Some Problems with Respect to Bait Trap Collections of Drosophilid Flies

By

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(With 4 Text-figures and 4 Tables)

Up to the present bait traps have been used in most ecological surveys of drosophilid flies. On the other hand, several investigators (Burla 1951, Basden 1954, Herting 1955, Toda *et al.* 1975) have pointed out that the results obtained do not always represent natural conditions, as they are affected by many factors: the weather, kinds and condition of bait, natural foods existing within the surveyed area, feeding and flight activities of the flies, and so on. The present paper deals with some of these factors: the efficiency of different types of trap with seasonal change, age of bait, and some behavioral aspects affecting trap collection.

Before going further, we wish to express our sincere thanks to Professor Eizi Momma and Dr. Shôichi F. Sakagami for their kind advice and reading through the manuscript. Cordial thanks are also due to Messrs. Masahito T. Kimura and Takashi Hosaka for their kind help in observation and collection.

1. Efficiency of different types of trap

In order to test the efficiency of two newly invented types of "retainer" trap, Toda's I and II (Toda *et al.* 1975, Toda 1976) which are abbreviated to T(I) and T(II) in subsequent pages, a comparison was undertaken with other types of trap hitherto used by previous investigators. In addition to the new "retainer" traps, two "open" types were used. 1. Dish Trap (DT): Bait is put on a dish set on the ground, a fallen tree, etc. Flies are collected by sweeping over the bait with an insect net. 2. Milk Can Trap (MC): The trap is a cylindrical dry-milk can. Flies are captured by covering the trap quickly with a vinyl sack.

The survey was carried out in a natural forest with a sparse admixture of conifers at the Misumai Arboretum of Hokkaido University in the suburb of Sapporo City (cf. Toda 1973a), for six days from July 25 to 30, 1974. Twelve traps baited with fermented banana, three of each type, were arranged in two different fashions. 1. Dependent Series: Four traps of each type, were set up about 2 m

apart to be competitive with each other. 2. Independent Series: The remaining eight traps were set up more than 30 m apart from each other. The "open" traps were visited seven times a day at 2 hr. intervals from 5:00 to 17:00 and the flies stored in "retainer" traps were removed every day in the evening (17:00~18:00).

As a result, a total of 2,886 specimens of drosophilid flies was obtained, consisting of 23 species, which are arranged in descending order of relative abundance: *Drosophila testacea*, *D. coracina*, *D. confusa*, *D. unispina*, *D. sordidula*, *D. biauraria*, *Amiota variegata*, *D. histrio*, *D. brachynephros*, *D. immigrans*, *D. bifasciata*, *D. nigromaculata*, *Leucophenga quinquemaculipennis*, *D. imaii*, *D. moriwakii*, *D. alboralis*, *D. lacertosa*, *D. throckmortoni*, *D. auraria*, *D. pseudosordidula*, *D. pengi*, *D. suzukii* and *D. sexvittata*. The number of species collected at each trap did not significantly vary among the different types of trap (Fig. 1). On the

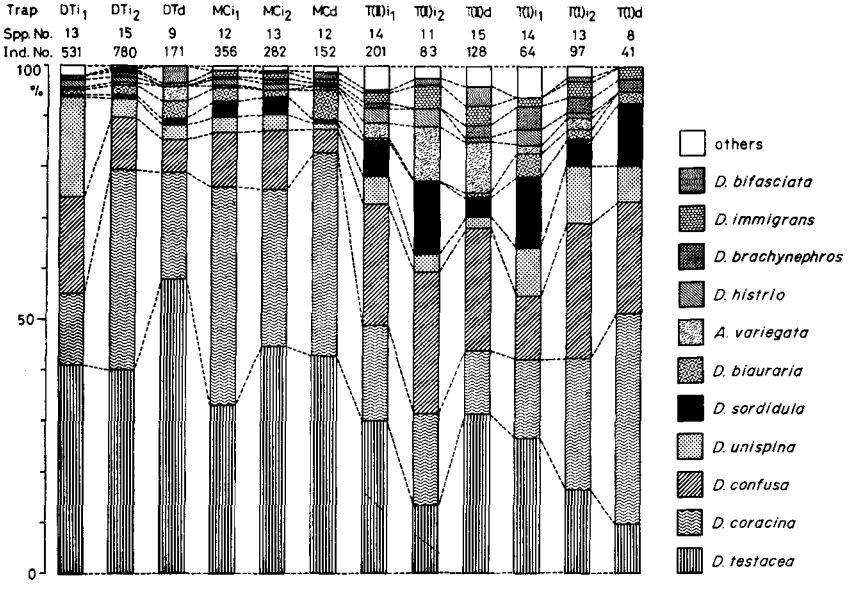

Fig. 1. Relative frequencies of the eleven leading species at each trap, together with total species and individual numbers. Each trap is abbreviated, according to the type of trap (see text) and its arrangement: i=independent, d=dependent.

