Preliminary Survey on the Relationship between Oribatid Mites and the Decomposition of Fresh Leaves (Acarina : Oribatidae)

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The succession of the oribatid fauna during decomposition process of fresh leaves was investigated. On the 4th of June, 1969, healthy fresh green leaves were picked from three kinds of plants, namely, needles (*Abies sachalinensis*), broad-leaves (*Acer mono* and *Quercus crispula*), and sasa (*Sasa paniculata*). The survey was done on the 9th of August, 1969, on the 22nd of September, 1969, on the 24th of January, and on the 4th of June, 1970. All kinds of leaves were prepared with and without *p*-dichlorobenzene.

The changes in dry weight of the leaves without insecticide were more or less steepened as compared with that of the leaves with insecticide. In all, 781 adult oribatid mites representing 40 species were collected. Nine of the 40 oribatid species were common to both with and without insecticide all of kinds of leaves examined. Of these nine species, *Oppia nova*, Damaeidae sp. and *Steganacarus striculus* were regarded as dominant species and the dominance varied among the kinds of leaves or seasons. The total number of species captured is 30 in needles, 26 in broad-leaves and 32 in sasa.

INTRODUCTION

Most oribatid mites are thought to be feeders on fungi or plant materials. Their feeding preference is frequently related to the stage of decomposition of the plant materials (HARTENSTEIN, 1962; HAYES, 1963, etc.), and their feeding rate and habits may not be constant throughout the life cycle (WALLWORK, 1967).

In Japan, very little is known on the details of biology and ecology of these mites. The purpose of the present paper is to investigate the succession of the oribatid fauna during decomposition process of fresh leaves. Other arthropod groups were also taken into consideration, but in less detail.

MATERIALS AND METHODS

The experiment was carried out at station No. 4 in the natural mixed stand of broad-leaves and coniferous trees. This station had been adequately reported in the previous paper (NAKAMURA *et al.*, 1970) and hence further discussion is omitted. This stand consists of *Abies sachalinensis* (FR. SCHM.) MASTERS, *Picea jezoensis* (SIEBOLD *et* ZUCCARINI) CARRIERE, *Acer mono* MAKINO, and *Quercus crispula* BLUME. *Sasa paniculata* MAKINO *et* SHIBATA is most predominant of all ground vegetations. The stand is located at about 495 m above sea level. Soil profile shows Bd type, with LFH horizon (4–5 cm in thickness) and A horizon (12–14 cm in thickness).

To prepare the experiment, healthy fresh green leaves were picked from different kinds of plants on the 4th of June, 1969. These leaves were placed in net bags (8 cm $\times$ 12 cm) of 'Kulemona' with a 12-mesh screen. This mesh size was used to prevent invasion of macrofauna into the net bags.

Bag N: 10 g in fresh weight of needles, *Abies sachalinensis*,

Bag M: a mixture of three leaves each of *Acer mono* and *Quercus crispula*,

Bag S: five leaves of sasa, *Sasa paniculata*.

KURCEVA (1960) used naphthalene to suppress animal populations. In the present work, *p*-dichlorobenzene was used to exclude meso-soil-animals from the net bags, and 5 g of *p*-dichlorobenzene (P) was inserted into the another series of the above mentioned three different bags. Twenty sets (one set comprising six different kinds of bags, namely, N, S, M, N+P, S+P, and M+P) were prepared. Number of the net bags reached a total of 120.

In every one of 5 plots (2 $\times$ 5 m²) arranged at intervals of 3 m in the forest, five sets of six bags were prepared. Each of the sets was arranged at intervals of 1 m and placed on the forest floor where the litter were removed. After the placement of the bags on the soil surface, they were covered with the removed litter.

The following four dates of sampling were decided on the basis of the average meteorological data during a period of 20 years, from 1948 to 1967 inclusive, at Sapporo (cf. FUJIKAWA, 1970a): the first sampling was done on the 9th of August, 1969 in summer (66 days after the beginning of experiment), the second sampling on the 22nd of September, 1969 in middle autumn (110 days after), the third sampling on the 24th of January, 1970 in middle winter (234 days after), and the last sampling on the 4th of June, 1970 in middle spring (just one year after the beginning of experiment). At every sampling time a set containing 6 bags, namely N, S, M, N+P, S+P, and M+P, was collected from each plot. Each bag was put into a separate polyethylene bag for transportation to the laboratory. Before extraction, the remaining *p*-dichlorobenzene was removed from the net bags, wet weights of net bags were measured, and they were placed in the modified Tullgren apparatus (FUJIKAWA, 1970b). After 5 days the lights (50 W bulbs) were turned off, and all leaves were examined for the presence of non-extracted animals under a dissecting microscope of about 20–30 times magnification power. They were then dried at 110°C for 24 hrs and their dry weights were measured.

