Influence of Forest Felling upon Drosophilid Fauna at Several Localities in Hokkaido

By

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北海道におけるショウジョウバエ相に与える森林伐採の影響

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Up to the present a number of studies have been published on the allogenic animal succession occurring in rapidly changing environments (WOODRUFF 1911, 1912, 1913, BLACKMAN and STAGE 1924, PARK 1931, SAVELY 1939, MOHR 1943, DAGGY 1946). However, changes occurring in the course of plant succession, being one of the most fascinating ecological problems, have relatively been ignored since the classic work by SHELFORD (1907, etc.). In Hokkaido few such studies have been carried out except those on field mice in planted areas and surrounding natural forests (KINOSHITA and MAEDA 1961, etc.) and on forest soil mesofauna by "Hokkaido Soil Animals Survey Group" (1970).

Faunal change of drosophilids in the course of plant succession after felling has been one of the main problems since I started in 1971 the ecology of this group. In the previous work (TODA 1973) it was observed that the microhabitat preference of each drosophilid species showed a more or less remarkable species specificity. This indicates that the change of drosophilid fauna by felling is plausible.

In the present study samples were collected from cut-over areas of diverse conditions, old or new, clearly cut or received selective cutting of various ratios, at three localities (Misumai, Bannosawa and Hyakumatsuzawa) in Jozankei mountaneous region and at four localities (Tenpoku Pass, Nakagawa, Osashima and Kami-Otoineppu) in Nakagawa Experiment Forest, Hokkaido University, (Fig. 1) in 1972, mainly adopting fruit-traps baited with fermented banana. Comparison of drosophilid assemblages in such cut-over areas may serve as the first approximation to know the influence of felling on drosophilid fauna. In the following pages the results obtained are reported separately for each locality, accompanied with a brief discussion. In all cases the faunal make-up before felling was not directly surveyed. Therefore, the faunal change was assumed through the comparison with the data taken at neighbouring unmodified forest environments.

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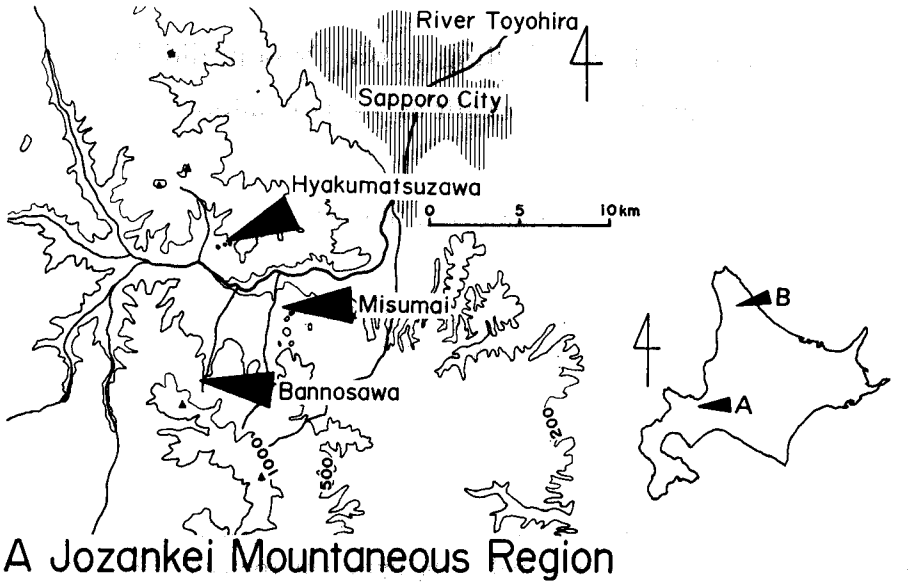

