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# THE DYNAMIC ASPECTS OF DROSOPHILA POPULATIONS IN SEMI-NATURAL AREAS

## I. ASSOCIATIONS AND RELATIVE NUMBERS OF SPECIES

## PART 1. RESULTS OF TRAPPING[1)2)]

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With a view toward analyzing the dynamic aspects of Drosophila population in a particular place, extensive collections were made at the University Botanical Gardens at Sapporo, starting in 1953. Between 1953 and 1962 many facts bearing on the distribution, ecology and cytogenetics of *Drosophila* were gathered, and a part of this data has been analyzed statistically. Preliminary reports have been made by the author and his collaborators in the series, *Drosophila Survey of Hokkaido* (numbers V, VII, XV, XVI and XVII), and in *Drosophila Information Service* (numbers 27-37). In the present article the author wishes to report the outcome of a study of the associations and relative numbers of species obtained over a period of ten years at several collecting stations in a semi-natural area.

## COLLECTING TECHNIQUES

Most of the collections of drosophilid flies dealt with in this article were made by exposing fermenting bananas and then capturing the flies which were attracted to this bait.

With two exceptions during the ten years, flies were trapped monthly from May to October. In 1953 bimonthly trapping was done in June, August and October. In 1955 trapping began in June rather than in May. Table 1 shows the collection dates for trapping during the course of this survey. Almost all collections were made with three traps of minced banana inoculated with baker's yeast (*Saccharomyces cervisiae*). The traps were placed in a shady location on the day preceding the days of collection. Collections were routinely carried out on three days near the end of each month. The traps were paper cups with a capacity of about 180 ml. These were arranged in a triangle at a distance of approximately two-meters, and they were suspended by strings

1) This paper is dedicated to Professor Sajiro Makino, Zoological Institute, Hokkaido University, Sapporo, in honor of his sixtieth birthday, June 21, 1966.

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from the branches of trees or shrubs. The flies were collected by covering these cups with a vinyl sack. The flies were then generally transferred to glass vials containing 60 percent alcohol and returned to the laboratory where they were identified by examining them with a binocular microscope. On each day of collection, flies were collected at one-hour intervals from sunrise to sunset, excepting in 1953, 1955 and 1959 (Table 1).

Table 1. Collection dates and times for trapping with the use of banana bait at the University Botanical Gardens in Sapporo, 1953 to 1962

| | | May | Jun | Jul | Aug | Sep | Oct | Nov |
|---|---|---|---|---|---|---|---|---|
| 1953 | Dates | | 25-27 | | 12,13 | | 29,30 | |
| | Times | | 4-9, 10.5, 12, 13.5, 15-19 | | 5-9, 10.5, 12, 13.5, 15-19 | | 6-9, 10.5, 12, 13.5, 15-17 | |
| 1954 | Dates | 21-23 | 25-27 | 20-22 | 19-21 | 28-30 | 19-21 | |
| | Times | 4-19 | 4-19 | 4-19 | 5-19 | 6-18 | 6-17 | |
| 1955 | Dates | | 28-30 | 25-27 | 26-28 | 20-22 | 19-21 | |
| | Times | | 5-7, 16-18 | 5-7, 17-19 | 6-8, 16-18 | 6-8, 15-17 | 9-11, 14-16 | |
| 1956 | Dates | 28-30 | 28-30 | 28-30 | 29-31 | 28-30 | 28-30 | |
| | Times | 4-19 | 4-19 | 4-19 | 5-19 | 6-18 | 6-17 | |
| 1957 | Dates | 29-31 | 27-29 | 29-31 | 23-25 | 26-28 | | 2,3,6 |
| | Times | 4-19 | 4-19 | 4-19 | 5-19 | 6-18 | | 6-17 |
| 1958 | Dates | 29-31 | 26-28 | 30- 1 (Aug) | 28-30 | 25-27 | 29-31 | |
| | Times | 4-19 | 4-19 | 4-19 | 5-19 | 6-18 | 6-17 | |
| 1959 | Dates | 14-16, 26-28 | 11-13, 25-27 | 11-13, 23-25 | 10-12, 28-30 | 10-12, 24-26 | 8-10, 22-24 | 5-7 |
| | Times | * | * | * | * | * | * | * |
| 1960 | Dates | 26-28 | 23-25 | 28-30 | 28-30 | 23-25 | 29-31 | |
| | Times | 4-19 | 4-19 | 4-19 | 5-19 | 6-18 | 6-17 | |
| 1961 | Dates | 27-29 | 25-27 | 22-24 | 24-26 | 28-30 | 28-30 | |
| | Times | 4-19 | 4-19 | 4-19 | 5-19 | 6-18 | 6-17 | |
| 1962 | Dates | 29-31 | 28-30 | 28-30 | 29-31 | 27-29 | 29-31 | |
| | Times | 4-19 | 4-19 | 4-19 | 5-19 | 6-18 | 6-17 | |

* Collections were made five times a day: the sunrise time, 2 or 3 hours after the sunrise, noon, 2 hours before the sunset, and the sunset time.

In 1959 five traps inoculated with different yeasts (*Saccharomyces cervisiae, S. rouxii, Candida pelliculosa, Hansenula anomala* and *Pichia membranaefaciens*) were set in each of the three major collecting sites in the Botanical Gardens. The intent was to determine the constitution of the Drosophila populations in relation to the different environments and to note the food preferences of the different species. Flies were collected for three successive days at approximately two-week intervals from May to November. Flies were collected five times each day of the collecting period, starting at sunrise and ending at sunset.

Starting in July of 1953 different baits were tested at one of the collecting sites in the Gardens. The effectiveness of tomato, loquat, strawberry and grape was tested in this way during the late summer and autumn of this year.

## COLLECTING AREAS

The semi-natural area chosen for this work was the University Bontanical Gardens of Hokkaido University (Fig. 1). These are located in the central part of Sapporo, a city of about 700,000, and a part of them dates back to 1878 when the Hokkaido Reclamation Bureau initiated a museum and experimental nursery there. At that time Hokkaido was wild land occupied by a small population of Ainu and a few Japanese colonists. The locality of Sapporo was quite uncivilized. In 1884 the museum and nursery were taken over by the University, and soon after this the extensive gardens were added as University Botanical Gardens. The greenhouse (2, Fig. 1) was built in 1886 and at present houses a large number of orchid plants. In 1937 a Rock Garden (1, Fig. 1) was constructed, and this was much enlarged in 1947. Now approximately 500 species of alpine plants are cultivated in it. A selection of species occupying 179 beds makes up the Medicinal Plant Garden (5, Fig. 1), and in 1952 a Shrub Garden (4, Fig. 1) of about 150 species was planted. At the present time the Gardens cover a gently undulating area of about 9 hectares. The most important trees of the Gardens are old elms, *Ulms propinqua,* the same species which covers a large portion of the lowlands of Hokkaido. The nature presserves of the Arboratum (6, Fig. 1) are characterized by a large community of *Aconitum* species. Maple (*Acer*), beech (*Fagus*), mountain ash (*Sorbus*), birch (*Betula*), alder (*Alnus*), oak (*Quercus*) and hazel (*Corylus*) are

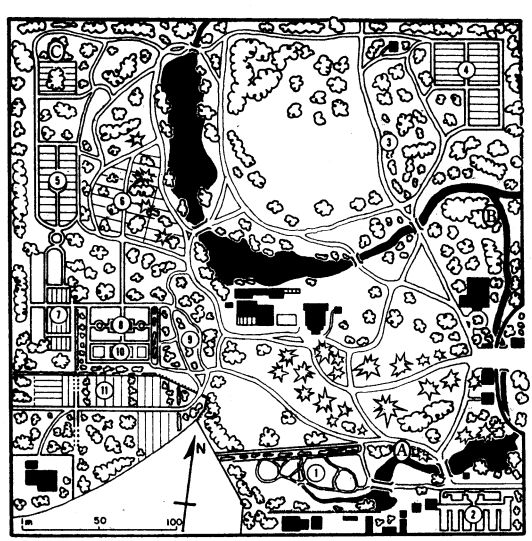


Fig. 1. Diagram of the University Botanical Gardens showing the three trapping sites. Site A is in the southeast part of the Gardens at the east end of the rock garden. Site B is in the eastern part of the Gardens near the water course (near the junction of the two streams at the far right of the figure). Site C is in the far northwest corner of the Gardens and rarely visited by the public. 1) rock garden. 2) greenhouse. 3) a row of a lilac trees. 4) shrub garden. 5) medical plant garden. 6) arboretum. 7) herbaceous garden. 8) flower garden. 9) nature reserves. 10) rose garden. 11) seeding beds.

also represented in the Arboratum. Beech are typically found in the southern part of Hokkaido, and the oak, *Quercus dentata,* is usually found along the coast of Hokkaido. Among the deciduous trees on Hokkaido, maple is the most familiar. Sakhalin spruces (*Picea Glehni* and *P. jezoensis*) and Sakhalin fir (*Abies sachaliensis*) are most characteristic of the evergreens. Yew trees (*Taxus cuspidata*) stand sparsely through the southern parts of the Gardens and grow well there. Other foreign spruces, firs and pines (*Picea excelsa, Pinus nigra, Pinus rigida,* etc.) also grow in this part of the Gar-

