Additional Notes on the Ecological Distribution of Ants in Sapporo and the Vicinity[1)2)]

By

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(With 4 Text-figures and 3 Tables)

Recently many contributions to the ecological distribution of ants have been made in Japan, by Hayashida (1960, 1963, 1964) and Hayashida and Maeda (1960) in Hokkaido, Yasuno (1963, 1964 a, b, 1965) in Northern Honshu, Kondo (1961, 1966) in Central Honshu, etc. Hayashida attempted to determine the ecological make-up of ant assemblage in a given habitat by counting the number of colonies discovered within a definite time interval, usually 30 minutes. By this procedure he established, in each habitat type, dominant species, nest site preference, degree of interspecific co-existence, etc. His procedure is certainly useful to obtain a general faunistic and ecological perspective at a given habitat, but has a defect of overlooking the detailed assemblage structure. A combination of various procedures would be necessary to obtain the most reasonable picture of the assemblage structure. Keeping such necessity in mind, the ecological distribution of ants in Sapporo and the vicinity was re-studied by the present writer, using two procedures different from that adopted by Hayashida.

Before going further, the writer wishes to express his cordial thanks to Prof. Mayumi Yamada and Dr. Shôichi F. Sakagami, Zoological Institute, Hokkaido University, Sapporo, for their kind guidance in the course of the present study. Sincere thanks are also due to Dr. Kazuo Hayashida, Biological Laboratory, Koen-Gakuen Junior College, Sapporo, for his expert guidance in myrmecology and identification of some difficult forms, and Mr. Hiroshi Tamura, now in Biological Institute, Ibaraki University, Mito, who kindly offered his valuable data on subterranean ants at the writer's disposal. He would like to express his thanks also to Prof. Masaaki Morisita, Zoological Institute, University of Kyoto, Kyoto, for the allowance of the use of his still unpublished procedure of sampling, and to Prof. Edward O. Wilson, Biological Laboratories, Harvard University, Cambridge, Mass., for his kind information on the specific names of *Lasius niger*-group.

1) Contribution No. 808 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

2) Studies of the ecological distribution of ants in Hokkaido, IV.

Methods

The quantitative sampling was made by using two procedures; 1) Five minutes sampling of individuals: In each place studied, a quadrate of 2 m × 5 m was chosen and ants found within this area were smapled during five minutes, in each species or form, up to five individuals[1]; 2) Colony counting: All colonies within the same quadrate were searched by digging the ground down to ca. 5 cm deep at intervals of ca. 20 cm. The combination of these two procedures was repeated five times for each place, and five places for each of eight habitat types. The classification of habitat types follows the system by Hayashida (1960) with minor modifications as follows:

BS. Bare sandy area or lands with sparse vegetation found in river-banks and dry river-beds.
BA. Bare area or lands with sparse vegetation such as crop-fields, road sides, etc.
SH. Grassy or herbaceous lands of sand dunes near sea-shore.
PT. Peat bogs.
HG. Grassy or herbaceous lands such as meadows and abandoned farms.
WM. Wood margins (In this study, only margins of deciduous woods).
WD. Deciduous woods.
WC. Coniferous woods (Mainly larch woods).

The extent of the area studied also more or less corresponds to the map given by Hayasida (Fig. 1 in Hayasida, 1960).

Results and discussions

1. *Faunal composition in various habitats*: As shown in Table 1, 22 forms, including subspecies and varieties, were collected from the area studied[2]. Among them, *Lasius crispus* was recorded by Wilson (1955) from Honshu and Shikoku but is new to the myrmecofauna of Hokkaido. *Myrmecina graminicola nipponica* is not rare in some districts in Honshu, but so far been recorded in Hokkaido only from Kojima, a small remote island in Tsugaru Strait (Hayashida, personal communication).

Paratrechina flavipes and *Lasius alienus* are obviously the most dominant species in the area studied. Although less abundant, *Myrmica ruginodis, Pheidole fervida, Lasius flavus, Aphaenogaster smythiensi, Myrmica lobicornis* var. *jessensis* and *Formica fusca japonica* are relatively common. The total number of the colonies of these eight species occupies 88.6% of all colonies discovered. The colony density (Number of colonies discovered per unit area) of these species in each habitat, converted to the value per 10 m sq., are given as follows (Abbreviations of specific names in Table 1):

1) This procedure was originally deviced by Morisita (unpublished). In his procedure, the number of obtained individuals, ranging 0–5, for each trial, is converted to the weights and receives further mathematical treatment. In the present study, however, the number of individuals obtained was used as an index of relative abundance, without converting to the weights. This usage involves theoretical defects but the obtained data allow, if necessary, further elaboration in future.

