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Some Ecological Studies in Drosophila

by

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Contents

Introduction

During the past several years a number of investigations have been carried out to show that natural populations of many species of *Drosophila* exhibit chromosomal polymorphism. Most of these studies have owed to the contributions made by Dobzhansky and coworkers (1937-1962). They have revealed that natural populations of most species of *Drosophila* are variable with respect to the gene arrangement in the chromosomes of different individuals. The degree of variability of the chromosome structure varies in geographic races of the same species, as well as in different species. According to them, the chromosomal polymorphism in *Drosophila* populations is adaptive and balanced, so that the amount of this polymorphism present in a race of species is likely to be a function of the number and variety of the ecological niches which the population has mastered. Most of these studies have been carried out, use being made of *Drosophila* species belonging to *virilis* group, *robusta* group, *melanogaster* group, *willistoni* group, *repleta* group, and nearctic and palaearctic species of *obscura* group.

On the other hand, studies in population ecology which have attracted the current attention of recent geneticists and ecologists, were undertaken for the first time by Timoféeff-Ressovsky and Timoféef-Ressovsky (1940), and then by Dobzhansky and his coworkers (1943, 1944, 1950) have investigated these studies during a past decade, with outstanding advances contributing to a great extent toward the increase in knowledge of cytogenetics and population studies.

The present author has had a special interest in genetical and ecological features of natural and experimental populations of the Drosophilidae. With a hope to extend knowledge in this field, some ecological and experimental investigations have been undertaken by the author, use being made of some 50 species of *Drosophila*, since the accumulation of data along this line of studies may contribute something to the development of the population genetic in general. Main research projects of the present article involve the taxonomy, morphology, distribution and ecology of drosophilid flies in natural populations of Hokkaido, and San-In region, lying in a south-western part of Japan. In addition the preference of two species of flies for some kinds of yeasts were studied use being made of experimental population-cages, in order to obtain some criteria available for understanding the mechanism of attractive behavior of flies to fruit-baits.

The data provided by the present studies are to be described separately into four parts. Part I is devoted to some ecological studies of drosophilid flies, involving their geographical distribution in Hokkaido, together with seasonal behavior of flies observed in the University Botanical Garden, Sapporo during a period from 1954 to 1956.

In Part II, ecological studies carried out in the San-In region, lying in a south-western part of Japan, in five successive years from 1957 to 1961, are recorded with special reference to their geographical distribution in that region, with some data on seasonal behavior observed on Mt. Dakesan, near Matsue City, in 1961. Notes on some statistical analyses are to be presented on population structure of *Drosophila*.

Part III deals with investigations of chromosomal polymorphism in *D. nigromaculata* which were based on data collected in the University Botanical Garden, Sapporo, during a period from late June to October, 1962; the results may involve some important criteria for understanding of the evolutionary process of organisms in general.

Finally, Part IV describes some observational results on the preference of two drosophilid

species to some kinds of yeasts: evidence presented seems to be essential for the analyses of the mechanism of attractive behavior of flies to fruit-baits in field.

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Part I

Ecological Studies of *Drosophila* in Hokkaido

1. Geographical distribution of the Drosophilidae in Hokkaido

Until a decado ago, only seven species had been known of the *Drosophila* fauna from Hokkaido (Kikkawa and Peng 1938). *Drosophila* survey of Hokkaido was begun in 1949 under the plan conducted by Professor Sajiro Makino who has been most anxious to fill the gaps in our knowledge on the drosophilid fauna of Hokkaido. A total of 15 certain and 13 unknown species of Drosophilidae have been found so far Hokkaido up to the year 1951, and they have briefly been reported in *Drosophila* Information Service from 1949 to 1951 (Vols. 23 to 25) by several investigators.

Since then, the investigations regarding the ecology of distribution of drosophilid flies in Hokkaido have made considerable progress.Mizuno(1952) reported the results of collection of *Drosophila* in some localities of Hokkaido. Makino, Momma and Takada(1952) investigated the distribution of *Drosophila* species in relation to altitudes on Mt. Asahidake. Makino, Momma and Ishihara(1952) surveyed distribution of drosophilid flies in several localities of Hokkaido. Momma and Takada(1954) described *Drosophila alboralis* (Subgenus *Hirtodroso-*

phila) as new to science. Suzuki (1955) investigated species of *Drosophila* living on plants and fungi in the City of Sapporo. Takada (1954) found two races of *D. auraria*, the commonest species in Hokkaido, with special regard to the difference in distribution by altitudes. Makino, Momma, Takada and Wakahama (1954) and Momma (1955) recorded the results of collection in various localities of Hokkaido, respectively. Wakahama (1956) recorded some flies new to *Drosophila* fauna of Hokkaido. Momma (1956) reported *D. lacertosa*, a new member of *robusta* group, with a note on some cytological events. Wakahama and Okada (1958) described a new species of *Amiota stylopyga* from Numanohata. Momma (1957) reported a comprehensive survey concerning the distribution and habitats of drosophilid flies in Hokkaido. Then, rather broad collections have continously been undertaken by the staff of the Makino Laboratory, and as a result some species new to science or new to the fauna of Hokkaido were described by Takada (*D. okadai* and *Scaptomyza polygonia*, 1959; *Mycodrosophila shikokuana*, *M. takachihonis* and *D. auraria* type C, 1960), Takada and Okada (*D. ezoana*, 1958; *D. mommai*, 1960), Kaneko and Shima (*Liodrosophila aerea*, 1962) and Wakahama, Kaneko and Tokumitsu (*D. raridentata* and *Chymomyza atrimana*, 1963). As a result, more than sixty species of drosophilid flies have been so far described in Hokkaido as listed below. In the following table are listed 62 species representing 9 genera which were obtained in 64 localities of Hokkaido (Fig. 1).

Fig. 1. Showing localities where collections were made in Hokkaido.

A list of the Drosophilidae from Hokkaido

Subfamily Steganinae
  Genus *Stegana* Meigen
    Stegana coleoptrata (Scopoli)
Genus *Amiota* Loew
  Subgenus *Amiota* Loew
    Amiota alboguttata f. *furcata* Okada
    Amiota stylopyga Wakahama and Okada
  Subgenus *Phortica* Schiner
    Amiota variegata (Fallen)
Genus *Leucophenga* Mik
  Subgenus *Leucophenga* Mik
    Leucophenga magnipalipis Duda
    L. maculata (Dufour)
    L. quinquemaculipennis Okada

Subfamily Drosophilinae
Genus *Mycodrosophila* Oldenberg
Mycodrosophila japonica Okada
M. poecilogastra (Loew)
M. shikokuana Okada
M. takachihonis Okada
Genus *Liodrosophila* Duda
Liodrosophila aerea Okada
Genus *Chymomyza* Czerny
Chymomyza atrimana Okada
C. caudatula Oldenberg
C. nigrimana (Meigen)
Genus *Parascaptomyza* Duda
Parascaptomyza pallida (Duda)
Genus *Scaptomyza* Hardy
Scaptomyza apicalis Hardy
S. graminum (Fallen)
S. monticola Okada
S. polygonia Okada
S. unipunctum (Zetterstedt)
S. sp., like *S. flaveora-montana* complex from North America
Genus *Drosophila* Fallen
Subgenus *Hirtodrosophila* Duda
Drosophila alboralis Momma and Takada
D. histrioides Okada and Kurokawa
D. nokogiri Okada
D. sexvittata Okada
D. trivittata Strobl
Subgenus *Dorsilopha* Sturtevant
D. busckii Coquilett
Subgenus *Paradrosophila* Duda
D. coracina Kikkawa and Peng
Subgenus *Sophophola* Sturtevant
obscura species group Sturtevant
obscura species subgroup Patterson and Wheeler
D. bifasciata Pomini
affinis species subgroup Patterson and Wheeler
Drosophila sp.cf. *helvetica* Burla
melanogaster species group Sturtevant
suzukii series Okada
suzukii species subgroup Hsu
Drosophila suzukii (Matsumura)
melanogaster series Okada
takahashii species subgroup Hsu
Drosophila lutea Kikkawa and Peng
melanogaster species subgroup Hsu
Drosophila melanogaster Meigen
montium series Okada
nipponica species subgroup Okada
Drosophila magnipectinata Okada
Drosophila nipponica Kikkawa and Peng
Drosophila mommai Takada and Okada
montium species subgroup Hsu
Drosophila auraria Peng
Drosophila rufa Kikkawa and Peng
Subgenus *Drosophila* Fallen
quinaria section Hsu
quinaria species group Sturtevant
Drosophila brachynephros Okada
Drosophila unispina Okada
Drosophila nigromaculata Kikkawa and Peng
Drosophila kuntzei Duda
testacea species subgroup Sturtevant
Drosophila testacea van Roser
bizonata species group Tan, Hsu and Sheng
Drosophila bizonata Kikkawa and Peng
mellanderi species group Hsu
Drosophila makinoi Okada
ungrouped species near *histrio* Meigen
Drosophila sternopleuralis Okada and Kurokawa
Drosophila histrio Meigen
ungrouped species near *grandis* Kikkawa and Peng
Drosophila tenuicauda Okada
ungrouped species near *quinaria* section
Drosophila raridentata Okada and Chung
funebris species group Sturtevant
Drosophila funebris (Fabricius)
Drosophila multispina Okada

immigrans species group Sturtevant
Drosophila immigrans Sturtevant
virilis section Hsu
melanica species group Sturtevant
Drosophila pengi Okada and Kurokawa
virilis species group Sturtevant
Drosophila virilis Sturtevant
Drosophila ezoana Takada and Okada
ungrouped species near *virilis* Sturtevant
Drosophila daruma Okada
robusta species group Sturtevant
Drosophila lacertosa Okada
Drosophila moriwakii Okada and Kurokawa
Drosophila okadai Takada
Drosophila sordidula Kikkawa and Peng
repleta species group Sturtevant
Drosophila hydei Sturtevant

Discussion

It is known that most species and specimens of the genus *Drosophila* except the subgenus *Hirtodrosophila* have attracted to the fermenting fruit. A large number of these specimens were collected with the use of traps baited with banana. Among the species luring to banana traps, *D. auraria* and *D. nigromaculata* are remarkable by their large number in occurrence, probably on account of the most extensive distribution through Hokkaido. *Drosophila auraria* is the highest in frequency of occurrence, specially at high temperature, being distributed abundantly in the southern part of Hokkaido. Okada(1956) reported three races, A, B and C, of this species divided by differences of genital apparatus. Among these three races, race A is found abundantly in low land in summer time. Race B is comparatively common in high or northern area and shows a high frequency in occurrence in early spring. Race C is rare and occurs in regions intermediate between the above two regions. *Drosophila nigromaculata* is one of common drosophilid species in Hokkaido, being distributed in low and high land widely through the year. Usually this species is obtainable from various kinds of grasses, fungi and fermenting fruits. Many plants seem to serve as suitable breeding and feeding sites for this species(Momma, 1957; Suzuki, 1955; Takada, 1957; Toyofuku and Kimura, 1961). Further, it is of interest and important to see that various types of chromosomal polymorphism have found in natural populations of this species(Toyofuku, 1958a, b, 1960). *Drosophila bifasciata* is one of the commonest species in high land areas of Hokkaido. Many specimens of this species were obtained in mountainous regions, such as Mt. Asahidake, Akan and Bihoro. However, this species displays high frequency in occurrence in low land including Sapporo, Nopporo, Otaru, Akkeshi and Naebutoro in the early summer period. *Drosophila testacea*, *D. histrio* and *D. makinoi* show a considerable high frequency in higher regions than in regions where *D. bifasciata* inhabits. But sometimes the great majority of *D. testacea* were found in plain land such as the Botanical Garden, Sapporo in the early spring season. *Drosophila brachynephros* is also common species in Hokkaido and a great number of this species is feeding on fungi as well as on fermenting fruits. This species distributes widely in low and southern parts. *Drosophila immigrans* and *D. lutea* attract to fermenting fruit. These species are common in neighbourhood of human habitation in the area not very high from sea-level; they have never occurred in high lands far from human habitation. Members of *robusta* group, *D. lacertosa*, *D. moriwakii*, *D. okadai* and *D. sordidula* are konwn as common species in wood land(Momma 1956). Among them, *D. lacertosa* has the most wide distribution and highest occurrence in this group in Hokkaido. *Drosophila okadai* was described by Takada(1960) as a new species and to distributes in northern parts of Hokkaido. Other two species in this group are rather rare in occurrence in

Hokkaido. *Drosophila suzukii* is common in late summer through autumn and it shows high frequency in low and southern part. *Drosophila bizonata* is very rare species and distributes only in the southern extremity of Hokkaido. Many specimens of *Parascaptomyza pallida*, *Scaptomyza* spp., *D. nipponica* and *D. nigromaculata* were captured on various kinds of grasses through a net-sweeping method. Among these species, *D. nigromaculata* were collected abundantly by the usual trapping method. *Parascaptomyza pallida*, members of the genus *Scaptomyza* and *D. nipponica* have rarely or never been lured to traps baited with fermenting banana. Among the members mentioned above, *P. pallida* was obtained in the place at an altitude of 4000ft. with the use of traps and through net-sweeping and a great number of this species was caught by net-sweeping in various localities of Hokkaido. It is supposed from this evidence that *P. pallida* may distribute not only in the areas of human habitation, but also in the high lands far from the village in Hokkaido. Many specimens of *D. nipponica* were obtained on various kinds of grasses through the year. Almost of these specimens were collected at various stations neighbouring Sapporo City. Summarizingly, *P. pallida* and *D. nipponica* seem to be the common species through Hokkaido.

In the collection carried out in Hiroo, in August, 1962, four femals and four males of *D. raridentata* were obtained. This species was reported by Okada and Chung (1960) as new to science from South Korea, based on only a male specimen. This is the first finding of this species in Japan and especially female specimen has never been recorded. Structure of egg-guide of this species is as follows:

Lobe brown, ventrally swollen, dorsal margin pointed, with 8 heavy reddish teeth, penultimate one being largest and thumb-like and with 3 discal teeth, dorsal half paler, upper apical margin brown, anterior portion quadrate and paler. Basal isthmus brown and long.

Most species belonging to the genera *Leucophenga*, *Mycodrosophila* and the subgenus *Hirtodrosophila* of the genus *Drosophila* found in Hokkaido are fungi-feeders. Few or no flies of these species have attracted to fermenting fruits. They were collected abundantly in number on various fungi in several parts of Hokkaido with the use of net-sweeping or sucking method with glass pipe. These species distribute widely in various districts excepting high mountains. Among them, *D. histrioides* and *D.sexvittata* of the subgenus *Hirtodrosophila* are abundant in number and exceptionally the former species attracts the fermenting fruit and can be bred in laboratory with the use of the general culture method.

Members of the genus *Amiota* generally hover about the eyes or ears of people and almost specimens of this genus were collected by net around our bodies. Three species of this genus have been found so far in Hokkaido and among them, *Amiota stylopyga* was reported by the present author as new to science (Wakahama and Okada, 1958).

2. Seasonal behavior of *Drosophila* observed in the University Botanical Garden, Sapporo

The general occurrence of periodic number changes in populations of wild animals and the significance of these changes in relation to evolutionary process have been emphasized by Elton (1927, 1946) and Spencer (1941). Fluctuating populations in various animals likewise have been considered by Mayr(1942), Huxley(1942) and Dobzhansky (1941).

Patterson's(1943) extensive work on the fluctuations of nine common species of *Drosophila* near Austin, Texas reveals that different species show marked seasonal changes in population

size. He found one or more periods of expansion per year; characteristic absences of several months during summer, and autumn and winter, and also periods of pessimum or low population frequency.

Dobzhansky and Epling (1944) observed the seasonal distribution of *D. pseudoobscura* at four localities near or on Mt. San Jacinto, in California. The period of maximum numbers of this species was shown to occur during March and April for the lowest elevation; April and May, for the next highest; and in June and July, for the two highest altitude stations.

Table 1. Collection records of drosophilid flies in the University Botanical Garden, Sapporo, during a period from May to October, 1954

Month	May	June	July	Aug.	Sept.	Oct.	Total
Species							
Amiota variegata	—	—	2	—	1	—	3
Parascaptomyza pallida	—	1	12	1	1	—	15
Drosophila histrioides	—	1	—	1	—	—	2
D. coracinaa	—	1	—	—	—	—	1
D. melanogaster	—	—	1	56	4	—	61
D. auraria	—	13	93	350	17	1	474
D. rufa	1	6	1	—	—	—	8
D. nipponica	—	4	5	1	1	3	14
D. lutea	—	—	—	8	1	—	9
D. suzukii	—	—	—	1	1	—	2
D. bifasciata	—	2	1	18	—	—	21
D. magnipectinata	4	—	—	1	2	—	7
D. nigromaculata	160	100	636	86	191	36	1209
D. brachynephros	3	60	27	153	49	5	297
D. virilis	—	—	—	6	—	—	6
D. testacea	8	4	7	58	—	—	77
D. funebris	—	—	—	2	—	—	2
D. hydei	—	7	3	—	—	—	10
D. spp. (robusta group)	—	2	—	26	8	1	37
D. immigrans	—	1	—	8	13	1	23
D. histrio	—	—	—	8	—	—	8
D. pengi	—	—	—	3	—	—	3
D. sp.	—	1	—	1	1	—	3
Total	176	203	788	788	292	46	2295

Dobzhansky and Pavan(1950) found month to month fluctuations of *Drosophila* populations occurring in tropical Brazil, both in areas where a wet and dry season alternated and also in regions of relatively warm humid climates. These authors state, "It is an open question to what extent these changes are cyclic and how regularly they are repeated in different years." Fruiting season, which occur even in areas of rather uniform climate, are apparently responsible changes in the available food supply, hence in the numbers of flies supported by a given region.

It was aimed in this study to illustrate as detail as possible the seasonal change of drosophilid flies observed in Hokkaido.

i). Seasonal activity of *Drosophila* observed in the University Botanical Garden, Sapporo

Through the field observations made in the University Botanical Garden, in the central part

of Sapporo City, the seasonal variations in frequency of drosophilid flies were studied throughout three years during a period from 1954 to 1956. We have snowfall from November to March every year. In the snowfall season the temperature is very low, so that the flies do not attract to the baits in the natural population. Collections were done for three days continuously with the use of traps baited with fermenting banana. A total of 6857 specimens were collected during the three years; they represented 31 species as shown in Tables 1, 2 and 3.

In the following, the author describes the aspects of fluctuation for total population size and seasonal changes of some abundant species in each year observed in the University Botanical Garden, Sapporo.

Table 2. Collection records of drosophilids flies in the University Botanical Garden, Sapporo, during a period from June to October, 1955

Month	June	July	August	September	October	Total
S. apicalis	—	3	—	—	—	3
D. histrioides	4	—	—	2	—	6
D. coracina	—	4	—	—	—	4
D. auraria	20	69	180	14	1	284
D. lutea	2	—	5	—	—	7
D. nipponica	—	—	—	1	—	1
D. suzukii	—	—	12	4	2	18
D. bifasciata	94	—	—	—	—	94
D. nigromaculata	38	52	11	75	18	194
D. brachynephros	36	16	19	48	1	120
D. testacea	4	16	7	—	—	27
D. lacertosa	1	—	—	6	2	9
D. moriwakii	—	—	—	1	—	1
D. sordidula	1	1	2	—	1	5
D. immigrans	1	1	21	—	1	25
D. histrio	—	1	—	—	—	1
Total	201	163	258	151	27	800

Fluctuation for total population size

In 1954, a total of 2295 specimens which represented 23 species was collected. In May, 176 specimens belonged to 5 species were obtained. In June, 203 specimens of 14 species were secured. In July, 788 specimens represented 11 species were found. In August, 788 specimens of 19 species were observed. In September, 292 specimens belonged to 13 species were collected. In October, 48 specimens of 6 species were secured (Tables 1, 2 and 3 and Fig. 2). That is, fluctuation for total population size in 1954 was shown in the monomodal curve, presenting seasonal peak in July and August (both 788 specimens, 34.2 per cent for the total specimens collected in this year).

As shown in Fig. 2, seasonal fluctuation for population size of total species collected in 1955 was shown by a bimodal curve. The first peak was seen in June (201 specimens, 25.1 per cent for the total specimens collected in this year), and following a low density in July, the second peak was observed in August (258 specimens, 32.2 per cent).

In 1956, seasonal fluctuation for total population size was presented by a monomodal curve as seen in Fig. 2. Following a sudden rising in number of flies in July (830 specimens), the

seasonal peak was occurred in August (949 specimens, 25.2 per cent for the total specimens collected in this year).

In the observations during the three years, fluctuations for total population size were shown by the monomodal curve in 1954 and 1956, presenting the seasonal peak in August, while in 1955 a bimodal curve was seen with two seasonal peaks, one in June and the other in August.

Table 3. Monthly collection records of drosophilid flies in the University Botanical Garden, Sapporo, during a period from May to October, 1956

Month	May	June	July	Aug.	Sept.	Oct.	Total
Species							
Amiota variegata	—	1	—	—	—	—	1
Parascaptomyza pallida	—	—	1	—	—	—	1
Drosophila alboralis	—	—	—	—	1	—	1
D. nokogiri	—	—	—	—	1	—	1
D. histrioides	82	85	1	1	—	—	169
D. sexvittata	—	2	—	—	—	—	2
D. busckii	—	—	1	1	—	—	2
D. coracina	8	—	19	—	—	—	27
D. bifasciata	—	240	35	31	—	—	306
D. auraria	61	85	326	273	19	1	765
D. lutea	—	14	42	139	153	102	450
D. melanogaster	—	—	—	—	1	—	1
D. suzukii	—	—	—	6	24	11	41
D. nigromaculata	251	83	107	156	238	11	846
D. brachynephros	89	41	84	195	97	1	507
D. testacea	100	11	150	38	1	—	300
D. virilis	—	—	3	2	—	—	5
D. immigrans	—	1	7	10	90	25	133
D. funebris	—	—	2	—	—	—	2
D. sordidula	—	3	25	2	—	—	30
D. lacertosa	—	5	18	94	35	1	153
D. moriwakii	—	—	—	—	1	—	1
D. histrio	—	6	4	1	1	—	12
D. sp.	—	—	5	—	—	—	5
Total	591	577	830	949	662	153	3762

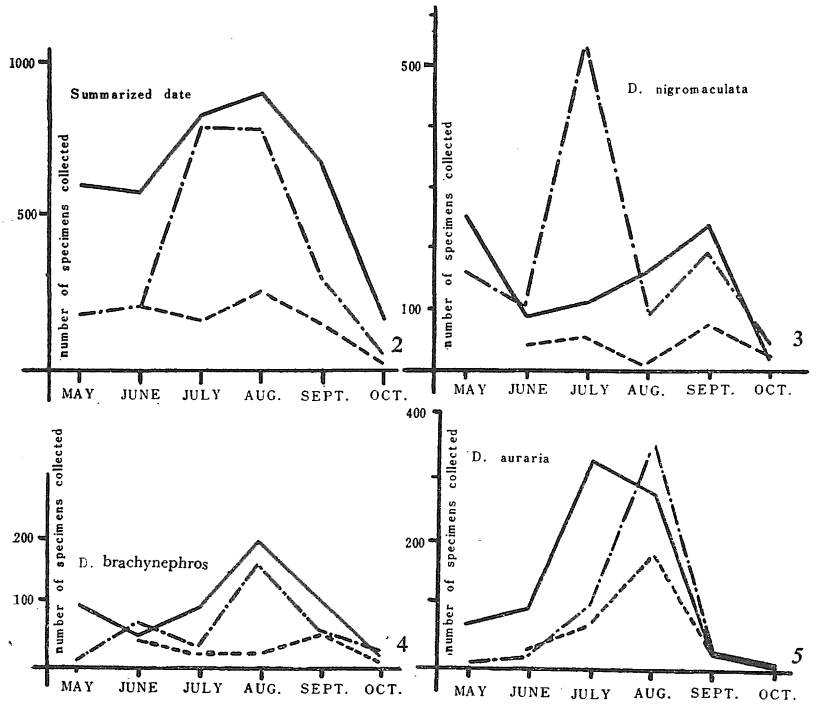
Seasonal activity of *Drosophila nigromaculata*

This is one of the most abundant species in Hokkaido. The numbers of specimens collected were 1209 specimens in 1954, 194 in 1955, and 846 in 1956, adding up to 2249. In the total of flies obtained this species represented 52.68 per cent in 1954, 24.25 per cent in 1955 and 22.48 per cent in 1956. The seasonal curve was shown by a bimodal curve for every year; that is, the first peak was observed in July in 1954(636 specimens) and 1955 (52 specimens), and the second peak was found in September (191 specimens in 1954 and 75 specimens in 1955), while in 1956, the first peak appeared in May (251 specimens), with the second peak in September (238 specimens), as shown in Tables 1, 2 and 3 and Fig. 3. Monthly numerical data of this species in collections were as follows: 160 specimens were obtained in May, 100 in June, 636 in July, 86 in August, 191 in September and 36 in October in 1954; 38 in May, 52 in June, 11 in

August, 75 in September and 18 in October in 1955; and 251 in May, 83 in June, 107 in July, 156 in August, 238 in September and 11 in October in 1956.

Seasonal activity of *Drosophila auraria*

This species is one of the abundant species in Hokkaido, especially prevalent in the southern part in summer. A total of 1523 specimens was collected during three years in the University Botanical Garden: 474(20.65 per cent) in 1954, 284(35.50 per cent) in 1955, and 765 (20.33 per cent) in 1956. This species showed a unimodal curve for every year. In the first two years, the seasonal maxima were observed in August (350 specimens in 1954 and 180 in 1955), showing very low frequency in the early and latter parts of month, while in 1956 a considerable number of this species was obtained in both July(326 specimens) and August(273 specimens). They showed a low frequency in September (19 specimens) and eventually disappeared altogether(Fig. 5). Monthly numerical records of collections were as follows: in 1954, no specimens was found in May, 13 in June, 93 in July, 350 in August, 17 in September and only 1 in October; 20 in June, 69 in July, 180 in August, 14 in September and 1 October in 1955; and 61 in May, 85 in June, 326 in July, 273 in August, 19 in September and 1 in October in 1956. From the above data, it is evident that this species contributes mostly to the seasonal peak of total population.



Figs. 2-.5 Graphs showing seasonal activity of *Drosophila* observed in the University Botanical Garden, Sapporo, in three successive years, ranging from 1954 to 1956; chain lines indicate the results of 1954, dotted lines those of 1955 and solid lines those of 1956. 2, summarized data from all species under observation. 3, *D. nigromaculata*. 4, *D. brachynephros* 5, *D. auraria*.

Seasonal activity of *Drosophila brachynephros*

This species is also abundant in the Botanical Garden. In a total of 923 specimens collected, 297 were obtained in 1954, 120 in 1955, and 507 in 1956. They show moderate frequencies, being 12.94 per cent in 1954, 16.0 per cent in 1955, and 13.47 per cent in 1956. Seasonal curves marked by this species were bimodal. In the first two years, the first peak was observed in June, while the second peak occurred in August in 1954 and in September in 1955. But in 1956, the first peak was shown in May with a sudden decrease in July, and the second peak was marked in August with 195 specimens. It is then evident that the occurrence of this species is characterized by frequency curves nearly similar to those of *D. nigromaculata* (Fig. 4). Monthly numerical records of collections were as follows: 3 specimens of this species were secured in May, 60 in June, 27 in July, 153 in August, 49 in September, and 5 in October in 1954; 36 in June, 16 in July, 19 in August, 48 in September and only 1 in October in 1955; and 89 in May, 41 in June, 84 in July, 195 in August, 97 in September and 1 in October in 1956.