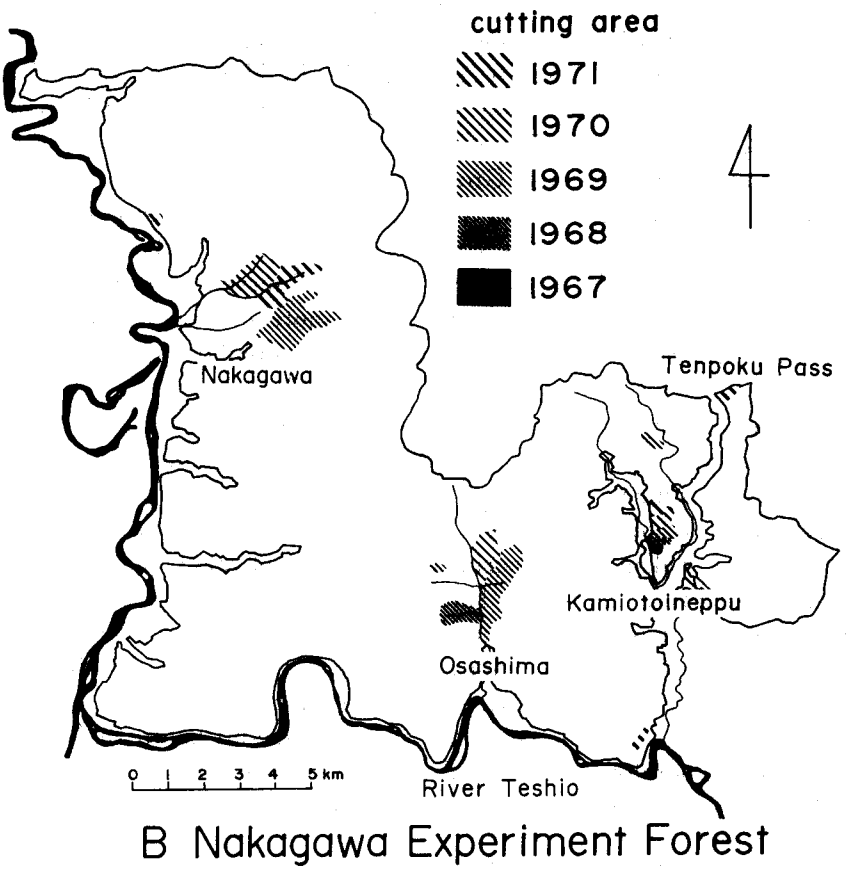

Fig. 1. Localities surveyed.

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Results and Discussion

1. Misumai

A natural forest at a northwestern slope near Misumai Arboretum was twice (late May~early June and early August in 1972) clearly cut as a house-lot. Two collections were made soon after this felling.

Survey (1)

Flies were collected during three days (June 16~18, 1972), seven times (5 : 00 ~17 : 00) per day, immediately after the first felling, when all plants covering land surface had been already completely removed by bulldozers. In total twelve traps were set in this naked area and its surroundings (Fig. 2-A).

A: Center of the clear cut area.
B: Along a stream running through the clear cut area.
C: A bush mainly composed of bamboo-grasses at the northeastern corner of the clear cut area.
D: Roadside larch trees at the lowest part of the clear cut area. The opposite side of the road is sparsely occupied by farm houses.
E: A grove of broad-leaved trees remained after clear cutting at the northwestern corner of the clear cut area.
F: A shrubbery edge along a gutter at the top of the clear cut area.
G, H: Edge of a streamside forest facing the clear cut area.
I: Edge of a larch forest facing the clear cut area.
J: A mixed forest of white birches and larches.
K: A streamside forest.
L: A larch forest.

Results

As shown in Table 1 and Fig. 2-A, *D. coracina* and *D. bifasciata* are predominant at every station, especially abundant at edges (D, E, G, H and I) of the clear cut area. *D. moriwakii* shows relatively high percentages in the clear cut area and at its edges, reaching 71.9% (41 specimens) at C and 42.4% (28 specimens) at F, and *D. lacertosa* belonging to *robusta* group as the former species has the same tendency, increasing in and around the clear cut area. On the contrary, *D. confusa* and *D. histrio* are not collected at all in the clear cut area but at forest edges and in forest interior, especially abundant at stations, J. K, L, (*D. confusa*: 20.9, 28.6 and 35.3% at J, K, and L, *D. histrio*: 16.3 and 14.7% at J and L, respectively). *D. testacea* also tends to be confined to the

Table 1. Flies collected in Survey (1) at Misumai.

Trap station	A		B		C		D		E		F		G		H		I		J		K		L		TOTAL
Vegetation	clear cut area		clear cut area (stream)		clear cut area edge		clear cut area edge		grove		forest edge		forest edge		forest edge		forest edge		forest		forest		forest		
	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	
A. variegata	—	—	—	—	—	—	—	—	2	1.9	1	1.5	—	—	—	—	—	—	—	—	—	—	—	—	3
C. atrimana	—	—	1	2.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
D. confusa	—	—	—	—	—	—	—	—	4	3.8	2	3.0	1	1.7	5	5.7	—	—	9	20.9	6	28.6	12	35.3	39
D. busckii	—	—	—	—	—	—	1	1.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
D. coracina	2	9.1	4	8.3	2	3.5	38	49.4	77	73.3	4	6.1	38	65.5	47	54.0	20	42.6	16	37.2	7	33.3	10	29.4	265
D. bifasciata	10	45.5	10	20.8	11	19.3	22	28.6	8	7.6	21	31.8	12	20.7	12	13.8	9	19.1	4	9.3	5	23.8	—	—	124
D. imaii	—	—	—	—	—	—	—	—	1	1.0	—	—	—	—	1	1.1	—	—	1	2.3	—	—	—	—	3
D. auraria	—	—	5	10.4	—	—	6	7.8	6	5.7	—	—	—	—	—	—	2	4.3	—	—	—	—	—	—	19
D. biauraria	—	—	—	—	—	—	3	3.9	5	4.8	—	—	2	3.4	1	1.1	4	8.5	—	—	—	—	5	14.7	20
D. testacea	1	4.5	—	—	1	1.8	—	—	1	1.0	3	4.6	1	1.7	3	3.4	—	—	5	11.6	2	9.5	2	5.9	19
D. nigro-maculata	—	—	—	—	—	—	—	—	—	—	1	1.5	—	—	—	—	—	—	—	—	—	—	—	—	1
D. histrio	—	—	—	—	—	—	—	—	—	—	1	1.5	1	1.7	—	—	—	—	7	16.3	1	4.8	5	14.7	15
D. immigrans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1.1	—	—	—	—	—	—	—	—	1
D. virilis	1	4.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
D. ezoana	1	4.5	3	6.3	—	—	1	1.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
D. sordidula	—	—	—	—	—	—	2	2.6	1	1.0	3	4.6	1	1.7	2	2.3	4	8.5	1	2.3	—	—	—	—	14
D. lacertosa	4	18.2	12	25.0	1	1.8	3	3.9	—	—	—	—	2	3.4	3	3.4	1	2.1	—	—	—	—	—	—	26
D. moriwakii	2	9.1	7	14.6	41	71.9	—	—	—	—	28	42.4	—	—	9	10.3	7	14.9	—	—	—	—	—	—	94
D. okadai	—	—	4	8.3	—	—	—	—	—	—	—	—	—	—	1	1.1	—	—	—	—	—	—	—	—	5
D. neokadai	—	—	2	4.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
D. multispina	—	—	—	—	—	—	1	1.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
D hydei	1	4.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
D. pengi	—	—	—	—	1	1.8	—	—	—	—	2	3.0	—	—	2	2.3	—	—	—	—	—	—	—	—	5
TOTAL	22		48		57		77		105		66		58		87		47		43		21		34		665