2) For convenience's sake, the term "species" is henceforth applied for species, subspecies and forms.

Table 1. Relative abundance of the ants in various habitats in Sapporo and of individuals by five

Scientific name	Abbreviation	BS	BA
Ponerinae			
Ponera japonica Wheeler[1]	*P*	— —	— —
Myrmicinae			
Myrmecina graminicola nipponica Wheeler	*My*	— —	— —
Myrmica ruginodis Nylander	*M*	1(7)	6(27)
M. lobicornis var. *jessensis* Forel	*Ml*	14(26)	20(44)
Aphaenogaster smythiensi var. *japonicus* Forel[2]	*A*	— —	1(3)
Pheidole fervida Smith	*Ph*	3 —	— —
Leptothorax spinosior Forel	*Lt*	8(15)	—(4)
Lept. sp.1	*Ltx*	— —	— —
Solenopsis fugax Latreille	*S*	— —	1 —
Formicinae			
Paratrechina flavipes (F.Smith)	*Pa*	4 —	—(6)
Lasius umbratus (Nylander)	*Lu*	— —	— —
L. flavus (Fabricius)	*Lf*	16 —	— —
L. fuliginosus (Latreille)	*Lg*	— —	— —
L. crispus Wilson	*Lc*	— —	— —
L. alienus (Foerster)[3]	*La*	5(28)	8(25)
L. niger (Linnaeus)[4]	*Ln*	4(11)	— —
L. sp.1[5]	*Ll*	— —	— —
Camponotus obscripes Mayr	*C*	— —	— —
C. herculeanus japonicus Mayr	*Cj*	8(14)	1(9)
Formica fusca japonica Motschulsky	*F*	10(97)	15(91)
F. truncorum yessensis Forel	*Fy*	1(12)	—(5)
F. sanguinea var. *fuscicepus* Emery	*Fs*	2(15)	3(25)
F. execta fukaii Wheeler	*Fe*	1(12)	— —
Total number of colonies and individuals in each habitat		77(237)	55(239)
Total number of species in each habitat		13	11

1) *Ponera scabra* Wheeler, 2) *Aphaenogaster famelica* (F.Smith), 3) *Lasius niger* (Linnaens),

	BS	BA	SH	PT	HG	WM	WD	WC
Pa	1.6	0	0	0	7.6	13.6	33.2	19.2
La	2.0	3.2	0.4	0.4	3.8	13.6	17.6	3.6
M	0.4	2.4	0	2.0	8.4	8.0	3.6	11.6
Ph	1.2	0	0	0	3.2	1.2	12.0	8.8
Lf	6.4	0	0	6.0	7.2	4.0	0	0
A	0	0.4	0	0	0	3.6	10.8	2.8
Ml	5.6	8.0	0.4	0	3.2	0	0	0
F	4.0	6.0	1.2	0.4	2.0	1.6	0	0

the vicinity. Numerals given are number of colonies and, in parentheses, minutes sampling

Relative abundance in each habitat						Total
SH	PT	HG	WM	WD	WC	
— —	— —	— —	— —	—(1)	— —	—(1)
— —	— —	— —	— —	1 —	— —	1 —
— —	5(24)	21(37)	20(55)	9(9)	29(54)	91(213)
1 —	— —	8(7)	— —	— —	— —	43(77)
— —	— —	—(1)	9(5)	27(23)	7(16)	44(48)
— —	— —	8 —	3(5)	30(30)	22(17)	66(52)
5(33)	— —	6(5)	— —	— —	— —	19(57)
— —	— —	— —	—(6)	— —	— —	—(6)
6 —	— —	2 —	— —	— —	— —	9 —
— —	— —	19(27)	34(40)	83(88)	48(23)	188(184)
— —	— —	— —	4 —	6 —	1 —	11 —
— —	15 —	18 —	10 —	— —	— —	59 —
— —	— —	— —	— —	—(21)	— —	—(21)
— —	— —	— —	—(1)	—(3)		—(4)
1(3)	1(5)	7(13)	34(81)	44(47)	9(23)	109(225)
— —	— —	— —	— —	— —	— —	4(11)
— —	— —	— —	1(62)	4(11)	— —	5(13)
— —	— —	— —	—(2)	1(12)	—(4)	1(18)
— —	— —	2(14)	— —	— —	— —	11(37)
3(21)	1(10)	5(35)	4(21)	— —	—(4)	38(279)
12(101)	— —	— —	— —	— —	— —	13(118)
— —	— —	—(8)	— —	— —	— —	5(48)
— —	— —	1(6)	1(5)	— —	— —	3(23)
28(158)	22(39)	97(153)	120(223)	205(245)	116(141)	720(1435)
6	4	13	13	12	8	23

4) *Lasius emarginatus* (Olivier), 5) *Lasius brunneus* (Latreille) in Hayashida (1960).