Seasonal activity of *Drosophila testacea*

Generally, this species is abundant in high mountainous region such as Mt. Asahidake and shows a population consisting of small number of specimens in the plain land including the University Botanical Garden. However, data obtained in 1956 offered a considerable number in the numerical count of specimens: this species showed a typical bimodal curve in activity, since the first peak appeared in May and the second peak in July. The number of specimens collected was 77 in 1954, 27 in 1955 and 300 in 1956 (Fig. 8). Monthly numerical variations of this species were as follows: 8 specimens of this species were found in May, 4 in June, 7 in July and 58 in August and no specimen was collected in September and October in 1954; 4 in June, 16 in July and 7 in August and no specimen was obtained in September and October in 1955; and 100 in May, 11 in June, 150 in July, 38 in August, 1 in September and no specimen in October in 1956. The activity of this species was indefinite type, for this species showed a unimodal type in the first two years, showing a seasonal peak in August in 1954 and in July in 1955, whereas this species showed a bimodal type in 1956.

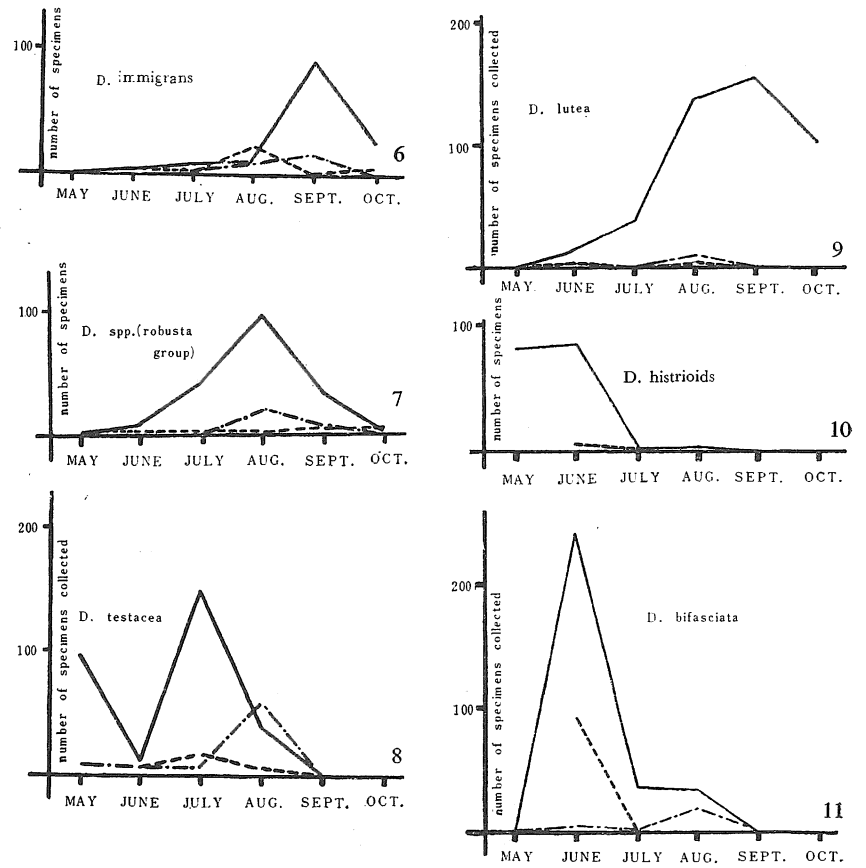
Seasonal activity of *Drosophila bifasciata*

Generally, this species also abounds in the mountainous region of the northeastern part of Hokkaido and is rather rare in the University Botanical Garden. In 1954, only 20 specimens (0.90 per cent) were collected, while the collection in June of 1955 showed 94 specimens. Thereafter no more were collected. On this basis of the present species is to be referred to as a non-seasonal type. A similar phenomenon is known to occur in *D. immigrans* in Aldrich, Texas (Patterson, 1943). In the 1956 collection, however, this species appeared in a high frequency in Sapporo and showed a typical unimodal activity; 240 specimens were obtained in June while none was collected in May. They showed a sudden decrease through July (35 specimens) and August (31 specimens), and disappeared in September. Then it can be stated that this species is of unimodal type in seasonal variation and of spring type in seasonal activity (Fig. 11 and Tables 1, 2 and 3).

Seasonal activity of *Drosophila* spp. (*robusta* group)

Two species of *D. sordidula* and *D. lacertosa*, a new species described by Okada (1956), represent this group. There were obtained 37 specimens in 1954 and 15 in 1955, while 184

were collected in 1956 showing a typical unimodal and summer type curve. The seasonal maximum was seen in August with 94 specimens (Fig. 7). Monthly numerical records of collections were as follows: 2 specimens of this group were obtained in June, 26 in August, 8 in September and 1 in October and no was found in May and July in 1954; 2 in June, 1 in July, 2 in August, 6 in September and 3 in October in 1955; and no in May, 8 in June, 43 in July, 96 in August, 35 in September and 1 in October in 1956 (Tables 1, 2 and 3).



Figs. 6~11. Graphs showing seasonal activity of *Drosophila* observed in the University Botanical Garden, Sapporo, in three successive years, ranging from 1954 to 1956; chain lines indicate the results of 1954, dotted lines those of 1955 and solid lines those of 1956. 6, *D. immigrans*. 7, *D.* spp. (*robusta*-group). 8, *D. testacea*. 9, *D. lutea*. 10, *D.histrioides*. 11, *D. bifasciata*.

Seasonal activity of *Drosophila lutea*

This species was rather rare in the University Botanical Garden. Only 9 specimens(0.39 per cent) in 1954 and 7 (0.87 per cent) in 1955 were obtained. But the 1956 collection offered 456 with a typical unimodal and autumn curve. The popuation size was suddenly increased in August(149 specimens); and it offered the seasonal maximum in September with 153 specimens. Interestingly, this species did not decrease in October (102 specimens), while other

species almost disappeared (Fig. 9). Monthly numerical records of collection in 1956 were as follows: no specimen of this species was found in May, 14 in June, 42 in July, 139 in August, 153 in September(seasonal maximum) and 102 in October (Table 3).

Shogaki(1952) who briefly reported on the seasonal activity of this species as observed in Kyoto stated that it showed a very high frequency in spring with a bimodal curve in seasonal activity. A similar feature was described by Ohba(1956) and Nozawa(1956) on the basis of their observations at Asakawa and Anjyo. The present author's results are not in agreement with those of other authors as such as aforementioned.

Seasonal activity of *Drosophila histrioides*

The collections showed only 2 specimens in 1954 and 6 in 1955, while in 1956, 167 specimens were collected, 82 in May and 85 in June. They showed a sudden decrease in July (only one male) (Tables 1, 2 and 3, and Fig. 10).

Okada and Kurokawa(1957) described this species as a new species and as member of the subgenus *Hirtodrosophila*. The members of this subgenus do not generally attracted to the traps with fermenting fruits, being mostly fungus-feeders. But this species, so far as the author is aware, is attracted by the banana trap; it can be cultured in the laboratory without difficulty.

Seasonal activity of *Drosophila immigrans*

Patterson (1943) reported a non-seasonal activity in this species which was caused by an unusually heavy rainfall. In the University Botanical Garden, this species appeared at a very low frequency in both 1954 (23: 0.99 per cent) and 1955(25: 3.12 per cent), while in 1956, 133(3.53 per cent) were obtained. Irrespective of a considerable fluctuation in population size they showed a unimodal type in seasonal activity. The seasonal maximum was found in September in 1954 and 1956, and in August in 1955. It is apparent that this is an abundant species in autumn(Fig. 6). Monthly numerical records of collections were as follows: 1 specimen was obtained in June, 8 in August, 13 in September (seasonal peak) and 1 in October and no was found in May and July in 1954; 1 in June, July and October, respectively, 21 in August (seasonal maximum) and no was collected in September in 1955; and 1 in June, 7 in July, 10 in August, 90 in September (seasonal maximum) and 25 in October and no was obtained in May in 1956 (Tables 1, 2 and 3, andFig. 6).

Discussion

Many papers have been published dealing with the fluctuation for population size in the various species of *Drosophila* from season to season(Patterson, 1943; Dobzhansky and Pavan, 1950; Williams and Miller, 1952; Baseden, 1954; Mather, 1956; Ohba, 1956; Nozawa, 1956; Wakahama, 1956, 1957, 1961, 1962b, c; Paik, 1958). The results of the present observations also indicate a considerable variation in the population size of species found in the University Botanical Garden. Ohba(1956) reported the occurrence of two peaks in seasonal curve. In the present observations there is no clear-cut evidence for the bimodal curve. Nozawa(1956) divided the population structure into the following four phases; the hibernating phase, the first active phase, the summer resting phase, and the second active phase. Baseden (1955) observed the autumn flash(equal to the second active phase) in Scotland. Nothing has been known as to

the hibernation of *Drosophila* in the University Botanical Garden. Dobzhansky and Pavan (1950) have reported in their study of seasonal variations of *Drosophila* in Brazil that there is a definite cycle of frequencies correlated with seasons in some species. In the present author's observations there are some data which suggest the presence of a definite cycle in some forms (*D. auraria*, *D. immigrans*, *D. nigromaculata*, *D. brachynephros* and *D.* spp. (*robusta* group).

Drosophila testacea and *D. bifasciata* are abundant in the mountain regions of Hokkaido, generally. *Drosophila testacea* showed a unimodal curve in the first two years, but presented a typical bimodal one in the third year. *Drosophila bifasciata* suddenly appeared in large numbers in June, 1955 (96 specimens), but has appeared no more since then. In the third year, this species appeared again with very high frequency and a unimodal curve. Thus it is evident that *D. testacea* is a species which breaks the constant cycle and that *D. bifasciata* shows a new constant cycle.

There are known some species which appear suddenly in great number in the population. Patterson (1943) observed this in *D. immigrans* in Aldrich, Texas. A similar feature was observed by the present author in the University Botanical Garden, in *D. melanogaster* (August, 1954), *D. bifasciata* (June, 1955), *D. lutea* (1956) and *D. histrioides* (1956) as descri bed above. It seems probable that a sudden rise may be due to certain favorable conditions affected by unknown environmental factors.

Based on the results of the present observations carried out in the University Botanical Garden it can be stated that the seasonal activity of *Drosophila* may be divided into the following four types; type-1 showing one seasonal maximum, type-2 with two yearly maxima in activity, type-3 presenting no sign of seasonal activity and type-4 showing fluctuations in each year. Type-1 is presented by *D. auraria*, *D. immigrans* and *D.* spp. (*robusta* group), type-2 by *D. nigromaculata* and *D. brachynephros*, type-3 by *D. lutea*, *D. histrioides* and *D. melanogaster*, while *D. testacea* and *D. bifasciata* may be referred to as type-4.

Part II

Ecological Studies of the *Drosophilidae* in San-In Region

1. Geographical distribution of the Drosophilidae in San-In region

San-In region is the south-western part of Japan-Hondo and faces to Japan Sea. It is a biologically very interest and excellent area to carry out such a distribution survey, because of particular biotypes with varied climatic and physiographic conditions. For example, in this region the temperature varies from −10°C to 35°C in low land, and altitudes of this region varies from a few feet in the costal plains to more than six thousand feet in the mountainous regions. Further, this region is humid and riches in the mountainous region, being adapted for living of drosophilid flies and includes Mt. Daisen (ca. 1800m above sea level), the Chugoku mountain range and Oki Islet where are very interest for biogeography and bionomy.

But until recently little has been known on the Drosophilidae in San-In region. Since a *Drosophila* survey made by Kikkawa and Peng in 1938, only 4 species have been found in San-In region up to the year 1956. They were *D. immigrans* and *D. virilis* collected in Tottori and *D. busckii*, *D. immigrans* and *D. lutea* which were obtained from the Oki Islet.

Okada (1956) reported 25 species from the Chugoku district where includes San-In and San-Yo regions. And he reported that it will considerably be emended after the more exaustive surveys in various localities are carried out, especially in Tohoku and Chugoku districts as well as the southern parts of Japan.

The present author has special interest in the distribution of Drosophilidae in this region and since the spring of 1957 when he moved to Matsue City from Sapporo, has carried out the survey, hoping to fulfill the handicap in this field in this region.

The present author (1960) reported preliminary 23 species from the five localities of this region. After that the further collections have been carried out and many individuals of the Drosophilidae were obtained from 11 localities in San-In region as shown in Table 4.

In this Part, the species found so far in San-In region and their habitats are listed below.

A list of the Drosophilidae obtained in San-In region

Diastata ussurica: Daisen (Sept. 1961)
Amiota alboguttata f. *furcata:* Daisen (Sept. 1961)
Amiota variegata: Daisen (June, 1958, July 1959, Aug. 1960, Sept. 1961), Chikuya (May 1959), Dakesan (Apr.-Nov. 1961), Rakuzan Park (July, Aug. 1957), Kawamoto (Aug. 1958).
Amiota magna: Dakesan (Sept. 1961).
Leucophenga argentosa: Dakesan (Aug., Nov. 1961).
L. magnipalpis: Daisen (July 1959), Dakesan (Oct. 1961).
L. maculata: Hirose (Sept. 1961), Daisen (Sept. 1961).
L. ornatipennis: Dakesan (Aug., Oct. 1961), Rakuzan Park (July 1958).
L. angusta: Dakesan (Oct. 1961).
L. concilia: Dakesan (Aug., Oct. 1961), Sho-o (Sept. 1961).
Microdrosophila-like sp.: Dakesan (July 1961).
Mycodrosophila splendida: Hirose (Sept. 1961), Daisen (June 1958, July 1959, Aug. 1960, Sept.

1961), Dakesan (May, Aug., Oct. 1961), Rakuzan Park (Apr., June-Oct. 1957, Sept., Oct. 1958, Aug. Nov., 1959).

M. poecilogastra: Hirose (Sept. 1961), Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961).

Dettopsomyia argentifrons: Sho-o (Sept. 1961).

Liodrosophila aerea: Daisen (Sept. 1961), Akana (Aug. 1961), Taisha (June 1960), Sho-o (Sept. 1961).

Parascaptomyza pallida: Kami-Ito (Sept. 1960, Oct. 1961), Daisen (June 1958, July 1959, Aug, 1960, Sept. 1961), Dakesan (June, Oct. 1961), Rakuzan Park (May-Oct. 1957, Apr.-Oct. 1958, Apr.-July, Sept.-Nov. 1959).

Scaptomyza graminum: Chikuya(Aug. 1959), Dakesan (Aug.,Oct. 1961).

Drosophila alboralis: Daisen (Sept. 1961), Dakesan (Sept. Oct. 1961).

D. sexvittata: Dakesan (Oct. 1961), Rakuzan Park (June 1958, Oct. 1959).

D. quadrivittata: Daisen (July 1959), Kitayama (Aug. 1961), Dakesan (July, Oct. 1961)

D. histrioides: Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Kitayama (Aug. 1961), Sambe (Aug. 1961), Dakesan (Apr.-Nov. 1961), Taisha (June 1960, May-Aug. 1961). Rakuzan Park (May 1957-1959), Sho-o (Sept. 1961).

D. busckii: Kami-Ito (Sept. 1960, Oct. 1961), Daisen (June 1958), Chikuya (May-Oct. 1959, Dec. 1960), Kuroda (May-Oct. 1960), Sambe (Aug. 1961). Dakesan (May, July Nov. 1961), Taisha (June 1960, May-Aug. 1961), Rakuzan Park (June 1957, Apr.-Nov. 1959), Kawamoto (Aug. 1958), Oki Islet (July 1957).

D. coracina: Chikuya (Aug. 1959), Masuda (Sept. 1961), Dakesan (June, Aug.-Nov. 1961), Taisha (June 1960, May-Aug. 1961), Rakuzan Park (Aug.-Oct. 1957, Apr.-June, Aug., Sept. 1958, Apr.-June 1959), Oki Islet (July 1957), Sho-o (Sept. 1961).

D. bifasciata: Daisen (June 1958, July 1959), Dakesan (May, June, Oct. 1961).

D. suzukii: Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Kitayama (Aug. 1961), Kuroda (Aug.-Oct. 1960), Akana (Aug. 1961), Sambe (Aug. 1961), Masuda (Sept. 1961), Dakesan (June-Nov. 1961), Taisha (Aug. 1961), Rakuzan Park (Sept.-Nov. 1957, Aug., Sept. 1958, Aug.-Oct. 1959), Kawamoto (Aug. 1958), Oki Islet (July 1957), Sho-o (Sept. 1961).

D. pulchrella: Daisen (Sept. 1961), Akana (Aug. 1961), Sambe (Aug. 1961), Dakesan (Oct. 1961), Sho-o (Sept. 1961).

D. lutea: Hirose (Sept. 1961), Kami-Ito (Sept. 1960, Oct. 1961), Daisen (June, 1958, July 1959, Aug. 1960, Sept. 1961), Kitayama (Aug. 1961), Chikuya (May-Oct. 1959, Dec. 1960), Kuroda (May-Oct. 1960), Akana (Aug. 1961), Sambe (Aug. 1961), Masuda (Sept. 1961), Dakesan (Apr.-Nov. 1961), Taisha (June 1960, May-Aug. 1961), Rakuzan Park (Apr.-Nov. 1957-1959), Kawamoto (Aug. 1958), Oki Islet (July, 1957), Sho-o (Sept. 1961).

D. melanogaster: Hirose (Sept. 1961), Kami-Ito (Sept. 1960, Nov. 1961), Daisen (June 1958), Kitayama (Aug. 1961), Chikuya (May-Oct. 1960), Kuroda (Aug.-Oct. 1960), Akana (Aug. 1961), Kokufu (Aug., Oct. 1961), Sambe (Aug. 1961), Masuda (Sept. 1961), Dakesan (Apr.-Nov. 1961), Taisha (June 1960), Rakuzan Park (July-Sept. 1957, June-Aug. 1958, May-Sept. 1959), Kawamoto (Aug. 1958), Oki Islet (July 1957), Sho-o (Sept. 1961).

D. auraria: Hirose (Sept. 1961), Kami-Ito (Sept. 1961), Daisen (June 1958, July 1959m, Aug. 1960, Sept. 1961), Kitayama (Aug.1961), Chikuya (May-Oct. 1959, Dec. 1960), Kuroda (May-Oct. 1960), Akana (Aug. 1961), Sambe (Aug. 1961), Masuda (Sept. 1961), Dakesan

(May-Nov. 1961), Taisha (June 1960, May-Aug. 1961), Rakuzan Park (Apr.-Aug., Oct., Nov. 1957, May-July 1958, Apr.-Sept. 1959), Kawamoto (Aug. 1958), Oki Islet (July 1957), Sho-o (Sept. 1961).

D. rufa: Hirose (Sept. 1961), Kami-Ito (Sept. 1960, Oct. 1961), Daisen (July 1959), Kitayama (Aug. 1961), Chikuya (May-Oct. 1959), Kuroda (May-Oct. 1960), Akana (Aug. 1961), Sambe (Aug. 1961), Dakesan (Apr.-Nov. 1961), Taisha (June 1960, May-Aug. 1961), Rakuzan (Apr.-Npv. 1957, Apr.-Sept. 1958, Apr.-Aug. 1959), Kawamoto (Aug. 1958), Oki-Islet (July 1957), Sho-o (Sept. 1961).

D. brachynephros: Kami-Ito (Sept. 1960, Oct. 1961), Daisen (Sept. 1961), Akana (Aug. 1961), Dakesan (Sept.-Nov. 1961), Taisha (Aug. 1961), Sho-o (Sept. 1961).

D. angularis: Hirose (Sept. 1961), Kami-Ito (Sept. 1960, Oct. 1961), Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Kitayama (Aug. 1961), Akana (Aug. 1961), Sambe (Aug. 1961), Masuda (Sept. 1961), Dakesan (Apr.-Nov. 1961), Taisha (May 1961), Rakuzan Park (Apr.-Nov. 1957, Apr.-Sept. 1958, Apr. May, July-Nov. 1959), Kawamoto (Aug. 1958), Oki Islet (July 1957), Sho-o (Sept. 1961).

D. unispina: Daisen (Sept. 1961), Dakesan (Oct. 1961).

D. nigromaculata: Chikuya (May-Oct. 1959), Kuroda (May, June 1960), Dakesan (Oct. 1961), Rakuzan Park (Apr.-June, Aug.-Oct. 1957, Apr.-July 1958, Oct. 1958, Apr.-June, Sept., Oct. 1959), Kawamoto (Aug.1958), Oki Islet (July 1957).

D. testacea: Daisen (Sept. 1961), Dakesan (Oct. 1961).

D. bizonata: Hirose (Sept. 1961), Kami-Ito (May 1962), Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Kitayama (Aug. 1961), Chikuya (Oct. 1959), Kuroda (Oct. 1960), Akana (Aug. 1961), Sambe (Aug. 1961), Masuda (Sept. 1961), Dakesan (Apr.-Nov. 1961), Taisha (June 1960, July, Aug. 1961), Rakuzan Park (Apr.-Oct. 1957, Apr.-Nov. 1958, Oct. 1959), Kawamoto (Aug. 1958), Oki Islet (July 1957), Sho-o (Sept. 1961).

D. sternopleuralis: Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Sambe (Aug. 1961), Masuda (Sept. 1961), Dakesan (June-Nov. 1961), Rakuzan Park (Apr.-July 1957, May 1958, Apr.-June 1959), Oki Islet (July 1957).

D. histrio: Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Dakesan (May, Nov. 1961).

D. grandis: Masuda (Sept. 1961), Dakesan (Oct. 1961).

D. immigrans: Kami-Ito (Sept. 1960, Oct. 1961), Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Chikuya (May-Oct. 1959, Dec. 1960), Kuroda (May-Oct. 1960), Akana (Aug. 1961), Kokufu (Oct. 1961), Sambe (Aug. 1961), Dakesan (May-Nov. 1961), Taisha (June, 1960 May-Oct. 1961), Rakuzan Park (Apr.-Nov. 1957, May, July-Oct. 1958, June-Nov. 1959), Kawamoto (Aug. 1958), Oki Islet (July 1957), Sho-o (Sept. 1961).

D. curviceps: Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961).

D. virgata: Dakesan (Sept.-Nov. 1961), Rakuzan Park (Sept. 1957), Oki Islet (July 1957).

D. subtilis: Daisen (Sept. 1961), Masuda (Sept. 1961), Dakesan (Apr.-Nov. 1961), Sho-o (Sept. 1961).

D. pengi: Daisen (Sept. 1961), Dakesan (May, June, Sept., Oct. 1961),

D. virilis: Kami-Ito (Sept. 1960, Oct. 1961), Chikuya (Dec. 1960), Kuroda (May 1960), Dakesan (May, July, Sept., Oct. 1961), Rakuzan Park (Apr.-Aug. 1957, Apr. May, July-Oct. 1958, Apr.-Aug. 1959), Kawamoto (Aug. 1958).

D. sordidula: Daisen (Sept. 1961), Dakesan (May, July, Sept., Oct. 1961).

D. lacertosa: Kami-Ito (Sept. 1960, Oct. 1961), Daisen (June 1958, July 1959, Aug. 1960, Sept. 1961), Kuroda (May-Oct. 1960), Akana (Aug. 1961), Sambe (Aug. 1961), Dakesan (May, June, Aug.-Oct. 1961), Taisha (June 1960), Rakuzan Park (Apr.-Sept., Nov. 1957, Apr.-Sept. 1958, Apr.-Aug. 1959), Oki Islet (July 1957).

D. daruma: Rakuzan Park (Dec. 1961).

Discussion

Table 4 summarized the records from the collections of the Drosophilidae in 16 localities of San-In region with peculiar regards to their numbers so far obtained. It is known that most species and specimens of the genus *Drosophila* except the members of the subgenus *Hirtodrosophila* in this genus have attracted to fermenting fruits. A large number of these speciemens were collected with the use of traps with banana through the procedure as mentioned in the foregoing pages.

Among the species luring to banana traps, *D. lutea* showed the highest frequency in number in occurrence, due probably to the most extensive distribution in this region through the all year round. This species was also high in frequency of occurrence, specially in spring and in autumn, being distributed abundantly in low land of this region.

A considerable number of *D. bizonata* was also captured in various localities of this region. This species was known as the vermin of fungi but most of them were collected with the use of banana traps on Mt. Dakesan and in the Rakuzan Park.

Drosophila immigrans was common species in summer. Most specimens of this species were obtained in low and domestic land in San-In region.

Drosophila busckii is known as rare species in wild area, though this species showed an explosive increase in the Rakuzan Park in 1959, and a thousand or more specimens were collected.

No specimen of *D. subtilis* was found till 1960, but in the collection of 1961 carried out on Mt. Dakesan, this species furnished a high frequency in occurrence. Besides this, only one specimen was found on Mt. Daisen in September, 1961, two in Masuda in September, 1961 and two in Sho-o in September, 1961, respectively.

Drosophila melanogaster, *D. auraria*, *D. rufa* and *D. angularis* displayed also a considerable high frequency in occurrence. Most specimens of *D. melanogaster* were obtained in the collection at Kokufu where the collection was limited in the human dwelling for typhoon. *Drosophila auraria* and *D. rufa* furnished a comparatively high frequency in low land like as Chikuya, the Rakuzan Park and Oki Islet. *Drosophila angularis* is known as a member of the fungus-feeder (Okada, 1956, etc.) but majority of them were collected with the use of traps in the collections of Rakuzan Park and on Mt. Dakesan.

Some remarks are given for the following species of San-In region.

Microdrosophila-like sp.: Only one male specimen of this species was captured in July, 1961 on Mt. Dakesan. Okada (1956, 1960) described 7 species of this genus from Japan. According to his personal communication, this species seems to belong to the genus *Microdrosophila* on general external features and the genital apparatus. But it differs on the acrostichal hairs having 4 rows. from the other seven species of this genus found in Japan.

Drosophila bifasciata: This species abundants in the northern part of Japan (Momma, 1957,

etc.) and a little is known in the high land of Japan-Hondo (Okada, 1956). In San-In region, this species has been found only on Mt. Daisen (ca. 1800m above sea level), but three specimens of this species were obtained in low land in the outskirt of Matsue City in May, June and September, 1961.

Drosophila testacea and *D. histrio:* Both species are known abundant in high land, especially the former species has been found in alpine flora of Mt. Asahidake of Hokkaido at an altitude of about 5400 ft. (Momma, 1957). In San-In region, these species were found at first in the collection of 1961, on Mt. Dakesan and Mt. Daisen.