RESULTS AND DISCUSSION

Loss in weight of leaves

Fig. 1 presents the percentage of loss in weight of leaves and *p*-dichlorobenzene during one year, the average of five measurements being shown. The changes in dry weight of the leaves without insecticide were more or less steepened as compared with that of leaves with insecticide, although the difference between them was not significant except for sasa removed on the 9th of August, 1969.

Among the three kinds of vegetations, the percentage loss of the broad-leaves was remarkably large in the first sampling. At this time, fungi growth was well developed over the surface of all leaves. Such a phenomenon, however, could not be seen at the next sampling, but the broad-leaves were changed in structure as well as in colour. After one year, only nerves of the broad-leaves remained in the net bags.

Fig. 1. Percentage of disappearance of *p*-dichlorobenzene and dry weight of leaves (mean $\pm$ 95% confidence limits).

Inserted *p*-dichlorobenzene in needle and broad-leaf bags was thoroughly sublimed till middle winter. On the contrary, that in sasa bag still remained in the state of a crystal at that time.

Mesofauna

From 120 net bags containing three kinds of leaves, a total of 3,785 arthropods and a small number of Enchytraeidae were obtained as shown in Table 1. Oribatid species counts refer to adults only, because the accurate identification of the immature stage is virtually impossible. The immature stages of oribatids were assessed separately.

The animals collected were grouped into six components and seasonal changes in

Table 1. INDIVIDUAL NUMBERS OF ORIBATID SPECIES AND OTHER GROUPS ENCOUNTERED

Species	Needles		Broad-leaves		Sasa	
	with insecti- cide	without insecti- cide	with insecti- cide	without insecti- cide	with insecti- cide	without insecti- cide
OR: Adults of Oribatei						
Ac: <i>Achipteria curta</i> AOKI, 1970	5	6	0	3	3	0
Cb: <i>Ceratoppia bipilis</i> (HERMANN, 1804)	3	12	1	2	1	2
Ce: <i>Cepheus latus</i> (C. L. KOCH, 1836)	0	5	0	0	0	0
Cl: <i>Camisia lapponica</i> (TRÄGÅRDH, 1910)	1	0	0	0	1	0
Cm: <i>Ceratozetes mediocris</i> BERLESE, 1908	2	0	1	2	2	4
Cp: <i>Chamobates pusillus</i> (BERLESE, 1895)	1	2	2	0	1	1
Ds: Damaeidae sp.	16	24	8	15	14	43
Ec: <i>Eupelops claviger</i> (BERLESE, 1916)	11	30	1	2	4	14
Eg: <i>Eohypochthonius gracilis</i> (JACOT, 1936)	0	0	0	1	0	0
Ej: <i>Eremobelba japonica</i> AOKI, 1959	0	11	0	5	0	6
Ep: <i>Eporibatula</i> sp.	0	0	0	0	1	0
Et: <i>Eremaeus tenuisetiger</i> AOKI, 1970	6	3	0	1	0	1
Gm: <i>Gustavia microcephala</i> (NICOLET, 1855)	0	1	2	0	1	5
Hm: <i>Hypochthoniella minutissima</i> BERLESE, 1904	6	8	11	8	1	23
Hr: <i>Hypochthonius rufulus</i> C. L. KOCH, 1836	0	0	2	1	0	1
Jt: <i>Jugatala tuberosa</i> EWING, 1913	0	0	0	0	0	1
La: <i>Liacarus acutidens</i> AOKI, 1965	1	2	3	0	0	1
Lc: <i>Liacarus contiguus</i> AOKI, 1969	0	0	1	0	0	0
Ls: Lioididae sp.	0	0	1	0	0	0
Mp: <i>Malacothonrus pygmaeus</i> AOKI, 1969	0	0	0	0	0	2
Ms: Metrioppiidae sp.	12	29	3	2	3	6
Mu: <i>Multioppia</i> sp.	0	0	0	0	0	2
My: <i>Mycobates parmelliae</i> (MICHAEL, 1884)	0	0	0	0	0	2
Na: <i>Neoribates aurantiacus</i> (OUDEMANS, 1914)	2	0	0	0	0	1
Nb: <i>Nothrus biciliatus</i> C. L. KOCH, 1844	2	1	0	0	1	0
Nn: <i>Nanhermannia nana</i> (NICOLET, 1855)	1	4	3	2	2	0
Ob: <i>Oribotritia berlessei</i> (MICHAEL, 1898)	2	4	0	2	0	0
On: <i>Oppia nova</i> (OUDEMANS, 1902)	14	60	14	13	39	18
Pc: <i>Platynothrus capillatus</i> (BERLESE, 1914)	0	3	0	0	0	2
Ps: <i>Phthiracarus</i> sp.	2	7	0	0	2	0
Py: <i>Platynothrus yamasakii</i> (AOKI, 1958)	9	10	1	1	2	0
Qq: <i>Quadroppia quadricarinata</i> (MICHAEL, 1880)	0	1	0	1	0	0
Ra: <i>Rhyssotritia ardua</i> (C. L. KOCH, 1841)	2	0	0	0	1	0
Sd: <i>Sphodrocephus</i> sp.	0	2	0	0	0	0
Sl: <i>Scheloribates latipes</i> (C. L. KOCH, 1841)	3	1	1	1	0	3
Ss: <i>Steganacarus striculus</i> (C. L. KOCH, 1836)	5	30	1	16	6	7
Su: <i>Suctobelba</i> sp.	0	1	1	0	0	0
Tj: <i>Trhypochthonius japonicus</i> AOKI, 1970	0	0	0	0	0	1
Tv: <i>Tectocephus velatus</i> MICHAEL, 1880	3	6	1	10	5	8
Uc: <i>Unguizetes clavatus</i> AOKI, 1967	3	9	3	1	2	1
Other animals						
AR: Araneae	0	3	0	1	0	3
CH: Chilopoda	1	2	1	0	2	0
CO: Collembola	224	363	158	134	272	427
DI: Diptera larva	0	0	0	0	0	122
EN: Enchytraeidae	6	11	3	2	5	8
FO: Formicidae	5	1	0	1	0	7
IN: Other Insecta	17	33	5	5	12	6
ME: Mesostigmata	106	450	45	127	52	178
NY: Nymph of Oribatei	36	63	13	35	31	51
PS: Pseudoscorpiones	1	7	0	2	0	2