For each habitat the colony density (Colony number/10 m sq.) is as follows: WD (82.0), WM (48.8), WC (46.4), HG (39.2), BS (30.8), BA (22.0), SH (11.2), PT (8.8). The remarkably high density in WD is mainly caused by *Paratrechina flavipes*, a tiny species forming a small colony. The poverity of ant fauna in PT is apparently related to excessively humid condition. The poverity in SH is also understood by its monotonous and severe environment. In the present case, however, another particular factor, the occupation of the area by an extremely exlcusive species, *Formica truncorum yessensis* is indubitably responsible.

To show the ant assemblages in various habitats, according to the occurrence probability method by Kato, Mastuda and Yamashita (1952), the ratio of the colony number in each species to the total number of colonies of all species obtained was calculated in each habitat, together with its confidence interval within 90% reliability. The results are shown in Fig. 1, in which various habitats are arraged approximately according to the gradual change in the occurrence of each species. The species, the lower limit of which exceeds the ratio of mean colony number to the total colony number, are regarded as dominant species in each habitat. The dominant species, given by individual sampling and colony counting, are:

	By colony counting	By individual sampling
WD	*Paratrechina flavipes* (40.5%), *Lasius alienus* (21.5%).	*Paratrechina flavipes* (37.8%), *Lasius alienus* (19.3%).
WC	*Paratrechina flavipes* (41.4%), *Myrmica ruginodis* (25.0%).	*Myrmica ruginodis* (38.3%).
WM	*Paratrechina flavipes* (28.3%), *Lasius alienus* (28.3%).	*Lasius alienus* (36.3%), *Myrmica ruginodis* (24.7%).
HG	*Myrmica ruginodis* (21.6%), *Paratrechina flavipes* (20.6%), *Lasius flavus* (18.4%).	*Myrmica ruginodis* (24.2%), *Formica fusca japonica* (22.9%), *Paratrechina flavipes* (17.7%).
PT	*Lasius flavus* (68.2%).	*Myrmica ruginodis* (61.6%).
BA	*Myrmica lobicornis* var. *jessensis* (36.4%), *Formica fusca japonica* (27.3%).	*Formica fusca japonica* (38.1%), *Myrmica lobicornis* var. *jessensis* (18.5%).
BS	*Lasius flavus* (20.8%), *Myrmica lobicornis* var. *yessensis* (18.2%).	*Formica fusca japonica* (40.9%).
SH	*Formica truncorum yessensis* (42.9%).	*Formica truncorum yessensis* (63.9%).
Whole area	*Paratrechina flavipes* (26.1%), *Lasius alienus* (15.1%), *Myrmica ruginodis* (12.6%).	*Formica fusca japonica* (19.5%), *Lasius alienus* (15.7%), *Myrmica ruginodis* (14.9%), *Paratrechina flavipes* (12.8%).

The results by two procedures agree in general for each other as shown in Fig. 1, except for some discrepancies, especially in *Lasius flavus*, *L. umbratus*, *Solenopsis fugax* and *Formica fusca japonica*. The significance of these discrepancies will be referred to later.

Further characterization of ant assemblages in various habitats was performed by Motomura's law of geometric series, using the formula $\log y + ax = b$ (cited from Hayashida 1960). From the gradient shown in Fig. 2, the complexity degree of the assemblage in each habitat is: $BS > HG \gg WM \geq BA \fallingdotseq SH \fallingdotseq WD \fallingdotseq WC \gg PT$ by colony counting; $HG \geq BS \fallingdotseq BA \geq WM \geq WD \geq WC \gg PT \geq SH$ by individual sampling. The density degree is: $WD > WC \gg WM \gg BA \fallingdotseq HG \fallingdotseq PT > BS \fallingdotseq SH$ by colony counting; $SH \gg WD \geq BA \fallingdotseq BS \geq WM \geq WC \gg HG > PT$ by individual sampling. The results by two procedures agree in WD, WC, WM, HG and PT, but differ in BS, BA and SH. The possible cause of such difference will also be given later.