Table 2. Climatic data; mean monthly temperatures in °C (MT), relative humidities in percent (RH), and rainfalls in mm (RF) for Sapporo from 1953 to 1962

| Years | | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | All years |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Months | | | | | | | | | | | | |
| Jun | MT | −6.5 | −5.4 | −5.7 | −5.2 | −4.2 | −3.8 | −5.4 | −6.2 | −6.2 | −4.7 | −5.33 |
| | RH | 76.2 | 76.9 | 77.3 | 72.8 | 75.1 | 76.2 | 70.9 | 74 | 71 | 77 | 74.74 |
| | RF | 107.2 | 178.1 | 188.7 | 94.6 | 96.2 | 190.0 | 98.7 | 111.3 | 72.1 | 135.3 | 127.22 |
| Feb | MT | −6.2 | −3.1 | −3.8 | −4.5 | −5.2 | −2.4 | −1.9 | −3.3 | −4.1 | −5.8 | −4.03 |
| | RH | 71.6 | 74.9 | 73.0 | 69.8 | 74.3 | 77.5 | 71.6 | 72 | 74 | 70 | 72.87 |
| | RF | 70.7 | 83.1 | 122.3 | 40.3 | 74.5 | 145.0 | 62.9 | 62.3 | 108.5 | 68.4 | 83.80 |
| Mar | MT | 0.0 | −1.4 | −0.8 | −0.1 | −1.9 | −0.5 | 1.6 | −0.5 | −0.1 | −2.9 | −0.66 |
| | RH | 73.1 | 69.4 | 72.8 | 72.7 | 73.4 | 67.0 | 74.7 | 72 | 71 | 71 | 71.71 |
| | RF | 72.7 | 25.8 | 103.3 | 100.7 | 69.1 | 75.1 | 49.0 | 66.2 | 72.2 | 91.8 | 72.59 |
| Apr | MT | 5.5 | 6.7 | 5.9 | 6.3 | 6.5 | 5.8 | 8.4 | 5.2 | 7.3 | 4.9 | 6.25 |
| | RH | 71.2 | 65.4 | 63.7 | 59.4 | 65.6 | 64.0 | 65.5 | 69 | 65 | 64 | 65.28 |
| | RF | 56.0 | 42.9 | 68.2 | 93.6 | 50.6 | 31.4 | 140.7 | 121.8 | 30.4 | 69.9 | 70.55 |
| May | MT | 11.3 | 10.6 | 10.2 | 14.0 | 12.1 | 11.4 | 12.8 | 11.1 | 12.5 | 9.1 | 11.51 |
| | RH | 72.4 | 69.1 | 74.8 | 57.4 | 67.7 | 69.0 | 66.7 | 71 | 69 | 71 | 68.81 |
| | RF | 70.8 | 58.2 | 109.9 | 19.6 | 105.4 | 30.1 | 49.6 | 64.3 | 102.0 | 20.8 | 63.07 |
| Jun | MT | 15.5 | 13.8 | 16.2 | 14.9 | 14.0 | 15.9 | 15.7 | 15.1 | 17.5 | 12.8 | 15.14 |
| | RH | 76.6 | 72.5 | 77.5 | 81.1 | 77.9 | 75.8 | 75.8 | 79 | 73 | 74 | 76.32 |
| | RF | 74.2 | 44.3 | 67.1 | 133.7 | 56.6 | 60.1 | 46.3 | 88.5 | 32.8 | 55.8 | 65.94 |
| Jul | MT | 20.1 | 17.7 | 23.6 | 18.2 | 19.7 | 20.1 | 20.1 | 20.0 | 21.6 | 17.7 | 19.88 |
| | RH | 81.3 | 78.6 | 76.4 | 81.9 | 80.5 | 80.2 | 80.6 | 78 | 79 | 81 | 79.75 |
| | RF | 154.3 | 58.4 | 40.8 | 70.5 | 51.2 | 164.4 | 48.9 | 86.1 | 193.0 | 124.9 | 99.25 |
| Aug | MT | 20.2 | 20.6 | 22.3 | 19.1 | 21.6 | 20.7 | 21.3 | 23.0 | 21.7 | 18.2 | 20.87 |
| | RH | 77.9 | 84.8 | 80.8 | 83.0 | 82.5 | 80.1 | 77.6 | 75 | 81 | 82 | 80.47 |
| | RF | 124.0 | 143.3 | 190.1 | 226.2 | 122.8 | 112.0 | 87.8 | 63.3 | 98.5 | 357.4 | 152.54 |
| Sep | MT | 16.7 | 17.9 | 16.2 | 17.5 | 15.7 | 16.9 | 17.2 | 17.9 | 19.3 | 15.5 | 17.08 |
| | RH | 75.0 | 78.9 | 78.4 | 77.6 | 79.3 | 79.2 | 79.0 | 75 | 79 | 76 | 77.74 |
| | RF | 154.7 | 136.0 | 80.7 | 30.5 | 307.7 | 122.5 | 166.7 | 128.9 | 155.1 | 106.7 | 138.95 |
| Oct | MT | 10.2 | 9.3 | 10.7 | 11.8 | 10.8 | 10.3 | 11.2 | 10.1 | 10.8 | 6.5 | 10.17 |
| | RH | 76.4 | 72.7 | 80.0 | 74.4 | 76.3 | 75.2 | 74.2 | 73 | 69 | 69 | 74.02 |
| | RF | 112.2 | 94.9 | 209.9 | 114.3 | 134.4 | 109.5 | 70.2 | 95.7 | 93.9 | 18.9 | 105.39 |
| Nov | MT | 0.3 | 3.5 | 3.7 | 3.5 | 5.3 | 4.2 | 3.4 | 4.7 | 4.2 | 2.2 | 3.50 |
| | RH | 76.5 | 68.6 | 71.1 | 73.0 | 69.3 | 69.6 | 73.6 | 71 | 73 | 67 | 71.27 |
| | RF | 213.9 | 52.7 | 111.2 | 58.2 | 27.6 | 115.6 | 112.5 | 110.9 | 83.8 | 76.8 | 96.32 |
| Dec | MT | −1.8 | −0.7 | 0.0 | −3.8 | −0.1 | 0.0 | −2.3 | −2.9 | −1.1 | −2.0 | −1.47 |
| | RH | 72.6 | 72.5 | 70.1 | 77.6 | 75.6 | 73.5 | 73.3 | 70 | 74 | 71 | 73.02 |
| | RF | 129.9 | 137.8 | 59.9 | 157.7 | 146.1 | 110.3 | 119.9 | 70.2 | 52.5 | 100.6 | 108.49 |
| Year | MT | 7.1 | 7.5 | 8.2 | 7.6 | 7.9 | 8.2 | 8.5 | 7.9 | 8.6 | 6.0 | 7.75 |
| | RH | 73.7 | 73.7 | 74.7 | 73.4 | 74.8 | 73.9 | 73.6 | 73.3 | 73.2 | 72.8 | 73.68 |
| | RF | 111.7 | 88.0 | 112.7 | 95.0 | 103.5 | 105.5 | 87.8 | 89.1 | 91.2 | 102.3 | 98.68 |
| May–Oct | MT | 15.7 | 15.0 | 16.5 | 15.9 | 15.7 | 15.9 | 16.4 | 16.2 | 17.3 | 13.3 | 15.79 |
| | RH | 76.6 | 75.3 | 78.0 | 75.9 | 77.4 | 76.6 | 75.7 | 75.2 | 75.0 | 75.5 | 76.19 |
| | RF | 115.0 | 89.2 | 116.4 | 99.1 | 129.7 | 99.8 | 78.3 | 87.8 | 112.6 | 114.1 | 104.14 |

dens, but they are often damaged by smog.

A small, spring-fed water reservoir extends through the southern part of the Gardens, and it is connceted by a winding, narrow stream to the north reservoir and the marsh. As a result of a recent drop in the ground water level, the north reservoir is now dry. The banks of the south reservoir are planted with willows, poplars, alders and other moisture-loving plants (*Primula, Petasites, Caltha, Lysichiton* and *Hosta*). The marsh, situated between the north lawn and the woods, was originally a part of a shallow stream. Its slopes are dominated by alders (*Alnus japonica*), and the marshy soil is planted with *Iris, Hemerocallis* and sedges of various kinds. Fruits, such as mulberries and wild grapes, as well as chestnuts and walnuts, are abundant in season, and many kinds of fungi appear in the Gardens from June to October.

The University Botanical Gardens are located at a mean elevation of 18 meters above sea level. The climate is moderate during collecting season from May to October, with an average temperature of 15.8°C. The rainfall of August and September was usually high, and September in 1957 and August in 1962 had exceptionally high precipitation showing 307.7 mm and 357.4 mm respectively. The winter is long, and there is abundant snow from December through March. The climatic data is shown in Table 2, and the mean monthly temperatures and relative humidities for the ten years are shown in Fig. 2.