other hand, the total individual number at each trap was clearly different. DT was the most efficient, followed by MC, T(II) and T(I) in order of efficiency. Basden (1954) reported the same result in comparing "open" and "retainer" traps. Fig. 1 shows the relative frequencies of the eleven leading species at each trap. Although the relative frequencies are affected not only by the types of trap but also by differences in microhabitat and trap arrangement, the overall pattern is, in

general, different between "open" and "retainer" traps. On closer inspection, *D. testacea* and *D. coracina* tended to show larger proportions at "open" traps than at "retainer" ones, while for some other species the opposite is true, e.g., *D. confusa*, *D. sordidula*, *D. unispina*, *D. histrio*, *D. brachynephros* and *D. immigrans*, though the difference is statistically insignificant by the occurence probability method (Katô *et al.* 1952). *Amiota variegata* was relatively frequent at T(II), while the tendency was indistinct in *D. biauraria* and *D. bifasciata*. Thus, the efficiency of the new "retainer" traps was less than that of traditional "open" ones. Moreover, the relative frequencies of drosophilid assemblage collected by the former were rather different to those collected by the latter. Consequently, when biofaunistic studies are made by using these new traps, it is necessary to pay attention to comparisons with the data obtained by using old-type traps.

Another aspect to be compared is the sex ratio. For comparison among different types of trap, female percentage ratios of the five leading species are calculated on the basis of the data summed up for each type of trap (Table 1). DT collection showed an excess of males in all the species concerned. Among the individual species, *D. testacea* and *D. confusa* showed a somewhat regular, though statistically insignificant, tendency for female percentages to be higher at "retainer" traps than at "open" ones. For further discussion, see parts 3 and 4.

Table 1. Female ratio at each type of trap expressed as a percentage of the total flies for each of five most frequent species. Actual numbers of females and males in brackets.

Trap-types	Dish		Milk Can		Toda's II		Toda's I	
	%	(♀/♂)	%	(♀/♂)	%	(♀/♂)	%	(♀/♂)
D. testacea	18.4	(116/515)	19.7	(61/248)	26.1	(29/82)	29.7	(11/26)
D. coracina	36.9	(154/263)	50.2	(151/150)	65.2	(45/24)	46.2	(24/28)
D. confusa	43.8	(84/108)	41.0	(32/ 46)	52.0	(53/49)	62.8	(27/16)
D. unispina	35.7	(50/ 90)	54.5	(12/ 10)	35.3	(6/11)	55.0	(11/ 9)
D. sordidula	44.4	(4/ 5)	45.5	(10/ 12)	45.2	(14/17)	36.8	(7/12)

2. Effect of age of bait

Another problem in bait collection is the age of the bait. Sequential changes of drosophilid assemblage attracted during the progress of fermentation or decay of food substances have been studied at several kinds of natural feeding sites, at tree sap bleeding from cut trunks by Burla (1955), at fallen fruits by Lachaise and Tsacas (1974) and at fungi by Kimura (1976). It is supposed that the age of bait used in trap collection affects considerably the results obtained. Hence, following the above test, the comparison of baits of different ages was carried out by the following procedure:

All DT, MC and T(II) traps were removed from the surveyed area at the end of the preceding test on July 30, but the T(I) traps were left intact, one dependent (d_1) and two independent ($i_{1,2}$). Flies trapped in these were collected on August 1, 7 and 14, leaving the bait intact. On August 1, three more T(I) traps newly baited with banana fermented by Baker's yeast were set up, one dependently (d_2) and the other two independently ($i_{3,4}$). Flies were collected on August 7 and 14 from them without bait renewal. On August 7, further three new traps were added, again one dependent (d_3) and two independent ($i_{5,6}$), and the samples were collected after one week, on August 14.