The similarity among various habitats was examined by using Renkonen's

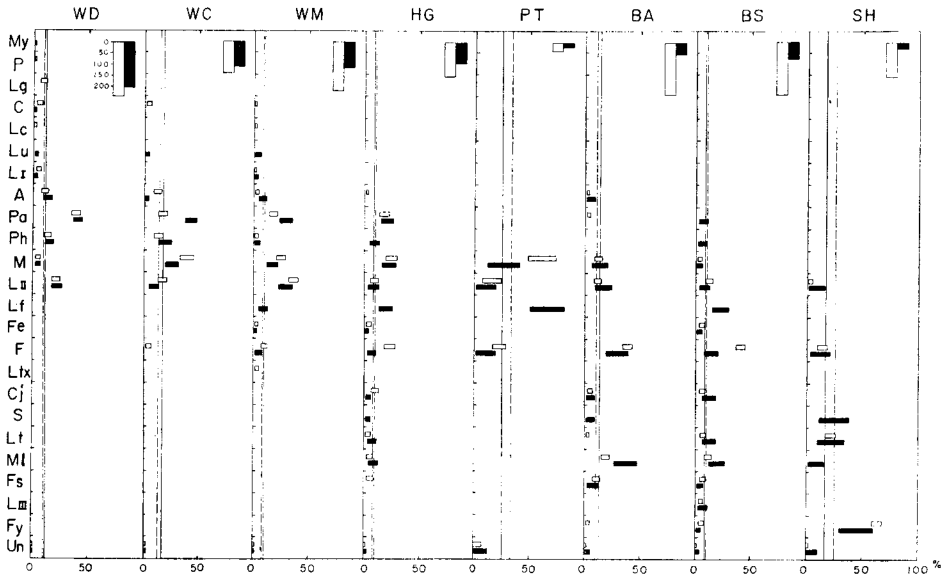

Fig. 1. Relative colony and individual abundance of various species and forms in different habitats. Scientific names are given by abbreviations in Table 1. Horizontal bars show the confidence interval (black, colony number; white, individual number). Vertical bars show the total number of colonies (black) and individuals (white) sampled. Vertical solid line means the ratio of mean colony number to the total colony number (broken line as to individual number).

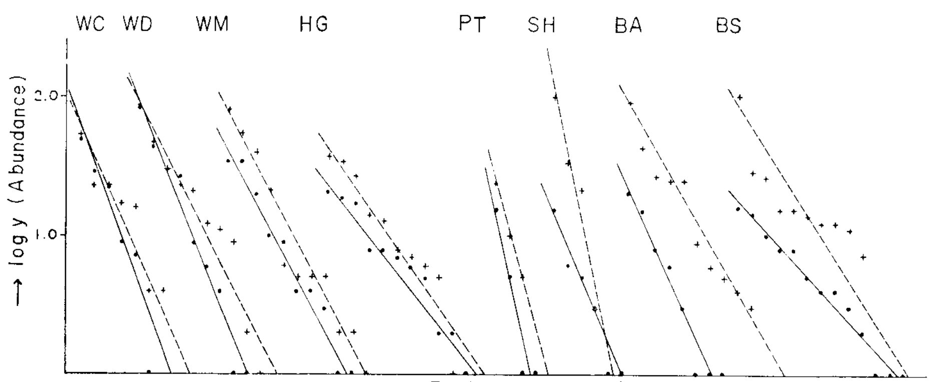

Fig. 2. Comparison of assemblage complexity in various habitats, studied by Motomura's law of geometric series. Scientific names are given by abbreviations in Table 1. Circles and solid lines, result from colony counting; crosses and broken lines, result from individual sampling.

index (cited from Aoki, 1962). Between two habitats concerned, the smaller percentage ratios of all species found in both habitats are summed up. This summed percentage ratio indicates the degree of similarity between two habitats, namely, a higher ratio indicates a closer similarity. The results, obtained from the data by colony counting, are shown in Fig. 3. Woodland habitats, WC, WD and WM, are very similar to each other, and differ from openland habitats except HG. While the similarity among openland habitats except HG is weak. In particular, SH has no particular similarity to other habitats.

2. *Habitat preference*: Some species apparently occur only in woodland or openland, nearly equally in certain habitat types classified in these. Also some others occur mainly in woodland or openland, and some others in almost all habitat types. The habitat preference of various species discovered in the area studied is classified into three types, woodland type, openland type and eurytopic type. The relatively abundant species are classified into these three types as follows: 1) Openland type-*Lasius flavus*, *Myrmica lobicornis* var. *jessensis*, *Formica fusca japonica*, *Leptothorax spinosior*, *Formica truncorum jessensis*, *Camponotus herculeanus japonicus*. 2) Woodland type-*Paratrechina flavipes*, *Pheidole fervida*, *Aphaenogaster symthiensi*, *Lasius umbratus*. 3) Eurytopic type-*Lasius alienus*, *Myrmica ruginodis*.