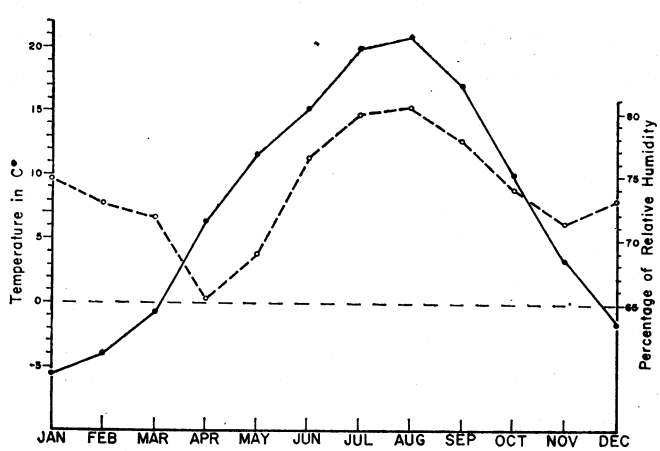


Fig. 2. Graph showing the monthly mean temperature and mean relative humidity for the ten years from 1953 to 1962 at Sapporo. Solid line indicates temperature. Dash line indicates relative humidity.

The trapping sites (A, B and C, Fig. 1) were selected within the Gardens in 1959. They were chosen to have different environments so that the constitutions of the *Drosophila* populations in each area could be compared. The choice of sites was based on the different microclimates and the flora of the habitat. The first of these, site A, was

the standard collection site during the entire period (1953–1962) of the survey. A brief description of these sites is as follows.

*Site A:* Three traps suspended from the branches of a yew tree, *Taxus cuspidata,* so that they were about one foot above the ground. The yew tree is about 13 feet high and is surrounded by other yew trees, pine trees, azalea, fern, raspberry, sedges and alpine plants.

*Site B:* Three traps suspended from the branches of shrubs. The surface of the ground is wet and covered with shrubs, grasses and other plants. Maple, beech, fir, oak and white birch provide cover, while smartweed (*Polygonum Thunbergii*), wild burdock (*Phytolacca esculanta*) and sedges predominate at the lower levels. Many different kinds of fungi (*Amillaria mellea, Coprinus micaceus, C. atramentarius, Pleurotus ostreatus, Pl. cornucopioides, Favolus squamosus, Polyporus varius)* grow in this area from June to October.

*Site C:* Three traps suspended from shrubs. This is the driest and most open of the three collecting sites. The shrubby growth is sparse. It is made up primarily of maple, beech, oak and wild grape. The grasses are *Urtica Thunbergiana, Heracleum lanatum, Osmorhiza aristata, Rumex Acetosa* and *Cardiocrinum cordatum.*

## RESULTS AND DISCUSSION

*General Features of the Collections*: During this survey a total of 46,619 individuals in forty-three species was collected by trapping in the Botanical Gardens. The collection data is summarized in Table 3. These forty-three species make up 61 percent of all species of drosophilids recorded from Hokkaido (Momma unpublished data) and 41 percent of all species recorded from Japan (Okada 1956). The majority (34) of the species represented in these collections belong to the genus *Drosophila,* and the remainder (9 species) belong to five other genera in the family *Drosophilidae.*

Some of the species listed in Table 3 were reported previously under different names. These are as follows: *Parascaptomyza pallida* as *Scaptomyza disticha* (Momma 1957); *Drosophila brachynephros* as *Drosophila transversa* type A (Wakahama 1956) or type 1 (Okada 1955); and *Drosophila unispina* as Drosophila transversa type C (Wakahama 1956) or type III (Okada 1955). Several other species were listed as unknown or unnamed forms. These were: *Drosophila sexvittata,* which listed as *Drosophila (Hirtodrosophila)* species I or species II (Mizuno 1952); *Drosophila bifasciata* which was listed as *Drosophila (Sophophora)* species I (Mizuno 1952); and *Drosophila moriwakii* which was listed as *Drosophila (Drosophila)* species of the *robusta* group (Momma 1954).

It is known that fermenting banana is one of the best baits for luring a large number of different species to traps (Patterson 1943; Spencer 1950). In 1953 a small survey was made to test this aspect of *Drosophila* biology with Japanese species. The effectiveness of various fermenting fruits was tested from July to October, and the re-

Table 3. Collection records of Drosophilidae from the University Botanical Gardens. The collecting techniques are mentioned in the text

| | Trapping | | | | | | | | | | Total for trapping |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | |
| *Amiota variegata* | — | 3 | — | 1 | 5 | — | 1 | — | 2 | — | 12 |
| *Leucophenga magnipalpis* | — | 1 | — | — | — | 4 | — | — | — | 1 | 6 |
| *L. maculata* | — | 4 | — | — | — | — | 5 | 1 | — | — | 10 |
| *Mycodrosophila shikokuana* | — | — | — | — | — | — | 1 | — | — | — | 1 |
| *Parascaptomyza pallida* | — | 14 | — | 1 | 1 | 8 | 3 | 12 | 2 | 1 | 42 |
| *Scaptomyza apicalis* | — | — | 3 | — | — | 7 | 2 | — | — | — | 12 |
| *S. monticola* | — | — | — | — | — | 1 | — | — | — | 1 | 2 |
| *S. graminum* | — | 1 | — | — | — | — | — | — | — | — | 1 |
| *S. polygonia* | — | — | — | — | — | 5 | — | — | — | — | 5 |
| *Drosophila alboralis* | — | — | — | 1 | — | — | 1 | — | — | — | 2 |
| *D. sexvittata* | 1 | — | — | 2 | — | — | 2 | — | — | — | 5 |
| *D. trivittata* | — | — | — | — | — | — | 1 | — | — | — | 1 |
| *D. nokogiri* | — | — | — | 1 | — | — | — | — | — | — | 1 |
| *D. histrioides* | — | 3 | 6 | 169 | 32 | 19 | 48 | 8 | 37 | 72 | 394 |
| *D. busckii* | — | — | — | 2 | 1 | — | 5 | 1 | — | — | 9 |
| *D. coracina* | 12 | 1 | 4 | 27 | 11 | 3 | 27 | 2 | 33 | 3 | 123 |
| *D. bifasciata* | 36 | 21 | 94 | 306 | 151 | 6 | 253 | 39 | 75 | 116 | 1097 |
| *D. helvetica* | — | — | — | — | — | 2 | — | — | — | — | 2 |
| *D. suzukii* | — | 2 | 18 | 41 | 31 | 11 | 558 | 8 | 136 | 18 | 823 |
| *D. lutea* | 55 | 9 | 7 | 449 | 34 | 85 | 3223 | 28 | 100 | 180 | 4170 |
| *D. melanogaster* | — | 61 | — | 1 | — | 3 | 1 | 1 | 1 | — | 68 |
| *D. nipponica* | — | 13 | 1 | — | 2 | 8 | 2 | 2 | — | — | 28 |
| *D. magnipectinata* | 3 | 7 | — | — | — | 2 | — | — | 4 | — | 16 |
| *D. auraria* | 400 | 487 | 284 | 765 | 1770 | 755 | 9385 | 1013 | 2112 | 1094 | 18065 |
| *D. rufa* | 7 | — | — | — | — | — | 2 | — | — | — | 9 |
| *D. mommai* | — | — | — | — | — | — | — | — | 1 | — | 1 |
| *D. brachynephros* | 171 | 305 | 120 | 505 | 192 | 162 | 882 | 205 | 462 | 328 | 3332 |
| *D. unispina* | — | — | — | — | 27 | 9 | 97 | 5 | 41 | 29 | 208 |
| *D. nigromaculata* | 412 | 1209 | 196 | 846 | 503 | 682 | 5797 | 586 | 1109 | 554 | 11894 |
| *D. testacea* | 76 | 77 | 27 | 302 | 248 | 82 | 338 | 119 | 257 | 109 | 1635 |
| *D. histrio* | 11 | 8 | 1 | 12 | 2 | 3 | 30 | 1 | 6 | — | 74 |
| *D. funebris* | 1 | 2 | — | 2 | 1 | — | 26 | — | — | — | 32 |
| *D. multispina* | — | — | — | — | — | — | 1 | — | — | — | 1 |
| *D. immigrans* | 165 | 23 | 23 | 136 | 185 | 15 | 2460 | 25 | 78 | 193 | 3303 |
| *D. pengi* | — | 3 | — | — | 1 | — | — | — | — | — | 4 |
| *D. virilis* | — | 6 | — | 5 | 8 | 3 | 9 | 3 | 3 | 1 | 38 |
| *D. ezoana* | — | 3 | — | — | — | 1 | 9 | — | 2 | 3 | 18 |
| *D. darma* | — | — | — | — | 2 | — | 1 | — | — | — | 3 |
| *D. sordidula* | 8 | 4 | 5 | 30 | 18 | 9 | 98 | 12 | 15 | — | 199 |
| *D. lacertosa* | 10 | 28 | 10 | 154 | 48 | 40 | 359 | 73 | 103 | 125 | 950 |
| *D. moriwakii* | — | — | 1 | 1 | — | 1 | 3 | 2 | 2 | 1 | 11 |
| *D. okadai* | — | — | — | — | — | — | 1 | — | — | 1 | 2 |
| *D. hydei* | — | 10 | — | — | — | — | — | — | — | — | 10 |
| Total | 1368 | 2305 | 800 | 3759 | 3273 | 1926 | 23631 | 2146 | 4581 | 2830 | 46619 |
| No. of species | | | | | | | | | | | |
| *Amiota* | — | 1 | — | 1 | 1 | — | 1 | — | 1 | — | 1 |
| *Leucophenga* | — | 2 | — | — | — | 1 | 1 | 1 | — | 1 | 2 |
| *Mycodrosophila* | — | — | — | — | — | — | 1 | — | — | — | 1 |
| *Parascaptomyza* | — | 1 | — | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| *Scaptomyza* | — | 1 | 1 | — | — | 3 | 1 | — | — | 1 | 4 |
| *Drosophila* | 15 | 21 | 15 | 21 | 20 | 21 | 28 | 19 | 20 | 16 | 34 |
| Total | 15 | 26 | 16 | 23 | 22 | 26 | 33 | 21 | 22 | 19 | 43 |

