folsomia octoculata* (12), followed by *O.* spp. (4), *F. fimetaria* (13), *Isotoma trispinata* (20), *Sinella coeca* (25), *Ptenothrix* sp. (30). *Xenyllodes armatus* (6) was dominant in *LF* but absent both in *QF* and *GL*, and Sminthuridae sp. 4 abundant in *GL* but absent in *QF* and *LF*. Species number in each habitat was: 25 (*QF*), 13 (*GL*) and 21 (*LF*). Samples from *QF-GL* and *LF-GL* show intermediate conditions of these ecotones qualitatively as well as quantitatively.

3. September: The number of species reached the maximum. Within 30 species sampled, the dominant species common to three habitats are *Onychiurus sibiricus* (2) and *Tullbergia krausbaueri* (5), and subdominant *Onychiurus* spp. (4), *O. octopunctatus* (1), *Folsomia octoculata* (12), followed by *Hypogastrura wrayia* (7), *Phylliomeria* sp. (10), *Folsomia fimetaria* (13), *Isotoma trispinata* (20), *Entomobrya* sp. (23). Species showing marked patchy distribution are *Xenyllodes armatus* (6), *Isotomodes* sp. (16) and sp. 4 (34), all restricted in a single habitat though being dominant three. Species number in each habitat was 22(*QF*), 18 (*GL*) and 22(*LF*). Sample from *DF*, though poor both in species and individual numbers, resembles those from *LF* in dominant species.

4. November: Twenty-eight species were sampled with *Onychiurus octopunctatus* (1), *O. sibiricus* (2) and *Folsomia octoculata* (12) superior in number in all habitats. Other common species are *Tullbergia krausbaueri* (5), *Phylliomeria* sp. (10), *Isotomiella minor* (17), *Isötoma trispinata* (20) and *Entomobrya corticalis* (23). The species of Symphypleona (29–34) were virtually absent in this month. Species number in each habitat was 24 (*QF*), 13 (*GL*) and 19 (*LF*).

5. January: Only 16 species were collected with the abundant species common to three stations, *Onychiurus octopunctatus* (1), *O. sibiricus* (2), *O.* spp. (4), *Tullbergia krausbaureri* (5) and *Folsomia octoculata* (12).
Pteronychella spatiosa (22) was dominant both in *QF* and *LF* but absent in *GL*. It is remarkable that the rare species were relatively scarce. Species number in each habitat was 14 (*QF*), 7 (*GL*) and 11 (*LF*).

5.3. *Vertical distribution.*

It was already mentioned in Figures 11–13 that the percentage vertical distribution of Collembola seasonally flucutated in relation to Acarina and other mesofauna groups. Although this does not necessarily indicate the actual seasonal change, the seasonal difference in vertical distribution of Collembola is clearly seen from Figure 17, in which the data from *GL* on January were omitted for the absense of samples from S_3. In warm and hot seasons they concentrate in the upper layer, in cool and cold seasons, in parallel with decreased temperature, tend to penetrate into deeper layers, and in spring, probably making the upward migration after the melting of frozen soil.

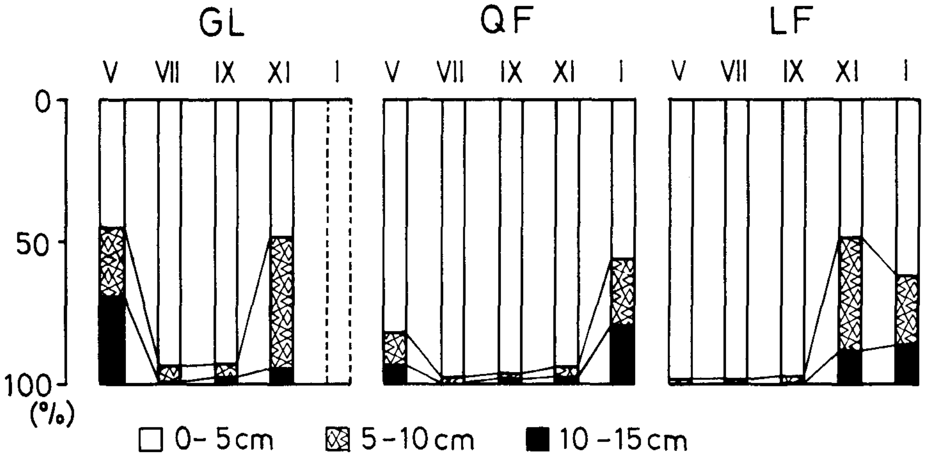


Fig. 17. Seasonal change of vertical distribution of total collembolan assemblage in each habitat.