HG is inhabited by many species both of openland and woodland types. This fact may explain that this habitat is moderately similar to all other habitats in faunal make-up, as shown in Fig. 3.

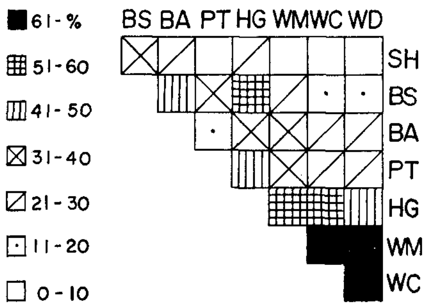

Fig. 3.

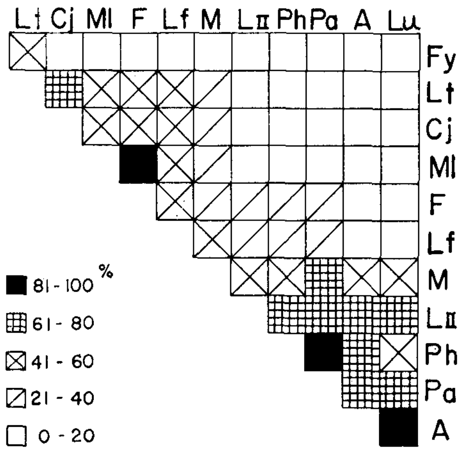

Fig. 4.

Fig. 3. Degree of similarity among various habitats in faunal make-up. Each degree is given by Renkonen's index.

Fig. 4. Degree of similarity among relatively abundant species and forms in habitat preference. Each degree is given by Renkonen's index. Scientific names are given by abbreviations in Table 1.

To examine the similarity in habitat preference between the species whose colonies were discovered more than ten, Renkonen's index used above was again applied, replacing the position of habitat by species. The result, shown in Fig. 4, indicates a strong similarity in the following three pairs: *Formica fusca japonica* and *Myrmica lobicornis* var. *jessensis*, *Paratrechina flavipes* and *Pheidole fervida*, *Lasius umbratus* and *Aphaenogaster smythiensi.* It is noteworthy that the strongest similarity was found in all cases between two species belonging to two different subfamilies, Formicinae and Myrmecinae. *Formica truncorum yessensis* occupies an isolate position from all other species except *Leptothroax spinosior.* But this isolation is perhaps due to the limited observations, as this species was recorded by Hayashida (1960) from various habitats, BS, BA, HG and WM.

3. *Specific diflerence in epigaeic activities*: As shown Table 1 and Fig. 1, there are some discrepancies in the results obtained by individual sampling and colony counting. *Paratrechina flavipes*, *Lasius alienus*, *Myrmica ruginodis* and *M. lobicornis* var. *jessensis*, especially *Formica fusca japonica* and *F. truncorum yessensis* are very abundant in comparison with the other species in individual sampling, whereas *Pheidole fervida* and *Aphaenogaster symthiensi* are less in individual smapling although abundant in colony counting. *Lasius flavus* and *L. umbratus* are also abundant in colony counting, but never obtained by individual sampling. This is apparently caused by the different modes of life. Strictly subterranean species such as *Lasius flavus*, *L. umbratus* and *Solenopsis fugax* may not be obtained by individual sampling, whereas the species, relatively large and making active epigaeic foraging, tend to be sampled more abundantly by individual sampling. *Formica fusca japonica* is the best example representing this type.

The number of dominant species in the individual sampling is relatively scarse in BA, BS and SH than in WD, WC, WM and HG (Fig. 1). It is also seen that dominant species in the individual sampling decidedly outnumber any other species in BS, BA and SH. Moreover the individual density is very high in comparison with the colony density in BS, BA and SH, and the complexity degree by individual sampling is remarkably low in comparison with that by colony counting in BS and SH (Fig. 2). These distribution patterns in BS, BA and SH may be explained mainly by strong epigaeic activities of a limited number of species, usually belonging to the genus *Formica* in the area studied. The epigaeic activities are, however, generally high in various species in these habitat types, perhaps, partly caused by the marked high soil temperature in these habitats, which, in turn, contributes to decrease the number of individuals active on the ground at daytime sampling of certain cryptobiotic species, such as *Paratrechina flavipes*, *Pheidole fervida*, etc.