The results are presented in Table 2, shown for the three collecting periods (Jul. 24～Aug. 1, Aug. 1～7, and Aug. 7～14) separately. The first period includes the data obtained in the preceding test. The procedure adopted in the present test enables dual comparisons of age-different baits. One is the sequential comparison of the same bait in the progress of aging, and the other is the simultaneous comparison among age-different baits within the same period.

Table 2. Drosophilid flies collected

Period	Jul. 24～Aug. 1	Aug. 1～7		Aug. 7～14		
Trap (Toda's I)	d_1	d_2	d_1	d_3	d_2	d_1
Drosophila testacea	9	180	29	146	109	26
D. confusa	10	262	-	68	19	-
D. coracina	25	100	39	4	64	21
D. sordidula	8	20	2	11	10	-
D. histrio	-	27	3	13	2	-
D. immigrans	2	8	1	3	7	1
D. brachynephros	1	4	1	10	1	-
Aulacigaster leucopeza	1	4	1	1	5	-
Amiota variegata	-	10	-	11	2	-
Drosophila biauraria	1	8	-	1	2	-
D. unispina	3	3	-	-	-	-
D. bifasciata	-	3	-	2	-	-
D. imaii	-	3	-	-	1	1
D. throckmortoni	-	5	-	1	2	-
D. nigromaculata	-	2	-	-	3	-
D. pengi	-	-	-	-	1	-
D. moriwakii	-	-	-	1	-	-
Leucophenga quinquemaculipennis	-	1	-	1	-	-
Drosophila auraria	-	-	-	-	-	-
D. lacertosa	-	-	-	2	-	-
D. pseudosordidula	-	-	-	-	-	-
Amiota stylopyga	-	1	-	-	-	-
A. (*Amiota*) spp. (♀)	-	1	-	-	-	-
A. (*Amiota*) sp. 1 (♂)	-	1	-	-	-	-
Drosophila busckii	-	-	-	-	-	-
Total Individual No.	60	643	76	275	228	49
Total Species No.	**9**	**19**	**7**	**15**	**14**	**4**

First, it is obvious that both total species and individual numbers are largest in the first week, followed by a slight decrease in the second week and an abrupt drop in the third week. As for each species, the patterns of visiting age-different baits are tentatively classified into three categories. A) Species which are most abundant in the first week: *D. confusa*, *D. histrio*, *D. brachynephros*, *A. variegata*, *D. unispina*, *D. bifasciata* and *D. moriwakii*. B) Species which are abundant in the first and second weeks: *D. sordidula*, *Aulacigaster leucopeza* (belonging to Aulacigastridae allied to Drosophilidae), *D. biauraria*, *D. imaii*, *D. throckmortoni*, *D. nigromaculata*, and *D. pengi*. C) Only three species, *D. testacea*, *D. coracina* and *D. immigrans*, are still collected in significant numbers in the third week, though the first two are clearly abundant in the first or second week. It should be noted that the classification is arbitrary, particularly between groups A and B. Furthermore, the analyses of artificial bait in the present study are too insufficient to discuss the temporal niche separation in the progress of changes of

on baits of different ages.

Jul. 24~Aug. 1		Aug. 1~7				Aug. 7~14						Total
i_1	i_2	i_3	i_4	i_1	i_2	i_5	i_6	i_3	i_4	i_1	i_2	
25	29	174	130	19	60	73	53	85	235	3	44	1,429
13	40	82	95	15	15	51	62	49	10	1	1	793
11	43	73	48	13	47	2	4	74	23	2	6	599
16	7	15	18	17	7	24	14	17	12	-	1	199
2	3	30	21	7	14	8	11	9	15	-	2	167
1	4	11	6	6	3	4	1	7	11	2	12	90
3	3	15	6	-	-	7	2	7	9	-	-	69
-	-	14	3	1	1	-	2	22	3	-	-	58
1	2	-	1	-	1	4	16	3	1	1	-	53
3	2	15	1	-	-	1	5	5	-	-	-	44
6	12	8	1	-	-	-	-	1	4	-	-	38
-	1	2	2	-	-	4	1	-	-	-	-	15
-	1	1	3	-	-	-	1	2	1	-	-	14
-	-	2	2	-	-	-	-	1	-	-	-	13
1	1	-	1	-	-	2	1	-	2	-	-	13
1	-	1	1	-	-	1	2	3	1	-	-	11
-	-	1	-	-	-	2	1	-	-	-	-	5
1	-	-	-	-	-	1	-	1	-	-	-	5
-	-	-	-	2	-	-	-	-	-	1	-	3
-	-	-	-	-	-	-	-	-	-	-	-	2
1	-	-	1	-	-	-	-	-	-	-	-	2
-	-	-	-	-	-	1	-	-	-	-	-	2
-	-	1	-	-	-	-	-	-	-	-	-	2
-	-	-	-	-	-	-	-	-	-	-	-	1
-	-	-	-	1	-	-	-	-	-	-	-	1
85	148	445	340	81	148	185	176	286	327	10	66	3,628
14	**13**	**16**	**17**	**9**	**8**	**15**	**15**	**15**	**13**	**6**	**6**	**25**

