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Seasonal Activity and Microdistribution of Drosophilid Flies in Misumai in Sapporo

By

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(With 7 Text-figures and 4 Tables)

Compared with enormous and elaborated cytogenetic studies on drosophilid flies, there are still much lacks of information on their ecology. The general occurrence of periodic number changes in animal populations has an evolutionary significance through the fluctuation of gene occurrence within the population. From such point of view, seasonal fluctuations in natural drosophilid assemblages have attracted current attention both of ecologists and geneticists, particularly in concomitance with the development of population genetics (Patterson 1943, Dobzhansky and Pavan 1950, Pipkin 1952, Basden 1953, Herting 1955, Cooper and Dobzhansky 1956, Mather 1956, Nozawa 1956, Ohba 1956, Wakahama 1956, 1957, 1961, 1962a, b, etc.). In the papers cited some environmental factors relating to seasonal fluctuation, for instance, general weather, temperature, relative humidity, altitude, etc. have been discussed. Furthermore, differences of microhabitats or microdistributions among several species and effects of micro-environmental factors upon seasonal activities have been repeatedly pointed out (Dobzhansky 1939, Dobzhansky and Wright 1943, 1947, Dobzhansky and Epling 1944, Dobzhansky and Pavan 1950, Timoféeff-Ressovsky and Timoféeff-Ressovsky 1940, Herting 1955, Kaneko unpubl.).

In Hokkaido, the basic information of drosophilid distribution has been clarified through the serial papers of "*Drosophila* Survey of Hokkaido" by Momma and his collaborators (1954-1969), but there are still few ecological studies analysing the problems mentioned above precisely. In this connection the present author has engaged in the ecology of Drosophilidae in and near Sapporo since 1971. The present report deals with the preliminary information obtained in 1971 on micro-distribution and seasonal activities with reference to the difference in habitat vegetations, which has so far relatively been ignored.

Before going further, the author wishes to express his sincere thanks to Dr. Shôichi F. Sakagami for his pertinent guidance in the course of the present study, and to Prof.

Mayumi Yamada for his reading through the manuscript. The special appreciation is due to Dr. Akasi Kaneko, Elementary and Secondary Education Bureau, Ministry of Education, Japan, who conducted the present study with many expert suggestions and encouragement. Cordial thanks are also due to Dr. Tatsuichi Tsujii, Botanical Garden, Hokkaido University, for his identification of undergrowth plants and giving many facilities for the present study in Misumai Arboretum, and Prof. Eiji Momma, Mr. Hiromi Fukuda and Mr. Takeo Kawamichi for their kind advices.

The area studied

The studied area is situated at Misumai Arboretum, belonging to Hokkaido University, about 15 km southwest of the center of Sapporo City (Figure 1, 2). The vertical position of trap stations varied 240–330 m at the northwest slope of Mt. Yakeyama (the highest point; 662 m), facing the River Toyohira. Vegetations are roughly divided into two parts; 1) natural forest mainly composed of broad-leaf trees, with sparse admixture of conifers, and 2) larch (*Larix leptolepis*) afforestation. Undergrowth is uniform and thick in both forests, consisting of bamboo-grass, *Sasa senanensis*, about one meter high.

The area is covered with snow nearly for a half year. In 1971, snow thawed in late April and began to cover land from mid November. Because of the northwest inclination, snow thawed a little later and covered there a little earlier than other surrounding slopes.

For continuous climatic records, a thermograph for air temperature was set in a shelter at 80 cm high above the ground in the natural forest (at Trap I). Daily mean temperatures were obtained from three sources (Fig. 3): 1) twelve readings per day taken from weekly thermograph records at the studied area, 2) the averages between daily maximum and minimum temperatures recorded at the center of Sapporo City, and 3) the records of eight readings per day from 1931 to 1960 in order to compare with 1). The latter two data were cited from the records by Sapporo Meteorological Observatory.

In 1971, the most monthly mean temperatures were lower than average annual trend because of frequent spreads of Okhotsk Air Mass. Crops, especially beans and rice, were damaged twice by severe weather, the snow fall in early May and the cloudy and rainy weather with abnormally low temperature lasting more than ten days in mid July.

Collecting method

A few traps were set in each of four different vegetations (in total ten traps): natural forest, secondary grasslands, cutting border line between forest and grassland, and streamside forest. Main topographical and ecological conditions of these stations are summarized in Table 1 and Fig. 2.

All traps were suspended from branches or trunks of trees, kept at the height of about 50–150 cm above the ground. To clarify seasonal activities, flies were

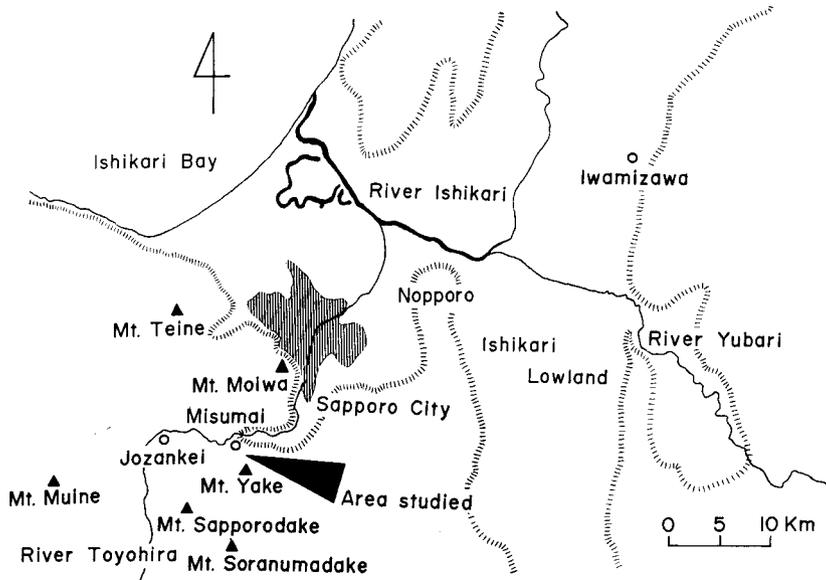


Fig. 1. Location and topography of the area studied.