The home range of some species was tentatively estimated by the formula, $(Q/C)\times(2\text{ m}\times5\text{ m})$, where Q is the number of quadrates in which one or more individuals of the concerned species was obtained, and C the total number of colonies of the same species obtained: *Formica truncorum yessensis* — 21.5 sq. m, *F. fusca* *japonica*–19.8 sq. m, *Camponotus herculeanus japonicus*–13.6 sq. m, *Myrmica ruginodis*—6.9 sq. m, *Lasius alienus*—5.9 sq. m, *Myrmica lobicornis* var. *jessensis*—5.6 sq. m, *Aphaenogaster smythiensi*—5.2 sq. m, *Leptothorax spinosior*—4.8 sq. m, *Pheidole fervida*—2.7 sq. m.

Tsuneki and Adachi (1957) measured the main foraging distance of certain ants: *Formica fusca japonica*—4～8 m, *Camponotus herculeanus japonicus*—3～5 m, *Tetramorium caespitum*—1～3 m, *Aphaenogaster famelica*—1～2 m. Yasuno (1965) recorded the size of territory of *Formica execta*—28 sq. m and *F. fusca japonica*—7.25 sq. m, but he noted the home range of the latter is remarkably larger than their territory. The result in the present study differs from those given above in the absolute values, but approximately agree in the order of relative size. Therefore, it is assumed that the estimation of home range by this method is useful as a basis for further observation of foraging behavior.

4. *Preliminary notes on the relative abundance of subterranean ants* (*sampled by Mr. H. Tamura*): The procedures so far mentioned, adopted either by Hayashida or by the present writer, are not appropriate to estimate the relative abundance of subterranean ant species. There is still no adequate unitary method which can estimate the relative abundance of both epigaeic and subterranean ants.[1]. Here the

Table 2. Number of soil blocks from which respective species was sampled (Number of total blocks 21 for each habitat)

Habitat		Herbaceous sandy field			Grassland			Pseudacasia wood			Elm wood			Japanese cedar wood			Total			
Number of individuals sampled		1	2～4	5～	1	2～4	5～	1	2～4	5～	1	2～4	5～	1	2～4	5～	1	2～4	5～	Total
Ant species sampled in abbreviations (*cf.* Table 1)	*P*							2	6	6	2	5	4		1	1	4	12	11	27
	Ap[2]							1									1			1
	Ph				1			2	3	1	2	5		1	3		6	11	1	18
	S		2	5														2	5	7
	M													1	2		1	2		3
	Ml	2															2			2
	Lt			2															2	2
	St[3]							3	2	2	1						4	2	2	8
	Pa							7	3		3	4	4	2			12	7	4	23
	F							1									1			1

1) Another difficulty may appear in southern districts by the increased number of arboreal species, which often outnumber epigaeic and subterranean species in certain habitats in tropical region (Sakagami, personal communciation).

2) *Amblyopone silvestrii* Wheeler. The species new to Hokkaido, except for the unpublished record by Dr. Sh. F. Sakagami from Oshoro by soil excavation.

3) *Stenamma nipponense* Yasumatsu et Murakami.

Table 3. Number of soil samples from which respective ant species was sampled (Number of total samples 105 for each soil layer). Ant species sampled in abbreviations (*cf.* Table 1)

Soil layer \ Species	*P*	*Ap*	*Ph*	*S*	*M*	*Ml*	*A*	*Lt*	*St*	*Pa*	*F*
Litter			9		3	1	1	1	5	17	
S 2	18		10	6	1	1		2	1	7	1
S 5	19		2	5				2	1	4	
S 10	10		2	3				1	1	5	
S 15	4	1	2	2					2	3	

data subsidiarily collected by Mr. H. Tamura in his study of the Collembolan fauna in and near Sappro are briefly referred to. Tamura (1967) sampled in 1965, many soil blocks of 10 cm sq. and 15 cm deep, from various habitats in and near Sapporo. Each block was subdivided vertically as follows: litter layer (L), soil of 0–2 cm (S2), 2-5 cm (S5), 5–10 cm(S10), 10–15 cm (S15) in depth. Among many soil invertebrates sampled by his survey, all ant specimens were generously offered by him to the present writer for study. The relative abundance of various species is given in Tables 2 and 3.