closed environment, though two specimens were collected in the open environment (A, C). *D. auraria* is collected only at stations near human habitation (B, D, E and I). *D. biauraria* shows the same tendency, but sporadically found in the closed environment.

Discussion

The most remarkable outcome soon after clear cutting is the withdrawal of forest species into surrounding forests. *D. confusa*, *D. histrio*, and probably *D. testacea* are difficult to survive in clearly cut open environment, so that they retire to surrounding forests. *D. coracina* and *D. bifasciata* are regarded as forest species but occur frequently at traps in open clear cut area, which suggests their wide-roaming nature visiting from surrounding forests, though the crucial information for their flight range is still absent. Furthermore, the significant abundance of these species at edges of the clear cut area suggests a condensation of previous populations at surrounding closed areas after clear cutting.

On the other hand, *D. moriwakii* was abundant in and around the clear cut area after felling. Furthermore, the records of *D. auraria*, a domestic species adapted to grassland (KUROKAWA 1956, KANEKO *et al.* 1966, TODA 1973), at traps near human habitation suggest its invasion from the latter.

Comparing the samples taken at two traps (A and B) in the clear cut area, relatively more specimens of four species belonging to *robusta* group (*D. lacertosa*, *D. moriwakii*, *D. okadai* and *D. neokadai*) and *D. ezoana* were collected at station B beside a stream. These hygrophilous species (TAKADA 1958, TAKADA and OKADA 1958, KANEKO and SHIMA 1962, KANEKO and TOKUMITSU 1969, WAKAHAMA *et al.* 1963, TODA 1973) may stay at streamside for an indefinite time even after clear cutting.

Survey (2)

After the lower section of the area mentioned above was clearly cut during late May~early June, the adjacent upper section received the same operation during early August and readjusted till mid September by bulldozers. In total nine traps were set in the two areas and their surroundings as follows (Fig. 2–B).

Four traps (A, B, H and K) in the lower section and its surroundings: The lower section had been changed to a well developed grassland. The detailed environment of each trap station was described in Survey (1).

Four traps in the upper section and its surroundings

M: A shrubbery remained at the center of the upper section clearly cut in early August.

N: A shrubbery belt between the upper section and grassland B.

P: Edge of a larch forest facing the upper section.

Q: A larch forest near P.

Further, another trap in grassland B

O: Trap VI (cf. TODA 1973).

Flies were collected six times (7:00~17:00) per day on September 9 and 10, 1972.

Results

As shown in Table 2 and Fig. 2–B, *D. auraria* is very abundant (85.7 and 91.3% at A and B, respectively) in the lower clear cut area, while *D. immigrans*, *D. lutea* and *D. sordidula* are predominant in its neighbouring forest (K). At the forest edge (H) between these two vegetations *D. auraria*, *D. immigrans* and *D. sordidula* are predominant, suggesting an ecotonal character of this habitat. On the other hand, individuals collected at every trap in the upper section and its surroundings are few, especially no specimen obtained at Q, though *D. suzukii* tends to be predominant at M and N.

Table 2. Flies collected in Survey (2) at Misumai.