food conditions at the same feeding site, which is expected to be precisely studied at various natural feeding sites in the future. In conclusion, the maximum efficient period of T(I) baited with fermented banana is judged to be two weeks, at least in summer.

Next, in order to estimate the minimum collecting period necessary for a biofaunistic study, the sequential increase of the cumulative number of species for three weeks at T(I) is shown in Fig. 2, together with the curves for six days at the other three kinds of trap. The results surprisingly coincide with each other among the four different kinds of trap, that is, the curve can be divided into two

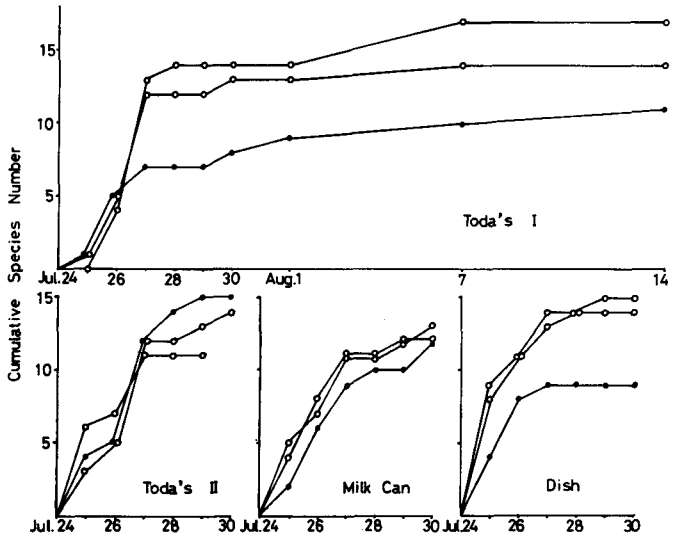

Fig. 2. Sequential increase of cumulative number of species at four different types of trap, separately shown for each trap. Black circle: dependent, White circle: independent.

parts, an initial steep increase for the first three days and a plateau or a slow increase after that. It can be easily concluded that, irrespective of the kind of trap, collections must be made for at least three days and, if possible, it is recommended to collect for a week. In spite of the general coincidence mentioned above, a closer inspection reveals slight differences in the initial increase among different kinds of trap. The curves of the initial increase at T(I) are upward concave, while those at DT are convex. The initial increase at MC and T(II) is generally linear, being intermediate between the former two. This indicates that T(I) remaines inefficient till the second day and becomes efficient on the third day, while DT begins to work readily from the first day. The speedy efficiency of "open" bait was also reported by Basden (1954). Consequently, when there is insufficient time to stay for collection, DT is the most recommended among the four types concerned.

3. Seasonal changes of efficiency of different types of trap

In the above test (Part 1), the comparison between "retainer" and "open" traps was carried out only during a quite limited period in summer. But it is known that drosophilid biofaunistic study within a locality should be continued throughout the entire active season of the flies, for the seasonal fluctuation of each species can vary differently. Therefore, the efficiency of different types of trap was compared throughout the whole season. Using T(I) and MC, the comparison was made monthly from May to October, 1974, in the Nopporo Natural Forest (cf. Beppu 1976). In total six traps, three of each type, were set up about 10 m apart from each other within similar microenvironmental conditions along a stream. Flies attracted to MC were collected at one hour intervals from 4:00 to 19:00, excepting September and October (from 5:00 to 17:00), for three successive days, while flies retained in T(I) were collected after a week's exposure.