Under this general pattern, the specific difference is recognized (*cf.* Tamura 1968). Glasgow (1939) also notes such specific difference in Slough, England. Especially *Onychiurus ambulance* was abundant in top layer in spring and autumn, while in deeper layers, in summer and winter. The seasonal change in vertical distribution of ten representative species is commented on (Fig. 18):

Tomocerus lameriferus: Exclusively surface dweller found only in S_1 throughout the year.

Sminthuridae sp. 1: Ditto but found only in warm and hot seasons, not in cool and cold seasons.

Pteronychella spatiosa: Surface dweller, but with a slight relative increase in S_2 in winter.

Folsomia fimetaria: Principally surface dweller, restricted in S_1 during May to September, but in cool and cold seasons found in deeper layers, in S_3 though scarce in number. In January more than 50% found in deeper layers.

Folsomia hidakana: Ditto, except for the relatively higher presence in deeper layers, where more than 70% were found in January.

Hypogastrura wrayia: More or less surface dweller; restricted in S_1 only during May to July. From September to January increasing in deeper layers, though not considerably.

Onychiurus octopunctatus: Intermediate species inhabiting both surface and deep layers over all seasons. In January about 90% found deeper layers, about 60% of which from S_3.

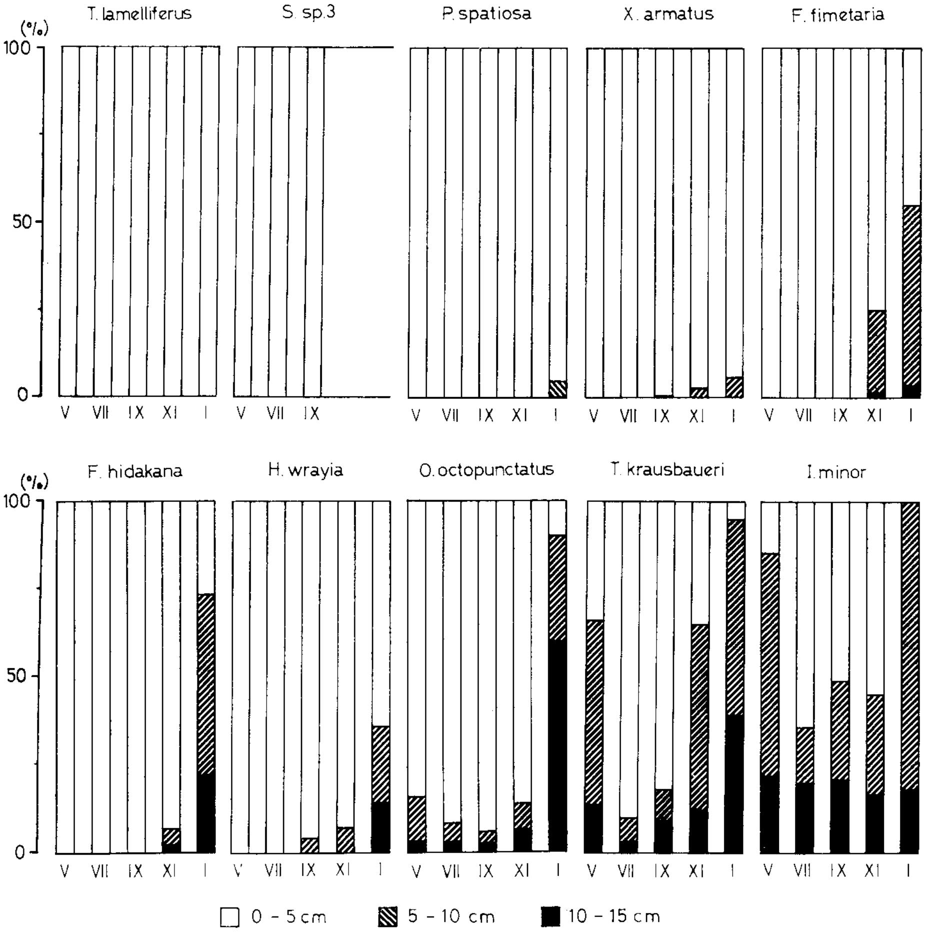


Fig. 18. Seasonal change of vertical distribution of some representative collembolan species. The samples in three habitats are shown in combination.

