Drosophila Survey of Hokkaido, XXX.

Microdistribution and Seasonal Fluctuations of Drosophilid Flies Dwelling among the Undergrowth Plants

By

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(With 3 Text-figures and 3 Tables)

Drosophilid flies dwelling among the undergrowth plants in forests or groves have been studied by previous investigators. Suzuki (1955) and Momma (1965b) observed the population constitution of such flies in the colonies of some different plants by the use of net sweeping in the Botanical Garden of Hokkaido University, Sapporo. They reported that most of the abundant species among the undergrowth plants were found to be rare species in trapped populations.

Breeding sites of some drosophilid species have been reported by several investigators. Some species of *Scaptomyza* are leaf-miners (Frost 1924); some flies belonging to *quinaria* species group breed on decaying water plants (Spencer 1942); and some Hawaiian *Drosophila* and *Scaptomyza* breed on decaying vegetations such as fallen leaves, grasses, stems, fungi, small fruits or fallen flowers (Heed 1968). Pipkin (1965) showed that neotropical ground-feeding *Drosophila* breed on various kinds of fallen fruits, and discussed population size in connection with their feeding and breeding habits. Momma (1965b) referred to the possibility that the flies dwelling among the undergrowth plants breed on leaf-mold. The present author has observed drosophilid flies dwelling among the undergrowth plants in and near Sapporo from 1972. The present paper deals with microdistribution and seasonal fluctuations of these flies with reference to their breeding sites.

Before going further, the author wishes to express his cordial thanks to Prof. Eizi Momma for his pertinent guidance in the course of this study and his reading of the manuscript. He is also grateful to Messrs. Masanori J. Toda and Katsura Beppu for their kind advice, and further to the Sapporo Meteorological Observatory for offering the meteorological data.

Area surveyed

The survey was made at three areas in and near Sapporo, the campus of Hokkaido University (UC), the University Botanical Garden (BG), and the Nopporo Natural Forest (NF). The original vegetation of these areas formed a forest of deciduous broad leaved trees admixed with a few coniferous trees. As UC and BG are situated in the central parts of Sapporo city, the original vegetation is left only in patches as groves, and is affected and modified by human activity extremely. NF is situated about 20 km east of the center of Sapporo. The original vegetation is preserved wide and is unaffected by human activity due to government protection.

Mean temperature and rainfall in Sapporo from 1972 to 1974 are shown in Fig. 1.

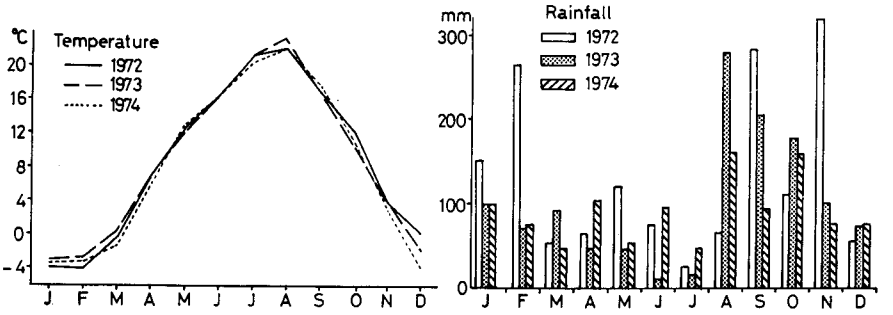

Fig. 1. Mean temperature and rainfall at Sapporo from 1972 to 1974.

Methods

Survey of Breeding sites: With a view to investigating breeding sites of drosophilid flies dewelling among undergrowth plants, various materials suspected to contain larvae or eggs were collected in the field and transported to the laboratory in polyethylene sacks. In order to identify the species of the specimens breeding on these materials, the larvae were cultured to grow into adults, since the identification of species in larval stage is either very difficult or impossible. The culture was carried out by settling these materials in milk bottles which contained a clump of tissue paper at the bottom and were plugged by cotton. The tissue paper at the bottom absorbed water and was used to save the larvae from drowning. These bottles were stored at room temperature (18°c-24°c).

Periodical collections: Periodical collections were made by net sweeping for the study of microdistribution and seasonal fluctuations of adult flies among the undergrowth plants. Two collecting stations (UCA and UCB) in UC and three stations (BGA, BGB, and BGC) in BG were located on the floor of the groves, and one station (BGL) was on the lawn in BG. Two stations (NFA and NFB) in NF were located on the floor of the forest along the streams, since the vegetation

along streams is very rich and complex. Each collecting station which occupied about 10 m×10 m was located on the undergrowth plants. The main vegetation and its phenology at each station are shown in Table 1.