Among 11 species smapled by Tamura, *Amblyopone silvestrii* and *Stenamma nipponense* were not obtained by three procedures so far mentioned. The abundance of *Ponera japonica* and *Stenamma nipponense* in broadleaf woods and of *Solenopsis fugax* in herbaceous sandy field was very high (Table 2). Moreover, *Ponera japonica* and *Solenopsis fugax* were not obtained from the litter layers (Table 3). Apparently these strictly subterranean species are quite abundant in the area studied, at least as comparable as *Paratrechina flavipes* or *Pheidole fervida*, but rarely obtained by the three procedures, developed for epigaeic ant species.[1]

Concluding remarks

In the present study, the ecological distribution of ants in Sapporo and the vicinity was re-studied by using the method different from the 30 minutes unit-interval sampling adopted by Hayashida (1960) in the previous survey of the same area. The method in the present study consists of two procedures, sampling of individuals during five minutes and counting of colonies, both within definite quadrates. The results obtained by these two procedures are different for each other in some aspects, and also from those obtained by Hayashida. The

1) This does not mean, however, they never leave the soil. Munakata, (personal communciation), captured a considerable number of *Ponera japonica* frequenting honeybee hives in Hakodate.

establishment of a reliable standarized method is indispensable for further studies of ecological distribution, which is basic to any special work in myrmecology. Therefore, here some differences by different procedures are briefly discussed.

At first, the two procedures adopted in the present study are compared. Each procedure has its own merits and defects. The merits involved in colony counting are as follows: 1) Nearly all species inhabiting a given quadrate can be counted, except some strictly subterranean species as mentioned in results, section 4. 2) The density of colonies per definite area can be calculated. The important defect is apparently that it takes too much time per sample. The procedure of individual sampling can be performed without taking much time. But it can not show the true assemblage structure. As seen in Fig. 1, the subterranean species, such as *Lasius flavus*, *L. umbratus* and *Solenopsis fugax*, are not obtained, and relative abundance among various species is decidedly unilateral, in favor of the species with large size, conspicuous appearance and marked epigaeic activities, such as *Formica fusca japonica* and *F. truncorum yessensis*. Therefore, the unbiassed picture of assemblage structure may be obtained only by colony counting, based upon numerous plots, however it takes much time. But individual sampling is useful to have a first approximation to the faunal make-up quickly, especially as far as epigaeic species are concerned.

The dominant species obtained by two procedures are given in the descending order of relative abundance:

Colony counting: $Pa \gg La > M > Ph > Lf > A \fallingdotseq Ml \geqq F > Lt \geqq Fy$

Individual sampling: $F \gg La > M \gg Pa \gg Fy \gg Ml > Lt \geqq Ph \geqq A = Fs$.

Nextly the procedure of colony counting per unit area is compared to the 30 minutes unit-interval sampling by Hayashida. Although the writer is less experienced than Hayashida, he spent 30–60 minutes to survey each quadrate, namely $(30\sim60)\times25=750\sim1500$ minutes per habitat, whereas Hayashida spent $30\times20=600$ minutes per habitat. The number of species and colonies discovered by the writer from 7 habitats, BS, BA, SH, PT, HG, WM and WD, was 19 species and 604 colonies, less than those obtained by Hayashida, 26 species and 1488 colonies. The species collected by Hayashida, but not by the present writer are *Tetramorium caespitum*, *Crematogaster laboriosa*, *Vollenhovia emeryi*, *Dolichoderus quadripunctatus sibiricus*, *Camponotus yessensis*, *C. caryae quadrinotatus*, *Lasius fuliginosus*, *L. spathepus* and *Ponera japonica* whereas the species collected by the present study, but not by Hayashida (1960) are only *Solenopsis fugax* and *Formica execta fukaii*. It is noticeable that some species such as *Lasius fuliginosus*, which are not rare but distributed in patches, were not obtained in the present study.

As given above, some noticeable differences are recognized as to the relative abundance of various species between these two procedures. The relatively abundant genera obtained by these two procedures are shown below, with the percentage ratio of the colony number of each genus to the total colony number in parentheses:

	Colony counting per unit area		30 minutes unit-interval sampling	
1.	*Lasius*	(29.5)	*Lasius*	(29.8)
2.	*Paratrechina*	(23.2)	*Formica*	(20.4)
3.	*Myrmica*	(15.7)	*Myrmica*	(17.7)
4.	*Formica*	(9.8)	*Paratrechina*	(7.6)
5.	*Pheidole*	(7.3)	*Camponotus*	(6.7)
6.	*Aphaenogaster*	(6.1)	*Pheidole*	(5.5)
7.	*Leptothorax*	(3.1)	*Aphaenogaster*	(5.3)
8.	*Camponotus*	(2.0)	*Leptothorax*	(1.9)