A total of 1,410 specimens of 21 species belonging to 2 genera was collected by T(I), and 3,528 specimens of 29 species belonging to 4 genera by MC. The component species were generally identical between the two types of trap, because all 21 species obtained by T(I) were also collected by MC, and the 8 species collected only by MC were sporadic. Predominant and frequent species are arranged in the following descending order of relative abundance: *D. testacea*, *D. immigrans*, *D. lacertosa*, *D. confusa*, *D. brachynephros*, *D. moriwakii*, *D. nigromaculata*, *D. coracina*, *D. biauraria*, *D. pengi*, *D. bifasciata* and *D. suzukii*.

As shown in Fig. 3, total assemblage constitutions are quite different (Harmonity Index=0.594, cf. Toda 1973a) between T(I) and MC. The species whose

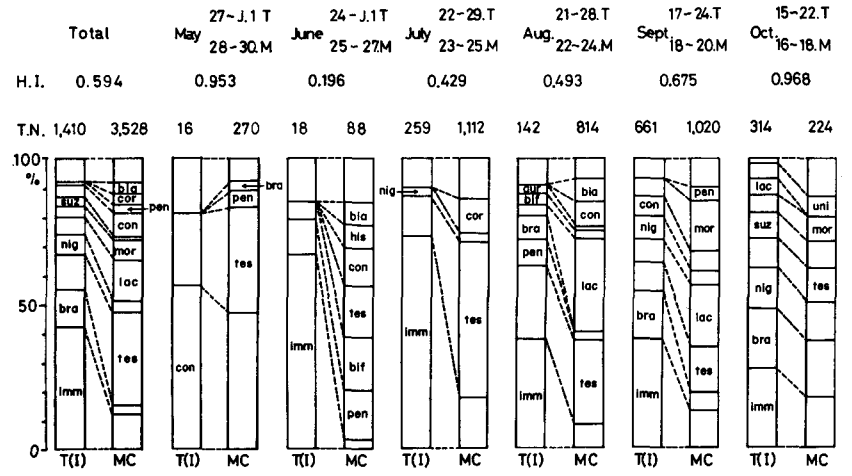

Fig. 3. Comparison of assemblage constitutions between T(I) and MC in different months, together with harmonity index (H.I.) for each pair and total individual numbers (T.N.).

percentages are larger in MC than in T(I) (expressed by MC>T(I) in the subsequent description) are *D. testacea*, *D. coracina*, *D. biauraria*, *D. confusa*, *D. lacertosa*, *D. moriwakii* and *D. pengi*, while for *D. immigrans*, *D. brachynephros*, *D. nigromaculata* and *D. suzukii* the reverse is true, being more frequent in T(I) than in MC, (T(I)>MC). However, on closer inspection of the figures in different months, it appears that the T(I)≷MC relationships of several species fluctuate by season. Relationships of T(I)>MC and MC>T(I) are seen in *D. confusa* and *D. brachynephros* respectively in May, and *D. pengi* is T(I)>MC in August, all of which are against the trends in total assemblage, but these figures may be misleading because of the small sample sizes. *D. lacertosa*'s T(I)>MC in October is noticeable and may or may not suggest a seasonal change of efficiency of the two types of trap for this species. *Drosophila nigromaculata* and *D. suzukii* are T(I)≒MC in July and October respectively, so that both types of trap seem to be equally efficient for these species. Two sibling species, *D. auraria* and *D. biauraria*, show opposite trends from one another in August, the former exhibiting T(I)>MC but the latter MC>T(I). The difference might be due to their competition at feeding sites, though critical evidence must be gathered in future studies. In contrast with the very similar assemblage constitutions between T(I) and MC in early spring and late autumn, the harmonity index values in summer show a dissimilarity, which mainly causes the ultimate differences in total assemblages. The dissimilarity is possibly due to the proportional increase of two predominant species, *D. immigrans* and *D. testacea*, whose relative frequencies are the opposite of one another in relation to the two types of trap, the former being T(I)>MC but the latter MC>T(I) as mentioned above. From these facts, comparative biofaunistic studies with special reference to the seasonal fluctuation of drosophilid assemblage should be made by using the same type of trap.