Trap station	M		A		B		N		O		P		H		K		TOTAL
Vegetation	cl. upper		cl. lower		cl. stream		cl. edge, GB		GB Ts. VI		forest edge, U		forest edge, L		forest (SF)		
	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	
A. variegata	1	14.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
D. busckii	—	—	—	—	1	1.4	—	—	—	—	—	—	—	—	—	—	1
D. bifasciata	—	—	—	—	—	—	—	—	—	—	1	50.0	2	5.9	1	5.3	4
D. melanogaster	—	—	—	—	2	2.9	—	—	—	—	—	—	—	—	—	—	2
D. suzukii	3	42.9	2	3.2	—	—	7	63.6	—	—	—	—	1	2.9	—	—	13
D. lutea	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5	26.3	5
D. auraria	1	14.3	54	85.7	63	91.3	—	—	—	—	—	—	16	47.1	—	—	134
D. biauraria	1	14.3	2	3.2	—	—	—	—	1	33.3	—	—	2	5.9	—	—	6
D. nigromaculata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	5.3	1
D. brachynephros	—	—	—	—	—	—	—	—	1	33.3	—	—	—	—	1	5.3	2
D. histrio	—	—	—	—	—	—	—	—	1	33.3	—	—	—	—	1	5.3	2
D. immigrans	1	14.3	1	1.6	—	—	2	18.2	—	—	1	50.0	4	11.8	8	42.1	17
D. virilis	—	—	—	—	1	1.4	—	—	—	—	—	—	—	—	—	—	1
D. sordidula	—	—	2	3.2	—	—	1	9.1	—	—	—	—	5	14.7	2	10.5	10
D. pseudosordidula	—	—	—	—	—	—	—	—	—	—	—	—	1	2.9	—	—	1
D. lacertosa	—	—	2	3.2	1	1.4	—	—	—	—	—	—	3	8.8	—	—	6
D. hydei	—	—	—	—	1	1.4	—	—	—	—	—	—	—	—	—	—	1
D. pengi	—	—	—	—	—	—	1	9.1	—	—	—	—	—	—	—	—	1
TOTAL	7		63		69		11		3		2		34		19		208

Discussion

The results of two successive surveys cannot exactly be compared owing to the specific differences in seasonal fluctuations. But there are some noticeable changes in faunal succession after clear cutting. The remarkable increase of *D. auraria* in the lower section in September may closely be related to grassing after