Many specimens of *P. pallida*, *D. nipponica* and *L. aerea* were obtained on various kinds of grasses through net-sweeping. These members have rarely or never been lured to usual traps baited with fermenting banana. Among them, *P. pallida* was found from various localities, being distributed widely in high and low lands or not only in the wild areas but also in the areas of human habitation. On the one hand, majority of *D. nipponica* were found in grassess in comparatively low land, neighbouring human dwellings. Contrarily, almost of *L. aerea* have been found in the place at an altitude of 4000 ft. like as Mt. Daisen.

In addition, one specimen of *Diastata ussurica was obtained by* net-sweeping on grasses on Mt. Daisen.

Most species belong to the genus *Mycodrosophila*, genus *Leucophenga* and the subgenus *Hirtodrosophila* of the genus *Drosophila* are known as the fungus feeder. A few or no specimens of these species have attracted the fermenting fruits. They were collected abundantly in number on various kinds of fungi by net-sweeping or sucking method in many localities. However, a fair number of *L. concilia*, *M. splendida* and *D. histrioides* were collected with the use of banana traps in the collections carried out in the Rakuzan Park and Mt. Dakesan.

Three species involving to the genus *Amiota*, viz., *Amiota albogutta* f. *furcata*, *A. variegata* and *A. magna* were obtained in San-In region. Members of this genus generally hover about the eyes or ears of people, and almost specimens of the above mentioned three species displayed a similar habit and were collected by net around our bodies. All of them were collected in high land at altitude of 1500 ft. or more such as Mt. Daisen or Mt. Dakesan.

In the following, the author wishes to compare the present records of collections with the data of Okada (1956) reported as the drosophilid fauna of Chugoku district. Okada reported 25 species including no species endemic to Chugoku district. The author obtained 50 species in 16 localities of San-In region. Following 28 species were treated as new to the drosophilid fauna of Chugoku destrict: they are *Amiota alboguttata* f. *furcata*, *Loucophenga ornatipennis*, *L. argentosa*, *L. magnipalpis*, *L. maculata*, *L. concilia*, *L. angusta*, *Microdrosophila* like sp., *Mycodrosophila splendida*, *M. poecilogastra*, *Dettopsomyia argentifrons*, *Scaptomyza graminum*, *D. alboralis*, *D. quadrivittata*, *D. histrioides*, *D. sexvittata*, *D. coracina*, *D. nipponica*, *D. angularis*, *D. nigromaculata*, *D. testacea*, *D. sternopleuralis*, *D. histrio*, *D. grandis D. curviceps*, *D. pengi*, *D.sordidula* and *D. daruma*.

2. Seasonal behavior of *Drosophila* observed on Mt. Dakesan, with a note on statistical analyses of population structure in *Drosophila*

Drosophila populations as well as all of the other organisms have to meet of fluctuating environmental chnages. Concerning the reaction of Drosophila populations to the radical changes in the environment, several studies have been made by Timoféef-Ressovsky and Timo-

féef-Ressovsky (1940), Patterson (1943), Dobzhansky and Pavan (1950), Mather (1956), Ohba (1956), Nozawa (1956), Wakahama (1956, 1957, 1960, 1962b, c) and Paik (1958). It has been confirmed by the workers that *Drosophila* populations of sympatric species react to local and seasonal variations in the environmental changes in the relative frequencies of constituent species. As reviewed by Patterson and Stone (1952), furthermore, population fluctuations to the environments have some significant aspects in studies pertaining to "Gene Ecology" in terms of population genetics or of evolutionary biology.

It is, therefore, the purpose of this study to furnish further data on some of the changes in population size and to provide some background for carrying the study of population genetics by the genus *Drosophila* on Mt. Dakesan in San-In region.

Seasonal activity of Drosophila observed on Mt. Dakesan, near the City of Matsue

Since the spring of 1961, the present author has undertaken some ecological survey of drosophilid flies on Mt. Dakesan (ca. 320m above sea level) with special concern to their seasonal variation. In this section, are presented data on monthly differences of population structure in *Drosophila*.

Collections carried out on Mt. Dakesan, were made in three different stations where were vertically placed at 100m intervals, so that the author wishes to describe the results of observations in three subsection as results obtained in Station I, results in Station II and results in Station III.

Fruits baits were used in making the collections. Sixteen traps were equipped from the foot of Mt. Dakesan to its summit. Out of them, 6 traps were set up along the foot to 100m level (Station I), 5 along 100 to 200m level (Station II), and the remaining 5 along 200m to its summit (Station III). Collections were made two times per week during a period from April to November, 1961. Baits were renewed once in a week.

Results obtained in Station I

As mentioned above, 6 traps were set up along the foot of Mt. Dakesan to 100m level. A total of 4416 specimens (44.2 per cent for the total specimens collected through the year) was obtained. They represent 37 known and one undistinguished species, belonging to 6 genera as shown in Table 5.

Seasonal fluctuation for total population size

Among of total specimens collected in Station I, 84 specimens (1.9 per cent) were collected in April, 429 (19.7 per cent) in May, 499 (11.3 per cent) in June, 89 (2.0 per cent), in July, 112 (2.5 per cent) in August, 233 (5.3 per cent) in September, 1476 (32.9 per cent) in October, and 1494 (33.6 per cent) in November (Table 5).

As a conclusion, the seasonal fluctuation for the population size of total species collected is shown by a typical bimodal curve. Following a sudden rising in number of flies in May, the first peak was observed in June. The second peak was observed in November (Fig. 14).

Change of members of abundant species appeared in Station I in each month

The abundant species showed high frequency in occurrence in Station I, are as shown in Table 6.

In April, *D. bizonata* (30 specimens, 35.7 per cent), *D. subtilis* (21, 25.9), *D. lutea* (16, 19.1),

Table 4. Collection record of *Drosophila* species in San-In region during from 1957 through 1961

Locealities	Hirose	Kami-Ito	Daisen	Kitayama	Chikuya	Kuroda	Akana	Kokufa	Sambe	Masuda	Dakesan	Taisha	Rakuzan	Kawamoto	Oki	Sho-o	Total
Species																	
Diastata ussirica	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
Amiota alboguttata f. furcata	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	1
A. variegata	—	—	20	—	1	—	—	—	—	—	13	—	3	1	—	—	38
A. magna	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
Leucophenga argentosa	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—	3
L. magnipalpis	—	—	1	—	—	—	—	—	—	—	3	—	—	—	—	—	4
L. maculata	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	2
L. ornatipennis	—	—	—	—	—	—	—	—	—	—	2	—	1	—	—	—	3
L. concilia	—	—	—	—	—	—	—	—	—	—	19	—	—	—	—	1	20
L. angusta	—	—	—	—	—	—	—	—	—	—	2	—	—	—	—	—	2
Mir odrosophila-like sp.	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1
Mycodrosophila splendida	1	—	11	—	—	—	—	—	—	—	16	—	71	—	—	—	99
M. poecilogatsra	1	—	8	—	—	—	—	—	—	—	—	—	—	—	—	—	9
Dettopsomyia argentifrons	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1
Liodrosophila aerea	—	—	139	—	—	—	1	—	—	—	—	2	—	—	—	1	143
Parascaptomyza pallida	—	151	8	—	—	—	—	—	—	—	2	—	71	—	—	—	232
Scaptomyza graminum	—	—	—	—	2	—	—	—	—	—	2	—	—	—	—	—	4
Drosophila alboralis	—	—	2	—	—	—	—	—	—	—	2	—	—	—	—	—	4
D. sexvittata	—	—	—	—	—	—	—	—	—	—	2	—	17	—	—	—	19
D. quadrivittata	—	—	2	3	—	—	—	—	—	—	3	—	—	—	—	—	8
D. histrioides	—	—	5	1	—	—	—	—	6	—	81	9	8	—	—	3	113
D. busckii	—	108	1	—	62	629	—	—	—	—	5	47	1064	3	19	—	1938
D. coracina	—	—	—	—	3	—	—	—	—	1	42	72	153	—	4	14	289
D. bifasciata	—	—	25	—	—	—	—	—	—	—	3	—	—	—	—	—	28
D. suzukii	—	—	183	9	—	7	143	—	142	6	159	1	73	5	57	98	883
D. pulchrella	—	—	10	—	—	—	7	—	3	—	1	—	—	—	—	4	25
D. lutea	18	175	427	161	228	126	309	—	351	165	2383	723	1724	12	578	308	7678
D. melanogaster	23	29	1	1	7	6	1	1421	4	1	64	2	83	7	4	2	1656
D. nipponica	—	72	—	—	—	—	—	—	—	—	—	—	54	—	—	—	126
D. ficusphila	—	—	—	—	—	—	—	—	—	7	11	—	—	—	—	22	40
D. auraria	5	7	40	8	182	26	36	—	19	2	140	37	516	25	86	312	1441
D. rufa	28	28	2	73	60	1	—	—	3	—	365	87	1090	22	67	5	1831
D. brachynephros	—	35	3	—	—	—	1	—	—	—	51	1	—	—	—	1	92
D. angularis	3	28	11	4	—	—	6	—	6	22	847	1	228	5	—	38	1259
D. unispina	—	—	5	—	—	—	—	—	—	—	5	—	—	—	—	—	10
D. nigromaculata	—	—	—	—	46	4	—	—	—	—	1	—	101	1	1	—	154
D. testacea	—	—	1	—	—	—	—	—	—	—	3	—	—	—	—	—	4
D. bizonata	5	—	26	5	3	1	1	—	6	2	2989	6	1622	3	6	28	4703
D. sternopleuralis	—	—	36	—	—	—	—	—	9	11	223	—	18	—	12	—	309
D. histrio	—	—	7	—	—	—	—	—	—	—	2	—	—	—	—	—	9
D. grandis	—	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	2
D. immigrans	—	235	147	—	220	390	49	9	37	—	620	313	—	35	354	160	2569
D. curviceps	—	—	14	—	—	—	—	—	—	—	—	—	—	—	—	—	14
D. virgata	—	—	—	—	—	—	—	—	—	—	8	—	2	—	14	—	24
D. subtilis	—	—	1	—	—	—	—	—	—	2	1746	—	—	—	—	1	1750
D. pengi	—	—	1	—	—	—	—	—	—	—	34	—	—	—	—	—	35
D. virilis	—	35	—	—	1	4	—	—	—	—	67	—	73	22	—	—	202
D. sordidula	—	—	2	—	—	—	—	—	—	—	30	—	—	—	—	—	32
D. lacertosa	—	5	7	—	—	42	1	—	1	—	91	1	223	—	18	—	389
D. daruma	—	—	—	—	—	—	—	—	—	—	—	—	23	—	—	—	23
undistinguished	—	3	1	—	4	—	—	—	—	—	1	1	12	—	—	—	22
Total	85	911	1150	265	819	1236	555	1430	587	220	10044	1303	7290	141	1220	999	28255

Table 5. Monthly collection records involving numbers of the species and specimens on Mt. Dakesan, from April to November in 1961

Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Frequency
Amiota variegata	1	—	1	1	1	8	1	—	13	0.13 %
A. magna	—	—	—	—	—	1	—	—	1	0.01
Leucophenga argentosa	—	—	—	—	2	—	—	1	3	0.03
L. magnipalpis	—	—	—	—	—	—	3	—	3	0.03
L. ornatipennis	—	—	—	—	1	—	1	—	2	0.02
L. concilia	—	—	—	—	—	—	17	—	17	0.17
L. angusta	—	—	—	—	—	—	2	—	2	0.02
Microdrosophila- like sp.	—	—	—	1	—	—	—	—	1	0.01
Mycodrosophila splendida	—	14	—	—	1	—	1	—	16	0.16
Parascaptomyza pallida	—	—	1	—	—	—	1	—	2	0.02
Scaptomyza graminum	—	—	—	—	1	—	1	—	2	0.02
Drosophila alboralis	—	—	—	—	—	1	1	—	2	0.02
D. sexvittata	—	—	—	—	—	—	2	—	2	0.02
D. quadrivittata	—	—	—	1	—	—	2	—	3	0.03
D. histrioides	13	12	36	9	6	3	1	1	81	0.81
D. busckii	—	1	—	2	—	—	—	2	5	0.05
D. coracina	—	—	3	—	23	2	9	4	41	0.41
D. bifasciata	—	1	1	—	—	—	1	—	3	0.03
D. suzukii	—	—	8	11	2	34	66	37	158	1.58
D. pulchrella	—	—	—	—	—	—	1	—	1	0.01
D. lutea	28	527	508	226	168	80	436	410	2383	23.94
D. melanogaster	1	1	1	1	3	6	27	24	64	0.64
D. ficusphila	—	—	—	—	—	—	1	10	11	0.11
D. auraria	—	43	50	9	17	8	9	4	140	1.40
D. rufa	7	14	66	55	137	60	22	3	364	3.64
D. brachynephros	—	—	—	—	—	23	8	19	50	0.50
D. angularis	3	18	29	4	10	2	468	301	835	8.38
D. unispina	—	—	—	—	—	—	5	—	5	0.05
D. nigromaculata	—	—	—	—	—	—	1	—	1	0.01
D. testacea	—	—	—	—	—	—	3	—	3	0.03
D. bizonata	64	114	102	39	109	120	862	1516	2926	29.38
D. sternopleuralis	—	—	8	3	26	59	94	29	219	2.19
D. histrio	—	1	—	—	—	—	—	1	2	0.02
D. grandis	—	—	—	—	—	—	1	—	1	0.01
D. immigrans	—	8	111	325	121	2	6	47	620	6.22
D. virgata	—	—	—	—	—	1	5	2	8	0.08
D. subtilis	32	178	320	93	124	199	587	213	1746	17.53
D. pengi	—	3	1	—	—	19	11	—	34	0.34
D. virilis	—	4	—	8	—	53	1	—	66	0.66
D. sordidula	—	—	1	—	—	26	2	1	30	0.30
D. lacertosa	—	5	1	—	2	81	2	—	91	0.92
undistinguished	—	1	—	—	—	—	—	—	1	0.01
Total	149	945	1248	788	754	788	2661	2625	9958	
Frequency (%)	1.5	9.5	12.5	7.9	7.5	7.9	26.6	26.0		
Number of species	8	17	18	16	18	21	36	19	41	
Times of collections	3	9	8	9	9	8	9	9	64	

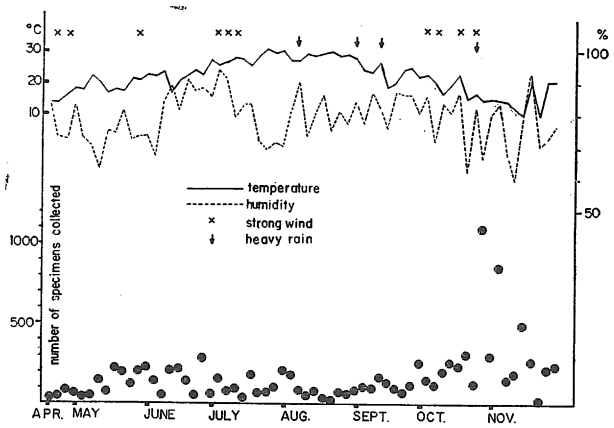


Fig. 12. Graph showing daily collection records of *Drosophila* species, temperature (left), humidity (right) and weather observed on Mt. Dakesan during a period from April through November, 1961.

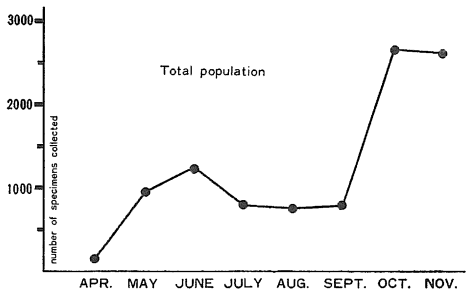


Fig. 13. Graphs showing seasonal activity of *Drosophila* observed on Mt. Dakesan, during a period from April to November, 1961.

and *D. histrioides* (10, 12.2) were the abundant species.

In May, *D. subtilis* (110, 25.6), *D. lutea* (235 54.8) and *D. bizonata* (39, 9.1) showed high frequency in occurrence.

In June, *D. subtilis* (185, 37.1) and *D. lutea* (184, 36.9) were abundant group.

In July, *D. lutea* (26, 29.2), *D. subtilis* (22, 24.7), *D. immigrans* (15, 16.9) and *D. rufa* (8 9.0) were included to the common group.

In August, *D. bizonata* (40, 35.7), *D. coracina* (20, 17.1), *D. rufa* (18, 16.1), *D. lutea* (12, 10.7) and *D. auraria* (10, 8.9) were common species.

In September, *D. subtilis* (65, 27.9), *D. bizonata* (32, 13.7), *D. lacertosa* (27, 11.6), *D. lutea* (21, 9.0), *D. sordidula* and *D. virilis* (both, 19, 8.2) showed high frequency in occurrence.

In October, *D. bizonata* (542, 36.7), *D. lutea* (296, 20.1), *D. subtilis* (219, 14.8) and *D. angularis* (209, 14.2) were abundant group.

In November, *D. bizonata* (839, 56.1), *D. lutea* (339, 22.6) and *D. angularis* (130, 8.7) were observed as common species (Table 6).

The data shown above indicate that the number of abundant species, their ranking and degree of abundance are highly variable by month.

It is evident that the above monthly variation as seen in common species affects the monthly fluctuation for the total population size observed in Station I.

Seasonal activity of the abundant species observed in Station I

In the following, the seasonal activity of four abundant species is described.

Seasonal activity of *Drosophila bizonata:* This species showed a typical monomodal (autumn) type, giving a seasonal peak in November (Fig.15). Numerical records of collections in each month were as follows: Among of 1568 specimens which was total number of this species collected in Station I through the year, 30 specimens were obtained in April, 39 in May, 39 in June, 7 in July, 40 in August, 32 in September, 542 in October and 839 in November (Table 6).

Seasonal activity of *Drosophila lutea:* This species was ranked the second abundant species in Station I. As a total, 1129 specimens were collected through the year, and among of them 16 specimens were obtained in April, 235 in May, 184 in June, 26 in July, 12 in August, 21 in

Table 6. Monthly collection records involving numbers of the species and specimens in Station I, on Mt. Dakesan, from April to November in 1961

Month	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Frequency
Species										
Amiota variegata	1	—	1	1	—	5	1	—	9	0.2 %
Leucophenga argentosa	—	—	—	—	—	—	—	1	1	0.02
L. magnipalpis	—	—	—	—	—	—	3	—	3	0.06
L. angusta	—	—	—	—	—	—	2	—	2	0.04
L. concilia	—	—	—	—	—	—	17	—	17	0.3
Mycodrosophila splendida	—	8	—	—	—	—	1	—	9	0.2
Parascaptomyza pallida	—	—	1	—	—	—	1	—	2	0.04
Drosophila alboralis	—	—	—	—	—	—	1	—	1	0.02
D. histrioides	10	—	11	2	1	—	—	1	25	0.3
D. quadrivittata	—	—	—	—	—	—	2	—	2	0.04
D. sexvittata	—	—	—	—	—	—	1	—	1	0.02
D. coracina	—	—	1	—	20	2	7	3	33	0.7
D. busckii	—	1	—	—	—	—	—	2	3	0.06
D. suzukii	—	—	7	1	—	6	44	17	75	1.7
D. pulchrella	—	—	—	—	—	—	1	—	1	0.02
D. lutea	16	235	184	26	12	21	296	339	1129	25.6
D. melanogaster	—	—	—	1	—	1	20	20	42	0.9
D. ficusphila	—	—	—	—	—	—	1	6	7	0.1
D. auraria	—	11	18	3	10	4	7	4	57	1.2
D. rufa	3	6	21	8	18	9	15	2	82	1.8
D. brachynephros	—	—	—	—	—	—	1	9	10	0.2
D. angularis	3	6	13	—	—	1	209	130	362	8.2
D. unispina	—	—	—	—	—	—	3	—	3	0.06
D. nigromaculata	—	—	—	—	—	—	1	—	1	0.02
D. testacea	—	—	—	—	—	—	3	—	3	0.06
D. bizonata	30	39	39	7	40	32	542	839	1568	35.4
D. sternopleuralis	—	—	2	1	1	10	58	18	90	2.0
D. histrio	—	—	—	—	—	—	—	1	1	0.02
D. grandis	—	—	—	—	—	—	1	—	1	0.02
D. immigrans	—	2	14	15	—	—	5	40	76	1.7
D. virgata	—	—	—	—	—	—	5	2	7	0.1
D. pengi	—	3	—	—	—	12	7	—	22	0.5
D. subtilis	21	110	185	22	9	65	219	60	691	15.7
D. virilis	—	4	—	2	—	19	—	—	25	0.5
D. sordidula	—	—	1	—	—	19	1	—	21	0.4
D. lacertosa	—	3	1	—	—	27	—	—	31	0.7
Scaptomyza graminum	—	—	—	—	1	—	1	—	2	0.04
undistinguished	—	1	—	—	—	—	—	—	1	0.02
Total	84	429	499	89	112	233	1476	1494	4416	
Frequency (%)	1.9	9.7	11.3	2.0	2.5	5.3	32.9	33.6		
Number of species	7	13	15	12	9	15	31	18	37+1	

September, 296 in October and 336 in November (Table 6). This species showed a well-corresponded bimodal (spring autumn) curve, appearing in nearly equal number in both spring and autumn, with two peaks, one in May and the other in October and November (Fig. 16).

Seasonal activity of *Drosophila subtilis:* This species also showed a well-corresponded curve (spring-autumn), giving the seasonal peaks in June and October (Fig. 17). Numerical data of collections in each month were as follows: Among of the total 691 specimens collected in this station through the year, 21 specimens were captured in April, 110 in May, 185 in June, 22 in July, 9 in August, 65 in September, 219 in October and 60 in November (Table 6).

Seasonal activity of *Drosophila angularis:* This species was typically monomodal in activity, giving the seasonal peak in October. Following very low frequency during a period from April to September, the sudden rising was occurred in October (Fig. 18). Numerical collection data in each month were as follow: Among the total specimens collected in Station I (362 individuals), 3 specimens were obtained in April, 6 in May, 13 in June, no specimen in July, and August, 1 in September, 209 in October and 130 in November (Table 6). Though this species is quite similar in activity of *D. bizonata*, the former differs from the latter by showing November decrease.

Monthly numerical variation of species observed in Station I

A total number of species collected in Station I is 37, as shown in Table 6.

Among them 7 species, were collected in April.

In May, there were observed 13 species. Compared the data of May with that of April, 7 species of *Mycodrosophila splendida*, *D. busckii*, *D. auraria*, *D. immigrans*, *D. pengi*, *D. virilis* and *D. lacertosa* were new members in May. While, *Amiota variegata* and *D. histrioides* were not collected in this month.

In June, 15 species were collected. Among them, *Amiota variegata*, *Parascaptomyza pallida*, *D. histrioides*, *D. coracina*, *D. suzukii*, *D. sternopleuralis* and *D. sordidula* were new members in June. On the contrary, *Mycodrosophila splendida*, *D. busckii*, *D. pengi* and *D. virilis* were not collected in this month.

In July, 12 species were collected. Within these species, *D. melanogaster* and D. *virilis* were collected newly in this month. Contrarily, *Parascaptomyza pallida*, *D. coracina*, and *D. angularis* were not secured in this month.

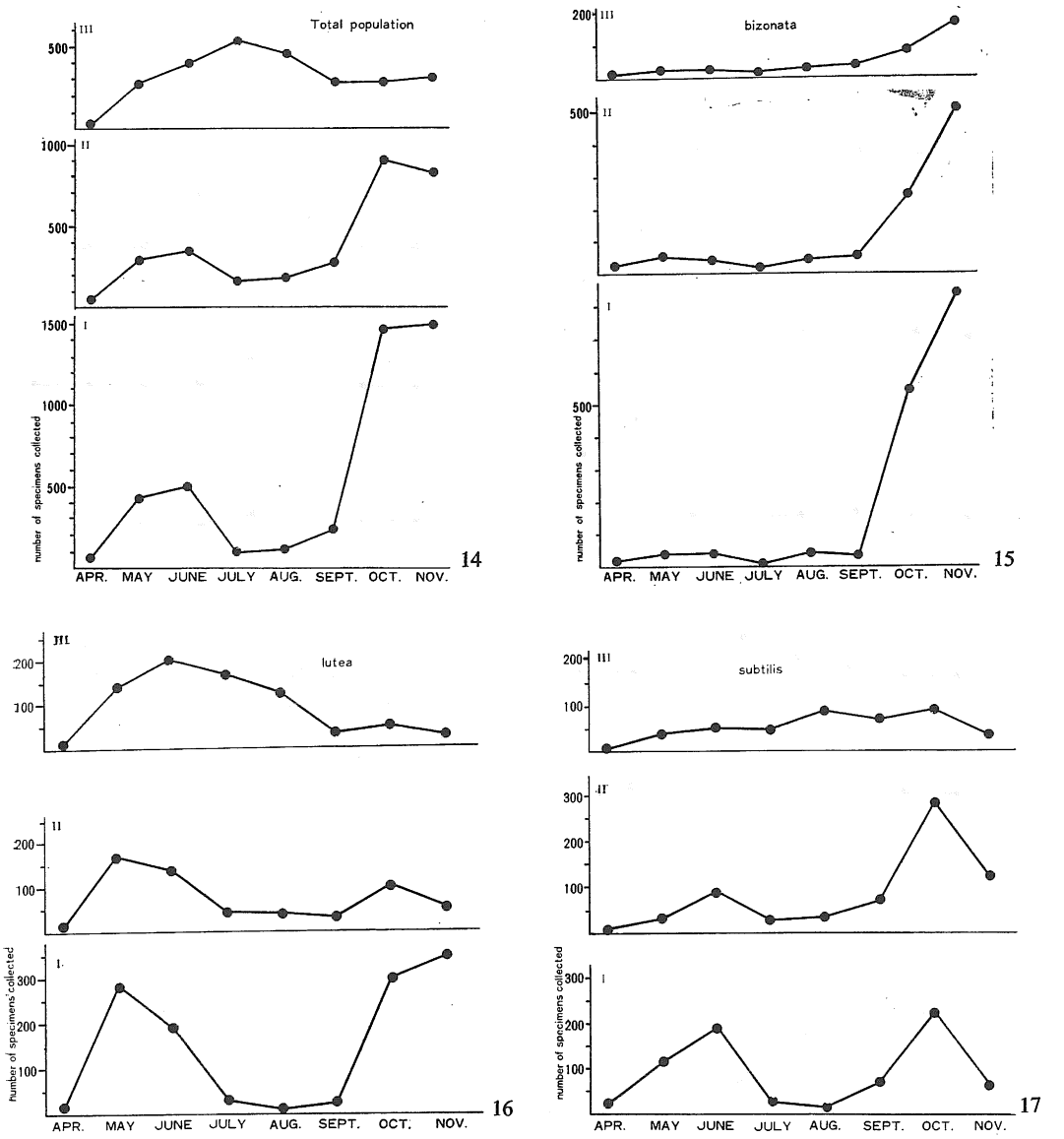
In August, 9 species were obtained. In these species, *Scaptomyza graminum* and *D. coracina* were secured newly in this month. As contrasted to this, *Amiota variegata*, *D. suzukii*, *D. melanogaster*, *D. immigrans* and *D. virilis* were not collected iu August.