Table 1. Main undergrowth plants at the collecting stations and their phenology. ⫲ dominant, ⫩ abundant, + common

Collecting station	UCA	UCB	BGA	BGB	BGC	BGL	NFA	NFB	Phenology
Anemone raddeana	⫲	⫲							IV-VI
Lamium album var. *barbatum*	⫲	⫩	+	+					VI-VII
Gynostemma pentaphyllum	⫲	+					+	+	VII-X
Cardamine leucantha	⫩	⫩					+	+	VI-IX
Pachysandra terminalis	⫩	⫩					⫩	⫩	IV-XI
Sasa senanensis	⫩	⫩		⫩	⫩		⫩	⫩	IV-VI
Trillium kamtschaticum	+	+	+	+	+				IV-VII
Viola sp.		⫲							IV-X
Gagea lutea	+	⫩	+	+	+				IV-VI
Anemone flaccida			⫲	+				+	IV-VI
Osmorhiza aristata	+	+	⫩	+			+	+	IV-VIII
Anthriscus sylvestris			⫩	+	⫲				IV-VIII, X
Cryptotaenia japonica			⫩	⫩			⫲		VI-X
Thladiantha dubia			⫩		⫲				VIII-X
Heracleum dulce	+	+	+	⫲	⫲				V-VIII
Lilium cordatum var. *glehni*	+	+	+	⫩	⫩		+	+	V-IX
Polygonum filiforme			+	+					VI-X
Trifolium repens						⫲			IV-X
Poa pratensis						⫲			IV-XI
Drypteris crassirhizoma	+	+	+	+	+		⫲	⫲	V-X
Polygonum thunbergii							⫲		VI-X
Sanicula chinensis	+	+	+				⫩		VI-X
Laportea bulbifera							⫩	+	VI-X
Corydalis ambigua var. *glabra*	+	+	+				+	⫩	IV-VI
Smilacina japonica			+				+	⫩	V-X
Petasites japonicus var. *gigantes*							+	+	V-X
Cacalia hastata var. *orientalis*		+					+	+	VI-IX
Cacalia auriculata var. *kamtschatica*							+	+	V-X
Crisium kamtschaticum	+	+					+	+	VI-IX
Impatiens noli-tangere	+	+					+		VI-X
Maianthemum dilatatum							+	+	V-X

Collections were made at UCA and UCB in 1972, at all stations in 1973, and at UCA, UCB, NFA, and NFB in 1974.

The net sweeping was carried out on the undergrowth plants randomly in each collecting station, and specimens collected were transferred to a vial containing Kahle's solution with a drawing pipe. The net used was 36 cm in diameter and the shaft was 120 cm long. The frequency of collection was once in the beginning

of each month from May to October. The number of sweeps at each collection was 400 in one direction. The collections at UCA and UCB in 1972 were made hourly, from sunrise to sunset. Other collections were made all at once in the afternoon.

Results and Discussions

1: *Breeding sites*

A total of 956 individuals representing 12 species bred on the decaying leaves and stalks of nine species of plants as shown in Table 2.

Table 2. Number of drosophilid flies reared from nine species of plants.

plant species	A	B		C	D	E		F		G	H	I	Total
collecting area	NF	BG	UC	BG	BG	BG	NF	BG	NF	NF	NF	NF	
Collecting month	VI	VII	IX	V,VI	V,VI	V,VI	VI	VI	VI	VI	VI	VI	
Scaptomyza pallida	44	6	2	70	74	310	2	1	-	-	-	-	509
S. consimilis	-	-	-	-	-	3	-	-	-	-	-	-	3
S. okadai	-	-	-	1	1	1	-	-	-	-	-	-	3
Drosophila collinella	-	-	-	-	2	5	1	1	-	-	-	-	9
D. mommai	-	-	-	-	-	-	1	-	-	-	-	-	1
D. nipponica	-	-	-	8	28	9	-	8	1	-	-	2	56
D. magnipectinata	-	-	-	1	1	4	5	-	-	1	3	-	15
D. auraria	-	-	-	-	-	34	-	-	-	-	-	-	34
D. nigromaculata	24	-	-	60	54	109	-	1	-	1	-	1	250
D. brachynephros	-	-	-	-	5	-	-	-	-	-	-	-	5
D. testacea	1	-	-	8	12	32	-	1	-	-	-	-	54
D. tenuicauda	-	-	-	-	-	-	-	-	-	2	15	-	17
Total	69	6	2	148	177	467	9	12	1	4	18	3	956

A: *Petasites japonicus*, B: *Trifolium repens*, C: *Heracleum dulce*, D: *Anthriscus sylvestris*, E: *Anemone flaccida*, F: *Lilium cordatum glehni*, G; *Smilacina japonica*, H: *Trillium* sp., I: *Maianthemum dilatatum*.