Tullbergia krausbaueri: Mainly subterranean, though found in upper layer in warm and hot seasons with relatively high percentage. In cool and cold seasons only less than 35% found in S_1.

Isotomiella minor: Subterranean mainly confined to lower layers throughout the year. Although more than 60% were obtained in S_1 in hot and cool seasons, less than 50% in other seasons. In January found only in deeper layers.

Among these species, *Onychiurus octopunctatus, Tullbergia krausbaueri* and *Isotomiella minör* were also abundant in the previous survey made in Sapporo (Tamura, 1967), in which the sampling was made during May to September, not in winter. In other seasons the vertical distibution of these three species coincided well between Sapporo and Hidaka-Mombetsu.

Wallwork (1959) described similar increase in deeper layers in winter and explained this by the increase of juveniles newly born in deeper layers, instead of by the downward migration. This opinion may be valid for many species, but some species like as *Pteronychella spatiosa* clearly have only one generation per year, in which the increase in deeper layers in winter is explained only by the downward migration. Probably various species behave differently on this aspect, according to their life cycle pattern, the study of which may form a so far ignored but fruitful field.

5.4. *Comparison of Collembolan cömmunities between in Sapporo and Hidaka-Mombetsu.*

The exact comparison between two surveys, made in Sapporo (Tamura, 1967) and the present area is impossible for the difference in extracting methods, the use of Para-Dichlorobenzene in the former, while of electric heating in the latter.

The inefficiency of Para-Dichlorobenzene as a stimulator was already commented, extracting only one tenth of efficiency by electric lamp. Therefore, here only some important points are commented on.

Table 8 shows the order of the relative abundance of various genera in two surveys, together with that obtained by occasional samplings performing in an *Abies* forest at Nopporo and a *Quercus* forest at seashore in Ishikari, both in the vicinity of Sapporo and extracted by electric heating as in the present survey.

At the generic level, the faunal makeup does not markedly differ among four localities. But the assemblage in Hidaka-Mombetsu appears to be different from the other three in the dominance of *Xenyllodes*, which was never collected in and near Sapporo. The genus *Xenyllodes* is originally restricted to the northern Holarctic region (*cf.* Salmon, 1963; Palissa, 1964). Therefore, its prosperity in Hidaka, with remarkable drop of soil temperature in winter, is conceivable.

Onychirus, Folsomia, Tullbergia, Isotoma, Isotomiella and *Hypogastrura* are dominant both in Hidaka district and Sapporo and the vicinity. It is plausible that these genera are dominant throughout Hokkaido. But further researches are required to establish the relative abundance of various genera in Hokkaido, also to ascertain the influence of freezing upon the faunal make up.

6. *Oribatid mites* (by T. Fujikawa)

As mentioned in Section 4, the majority of the mesofauna in Hidaka-Mombetsu is, as is usual in many localities, consisted of Collembola and Acarina, approximately in the same proportion. Unfortunately, no closer analysis of Acarina extracted in the present survey was undertaken, except for the identification of oribatid mites.

In most cases the oribatid mites occupy the outstanding position soil Acarina by their numerical predominance. Their role in the process of soil decomposition has gradually been understood (Wallwork, 1967). Although no exact count was made the oribatid mites were the most dominant group among all Acarina in the present survey. The specimens collected by Y.N. and H.T. in soil samples taken were placed at the author's disposal for identification. The species accurately identified are listed below. In each, species name is followed by the total number of specimens examined, in parentheses, and the number of specimens collected at each sampling, all in 1966.

Hypochthoniidae

Hypochthonius rufulus C.L. Koch, 1836. (59): July–22 (9), Sept.–16–17 (26), Nov.–18–19 (24).