In September, 15 species were observed. Among them, *Amiota variegata*, *D. suzukii*, *D. melanogaster*, *D. angularis*, *D. pengi*, *D. virilis*, *D. sordidula* and *D. lacertosa* were collected newly in this month. On the contrary, *Scaptomyza graminum* and *D. histrioides* were not obtained in this month.

In October, 31 species were collected. In these species, *Leucophenga magnipalpis*, *L. angusta*, *L. concilia*, *Mycodrosophila splendida*, *Parascaptomyza pallida*, *Scaptomyza graminum*, *D. alboralis*, *D. quadrivittata*, *D. sexvittata*, *D. pulchrella*, *D. ficusphila*, *D. brachynephros*, *D. unispina*, *D. nigromaculata D. testacea*, *D. grandis*, *D. immigrans* and *D. virgata* appeared newly in this month. While, *D. virilis* and *D. lacertosa* were not collected in October.

In November, 18 species were obtained. Compared the data of this month with that of

Octotber, *Amiota variegata*, *Leucophenga magnipalpis*, *L. angusta*, *L. concilia*, *Mycodrosophila splendida*, *Parascaptomyza pallida*, *Scaptomyza graminum*, *D. alboralis*, *D. quadrivittata*, *D. sexvittata*, *D. pulchrella*, *D. unispina*, *D. nigromaculata*, *D. testacea*, *D. grandis*, *D. pengi* and *D. sordidula* were not collected in this month. Whereas, *Leucophenga angusta*, *D. histrioides*, *D. busckii* and *D. histrio* were newly obtained in November (Table 6).

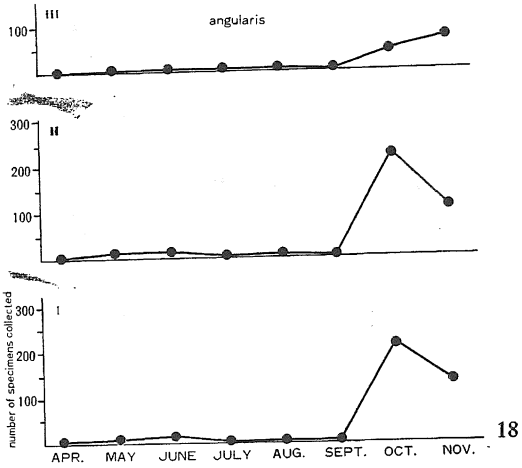


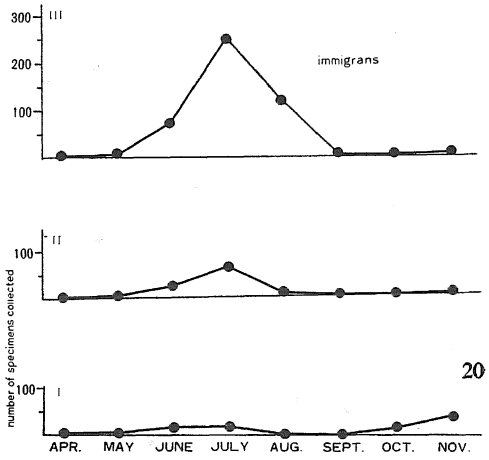
Figs. 14-17. Graphs showing seasonal activity of *Drosophila* in the three stations observed on Mt. Dakesan, during a period from April to November, 1961. Abscissa; Month. Ordinate; number of specimens collected. I, Station I. II, Station II. III, Station III, 14, total population. 15, *D. bizonata*. 16, *D. lutea*. 17, *D. subtilis*.

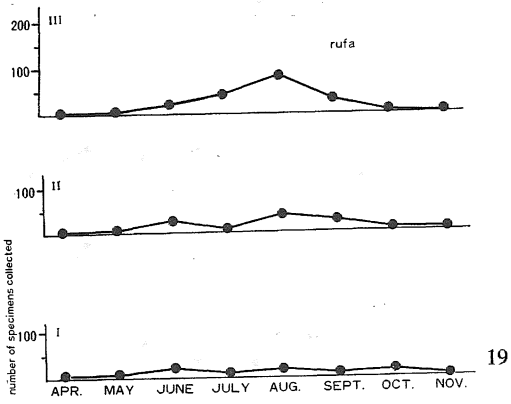
Results obtained in Station II

As indicated above, 5 traps were set up along the 100 to 200m level of Mt. Dakesan. A total of 3008 specimens (30.2 per cent for the total specimens collected through the year) were captured. They comprise 24 species belonging to 4 genera as shown in Table 7.

Seasonal fluctuation for total population size: Among the total specimens collected, 41 specimens (1.4 per cent) were obtained in April, 288 (9.5) in May, 340 (11.5) in June, 159 (5.2) in July, 181 (6.0) in August, 271 (9.0) in September, 901 (29.9) in October and 821 (27.2) in November (Table 7).







Figs. 18-20. Graphs showing seasonal activity of *Drosophila* in the three stations observed on Mt. Dakesan, during a period from April to November. 1961. Abscissa, month. Ordinate, number of the specimens collected. I, Station I, II, Station II. III, Station III. 16, *D. lutea.* 17, *D. subtilis.* 18, *D. angularis.* 19, *D. rufa.* 20, *D. immigrans.*

As seen in Figure 14, the seasonal fluctuation for the population size of total specimens collected is shown by a typical bimodal curve. Following a rapid increasing in number of flies, the first peak was occurred in June, the second peak was observed in October. Though this feature is quite similar in figure obtained in Sta. I, the former differs from the latter by showing November decrease.

Change of members of abundant species appeared in each month

The abundant species collected in each month are as shown in Table 17.

In April, only one species, *D. bizonata* was denoted as abundant (23 specimens, 56.1 per

cent). Although *D. lutea* and *D. subtilis* showed high per centage (17.8, 14.6, respectively), number of specimens collected of both species were 7 and 6.

In May, three species, *D. lutea* (163, 56.6), *D. bizonata* (51, 17.7) and *D. subtilis* (31, 38.2) showed high frequency in occurrence.

In June, *D. lutea* (132, 38.2), *D. subtilis* (87, 25.1), *D. bizonata* (39, 11.3), *D. rufa* (26, 7.5) and *D. immigrans* (23, 6.6) were abundant group.

In July, *D. immigrans* (62, 39.0), *D. lutea* (40, 25.4), *D. subtilis* (25, 15.7) and *D. bizonata* (15, 9.4) were included to the common group.

In August, *D. bizonata* (42, 23.2), *D. lutea* (38, 21.0), *D. rufa* (36, 19.9), *D. subtilis* (32, 17.7) and *D. sternopleuralis* (14, 7.7) were abundant species.

In September, *D. subtilis* (67, 24.7), *D. bizonata* (50, 18.5), *D. lutea* (28, 10.3), *D. lacertosa* (25, 9.2), *D. rufa* (21, 7.7), *D. suzukii* (19, 7.0), *D. sternopleuralis* (18, 6.6) and *D. virilis* (15, 5.5) showed high frequency in occurrence.

In October, *D. subtilis* (281, 31.2), *D. bizonata* (238, 26.4), *D. angularis* (218, 24.1) and *D. lutea* (97, 10.8) were abundant species.

In November, *D. bizonata* (507, 61.7), *D. subtilis* (121, 14.7), *D. angularis* (103, 12.5) and *D. lutea* (47, 5.7) were observedd as the abundant species (Table 7).

The data obtained in Sta. II, as well as those of Sta. I, indicate that the number of abundant species, their ranking and degree of abundance are highly variable by month. It is apparent that the above monthly variations as seen in the abundant species affects the monthly fluctuation for the total population size. Especially, high occurrence of *D. lutea* in spring corresponds to the first peak of total population observed in June and high frequency in appearance of *D. bizonata* and *D. angulris* seems to be corresponded to the second peak of total population observed in October.

Summarizing the date derived from monthly collections during a period from April to November, it is decided that the following four species were the abundant species in Sta. II considered on Mt. Dakesan: *D. bizonata*, *D. subtilis*, *D. lutea* and *D. angularis*.

Seasonal activty of abundant species

In the following, the seasonal activity of those four abundant species is described.

Seasonal activity of *D. bizonata:* This species showed a typical monomodal (autumn) type, presenting a seasonal peak in November (Fig. 15). This feature is quite similar in that of this species observed in Sta. I.

Seasonal activity of *D. subtilis:* This species ranked the third in Sta. I, while it ranked the second in Sta. II. This species displayed a bimodal type in its activity, showing two seasonal peaks, one in June and the other in October (Fig. 17). This aspect is a little different for that of this specis which was observed in Sta. I, in low occurrence in June.

Seasonal activity of *D. lutea:* This species ranked the second in Sta. I, whereas it ranked the third in Sta. II. This species showed also a bimodal type, presenting two sesonal peaks, one in May and the other in October (Fig. 16). This figure differs from that of this species obtained in Sta. I in low occurrence in October and November decrease.

Seasonal activity of *D. angularis:* This species ranked the fourth in Sta. I and II. A typical monomodal (autumn) type was seen in this station, forming a seasonal peak in October (Fig. 18). This feature is quite similar in that of this species observed in Sta. I.

Monthly numerical variation of species observed in Station II

A total number of species collected in Sta. II is 24, as shown in Table 7.

Among them, 6 species were collected in April.

In May, there were observed 11 species. Compared the data of May with those of April, 5 species, *M. splendida*, *D. bifasciata*, *D. auraria*, *D. angularis* and *D. immigrans* were new members in May.

Table 7. Monthly collection records involving numbers of the species and specimens in Station II, on Mt. Dakesan, from April to November in 1961

Month / Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Frequency
Amiota variegata	—	—	—	—	—	1	—	—	1	0.03%
Leucophenga argentosa	—	—	—	—	2	—	—	—	2	0.07
L. ornatipennis	—	—	—	—	1	—	1	—	2	0.07
Mycodrosophila splendida	—	5	—	—	—	—	—	—	5	0.17
Drosophila histrioides	3	4	13	5	2	2	—	—	29	0.96
D. coracina	—	—	2	—	1	—	1	1	5	0.17
D. busckii	—	—	—	1	—	—	—	—	1	0.03
D. bifas ciata	—	1	—	—	—	—	1	—	2	0.07
D. suzukii	—	—	—	2	—	19	17	17	55	1.83
D. melanogaster	1	1	—	—	2	3	5	2	14	0.47
D. lutea	7	163	132	40	38	28	97	47	552	18.35
D. ficusphila	—	—	—	—	—	—	—	3	3	0.10
D. auraria	—	13	8	2	1	2	2	—	28	0.93
D. rufa	1	5	26	5	36	21	3	1	98	3.26
D. brachynephros	—	—	—	—	—	7	7	8	22	0.73
D. angularis	—	11	12	—	5	—	218	103	349	11.60
D. bizonata	23	51	39	15	42	50	238	507	965	32.08
D. sternopleuralis	—	—	3	—	14	18	25	8	68	2.26
D. immigrans	—	3	23	62	5	—	—	2	95	3.08
D. pengi	—	—	1	—	—	7	3	—	11	0.37
D. subtilis	6	31	87	25	32	67	281	121	650	21.61
D. virilis	—	—	—	2	—	15	1	—	18	0.60
D. sordidula	—	—	—	—	—	6	1	1	8	0.27
D. lacertosa	—	—	—	—	—	25	—	—	25	0.83
Total	41	288	346	159	181	271	901	821	3008	
Frequency (%)	1.4	9.5	11.5	5.2	6.0	9.0	29.9	27.2		
Number of species	6	11	11	10	13	15	16	13	24	

In June, 11 species were collected. Among them, *D. coracina*, *D. sternopleuralis* and *D. pengi* were newly collected. On the contrary, *M. splendida*, *D. bifasciata* and *D. melanogaster* disappeared in June.

In July, 10 species were obtained. Within these species, *D. busckii*, *D. suzukii* and *D. virilis* were collected newly in this month. Contrarily, *D. coracina*, *D. angul aris*, *D. sternopleuralis* and *D. pengi* were not collected in this month.

In August, 13 species were observed. In these species, *L. argentosa*, *L. ornatipennis*, *D.*

coracina, *D. melanogaster*, *D. angularis* and *D. sternopleuralis* were new members in August. On the contrary, three species, *D. busckii*, *D. suzukii* and *D. virilis* were not obtained in this month.

In September, 15 species were collected. Compared the data of this month with those of August, seven species, *A. variegata*, *D. suzukii*, *D. brachynephros*, *D. pengi*, *D. virilis*, *D. sordidula* and *D. lacertosa* were new members in September. As contrasted to this, *L. argentosa*, *L. ornatipennis*, *D. coracina*, *D. angularis* and *D. immigrans* disappeared in this month.

In October, there were observed 16 species. Among them, four species, *L. ornatipennis*, *D. coracina*, *D. bifasciata* and *D. angularis* were new members in this month. Contrarily, *A. variegata*, *D. histrioides* and *D. lacertosa* were not collected in this month.

In November, 13 species were found in this station. Compared the data of November with those of October, two species, *D. ficusphila* and *D. immigrans* were new members in this station. On the contrary, *L. ornatipennis*, *D. bifasciata*, *D. auraria*, *D. pengi* and *D. virilis* were not collected in November (Table 7).

Results obtained in Station Ⅲ

As above mentioed, 5 traps were set up along the 200m to the summit of Mt. Dakesan. A total of 2534 speciemns (25.4 per cent for the total specimens collected in this year) were obtained in Sta. Ⅲ, and they represent 30 species belonging to 4 genera (Table 8).

Seasonal fluctuation for total population size: Among of total specimens collected, 24 specimens (0.95 per cent) were collected in April, 228 (9.0) in May, 403 (15.9) in June, 540 (21.3) in July, 461 (18.1) in August, 284 (11.2) in September, 294 in October and 310 (12.2) in November (Table 8). A sudden increase was occurred in May, and following high frequency in number of flies observed in June, the seasonal peak was seen in July. After that, a gradual decrease has been observed during a period from August to November. As a result, the activity curve of total population was shown in a typical monomodal (summer) type (Fig.14). This feature quite differs from those of the other two figures obtained in Sta's Ⅰ and Ⅱ.

Change of members of abundant species appeared in Station Ⅲ in eech month

The abundant species showed high frequency in occurrence in Sta. Ⅲ, are as shown in Table 8.

In April, only *D. bizonata* (11 specimens, 45.8 per cent) was abundant species. *D. lutea* (20.8), *D. subtilis* (20.8) and *D. rufa* (12.5) furnished a considerable high frequency in occurrence but number of specimens collected of these species were 5, 5 and 3, respectively.

In May, the following four species, *D. lutea* (129, 56.6), *D. subtilis* (37, 16.2), *D. bizonata* (24, 10.5) and *D. auraria* (19, 8.3) were abundant species.

In June, *D. lutea* (192, 47.6), *D.immigrans* (74, 18.4), *D. subtilis* (48, 11.9) and *D. bizonata* (24, 6.0) showed high frequency in occurrence.

In July, *D. immigrans* (248, 45.9), *D. lutea* (160, 29.6), *D. subtilis* (46, 8.5) and *D. rufa* (42, 7.8) were included to abundant group.

In August, five species, *D. lutea* (118, 25.6), *D. immigrans* (116, 25.2), *D. subtilis* (83, 18.0), *D. rufa* (83, 18.0) and *D. bizonata* (27, 5.9) were common species.

In September, the following 8 species, *D. subtilis* (67, 22.8), *D. bizonata* (38, 13.4), *D. lutea* (31, 10.9), *D. sternopleuralis* (31, 10.9), *D. rufa* (30, 10.6), *D. lacertosa* (29, 10.5), *D. virilis* (19, 6.7) and *D. brachynephros* (16, 5.6) showed high frequency in occurrence.

In October, *D. subtilis* (87, 30.6), *D. bizonata* (82, 28.8), *D. lutea* (43, 15.1) and *D. angularis* (41, 14.4) were abundant group.

In November, *D. bizonata* (170, 54.8), *D. subtilis* (32, 10.3) and *D. lutea* (24, 7.7) were observed as abundant species (Table 8).

Table 8. Monthly collection records involving numbers of the species and specimens in Station III, on Mt. Dakesan, from April to November in 1961

Month / Species	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Total	Frequency
Amiota variegata	—	—	—	—	1	2	—	—	3	0.11 %
A. magna	—	—	—	—	—	1	—	—	1	0.03
Microdrosophila-like sp.	—	—	—	1	—	—	—	—	1	0.03
Mycodrosophila splendida	—	1	—	—	1	—	—	—	2	0.07
Drosophila alboralis	—	—	—	—	—	1	—	—	1	0.03
D. histrioides	—	8	12	2	3	1	1	—	27	1.1
D. quadrivittata	—	—	—	1	—	—	—	—	1	0.03
D. sexvittata	—	—	—	—	—	—	1	—	1	0.03
D. coracina	—	—	—	1	—	2	—	1	—	4	0.15
D. busckii	—	—	—	1	—	—	—	—	1	0.03
D. bifasciata	—	—	1	—	—	—	—	—	1	0.03
D. suzukii	—	—	1	8	2	9	6	3	29	1.14
D. lutea	5	129	192	160	118	31	43	23	702	27.7
D. melanogaster	—	—	1	—	1	2	2	2	8	0.31
D. ficusphila	—	—	—	—	—	—	—	1	1	0.03
D. aurariia	—	19	23	4	6	2	—	—	54	2.1
D. rufa	3	3	19	42	83	30	4	—	184	7.2
D. brachynephros	—	—	—	—	—	16	—	2	18	0.7
D. angularis	—	1	4	4	5	1	41	68	124	4.9
D. unispina	—	—	—	—	—	—	2	—	2	0.07
D. bizonata	11	24	24	17	27	38	82	170	393	15.5
D. sternopleuralis	—	—	3	2	11	31	10	3	60	2.4
D. histrio	—	1	—	—	—	—	—	—	1	0.03
D. immigrans	—	3	74	248	116	2	1	5	449	17.7
D. virgata	—	—	—	—	—	1	—	—	1	0.03
D. pengi	—	—	—	—	—	—	1	—	1	0.03
D. virilis	—	—	—	4	—	19	—	—	23	0.9
D. subtilis	5	37	48	46	83	67	87	32	405	15.9
D. sordidula	—	—	—	—	—	1	—	—	1	0.3
D. lacertosa	—	2	—	—	2	29	2	—	35	01.4
Total	24	228	403	540	461	284	284	310	2534	
Frequency (%)	0.95	9.0	15.9	21.3	18.1	11.2	11.2	12.2		
Number of species	4	11	13	14	15	19	15	10	30	

The data shown above indicate that the number of abundant species, their ranking and degree of abundance are highly variable by month. It is evident that above monthly variation as seen in abundant species affects the monthly fluctuation for the total population size observed in Sta.

III, and especially, high frequency of *D. immigrans* and *D. rufa* in summer corresponds the seasonal peak observed in July.

Summarizing the data derived from monthly collections during a period from April to November, it is decided that the following 6 species were the abundant species in Sta. III considered on Mt. Dakesan: *D. lutea, D. immigrans, D. subtilis, D. bizonata, D. rufa* and *D. angularis*. Compared the abundant members in three stations, though their ranking are variable by station, *D. bizonata, D. lutea, D. subtilis* and *D. angularis* were included to the abundant group in all stations, while *D. immigrans* and *D. rufa* showed high frequency in occurrence only in Sta. III.

Seasonal activity of the abundant species

In the following, the seasonal activity of those six abundant species is described.

Seasonal activity of *D. lutea:* This species showed a typical monomodal (spring) activity, giving the seasonal peak in June. Compared the results obtained in three stations, this species showed a bimodal curve in Sta's. I and II, while it was a monomodal type in Sta. III. Moreover, the curve observed in Sta. I was a well corresponded type and seasonal peaks were observed in May and November, whereas, seasonal peaks which were seen in Sta. II, occurred in May and October, and the former was higher than the latter (Table 8 and Fig. 16).

Seasonal activity of *D. immigrans*: This species showed a typical monomodal (summer) curve, appearing the seasonal peak in July. This species showed abundance only in Sta. III. Although number of this species collected in Sta's. I and II was very low, majority of them were obtained in July in Sta. II, while this species displayed an indefinite type in Sta. I (Table 8 and Fig. 20).

Seasonal activity of *D. subtilis*: This species displayed an indefinite curve. Compared the features of this species observed in three stations, bimodal curve was seen in Sta's. I and II, while it was an indefinite type in Sta. III. Further, seasonal activity of this species in Sta. I was well corresponded curve, appearing in nearly equal number in both June and October, but the second peak observed in October in Sta. II was higher than the first peak which was seen in June, contrasted to *D. lutea* (Table 8 and Fig. 17).

Seasonal activity of *D. bizonata:* This species was typically monomodal (autumn) in activity, showing the seasonal peak in November. This species furnished quite similar type in activity in all stations, giving the seasonal peak in November (Table 16 and Fig. 55).

Seasonal activity of *D. rufa:* This species was found to be of monomodal type in activity with a summer peak. This species, as well as *D. immigrans*, displayed high frequency in occurrence only in Sta. III. The activity type of this species in Sta. II was of the bimodal curve, showing two seasonal peaks, one in June and the other in August. While in Sta. I, number of this species collected was too low to determine the seasonal activity type (Table 8 and Fig. 19).

Seasonal activity of *D. angularis:* This species showed a typical monomodal (autumn) activity, giving the seasonal peak in November. This species also showed monomodal type in activity in three stations. Seasonal peak occurred in October in Sta's. I and II, while it was observed in November in Sta. III (Table 8 and Fig. 18).

Monthly numerical variation of species

A total number of species collected in Sta. III is 30, as shown in Table 8.

Among them, 4 species appeared in April.

In May, there were observed 11 species. Compared the data of May with those of April, *M.*

splendida, *D. histrioides*, *D. auraria*, *D. angularis*, *D. histrio*, *D. immigrans* and *D. lacertosa* were new members in May.

In June, 12 species were collected. Among them, *D. coracina*, *D. bifasciata*, *D. suzukii*, *D. melanogaster* and *D. sternopleuralis* were new members in June. On the contrary, *M. splendida*, *D. histrio* and *D. lacertosa* were not collected in this month.

In July, 14 species were collected. Among them, *Microdorosophila*-like sp., *D. quadrivittata*, *D. busckii* and *D. virilis* were collected newly in July. Contrarily, *D. coracina*, *D. bifasciata* and *D. melanogaster* were not secured in this month.

In August, 15 species were obtained. In these species. *A. variegata*, *M. splendida*, *D. coracina*, *D. melanogaster* and *D. lacertosa* were secured newly in this month. While, *Microdrosophila*-like sp., *D. quadrivittata*, *D. busckii* and *D. virilis* were not collected in this month.

In September, 19 species were observed. Among them, *A. magna*, *D. alboralis*, *D. virgata*, *D. virilis* and *D. sordidula* were collected newly in this month. On the contrary, *M. splendida* and *D. coracina* were not collected in September.

In October, 15 species were collected. In these species, *D. sexvittata*, *D. coracina*, *D. unispina* and *D. pengi* appeared newly in this month. While, *A. variegata*, *A. magna*, *D. alboralis*, *D. auraria*, *D. brachynephros*, *D. virgata*, *D. virilis* and *D. sordidula* disappeared in this month.

In November, 10 species were collected. Compared the data of this month with those of October, *D. ficusphila* and *D. brachynephros* were newly collected in November. Whereas, *D. histrioides*, *D. sexvittata*, *D. coracina*, *D. rufa*, *D. unispina*, *D. pengi* and *D. lacertosa* were not collected in this month.

Discussion

Population studies of *Drosophila*, particularly in connection with the fluctuation and size of the population, have been carried out for several years by many investigators (Patterson, 1943; Dobzhansky *et al.*, 1950; Williams and Miller, 1952; Baseden, 1955; Mather, 1956; Nozawa,

Table 9. Seasonal fluctuation for the total population and some species of *Drosophila* common in 6 localities

Species	Sapporo	Asakawa[1)]	Anjyo[2)]	Rakuzan	Dakesan	Mootung[3)]
Total size	M (Su)	B (w-Su)	B (Sp-1.a)	B (Sp-a)	B (sp-A)	B (e.Sp-a)
bizonata	X	M (W)	M (A)	B (Sp-A)	B (sp-A)	B (l.A-e.sp)
angularis	B (sp-A)*	M (e.A)	B (sp-A)*	B (sp-A)	M (A)	B (sp-A)
coracina	M (Su)	M (Su)	M (Su)	M (Su)	M (Su)	B (e.Sp-a)
auraria	M (Su)	M (A)	B (sp-A)	M (Sp)	M (Sp)	B (Sp-a)
lacertosa	M (Su)#	X	B (sp-A)	M (Sp)	M (A)	B (Sp-A)
suzukii	M (A)	M (Sp)	M (A)	M (A)	M (A)	M (A)
lutea	M (A)	M (Sp)	B (Sp-A)	M (Sp)	B (Sp-A)	M (A)
rufa	X	M (Su)	B (sp-A)	M (Sp)	M (Su)	X
subtilis	X	X	B (sp-A)	X	B (sp-A)	X
immigrans	M (A)	M (Sp)	B (sp-A)	M (A)	M (Su)	X

M; monomodal type. B; bimodal type. X; none or very few exsistence. Letters in parentheses denote the season when peak occurred. Capital letter denotes major peak. W and w; winter. Sp and sp; spring. Su; summer. A and a; autumn. e; early. l; later. *; data from *transversa*-complex. #; data from *robusta* group or *cheda-lacertosa*. 1) based on Ohba (1956). 2) based on Nozawa (1956). 3) based on Paik (1958).

1956; Ohba, 1956; Wakahama, 1956b, 1957a, b, 1960, 1962b, c; Paik, 1958). It was shown that the fluctuation in size of the population in *Drosophila* is gradual towards the same direction increasing or sometimes decreasing. Sometimes a sudden fluctuation occurs in certain species. For instance, Patterson (1943) found that there are various environmental factors which influence fluctuations in population size, and that the effects of these factors are different for the different species. Some species show a single peak (population maximum) during the year, while other show two, or even three, such peaks. And many authors, as mentioned above, concluded that the fluctuation of population occurred in relation to a change of climate and vegetation and an artificial or natural change of habitats.

In the following, the author wishes to review the seasonal variation of population in *Drosophila* common to five localities in Japan, viz., Sapporo, Asakawa (near Tokyo), Anjyo (Aichi Pref.), Rakuzan Park and Mt. Dakesan (near Matsue) and Mt. Mootung in South Korea, based on the data presented by Wakahama (1956, 1957b, 1960, 1961), Ohba (1956), Nozawa (1956) and Paik (1958).

A monomodal activity type of *Drosophila* was found in Sapporo, showing a summer peak, while in the other five localities a bimodal type was observed, though the seasonal peak differed by localities as follows: the seasonal activity is a summer-winter type in Asakawa, spring-late autumn type in Anjyo, spring-autumn type in the Rakuzan Park and Mt. Dakesan, and early spring-autumn type in Mt. Mootung.

Drosophila bizonata showed a monomodal activity, being in winter in Asakawa, while in autumn in Anjyo. Further, it furnished a bimodal (spring-autumn) type in the Rakuzan Park and Mt. Dakesan, and a bimodal (early spring-late autumn) type in Mt. Mootung.