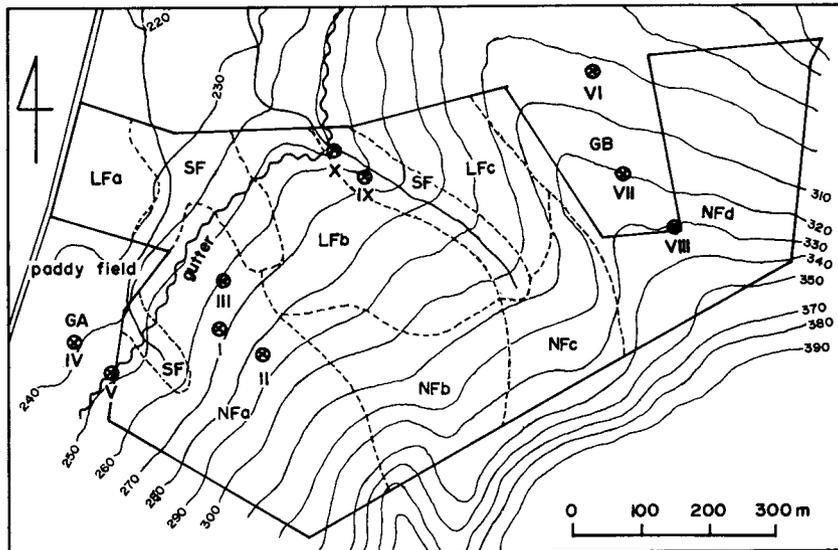


Fig. 2. Misumai Arboretum, Botanical Garden of Hokkaido University.
 NF; natural forest LF; larch forest SF; streamside forest GA; grassland A GB; grassland B
 X ⊗ trap station

Table 1. Topographical and ecological conditions of trap stations. NFa; natural forest mainly composed of broad-leaf trees, with sparse admixture of conifers (tree-tops; about 20 m high). GA; grassland A, afforested young larches (about 1.5 m high, about 2-3 m interval), near paddy field.) FEA; forest edge between natural forest and grassland A, beside a gutter. GB; grassland B, felled land as house-lot. FEB; forest edge of another natural forest facing grassland B. SF; forest beside a small stream (about 1-2 m wide). + common ++ frequent
 ## abundant ### very abundant

Trap NO.	I	II	III	IV	V	VI	VII	VIII	IX	X
Trap height (cm)	100	80	80	100	88	60	100	100	90	140
Altitude (m)	265	285	260	240	245	305	320	330	260	255
Vegetation	NFa		GA FEA		GB	FEB	SF			
Main undergrowth plants										
<i>Sasa senanensis</i>	##				##	##	##			
<i>Pachysandra terminalis</i>	##									
<i>Cephalotaxus nana</i>	+									
<i>Cardamine leucantha</i>	+						+	+		
<i>Galium trifloriforme</i>	##						##			
<i>Adonis amurensis</i>	+									
<i>Smilacina japonica</i>	+						+			
<i>Hydrangea petiolaris</i>	+						+			
<i>Rhus ambigua</i>	##									
<i>Chloranthus japonicus</i>	+									
<i>Anemone flaccida</i>	+									
<i>Larix leptolepis</i>			+							
<i>Poa annua</i>			##							
<i>Taraxacum officinale</i>			+			+				
<i>Oenothera biennis</i>			##		+	##				
<i>Artemisia montana</i>			##		+	##	##	+		
<i>Dactylis glomerata</i>			##			##				
<i>Trifolium repens</i>			+			##				
<i>Picris hieracioides</i>			+			##				
<i>Erigeron annuus</i>			##		+	##	##			
<i>Petastites japonicus</i> subsp. <i>giganteus</i>					##	##	##	##		
<i>Viola grypoceras</i>					##					
<i>Urtica platyphylla</i>					+			##		
<i>Impatiens noli-tangere</i>					##	+		##		
<i>Sanicula chinensis</i>					##					
<i>Chelidonium majus</i>					+					
<i>Morus bombycis</i>					+					
<i>Osmorhiza aristata</i>					##					
<i>Carpesium abrotanoides</i>						+				
<i>Polygonum lapathifolium</i>						##				
<i>Schizophragma hydrangeoides</i>							##			
<i>Sium suave</i>								+		
<i>Rubus crataegifolius</i>								##		
<i>Chrysosplenium grayanum</i>								##		
<i>Clinopodium multicaule</i> var. <i>sachalinense</i>								##		