Eohypochthonius gracilis crassisetiger Aoki, 1959. (4): May–12 (1), Nov. –18–19 (3).

Eniochthoniidae

Eniochthonius minutissimus (Berlese, 1904). (208): May–12 (44), July–22 (4), Sept.–17 (1), Nov.–18–19 (159).

Mesoplophoridae

Mesoplophora pulchra Sellnick, 1928. (3): May–12 (1), July–22 (2).

Phthiracaridae

Steganacarus striculus (C.L. Koch, 1836). (3): May–12 (1), July–22 (1), Sept.–16(1).

Euphthiracaridae

Rhysotritia ardua (C.L. Koch, 1841). (4): May–12 (1), July–22, (1), Sept. –16 (1), Nov.–18–19 (1).

Nothridae

Nothrus biciliatus C.L. Koch, 1844. (5): May–12 (1), July—22 (2), Sept.– –16 (1), Nov.–18–19 (1).

Camisiidae

Platynothrus yamasakii (Aoki, 1958). (21): July–22 (1), Sept.–16–17 (5), Nov. –18–19 (14), Jan.–18–19 (1).

Nanhermanniidae

Cyrthermannia parallela (Aoki, 1961). (7): May–12 (1), July–22 (4), Sept. –16 (1), Nov.–18–19 (1).

Tectocepheidae

Tectocepheus velatus Michael, 1880. (29): May–12 (1), July–22 (13), Sept.–16 –17 (9), Nov.–18–19 (6).

Oppiidae

Oppia nova (Oudemans, 1902). (495): May–12 (32), July–22 (83), Sept.–16–17 (93), Nov.–18–19 (287).

Ceratozetidae

Ceratozetes imperatorius Aoki, 1963. (1): July–22 (1).

Oribatulidae

Scheloribates latipes (C.L. Koch, 1841). (10): May–12 (1), July–22 (3), Sept.–17 (1), Nov.–18–19 (4), Jan.–18–19 (1).

Haplozetidae

Protoribates lophotrichus (Berlese, 1904). (6): May–12 (1), July–22 (4), Nov. –18–19. (1).

It is premature to give any conclusions from this preliminary list, but as far as the number of individuals is concerned, *Hypochthonius rufulus*, *Eniochthonius minutissimus* and *Oppia nova* could certainly be regarded as dominant species.

Although no detailed analysis upon the relationship between species and habitat preference could be done, the presence or absence of certain species (sampled by Y.N. in July) in three habitats is summarized as follows:

Species	*DF*	*GL*	*QF*
Eniochthonius minutissimus		○	○
Mesoplophora pulchra			○
Steganacarus striculus		○	
Nothrus biciliatus		○	
Cyrthermannia parallela		○	
Damaeidae sp.			○
Tectocepheus velatus		○	
Oppia nova	○	○	○
Punctoribates sp.	○		
Scheloribates latipes		○	
Protoribates lophotrichus		○	○

The scarcity in *DF*, as like in most other groups given in preceding sections, is conceivable, when its monotonous and unstable environmental conditions are considered. On the other hand, the scarcity in *QF* is noteworthy, and many other studies report the abundance of oribatid mites in forest floor. Further critical studies are needed to clarify this strange circumstance.

Concluding Remarks

As already mentioned, the present survey dealing with soil animals in Hidaka-Mombestu, involve a number of defects in procedure, by which the survey cannot properly be called the comprehensive study. At first these defects are repeated here in order to make the limit of the present survey clear and to give some precautions for more improved studies for the future. The main defects are itemized as follows: 1). Sampling plots in each habitat were independently selected in each animal group, so that the results cannot exactly be compared among groups, especially as far as the difference among habitats is concerned. 2). The periodical sampling was made bimonthly, which can give a perspective of phenology of soil fauna but still imperfect to elucidate the seasonal change precisely. Moreover, the sampling in November and January was made only as to mesofauna, consequently the behavior of macrofauna populations in late autum to winter was not analysed. 3). Only some representative groups were precisely studied, that is, earthworms and ants in macrofauna and Collembola in mesofauna. The most important defect is the lack of detailed analysis of soil mites. They share nearly always the dominant position in soil mesofanna with Collembola. Nevertheless, the study was confined to one group, the orbatid mites, and made only qualitatively.