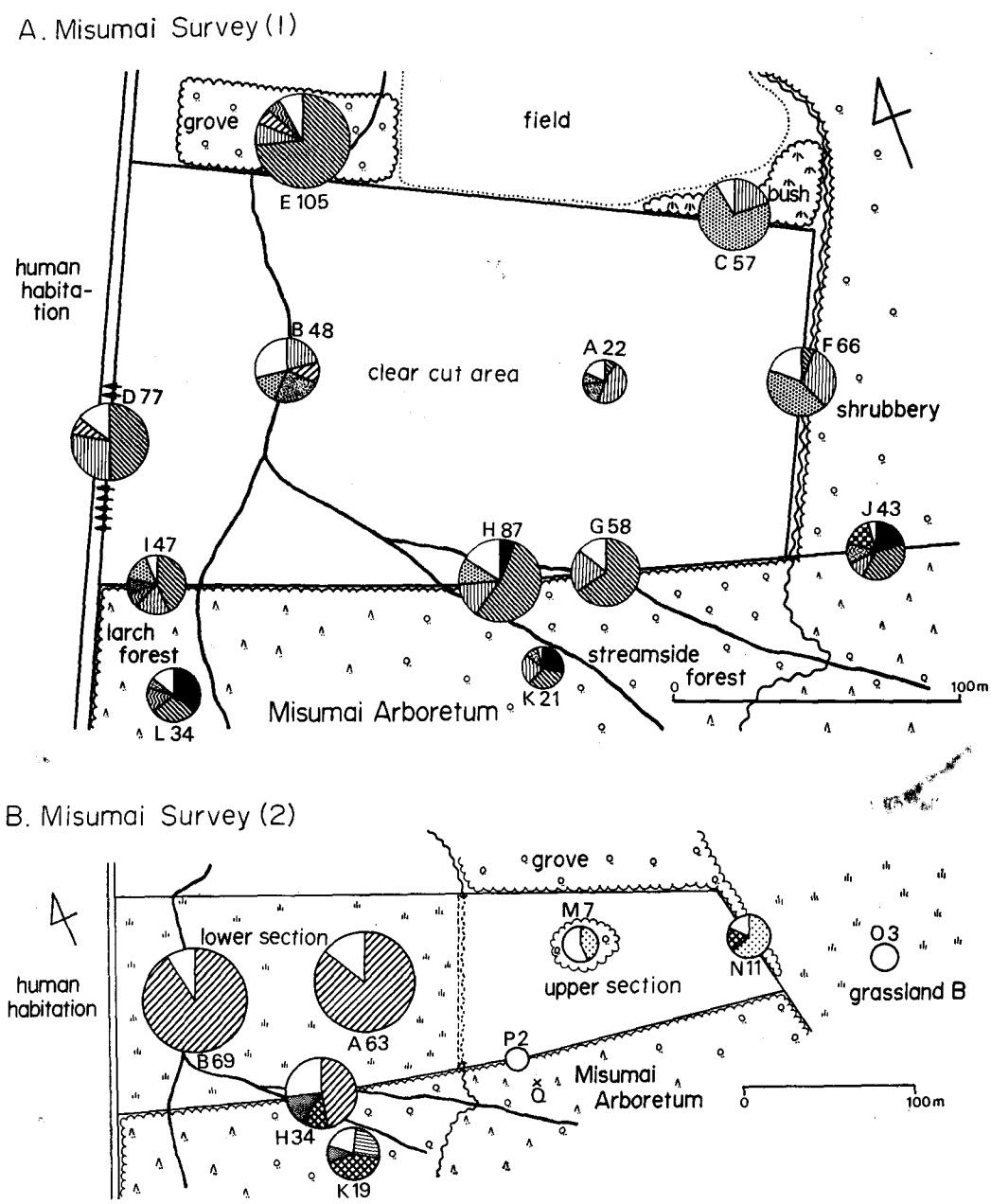

Fig. 2. Assemblage structure with relative abundance of predominant species (whose hatching patterns are shown in Fig. 3) in Misumai surveys, separately shown for each trap. Total specimen number at each station is given after station symbol, and sample size per trap is shown by the size of circle, which is same scaled only in the same survey.

clear cutting. Probably this domestic species is also adapted to the grassland of particular type. It invaded into the clear cut area in June and established there successfully by occupying its proper niche. The absence of this species in grassland B, similar to the lower section, indicates that the invasion was prevented by the forest having existed before the later clear cutting between the lower section and grassland B, which, though only 200 m wide, would act as an effective barrier. On the other hand, the high percentage of *D. moriwakii* soon after clear cutting in June, and its virtual disappearance in September may be related to

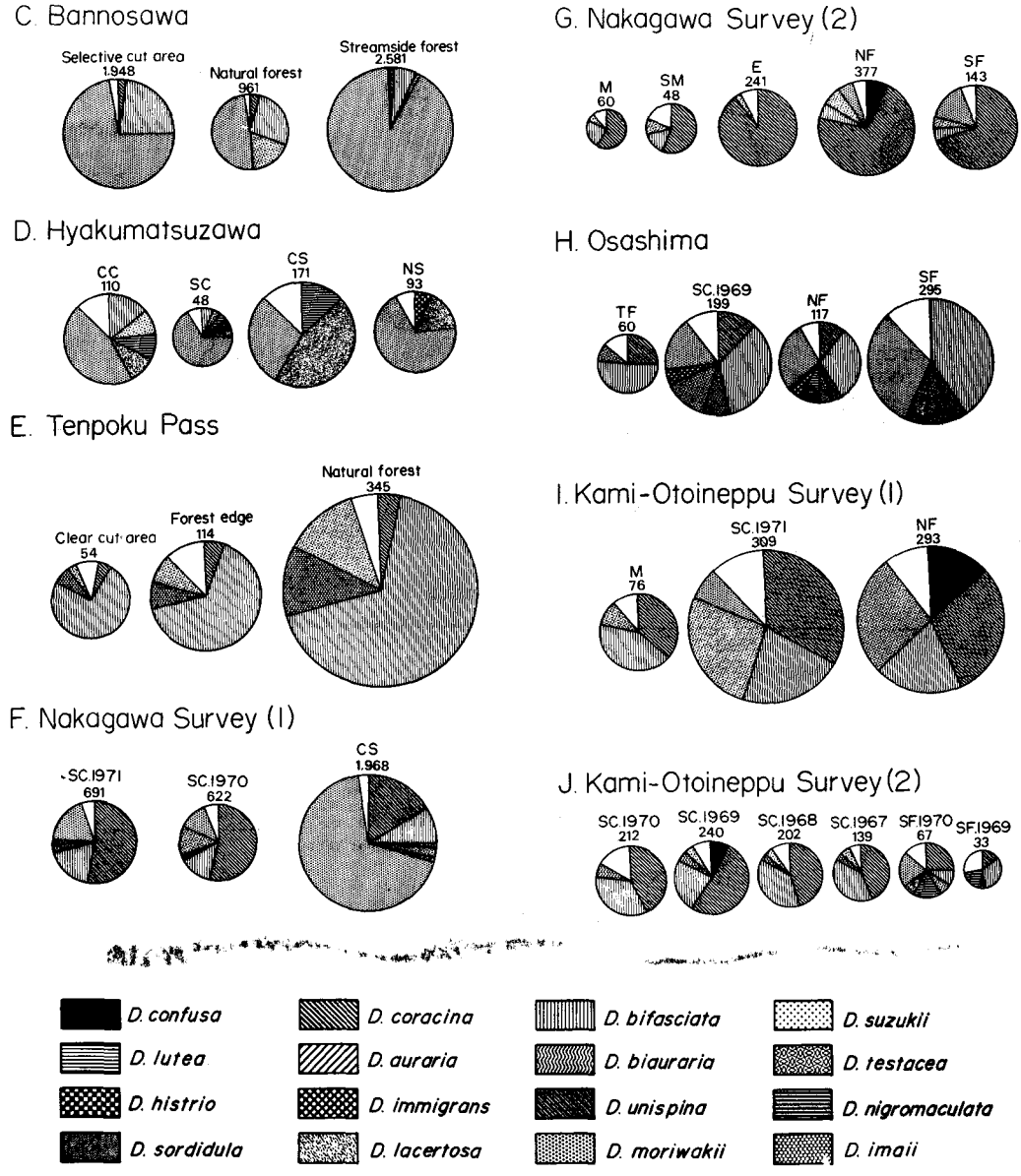

Fig. 3. Assemblage structure in other surveys.

some environmental changes in the course of grassing, though the pattern of its seasonal fluctuation, unfortunately still not well known, must also be considered.