The abbreviated words are used in Figs. 2-5, and Tables 2-4.

Fig. 2. Percentage distribution of six components of mesofauna.

their percentage distribution is shown in Fig. 2. The six components were (1) adults of Oribatei, (2) nymphs of Oribatei, (3) Mesostigmata, (4) Collembola, (5) other Insecta including Diptera larvae, Formicidae and others (cf. Table 1) and (6) other animals including Araneae, Chilopoda, Enchytraeidae and Pseudoscorpiones (cf. Table 1). At the first sampling, the population was dominated by Collembola in all the leaves, except for needles and broad-leaves without insecticide, and they amounted to 63–75% of the total number of animals encountered. After that, however, Acarina, namely, nymphs and adults of Oribatei, and Mesostigmata dominated in most of the cases, except at the last sampling of sasa without insecticide, when the most numerous group was the larvae of Diptera, which amounted to 44% of the animals. Except for the first sampling, the percentage of adults of Oribatei was almost constant. On the contrary, the percentage of nymphs of Oribatei as well as Mesostigmata was not constant, that is, the former showed the highest population at the third sampling (24, January) in the leaves without insecticide, while the latter also showed up at the third

Table 2. F-VALUES FOR DIFFERENCES AMONG SEASONS

Group	Needles		Broad-leaves		Sasa	
	with insecticide	without insecticide	with insecticide	without insecticide	with insecticide	without insecticide
OR	3.29**	0.80	1.33	2.63*	1.93	2.23
NY	0.77	0.64	2.97*	1.26	0.24	0.99
ME	4.37**	0.75	1.58	2.25	7.02**	1.58
CO	1.31	5.94**	4.58**	4.86**	17.53**	6.48**

Degrees of freedom: $n_1=3$, $n_2=19$.Levels of significance indicated thus: ** $P=0.05$, * $P=0.10$.

Table 3. F-VALUES FOR DIFFERENCES AMONG THREE KINDS OF LEAVES

Group	with insecticide				without insecticide			
	9th Aug. 1969	22nd Sept. 1969	24th Jan. 1970	4th Jun. 1970	9th Aug. 1969	22nd Sept. 1969	24th Jan. 1970	4th Jan. 1970
OR	4.84**	0.58	1.46	1.50	1.07	5.01**	1.89	2.37
NY	0.48	2.23	0.22	1.09	0.87	2.17	0.41	0.54
ME	0.43	1.00	4.09	1.47	0.11	5.56**	4.78**	5.91**
CO	3.19*	1.03	0.96	1.60	6.98**	2.50	4.06*	3.64*

Degrees of freedom:

n_1	2	2	2	2	2	2	2	2
n_2	8	8	6	10	8	8	10	6

Levels of significance indicated thus: ** $P=0.05$, * $P=0.10$.Table 4. TEST OF t FOR DIFFERENCE BETWEEN THE LEAVES WITH AND WITHOUT INSECTICIDE (p -DICHLOROBENZENE)

Group	Needles				Broad-leaves				Sasa			
	9th Aug. 1969	22nd Sept. 1969	24th Jan. 1970	4th Jun. 1970	9th Aug. 1969	22nd Sept. 1969	24th Jan. 1970	4th Jun. 1970	9th Aug. 1969	22nd Sept. 1969	24th Jan. 1970	4th Jun. 1970
OR	++	—	—	—	+	—	—	—	—	—	—	—
NY	—	—	—	—	—	—	—	—	—	—	—	—
ME	++	++	—	—	—	—	—	—	—	++	—	—
CO	—	—	—	—	—	—	—	—	—	—	—	—

Levels of significance indicated thus: ++; $P=0.05$, +; $P=0.10$.

sampling but in the leaves with insecticide.