Table 4. Collection of flies from baits of different fermenting fruits during 1953

| | July | | | | August | | | | September | | | October | | | Total for all collections |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tomato | Loquat | Straw-berry | Total | Tomato | Grape | Loquat | Total | Tomato | Grape | Total | Tomato | Wild-grape | Total | |
| *D. sexvittata* | — | — | — | — | — | — | — | — | — | — | — | — | 1 | 1 | 1 |
| *D. coracina* | — | — | — | — | 10 | 2 | — | 12 | — | — | — | — | — | — | 12 |
| *D. bifasciata* | 2 | — | — | 2 | 1 | 3 | — | 4 | — | — | — | — | — | — | 6 |
| *D. lutea* | 1 | 1 | — | 2 | — | — | — | — | 3 | 21 | 24 | — | 16 | 16 | 42 |
| *D. magnipectinata* | — | 1 | — | 1 | 1 | — | 1 | 2 | — | — | — | — | — | — | 3 |
| *D. auraria* | 12 | 18 | 5 | 35 | 11 | 10 | 6 | 27 | 18 | 6 | 24 | 2 | 1 | 3 | 89 |
| *D. brachynephros* | — | — | — | — | 12 | 7 | — | 19 | — | 2 | 2 | — | 1 | 1 | 22 |
| *D. nigromaculata* | 36 | 5 | 2 | 43 | 99 | 82 | 5 | 186 | 3 | — | 3 | 1 | — | 1 | 233 |
| *D. testacea* | — | — | — | — | 23 | 28 | — | 51 | — | — | — | — | — | — | 51 |
| *D. histrio* | — | — | — | — | 1 | 3 | — | 4 | — | — | — | — | — | — | 4 |
| *D. immigrans* | 1 | — | 1 | 2 | — | — | 2 | 2 | 33 | 30 | 63 | 25 | — | 25 | 92 |
| *D. sordidula* | — | — | 1 | 1 | — | — | — | — | — | — | — | — | — | — | 1 |
| *D. lacertosa* | — | — | — | — | 9 | 1 | — | 10 | — | — | — | — | — | — | 10 |
| Total | 52 | 25 | 9 | 86 | 167 | 136 | 14 | 317 | 57 | 59 | 116 | 28 | 19 | 47 | 566 |

sults are recorded in Table 4. It was found that, of the fruits tested, tomato and grape were the most attractive. However, banana was still superior to these fruits as bait, and it is also more practical to obtain during all seasons. Fermenting banana was therefore used as the bait during the remainder of the survey.

*Constituents:* A very large population sample was obtained by trapping at site A during the ten years of this survey. In addition, many flies were obtained from site B and C in 1959.

Some species were much more plentyful in the collection than others. The highest numbers of individuals (17,976) was for *D. auraria,* while six species, representing three genera, were present only as single individuals. *Drosophila auraria* constitutes 39.03 percent of the population of Drosophilidae sampled by trapping in the Gardens, showing the highest frequency in 1957 and the lowest one in 1956, as is shown in Table 5. The

Table 5. Percentage frequencies of abundance of the thirteen leading dominant species of *Drosophila* during the period of the survey, as sampled by trapping with the use of banana bait

| | 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *auraria* | 38.78 | 21.13 | 35.50 | 20.35 | 54.08 | 39.20 | 39.71 | 47.20 | 46.10 | 38.66 | 39.03 |
| *nigromaculata* | 22.32 | 52.45 | 24.50 | 22.51 | 15.37 | 35.41 | 24.53 | 27.31 | 24.21 | 19.58 | 25.32 |
| *lutea* | 1.62 | 0.39 | 0.88 | 11.94 | 1.04 | 4.41 | 13.64 | 1.30 | 2.18 | 6.36 | 8.96 |
| *brachynephros* | 18.58 | 13.23 | 15.00 | 13.43 | 5.87 | 8.41 | 3.73 | 9.55 | 10.09 | 11.59 | 7.19 |
| *immigrans* | 9.10 | 1.00 | 2.88 | 3.62 | 5.65 | 0.78 | 10.41 | 1.16 | 1.70 | 6.82 | 6.97 |
| *testacea* | 3.12 | 3.34 | 3.38 | 8.03 | 7.58 | 4.26 | 1.43 | 5.55 | 5.59 | 3.85 | 3.44 |
| *bifasciata* | 3.74 | 0.91 | 11.75 | 8.14 | 4.61 | 0.31 | 1.07 | 1.82 | 1.64 | 4.10 | 2.37 |
| *lacertosa* | 0 | 1.21 | 1.25 | 4.10 | 1.47 | 2.08 | 1.52 | 3.40 | 2.25 | 4.42 | 2.04 |
| *suzukii* | 0 | 0.13 | 0.25 | 1.09 | 0.95 | 0.57 | 2.36 | 0.37 | 2.97 | 0.64 | 1.79 |
| *histrioides* | 0 | 0.08 | 0.38 | 4.50 | 0.98 | 0.99 | 0.20 | 0.37 | 0.81 | 2.54 | 0.86 |
| *unispina* | 0 | 0 | 0 | 0 | 0.82 | 0.47 | 0.41 | 0.23 | 0.90 | 1.02 | 0.45 |
| *sordidula* | 0.87 | 0.17 | 0.63 | 0.80 | 0.55 | 0.47 | 0.41 | 0.56 | 0.33 | 0 | 0.43 |
| *coracina* | 0 | 0.04 | 0.50 | 0.72 | 0.34 | 0.16 | 0.11 | 0.09 | 0.72 | 0.11 | 0.24 |

frequency shown by this species in year's sample was usually the highest in the drosophilid population excepting in 1954 and in 1956, when the highest frequencies were occupied by *D. nigromaculata*. There are three races of *D. auraria*, and race A comprised over 90 per cent of the *auraria* in the population samples. The next highest number of individuals was for *D. nigromaculata* with a total of 11,661, or 25.32 percent of the eintire sample, showing the highest frequency in 1954 and the lowest one in 1957. These two species, *auraria* and *nigromaculata*, made up 64.35 percent of the collection, and they are also found as the most common species in many places of Hokkaido. They correspond to the "abundant" species of Mather (1956). Mather's "common" species are represented in these collections by seven forms: *D. lutea*, with a total of 4,128; *D. brachynephros*, with 3,310; *D. immigrans*, with 3,211; *D. testacea*, with 1,584; *D. bifasciata*, with 1,091; *D. lacertosa* with 940; and *D. suzukii*, with 823. These seven species made up 32.76 percent of the trapping sample from the Gardens, though each of these showed considerable variations of frequencies from year to year as indicated in Table 5. Of these, *D. lutea* is abundant in the southern part of Hokkaido but rare in the northern part. Population level of this species in the Gardens was usually low with frequency of one or two percent of the year's sample. However, considerable high frequencies suddenly appeared in 1956 with 11.94 percent and in 1959 with 13.64 percent. *Drosophila brachynephros* is frequently found in domestic habitats throughout Hokkaido. This species showed usually the frequency near or over ten percent of the year's sample in the Gardens, excepting in 1957 and in 1959. *Drosophila immigrans* is associated with human habitations and is common in southern Hokkaido. In this Gardens, comparatively high level of *immigrans* population was found in 1953 and 1959 and low level in 1954, 1958, 1960 and 1961. Of the remaining four species, *D. testacea* and *D. bifasciata* are very common in northern Hokkaido as wild species, especially at high altitudes. In the Gardens, relatively high frequencies were found in 1956 and 1957 in the former species, and in 1955 and 1956 in the latter species. Considerably low frequencies occurred in 1959 in the former; and in 1954, 1958, 1959, 1960 and 1961 in the latter. *Drosophila lacertosa* is widely distributed with many specimens as a wild form in wooded lowlands of Hokkaido. This species was not obtained in 1953, and comparatively high frequencies were observed in 1956, 1960 and 1962. *Drosophila suzukii* is common in the southern part of the island. This species was also not collected in 1953 in the Gardens. Relatively high frequencies occurred in 1959 and 1961.