Drosophila angularis displayed a monomodal (autumn) activity in Mt. Dakesan, while in the other four localities, it was bimodal (spring-autumn) in activity.

Drosophila coracina showed a monomodal activity, being in summer in all five localities in Japan, while it was in early spring in Korea.

Drosophila auraria presented a monomodal type in activity in Sapporo (summer), Asakawa (autumn), Rakuzan Park (spring) and Mt. Dakesan (spring), whereas it showed a bimodal type in Anjyo (spring-autumn) and Mt. Mootung.

Drosophila lacertosa displayed a monomodal activity in Sapporo (summer), Rakuzan Park (spring) and Mt. Dakesan (autumn), while a bimodal activity in Anjyo and Mt. Mootung (spring-autumn).

Drosophila suzukii was a monomodal (autumn) type in activity in all localities, except Asakawa where the activity was monomodal with a spring peak.

Drosophila lutea showed a monomodal (spring) activity in Asakawa and Rakuzan Park, while an autumn type in Sapporo and Mt. Mootung. However, in Anjyo and Mt. Dakesan, this species was bimodal in activity showing two peaks in spring and autumn.

Drosophila rufa was monomodal in activity showing a spring peak in the Rakuzan Park, and a summer peak in Asakawa and Mt. Dakesan. In Anjyo, however, this species displyed a bimodal (spring-autumn) type.

Drosophila subtilis showed abundance in Anjyo and Mt. Dakesan, giving a bimodal (spring-autumn) activity in both localities.

Drosophila immigrans was monomodal in activity in Sapporo (autumn), Asakawa (spring).

Rakuzan Park (autumn) and Mt. Dakesan (summer), while bimodal (spring-autumn) in Anjyo (Table 9).

Paik (1958) compared seasonal changes for the population size of total species collected between Asakawa and Mt. Mootung and reported that, in temperate zones, the seasonal fluctuation for the total population size differed by different localities. The pattern of fluctuations, however, is not uniform but variable in response to a little bioclimatic gradient, particularly temperature gradient, especially in the period of summer and winter. The data derived from a comparative survey given above are in favor of the view of Paik (1958). For instance, Sapporo is situated in the northern-most part (N. 42° 04″), and the fluctuation for the total population size was of the monomodal type, while some species such as *D. nigromaculata* and *D. trascersa*-complex, showed bimodality (Wakahama, 1956, 1957b).

It is interesting to see that, even in the rather close togethered places such as the Rakuzan Park and Mt. Dakesan, there is a considerable difference in the seasonal activity of the species collected there. The difference in activity may be caused by the climatic difference in the collection season. Paik (1958) stated that the seasonal activity of *Drosophila* was definitive in the adjacent locality. The results derived by the author's observations indicate that the seasonal activity of *Drosophila* is variable by season as well as by altitude.

It was reported that there were some species which showed an altitudinal difference in seasonal activity. The effects of altitude on seasonal activity should therefore be considered in relation to the fluctuation for population structure in *Drosophila*. Previously correlation between distribution and altitude was studied in several species of *Drosophila* by Takada (1954, 1958), Kurokawa (1956) and Heed (1957), but the altitudinal difference of seasonal variation of population structure has remained without consideration.

In the following, the author deals with the relation of altitude to seasonal variation of population structure in *Drosophila* observed on Mt. Dakesan during a period from April to November, 1961.

A total number of species collected in this survey is 42, as shown in Table 5.

Among them, 8 species appeared in April and 7 species were collected in Sta. Ⅰ, 6 species in Sta. Ⅱ and 4 species in Sta. Ⅲ. Drosophila lutea, *D. rufa*, *D. bizonata* and *D. subtilis* were found in the three stations and *A. variegata* and *D. angularis* were collected in Sta. Ⅰ, while *D. melanogaster* in Sta. Ⅱ. *Drosophila histrioides* was obtained in Sta's, Ⅰ and Ⅱ.

Among 17 species which were secured in May, *M. splendida*, *D. lutea*, *D. auraria*, *D. rufa*, *D. angularis*, *D. bizonata*, *D. immigrans* and *D. subtilis* were collected in all stations. *Drosophila histrioides* was collected in Sta's. Ⅰ and Ⅲ, while *D. lacertosa* in Sta's. Ⅰ and Ⅱ. *Drosophila busckii*, *D. pengi*, *D. virilis* and one undistinguished specimen were collected in Sta. Ⅰ, *D. bifasciata* and *D. melanogaster* in Sta. Ⅱ and *D. histrio* in Sta. Ⅲ. Compared the data of May with those of April, it is evident that *M. splendida*, *D. busckii*, *D. immigrans*, *D. virilis*, *D. pengi*, *D. lacertosa* and one undistinguished specimen appeared newly in Sta. Ⅰ, while *D. histrioides* was not obtained in this station. *Mycodrosophila splendida*, *D. bifasciata*, *D. auraria*, *D. angularis* and *D. immigrans* were new members in Sta. Ⅱ. *Mycodrosophila splendida*, *D. histrioides*, *D. auraria*, *D. angulris*, *D. histrio*, *D. immigrans* and *D. lacertosa* were found newly in Sta. Ⅲ.

In June, 18 species were collected; amongst them 15 species were obtained in Sta. Ⅰ, 11

species in Sta. II and 13 species in Sta. III. In these members, *D. histrioides*, *D. coracina*, *D. lutea*, *D. auraria*, *D. angularis*, *D. bizonata*, *D. sternopleuralis*, *D. immigrans* and *D. subtilis* appeared in the three stations. *Drosophila suzukii* was collected in Sta's. I and III. *Amiota variegata*, *P. pallida*, *D. sordidula* and *D. lacertosa* were in Sta. I. *Drosophila pengi* and *D. bifasciata* were seen in Sta. II, while *D. melanogaster* in Sta. III. In comparison of population structure in June with that of May, it was found that *A. variegata*, *P. pallida*, *D. histrioides*, *D. coracina*, *D. suzukii*, *D. sternopleuralis* and *D. sordidula* appeared newly in Sta. I, whereas *M. splendida*, *D. busckii*, *D. pengi*, *D.virilis* and one undistinguished specimen were not collected in this station. In Sta. II, *D. coracina*, *D. sternopleuralis* and *D. pengi* were added as new members, and *M. splendida*, *D. bifasciata and D. melanogaster* were not observed in this station. *Drosophila coracina*, *D. bifasciata*, *D. suzukii*, *D. melanogaster* and *D. histrio* were newly found in Sta. III and *M. splendida*, *D. histrio* and *D. lacertosa* were not collected.

In July, 16 species were obtained; among them 12 species were observed in Sta. I, 10 species in Sta. II and 14 species in Sta. III. In these species, *D. suzukii*, *D. lutea*, *D. auraria*, *D. rufa*, *D. bizonata*, *D. immigrans*, *D. subtilis*, *D. histrioides* and *D. virilis* were collected in the three stations. *Drosophila sternopleuralis* was collected in Stations I and II, while *D.* busckii in Stations II and III. *Amiota variegata* and *D. melanogaster* were obtained in Sta. I, whereas *Microdrosophila* like sp., *D. quadrivittata* and *D. angularis* were observed in Sta. III. In this month, *D. virilis* and *D. melanogaster* were new members in Sta. I and *P. pallida*, *D. coracina*, *D. angularis* and *D. lacertosa* were not collected in this station. In Sta. II, *D. busckii*, *D. suzukii* and *D. virilis* were added as new members, while *D. coracina*, *D. angularis*, *D. sternopleuralis* and *D. pengi* did not appear in this station. In Sta. III, *Microdrosophila* like sp., *D. qudrivittata*, *D. busckii* and *D. virilis* were newly found, whereas *D. coracina*, *D. bifasciata* and *D. melanogaster* were not collected in this station.

In August, 18 species were collected, 9 species out of which were found in Sta. I, 13 species in Sta. II and 15 species in Sta. III. In these species, *D. histrioides*, *D. coracina*, *D. lutea*, *D. auraria*, *D. rufa*, *D. bizonata*, *D. sternopleuralis* and *D. subtilis* were collected in the three stations, and *D. melanogaster*, *D. angularis* and *D. immigrans* were obtained in Stations II and III. *Scaptomyza graminum* was collected in Sta. I. *Leucophenga argentosa* and *L. ornatipennis* were found in Sta. II, while *A. variegata*, *M. splendida*, *D. suzukii* and *D. lacertosa* were obtained in Sta. III. In comparison with the members obtained in the former month, *S. graminum* and *D. coracina* were new members in Sta. I, while *A. variegata*, *D. suzukii*, *D. melanogaster*, *D. immigrans* and *D. virilis* did not appear in this station. In Sta. II, *L. argentosa*, *L. ornatipennis*, *D. coracina*, *D. melanogaster*, *D. angularis* and *D. sternopleuralis* were found as new members, whereas *D. busckii*, *D. suzukii* and *D. virilis* were not collected. In Sta. III, *A. variegata*, *M. splendida*, *D. coracina*, *D. melanogaster* and *D. lacertosa* newly appeared, whereas *Microdorosophila* like sp., *D. qaudrivittata*, *D. busckii* and *D. virilis* were not collected in this station in this month.

In September, 21 species were collected, 15 species of which were obtained in Sta, I, 15 species in Sta. II and 19 species in Sta. III. Among them, *Amiota variegata*, *D. suzukii*, *D. lutea*, *D. melanogaster*, *D. auraria*, *D. rufa*, *D. bizonata*, *D. sternopleuralis*, *D. subtilis*, *D. virilis*, *D. sordidula* and *D. lacertosa* were collected in the three stations. *Drosophila pengi* was obtained in Stations I and II, *D. histrioides* and *D. brachynephros* in Stations II and III, and

D. angularis in Stations I and III. *Drosophila coracina* was collected only in Sta. I, while *A. magna*, *D. alboralis*, *D. immigrans* and *D. virgata* were gathered in Sta. III. Compared the data of this month with those of August it is apparent that A. *variegata*, *D. suzukii*, *D. melanogaster*, *D. angularis*, *D. pengi*, *D. virilis*, *D. sordidula* and *D. lacertosa* were new members in Sta. I, while, *S. graminun* and *D. histrioides* did not appear in this station. In Sta. II, *A. variegata*, *D. suzukii*, *D. brachynephros*, *D. pengi*, *D. virilis*, *D. sordidula* and *D. lacertosa* appeared as new members in this station. On the other hand, *L. argentosa*, *L. ornatipennis*, *D. coracina*, *D. angularis* and *D. immigrans* were not collected in this station. In Sta. III, *A. magna*, *D. alboralis*, *D. brachynephros*, *D. virgata*, *D. virilis* and *D. sordidula* consisted of new members in this station, whereas *M. splendida* and *D. coracina* were not consisted in this station.

In October, 36 species were collected and among of them, 31 species were found in Sta. I, 16 species in Sta. II and 15 species in Sta. III. In these species, *D. coracina*, *D. suzukii*, *D. lutea*, *D. melanogaster*, *D. rufa*, *D. angularis*, *D. bizonata*, *D. sternopleuralis*, *D. pengi* and *D. subtilis* were coll ected in the three stations. *Drosophila auraria*, *D. brachynephros* and *D. sordidula* were obtained in Stations I and II, while *D. sexvittata*, *D. unispina* and *D. immigrans* were seen in Stations I and III. *Amiota variegta*, *L. magnipalpis*, *L. concilia*, *L. angusta*, *M. splendida*, *P. pallida*, *S. graminum*, *D. alboralis*, *D. quadrivitta*, *D. pulchrella*, *D. ficusphila*, *D. nigromaculata*, *D. testacea*, *D. grandis* and *D. virgata* were found only in Sta. I, *L. ornatipennis*, *D. bifasciata* and *D. virilis* in Sta. II, and *D. lacertosa* in Sta. III. In this month, *L. magnipalpis*, *L. concilia*, *L. angusta*, *M. splendida*, *P. pallida*, *S. graminum*, *D. alboralis*, *D. sexvittata*, *D. pulchrella*, *D. ficusphila*, *D. brachynephros*, *D. unispina*, *D. nigromaculata*, *D. testacea*, *D. grandis*, *D. immigrans* and *D. virgata* were added as new members in Sta. I, while *D. virilis* and *D. lacertosa* were not collected in this station. In Sta. II, *L. ornatipennis*, *D. coracina*, *D. bifasciata* and *D. angularis* were new members in this station, whereas *A. variegata*, *D. histrioides* and *D. lacertosa* did not appear in Sta. II. In Sta. III, *D. sexvittata*, *D. coracina*, *D. unispina*, *D. histrio* and *D. pengi* were newly found in this station, while *A. variegata*, *A. magna*, *D. alboralis*, *D. auraria*, *D. brachynephros*, *D. virgata*, *D. virilis* and *D. sordidula* were not seen in this station.

In November, 18 species were found of which 18 species were collected in Sta. I, 13 species in Sta. II and 10 species in Sta. III. In these species, *D. suzukii*, *D. lutea*, *D. melanogaster*, *D. ficusphila*, *D. brachynephros*, *D. angularis*, *D. bizonata*, *D. sternopleuralis*, *D. immigrans* and *D. subtilis* were collected in the three stations. *Drosopihla coracina* and *D. rufa* were obtained in Stations I and II. *Drosophila auraria*, *D. histrio* and *D. virgata* were collected only in Sta. I, while *D. sordidula* was seen in Sta. II. In comparison the data of this month with those of the former month, *L. argentosa*, *D. histrioides*, *D. busckii* and *D. histrio* were newly found in Sta. I, *A, variegata*, *L. angusta*, *L. magnipalips*, *L. concilia*, *M. splendida*, *P. pallida*, *S. graminum*, *D. alboralis*, *D. sexvittata*, *D. quadrivittata*, *D. pulchrella*, *D. nigromaculata*, *D. testacea*, *D. grandis*, *D. pengi*, *D. virilis* and *D.* sordidula did not appear in this station. In Sta. II, *D. ficusphila* and *D. immigrans* were new members in this station. On the other hand, *L. ornatipennis*, *D. bifasciata*, *D. auraria*, *D. pengi* and *D. virilis* were not collected in this station. In Sta. III. *D. ficusphila* and *D. brachynephros* were newly observed in this station, while *D. sexvittata*, *D. histrioides*, *D. coracina*, *D. rufa*, *D. unispina*, *D. pengi*, *D. virgata* and *D. lacertosa* were not obtained in this station.

Ohba (1956) stated that the montly population structure in Asakawa forest consisted of 6 to 14 species. The results of the present survey indicate that 10 or more species consist of monthly population structure, and that the highest collection record with 31 species was obtained in Sta. I in October. Heed (1957) pointed that in *Drosophila* population of El Sarvador most species showed a definite favor to either a highland or lowland. Based on the data obtained in this survey it seems to the author that, 50 per cent or more of collected species may be members of both habitats.

The results of the present survey indicate that the number of species collected was abundant on the foot and midway of the mountain in spring and autumn seasons, but on the summit in summer.

Further, there was observed a related feature with respect of the dispersion-frequency in number of individuals collected of each species. In the following, the author describes the monthly variation of dispersion-frequency in the five dominant species to each altitude.

Table 10. Monthly variation on dispersal frequency of each species to three stations

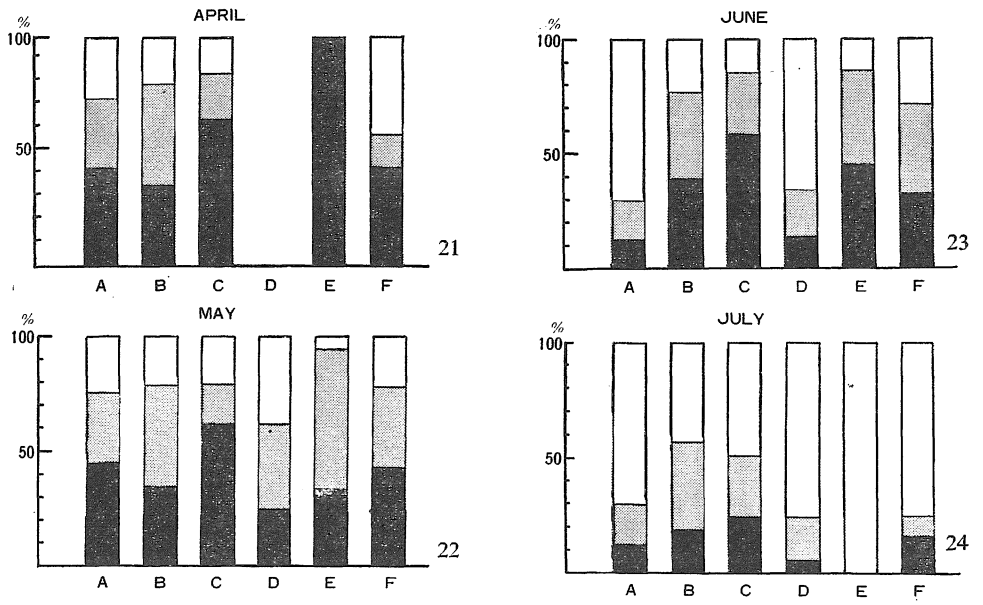
Month		April	May	June	July	August	September	October	November
Species									
bizonata	Sta. I	30	39	39	7	40	32	542	839
	Sta. II	23	51	39	15	42	50	238	507
	Sta. III	11	24	24	17	27	38	82	170
lutea	Sta. I	16	235	184	23	12	21	296	339
	Sta. II	7	163	132	40	38	28	97	47
	Sta. III	5	129	192	160	118	31	43	24
subtilis	Sta. I	21	110	185	22	9	65	219	60
	Sta. II	6	31	87	25	32	67	281	121
	Sta. III	5	37	48	46	83	67	87	32
angularis	Sta. I	3	6	13	0	0	1	209	130
	Sta. II	0	11	12	0	5	0	218	103
	Sta. III	0	1	4	4	5	1	41	68
immigrans	Sta. I	0	2	14	15	0	0	5	40
	Sta. II	0	3	23	62	5	0	0	2
	Sta. III	0	3	74	248	116	2	1	5
Others	Sta. I	14	26	46	16	51	70	208	82
	Sta. II	7	24	27	12	23	105	64	40
	Sta. III	0	31	42	23	29	115	26	11
Total species	Sta. I	84	429	499	89	112	233	1476	1494
	Sta. II	41	288	346	159	181	271	901	821
	Sta. III	24	228	403	540	461	284	284	310

D. bizonata: A total of 2926 specimens was collected through the year on Mt. Dakesan. Among them, 64 specimens were collected in April and 30 specimens (46.9 cent) were obtained in Sta. I, 23 in Sta. II (35.9) and 11 (17.2) in Sta. III. In May, 114 specimens of this species were collected as a total. Among them, 39 specimens (34.2) were obtained in Sta. I, 51 specimens (44.7) in Sta. II and 24 (21.1) in Sta. III. In June, 102 specimens of this species were

collected. In these specimens, 39 specimens (38.2) were obtained in Sta. I, 39 specimens in Sta. II and 24 specimens (23.6) in Sta. III. In July, within 39 specimens of total specimens collected in this month, 7 specimens (17.9) were obtained in Sta. I, 15 (38.5) in Sta. II and 17 specimens (43.6) in Sta. III. In August, a total of 109 specimens were secured. Among them, 40 specimens (36.7) were obtaind in Sta. I, 42 specimens (38.5) in Sta. II and 27 (24.8) in Sta. III. In September, 120 specimens were collected as a total. Amongst them, 32 specimens (26.7) were secured in Sta. I, 50 (41.7) in Sta. II and 38 specimens (31.7) in Sta. III. In October, a total of 862 specimens were collected and among them, 542 specimens (62.9) were obtained in Sta. I, 238 (27.6) in Sta. II and 82 (9.5) in Sta. III. In November, among a total of 1516 specimens collected, 839 specimens (55.3) were obtained in Sta. I, 507 (33.4) in Sta. II and 170 (11.2) in Sta. III (Table 10).

It is evident from the above findings that this species showed the highest frequency of dispersion on the foot in April, October and November, on the midway in May, June, August and September and on the summit in July.

Drosophila lutea: In April, 28 specimens of this species were secured. Among them, 16 specimens (57.1 per cent) were obtained in Sta. I, 7 (25.0) in Sta. II and 5(17.9) in Sta. III. In May, 527 specimens were collected as a total. Among of them, 235 specimens (44.6) were obtained in Sta. I, 163 (30.9) in Sta. II, and 129 (24.5) in Sta. III. In June, 508 specimens were collected in a total. In these specimens, 184 (36.2) were obtained in Sta. I, 132 (26.0) in Sta. II and 192 (37.8) in Sta. III. In July, 226 specimens were secured as a total, and amongst them, 26 specimens (11.5) were obtained in Sta. I, 40 (17.7) in Sta. II and 160 (70.8) in Sta.



Figs. 21-24. Bar graphs showing seasonal differences on dispersal frequency of abundant species observed on Mt. Dakesan, during a period from April to November, 1961. A, *D. bizonata.* B, *D. lutea.* C, *D. subtilis.* D, *D. angularis.* E, *D. immigrans.* F, *D. rufa.* Black bars showing the frequency of each species in Station I, dotted bars that of in Station II, and white bars that of in Station III. 21, April. 22, May. 23, June. 24, July.

Ⅲ. In August, a total of 168 specimens was collected. Among them, 12 specimens (7.1) were obtained in Sta. Ⅰ, 38 (22.6) in Sta. Ⅱ and 118 (70.2) in Sta. Ⅲ. In September, 80 specimens were collected as a total. Among them, 21 specimens (26.3) were secured in Sta. Ⅰ, 28(35.0) in Sta. Ⅱ and 31 specimens (38.7) in Sta. Ⅲ. In October, a total of 436 specimens was collected. In these specimens, 296(67.9) were obtained in Sta. Ⅰ, 97(22.2) in Sta. Ⅱ and 43 (9.9) in Sta. Ⅲ. In November, 410 specimens of this species were collected. Among them, 339 specimens (82.7) were obtained in Sta. Ⅰ, 47(11.5) in Sta. Ⅱ and 24 (5.9) in Sta. Ⅲ(Table 10).

As a results, this species showed the highest occurrence in number on the foot in April, May, October and November and on the summit in June, July, August and September (Figs. 21-28).

Drosophila subtilis: In April, a total of 32 specimens were collected. Among them, 21 specimens (65.6) were found in Sta. Ⅰ, 6 (18.8) in Sta. Ⅱ and 5 (15.6) in Sta. Ⅲ. In May, 178 specimens of this species were obtained. Amongst them, 110 specimens (61.8) were found in Sta. Ⅰ, 31 (17.4) in Sta. Ⅱ and 37 (20.8) in Sta. Ⅲ. In June, a total of 320 specimens were collected. In these specimens, 185 specimens (57.8) were secured in Sta. Ⅰ, 87 (27.2) in Sta. Ⅱ and 48 (15.0) in Sta. Ⅲ. In July, 93 specimens were collected as a total. Among of them, 22 specimens (23.7) were found in Sta. Ⅰ, 25 (26.9) in Sta. Ⅱ and 46 (49.5) in Sta. Ⅲ. In August, a total of 124 specimens were secured. In these specimens, 9 specimens (7.3) were obtained in Sta. Ⅰ, 32 (25.8) in Sta. Ⅱ and 83 (66.9) in Sta. Ⅲ. In September, a total of 199 specimens was collected. Among them, 65 specimens (32.7) were found in Sta. Ⅰ, 67 (33.7) in Sta. Ⅱ and 67 in Sta. Ⅲ. In October, a total of 587 specimens was collected. Amongst them, 219 specimens (37.3) were secured in Sta. Ⅰ, 281 (47.8) in Sta. Ⅱ and 87 (14.8) in Sta. Ⅲ. In November, 213 specimens were collected as a total. Among them, 60 specimens (28.2) were found in Sta. Ⅰ, 121 (56.8) in Sta. Ⅱ and 32 (15.0) in Sta. Ⅲ.

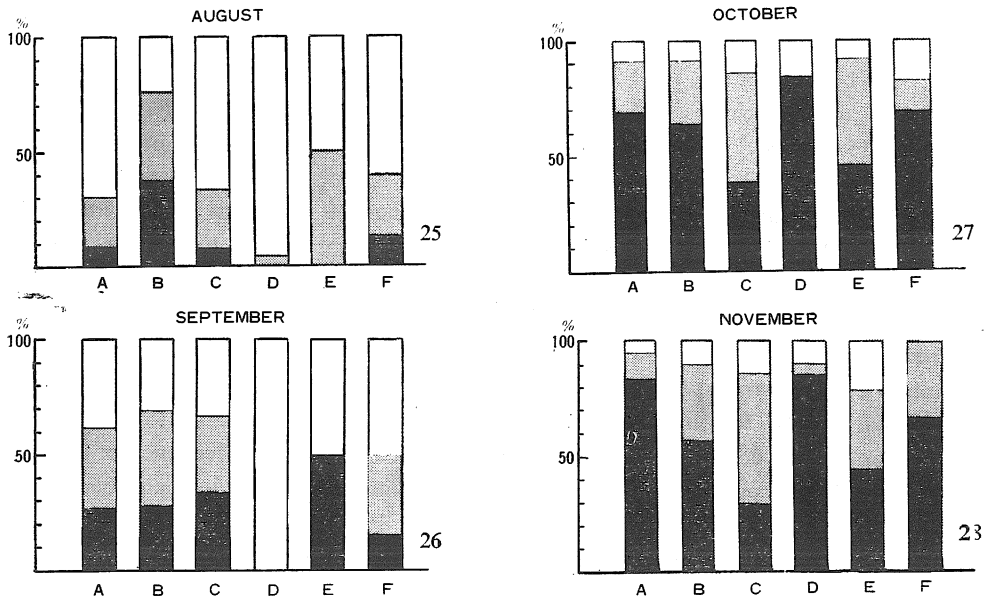
It was found as a conclusion that this species showed the highest frequency of dispersion on the foot of the mountain in April, May and June, on the midway in September, October and November and on the summit in July, August and September (Table 10 and Figs. 21-28).

Drosophila angularis: In April, 3 specimens of this species were obtained and all of them were found in Sta. Ⅰ. In May, 18 specimens were caught and among them, 6 (33.3) were found in Sta. I, 11 (61.1) in Sta. Ⅱ and 1 (5.6) in Sta. Ⅲ. In June, a total of 29 specimens were collected. Within them, 13 specimens (44.8) were secured in Sta. Ⅰ, 12 (41.4) in Sta. Ⅱ and 4 (13.8) in Sta. Ⅲ. In July, 4 specimens were secured and all of them were found in Sta. Ⅲ. In August, a total of 10 specimens was obtained. Among them, 5 specimens were found in Stations Ⅱ and Ⅲ, respectively. In Septemper, 2 specimens of this species were found and they were secured in Stations Ⅰ and Ⅲ, respectively. In October, 468 specimens were collected. Among of them, 209 specimens (44.7) were obtained in Sta. Ⅰ, 218 (46.6) in Sta. Ⅱ and 41 (8.8) in Sta. Ⅲ. In November, a total of 301 specimens was collected. Amongst them, 130 specimens (43.2) were found in Sta. Ⅰ, 103 (34.2) in Sta. Ⅱ and 68 (22.6) in Sta. Ⅲ (Table 10 and Figs. 21-28).