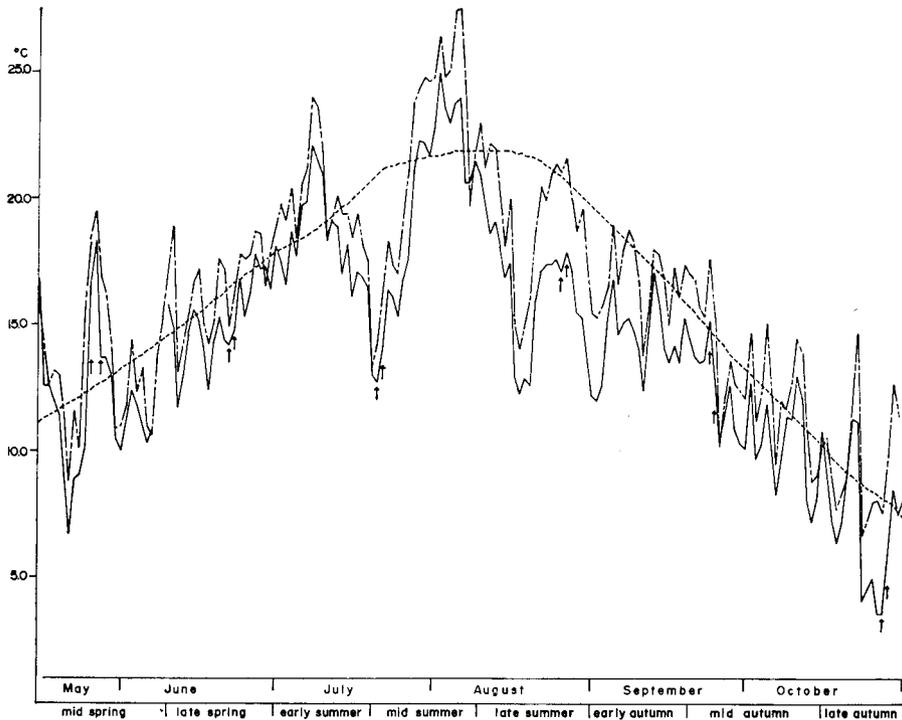


Fig. 3 Daily mean temperatures from May 16 to November 3 in 1971 (solid: area studied, dashed: center of Sapporo City), together with mean trend of 30 years from 1931 to 1960 (broken line). Arrows show collecting dates.

collected for two days during the last ten days of each month, from May to October in 1971. Collections were made at 2 hr. intervals from 5:00 to 17:00, except for October (from 7:00 to 15:00). One regular cruise of collection took about 1.5 hr. with the regularly ordered visits to traps: IX-X-VI-VII-VIII-III-I-II-V-IV (Fig. 2).

The traps used are cylindrical dry-milk tins (13 cm in diameter, 19 cm in depth), each with the bait of a handful of banana pieces fermented enough with Baker's yeast for one or two days before use. The attracted flies were captured by covering the trap quickly with a vinyl sack and were transferred from the sack into a small glass vial containing 70% alcohol. The specimens were identified mainly according to the key by Kaneko (unpubl.).

Results and discussion

In total 1,525 specimens were obtained, consisting of 24 species belonging to three genera, *Amiota*, *Leucophenga* and *Drosophila*. Table 2 shows the numerical

data of the flies collected at each trap in four different vegetations. Generally speaking, the numbers of both specimens and species in grasslands were smaller than those in the other vegetations. In the latter, the numbers of species were quite similar while the numbers of specimens varied moderately with each other.

1 *Microdistribution*

On microdistribution or microhabitat preference of drosophilid flies Dobzhansky and Pavan (1950) reported patchy distribution of several species at some cross-shaped survey fields in Brazil. Herting (1955) compared distributions of several species between oak and beech forests, as well as between neutral soil and acid soil forests in Westfalia, Germany.

For the precise and unbiased analysis of microdistribution, the adopted method, which depends on bait attractiveness, is not optimum, but it may serve to give the general outline as a first approximation to know the habitat preference. The species referred to here are those with more than thirty individuals collected. The relative frequency of each species at ten traps is shown in Table 3. The preferred habitat types and total specimens collected of these predominant species are given in brackets in the following descriptions. The habitat types given in Table 3 are shown by combination of letters (f: forest, e: forest edge, g: grassland, and s: streamside forest), arranged in the descending order of relative frequency. Capitals (F E G and S) mean significantly preferred habitats.

D. confusa (Fes; 256): Seemingly characteristic to forest (relative frequencies at Trap I: 32.8%, II: 25.4%, III: 22.7%). This species is unique within *Hirtodrosophila* by frequent visits not only to fungi but also to fermented fruits, whereas other species of the same subgenus are fungivorous, rarely or never collected on fermented fruits.

D. coracina (Fesg; 152): Collected in all vegetations, but especially in forest (Trap I: 16.4%, II: 23.0%, III: 25.0%). A particular diurnal activity showing a midday peak reported by Shima (1961) was observed in this survey, too.

D. bifasciata (fegs; 343): Although the total frequency at each trap throughout the collecting period is more or less equal, the habitat preference shows an interesting seasonal shift as referred to the next section. This species is the most predominant in mountaneous forests in northern Hokkaido among drosophilid flies attracted to fermented banana (Takada 1971).

D. auraria A (Ge; 71): Collected most frequently in grasslands, particularly in GA (Trap IV: 74.0%) near paddy field. *D. auraria* B (efsg; 73): Collected nearly equally in all vegetations.

In lowland of Hokkaido, *auraria* A and B are dominant but C is rare (Kurokawa 1952, 1956, 1958, Takada 1954, 1960, 1971, Momma 1957, etc.). According to Kurokawa (1956), A is rather domestic, B more predominant in mountaneous areas and C intermediate.

D. testacea (Fse; 204): Characteristic to forest (Trap I: 27.9%, II: 20.6%, III: 27.5%). This Holarctic species is very common in Hokkaido, showing a wide

Table 2. Drosophilid flies

Vegetation	NFa		
	I	II	III
Trap No.			
<i>Amiota (Amiota)</i>			
<i>dispina</i> Okada, 1960	-	-	-
<i>Leucophenga (Neoleucophenga)</i>			
<i>quinquemaculipennis</i> Okada, 1956	1	-	-
<i>Drosophila (Hirtodrosophila)</i>			
<i>quadrivittata</i> Okada, 1956	-	-	-
<i>confusa</i> Staeger, 1844	84	65	58
<i>D. (Scaptodrosophila)</i>			
<i>coracina</i> Kikkawa and Peng, 1938	25	35	38
<i>D. (Sophophora)</i>			
<i>bifasciata</i> Pomini, 1940	91	75	29
<i>imaii</i> Moriwaki and Okada, 1969	2	3	3
<i>suzukii</i> (Matsumura, 1931)	-	-	-
<i>lutea</i> Kikkawa and Peng, 1938	-	-	1
<i>auraria</i> Peng, 1937 A	-	1	-
B	7	4	9
C	-	-	-
<i>D. (Drosophila)</i>			
<i>testacea</i> van Roser, 1940	57	42	56
<i>nigromaculata</i> Kikkawa and Peng, 1938	1	2	-
<i>brachynephros</i> Okada, 1956	1	3	4
<i>unispina</i> Okada, 1956	6	14	14
<i>histrion</i> Meigen, 1830	5	2	4
<i>immigrans</i> Sturtevant, 1938	12	5	11
<i>sordidula</i> Kikkawa and Peng, 1938	11	1	3
<i>pseudosordidula</i> Kaneko, Tokumitsu and Takada, 1964	-	1	3
<i>lacertosa</i> Okada, 1956	1	-	2
<i>moriwakii</i> Okada and Kurokawa, 1957	1	5	1
<i>okadai</i> Takada, 1959	-	-	-
Total	305	258	236

altitudinal distribution.