Concerning to sex ratio, a female excess was seen in 15 of the total of 21 species collected in T(I), while in MC 19 of the 29 species showed a male excess. A scarcity of males collected by "retainer" traps, especially in *D. subobscura*, has also been reported by some European investigators (Basden 1954, Shorrocks 1970, 1975, etc.).

4. Behavioral observation at traps

As shown previously (Figs. 1 and 3), the relative frequencies of some species vary considerably among different types of trap. In order to clarify behavioral aspects causing these differences, some observations were carried out on May 31 and September 21, 1975, at Misumai, using three types of trap, DT, MC and T(I). Three traps, one of each type, were set up more than 10 m apart from each other within the same forest as where the above tests (Parts 1 and 2) were made. The number of individuals was counted every 15 minutes from 5:00 to 19:00 in May and from 5:00 to 18:00 in September, separately for different parts of the traps. DT: on the bait, around it, and under the dish; MC: on the bait, inner surface of the

can, and outer surface; T(I): entrance, trap can, and "retainer". Since the species could not be accurately identified by the naked eye in the field, they were divided into four groups by color and size, YL, YS, BL and BS (Y: yellow, B: black, L: large, and S: small). In September, in addition to the three traps for counting, two more traps, one DT and the other MC, were used to collect flies separately for different parts of the traps. This collection was intended to obtain basic data for species identification of the four groups classified at counting and further to throw light on behavioral differences between the sexes.

From the data gained by the simultaneous collections in September and by other surveys carried out in the corresponding season in the same area, the species belonging to each group were inferred to be as follows: May, YL=*D. confusa*, YS=*D. testacea*, BS=*D. coracina*, and September, YL=*D. histrio*+*D. confusa*+*D. immigrans*, YS=*D. brachynephros*+*D. unispina* +*D. testacea*, BL=*D. sordidula*. In Fig. 4, daily fluctuations of the numbers of individuals counted at different parts of the traps are shown separately for each group. In May, *D. confusa* (YL) showed a clear bimodal pattern of activity, while the daily activity pattern of *D. coracina* (BS) was unimodal and around the middle of the day. *Drosophila testacea* (YS) showed different patterns between the two types of trap, unimodal at MC but a plateau lasting from morning to evening at DT. These agree generally with the results obtained from collections (Toda 1973b). In September, none of the three groups corresponded to a single species, so that general patterns were roughly divisible into two types: bimodal at the open surface of DT and the outer surface of MC, and unimodal with large individual numbers at the shaded places, i.e., the inner surface and on the bait of MC. This leads to an assumption that most drosophilid flies stay at the shaded portion of feeding sites for fairly long periods throughout the daytime in autumn.

Concerning the relative abundance at different parts of the traps, the under surface of DT was almost fruitless (no flies were observed in September), probably being avoided by drosophilid flies for landing or resting. As for each species, *D. coracina* and *D. testacea* were more abundant on the bait than other parts of the traps in May, while for *D. confusa* the opposite was true; in particular they aggregated on the outer surface of MC in the evening. These species-specific distributions suggest behavioral differences among different species in approaching traps, that *D. coracina* and *D. testacea* tend to alight directly on the bait while *D. confusa* alights near the bait and walks towards it after a while. In fact these two different ways of entering the traps were confirmed by observation at T(I). One is that flies fly into the trap without stopping at the entrance (seen in *D. brachynephros* and probably also in *D. testacea*) and the other is that flies alight on the outer surface and walk into the interior (seen in *D. confusa* and *D. sordidula*). These behavioral differences must affect the results obtained by different types of trap. It is supposed that species having the former behavioral type are more influenced than the latter by structural differences between "retainer" and "open" traps, the bait being completely enclosed and moreover the entrance being

covered with wire net (5 mm mesh) in a "retainer" trap. The proportional reduction of *D. coracina* and *D. testacea* in "retainer" trap collections (Parts 1 and 3) could be explained in part by this.