Scaptomyza pallida was found in six kinds of plants, constituting about 50% of the total number of flies. Frost (1924) reported this species as a leaf-miner, and Okada (1968) suggested that the species has bred on decaying leaves of *Trifolium repens*. In the present survey, most flies of this species bred on the decaying leaves or stalks of *Anemone flaccida*, and some on others.

A few specimens of *S. consimilis* and *S. okadai* bred on some plants.

Several specimens of *D. collinella* of subgenus *Lordiphosa* were found on some decaying plants.

Three species, *D. nipponica*, *D. magnipectinata*, and *D. auraria* belonging to subgenus *Sophophora* were also observed to breed to some extent on decaying plants, and only one individual of *D. mommai* of *Sophophora* was found on *Anemone flaccida*. On the other hand, Momma (1965b) reported that *D. auraria* bred on

wild grapes or tomatoes.

Okada (1968) observed that *D. testacea* of subgenus *Drosophila* bred on the fallen leaves of *Petasites japonicus*. Further, the present author found that *D. nigromaculata*, *D. brachynephros*, and *D. tenuicauda* of this subgenus bred on decaying plants. These three species belonging to subgenus *Drosophila* excepting *D. tenuicauda* are known as fungus feeder (Okada 1954, etc.).

All of the 12 species reared from 9 species of plants were found in 29 species obtained by the periodical collections. These very commonly constituted 97.5% of the total flies of the periodical collections (see Table 3). This suggests that most drosophilid flies dwelling among undergrowth plants breed on decaying leaves and stalks of herbs.

2: *Microdistribution*

During the periodical collections a total of 3,990 drosophilid flies representing 29 species were obtained. Table 3 shows the 13 higher ranked species and their relative frequencies at each station in each year. These 13 species accounted for 99.3% of the total number of collected flies. The remaining 16 rare species and the total number of each species collected were as follows; *Leucophenga maculata* (1), *L. magnipalpis* (4), *L. ornatipennis* (1), *Chymomyza caudatula* (1), *Mycodrosophila bifibulata* (1), *Scaptomyza graminum* (1), *Drosophila sexvittata* (4), *D. alboralis* (1), *D. confusa* (1), *D. busckii* (1), *D. bifasciata* (1), *D. lutescens* (1), *D. biauraria* (2), *D. triauraria* (1), *D. unispina* (4), and *D. immigrans* (3).

Scaptomyza pallida was the most dominant species at the four collecting stations in lightly wooded locations (UCA, UCB, and BGA) and in the clover rich location (BGL). The dominancy of this species decreases in deeper wooded regions (the second most dominant at BGB and BGC, the third and lower at NFA and NFB). Such habitats observed in the present survey coincide with the investigation of Stalker (1945).

Scaptomyza consimilis and *S. polygonia* were found at UCA and UCB as common species, though the flies of these species varied in relative abundance from year to year. An especially conspicuous decrease in the frequencies of *S. polygonia* was observed in 1974.

Drosophila collinella was dominant at the two stations in NF, but was rare in UC and in BG.

Two species of *Sophophora*, *D. nipponica* and *D. magnipectinata*, were collected at almost all stations in considerable number, but *D. mommai* was found only in NF.

Drosophila nigromaculata was collected at all stations except BGL, as one of the most dominant species at BGB and BGC. *Drosophila tenuicauda* was abundant in NF.

As mentioned above, different patterns of distribution were observed. Three species of *Scaptomyza*, *S. pallida*, *S. consimilis* and *S. polygonia* represented the predominant species in the lightly wooded locations of UC or BG. In contrast, *D.*

Table 3. Relative abundances (%) of 13 higher ranked species observed in the periodical collections.