quinaria group: Three species of this group, *D. brachynephros* (Gefs; 57), *D. unispina* (Fse; 44) and *D. nigromaculata* (sgef; 60), were collected. *D. brachynephros* was most frequent in grasslands, particularly in GA (Trap IV: 43.5%). Its high frequency at Trap IV was similar to *D. auraria* A, though less abundant than the latter. Contrary to *D. brachynephros*, *D. unispina* was abundant in forest (Trap I: 13.6%, II: 31.8%, III: 31.8%). *D. nigromaculata* was collected in all vegetations but relatively poor in forest (Trap I: 1.7%, II: 3.3%, III: no specimen).

D. nigromaculata is the most dominant and widely spread species in Hokkaido, but was not much collected in this study. A successive survey through years may solve whether the low abundance is characteristic to the area or particular in the year surveyed.

collected at each trap station.

GA	FEA	GB		FEB	SF		Total
		VI	VII		VIII	IX	
-	-	1	-	-	-	-	1
-	-	-	-	1	-	-	2
-	1	-	-	-	-	-	1
-	17	2	-	13	5	12	256
7	14	-	2	15	14	2	152
4	19	38	28	45	7	7	343
1	5	4	3	5	1	-	27
1	-	3	1	-	-	-	5
-	-	-	-	-	-	-	1
53	5	6	1	5	-	-	71
7	17	6	3	7	1	12	73
-	-	-	-	1	1	-	2
-	8	2	3	11	20	5	204
9	10	6	4	5	12	11	60
25	12	4	2	3	1	2	57
-	4	-	1	-	4	1	44
-	4	-	-	-	2	3	17
-	1	1	2	2	3	3	40
-	11	-	1	6	3	5	41
-	-	-	-	2	-	-	6
1	6	-	-	2	26	38	76
-	-	1	-	7	6	10	31
-	1	-	2	-	6	6	15
108	132	74	53	130	112	117	1,525

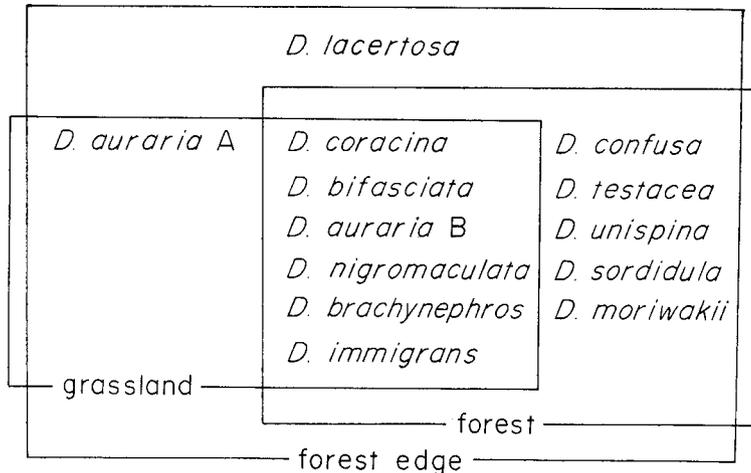
D. immigrans (Fseg; 40): This domestic species was collected in any vegetation but most frequently in forest (Trap I: 30.0%, II: 12.5%, III: 27.5%).

robusta group: *D. lacertosa* (Se; 76), *D. sordidula* (Efs; 41) and *D. moriwakii* (sef; 31). *D. lacertosa* was characteristic to streamside forest (Trap IX: 34.2%, X: 50.0%). *D. sordidula* and *D. moriwakii* showed a slightly wider preference, both collected besides streamside forest, also from interiors and edges of forest. Two other species of the same group, *D. pseudosordidula* and *D. okadai*, were extremely rare, 6 and 15 specimens in forest and streamside forest respectively. The result supports the conclusion by Kaneko and Tokumitsu (1969), that the *robusta* group is hygrophilous, preferring riverside areas.

From the microdistribution of the above mentioned species summarized in Fig. 4, three items of information are derived; 1) all species are collected from more than two vegetations, 2) the number of species is lowest in grasslands and 3) forest

Table 3. Relative frequencies of each species among trap stations.

Vegetation	NFa			GA	FEA	GB		FEB	SF		Total individual number
Trap No.	I	II	III	IV	V	VI	VII	VIII	IX	X	
<i>Drosophila confusa</i>	32.8	25.4	22.7	-	6.6	0.8	-	5.1	2.0	4.7	256
<i>coracina</i>	16.4	23.0	25.0	4.6	9.2	-	1.3	9.9	9.2	1.3	152
<i>bifasciata</i>	26.5	21.9	8.5	1.2	5.5	11.1	8.2	13.1	2.0	2.0	343
<i>auraria</i> A	-	1.4	-	74.6	7.0	8.5	1.4	7.0	-	-	71
<i>auraria</i> B	9.6	5.5	12.3	9.6	23.3	8.2	4.1	9.6	1.4	16.4	73
<i>testacea</i>	27.9	20.6	27.5	-	3.9	1.0	1.5	5.4	9.8	2.5	204
<i>nigromaculata</i>	1.7	3.3	-	15.0	16.7	10.0	6.7	8.3	20.0	18.3	60
<i>brachynephros</i>	1.8	5.3	7.0	43.9	21.1	7.0	3.5	5.3	1.8	3.5	57
<i>unispina</i>	13.6	31.8	31.8	-	9.1	-	2.3	-	9.1	2.3	44
<i>immigrans</i>	30.0	12.5	27.5	-	2.5	2.5	5.0	5.0	7.5	7.5	40
<i>sordidula</i>	26.8	2.4	7.3	-	26.8	-	2.4	14.6	7.3	12.2	41
<i>pseudosordidula</i>	-	16.7	50.0	-	-	-	-	33.3	-	-	6
<i>lacetosa</i>	1.3	-	2.6	1.3	7.9	-	-	2.6	34.2	50.0	76
<i>moriwakii</i>	3.2	16.1	3.2	-	-	3.2	-	22.6	19.4	32.3	31
<i>okadai</i>	-	-	-	-	6.7	-	13.3	-	40.0	40.0	15

Fig. 4. Microdistribution of each species in three vegetations. All except *D. auraria* A were collected from streamside forest.

edges are richest in species, involving those preferring various microhabitats.