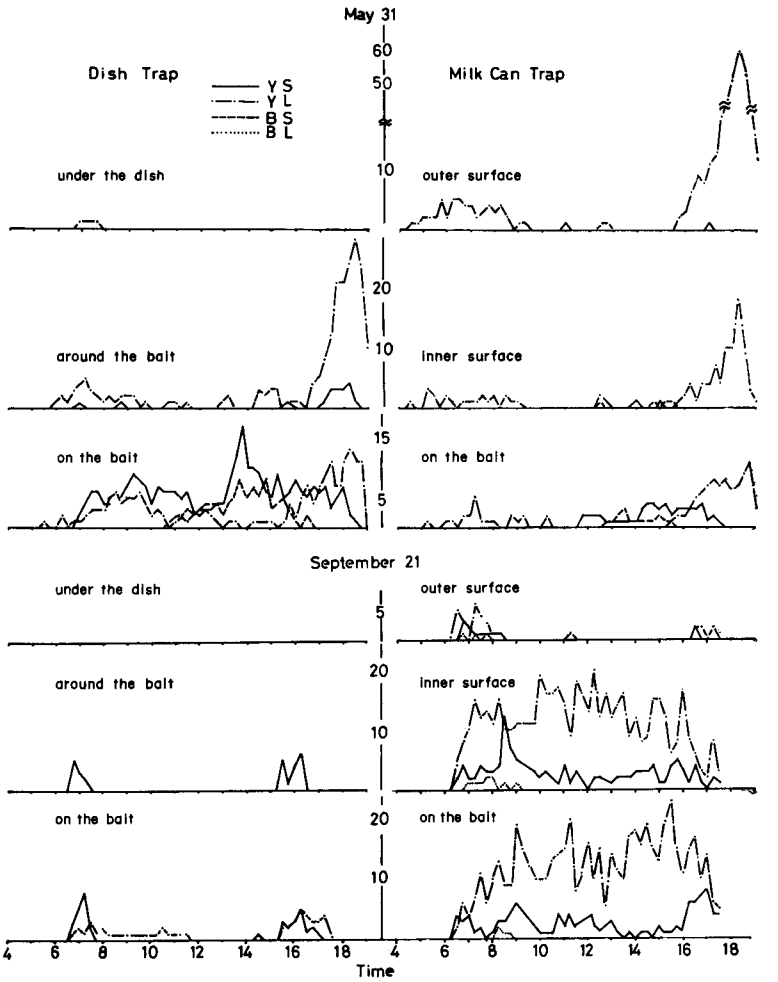

Fig. 4. Daily fluctuation of individual numbers counted separately for different parts of traps.

The tendency for an excess of males in "open" trap collections and the opposite tendency in "retainer" traps mentioned in Parts 1 and 3 agrees with the results by other investigators. To clarify a behavioral aspect causing this difference, numbers of individuals of each sex of species collected in September are

presented in Table 3 for different parts of the traps separately. It is obvious that most species show a male excess around the bait and a female excess on it. This is also supported by the observation at counting especially in *D. confusa* in May, that is, most individuals on the outer surface of MC and around the bait of DT are seemingly males, judging from their sexual behavior, i.e., the persistent following of other individuals for mating. Basden (1954) described that "at open baits males were resting on the outskirts of the bait", and further Spieth (1974) mentioned: "At the food sites, the females devote most of their time and attention to feed and ovipositing. The males spend only a short time feeding and then persistently approach and attempt to court and mate with various females". As pointed out by Basden (loc. cit.), many males on the outskirts would be caught by sweeping over the "open" bait with an insect net even though not actually on the bait, which would cause the male excess at "open" traps, especially at DT in the case of the present survey.

Table 3. Drosophilid flies collected separately at different parts of traps. Individual number of each sex shown by ♀/♂.

Trap	Dish		Milk Can	
Part	Bait	Outskirts	Bait	Outskirts
D. testacea	0/1	1/19	3/2	3/11
D. immigrans	2/0	2/8	6/5	3/8
D. histrio	4/1	2/5	-	1/5
D. unispina	1/0	2/2	1/0	-
D. sordidula	-	2/5	3/2	3/0
D. suzukii	-	1/2	2/1	0/2
D. brachynephros	-	1/0	-	-
D. confusa	-	0/1	1/2	1/0
D. lutescens	-	-	-	0/2
D. busckii	-	-	-	0/1
A. variegata	-	-	-	1/0

Concluding Remarks

On the basis of the peculiarities of each type of trap clarified through the present study, the relative efficiency of different types of trap is evaluated for various types of field survey on drosophilid flies (Table 4). For speedy efficiency, "open" traps are useful for a biofaunistic study within a locality for a short period, the survey of daily activity, and collection of living material for laboratory culture. Furthermore, their open structure facilitates behavioral observations. However, they have the inevitable defect that, in order to collect sufficient samples, they must be visited at frequent intervals throughout the day, so that many traps can not be used at once, and further the investigator cannot leave the area during the surveyed period. To overcome this defect the "retainer" traps were invented. Their automatic collection and storage of samples permits the investigator to leave

Table 4. Suitability of trap-types for various kinds of field survey.