The remaining 34 species make up only 2.89 percent of the sample of *Drosophilidae*. These are "rare" species of Mather, each comprising less than one percent of the sample. Among these less common species, the highest number of trapped flies is that for *D. histrioides*, with a total of 394 individuals, of which near the half was caught in 1956. Still, this constitutes only 0.86 percent of the sample. Three species showed relatively high numbers of individuals among the "rare" species. *Drosophila unispina* captured since 1957, was represented by 208. *Drosophila sordidula* was represented by 199 of

Table 6. Collections at three different sites during 1959

| Sites | A | | | B | | | C | | | Aa* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of flies | PA** | PF** | No. of flies | PA** | PF** | No. of flies | PA** | PF** | No. of flies | PA** | PF** |
| *D. auraria* | 3305 | 42.80 | 47.47 | 3125 | 40.23 | 47.49 | 2955 | 36.29 | 37.75 | 790 | 52.18 | 50.38 |
| *D. nigromaculata* | 1740 | 22.53 | 39.02 | 1918 | 24.69 | 41.24 | 2139 | 26.27 | 44.51 | 304 | 20.08 | 41.45 |
| *D. lutea* | 1112 | 14.40 | 50.09 | 938 | 12.08 | 44.56 | 1173 | 14.41 | 42.03 | 148 | 9.78 | 43.92 |
| *D. immigrans* | 524 | 6.79 | 39.89 | 819 | 10.54 | 42.00 | 1117 | 13.72 | 35.36 | 44 | 2.91 | 38.64 |
| *D. brachynephros* | 306 | 3.96 | 29.08 | 339 | 4.36 | 43.07 | 237 | 2.91 | 38.40 | 39 | 2.58 | 35.90 |
| *D. suzukii* | 228 | 2.95 | 42.11 | 159 | 2.05 | 46.54 | 171 | 2.10 | 34.50 | 60 | 3.96 | 26.67 |
| *D. lacertosa* | 139 | 1.80 | 36.69 | 171 | 2.20 | 38.60 | 49 | 0.60 | 44.90 | 46 | 3.04 | 50.00 |
| *D. testacea* | 132 | 1.71 | 52.27 | 77 | 0.99 | 68.83 | 129 | 1.58 | 48.84 | 34 | 2.25 | 67.65 |
| *D. bifasciata* | 102 | 1.32 | 42.16 | 85 | 1.09 | 58.82 | 66 | 0.81 | 42.42 | 27 | 1.78 | 29.63 |
| *D. sordidula* | 51 | 0.66 | 39.22 | 32 | 0.41 | 56.25 | 15 | 0.18 | — | 11 | 0.73 | — |
| *D. unispina* | 27 | 0.35 | 40.74 | 35 | 0.45 | 48.57 | 35 | 0.43 | 40.00 | 1 | 0.07 | — |
| *D. histrioides* | 14 | 0.18 | — | 20 | 0.26 | — | 14 | 0.17 | — | 4 | 0.26 | — |
| *D. histrio* | 9 | 0.12 | — | 10 | 0.13 | — | 11 | 0.14 | — | 1 | 0.07 | — |
| *D. coracina* | 0 | — | — | 13 | 0.17 | — | 14 | 0.17 | — | 0 | — | — |
| *D. funebris* | 12 | 0.16 | — | 8 | 0.10 | — | 6 | 0.07 | — | 1 | 0.07 | — |
| *D. virilis* | 5 | 0.06 | — | 3 | 0.05 | — | 1 | 0.01 | — | 1 | 0.07 | — |
| *D. ezoana* | 6 | 0.08 | — | 3 | 0.05 | — | 0 | — | — | 1 | 0.07 | — |
| *L. maculata* | 1 | 0.01 | — | 2 | 0.03 | — | 2 | 0.02 | — | 0 | — | — |
| *D. busckii* | 3 | 0.04 | — | 2 | 0.03 | — | 0 | — | — | 0 | — | — |
| *D. moriwakii* | 3 | 0.04 | — | 0 | — | — | 0 | — | — | 1 | 0.07 | — |
| *P. pallida* | 1 | 0.01 | — | 0 | — | — | 2 | 0.02 | — | 1 | 0.07 | — |
| *D. sexvittata* | 0 | — | — | 2 | 0.03 | — | 0 | — | — | 0 | — | — |
| *D. nipponica* | 0 | — | — | 1 | 0.01 | — | 1 | 0.01 | — | 0 | — | — |
| *D. rufa* | 0 | — | — | 2 | 0.03 | — | 0 | — | — | 0 | — | — |
| *S. apicalis* | 0 | — | — | 0 | — | — | 2 | 0.02 | — | 0 | — | — |
| *D. trivittata* | 0 | — | — | 1 | 0.01 | — | 0 | — | — | 0 | — | — |
| *D. alboralis* | 1 | 0.01 | — | 0 | — | — | 0 | — | — | 0 | — | — |
| *D. multispina* | 0 | — | — | 0 | — | — | 1 | 0.01 | — | 0 | — | — |
| *D. melanogaster* | 0 | — | — | 0 | — | — | 1 | 0.01 | — | 0 | — | — |
| *D. daruma* | 1 | 0.01 | — | 0 | — | — | 0 | — | — | 0 | — | — |
| *D. okadai* | 0 | — | — | 1 | 0.01 | — | 0 | — | — | 0 | — | — |
| *A. variegata* | 0 | — | — | 0 | — | — | 1 | 0.01 | — | 0 | — | — |
| *M. shikokuana* | 0 | — | — | 1 | 0.01 | — | 0 | — | — | 0 | — | — |
| Total | 7722 | — | 44.31 | 7767 | — | 45.00 | 8142 | — | 40.41 | 1514 | — | 46.17 |
| No. of species collected | | 22 | | | 25 | | | 23 | | | 18 | |

* The data are for yeast, *S. cervisiae*, pulled out from the data for site A.
** PA: Percentage frequencies of abundance. PF: Percentages of females.

which about the half was collected in 1959, and *D. coracina* by 111, a few specimens of which were caught every year. These four species are found as wood-dwelling forms throughout Hokkaido, with various frequencies in all Drosophila populations. The following species are distributed at low frequencies throughout the wooded highlands of Hokkaido: *D. histrio, D. ezoana, D. moriwakii, D. alboralis, D. helvetica* and *D. okadai.* Of the specimens which are "rare" in Hokkaido, the following are known to be cosmopolitan (Patterson and Stone 1952): *D. melanogaster, D. virilis, D. funebris, D. busckii* and *D. hydei.* One of the "common" species, *D. immigrans,* is also cosmopolitan. These six species are almost completely domestic species, and they are closely associated with human dwellings on this island. Flies of *D. hydei* were obtained only in 1954, and most of *D. melanogaster* were caught in that year. A considerable number of

specimens of these two species was collected in other built-up areas upon rare occasions (Takada 1957), but these had been scarcely found in fields far from human habitats in this island. These may be imported species for Hokkaido. The remainder of the species are rare wild forms, with the possible exception of *D. rufa* and *D. daruma*, which are probably introduced from Honshu or elswhere as well as the above two species. *Drosophila daruma* is found in good numbers in Kyushu, and is described by Okada (1956). Aside from those indicated in Table 3, no other specimen of this species have been collected so far.

Dobzhansky and Pavan (1950) recorded that the absolute and relative numbers of flies of different species attending a bait depend not only upon the nature of the bait but also upon the microenvironment in which the bait is exposed. The distribution and preference to yeast of drosophilid species in the Gardens were investigated in 1959. A total of 23,631 flies was collected with five kinds of yeasts at three different sites. They were comprised of 33 species of six genera as shown in Table 3. The complex of species excepting several rare forms is almost same as those in samples for site A collected in the other years. Of the "rare" species, *Mycodrosophila shikokuana, Drosophila trivittata* and *D. multispina* were not collected in the other years. The former two species were obtained from site B, and the third one from site C, both in the traps with the use of yeast, *Pichia membranaefaciens* (Table 7). "Abundant" species in 1959 were also represented by *D. auraria* and *D. nigromaculata* with frequencies of 39.71 percent and 24.53 percent in the drosophilid sample respectively (Table 5). These frequencies did not show much change from those of 38.32 percent and 26.15 percent in a total sample of the other nine years. In some instances, however, the relative proportions of "common" species observed in 1959 were different from those in the other years. For example, *D. lutea* and *D. immigrans* showed considerably high frequencies in 1959 respectively, while low frequencies of the two species were indicated in a total sample of the other years. On the contrary, *D. brachynephros, D. testacea* and *D. bifasciata* proved markedly low in proportions in 1959, and high percentages in the other years respectively. Various population patterns of species of *Drosophila* based on discrepancy among the collection years have been analyzed on the annual samples for the same site A. These detailed data will be presented in the following papers.