The results mentioned above are regarded as the first approximation to the interspecific difference of microhabitat preference. For closer analysis of "habitat" and "habitat preference", however, there are still much to be solved, for instance; 1) Flight activities, 2) Relation between flight ranges and relative preference to

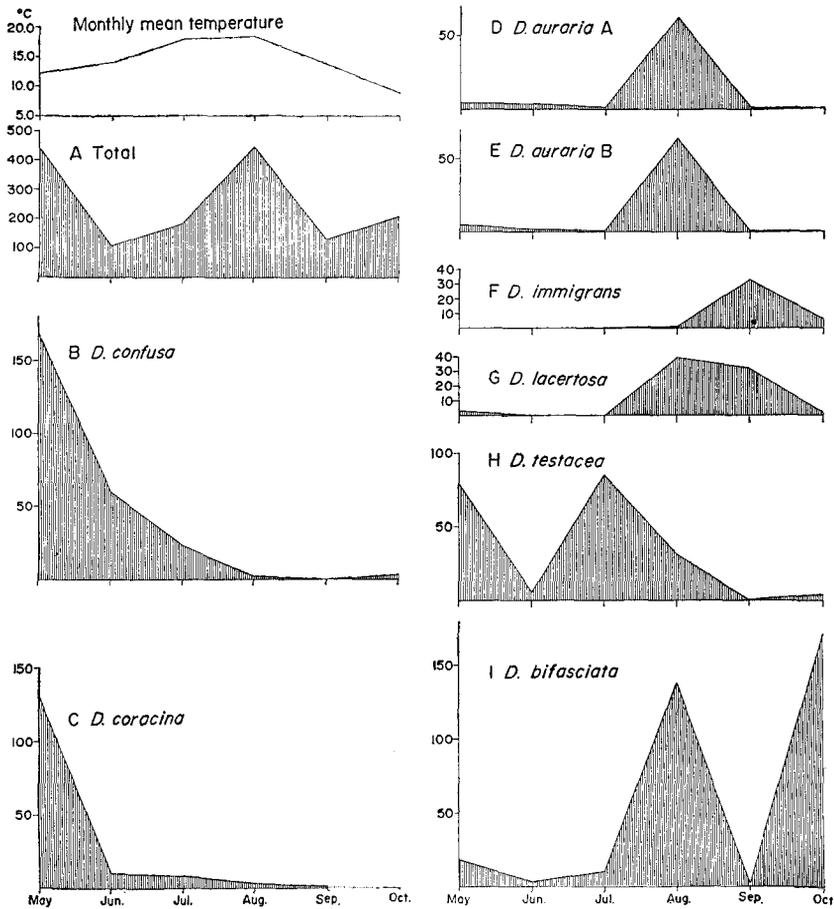


Fig. 5. Seasonal activities of some predominant species

baits and 3) Detailed life history including immature stages and succession of generations.

2 Seasonal activity

Periodical collecting of drosophilid flies in the same locality discloses a marked seasonal difference of relative abundance among species. Seasonal activities envisaged from sampling data of six predominant species (*D. bifasciata* 22.5%, *D. confusa* 16.8%, *D. testacea* 13.4%, *D. coracina* 10.0%, *D. lacertosa* 5.0%, *D. auraria B* 4.8%, and *D. auraria A* 4.7%) are classified in the following five patterns.