It was clarified from the above findings that this species displayed the highest frequency of dispersion on the foot of the mountain in April, June, September, October and November, on the midway in May and September and on the summit in July, August and September.

Drosophila immigrans: In April, no specimen of this species was found. In May, 8 specimens were found. Among them, 2 specimens (25.0) were found in Sta. Ⅰ, 3 specimens (37.5) in

Sta. II and 3 in Sta. III. In June, a total of 111 specimens was found. Amongst them, 14 specimens (12.6) were obtained in Sta. I, 23 (20.7) in Sta. II and 74 (66.7) in Sta. III. In July, 325 specimens were secured. Among them, 15 specimens (4.6) were obtained in Sta. I, 62 (19.1) in Sta. II and 248 (76.3) in Sta. III. In August, a total of 121 specimens was obtained. No specimen was found in Sta. I, 5 (4.1) in Sta. II and rest of 116 (95.9) in Sta. III. In September, 2 specimens were found and all of them were secured in Sta. III. In October, 6 specimens were collected and among them 5 specimens (83.3) were obtained in Sta. I and rest 1 was in Sta. III. In November, a total of 47 specimens were obtained. Among them, 40 specimens (85.1) were secured in Sta. I, 2 (4.3) in Sta. II and 5 (10.6) in Sta. III (Table 10 and Figs. 21-28).



Figs. 25-28. Bar graphs showing seasonal differences on dispersal frequency of abundant species observed on Mt. Dakesan, during a period from April to November, 1961. A, *D. bizonata*. B, *D. lutea*. C, *D. subtilis*. D, *D. angularis*. E, *D. immigrans*. F, *D. rufa*. Black bars showing the frequency of each species in Station I, dotted bars that of in Station II, and white bars that of in Station III. 25, August. 26, September. 27, October. 28, November.

It is evident from the above findings that this species showed the highest frequency of dispersion on the foot of the mountain in October and November, on the midway in May and to the summit in May, June, July, August and September.

Based on the present data obtained in this survey, it seems to the author that species of *Drosophila* are abundant in number on the foot and midway of Mt. Dakesan in spring and autumn seasons, while on the summit in summer time.

ii). On some statistical analyses of population structure in *Drosophila*

In the analysis of population structure, Motomura (1935) proposed "the law of geometrical series". Many investigators have attempted successufully to analyse population structure, use

being made of this formula.

Kato (1954) applied this formula for analysis of his collection data of *Drosophila* which was obtained on the foot of Mt. Kago-bo, Miyagi Prefecture, and showed a general adaptability of this formula on analysis of population structure.

Further, for comparison of the resemblance of population structure, Motomura (1952) proposed the use of the method of correlation coefficients. He applied this method to the comparison of benthonic populations of the Fuji Lakes. According to him, the method of the correlation coefficients was more suitable for comparison of population structure that other methods such as the reciplocal treatment, the variant analysis and chi square method.

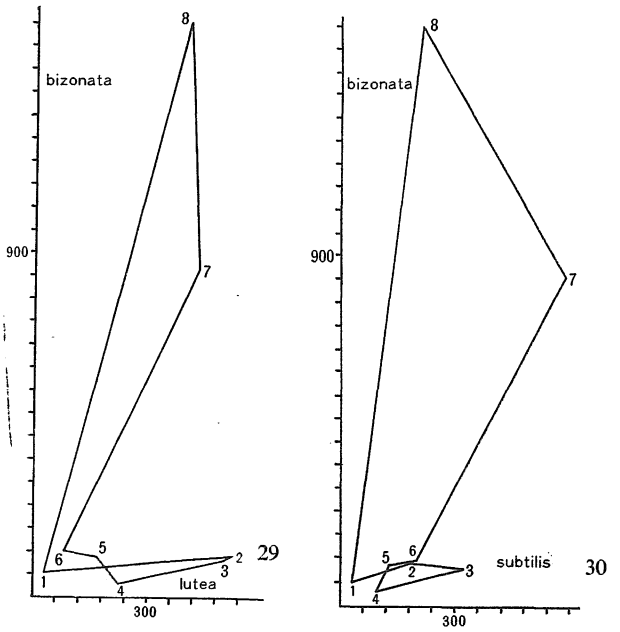
Nozawa (1956) studied the diurnal and seasonal successions of *Drosophila* in a natural population inhabiting a latifolite forest in Anjyo City, the central part in Japan, during a period from 1952 to 1954. He described the following four types of their activity: (A) a high peak in the morning and a low peak in the evening (the commonest type); (B) two peaks at the sunrise and at the sunset (*D. auraria*); (C) a peak in the midday (*D. subtilis*); and (D) a peak in the evening (*D. coracina*). Also he designated four types on their seasonal activity as below: (1) spring-autumn type in which *D. lutea*, *D. auraria*, *D. rufa*, *D. transversa* (*D. nigromaculata*), *D. lacertosa*, *D. subtilis* and *D. immigrans* were included; (2) summer-type which was represented by *D. coracina*; (3) autumn-type in which *D. suzukii* (*D. pulchrella*), *D. melanogaster* and *D. bizonata* were contained; and (4) winter-type as shown by *D. curviceps*. Further, he analyzed population structure in *Drosophila* according to the following criteria; a total number of the specimens collected, the number of specimens of dominant species, the variance of the percentages of individual species, constants "a" and "b" of the formula of geometrical series, Pareto constant (α), and correlation coefficient of population between the successive periods. Following above mentioned criteria, he recognized the following four phases in their seasonal activity: (1) the hibernating phase (early November through early May), as seen in the population of low density monopolised by *D. curviceps*; (2) the first active phase (early May through early August), as population of high density dominated by *D. lutea*, and *D. immigrans* with mixture of *D. auraria*; (3) summer resting phase (early August through late August), as represented by the population of low density dominated by *D. auraria* in the morning and in the evening, and by *D. coracina* in the day time; and (4) the second active phase (late August through early November), as seen in the population of high density consisting of *D. melanogaster*, *D. lutea*, *D. auraria* and *D. bizonata*. And, he concluded that in the animal population composed closely related species, if they are highly motile and broadly adaptable, co-exsisting of them in the same environment as well as habitat-segregation, is very common.

In the following, the author wishes to deal with some statistical analyses of seasonal activity of *Drosophila* species observed on Mt. Dakesan during a period from April to November, 1961, with the application of the method of correlation coefficients. On the other hand, the author wishes to describe the comparison of population structure in each month during this experimental period, utelizing the method of correlation coefficients. Finally, the comparison may be made on the vertical and seasonal variations of the population structure in each month following the method of the least square.

Statistical analyses of seasonal activity of *Drosophila*

In the foregoing pages, the author described three types of seasonal activity in the five dominant species observed on Mt. Dakesan during a period from April to November, 1961: *D. bizonata*, *D. lutea* and *D. subtilis* displayed two seasonal peaks in activity, one in spring and the other in autumn, while *D. angulris* and *D. immigrans* showed a single seasonal peak, the former in autumn and the latter in summer.

Although three species of *D. bizonata*, *D. lutea* and *D. subtilis* displayed a similar bimodal curve, these activity types seem to be of another pattern from statistical viewpoint, and the monomodal type observed in *D. angularis* and *D. immigrans* could be divided into different patterns on the basis of the above view.



Figs. 29-30. Graphs showing the correlation of seasonal activity in two abundant species observed on Mt. Dakesan in each month during a period from April to November, 1961. 1, number of specimens collected in two species in April. 2, that of in May. 3, that of in June. 4, that of in July. 5, that of in August. 6, that of in September. 7, that of in October. 8, that of in November. Fig. 29, showing correlation on seasonal activity of *D. bizonata* and *D. lutea*. Fig. 30, showing that of *D. bizonata* and *D. subtilis*.

In the following, the comparison is to be made on seasonal changes of these five species from statistical standpoint.

D. bizonata and *D. lutea:* As noted above, the seasonal change of both species were of bimodal type. Monthly numerical data of both species were as follows: 64 specimens of *D. bizonata* and 28 of *D. lutea* were collected in April, 114 and 527 in May, 102 and 508 in June, 39 and 226 in July, 109 and 168 in August, 120 and 80 in September, 862 and 436 in October and 1516 and 410 in November (Table 5 and Fig. 29).

Correlation coefficient between seasonal changes of both species was obtained as 0.68, being significant statistically.

D. bizonata and *D. subtilis:* Each species also furnished a bimodal curve in their seasonal activity. Monthly numerical records of collections were as follows: 64 specimens of *D. bizonata* and 32 of *D. subtilis* were obtained in April, 114 and 178 in May, 102 and 320 in June, 39 and 93 in July, 109 and 124 in August, 120 and 199 in September, 862 and 587 in October and 1516 and 213 in November (Table 5 and Fig. 30).

Correlation coefficient concerning seasonal changes of two species was found to be 0.44, being insignificant statistically.

D. bizonata and *D. angularis:* The former species showed a bimodal curve, presenting a seasonal peak in May and November, while the latter displayed a monomodal type, showing a peak

in October. Monthly numerical data of two species were found as follows: 64 specimens of *D. bizonata* and 3 specimens of *D. angularis* were caught in April, 114 and 18 in May, 102 and 29 in June, 39 and 4 in July, 109 and 10 in August, 120 and 2 in September, 862 and 468 in October and 1561 and 301 in November (Table 5 and Fig. 31).

Correlation coefficient concerning variation of two species was obtained as 0.84, being highly significant statistically.

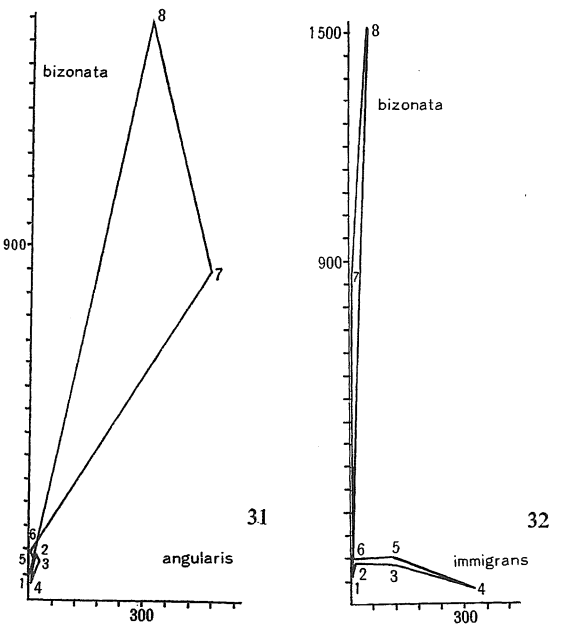
D. bizonata and *D. immigrans:* The activity type of *D. bizonata* was bimodal as mentioned above, while that of *D. immigrans* was monomodal showing a seasonal peak in summer. Numerical collection data in each month were as follows: 64 specimens of *D. bizonata* and no specimen of *D. immigrans* were obtained in April, 114 and 8 in May, 102 and 111 in June, 39 and 325 in July, 109 and 121 in August, 120 and 2 in September, 587 and 6 in October and 1516 and 47 in November (Table 5 and Fig. 32).

Correlation coefficient regarding seasonal changes of two species was obtained to be −0.26, insignificant statistically.

D. lutea and *D. subtilis:* Each species displayed a bimodal curve in their seasonal activity, showing two peaks, one in spring and the other in autumn. Monthly numerical records were as follows: 28 specimens of *D. lutea* and 32 specimens of *D. subtilis* were collected in April, 527 and 178 in May, 508 and 320 in June, 226 and 93 in July, 168 and 124 in August, 80 and 320 in September, 436 and 587 in October and 410 and 301 in November (Table 5 and Fig. 33).

Correlation coefficient concerning seasonal change of two species was found as 0.48, being insignificant statistically.

D. lutea and *D. angularis:* The activity type of *D. lutea* was bimodal, while that of *D. immigrans* was of a monomodal type. Monthly numerical data were as follows: 28 specimens of *D. lutea* and 3 specimens of *D. angularis* were obtained in April, 527 and 18 in May, 508 and 29 in June, 226 and 4 in July, 168 and 10 in August, 80 and 2 in September, 436 and 468 in October and 410 and 301 in November (Table 5 and Fig. 34).



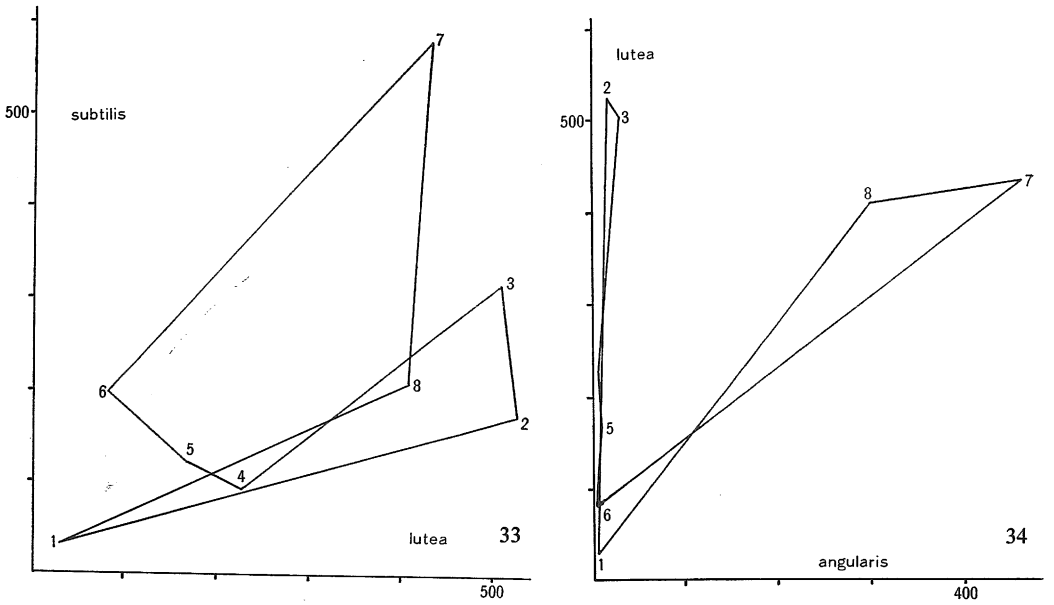
31 32

Figs. 31-32. Graphs showing the correlation of seasonal activity in two abundant species observed on Mt. Dakesan in each month during a period from April to November, 1961. 1, number of specimens collected in two species in April. 2, that of in May. 3, that of in June. 4, that of in July. 5, that of in August. 6, that of in September. 7, that of in October. 8, that of in November. Fig. 31, showing that of *D. bizonata* and *D. angularis*. Fig. 32, showing that of *D. bizonata* and *D. immigrans*.

Correlation coefficient concerning seasonal changes of two species was obtained as 0.33, being insignificant statistically.

D. lutea and *D. immigrans:* These two species also showed the quite different type in their seasonal activity, the former showed two seasonal peaks, one in spring and the other in autumn, while the latter furnished a monomodal activity, showing a seasonal peak in summer. Monthly numerical records of collections were as follows: 28 specimens of *D. lutea* and no specimen of *D. immigrans* were obtained in April, 527 and 1 in May, 508 and 111 in June, 226 and 325 in July, 168 and 121 in August, 80 and 2 in September, 436 and 6 in October and 410 and 47 in November (Table 5 and Fig. 35).

Correlation coefficient concerning seasonal changes of two species was found to be −0.02, being insignificant statistically.

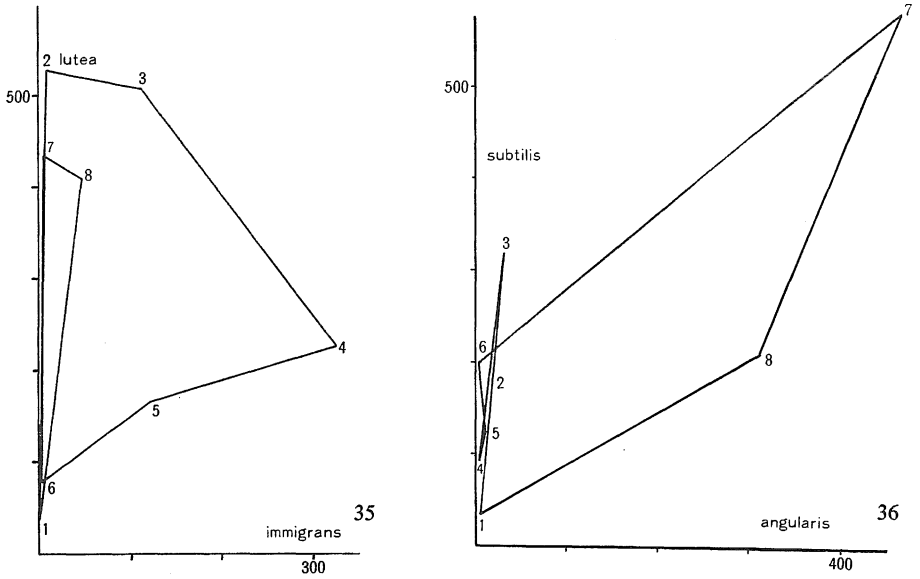


Figs. 33-34. Graphs showing the correlation of seasonal activity in two abundant species observed on Mt. Dakesan in each month during a period from April to November, 1961. 1, number of specimens collected in two species in April. 2, that of in May. 3, that of in June. 4, that of in July. 5, that of in August. 6, that of in September. 7, that of in October. 8, that of in November. Fig. 33, showing that of *D. lutea* and *D. subtilis*. Fig. 34, showing that of *D. lutea* and *D. angularis*.

D. subtilis and *D. angularis:* The former displayed a bimodal curve in its seasonal activity, showing two peaks, one in spring and the other in autumn, whereas the latter showed a monomodal activity curve, presenting a peak in late autumn. Monthly numerical records of collections were as follows: 32 specimens of *D. subtilis* and 3 specimens of *D. angularis* were secured in April, 178 and 18 in May, 320 and 29 in June, 93 and 4 in July, 124 and 10 in August, 199 and 2 in September, 587 and 468 in October and 213 and 301 in November (Table 5 and Fig. 36).

Correlation coefficient concerning seasonal changes of two species was found as 0.25, being insignificant statistically.

D. subtilis and *D. immigrans:* The seasonal activity of the former species was shown in bimodal, while that of the latter was monomodal. Monthly numerical data of collections were as follows: 32 specimens of *D. subtilis* and no specimen of *D. immigrans* were collected in



Figs. 35-36. Graphs showing the correlation of seasonal activity in two abundant species observed on Mt. Dakesan in each month during a period from April to November, 1961. 1, number of specimens collected in two species in April. 2, that of in May. 3, that of in June. 4, that of in July. 5, that of in August. 6, that of in September. 7, that of in October. 8, that of in November. Fig. 35, showing that of *D. lutea* and *D. immigrans*. Fig. 36, showing that of *D. subtilis* and *D. angularis*.

April, 178 and 8 in May, 320 and 111 in June, 93 and 325 in July, 124 and 121 in August, 199 and 2 in September, 587 and 6 in October and 213 and 47 in November (Table 5 and Fig. 37).

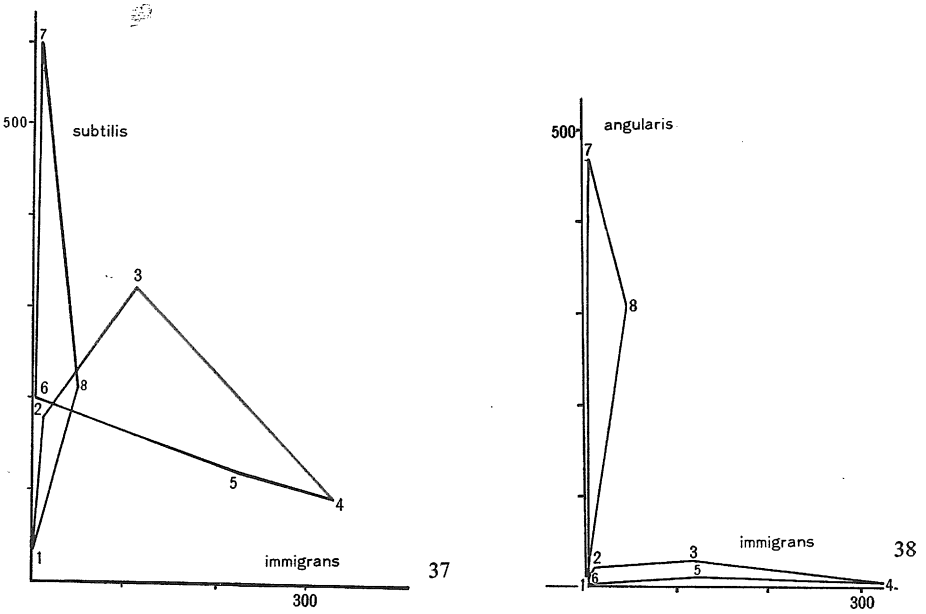
Correlation coefficient concerning seasonal changes of two species was obtained as 0.28, being insignificant statistically.

D. angularis and *D. immigrans:* These species were of a monomodal activity type, showing a seasonal peak the former in autumn and the latter in summer. Monthly numerical records of collections were as follows: 3 specimens of *D. angularis* and no specimen of *D. immigrans* were found in April, 18 and 8 in May, 29 and 111 in June, 4 and 325 in July, 10 and 121 in August, 2 and 2 in September, 468 and 6 in October and 301 and 47 in November (Table 5 and Fig. 38).

Correlation coefficient concerning seasonal changes of two species was shown to be -0.89, being highly but negatively significant statistically.

In the light of the above features obtained, five series of correlation coefficients were gained regarding seasonal fluctuations of *Drosophila* species based on the data from which were derived from the observations on Mt. Dakesan (Fig. 39). In Figure 79, the first series (*D. bizonata*) and the forth series (*D. angularis*) showed a similar value, while no such similarity was shown in other three series.

Based on the data derived from the present investigation, it seems to the author that seasonal activiteis of the five abundant species observed on Mt. Dakesan are sorted into four patterns:



Figs. 37-38. Graphs showing the correlation of seasonal activity in two abundant species observed on Mt. Dakesan in each month during a period from April to November, 1961. 1, number of specimens collected in two species in April. 2, that of in May. 3, that of in June. 4, that of in July. 5, that of in August. 6, that of in September. 7, that of in October. 8, that of in November. Fig. 37, showing that of *D. subtilis* and *D. immigrans*. Fig. 38, showing that of *D. angularis* and *D. immigrans*.

A-type as displayed by *D. bizonata* and *D. angularis*; B-type as displayed by *D. lutea*; C-type as displayed by *D. subtilis*; and D-type as displayed by *D. immigrans*.

Statistical analysese of seasonal changes of population structure

Populations observed on Mt. Dakesan in each month during from April to November, 1961, were compared on the similarity of structure, with the use of the method of correlation coefficients.

Data presented in Tables 11 and 12 indicate that the structure of April population shows a correlation to those of populations of August (+0.612), September (+0.706), October (+0.846) and November (+0.844). The structure of May population seems to be correlated to the structure of populations of June (+0.939), September (+0.538) and October (0.597). The population structure of June was found to be correlated to the population structures of August (+0.811), September (+0.612) and October (+0.607). The structure of June population shows a correlation to the population structures of August (+0.771) and November (+0.601). The structure of August population displayed a correlation to the population structures of April (+0.612), June (+0.811), July (+0.711), September (+0.630) and October (+0.608). The structure of September population shows a correlation to the population structures of April (+0.706), May (+0.538), June (+0.612), August (+0.630), October (+0.694) and November (+0.519). The structure of October population shows a correlation to the population structures of April (+0.846), May (+0.597), June (+0.607), August (+0.608),

September (+0.694) and November (+0.878). The structure of November population displayed a correlation to the population structures of April (+0.844), July (+0.601), September (+0.519) and November (+0.878).

In virtue of the results obtained above and of the similarity in correlation coefficient series as shown in Figure 40, it seems very apparent that the population in each month was divided into the following five types; type-1 covering over-winter period (from November throguh April), type-2 covering the first active period (from May through June), type-3 presented by the pre-summer resting period (July), type-4 covering post-summer resting period (August) and type-5 which covers the second active period (from September through October).

Population of type-1 is represented dominantly by *D. bizonata* and *D. angularis*. There was collected no *Drosophila* during a period from December to early April in Matsue.

In the first active period, population increases in size and is represented by. *D. lutea*, *D. subtilis* and *D. auraria*.

In the pre-summer resting period, population decreases in size, being represented by *D. immigrans* and *D. rufa*.

In the post-summer resting period (August), population is of lower density than the former but species are numerous and large in number.

In the second active period, population is of high density again and it is dominated by *D. bizonata*, *D. lutea*, *D. subtilis* and *D. angularis*. Amongst them, species are numerous and large in number, showing a seasonal peak in this period.

Nozawa (1956) analysed population stucrure of *Drosophila* in Anjyo City and divided into the following four phases: the hibernating phase (early November through early May); the first active phase (early May throguh early August); the summer resting phase (early August through late August); and the second active phase (late August through early November). He reported that population of hibernating phase was of low density monopolised by *D. curviceps*, that of the first active phase was of high density which was dominated by *D. lutea*,

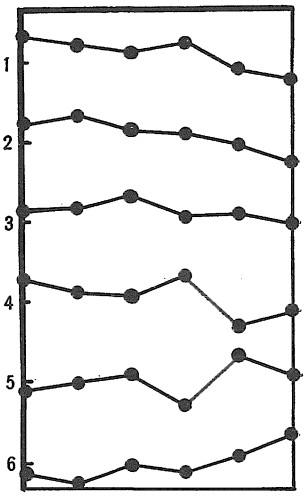


Fig. 39. Graph showing correlation coefficients on seasonal activity of abundant species of *Drosophila* observed on Mt. Dakesan, in each month from April to November, 1961. 1, *D. bizonata*. 2, *D. lutea*. 3, *D. subtilis*. 4, *D. angularis*. 5, *D. immigrans*. 6, *D. rufa*.

Table 11. Correlation coefficients on population structure in each month observed on Mt. Dakesan, ranging from April to November in 1961

	April	May	June	July	August	September	October
May	+0.549						
June	+0.561	+0.939					
July	+0.208	+0.540	+0.669				
August	+0.612	+0.389	+0.811	+0.771			
September	+0.706	+0.538	+0.612	+0.187	+0.630		
October	+0.846	+0.597	+0.607	+0.314	+0.608	+0.694	
November	+0.844	+0.416	+0.351	+0.601	+0.477	+0.519	+0.878

and *D. immigrans* with mixture of *D. auraria*, that of the summer resting phase was of low density and dominated by *D. auraria* in the morning and in the evening, and by *D. coracina* in the daytime, and that of the second phase was of high density consisting of many species, the dominant species being *D. melanogaster*, *D. lutea*, *D. auraria* and *D. bizonata.*

In comparison with those of Nozawa, the data presented in this observation are in agreement with his data, except those in summer time. This difference may be attributable by difference of locality where collections were carried out.