Collecting station	UCA			UCB			BGA	BGB	BGC	BGL	NFA		NFB		Total
Collecting year	1972	1973	1974	1972	1973	1974	1973	1973	1973	1973	1973	1974	1973	1974	
Scaptomyza pallida	56.5	50.4	76.8	33.3	63.0	67.3	72.4	26.4	25.7	99.4	10.0	12.6	3.3	11.5	2,342
S. consimilis	12.1	6.4	7.2	14.7	15.0	6.3	0.3	11.3	2.1	—	0.7	0.7	3.3	0.7	203
S. polygonia	3.6	8.0	0.2	19.2	11.0	0.4	0.8	—	—	0.6	0.7	0.4	—	—	70
S. okadai	0.4	0.8	—	0.6	—	0.4	—	1.9	2.1	—	—	—	—	—	11
Drosophila collinella	0.9	2.4	2.3	1.9	1.0	2.2	3.9	1.9	0.7	—	29.3	24.5	45.0	52.7	302
D. mommai	—	—	—	—	—	—	—	—	—	—	17.1	6.5	0.8	1.4	45
D. nipponica	6.3	4.8	2.0	7.1	1.0	4.0	6.2	11.3	30.2	—	19.3	34.9	3.3	4.1	316
D. magnipectinata	4.5	6.4	0.8	3.2	1.0	1.8	6.5	3.8	12.2	—	5.0	0.7	20.0	2.0	134
D. auraria	1.3	5.6	0.2	3.2	2.0	1.3	0.6	1.9	—	—	—	1.1	0.8	0.7	31
D. nigromaculata	11.7	12.0	9.9	7.1	3.0	9.9	6.8	32.1	22.9	—	6.4	6.1	3.3	12.2	362
D. brachynephros	0.9	3.2	0.5	1.9	1.0	2.2	1.4	—	2.1	—	—	1.1	—	1.4	39
D. testacea	—	—	0.2	2.6	1.0	1.8	0.8	1.9	—	—	—	—	2.5	2.0	21
D. tenuicauda	—	—	—	0.6	—	—	0.3	7.5	1.0	—	10.7	10.4	15.9	9.5	86
Others	1.8	—	—	4.5	1.0	2.2	—	—	0.7	—	0.7	1.1	1.7	2.0	28
Total individuals	223	125	1,317	156	100	223	355	53	288	464	140	278	120	148	3,990

collinella, *D. mommai*, and *D. tenuicauda* were abundant in number in the deep wooded locations of NF. *Drosophila nipponica*, *D. magnipectinata*, and *D. nigromaculata* were collected in both wooded locations. In addition, among the stations in each area, differences in the population constitution were observed. *Scaptomyza pallida* was predominant at BGL, BGA, UCA, and UCB, while *S. pallida*, *D. nipponica* and *D. nigromaculata* were predominant at BGB and BGC. Such differences in population constitution are considered to be caused in part by the flora at each area.

3: *Seasonal fluctuation*

It is suggested that the decaying season of plants affects the breeding season and the seasonal fluctuation of the flies.

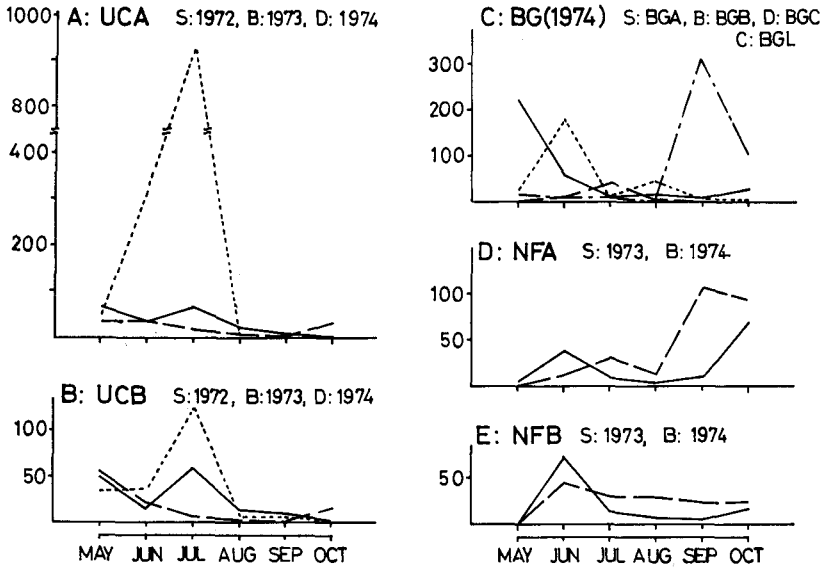

Fig. 2. Seasonal fluctuations of total drosophilid flies.
S: solid line, B: broken line, D: dot line, C: chain line.