(1) *Unimodal (spring-early summer) type*: *D. confusa* (Fig. 5-B) showed a

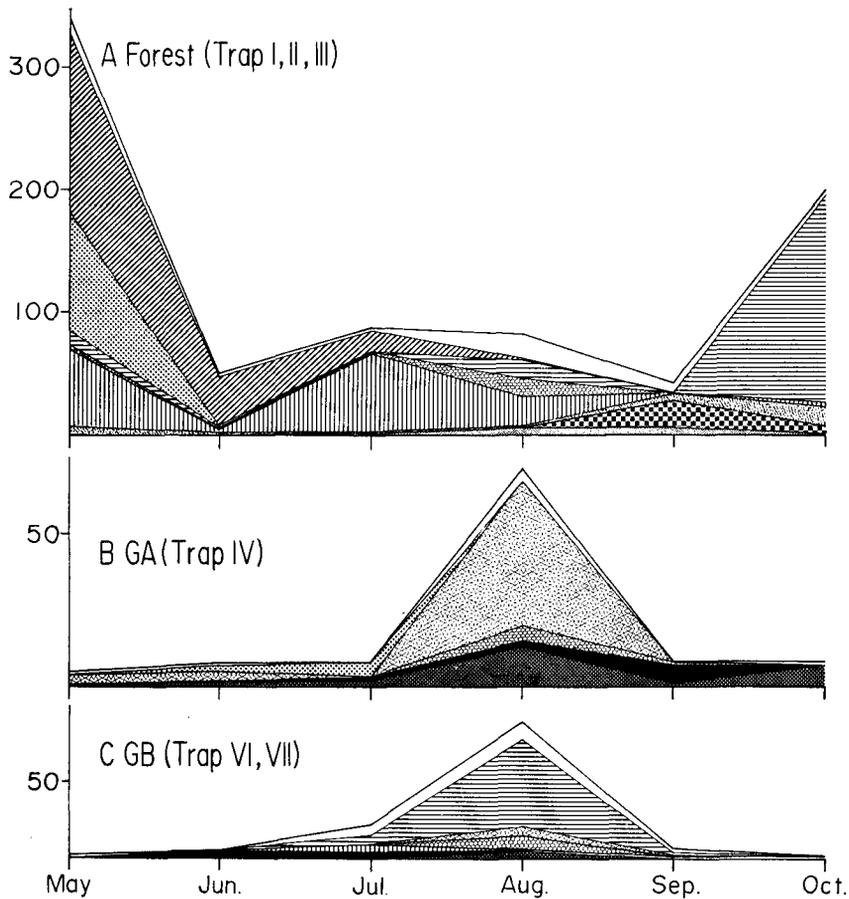
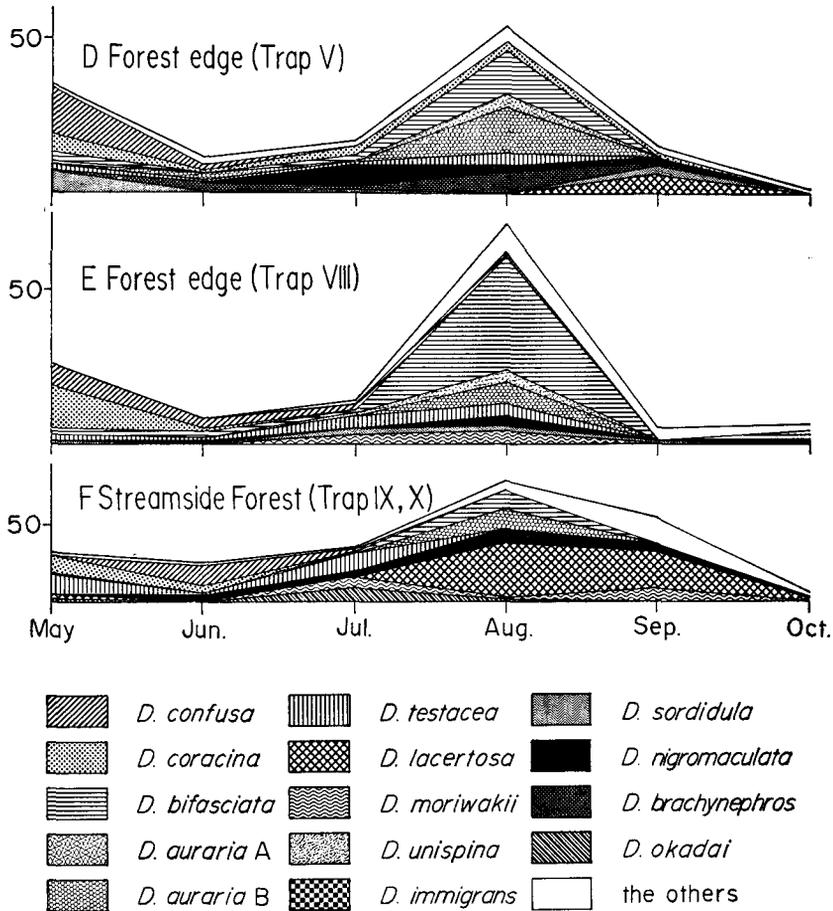


Fig. 6. Seasonal changes of drosophilid

typical unimodal curve with one high peak in spring, as already described in other studies made in Hokkaido (Wakahama 1957, Kaneko and Tokumitsu 1963).

D. coracina also showed a unimodal pattern as reported by many authors, with a conspicuous peak in May, followed by a rapid decrease in June (Fig. 5-C). The peak of this species seems, however, not to be fixed, showing possible local difference, that is, the peak in summer in Honshu (Nozawa 1956, Ohba 1956, Wakahama 1960, 1962) in spring in Hokkaido (this station, and Nopporo; Kaneko and Tokumitsu 1963) and South Korea (Paik 1958).

(2) *Unimodal (summer) type*: As shown by previous authors both A and B of *D. auraria* belong to the unimodal (summer) type. Contrary to other papers reporting the abundance in July, the present data showed an abrupt peak in



assemblage in each vegetation.

August (Fig. 5-D, E), probably reflecting abnormal climatic conditions in this year.

(3) *Unimodal (late summer-autumn) type*: As in other localities in Hokkaido (Wakahama 1957, Kaneko 1960, Kaneko and Tokumitsu 1963) *D. immigrans* showed a typical peak in autumn (Fig. 5-F). But the shift of the peak is reported in some localities in Honshu (Nozawa 1956, Ohba 1956, Wakahama 1960, 1962).

Similar to the result by Kaneko and Tokumitsu (1963) in Nopporo the peak of *D. lacertosa* lies during late summer and autumn (Fig. 5-G), though different patterns have been reported in other localities in Japan by some authors (Nozawa 1956, Wakahama 1960).

(4) *Bimodal (spring-summer) type*: Although two peaks of *D. testacea* lie in May and July (Fig. 5-H), seasonal activities of this species in Hokkaido do not

seem to be stable. According to Wakahama (1957), the seasonal activities for three years (1954-'56) highly fluctuated but one of which recorded in 1956 was quite similar to the present result. Under the abnormal climate, this species was abundant in July, in spite of the scarcity of other species in the same month.

(5) *Bimodal (summer-autumn) type*: *D. bifasciata* had the first peak in August and the second major one in October (Fig. 5-1), the former in grasslands, particularly in GB, while the latter in forest. Wakahama (1957) classified the seasonal activity pattern of this species in a pattern fluctuating annually, based upon the unstable mode, including a sudden increase recorded in June, 1956, in Botanical Garden, Sapporo. The steep increase in October at the present study also indicates a sudden increase of the population in forest. Similar explosive increase is also observed in other species by Wakahama (1957): *D. melanogaster* in August, 1954, *D. lutea* in 1956 and *D. confusa* in 1956. On the causes of such increase, Patterson (1957) suggested the influence of certain unknown but favourable environmental conditions.