2. Bannosawa

A natural mixed forest at Bannosawa was selectively cut at about 80% cutting ratio in 1971. Flies were collected for three days (July 14~16) in 1972, from two traps each in the following vegetation ; selective cut area, natural forest and streamside forest (in total six traps). Sampling from traps was repeated seven times (5 : 00~17 : 00) on July 14 and 16, and eight times (5 : 00~19 : 00) on July 15.

Results

Comparing the drosophilid assemblage in selective cut area with that in natural forest by Table 3 and Fig. 3-C, the following two differences are remarkable. *D. testacea* is clearly more frequent in natural forest (173 specimens, 18.00%) than in selective cut area (15, 0.77%), while *D. moriwakii* shows an opposite tendency, more abundant in the latter (1,407, 72.23%) than in the former (469, 48.80%). A clear habitat preference is also found in some less abundant species: *D. confusa* collected only in natural forest, while *D. sordidula*, *D. okadai* and *D. lacertosa vice versa*. Two predominant species, *D. bifasciata* and *D. coracina*, are abundant in both vegetations without significant difference. Finally the assemblage in streamside forest is almost exclusively composed of *D. moriwakii* (2,363, 91.55%).

Table 3. Flies collected at Bannosawa.

Vegetation	selective cut area		natural forest		streamside forest		TOTAL
	N	%RF	N	%RF	N	%RF	
L. quinquemaculipennis	—	—	1	0.10	—	—	1
A. variegata	5	0.26	3	0.31	1	0.04	9
C. atrimana	1	0.05	—	—	—	—	1
C. caudatula	2	0.10	—	—	—	—	2
D. confusa	—	—	5	0.52	—	—	5
D. coracina	45	2.31	43	4.47	33	1.28	121
D. bifasciata	444	22.79	254	26.43	138	5.35	836
D. imaii	8	0.41	7	0.73	4	0.15	19
D. helvetica	4	0.21	—	—	—	—	4
D. testacea	15	0.77	173	18.00	31	1.20	219
D. nigromaculata	—	—	1	0.10	1	0.04	2
D. unispina	—	—	1	0.10	—	—	1
D. immigrans	—	—	—	—	1	0.04	1
D. sordidula	13	0.67	4	0.42	4	0.15	21
D. lacertosa	1	0.05	—	—	—	—	1
D. moriwakii	1,407	72.23	469	48.80	2,363	91.55	4,239
D. okadai	3	0.15	—	—	5	0.19	8
TOTAL	1,948		961		2,581		5,490

Discussion

The increase of *D. moriwakii* soon after felling, the tendency observed in June at Misumai, was again confirmed, showing an explosive increase. In this case this explosion in selective cut area extended also into neighbouring unmodified forests, both natural and streamside ones, especially into the latter. Furthermore, *D. sordidula*, *D. okadai* and *D. lacertosa*, all belonging to *robusta* group as *D. moriwakii*, showed a similar increase in selective cut area. The selective cutting at about 80% ratio seems to affect the distribution of *D. testacea* and *D. confusa*, but not of *D. bifasciata* and *D. coracina*, that is, the former two stenotopic forest species retire into natural forest after selective cutting.

3. Hyakumatsuzawa

A natural mixed forest at Hyakumatsuzawa was selectively cut at about 50% ratio during early July~early September in 1972. Flies were collected six times (7 : 00~17 : 00) per day on September 15 and 16, 1972, from two traps set each in the following vegetations (in total eight traps).

Clear cut area (CC): A clear cut area of about 2,500 m² isolated at the center of selective cut area for accumulation of cut trees.
Selective cut area (SC): A forest cut selectively.
Selective cut streamside area (CS): Along a stream running through selective cut area.
Natural streamside forest (NS): Along a stream running through natural forest.

Results and Discussion

Predominant species in each vegetation are referred to here (Table 4 and Fig. 3–D). In both CC and SC, *D. moriwakii* is the top-ranked species, followed by *D. bifasciata*, *D. testacea*, *D. nigromaculata* and *D. lacertosa*, showing a similar assemblage structure. *D. lacertosa*, *D. moriwakii* and *D. nigromaculata* are predomiant in CS, and *D. moriwakii*, *D. lacertosa* and *D. histrio* in NS.

The increase of *D. moriwakii* in all vegetations is again remarkable but not so explosive as at Bannosawa. Not so extensive clear cutting within surrounding selective cut area may not show its characteristic effects in assemblage structure.

4. Tenpoku Pass

A natural mixed forest was clearly cut along the road at Tenpoku Pass in 1971. Collection was made five times (5 : 00~17 : 00) per day on August 18 and 19, 1972, from two traps set in each of the following vegetations (in total six traps); clear cut area, forest edge and natural forest.