Table 12. Pattern and similarity of population structure in each month observed on Mt. Dakesan, from April to November in 1961

Pattern	Month	April	May	June	July	August	September	October	November
I	November	+	−	−	+	−	+	+	+
	April	+	−	−	−	+	+	+	+
II	May	−	+	+	−	−	+	+	−
	June	−	+	+	−	+	+	+	−
III	July	−	−	−	+	+	−	−	+
IV	August	+	−	+	+	+	+	+	+
V	September	+	+	+	−	+	+	+	+
	October	+	+	+	−	+	+	+	+

Statistical analyses of the vertical variation of population structure

As noted previously, three stations were set up vertically on Mt. Dakesan at 100m intervals.

Correlation between distribution and altitudes was studied in several species of *Drosophila* by Takada (1954, 1958), Kurokawa (1956), Heed (1957) and Wakahama (1962c). Further, Ohba (1956) and Paik (1958) assumed that seasonal activity and population structure of *Drosophila* are controlled by altitudinal difference.

Here, the author wishes to analyse seasonal and vertical variation of population structure according to the method of the least square.

As shown in Figures 41 to 48, the author described the frequency of each species collected in three stations according to their ranking. Population structure of each month showed uniformly an exponential curve. Based on the features as shown in Figures 41 to 48, and further the general concept that population fluctuation is expressed as functions for transition of season and variation of altitude, semi-logalithmic graphs were set up by the author on population structure in each station. Then he divided each population into four patterns following the formula of the least square: $X'_t = a.b^t$

(X'_t; trend value of seasonal fluctuation, t; rank of each species collected in each station, "a" and "b"; constants).

The value of the constants "a" and "b" were calculated by the following formula:

$$\log a = \frac{\Sigma 1 \log X_t}{n} \quad , \log b = \frac{\Sigma_t . \log X_t}{\Sigma t^2}$$

(n; numbers of species collected in each station)

In each graph, the trend lines indicate a negative direction and the value of constant "b" is expressed as a negative number.

Value of constants "a" and "b" are indictoars for the complexity of population and accompanied with the increase of "b" and the decrease of "a", population shows complexity on its structure. The value of "a" and "b" in each populction was shown in Table 13.

As indicated above, the value of each population, even though in the one and same month, are variable. But the difference in values of "a" and "b" of each population are too small to arrange them orderly on the complexity of each population. Then, a correlation graph was set up concerning values of two constants in each population as shown in Figure 49. Based on the temporary ordinate and abcissa which were placed at the central point between the highest and the least values of two constants, the population was divided into 4 zones (A, B, C, and D), and the axes were assumed as "a"=O, and "b"=O. Populations of A-zone show a relation of "a"$\leqslant$O and "b"$\geqslant$O, in values of the two constants, those of B-zone "a"$\geqslant$O and "b"$\geqslant$O, those of C-zone "a"$\leqslant$O and "b"$\geqslant$O and those of D-zone "a"$\geqslant$O and "b"$\geqslant$O. These relations seem to be significant to determine the complexity or simplicity of population structure. Populations of A-zone are most complex in structure and those of B-zone rank next A-zone. Populations of C-zone seem to be of simple ones, and those of D-zone are of the most simple structure.

Table 13. Value of constants "a" and "b" of the trend line on population structure in each month observed on Mt. Dakesan from April to November in 1961

Month		April	May	June	July	August	September	October	November
Station I	"a"	7.1	8.8	7.5	3.7	6.3	8.6	5.5	10.6
	"b"	−1.8	−1.2	−1.5	−1.2	−1.6	−1.4	−1.1	−1.2
Station II	"a"	3.8	8.1	13.1	6.7	5.6	9.9	5.7	9.3
	"b"	−1.4	−1.6	−1.6	−1.3	−1.5	−1.3	−1.0	−1.7
Station III	"a"	5.4	5.9	8.4	7.7	7.7	5.4	4.9	8.3
	"b"	−1.2	−1.6	−1.6	−1.4	−1.5	−1.3	−1.4	−1.3

Table 14. Classification on population structure in each month by the least square method

Month	April	May	June	July	August	September	October	November
Station I	C	B	C	A	C	B	A	B
Station II	A	C	D	A	C	B	A	D
Station III	A	C	C	A	C	A	A	A

In the light of the above results, it is evident that three populations in July and October, two populations in Stations II and III in April and one population in Sta. III in November are of A-zone. Population of Sta. I in May that of Sta. I in November and those of Stations I and II in September belong to B-zone. Populations of three stations in August, population of Sta. I in April, those of Stations II and III in May and those of Stations II and III in June are of C-zone. Population of Sta. II in June and that of Sta. II in November are of D-zone (Table 14).

Discussion

Miyadi *et al.* (1961) reported that there are two factors which concern to the complexity of population structure: one in that many species inhibit in the population and the other is that each species shows nearly an equal abundance in that population.

Although it may be premature to discuss population structure from the data obtained in this study, it seems to the author that the fisrt factor is less significant than the latter one for comp-

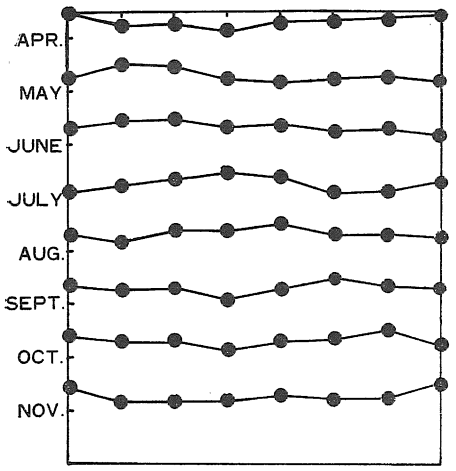


Fig. 40. Graphs showing correlation coefficients on population structure in each station of every month from April to November observed on Mt. Dakesan in 1961.

lexity of population. For instance, population of April shows a considerable compexity, regardless the exsistence of a low numner of species. Only 149 specimens representing 8 species were collected in this month as follows: *D. bizonata* (64 specimens), *D. subtilis* (32), *D. lutea* (28), *D. rufa* (7), *D. angularis* (3) and *D. melanogaster* and *A. variegata* (1).

Kato and Toriumi (1950) reported that the relation between the complexity of population and size of population based on "the geometrical series of Motomura", but it seems to the author that the size of population is not so significant for the complexity of population.

Based on the data derived from the present investigation, the author analyzed vertical and seasonal changes of population. In the opening of the collection season (April), only a few species appeared abundantly on the foot of the mountain and they cnstract a simple population, but in the midway and the summit, each species was nearly equal in number, so that the populations were complex in structure.

In the first active period, the population of the low land consisted species which were not met with previously, so that a comparatively complex population was resulted. On the other hand, populations of the midway and summit are dominated by the species which were abundant in the former period and they constract a simple population. These tendencies were observed in all populations in June.

In the pre-summer resting period, most species appeared with a low frequency, so that all populations were of complexity.

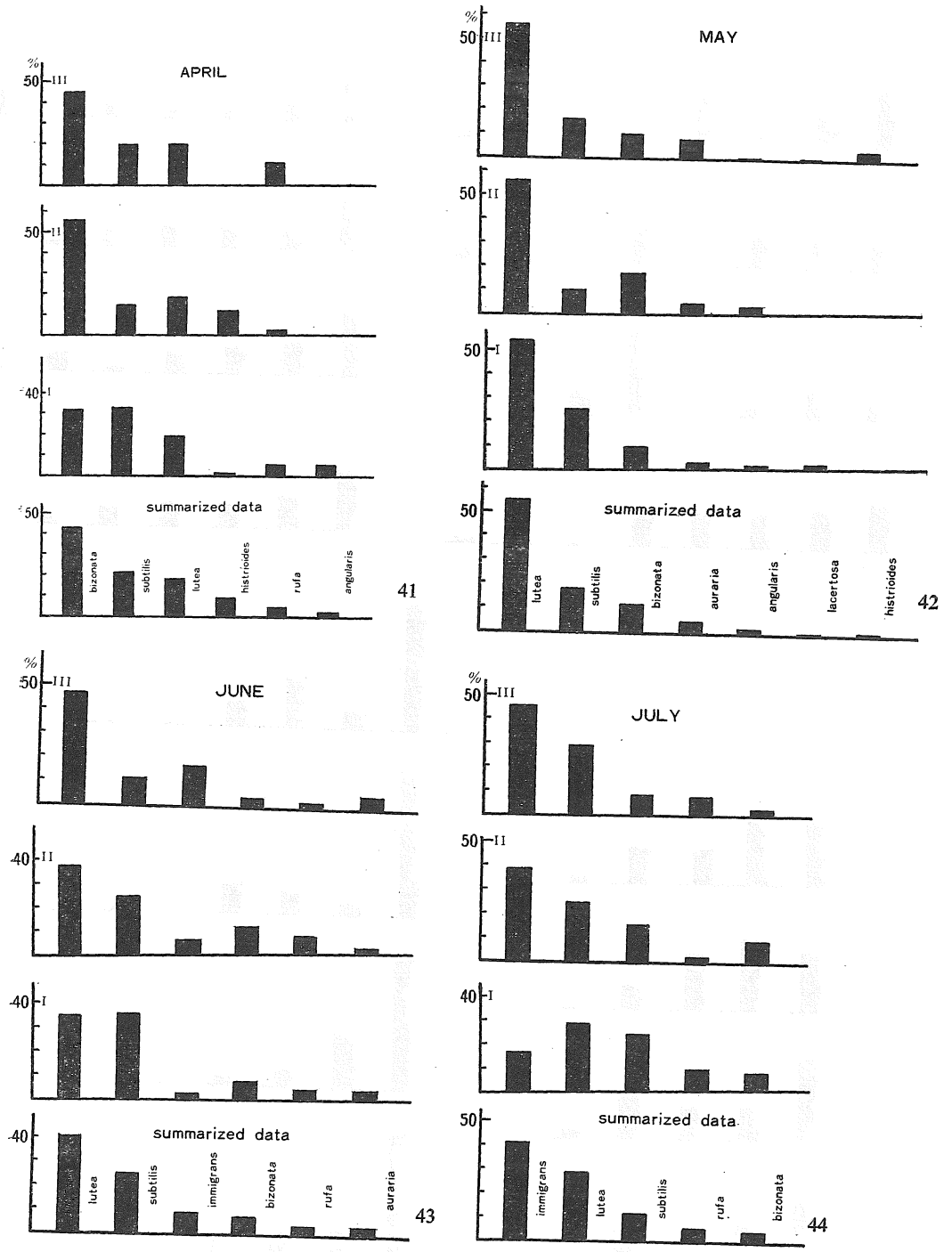
In the post-summer resting period, the population in the summit was simple, and there were observed abundant species represented by *D. immigrans* and *D. rufa* which show a summer-type in their seasonal activity.

In the second activity period, like as reported by Baseden (1955), an "autumn flash" of *Drosophila* species was observed: there were many species which appeared in nearly equal frequency. Then, all populations are complex in structure.

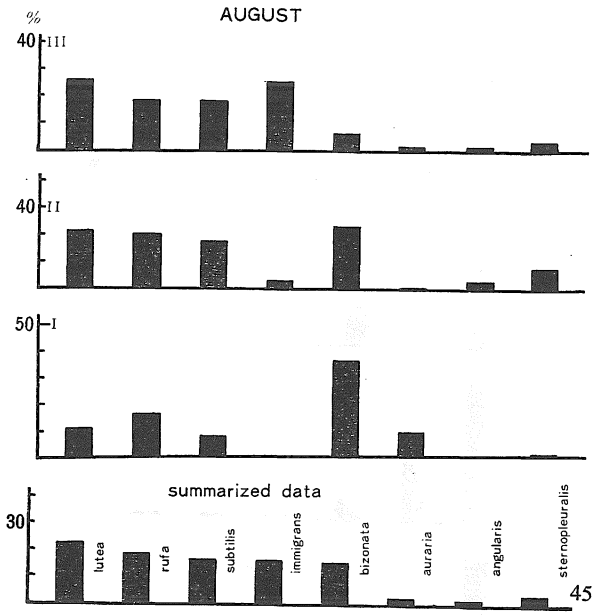
Following the transition of the season, the species forming the population of the summit enter hibernation, and therefore the population become complex in structure. In the midway, the low temperature species appeared abundantly, and therefore the population was simple in structure. On the other hand, the low land offers the better condition for flies than that of midway, so that, the population showed a comparatively complex feature.

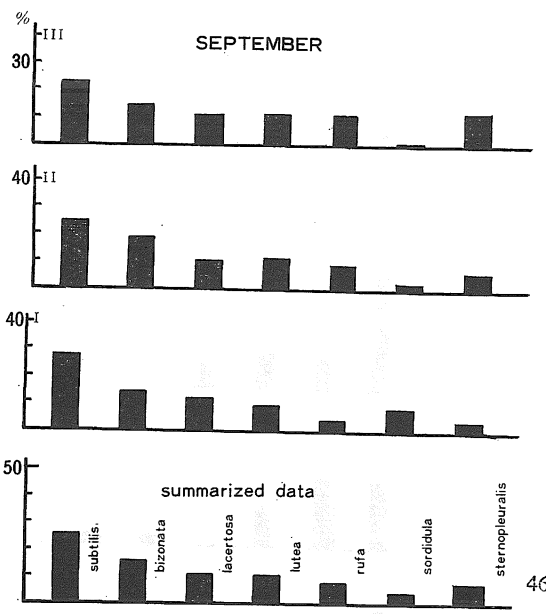
In Sta. I in April, only one species, *D. bizonata*, showed dominancy and in Stations II and III, all species appeared in a nearly equal number except *D. bizonata* (Fig. 41).

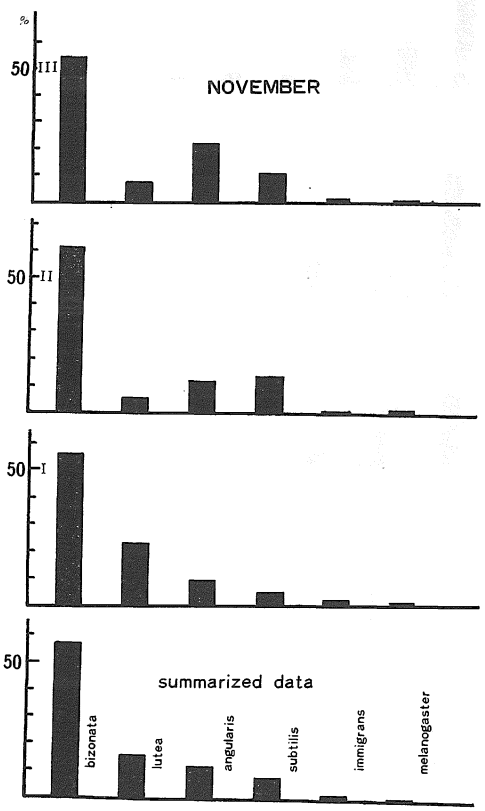
In May, among 13 species collected in Sta. I, only *D. lutea* and *D. subtilis* were abundant, but other occurred in similar frequency. Only *D. lutea* showed dominancy in Stations II and

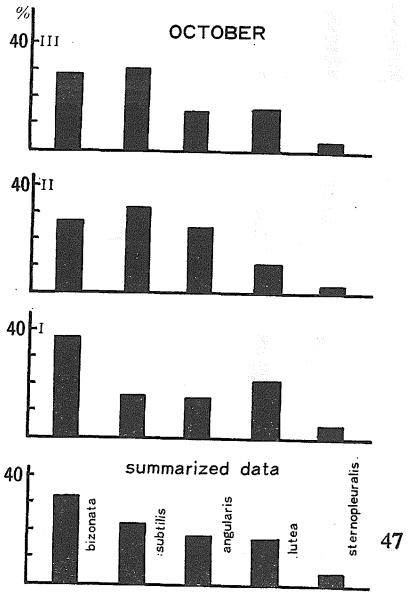


Figs. 41-44. Bar graphs showing monthly collection results in the three stations from April to November, 1961, observed on Mt. Dakesan. Lowest figures showing the summarized result in the three stations. I, Station I. II, Station II. III, Station III. Abscissa, species. Ordinates, frequencies of specimens collected in percentage. 41, April, 42, May. 43, June. 44, July.









Figs. 45-46. Bar graphs showing monthly collection results in the three stations from Apilr to November, 1961, observed on Mt. Dakesan. Lowest figures showing the summarized result in the three stations. I, Station I. II, Station II. III, Station III. Abscissa, species. Ordinates, frequencies of specimens collected in percentage. 45, August. 46, September. 47, October. 48, November.

Ⅲ. Eleven species were collected in Sta. Ⅱ and also the same number of species in Sta. Ⅲ (Fig. 43).

In June, only *D. lutea* and *D. subtilis* were abundance within 15 species collected in Sta. Ⅰ. *Drosophila lutea* and *D. subtilis* also were found in high frequency in Sta. Ⅱ, while *D. lutea* and *D. immigrans* showed a similar feature in Sta. Ⅲ (Fig. 44).

In three stations in June, two groups were divided on the basis of difference in number of specimens. Though there is a difference in number of specimens between two groups, the number of specimens is nearly the same in the one and the same group (Fig. 45).

In August, *D. bizonata* showed dominancy in appearance and other species were divided into two groups based on their number. In Sta. Ⅰ, the frequency of each species was similar with each other, so that the population was of the most complex among the populations of C-zone. In Sta. Ⅱ, *D. lutea* and *D. immigrans* were very abundant and there observed three groups which showed a considerable difference in number (Fig. 46).

In Sta. Ⅰ in September, *D. subtilis* was dominant in occurrence but other species appeared in a nearly equal number. In Sta. Ⅱ, there were observed three groups within 15 species collected in this station. Though a considerable difference was seen on the frequency of each group, they were similar in frequency in the one same group. In Sta. Ⅲ, *D. subtilis* showed a high frequency in occurrence and 7 species, such as *D. lutea, D. brachynephros, D. rufa, D. bizonata, D. sternopleuralis, D. virilis* and *D. lacertosa* appeared in a nearly equal number (Fig. 47).

In Sta. Ⅰ of October, there were 31 species. *Drosophila bizonata* dominated overwhelming majority. Following *D. bizonata, D. lutea, D. angularis* and *D. subtilis* appeared in a considerable high frequency with a similar number. In Sta. Ⅱ, three species, such as *D. bizonata, D. angularis* and *D. subtilis* showed high frequency in occurrence and *D. lutea* followed them. Other 9 species collected in this station appeared in similar frequency. In Sta. Ⅲ, 15 species were collected and divided into three groups by their number collected (Fig. 48).

In November, *D. bizonata, D. lutea* and *D. angularis* formed a predominant species. Other species appeared in a nearly equal number in Sta. Ⅰ, while only *D. bizonata* showed a high frequency in appearance which was more than a half of the total specimens collected in Sta. Ⅱ. In Sta. Ⅲ, as well as in Sta. Ⅱ, *D. bizonata* appeared in a large number. Other species occurred in a similar frequency (Fig. 49).

Summarizing the data obtained in the above statistical analyses, the conclusion is possible that population structure seems to be variable according to altitude, being considerably controlled by altitudinal difference as well as by seasonal diffaerence.

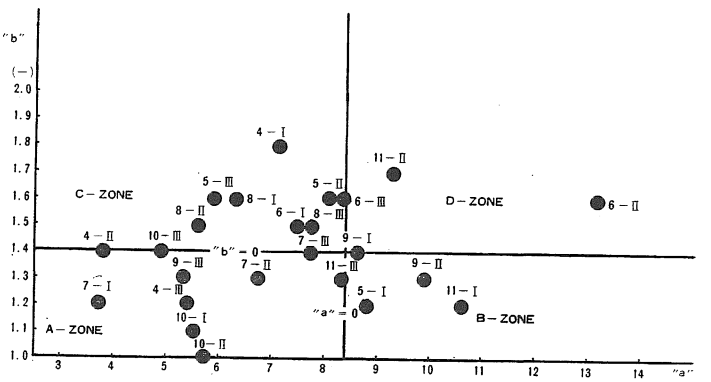


Fig. 49. Graph showing correlation values of constants "a" and "b" in each population indicated by the least square method.

Part III

On Chromosomal Polymorphism of *Drosophila nigromaculata* Observed in the University Botanical Garden

In view of the karyological importance in understanding of the mechamism of evolution in organisms, chromosomal polymorphism occurring in natural population has long attracted special attention of geneticists. Particularly, the salivary chromosomes of *Drosophila* has been subjects of repeated investigations by many authors in relation to chromosomal polymorphism (Dobzhansky and Sturtevant, 1938; Da Cunha, Burla and Dobzhansky, 1950; Dobzhansky, Burla and Da Cunha, 1950; Mainx and Smital, 1953; Dobzhansky and Pavlovsky, 1962; Brncic, 1962; etc.).

Previously, Midzuno (1952) dealt with some chromosomal inversions in *D. immigrans* and *D. nigromaculata* occurring in Hokkaido. Moriwaki and Kitagawa (1955) studied the salivary chromosomes of *D. bifasciata* collected in various localities of Japan, with special reference to chromosomal polymorphism. Toyofuku (1957, 1958a, b) investigated the chromosomal aberrations occurred in a certain drosophilid flies obtained from several localities of Hokkaido.

Drosophila nigromaculata is one of the common species in Hokkaido and its standard salivary chromosome map was established by Toyofuku (1960). Further, this species is remarkable as a species showing a striking chromosomal polymorphism in natural population. Toyofuku (1962) reported 22 different kinds of inversions in this species obtained from several localities of Hokkaido.

In the following, the author deals with further studies of chromosomal polymorphism in this species collected in the University Botanical Garden, during a period from late June to October, 1962.

Material and Methods

The material used in the present study consists of 285 female flies of *D. nigromaculata* which were obtained in the University Botanical Garden during a period from late June to October, 1962. The females which had been copulated in nature were transferred individually to laboratory culture bottles supplied with corn-meal-molasses-agar food to which a few drops of yeast-rich solution had been added. The cytological preparation was made according to the squash technique devised by Slizynsky (1952). Preparations were examined with a standard microscope under high power and oil immersion using a green filter. Camera-lucida drawings and photomicrographs were made of selected nuclei showing well spread arms of the salivary chromosomes. Types and sites of inversions were determined in comparison with the standard map presented by Toyofuku (1960).

Observations

Out of a total of 285 female flies collected for this study, 47 females laid eggs. The salivary chromosomes derived from 569 larvae consisted the subject of the present investigation (Table 15). There were among them only 3 larvae which showed non-inverted chromosomes. It is obvious from this feature that *D. nigromaculata* is a species showing a remarkable chromosomal polymorphism in natural population of Hokkaido. Therty-three different kinds of

Table 15. Heterozygous inversions of *Drosophila nigromaculata* observed in the University Botanical Garden, Sapporo in 1962

Date	No. of females produced eggs	No. of larvae examined	Type of inversions observed
June 29	3	52	X-c, B-b, C-g, C-h
July 3	3	66	X-c, A-a, A-b, C-g, D-a
July 4	9	89	X-b, X-c, X-e, X-f, A-c, A-g, B-e, C-c, C-d, C-g, D-a, D-c, D-d
July 5	7	92	X-b, X-c, B-e
July 18	5	68	X-b, X-c, X-d, B-d, C-f, D-a, D-c
July 23	4	30	A-a
Aug. 28	3	24	X-b, X-e, A-e, A-f, C-b, C-g, D-a. D-d
Aug. 29	2	30	X-e, A-h, B-b
Aug. 30	6	47	X-c, A-a, A-d. B-a, B-d, B-f, B-g, B-h, C-a, C-b, C-e, C-g, D-a
Aug. 31	4	46	X-e, A-c, A-e, A-f, B-b, C-c, C-d, C-e, D-a, B-d
Oct. 1	1	25	A-i, A-j
Total	47	569	33 kinds

chromosomal rearrangements, all ascertained as heterozygous inversions, were found in the present investigation. Their distribution on each chromosome was determined as follows: 5 different inversions on X chromosome, 10 in A chromosome, 7 in B chromosome, 8 in C chromosome and 3 in D chromosome. No inversion was found to occur in the dot-like E chromosome. Toyofuku (1962) reported 22 different kinds of inversions in this species obtained from several localities of Hokkaido. Compared the present data with those of Toyofuku, 14 inversions were newly observed in this study. Among them, 3 were found in X chromosome, 3 in A chromosome, 4 in B chromosome, 3 in C chromosome and 1 in D chromosome.

Newly found inversions in X chromosome: Toyofuku (1962) reported three different inversions, 'a', 'b' and 'c' inversion, in this chromosome. In the present study, 'b' and 'c' inversion were observed. In addtion, 3 different types of inversion as referred to as 'd', 'e' and 'f', were newly found.

Inversion 'd' is widely overlapped with inversion 'b', but does not include the characteristic segment of section 6 which has an inflated bulb-like swelling (Fig. 56). This inversion was found in a female larvae collected on the 18th, July.

Inversion 'e' is of sub-median type which is located between inversion 'b' and 'c' (Fig. 60). This inversion was found to occur in four females larvae collected on the 28th, 29th and 31st, August.

Inversion 'f' is of terminal type (Fig. 60). This inversion was found to occur a female larvae collected on the 4th, July.

Newly observed inversions on A chromosome: In this chromosome, 7 different kinds of inversion designated as 'a', 'b', 'c', 'd', 'e', 'f' and 'g' were reported by Toyofuku (1962). The present author found all of them, and in addition three new inversions as referred to as 'h', 'i' and 'j' in this study.

Inversion 'h' situates in the distal part of A chromosome and containes widely overlapped area with inversion 'g'. This is derived from a female collected on the 24th, August (Fig. 53).

Inversion 'i' includes a characteristic area in section 31. This was found in a female larvae

obtained on the lst, October (Fig. 57).

Inversion 'j' involves area of section 36 and observed together with inversion 'i' (Fig. 57).

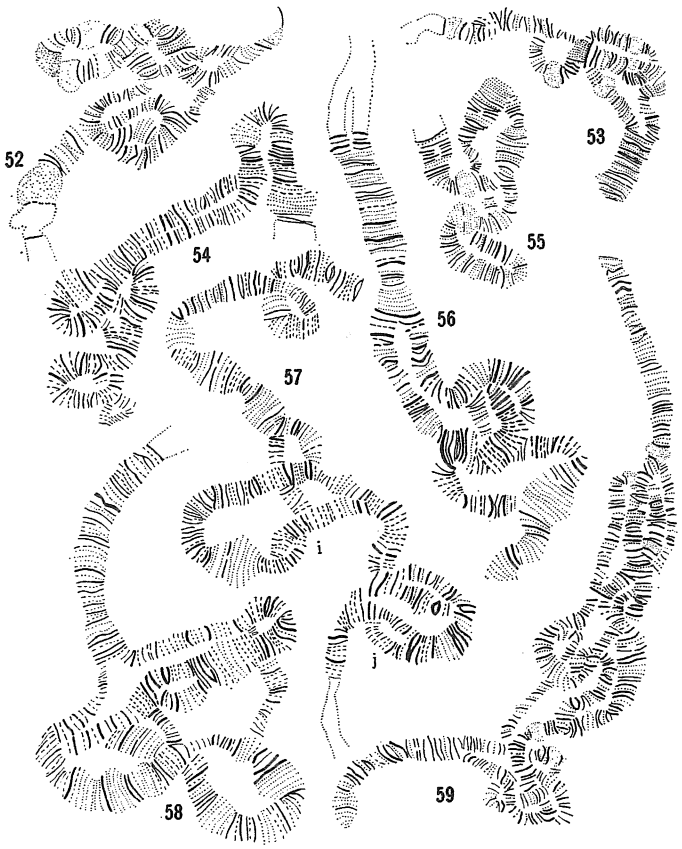
Newly found inversions on B chromosome: Four different types of inversions as referred to as 'a', 'b', 'c' and 'd' were observed by Toyofuku (1962). In the present observations, 'a', 'b' and 'd' and additional four types were found.