The seasonal fluctuation of total drosophilid assemblage in all vegetations showed in total three peaks, in May, August and October (Fig. 5-A). It is considered that this seasonal fluctuation shows the result affected by seasonal succession of predominant species.

3 Seasonal assemblage fluctuation in different vegetations

As mentioned above, the seasonal fluctuation of total samples including all vegetations showed three peaks. But as for each vegetation, there were only one or two peaks and their seasonal positions were very different among vegetations as follows: forest assemblage showed two high peaks in spring and autumn and a low plateau in summer, forest edge assemblages one high peak in August and a lower one in May, grassland assemblages only one sharp peak in August, and streamside forest assemblage one plateau like peak during late summer and early autumn.

The fluctuation in forest assemblage (Trap I, II, III) is mainly caused by the predominant species, *D. confusa*, *D. coracina*, *D. testacea* and *D. bifasciata*, the high peak in May by *D. confusa* and *D. coracina*, in October by *D. bifasciata* and the summer plateau by *D. testacea* (Fig. 6-A).

As to grassland assemblages, the composition of summer peak is quite different between GA (Trap IV) and GB (Trap VI, VII), the former mainly caused by *D. auraria* A and *D. brachynephros*, while the latter by *D. bifasciata* (Fig. 6-B, C).

In forest edge assemblages (Trap V facing grassland GA, and Trap VIII facing grassland GB), the peak in May is mainly caused by forest species, *D. confusa* and *D. coracina*. In August when grassland assemblages increased, some of grassland species increased in the forest edge assemblages, too, that is, *D. auraria* A and *D. brachynephros* at Trap V and *D. bifasciata* at Trap VIII, resulting in a more complex structure (Fig. 6-D, E).

Table 4. Harmony Indexes among trap stations and diversity index of each trap station.

	Trap No.	I	II	III	IV	V	VI	VII	VIII	IX	X
HI	I	1.000	0.984	0.886	0.073	0.695	0.671	0.686	0.857	0.468	0.343
	II	0.984	1.000	0.901	0.102	0.716	0.671	0.691	0.880	0.495	0.330
	III	0.886	0.901	1.000	0.091	0.698	0.355	0.389	0.670	0.598	0.345
	IV	0.073	0.102	0.091	1.000	0.331	0.279	0.165	0.218	0.110	0.106
	V	0.695	0.716	0.698	0.331	1.000	0.544	0.530	0.766	0.570	0.538
	VI	0.671	0.671	0.355	0.279	0.544	1.000	0.980	0.861	0.236	0.237
	VII	0.686	0.691	0.389	0.165	0.530	0.980	1.000	0.872	0.286	0.228
	VIII	0.857	0.880	0.670	0.218	0.766	0.861	0.872	1.000	0.472	0.364
	IX	0.468	0.495	0.598	0.110	0.570	0.236	0.286	0.472	1.000	0.810
	X	0.343	0.330	0.345	0.106	0.538	0.237	0.228	0.364	0.810	1.000
λ		0.208	0.194	0.163	0.305	0.089	0.283	0.288	0.158	0.120	0.147

As for the streamside forest assemblage, the spring (May and June) components were forest dwellers, *D. confusa*, *D. testacea* and *D. coracina*, while the plateau like peak during late summer to early autumn mainly consisted of *D. lacertosa* characteristic to the habitat (Fig. 6-F).

4 Statistical analyses of the drosophilid assemblage structures among the different vegetations

In order to compare the assemblage structures at different traps with each other, the author adopted the Simpson's diversity index (Simpson 1949) and Harmony Index (Kimoto 1971).

Simpson's diversity index (λ)

$$\lambda = \frac{\sum_{i=1}^{\infty} n_i(n_i - 1)}{N(N - 1)}$$

Harmony Index (HI)

$$HI = \frac{2 \sum_{i=1}^{\infty} n_{1i} n_{2i}}{(\sum \pi_1^2 + \sum \pi_2^2) N_1 N_2}$$

where N=the total individual number, n_i =the individual number of species i , $\sum \pi_1^2 = \sum n_i^2 / N_1^2$, $\sum \pi_2^2 = \sum n_i^2 / N_2^2$, N_1 , N_2 =respectively total individual number of assemblage I and II, and n_{1i} or n_{2i} =individual number of species i found in the assemblage I or II.

The value of λ will be 1 when the assemblage is composed of only one species and zero when each component species of the assemblage has only one specimen. The value of HI near 1 shows similar make-up between two assemblages, while the value near zero that these are completely different.