In spite of these defects, the results of the present survey, the first of this type made in Hokkaido, give something on the spatiotemporal community structure of soil fauna in the area surveyed, which are, in the authors' conviction, worth to mention for the future progress of pedozoological studies in Hokkaido.

1. *Relationship between habitat and community structure*

In spite of the difference in the selection of sampling plots among various animal groups, there is found a remarkable correspondence as to the faunal makeup and richness in relation to habitats, especially in macrofauna (*cf. 1.2.*) other than earthworm and Collembola (*cf. 5.1.*). In most groups precisely studied, the faunal makeup is richest in *Quercus* forest (*QF*), intermediate in *Larix* forest (*LF*) and poorest in grassland (*GL*). The difference is relatively small between *QF* and *LF*, while large between forest (*QF* and *LF*) and grassland (*GL*). The same can be applied to the faunal similarity, which is also small between *QF* and *LF*, and large between forest and grassland. This relation formulated as $(QF \fallingdotseq LF) \neq GL$, or forests $\neq$ grassland. Apart from this static difference, *GL* is characterized by a marked instability by frequent human interference, such as soil agitation, stamping and grazing by cattles, *etc.*, which indubitably related to its relatively poor and simple community structure. This tendency is more exaggerated in a dent-corn field (*DF*) standing nearby, where the human interference is obviously very intense. Of course these differences do not abruptly but gradually change at the boundary between two habitats, as shown by the results obtained at such ecotonal zones (*GL-LF*, *QF-GL*) (*cf. 3.2, 4.2., 5.2.*).

It must be mentioned that this difference developed during a relatively short period. Since the destruction of the original vegetation, *Quercus* forest, in 24 years ago, the soil fauna followed an allogenic succession, through the process of replacement of constituents, both qualitatively and quantitatively. The leitmotiv in this process must be a gradual impoverishment. But it is certain that some species secondarily aquired the way to the flourishment by the coincidence of the optimal zones to various external factors due to the change of environment. The whole process must essentially be more or less similar to that now in progress in various localities in Hokkaido, in relation to the increasing land use, by reforestation, cultivation and urbanization.

2. *Seasonal fluctuation and vertical distribution*

The population trend shows a considerable difference among groups, and among habitats in each group. This is easily understood because each species constituting a soil fauna has its own annual cycle, expressed as the combined result of more or less innately fixed pattern and its secondary modification by various environmental factors, including difference in habitats. In the present survey, however, the maximum peak is found in most groups in autumn. Probably this general trend is caused by the increased population density, resulted from the reproduction principally made in spring to summer. Some notable deviation from the rule is seen in some Collembolan species (*cf. 5.2.*), which may be explained by the difference in life cycle pattern or by some defects in sampling procedure. In this connection, one remark must be given as to the ignorance of life cycle approach in soil ecology.

In contrast to the marked advance in procedures for the comparison of obtained samples as a whole, the life cycle of each species has so far relatively been ignored. Of course it is virtually impossible to clarify the life cycle of all members. But unless the life cycle patterns of dominant constitutents have been established, not always through the so called autecological approach but through the analysis of the obtained samples themsevles, for instance, by the distinction of age classes, by the food-chain, etc., the community phenology could not ultimately be understood with precision. Another peculiarity in soil phenology must lie in the freezing of soil layers in winter caused by poor snowfall. By this characteristic the area surveyed is distinguished from other areas in Hokkaido such as Sapporo and the vicinity with heavy snowfall, where the soil does not frozen in winter, nevertheless atmospheric climate is less mild than in Hidaka-Mombetsu. The influence of this continuous freezing was clarified only in mesofauna in general and Collembola in particular, as shown by their vertical distribution. The general trend in vertical distribution coincided with that obtained by other studies (Watanabe, 1968; Tamura, 1967), characterized by the concentration of 52.3% (macrofauna) or more than 95% (mesofauna) to the top soil layer. Under this generality, however, a closer inspection suggests the specific difference in vertical distribution and its change according to the season, seen notably in Collembola/Acarina ratio, and in various dominant species of Collembola. The higher relatively abundance of all mesofaunal groups particularly, Collembolan species in deeper layers in winter, suggests their winter migration to these layers apparently in connection with the severe pedoclimatic conditions mentioned above.