The total population size of the flies at UCA and UCB (Fig. 2, A and B) was large from May to July. At that time some plants, *Anemone raddeana*, *Corydalis ambigua*, *Gagea lutea*, and *Trillium kamtschaticum*, were under decaying conditions at those stations. Among the plants, *A. raddeana*, which is considered as the most important plant utilized by the flies, was the most abundant and well decayed. In the other months few decayed plants were observed at the areas.

At BG the seasonal fluctuations showed different curves among the collecting stations (Fig. 2, C). At BGA the seasonal fluctuation was similar to that of UCA

or UCB in 1973, with the population peak in May. At that time *A. flaccida* which was the most abundant in specimens at the station was in a decayed condition in June and was utilized by the flies. At BGB and BGC relatively high peaks were observed in July and June respectively. *Anthriscus sylvestris*, *Heracleum dulce*, and *Thladiantha dubia* were very common in BGC, and *H. dulce* in BGB. The former two plants decayed well in June and July, and were considered as breeding sites. Decayed *Lilium cordatum glehni* which was common at both areas, BGB and BGC, was also utilized by the flies in June. The peak of the seasonal fluctuation occurred in September at BGL. At this area *Trifolium repens* and *Poa pratensis* are dominant, and some flies were found to be reared from decayed *T. repens*.

At NFA the largest population size was found in October (1973) and in September (1974). On the other hand, the largest population was in June of both years at NFB. For breeding sites these flies seem to utilize various kinds of plants such as *Petasites japonicus gigantes*, *Lilium cordatum glehni*, *Smilacina japonica*, *Trillium* sp., *Maianthemum dilatatum* and *Anemone flaccida* as shown in Table 2. The decaying of these plants was observed to be abundant in June and July at both areas. The appearance of a large population in the fall at NFA may be due to the abundance of the decayed plants (*Cryptotaenia japonica*, *Sanicula chinensis*, *Polygonum thunbergii*, and *Laportea bulbifera*), though flies were not observed breeding on these plants in the present survey.

On the whole, the peaks of the population size appear at the decaying season of the plants utilizable for feeding and ovipositing. For example, the flies are found plentifully at the colonies of *A. raddeana* or *A. flaccida* in May or June, and of *A. sylvestris* or *H. dulce* in June and July. Accordingly, the seasonal fluctuations are affected by the decaying season of the utilizable plants.

Scaptomyza pallida: Seasonal fluctuation of *S. pallida* varied in pattern from year to year among collecting stations (Fig. 3, A). A bimodal pattern of population showed in 1972 with peaks in May and July (UCA and UCB), and unimodal types were found in 1973 with a peak in May and in 1974 in July. According to Stalker (1945), the body color of this fly is affected by temperature in the larval or pupal period, yellow in high and black in low temperature. In the present survey the color of the flies collected in May and June was black, and yellow in July. This suggests that the change of generations occurred between June and July. The flies of the first generation after hibernation seem to appear in late April or early May to oviposite on decaying leaves of *A. raddeana* or of others. The larvae of the second generation grow during May and June. Thus the second peak of population might be formed by the new ecdyses flies. In 1973, the rainfall in June was so poor (Fig. 1) that the leaves of the plants were dried up without decaying. On the other hand, in 1974 the rainfall was very rich and decaying of the leaves proceeded well. Such differences of rainfall between 1973 and 1974 would affect the seasonal fluctuations of the flies. In BG the peculiar pattern of variations was found among the stations of BGA, BGB, BGC, and BGL. It seems to depend on the differences of the flora and the rainfall.