*Distribution:* Of the 33 species obtained from three sites; 16 were found in all sites; 5 between the three sites with combinations of sites A and B (2 species), B and C (2 species), and A and C (1 species); and the remaining 12 in only one site, 3 in A, 5 in B and 4 in C. Sample sizes from the different sites were similar to each other, represented by 7,722 flies with 22 species for site A, 7,767 with 25 species for site B, and 8,142 with 23 species for site C. These are shown in Table 6. In every site the most abundant species was represented by *D. auraria*. The next abundant species was for *D. nigromaculata*. Each of the "common" species, except *D. lutea* and *D. brachyne-*

Table 7. Collections from baits with different yeasts during 1959

| Yeasts | *S. cervisiae* | | | *S. rouxii* | | | *C. pelliculosa* | | | *H. anomala* | | | *P. membranaefaciens* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. of flies | PA* | PF* | No. of flies | PA* | PF* | No. of flies | PA* | PF* | No. of flies | PA* | PF* | No. of flies | PA* | PF* |
| *D. auraria* | 2495 | 46.63 | 47.41 | 2049 | 46.18 | 47.33 | 2003 | 37.96 | 41.19 | 1835 | 33.42 | 39.55 | 1005 | 34.27 | 48.46 |
| *D. nigromaculata* | 1294 | 24.18 | 44.36 | 1301 | 29.32 | 40.28 | 1104 | 20.37 | 40.67 | 1177 | 21.44 | 39.25 | 921 | 31.40 | 44.84 |
| *D. lutea* | 577 | 10.08 | 48.35 | 435 | 9.80 | 43.22 | 1010 | 18.64 | 47.82 | 904 | 16.46 | 42.92 | 297 | 10.13 | 43.77 |
| *D. immigrans* | 279 | 5.21 | 42.65 | 288 | 6.49 | 38.19 | 691 | 12.75 | 38.93 | 863 | 15.71 | 35.46 | 339 | 11.56 | 42.48 |
| *D. brachynephros* | 234 | 4.37 | 38.03 | 114 | 2.57 | 28.07 | 169 | 3.12 | 40.83 | 230 | 4.19 | 44.33 | 135 | 4.60 | 34.07 |
| *D. suzukii* | 115 | 2.15 | 40.00 | 80 | 1.80 | 46.25 | 130 | 2.40 | 36.15 | 154 | 2.80 | 40.91 | 79 | 2.69 | 45.57 |
| *D. lacertosa* | 132 | 2.47 | 38.64 | 54 | 1.22 | 42.59 | 77 | 1.42 | 36.36 | 74 | 1.35 | 37.84 | 22 | 0.75 | 40.91 |
| *D. testacea* | 112 | 2.09 | 57.14 | 44 | 0.99 | 56.82 | 67 | 1.24 | 59.70 | 65 | 1.18 | 44.62 | 50 | 1.70 | 54.00 |
| *D. bifasciata* | 41 | 0.77 | 36.59 | 28 | 0.63 | 60.71 | 55 | 1.01 | 56.36 | 93 | 1.69 | 41.94 | 36 | 1.23 | 52.78 |
| *D. sordidula* | 14 | 0.26 | — | 13 | 0.29 | — | 39 | 0.72 | 46.15 | 24 | 0.44 | 54.17 | 8 | 0.27 | — |
| *D. unispina* | 11 | 0.21 | — | 12 | 0.27 | — | 28 | 0.52 | 28.57 | 30 | 0.55 | 56.67 | 16 | 0.55 | — |
| *D. histrioides* | 23 | 0.43 | 17.39 | 4 | 0.09 | — | 9 | 0.17 | — | 8 | 0.15 | — | 4 | 0.14 | — |
| *D. histrio* | 4 | 0.07 | — | 1 | 0.02 | — | 8 | 0.15 | — | 14 | 0.25 | — | 3 | 0.10 | — |
| *D. coracina* | 9 | 0.17 | — | 3 | 0.07 | — | 6 | 0.11 | — | 6 | 0.11 | — | 3 | 0.10 | — |
| *D. funebris* | 2 | 0.04 | — | 5 | 0.11 | — | 9 | 0.17 | — | 5 | 0.09 | — | 5 | 0.17 | — |
| *D. virilis* | 1 | 0.02 | — | 4 | 0.09 | — | 4 | 0.07 | — | 0 | — | — | 0 | — | — |
| *D. ezoana* | 3 | 0.06 | — | 0 | — | — | 6 | 0.11 | — | 0 | — | — | 0 | — | — |
| *L. maculata* | 1 | 0.02 | — | 0 | — | — | 0 | — | — | 2 | 0.04 | — | 2 | 0.07 | — |
| *D. busckii* | 1 | 0.02 | — | 1 | 0.02 | — | 1 | 0.02 | — | 1 | 0.02 | — | 1 | 0.03 | — |
| *D. moriwakii* | 1 | 0.02 | — | 0 | — | — | 1 | 0.02 | — | 0 | — | — | 1 | 0.03 | — |
| *P. pallida* | 1 | 0.02 | — | 0 | — | — | 0 | — | — | 1 | 0.02 | — | 1 | 0.03 | — |
| *D. sexvittata* | 0 | — | — | 0 | — | — | 0 | — | — | 2 | 0.04 | — | 0 | — | — |
| *D. nipponica* | 0 | — | — | 0 | — | — | 1 | 0.02 | — | 1 | 0.02 | — | 0 | — | — |
| *D. rufa* | 0 | — | — | 0 | — | — | 0 | — | — | 2 | 0.04 | — | 0 | — | — |
| *S. apicalis* | 0 | — | — | 0 | — | — | 0 | — | — | 2 | 0.04 | — | 0 | — | — |
| *D. trivittata* | 0 | — | — | 0 | — | — | 0 | — | — | 0 | — | — | 1 | 0.03 | — |
| *D. alboralis* | 0 | — | — | 1 | 0.02 | — | 0 | — | — | 0 | — | — | 0 | — | — |
| *D. multispina* | 0 | — | — | 0 | — | — | 0 | — | — | 0 | — | — | 1 | 0.03 | — |
| *D. melanogaster* | 0 | — | — | 0 | — | — | 0 | — | — | 0 | — | — | 1 | 0.03 | — |
| *D. daruma* | 0 | — | — | 0 | — | — | 1 | 0.02 | — | 0 | — | — | 0 | — | — |
| *D. okadia* | 1 | 0.02 | — | 0 | — | — | 0 | — | — | 0 | — | — | 0 | — | — |
| *A. variegata* | 0 | — | — | 0 | — | — | 0 | — | — | 0 | — | — | 1 | 0.03 | — |
| *M. shikokuana* | 0 | — | — | 0 | — | — | 0 | — | — | 0 | — | — | 1 | 0.03 | — |
| Total | 5351 | — | 45.67 | 4437 | — | 44.04 | 5419 | — | 42.22 | 5491 | — | 45.67 | 2933 | — | 45.52 |
| No. of species collected | | 22 | | | 18 | | | 21 | | | 22 | | | 24 | |

* PA: Percentage frequencies of abundance. PF: Percentages of females.

*phros* (the 3rd and 5th abundant species in every sites) changed the relative frequencies considerably among the three sites. *Drosophila immigrans,* the 4th abundant species for each site, showing relatively high frequency for site C, while low frequency was observed in site A. *Drosophila suzukii* was the 6th abundant species for site A and for site C, but 7th for site B being inferior to *D. lacertosa*. *Drosophila lacertosa* was the 6th abundant species for site B, the 7th for site A, and the 9th for site C with a considerably low frequency of 0.60 percent. *Drosophila testacea* was the 7th abundant species for site C, the 8th for site A, and the 9th for site B. *Drosophila bifasciata* was the 8th abundant species for site B and for site C, and the 9th for site A. Distributions (percentages of abundance) of each of the ten leading species among the three sites were as follows:

| | |
|---|---|
| *D. auraria* | 35.22% for A, 33.30% for B, 31.49% for C |
| *D. nigromaculata* | 30.02% for A, 33.09% for B, 36.90% for C |
| *D. lutea* | 34.50% for A, 29.10% for B, 36.39% for C |
| *D. immigrans* | 21.30% for A, 33.29% for B, 45.41% for C |
| *D. brachynephros* | 34.69% for A, 38.44% for B, 26.87% for C |
| *D. suzukii* | 40.86% for A, 28.49% for B, 30.65% for C |
| *D. lacertosa* | 38.72% for A, 47.63% for B, 13.63% for C |
| *D. testacea* | 39.05% for A, 22.78% for B, 38.17% for C |
| *D. bifasciata* | 40.32% for A, 33.60% for B, 26.09% for C |
| *D. sordidula* | 52.04% for A, 32.65% for B, 15.31% for C |

The differences of these percentage frequencies between the highest and the lowest shown by each of the ten leading species are 3.73, 6.88, 7.29, 24.11, 11.57, 12.73, 33.98, 16.27, 14.23 and 36.73 respectively. In general, the more abundant or more common species showed the less differences among the sites. These species may have larger adaptive abilities in relation to available environments than the less abundant or less common species. Of the "common" species, *D. suzukii, D. bifasciata* and *D. sordidula* made conspicuous by their relative abundances for site A, *D. lacertosa* for site B, and *D. immigrans* for site C. Each of them occupied above 40 percent of the total specimens collected. On the contrary, *D. immigrans* was striking by its relative fewness for site A, *D. testacea* for site B, and *D. lacertosa* and *D. sordidula* for site C.