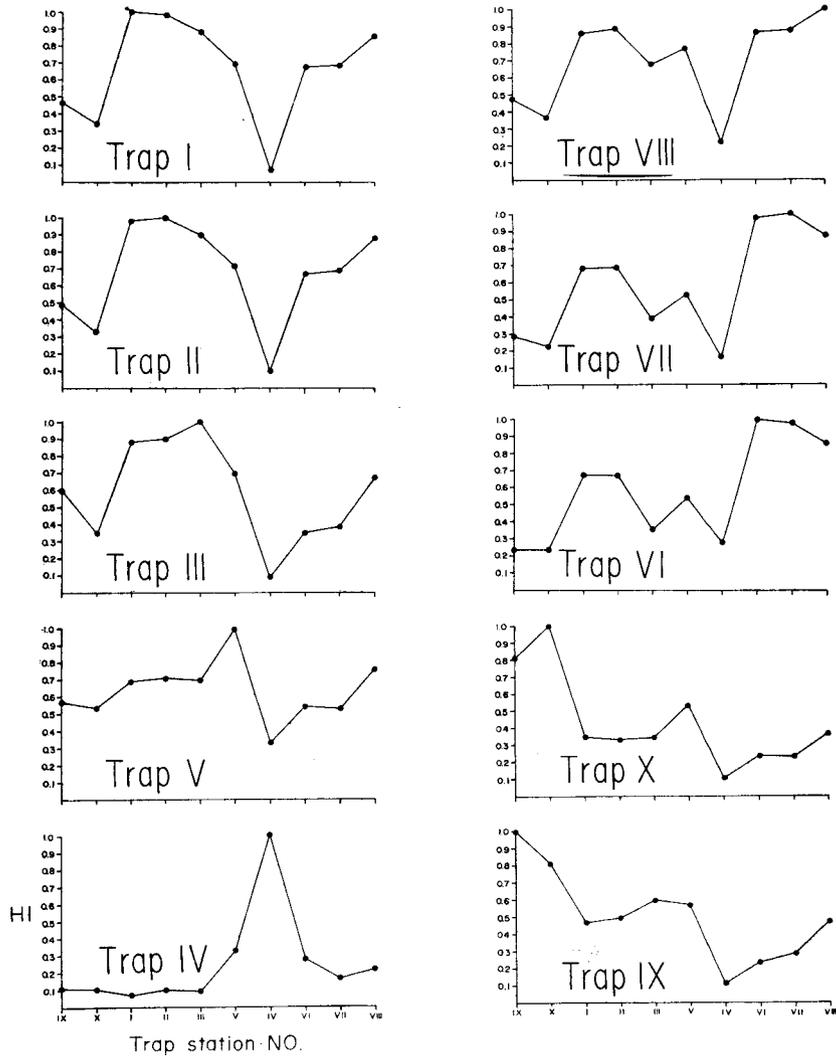


Fig. 7. Similarity of assemblage make-up among trap stations.

Based upon the data in Table 2, λ of each assemblage and HI of all pairs of assemblages were calculated and presented in Table 4.

For the comparison of similarities among more than three assemblages, the values of HI between a given assemblage and either of the other ones were plotted in the regular order (IX-X-I-II-III-V-IV-VI-VII-VIII) in Fig. 7, adopting Motomura's correlation graph method (Motomura 1935).

The patterns of graphi are quite similar for each other in the same vegetation,

especially among three traps (I, II, III) in forest, and between two traps (VI, VII) in grassland GB, while the patterns in forest and grassland GB are basically different for each other. Such pattern specificity are recognized also in other vegetations, but the pattern can vary even within the same vegetation, for instance, grassland and forest edge vegetations (Trap IV-VI, VII and Trap V-VIII). Such variations, probably in part caused by differences in vertical distribution, are more clearly demonstrated by Motomura's graphic method than by Figures 6. The difference in relative abundance of various species in these samples were described in the former section. Dobzhansky and Epling (1944), Pipkin (1952), Cooper and Dobzhansky (1956) and Wakahama (1962, 1964) mentioned the differences of the seasonal fluctuation and corresponding changes in structures of assemblage at different strata.

The assemblage at Trap V in forest edge shows the pattern intermediate between those of grassland GA (Trap IV) and forest (Trap I, II, III). The same tendency is also seen in the assemblage at Trap VIII, though there are no corresponding data in the forest interior. The lower value of λ in forest edge (Trap V; $\lambda=0.089$) shows the complexity by the mixture of both components of forest and grassland, indicating an ecotonal character. Whether these results mean an intermediate but in itself stable assemblage structure or invasions from adjacent vegetations is open for further studies.

Concluding remarks

Up to the present, studies of drosophilid flies have mainly been carried out by using fermented fruits as baits. The bait attractiveness depends on kinds and conditions of baits and various environmental factors. Even if these parameters could be removed as much as possible, such studies are always restricted to "the species much attracted by fermented fruits", in other words, biased by feeding habits as only one aspect of their lives.

For more precise and unbiased studies, the following two approaches are necessary. 1) Application of various sampling methods, such as net sweeping and collections at wild fruits, fungi and bleeding tree sap in various vegetations, together with the ordinary bait trapping using fermented fruits. 2) Promotion of autecological studies at least with dominant species involving both life mode and life histories, analysis of interspecific relations and the role of each species within the community.

In the present study the ordinary bait trap using fermented banana was adopted but a care was taken to select different vegetations within a small area in setting traps. Consequently, some differences in assemblage structure were detected among different vegetations even within a limited area. Each species possessed its own microhabitat preference, especially, the following species were recognized as characteristic species to particular vegetations; *D. confusa*, *D. testacea* and *D. coracina* in forest, *D. lacertosa* in streamside forest, and *D. auraria* A and *D. brachynephros* in grassland GA. Because of different seasonal

activities of dominant species, the seasonal fluctuation of drosophilid assemblages in different vegetations showed different patterns. Thus, the present study shows, though still in a preliminary nature, the necessity of paying attentions to the vegetations of the area to be studied in the biofaunistic comparison of drosophilid assemblages among various localities.

Summary

1) Using fermented banana baits, drosophilid flies were collected from May to October in 1971, in Misumai Arboretum, belonging to Botanical Garden, Hokkaido University, Sapporo. In total 1,525 specimens were obtained which involved 24 species belonging to three genera, *Amiota*, *Leucophenga*, and *Drosophila*, the last genus with the majority of the specimens.

2) From the collections in four different vegetations, natural forest, forest edges, grasslands and streamside forest, the microhabitat preference of predominant species was confirmed.

3) Seasonal activities of six predominant species were classified to five types; unimodal (spring-early summer): *D. confusa* and *D. coracina*, unimodal (summer): *D. auraria* A and B, unimodal (late summer-autumn): *D. immigrans* and *D. lacertosa*, bimodal (spring-summer): *D. testacea*, bimodal (summer-autumn): *D. bifasciata*.

4) The assemblages in different vegetations showed different seasonal fluctuation pattern, depending upon different seasonal activities of predominant species.

5) From statistical analysis of similarity and complexity of assemblage structures in different vegetations, it was made clear that assemblage compositions are considerably different among different vegetations even within the small area.

6) From the results obtained, the necessity of paying attention to vegetation was pointed out as to the biofaunistic comparison of drosophilid assemblages among different localities.

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