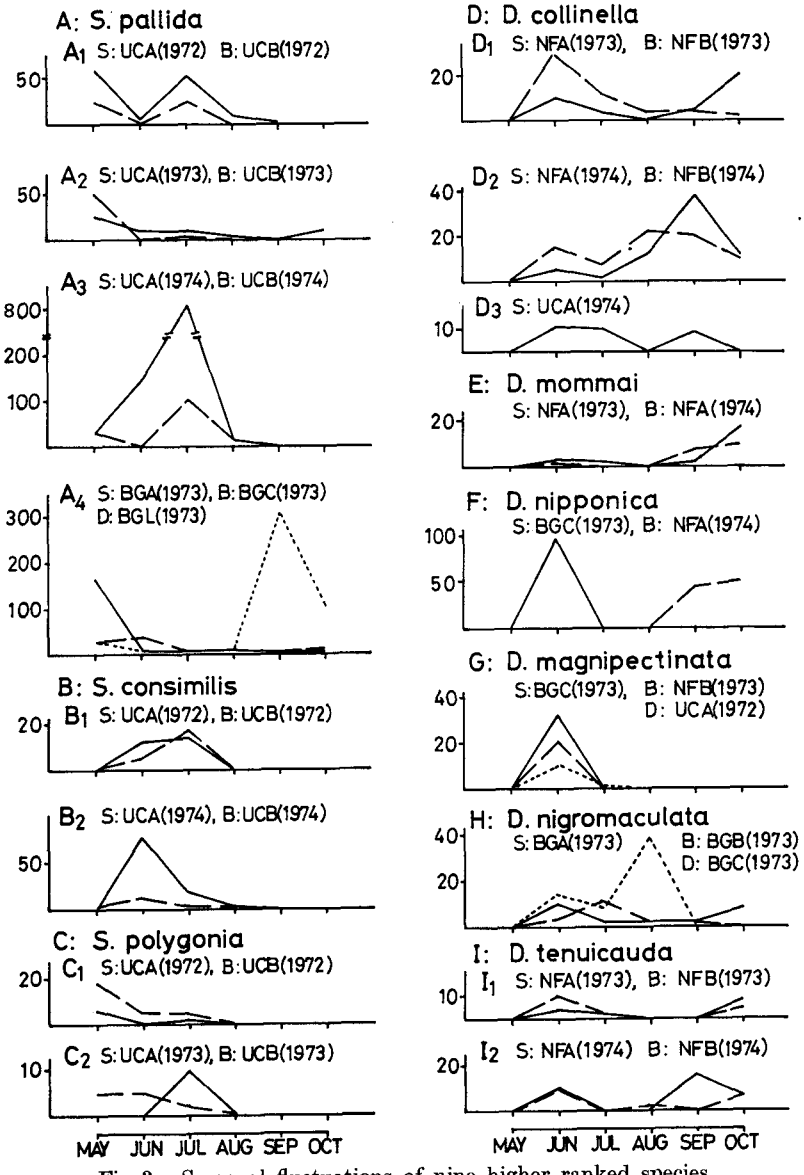

Fig 3. Seasonal fluctuations of nine higher ranked species.
S: solid line, B: broken line, D: dot line

Among the other common species, a unimodal type of seasonal fluctuation was observed on *S. consimilis* (Fig. 3, B), *S. polygonia* (Fig. 3, C), *D. nipponica* (Fig. 3, F) and *D. magnipectinata* (Fig. 3, G). On the other hand, *D. collinella* (Fig. 3, D),

D. mommai (Fig. 3, E), and *D. tenuicauda* (Fig. 3, I) showed bimodal types. *Drosophila nigromaculata* (Fig. 3, H) was recognized showing its peculiar patterns of the fluctuation.

As mentioned above the seasonal fluctuations of the flies were affected not only by the utilizable plants, but also by meteorological factors such as rainfall. In addition, the species-specific seasonal flucutation observed in the present survey may be affected by other factors such as physiology and competition among the species.

4: *Annual fluctuation*

A large annual fluctuation of the population size was observed among the collecting stations. Only 125 individuals were collected at UCA in 1973, but more than ten times that number was collected in 1974. Similarly larger population sizes in 1974 than in 1973 were also found at UCB, NFA, and NFB. This fluctuation is considered to be partly caused by decaying conditions affected by the amount of rainfall.

Summary

A study was carried out on the drosophilid flies dwelling among the undergrowth plants in and near Sapporo from 1972 to 1974.

1) Twelve species were observed to utilize decaying leaves and stalks of herbs as their breeding sites. Most of them were found among the undergrowth plants as predominant species.

2) Microdistribution of the flies is divided into three group, predominant species in lightly wooded region, predominant species in deep wooded regions, and predominant species in both regions.

3) The microdistribution of these flies seems to be affected by flora.

4) Seasonal fluctuations of total flies corresponded to the decaying season of the utilizable plants.

5) The decaying condition of plants is affected by meteorological factors such as rainfall.

6) The seasonal fluctuations of the nine leading species appeared to be species-specific.

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