*Yeast preferences:* The preference of these flies to five different kinds of yeasts have been reported by Kaneko (1960). He stated that the most common species, *D. auraria* and *D. nigromaculata,* showed no significant preference for the yeasts used, with the one exception of yeast *P. membranaefacience,* and the other seven dominant species showed their own characteristic preferences for different yeasts. After that, Kaneko's data was strictly retraced by the author, and was slightly modified. These revised data are shown in Table 7. Among 33 species collected by the five kinds of yeasts, 15 leading species and one of the "rare" species, *D. busckii,* were attracted to every yeast used, with various number of specimens. Among the "rare" species four were attracted to three kinds of yeasts, two to two kinds of yeasts, and eleven to only

one kind of yeast. Of the total of 23,631 flies attracted to the five different kinds of yeasts, 5,351 (22.64 percent of the total specimens) of 22 species were for yeast *Saccharomyces cervisiae,* 4,437 (18.78 percent) of 18 species for *S. rouxii,* 5,419 (22.93 percent) of 21 species for *Candida pelliculosa,* 5,491 (23.24 percent) of 22 species for *Hansenula anomala,* and 2,933 (12.41 percent) of 24 species for *Pichia membranaefaciens.* The fifth yeast *P. membranaefaciens* was generally and distinctly weak attractant to drosophilid flies as compared with the other four kinds of yeasts. However, the highest number of species was attracted to this yeast. This is owing to entrance of some unusual species, and these species were too rare to reveal certainly their food preferences. The most universal attractiveness to these yeasts was represented by one of the "abundant" species, *D. nigromaculata.* The other "abundant" species, *D. auraria,* was attracted with relatively high proportion to yeast *S. cervisiae,* and with low proportion to yeast *P. membranaefaciens.* Among the "common" species, *D. lacertosa* and *D. testacea* visited most frequently yeast *S. cervisiae, D. lutea* and *D. sordidula* yeast *C. pelliculosa,* and *D. immigrans* and *D. bifasciata* yeast *H. anomala.* Yeast *S. rouxii* was a weak attractant to all "common" species as well as yeast *P. membranaefaciens.* Analogous yeast preferences were generally observed between the "common" species, *D. lutea* and *D. sordidula, D. immigrans* and *D. bifasciata, D. brachynephros* and *D. suzukii,* and *D. lacertosa* and *D. testacea.* Percentage frequency distributions of each of the ten leading species for the five different kinds of yeasts were as follows:

| Yeasts | *S. c.* | *S. r.* | *C. p.* | *H. a.* | *P. m.* |
|---|---|---|---|---|---|
| *D. auraria* | 26.58 | 21.83 | 21.34 | 19.55 | 10.71 |
| *D. nigromaculata* | 22.32 | 22.44 | 19.04 | 20.30 | 15.89 |
| *D. lutea* | 17.90 | 13.50 | 31.34 | 28.05 | 9.22 |
| *D. immigrans* | 11.34 | 11.71 | 28.09 | 35.08 | 13.78 |
| *D. brachynephros* | 26.53 | 12.93 | 19.16 | 26.08 | 15.31 |
| *D. suzukii* | 20.61 | 14.34 | 23.30 | 27.60 | 14.16 |
| *D. lacertosa* | 36.77 | 15.04 | 21.45 | 20.61 | 6.13 |
| *D. testacea* | 33.14 | 13.02 | 19.82 | 19.23 | 14.79 |
| *D. bifasciata* | 16.21 | 11.07 | 21.74 | 36.76 | 14.23 |
| *D. sordidula* | 14.29 | 13.27 | 39.80 | 24.49 | 8.16 |

As mentioned above, *D. lutea* and *D. immigrans* were collected with considerably high frequencies in the sample of 1959 as compared with those of the other years. As one of the reasons of the abundance, many flies of these species were found on yeasts, *C. pelliculosa* and *H. anomala,* rather than on *S. cervisiae* which was adopted as a kind of yeast in the other years. In addition, *D. immigrans* was distributed with high proportions in samples from site B and site C. On the other hand, *D. brachynephros* and *D. testacea* were obtained with very low frequencies in the sample of 1959. More specimens of these species were attracted to yeast *S. cervisiae* than to the other kinds of yeasts. Such a different attractiveness of different yeasts to different species of *Drosophila* has been pointed out by da Cunha, Dobzhansky and Sokoloff (1951) with the use of suspensions of yeasts isolated from the crops of *D. persimilis* and *D. azteca* as baits

to attract *Drosophila* flies. For analysis of annual changes of the Drosophila population, therefore, data for yeast *S. cervisiae* pulled out from the sample of site A, which is shown in Table 6, is more reasonable than those of the total sample of 1959, because every year's collection except in that year was made at site A with the use of only *S. cervisiae* yeast. The data indicates that in 1959 *D. auraria, D. lutea* and *D. suzukii* appeared with very high percentages of frequencies with 52.18, 9.78 and 3.96, while, *D. brachynephros, D. immigrans* and *D. testacea* showed comparatively low frequencies of 2.53, 2.91 and 2.25 respectively in comparision with those of other years.

*Sex-ratio:* Sexual discrimination of flies collected on banana bait was carefully made with the exception of the first year's collection. In a total of 45,251 drosophilid flies examined, 20,639 specimens (45.61 percent of the total) was females. Annual percentage frequencies of females of the ten leading species during the nine years (1954–1962) are listed in Table 8. In a total sample of each species, nine of the ten leading species showed male superiority with various sex-ratios. Only in one species, *D. testacea,* among the leading species, females were more abundant than males. Percentages of females, however, varied more or less from year to year. A little excess of females in number to males was observed in *D. auraria* (1957, 1960, 1961 and 1962), *D. nigromaculata* (1955), *D. lutea* (1956, 1957, 1958, 1961 and 1962), *D. immigrans* (1954, 1956 and 1960) and *D. bifasciata* (1962). *Drosophila brachynephros, D. lacertosa, D. suzukii* and *D. histrioides* indicated male superiority every year. Among the four species, the preponderance of males for the bait seems to be a constant nature in *D. brachynephros* (Table 8). Though the specimens in samples were a few, the extreme unbalance of sex-ratio was found in certain years in the other less common species. The female percentage frequencies of these species were 28.57 (*D. lacertosa,* 1954), 12.90 (*D. suzukii,* 1957), and 25.00, 27.08 and 27.03 (*D. histrioides,* 1957, 1959, 1961 respectively). The pre-

Table 8. Percentages of females for each of the ten leading species of *Drosophila* in the Gardens, as shown by trapping records*

| | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | 1961 | 1962 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| *auraria* | 50.51 | 46.83 | 49.15 | 51.02 | 49.67 | 44.73 | 54.89 | 53.60 | 54.94 | 48.23 |
| *nigromaculata* | 44.09 | 54.08 | 50.71 | 46.72 | 42.23 | 41.78 | 43.17 | 39.59 | 40.61 | 42.94 |
| *lutea* | — | — | 58.57 | 52.94 | 55.29 | 45.55 | 39.29 | 55.00 | 52.22 | 47.70 |
| *brachynephros* | 43.28 | 44.17 | 43.17 | 46.35 | 45.06 | 36.96 | 38.54 | 47.84 | 40.85 | 41.92 |
| *immigrans* | 60.87 | 47.83 | 56.62 | 42.70 | — | 38.34 | 68.00 | 50.00 | 41.97 | 40.47 |
| *testacea* | 49.35 | 55.56 | 58.61 | 73.79 | 56.10 | 54.73 | 66.39 | 60.94 | 49.54 | 59.85 |
| *bifasciata* | 47.62 | 36.17 | 36.27 | 56.95 | — | 47.83 | 48.72 | 42.67 | 56.03 | 45.43 |
| *lacertosa* | 28.57 | — | 35.06 | 45.83 | 35.00 | 38.72 | 39.73 | 41.75 | 36.00 | 38.09 |
| *suzukii* | — | — | 34.15 | 12.90 | — | 41.04 | — | 41.18 | — | 39.85 |
| *histrioides* | — | — | 31.95 | 25.00 | — | 27.08 | — | 27.03 | 40.28 | 32.99 |
| Total species of *Drosophilidae* | 44.51 | 47.13 | 48.34 | 50.99 | 46.57 | 43.19 | 49.67 | 48.68 | 47.67 | 45.61 |

* Female percentages in 1953 are omitted, becauses some of the specimens were not checked up females or males.

Female percentages in samples under 20 flies are not recorded.

ponderance of females was annually observed in *D. testacea* with the highest frequency of 73.79 percent in 1957, excepting in 1954 and 1962 when about equal numbers of females and males were caught.

The records in 1959 are rather useful for multifarious analyses of the sex-ratio. The results of the experiments in which five different kinds of yeasts were used at the three different sites, are reported in Tables 6 and 7. A total sample from site C showed a relatively low frequency of females as compared with those from the other two sites, A and B. The decrease of the female percentage at site C was obviously due to that (37.75 percent) of the most abundant species, *D. auraria*. An extraordinarily low frequency of females was indicated by *D. brachynephros* at site A. On the other hand, a considerable superiority of females was recorded by *D. testacea* at site B. *Drosophila bifasciata* showed female superiority at site B, and female inferiority at the other sites, A and C. Frequencies of females in total species attracted to the five kinds of yeasts were not much different from each other with a variation of 42.22 percent to 45.67 percent as shown in Table 7. Relatively low frequency of females was found in *D. brachynephros* attracted to yeast *S. rouxii,* and high frequencies in *D. bifasciata* to yeasts, *S. rouxii* and *C. pelliculosa,* respectively. In *D. testacea* the number of females attracted was larger than that of males to four different kinds of yeasts. A sample of this species, however, showed slightly male superiority for yeast *H. anomala*. Table 9 re-