Among the differences in various genera, those in *Formica*, *Paratrechina* and *Camponotus* are remarkable. The same difference can be shown by the comparison of ten dominant species:

	Colony counting per unit area		30 minutes unit-interval sampling	
1.	*Paratrechina flavipes*	(23.2)	*Formica fusca japonica*	(15.6)
2.	*Lasius alienus*	(16.5)	*Lasius niger*[1)]	(14.2)
3.	*Myrmica ruginodis*	(10.3)	*Myrmica lobicornis* var. *jessensis*	(10.8)
4.	*Lasius flavus*	(8.8)	*Paratrechina flavipes*	(7.7)
5.	*Pheidole fervida*	(7.3)	*Lasius flavus*	(7.7)
6.	*Myrmica lobicornis* var. *jessensis*	(7.1)	*Myrmica ruginodis*	(6.2)
7.	*Formica fusca japonica*	(6.3)	*Pheidole fervida*	(5.5)
8.	*Aphaenogaster smythiensi*	(6.1)	*Aphaenogaster famelica*[2)]	(5.5)
9.	*Leptothorax spinosior*	(3.1)	*Camponotus herculeanus japonicus*	(3.5)
10.	*Formica truncorum yessensis*	(2.2)	*Formica truncorum yessensis*	(3.4)

Obviously the difference is caused by the difference in the chance of discovery which depends on the life form of various species. As mentioned by Hayashida (1960), the defect of 30 minutes unit-interval sampling exists in a biased estimation for relative abundance caused by such specific difference in the chance of discovery. Generally the species conspicuous in body size, epigaeic activity, and colony size are much more sampled in 30 minutes unit-interval sampling. Nevertheless this method is useful to obtain a general perspective of myrmecofauna, both qualitatively and quantitatively, in a given habitat when the available time for study is limited. Moreover, further studies might discover the method of converting the result obtained by one procedure in terms of the other, when some definite relations between the results by two procedures would be established.

It is concluded, therefore: 1) Individual sampling during five minutes is useful

1) See in Table 1.
2) See in Table 1.

to obtain a first approximation to the faunal make-up, especially of epigaeic species, quickly. 2) 30 minutes unit-interval sampling is useful to obtain the relative abundance in relation to local and ecological difference of habitats as well as some ecological characteristics of each species, when the available time for study is limited. 3) Colony counting per unit area is useful to obtain the unbiased colony density of various species, which is basic to further detailed analysis. 4) Further comparative studies using various procedures are required in order to establish a reliable and standardized procedure.

Summary

The ecological distribution of ant in Sapporo and the vicinity was re-studied as a continuation of the work by Hayashida (1960), adopting his classification of habitat types, while using different sampling procedures: individual sampling during five minutes and colony counting in 2 m × 5 m quadrates. 19 forms belonging to 11 genera were collected in the area studied, among then *Paratrechina flavipes, Lasius alienus, Myrmica ruginodis, Pheidole fervida, Lasius flavus, Aphaenogaster symthiensi, Myrmica lobicornis* var. *jessensis* and *Formica fusca japonica* were relatively abundant, occupying 88.6% of the total colony number discovered. The results by two procedures agree in general for each other as to the relative abundance of various forms, but show some discrepancies, especially as to *Lasius flavus, L. umbratus, Solenopsis fugax* and *Formica fusca japonica,* apparently reflecting the difference in the modes of life. The results by two procedures agree for each other in the woodlands, but not in openlands, especially in sandy area. This may be explained mainly by the marked epigaeic activities of a few species, *Formica fusca japonica* and *F. truncorum yessensis,* and high soil temperature in daytime inhibiting activities of some cryptobiotic species. A marked similarity in habitat preference is recognized in the following pairs: *Formica fusca japonica* and *Myrmica lobicornis* var. *jessensis, Paıatrechina flavipes* and *Pheidole fervida,* and *Lasius umbratus* and *Aphaenogaster smythiensi.* Between the results by Hayashida (1960) and by the colony counting in the present study, the relative abundance of *Paratrechina flavipes, Formica fusca japonica* and *Camponotus herculeanus japonicus* is conspicuously different for each other. The data, offered by Mr. Tamura, shows the abundance of *Ponera japonica, Solenopsis fugax* and *Stenamma nipponense* in the area studied, and inefficacy of the method in the present study and that by Hayashida to make unbiased sampling of these strictly subterranean species.

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