Results and Discussion

As seen in Table 5 and Fig. 3–E, the relative abundance of four predominant species common to three vegetations is quite similar: *D. bifasciata* is top-ranked, followed by *D. testacea*, *D. imaii* and *D. coracina*. The amounts of total collected individuals differred among vegetations, showing an increased gradient from open

Table 4. Flies collected at Hyakumatsuzawa.

Vegetation	CC		SC		CS		NS		TOTAL
	N	%RF	N	%RF	N	%RF	N	%RF	
A. variegata	6	5.5	—	—	1	0.6	—	—	7
D. coracina	1	0.9	—	—	—	—	—	—	1
D. bifasciata	16	14.5	3	6.3	—	—	2	2.2	21
D. imaii	—	—	1	2.1	—	—	—	—	1
D. suzukii	—	—	1	2.1	—	—	—	—	1
D. testacea	10	9.1	2	4.2	—	—	—	—	12
D. nigromaculata	10	9.1	2	4.2	23	13.5	2	2.2	37
D. unispina	2	1.8	3	6.3	1	0.6	—	—	6
D. histrio	—	—	1	2.1	3	1.8	6	6.5	10
D. immigrans	1	0.9	1	2.1	5	2.9	—	—	7
D. lacertosa	11	10.0	2	4.2	78	45.6	16	17.2	107
D. moriwakii	50	45.5	32	66.7	49	28.7	64	68.8	195
D. okadai	3	2.7	—	—	8	4.7	2	2.2	13
D. neokadai	—	—	—	—	3	1.8	—	—	3
D. pengi	—	—	—	—	—	—	1	1.1	1
TOTAL	110		48		171		93		422

Table 5. Flies collected at Tenpoku Pass.

Vegetation	clear cut area		forest edge		natural forest		TOTAL
	N	%RF	N	%RF	N	%RF	
L. quinquemaculipennis	—	—	—	—	2	0.6	2
A. stylopyga	—	—	1	0.9	—	—	1
A. variegata	2	3.7	4	3.5	2	0.6	8
D. confusa	—	—	—	—	3	0.9	3
D. coracina	3	5.6	7	6.1	13	3.8	23
D. rufifrons	—	—	1	0.9	—	—	1
D. bifasciata	40	74.1	75	65.8	233	67.5	348
D. imaii	4	7.4	9	7.9	41	11.9	54
D. suzukii	—	—	1	0.9	—	—	1
D. melanogaster	—	—	—	—	1	0.3	1
D. auraria	1	1.9	—	—	—	—	1
D. testacea	2	3.7	10	8.8	43	12.5	55
D. brachynephros	—	—	1	0.9	—	—	1
D. immigrans	1	1.9	4	3.5	3	0.9	8
D. lacertosa	—	—	—	—	1	0.3	1
D. moriwakii	—	—	1	0.9	3	0.9	4
D. hydei	1	1.9	—	—	—	—	1
TOTAL	54		114		345		513

to closed environment. These results suggest the withdrawal of the forest species from opened area to surrounding closed forest after clear cutting with occasional visits to the former, as observed in *D. bifasciata* and *D. coracina* at Misumai. Moreover, the higher percentage of *D. bifasciata* in clear cut area than in the other vegetations suggests that this species is wider-roaming than the other three. Among other rare species, *D. confusa* showed a clear habitat preference, collected only in natural forest. Furthermore, in this case *D. moriwakii* did not exhibit an increase after felling as at Misumai, Bannosawa and Hyakumatsuzawa.

5. Nakagawa

Survey (1)

A natural mixed forest was selectively cut at about 60% ratio in 1970 and 1971. Flies were collected five times (5 : 00～17 : 00) per day on July 29 and 30, 1972, from two traps set in each of the following vegetations (in total six traps).

Selective cut area in 1970 (SC. 1970)
Selective cut area in 1971 (SC. 1971)
Selective cut streamside forest (CS): Along a stream running along the border line between two selective cut areas.

Table 6. Flies collected in Survey (1) at Nakagawa.

Vegetation	SC. 1971		SC. 1970		CS		TOTAL
	N	%RF	N	%RF	N	%RF	
L. maculata	1	0.14	—	—	—	—	1
L. quinquemaculipennis	—	—	1	0.16	—	—	1
Amiota (*A.*) spp.	3	0.43	2	0.32	—	—	5
A. variegata	9	1.30	4	0.64	5	0.25	18
D. trivittata	—	—	—	—	1	0.05	1
D. confusa	8	1.16	8	1.29	11	0.56	27
D. coracina	365	52.82	335	53.86	322	16.36	1,022
D. rufifrons	5	0.72	5	0.80	—	—	10
D. bifasciata	125	18.09	84	13.50	167	8.49	376
D. imaii	24	3.47	15	2.41	22	1.12	61
D. melanogaster	—	—	1	0.16	—	—	1
D. testacea	12	1.74	77	12.38	44	2.24	133
D. nigromaculata	—	—	—	—	1	0.05	1
D. unispina	—	—	1	0.16	—	—	1
D. brachynephros	—	—	1	0.16	—	—	1
D. histrio	—	—	5	0.80	—	—	5
D. virilis	—	—	—	—	2	0.10	2
D. ezoana	—	—	—	—	13	0.66	13
D. lacertosa	1	0.14	—	—	23	1.17	24
D. moriwakii	129	18.67	75	12.06	1,343	68.24	1,547
D. okadai	1	0.14	—	—	12	0.61	13
D. neokadai	—	—	—	—	1	0.05	1
D. pengi	8	1.16	8	1.29	1	0.05	17
TOTAL	691		622		1,968		3,281