Table 9. Percentage frequencies of females and of males of a given species on each of the five different yeasts (1959)

| Yeasts | | *S. cervisiae* | *S. rouxii* | *C. pelliculosa* | *H. anomala* | *P. membranaefaciens* |
|---|---|---|---|---|---|---|
| *auraria* | Female | 28.18 | 23.30 | 19.65 | 17.27 | 11.60 |
| | Male | 25.29 | 20.65 | 22.71 | 21.36 | 9.99 |
| *nigromaculata* | Female | 23.70 | 21.64 | 18.54 | 19.08 | 17.05 |
| | Male | 21.33 | 23.02 | 19.41 | 21.19 | 15.05 |
| *lutea* | Female | 19.01 | 12.81 | 32.90 | 26.43 | 8.86 |
| | Male | 16.98 | 14.07 | 30.03 | 29.40 | 9.52 |
| *immigrans* | Female | 12.55 | 11.60 | 28.38 | 32.28 | 15.19 |
| | Male | 10.58 | 11.77 | 27.91 | 36.84 | 12.90 |
| *brachynephros* | Female | 27.30 | 9.82 | 21.17 | 27.61 | 14.11 |
| | Male | 26.08 | 14.75 | 17.99 | 25.18 | 16.01 |
| *suzukii* | Female | 20.09 | 16.16 | 20.52 | 27.51 | 15.72 |
| | Male | 20.97 | 13.07 | 25.23 | 27.66 | 13.07 |
| *lacertosa* | Female | 36.70 | 16.55 | 20.14 | 20.14 | 6.47 |
| | Male | 36.82 | 14.09 | 22.27 | 20.91 | 5.91 |
| *testacea* | Female | 34.59 | 13.51 | 21.62 | 15.68 | 14.59 |
| | Male | 31.37 | 12.42 | 17.65 | 23.53 | 15.03 |
| *bifasciata* | Female | 12.40 | 14.05 | 25.62 | 32.23 | 15.70 |
| | Male | 19.70 | 8.33 | 18.18 | 40.91 | 12.88 |
| *sordidula* | Female | 10.87 | 13.04 | 39.13 | 28.26 | 8.70 |
| | Male | 17.31 | 13.46 | 40.38 | 21.15 | 7.69 |
| Total species | Female | 23.94 | 19.14 | 22.42 | 21.42 | 13.08 |
| | Male | 21.66 | 18.50 | 23.32 | 24.62 | 11.90 |

cords the data in each of the ten leading species for the attractiveness of the five different yeasts to females and males. Reaction to the five kinds of yeasts was different to some extent between the sexes in each species. In general, the differences were slight in "abundant" and more "common" species, and wide in less "common" species as shown by *D. suzukii* for *C. pelliculosa, D. testacea* for *H. anomala, D. bifasciata* for *S. cervisiae,* for *S. rouxii,* for *P. pelliculosa,* and for *H. anomala.* Yeast *P. membranaefaciens* was the weakest attractant to both sexes of the two "abundant" species, *D. auraria* and *D. nigromaculata,* and of four of the eight "common" species, *D. lutea, D. suzukii, D. lacertosa* and *D. sordidula.* Further, this yeast showed a weak attractiveness to both sexes of the remaining four "common" species. Low attractiveness to both sexes in all "common" species was also found in yeast *S. rouxii,* however, this yeast attracted females and males of the two "abundant" species with relatively high proportions. The lowest attractiveness shown by the yeast *S. rouxii* was for both sexes of *D. brachynephros,* and *D. testacea,* for females of *D. immigrans,* and for males of *D. bifasciata.* On the other hand, yeast *S. cervisiae* which was used throughout the period of collection, attracted both sexes of *D. auraria, D. brachynephros, D. lacertosa* and *D. testacea,* and females of *D. nigromaculata* with the highest percentages among the five different yeasts. The lowest attractiveness, however, was represented by males of *D. immigrans* and females of *D. bifasciata.* Relatively low attractiveness was observed in both sexes of *D. sordidula,* in females of *D. immigrans,* and in males of *D. lutea.* Regardless of the sexes, *D. lutea* and *D. immigrans* were attracted with very high proportions to yeasts, *C. pelliculosa* and *H. anomala, D. brachynephros, D. suzukii* and *D. bifasciata* to yeast *H. anomala,* and *D. sordidula* to yeast *C. pelliculosa* as shown in Table 9. Thus the observations show that the sex-ratios of most of the species are affected more or less by the site of collection and yeast attractant.

Da Cunha, Dobzhansky and Sokoloff (1951) reported that banana bait attracted approximately equal numbers of females and males of the *obscura* species group, while, baits consisting of yeasts alone were visited by more males than females. Unbalanced sex-ratios in the trapped samples of *Drosophila* have been reported by several investigators (Spencer 1942; da Cunha, Dobzhansky and Sokoloff 1951; Basden 1954; Levitan 1954; Cooper and Dobzhansky 1956; Dobzhansky et al. 1956; Mather 1956). Mather (1956) observed male superiority of *Drosophila* in eastern Queensland, and observed that it can not be acertained whether this was due to a real preponderance of males or whether there was a differential attraction to, or tendency for males to remain at, the baits. While, Cooper and Dobzhansky (1956) suggested that reaction of both sexes to bait may undergo changes with season. Their consideration has been confirmed in the most abundant species, *D. auraria* (race A), trapped during seven years (1956-1962) in this Gardens by the aurthor's (1964), finding of the existance of inverse relation between the seasonal variation of female frequency and the seasonal population change.

From the results of the above observations, it is possibly supposed that *D. immigrans* prefers rather dry area, at where site C was chosen, than wet one (site B) in this Gardens, and the reversing trend occurs in *D. lacertosa* of which many flies were collected with very high frequency at site B. Williams and Miller (1952) recorded that the varying weather conditions must have greatly influenced the collections. In the Gardens, however, no positive information is available on the relationship of the relative frequencies of abundance of the above two species in the year's sample to the year's mean relative humidity or rainfall. Indeed, mean humidities and rainfalls during the ten collecting years shown by each year or each collecting season might not be so different as to exert an influence upon the relative frequencies of these species. The maxima in mean yearly humidities and rainfalls were 74.8 percent in 1957 and 112.7 mm in 1955, and the minima 72.8 percent in 1962 and 87.8 mm in 1959 respectively. The maxima in mean seasonal (May to October) humidities and rainfalls were 78.0 percent in 1955 and 128.7 mm in 1957, and the minima 75.0 percent in 1961 and 78.3 mm in 1959 respectively (Table 2). For instance, in 1955 and in 1957 when relative humidities and rainfalls were the highest, *D. lacertosa* which seems to have a preference for wet places indicated only 1.25 percent and 1.47 percent in each year's sample, while *D. immigrans* which was abundant at dry areas in this Gardens contained relatively high percentages of 2.88 and 5.65 in each year's sample respectively (Table 5). For evaluation of such yearly changes in the collection frequencies of these *Drosophila* species, it is necessary to have much comprehensive knowledge of their ecological relations. Patterson (1943) pointed out 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. Variations in the other environments in this Gardens may occur from year to year affecting the relative frequencies of these species to a large extent. The other leading species were more universal for the three sites than the above two species. Among these species, *D. auraria, D. brachynephros, D. bifasciata* and *D. sordidula* seem to be relatively more abundant at damp places than at exsiccated ones, in contrast to *D. nigromaculata, D. lutea* and *D. testacea* in this Gardens.

## SUMMARY

Aspects of *Drosophila* populations in a semi-natural state carrying various kinds of vegetations in the University Gardens at Sapporo were investigated during the years 1953 through 1962. A general account of the Gardens and some of the climatological features are described. For this study collections of drosophilid flies on a large scale have been done with the use of banana traps at a single site during the ten years. Collections were made monthly from May to October, except in 1953 and 1955. These collection dates and times are shown in Table 1. In 1959 differential attraction of drosophilid species to five different kinds of yeasts was examind using fermenting banana

bait, in which the test yeast was actually growing, at three different sites in the Gardens.

During the period of this survey, a total of 46,619 specimens of fourty-three species of Drosophilidae was obtained by the method of trapping. These collection data were summarized in Table 3.

Population sample obtained from the semi-natural areas in traps of banana bait, has been constructed from two "abundant", seven "common" and thirty-four "rare" species. Relative frequencies of the thirteen leading species are shown in Table 5. Among the "abundant" and "common" species, *D. auraria* race A (a representative of the *auraria* species population in this Gardens), *D. nigromaculata, D. lutea, D. brachynephros, D. immigrans* and *D. suzukii* have been found to be domestic forms closely associated with man, while *D. testacea, D. bifasciata* and *D. lacertosa* have had wild habitats throughout Hokkaido. Yearly changes in the relative frequencies of abundance of these species were more conspicuous in "common" species than in "abundant" ones. Mean humidity and rainfall shown by each year or each collecting season during the ten years seem to exert no influence upon the relative frequencies of these drosophilid species. Variations in the other environments in this Gardens may occur from year to year affecting such frequencies of *Drosophila* species.

The distribution and preferences to yeast of drosophilid species in this Gardens are described. Abundant and more common species showed generally larger adaptive abilities in relation to the collecting sites and to the yeasts than less common species so far investigated. Percentage frequency of females in total drosophilid flies sampled by banana traps during nine years (1954–1962) was 45.61. Only one species, *D. testacea*, among the "abundant" and "common" species showed female superiority with the frequency of 59.85 percent. Sex-ratios of most of the species seem to be affected more or less by collecting site and yeast attractant.

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