Types of field survey \ Trap-types	Dish	Milk Can	Toda's (II)	Toda's (I)
Biofaunistic study				
Within a locality				
for a short period	++	+	±	−
for a long period	±	±	+	++
Over a wide area	−	−	++	++
Seasonal activity	−	−	+	++
Daily activity	++	+	−	−
Collection at unvisitable places	−	−	++	++
Collection of living material for laboratory culture	++	+	−	−
Behavioral observation	++	+	−	−

the area after setting up the traps. This improvement enables the simultaneous comparison of distribution over a wide range, e.g., altitudinal or geographical distribution, and continuous collections throughout the whole season, which are necessary for surveying seasonal population trends. Moreover, unless a "retainer" trap is used, one cannot make collections at particular places which cannot be frequently visited by investigators, e.g., the forest canopy. Consequently, the kind of traps adopted should be chosen in conformity with the purpose of each survey.

Summary

In order to clarify some problems with respect to the bait trap collections of drosophilid flies, several surveys were carried out at the Misumai Arboretum of Hokkaido University and in the Nopporo Natural Forest in the suburbs of Sapporo City, northern Japan, in 1974 and 1975.

1) Four different types of traps, two new "retainer" traps (Toda's I and II) and two traditional "open" ones (Dish Trap and Milk Can Trap), were compared for efficiency. The Dish Trap was the most efficient in the total number of individuals caught, followed by the Milk Can Trap, Toda's II and Toda's I in that order, though the number of species did not vary significantly among the different types of trap. The constitutions of relative frequencies of the assemblage were different between "retainer" traps and "open" ones, *D. coracina* and *D. testacea* being relatively more frequent in "open" traps than in "retainer" traps, while for *D. confusa*, *D. sordidula*, *D. unispina*, *D. histrio*, *D. brachynephros* and *D. immigrans* the opposite was true.

2) The effects of bait of different ages were surveyed at Misumai, following the above test. After using the same baits for three weeks, the maximum efficient period for Toda's I baited with fermented banana was judged to be two weeks, at least in summer. From the pattern of sequential increase of the cumulative

number of species, which showed an initial steep increase for the first three days followed by a slow increase resulting in a plateau, it was concluded that the minimum collecting period necessary for biofaunistic study was three days.

3) The comparison between Toda's I and Milk Can Trap was carried out throughout the entire active season of the flies. *Drosophila testacea*, *D. coracina*, *D. biauraria*, *D. confusa*, *D. lacertosa*, *D. moriwakii* and *D. pengi* were relatively more frequent in Milk Can Trap than in Toda's I, while for *D. immigrans*, *D. brachynephros* and *D. auraria* the opposite was true, though several species reversed their trends somewhat from season to season. The assemblage constitutions were similar in early spring and late autumn, but very different in summer. The dissimilarity in summer seemed to be due to the proportional increase of two predominant species, *D. immigrans* and *D. testacea*, whose relative frequencies were opposed to one another in relation to the two types of trap, and this ultimately caused a difference in total assemblage constitutions throughout the whole season.

4) Behavioral observations were made at three different types of trap, the Dish Trap, Milk Can Trap and Toda's I. Daily activity patterns based on individual numbers not collected but counted at the traps, which were reported for the first time in the present study, generally coincided with the results hitherto obtained by collection in other surveys. The species-specific distributions of counted individual numbers among different parts of the traps suggested that *D. coracina* and *D. testacea* tend to alight directly on the bait, while *D. confusa* alights near the bait and walks towards it after a while. Consequently, the structural differences of "retainer" traps from "open" ones would affect the former species more seriously, causing their proportional reductions.

5) The tendency towards an excess of males in "open" trap collections and female excess in "retainer" ones was attributed to behavioral differences at the traps between the sexes. Females spend most of their time on the bait for feeding and laying, while males stay on the outskirts for courting and mating.

6) On the basis of the peculiarities of each type of trap, the relative efficiency of different types of trap was evaluated for various kinds of field surveys.

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