Inversion 'e' is a complex double-inversion which extends from section 57 to the chromocenter. This was derived from two females collected on the 4th and 5th, July (Fig. 63).

Inversion 'f' was a small-inversion involving area of section 46 and found in a female larvae obtained on the 30th, August (Fig. 61).

Inversion 'g' is also complex double-inversion extending from section 54 to the chromocenter. This was derived from a female secured on the 30th, August (Fig. 52).

Inversion 'h' is a long-inversion extending from the subteminal part to the sub-basal part of B chromosome, being of very complex construction. This was derived from a female collected on the 28th, August (Fig. 59).



Figs. 52-69. Showing chromosomal aberrations of *D. nigromaculata* found in the University Botanical Garden, Sapporo, during a period from late June to October, 1962. Fig. 52, showing inversion 'g' in B chromosome. Fig. 53, showing inversion 'h' in A chromosome. Fig. 54, showing inversion 'h' in C chromosome. Fig. 55, showing inversion 'd' in D chromosome. Fig. 56, showing inversion 'd' in X chromosome. Fig. 57, showing inversion 'i' and 'j' in A chromosome. Fig. 58, showing inversion 'g' in C chromosome. Fig. 59, showing inversion 'h' in B chromosome.

Newly observed inversions on C chromosome: Five different types, 'a', 'b', 'c', 'd' and 'e', were reported by Toyofuku (1962). In this study, 3 additional types was observed, together with the above five inversions.

Inversion 'f' is a small-inversion located at near section 68. This was derived from a female obtained on the 18th, July (Fig. 62).

Inversion 'g' is a complex triple-inversion extending from terminal part to the median area of C chromosome. This was derived from 4 females collected on the 28th and 29th, August (Fig. 58).

Inversion 'h' is a double-inversion located at near the chromocenter. This occurred in larvae derived from a female secured on the 29th, June (Fig. 54).

Newly found inversion in D

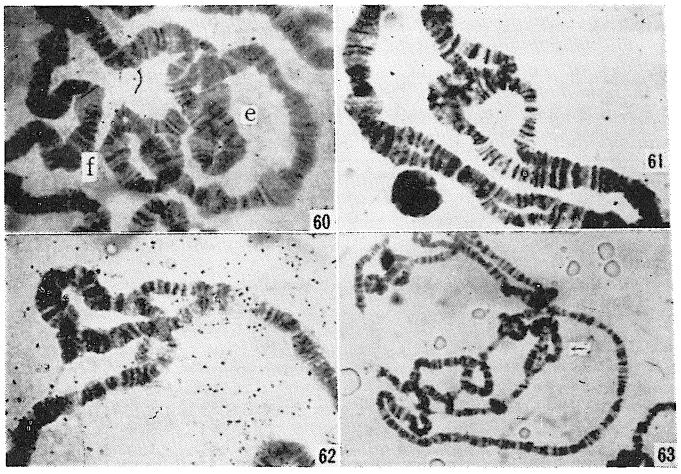
chromosome: In D chromosome, four types as designated as 'a', 'b', 'c' and 'd', were observed by Toyofuku (1962). In the present study, the author found one new inversion together with inversion 'a' and 'c'.

Inversion 'e' is a median-inversion which is overlapped partially with inversion 'a'. This inversion was found in 3 females collected on the 4th, July and 28th and 31st, August (Fig. 55).

Discussion

It has been discussed repeatedly by many authors that a considerable number of heterozygous inversions exsists in natural populations and these heterozygous inversions show a superiority over homozygous gene arrangement. There are two main hypotheses to explain the above phenomenom; the one is heterotic gene hypothesis and the other is the dominant adaptive gene hypothesis.

Although the issue between the two hypotheses has not yet been settled, Toyofuku (1962) explained this subject as follows: when a certain inversion associated with beneficial gene is established in a population, the next step, at least one of the next step, to attain a high degree of adaptation will be association with one more inversion which also involves some advantage genes. This next step may in most cases very seldom take place by a simple recombination mechanism, but when it does once, then the new gene block involving two inversions will increase in frequency; under certain conditions it may replace the pre-exsisting "original" single inversion, and even may replace the non-inverted "standard" gene sequence. When this new doubly inverted gene sequence is fixed in a population or species, it forms a new standard sequence.



Figs. 60-63. Showing chromosomal aberrations of *D. nigromaculata* found in the University Botanical Garden, Sapporo, during a period from late June to October, 1962. Fig. 60, showing inversion 'e' and 'f' in X chromosome. Fig. 61, showing inversion 'f' in B chromosome. Fig. 62, showing inversion 'f' in C chromosome. Fig. 63, showing inversion 'e' in B chromosome.

The author's view well agrees with her statements based on the following view points: 14 new types of inversions were found in *D. nigromaculata* which is one of the common species in Hokkaido, and most specimens showed highly chromosomal polymorphism with heterozygous inversions.

The chromosomal aberrations in natural populations of *D. willistoni* have heen analysed, and the following three types of inversions were reported by Da Cunha *et al.* (1950), and Dobzhansky (1954): 1) rare endemic inversion, 2) inversions restricted to a considerable part of the species area, and 3) widely distributed inversions. Brncic (1962) investigated the salivary chromosomes of *D.*

flavopilosa in Chile and reported as follows: quantitative data on the distribution of the inversions show that there is an altitudinal gradient in the frequencies of two of the four types inversions. Heterozygotes for *Inversion A*, are more frequent at high altitudes than at sea level. On the contrary, heterozygotes for *Inversion B*, are abundant at sea level, but practically disappears at high altitudes.

It seems probable from the data presented in this study that, though final conclusion should be premature, the type and frequency of inversion in natural populations may be variable seasonally.

Part IV

On Preference of Drosophild Flies to Some Kinds of Yeasts

The exsistence of isolating mechanisms is not the only necessary condition for the sympatric coexsistence of species. Besides being genetically isolated, sympatric species must be ecologically compatible (Mayr 1949). Gause (1934) clearly showed on the struggle for exsistence of organisms that when two or more sympatric species subsist on the same type of food, they cannot live together in the same region, if they exploit the same ecological niche in the same region.

Patterson (1943) made extensive collections of *Drosophila* in Texas and resulted in the accumulation of a great deal of ecological data pertaining to the species of this genus. Further based on the data collected by Patterson, Wagner (1944, 1949) pointed out a correlation exsisted between the fruiting season of *Opuntia* and the highest yearly populations of two species, *D. muelleri* and *D. aldrichi* common in Texas.

Furthermore, the work of Guyénot (1913), Baumbergei (1917, 1919) and Northrop (1917) demonstrated conclusively that *D. melanogaster* is dependent on the yeasts present in its food substrate when it is cultured in the laboratory. Since then, the relationship of drosophilid flies to different nutritional conditions, and the attractiveness of flies to different yeasts have been studied by Wagner (1944, 1949), Shehata and Mrak (1952), Dudgeon (1954), Dobzhansky and Da Cunha (1955), Suzuki (1955), Da Cunha *et al.* (1957), Robertson (1959) and Kaneko (1960). The present author has long been interested in ecological features of drosophilid flies attracted to different kinds of yeasts in relation to their oviposition. In the following, the author describes the results of some observations on different attractiveness of some kinds of yeasts to the oviposition of drosophilid flies in population cage; evidence presented seems to be essential for the analyses of the mechanism of attractive behavior of flies to fruit-baits found in the field.

Material and Methods

The kinds of yeasts used in this experiment were as follows: (A) *Candida pelliculosa*, (B) *Saccharomyces cervisiae* and (C) *Pichia membranaefaciens*. They have been cultured in the Applied Bacteriological Institute, Faculty of Agriculture, Hokkaido University. Two species, *D. auraria* (Oshoro strain) and *D. immigrans* (Sapporo strain), common in Hokkaido, provided the material for this experiment. They were collected in field and have been cultured from 1959 in the Zoological Institute, Faculty of Science, Hokkaido University, for several generations by random mating.

As shown in Figure 64, each experimental equipment consists of four population tubes which

are connected with vinyl-pipe with each other, except a central tube.

The three tubes except the central one contain cornmeal-mollasses-agar medium fermented with three different kinds of yeasts solution at bottom. The experiments were started, with 20 females and 20 males of *D. auraria* in one experimental set, and in the other with 10 females and 10 males of *D. immigrans:* the specimens are 2 to 3 days old after emergence. Media were placed for 24 hours in experimental tubes and changed daily for successive ten days. Eggs which were oviposited in each tube were counted on every day.

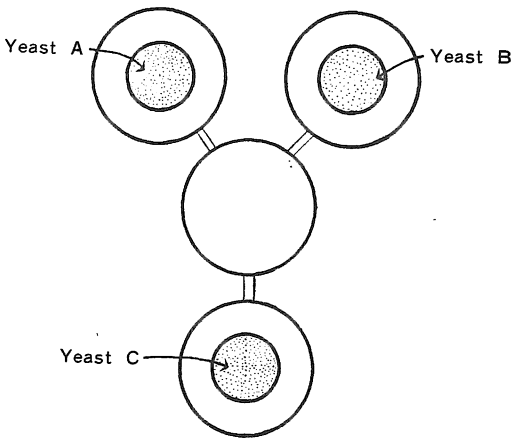


Fig. 64, showing experimental population-cages used in test on preference of drosophilid flies to some kinds of yeatts.

Results of Experiments

Preference of *Drosophila auraria* to three kinds of yeasts

Five experimental series were carried out in *D. auraria*, use being made of the following three kinds of yeasts: *Candida pelliculosa* (yeast A), *Saccharomyces cervisiae* (yeast B), and *Pichia membranaefaciens* (yeast C). The data are presented in Table 16.

As shown in Table 16, a total of 10663 eggs were obtained from 100 females, of which 5984 eggs were gathered in culture media containing yeast A, 3522 eggs in media involving yeast B and the remaining 1157 eggs in media fermented by yeast C. In the first experimental group, this species oviposited 699 eggs in yeast A, 456 eggs in yeast B and 377 eggs in yeast C. In the second group, this species laid 801 eggs in yeast A, 297 eggs in yeast B and 172 eggs in yeast C. In the third series, this species laid 1450 eggs in yeast A, 625 eggs in yeast B and 380 eggs in yeast C. In the forth, they oviposited 1210 eggs in yeast A, 604 eggs in yeast B and 385 eggs in yeast C. In the fifth, flies laid 1824 eggs in yeast A, 1540 eggs in yeast B and 143 eggs in yeast C.

As noted above, this species showed the most intensive preference to media containing yeast A as compared with other two kinds of media, yeasts B and C, in every experimental series. This species also laid a comparatively number of eggs in the culture media containing yeast B, with the weakest preference to culture media containing yeast C.

Preference of *Drosophila immigrans* to three kinds of yeasts

Seven experimental series were set up for *D. immigrans*, use being made of the same kinds of yeasts as for the above species. The results are summarized in Table 17.

As shown in Table 17, a total of 7531 eggs were obtained from 70 females, of which 3404 eggs were gathered in culture media containing yeast A, 3130 eggs in media involving yeast B and the rest of 1024 eggs in media fermented by yeast C.

In the first experimental group, this species deposited 517 eggs in media containing yeast A, 143 eggs in media involving yeast B and 282 eggs in media fermented by yeast C. In the second

series, they laid 84 eggs in yeast A, 441 eggs in yeast B and 198 eggs in yeast C. In the third series, this species oviposited 273 eggs in yeast A, 819 eggs in yeast B, and 275 eggs in yeast C.

Table 16. Number of eggs oviposited in each culture medium containing different kinds of yeasts in *Drosophila auraria*

Yeast	Experimental series	Days											
		1	2	3	4	5	6	7	8	9	10	11	Total
	I	0	7	36	78	86	43	164	83	192	10	—	699
	II	1	14	27	36	47	95	361	62	20	138	—	801
A	III	0	76	203	222	209	234	105	44	88	89	180	1450
	IV	0	20	50	55	156	278	239	162	47	70	133	1210
	V	0	0	0	34	87	470	336	397	211	172	117	1824
	Total	1	117	316	425	585	1120	1205	748	558	479	430	5984
	I	0	0	21	110	69	29	95	55	37	40	—	456
	II	0	1	62	89	50	58	2	24	0	11	—	297
B	III	0	20	31	32	42	128	59	133	36	63	81	625
	IV	22	51	112	47	86	207	0	74	2	0	3	604
	V	0	0	63	11	319	337	160	219	263	92	76	1540
	Total	22	72	289	289	566	759	316	505	338	206	160	3522
	I	0	0	1	25	31	10	228	64	13	5	—	377
	II	0	0	17	28	7	7	83	30	0	0	—	172
C	III	2	19	2	2	17	0	0	16	16	6	0	80
	IV	0	16	7	45	72	66	57	66	12	13	31	385
	V	0	0	0	0	6	120	0	0	17	0	0	143
	Total	2	35	27	100	133	203	368	176	58	24	31	1157

In the forth, 1106 eggs were found in the media containing yeast A, 679 eggs in yeast B and 72 eggs in yeast C. In the fifth series, flies laid 275 eggs in yeast A, 456 eggs in yeast B and 38 eggs in yeast C. In the sixth, 428 eggs were deposited in yeast A, 336 eggs in yeast B and 78 eggs in yeast C. In the seventh series, flies laid 719 eggs in media involving yeast A, 22 eggs in media containing yeast B and 81 eggs in media fermented by yeast C.

In the light of the results obtained in the present study, it is evident that *D. immigrans* showed an indefinite preference to the three kinds of yeasts used for experiment. However, this species displayed a stronger favor to yeasts A and B than yeast C, as understood by the number of eggs obtained in this experimental series.

Discussion

Delcourt and Guyénot (1910) were successful in growing aseptic *Drosophila* larvae with potatoes, water and dead bakers' yeast. Guyénot (1913) reported fourteen generations of these flies raising on living yeast and potatoes, dead yeast and potatoes, or on dead yeast alone. Loeb and Northrop (1916) raised twelve successive generations of aseptic *Drosophila* on bakers' yeast, water, and citric acid, while Northrop (1917) found that a mixture of banana and 33 per cent yeast was a more satisfactory medium than yeast alone. Baumberger (1919) observed that *Drosophila* larvae raised under sterile conditions would not grow on a medium of sugar, salts and ammonium tartrate, or on a banana infusion medium, but that non-sterile larvae

Table 17. Number of eggs oviposited in each culture medium containing different kinds of yeasts in *Drosophila immigrans*

Yeast	Experimental series	Days											
		1	2	3	4	5	6	7	8	9	10	11	Total
A	I	0	1	39	44	46	25	212	2	76	72	—	517
	II	2	12	17	7	0	4	44	0	0	0	—	86
	III	13	63	0	17	65	38	77	0	0	0	0	273
	IV	0	0	109	94	124	81	412	85	95	106	—	1106
	V	0	0	27	48	13	0	67	53	49	18	—	275
	VI	0	0	0	0	37	4	199	0	153	35	—	428
	VII	0	0	79	74	118	136	231	22	17	42	—	719
	Total	15	76	271	284	403	288	1242	162	390	273	0	3404
B	I	0	0	4	0	1	11	0	36	34	57	—	143
	II	0	37	38	122	110	68	1	22	43	0	—	441
	III	0	0	0	0	85	282	59	93	120	142	38	819
	IV	0	0	0	0	17	138	181	78	111	154	—	679
	V	0	0	71	0	0	27	216	49	43	50	—	456
	VI	0	0	0	0	24	65	102	11	111	23	—	336
	VII	0	3	91	79	0	0	12	44	0	0	—	229
	Total	0	40	204	201	237	591	571	333	462	426	38	3103
C	I	0	0	0	0	0	7	234	14	22	5	—	282
	II	0	39	24	3	17	19	21	11	47	17	—	198
	III	0	0	19	30	28	7	81	25	41	5	39	275
	IV	0	1	0	0	16	16	39	0	0	0	—	72
	V	0	0	0	0	38	0	0	0	0	0	—	38
	VI	0	14	21	1	0	39	3	0	0	0	—	78
	VII	0	0	0	12	33	35	0	0	1	0	—	81
	Total	0	54	64	46	132	123	378	50	111	27	39	1024

would grow on such media. He further observed that the non-sterile cultures almost always had *Saccharomyces* yeast present, and that the addition of live *Saccharomyces ellipsoides* to a fermented banana agar medium resulted in normal development of the aseptic larvae. Then, it becomes evident that yeast is an indispensable material for growth of *Drosophila*.

Following the observations by Patterson (1943) showing that the population peak of the mulleri-aldrich species complex of *Drosophila* was correlated with the ripening of fruits of the prickly pear, Wagner (1944) isolated eight types of yeasts from fruits of the genus *Opuntia* and sugar utilization tests. He found interesting species differences in nutritional requirements when *D. mulleir* and *D. aldrichi* were raised under sterile conditions on pure cultures of these yeasts. Dobzhansky and Epling (1944), by dissecting out the crops of *D. pseudoobscura* caught before they reached the banana bait of the collecting traps, demonstrated the great variety of yeast forms ingested under natural conditions. Da Cunha (1951) used eight species of yeasts isolated from the crops of *D. pseudoobscura* to test for nutritional effects on the adaptive value of two chromosomal inversion types of this species and found that two of these yeasts destroyed the heterosis usually displayed by the heterozygotes. Kaneko (1960) observed the preference or

attraction of drosophilid flies to five different kinds of yeasts in the Hokkaido University Botanical Garden. He reported that *D. auraria* and *D. nigromaculata*, the most common species in Hokkaido, showed no significant preference to the five yeasts used with the one exception of *Pichia membranaefaciens* (yeast C in the present study). Based on the findings mentioned above, it is probable that each species showed their own characteristic preference to different yeasts in both field and experimental cages.

In the present experiment, the frequency on oviposition of two species of drosophilid flies to three different yeasts was observed. It was found that *D. auraria* showed a significant preference to yeast A, while *D. immigrans* displayed a remarkable preference to yeasts A and B, laying a well corresponded number of eggs in the two kinds of culture media containing yeasts A and B. However, both species exhibited commonly unfavorable attitude to yeast C.

It seems probable that such a different preference of two species to different yeasts might be attributable to their own specific characters: *D. auraria* inhibits in the localities far from human habitations, while *D. immigrans* lives both areas near the human dwellings and wild populations. Further, yeast A is found abundantly in many kinds of fruits growing in the field, whereas yeast B grows in material cultured by man, like as beer, wine and so on.

Summary

The present studies have been undertaken in a hope to analyse ecological and genetical features of flies belong to the genus *Drosophila*, on the basis of material derived from research work, done in Hokkaido, the northern most island of Japan, and in San-In region, lying a south-western part of Japan, during a period from 1954 to 1962.

Data obtained are to be described in four parts separately in the present paper.

In Part I, the results of some ecological studies in drosophilid flies are described, regarding specially their geographical distribution in Hokkaido. Additionally, some accounts on the seasonal behavior of flies observed in the University Botanical Garden, Sapporo, and in some other localities of this island, during a period from 1954 to 1956 were reported in Part Ⅰ. Part Ⅱ deals with some ecological studies carried out in San-In region during five successive years ranging from 1957 to 1961, with special reference to their geographical distribution in that region, together with some supplementary data on seasonal behavior observed on Mt. Dakesan, near Matsue City, in 1961. Data derived from some statistical analyses regarding population structure of *Drosophila* are to be presented in Part Ⅱ. Part Ⅲ was devoted to the investigations of chromosomal polymorphism in *D. nigromaculata* based on the material collected in the University Botanical Garden, during a period from late June to October, 1962. The results may involve some important criteria for understanding of the evolutionary process of organisms in general. In Part Ⅳ are described some experimental results on the preference of two *Drosophila* species to some kinds of yeasts; evidence presented seems to be essential for the analyses of the mechanism of attractive behavior of flies to fruit-baits in the field.

Summaries are to be given separately in the following:

Part Ⅰ

Since 1949, extensive collections of the Drosophilidae have been undertaken in 64 localities of Hokkaido. Up to date 62 species representing 9 genera have been listed. Among them, *D.*

auraria and *D. nigromaculata* were known as the commonest species in Hokkaido.

The structure of the egg-guide of *Drosophila* (*Drosophila*) *raridentata* which was newly recorded from Japan was described.

The seasonal change of *Drosophila* was investigated in the University Botanical Garden, based on 6857 specimens collected in three successive years from 1954 to 1956 with the use of banana baits. The results of observations indicate that there are four types of seasonal activity: type-1 of unimodal activity (*D. auraria*, *D. immigrans* and *D. robusta* group spp.), type-2 of bimodal activity (*D. nigromaculata* and *D. barchynephros*), type-3 of non-modal activity (*D. lutea*, *D. histrioides* and *D. melanogaster*), and type-4 of variant activity (*D. testacea* and *D. bifasciata*).

Part II

Drosophila survey was done in San-In region since 1957 and up to date 50 species belonging to 10 genera have been obtained in 16 localities. A list of the Drosophilidae obtained in this region listed with their habitats. Among them, *D. lutea*, *D. bizonata*, *D. subtilis*, *D. immigrans*, *D. angularis* and *D. rufa* were known to be of the common species in this region.

In reference to the data presented by Okada (1956), the following 28 species are to be new to the *Drosophila* fauna of the Chugoku district: they are *Leucophenga ornatipennis*, *L. argentosa*, *L. magnipalpis*, *L. maculata*, *L. concilia*, *L. angusta*, *Microdrosophila*-like sp., *Mycodrosophila splendida*, *M. poecilogastra*, *Dettopsomyia argentifrons*, *Scaptomyza graminum*, *Drosophila alboralis*, *D. quadrivittata*, *D. sexvittata*, *D. histrioides*, *D. coracina*, *D. nipponica*, *D. angularis*, *D. nigromaculata*, *D. testacea*, *D. sternopleuralis*, *D. histrio*, *D. grandis*, *D. curviceps*, *D. pengi*, *D. sordidula*, and *D. daruma*.

The relation of altitude to the distribution of *Drosophila* species was investigated on Mt. Dakesan, near Matsue, in 1961. Three stations were vertically placed on this mountain at 100m intervals. A total of 42 species was collected on Mt. Dakesan. Among them 50 per cent or more was members in both high and low habitats.

Seasonal behavior of *Drosophila* was observed on Mt. Dakesan during a period from April through November, 1961.

On Mt. Dakesan, three stations were vertically placed at 100m intervals along the foot to its summit, and the relation of altitude to the seasonal activity of *Drosophila* species, monthly numerical variation of species and monthly variation of population structure were investigated in detail. The results are as follows:

Seasonal fluctuation for a total population size was shown by a bimodal curve in Stations I and II, with two seasonal peaks, one in June and the other in November in Sta. I and in October in Sta. II, while a monomodal (summer) curve was observed in Sta. III, showing a seasonal peak in July.

Drosophila bizonata and *D. angularis* were of a monomodal activity type in three stations, presenting a seasonal peak in autumn. While, *D. lutea* and *D. subtilis* displayed a bimodal activity in Stations I and II, with two seasonal peaks, one in spring and the other in autumn. However, the former showed a monomodal (spring) type and the latter indefinite type in Sta. III. *Drosophila immigrans* and *D. rufa* were abundant in number only in Sta. III and displayed a monomodal activity type, with a seasonal peak in summer.

The number of abudant species, their ranking and degree of abundance in each station were highly variable by month. The number of species collected was abundant in the foot and the midway of the mountain in spring and autumn seasons, while on the summit in summer.

Monthly variation on dispersion-frequency of each species was studied. It was shown that the species of *Drosophila* are abundant in number on foot and midway of Mt. Dakesan in spring and autumn seasons, while on the summit in summer time.

Based on the data obtained on Mt. Dakesan, some statistical analyses are undertaken on seasonal activity of some flies and monthly variation of population structure applying the correlation coefficient method and the least square method.

Seasonal activity of the followiug five abundant species, *D. bizonata*, *D. lutea*, *D. subtilis*, *D. angularis* and *D. immigrans* was divided into the following four types according to the correlation coefficient method: 1) bizonata-angularis type, 2) lutea type, 3) subtilis type, and 4) immigrans type.

The monthly variation of population structure of each month during a period from April to November was classified with respect to structural similarity, and divided into the following five patterns according to the least square and correlation coefficient methods: 1) the over-winter period (November through April), 2) the first active period (May through June), 3) the pre-summer resting period (July), 4) the post-summer resting period (August), and 5) the second active period (September through October).

Part III

Chromosomal polymorphism was investigated in *D. nigromaculata* obtained in the University Botanical Garden during a period from late June to October, 1962. *Drosophila nigromaculata* was known as a species showing remarkable chromosomal polymorphism in natural populations of Hokkaido. In reference to the standard salivary-chromosome map and inversions in this species presented by Toyofuku (1960, 1962), the present author has undertaken further observations, and found 33 inversions in heterozygous condition based on the examinations of 569 larvae derived from 47 females. The number of inversion types in each chromosome was as follows: 5 different inversions in X chromosome, 10 in A chromosome, 7 in B chromosome, 8 in C chromosome, and 3 in D chromosome.

Out of 33 inversions found by the author, 14 are additional ones to the report of Toyofuku (1962). Their distribution on the chromosomes is as follows: 3 in X chromosome, 3 in A chromosome, 4 in B chromosome, 3 in C chromosome and 1 in D chromosome.

It was shown by the present investigation that the frequency of each inversion seems to be variable by season in natural populations.

Part IV

Preference of two drosophilid species, *D. auraria* and *D. immigrans*, to three kinds of yeasts was investigated with the use of population cages, containing culture media fermented by three kinds of yeasts. Three species of yeasts used in the experiment were: *Candida pelliculosa* (yeast A), *Saccharomyces cerivsiae* (yeast B) and *Pichia membranaefaciens* (yeast C).

Five experimental series were set up for *D. auraria* with the use of 20 females and 20 males. Seven experimental series were set up for *D. immigrans* with the use of 10 males and 10

females. Eggs laid in culture media were counted on every day during for successive 10 days. In *D. auraria*, a total of 10663 eggs were obtained, of which 5984 eggs were gathered from culture meida containing yeast A, 3522 eggs in yeast B and 1157 eggs in yeast C. On the other hand, *D. immigrans* oviposited a total of 7531 eggs, of which 3404 eggs found in yeast A, 3130 eggs in yeast B and 1024 eggs in yeast C.

Based on the data obtained in the present study, the conclusion is possible that *D. auraria* showed the strongest preference to yeast A, while *D. immigra*ns displayed a similar preference to yeasts A and B. This difference may be due to the difference of their own characteristic preference.

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