The seasonal, vegetational, and experimental dispersions of these groups of Collembola, Mesostigmata, nymphs and adults of Oribatei were also examined statistically, and the results are as summarized in Tables 2–4. The difference between the leaves with and without insecticide is significant only in oribatid adults (9, August of needles and broad-leaves) and Mesostigmata (9, August of needles, and 22, September of needles and sasa).

Oribatid mites

In all, 781 adult oribatid mites representing 40 species were collected. The

Fig. 3. Occurrence probability of all species found from needles. (—: with insecticide; ---: without insecticide; 90% confidence limits.) The vertical line means the reciprocal of the number of species captured.

Fig. 4. Occurrence probability of all species found from broad-leaves. (—: with insecticide; ---: without insecticide; 90% confidence limits.)

Fig. 5. Occurrence probability of all species found from sasa.
(—: with insecticide; ---: without insecticide; 90% confidence limit.)

number of individuals of these species were converted to percentage ratios and are shown in Figs. 3, 4 and 5, applying the occurrence probability method of KATO, MATSUDA and YAMASHITA (1952). In the figure, the percentage ratio of each species is given by horizontal bars, the length of which shows the confidence interval at 90 percent reliability. The vertical line means the reciprocal of the number of species captured. The species, the lower confidence limit of which exceeds this line, can be regarded as dominant species. Table 1 shows that the following nine of the 40 species listed were common to both with and without insecticide of all kinds of leaves examined: *Ceratopopia bipilis*, *Damaeidae* sp., *Eupelops claviger*, *Hypochthoniella minutissima*, *Metrioppiidae* sp., *Oppia nova*, *Steganacarus striculus*, *Tectocephus velatus* and *Unguizetes clavatus*. Of these nine species, as suggested in Figs. 3–5, *Oppia nova*, *Damaeidae* sp. and *Steganacarus striculus* were regarded as dominant species and the dominance varied among the kinds of leaves or seasons. On the contrary, *Cepheus latus* and *Sphodrocephus* sp. were rare and captured only in needles without insecticide; *Eohypochthonius gracilis*, *Liaccarus contiguus* and *Lioididae* sp. in broad-leaves with and without insecticide; *Eporibatula* sp., *Jugatala tuberosa*, *Malaconothrus pygmaeus*, *Multioppia* sp., *Mycobates parmelliae*, *Trhypochthonius japonicus* in sasa with and without insecticide, respectively. The total number of species captured is 30 in needles, 26 in broad-leaves and 32 in sasa, respectively.

Table 1 and Figs. 3–5 also show the difference between the leaves with and without insecticide. Eleven species were captured only in the leaves without insecticide, while 5 other species were found only in the leaves with insecticide. The difference between

the leaves with and without insecticide is significant in *Eremaeus tenuisetiger* (22, September), *Platynothrus yamasakii* and *Oppia nova* (24, January) of needles; in *Liacarus acutidens* (22, September) and *Steganacarus striculus* (4, June) of broad-leaves; in *Oppia nova* (9, August and 22, September), *Damaeidae* sp. (9, August) and *Hypochthoniella minutissima* (4, June) of sasa.

The degrees of similarity in habitats of meso-animal group and oribatid species (cf. Table 1) were confirmed by Agrell's index. The high degrees of similarity were found in the following combinations in needles and sasa without insecticide; the 85% or 75% values of index between Collembola and Mesostigmata; 70% or 55% between Collembola and oribatid nymphs; 75% or 55% between Mesostigmata and oribatid nymphs; 55% between Collembola and *Damaeidae* sp., between Mesostigmata and *Damaeidae* sp., and between Mesostigmata and larvae of Insecta.

The technique adopted in the present work is not sufficient and some unsolved problems remain and these are; (1) The green leaves picked from trees were used in place of litter. There seems to be a difference in quality between green leaves picked from trees and fallen leaves (BURGES, 1967), and this difference seems to affect the succession of fauna. (2) The litter required by soil animals as their food, habitat and for other necessities of their living, composed of various materials, for example fallen leaves, branches, stems, fruits or flowers, etc. (WALLWORK, 1967). The present results, using only leaves, give only partial information of the role of soil animals.

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