3. *Faunal peculiarity of the area studied.*

The comparison of faunal make up, between Hidaka-Mombetsu and Sapporo, including the vicinity, was made in each section, mainly qualitatively but in part quantitatively, based upon the previous information (macrofauna, Nakamura 1968b, ant, Yamauchi 1968 and mesofauna, Tamura 1967). In most groups, especially in macrofauna, the similarity is prevailing than the difference between these two areas. Therefore, the dominant groups or species as well as certain definite trends in relative abundance common to the both areas might more or less be expected or at least suggestive, for further pedozoological researches in middle Hokkaido. The difference in Collembola is larger, probably in part caused by the severe winter conditions mentioned above, resulting in the impoverishment of fauna and dominance of cold-resistant species. Probably the same could be revealed in Oribatei and other mesofaunal constitutents, which did not pass the winter in cold-resistant state or in deeper layers, provided that detailed analyses would be carried out.

To give a conclusive answer to this problem, however, we need the accumulation of information concerning the life cycle studies mentioned above. Another approach indispensable would be the execution of comparative pedozoological surveys in various localities in Hokkaido, representing different climate, especially in Northern and Eastern Hokkaido, where the climatic conditions are much more severe, resulting in the prolonged freezing of soil down to deeper layers.

At the present, detailed comparison of faunal makeup between Hokkaido and Southern Japan cannot be made accurately for the lack of sufficient data. Naturally the faunal makeup may be quite different at the specific level. For instance, in the ant community survey made at a warm- temperate forest in Manazuru, Kanagawa Pref., Kondo *et al.* (1968) reported 15 species. Only one of them, *Paratrechina flavipes*, was common to both their and the authors' results. However, at the family or order level, there is no essential difference between the present survey and those made in Southern Japan (*cf. 1.2., 4.2.*), except for the lower population density of macrofauna in the present survey, than in that made in Kyushu (Kitazawa *et al.*, 1960). The accumulation of further information is needed for closer comparison of soil fauna communities both taxonomic and ecological, throughout Japan.

Summary

The present study deals with the sturucture of soil animal community surveyed at three different habitats, *Quercus* forest (*QF*), *Larix* forest (*LF*) and grassland (*GL*), in Hidaka-Mombetsu during 1966-'67, approximately bimonthly, with the follwing results.

1. Faunal makeup differs both qualitatively and quantitatively among habitats as follows: $QF \fallingdotseq LF \neq GL$. The richness measured by relative and absolute abundance follows the order: $QF > LF \geqslant GL$. These tendencies are proven both in macro- and mesofaunas in general, ants and Collembola, but not in earthworms.

2. The basic faunal makeup coincides with those studied in various localities in and out of Japan. In macrofauna, earthworms took the dominant position, occupying about 48% of the individuals sampled. Dominant earthworm species are *Allolobophora japonica* in *QF* and *DF*, *Dendrobaena octaedra* in *LF* and *GL*.

3. In mesofauna, Collembola (Co) and Acarina (Ac) in combination occupy 97.4% (*LF*), 96.8% (*QF*) and 91.3% (*GL*) in annual mean. Co/Ac ratio is annually 1.58 (*LF*), 0.63 (*QF*) and 0.39 (*GL*). Dominant Collembolan species are *Onychiurus sibiricus* (= *O. watanabei*) and *Folsomia fimetaria* in *QF*: *Tullbergia krausbaueri* and *octopunctatus* in *GL*; *Xenyllodes armatus* and *O. sibiricus* in *LF*, in general similar to those in Sapporo and the vicinity, except for *O. sibiricus* and *X. armatus*.

4. Seasonal fluctuation and vertical distribution were analysed incompletely. Both are affected by the prolonged freezing of soil layers down to 50 cm in winter. The difference of soil faunas between Sapporo and Hidaka-Mombetsu must in part relates to this severe winter condition, in spite of the relatively mild atomospheric climate in the latter.

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