Results

Comparing two selective cut areas (Table 6 and Fig. 3-F), *D. coracina*, *D. bifasciata* and *D. moriwakii* are predominant in both. *D. testacea* was thirdly ranked in SC. 1970 (77 specimens, 12.38%) but remarkably decreased (12, 1.74%) in SC. 1971. Among other rare species *D. histrio* is limited to SC. 1970. In CS *D. moriwakii* is very abundant (1,343 specimens), occupying more than a half of total individuals collected (68.24%).

Survey (2)

Another survey was made on August 1 and 2, 1972, five times (5 : 00~17 : 00) per day as a control for Survey (1) in an area not so distant from the selective cut areas mentioned above, involving natural mixed forest and meadow. In total eight traps were set in the following vegetations.

Two traps in meadow (M)
One trap in streamside meadow (SM): In a bush along a stream running through meadow.
Two traps at forest edge (E)
Two traps in natural forest (NF)
One trap in streamside forest (SF)

Results

As shown in Table 7 and Fig. 3-G, the total number of collected individuals is smaller in open environments (M and SM), *D. coracina*, *D. bifasciata* and *D. testacea* being predominant. At E *D. coracina* is significantly abundant (217 specimens), occupying the majority (90.0%). The assemblages in NF and SF are similar in composition, both possessing *D. coracina* as predominant species with two noticeable exceptions: Most specimens of *D. confusa* were collected in NF (28 out of 31 total specimens), and *D. moriwakii* took the second rank (15.4%), following *D. coracina*, in the assembalge of SF, while 5.3% in NF.

Discussion

As in the case of Misumai, the direct comparison of two surveys cannot exactly be made for difference in climatic conditions and resulting daily activities. But there are some peculiarities of drosophilid fauna in selective cut area, which suggest the influence of felling. The increase of *D. moriwakii* is clearly observed in selective cut area, especially very explosive along a stream as at Bannosawa. The selective cutting at about 60% ratio removes *D. confusa*, *D. testacea* and *D. histrio* from there, though the latter two species seem to recover their population densities about two years later by still unknown causes. Occasional visits of *D. coracina*, *D. bifasciata* and *D. testacea* to open meadow are also observed in Survey (2), like as at Misumai and Tenpoku Pass.

6. Osashima

Flies were collected five times (5 : 00~17 : 00) per day on August 14 and 15,

Table 7. Flies collected in Survey (2) at Nakagawa.

Vegetation	M		SM		E		NF		SF		TOTAL
	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	
A. variegata	—	—	—	—	1	0.4	3	0.8	—	—	4
D. confusa	—	—	1	2.1	2	0.8	28	7.4	—	—	31
D. coracina	35	58.3	27	56.3	217	90.0	268	71.1	100	69.9	647
D. rufifrons	—	—	—	—	1	0.4	2	0.5	—	—	3
D. bifasciata	14	23.3	7	14.6	3	1.2	20	5.3	7	4.9	51
D. imaii	1	1.7	—	—	4	1.7	5	1.3	3	2.1	13
D. suzukii	—	—	1	2.1	—	—	—	—	—	—	1
D. biauraria	1	1.7	—	—	—	—	—	—	—	—	1
D. testacea	4	6.7	5	10.4	7	2.9	25	6.6	6	4.2	47
D. nigromaculata	1	1.7	1	2.1	1	0.4	—	—	—	—	3
D. unispina	—	—	—	—	—	—	1	0.3	—	—	1
D. brachynephros	—	—	1	2.1	—	—	—	—	—	—	1
D. histrio	—	—	—	—	—	—	1	0.3	2	1.4	3
D. immigrans	—	—	—	—	—	—	1	0.3	—	—	1
D. ezoana	1	1.7	—	—	—	—	—	—	—	—	1
D. lacertosa	—	—	1	2.1	—	—	—	—	1	0.7	2
D. moriwakii	—	—	1	2.1	4	1.7	20	5.3	22	15.4	47
D. multispina	—	—	—	—	—	—	1	0.3	—	—	1
D. pengi	3	5.0	3	6.3	1	0.4	2	0.5	2	1.4	11
TOTAL	60		48		241		377		143		869

1972, in the following vegetations, in each of which two traps were set up (in total eight traps).

Planted area with Saghalien fir (*Abies sachalinensis*) seedling TF: An open environment received clear cutting in 1968 and planted with Saghalien fir seedling after that.
Selective (about 60%) cut area in 1969 (SC. 1969)
Natural mixed forest (NF)
Streamside forest (SF)

Results and Discussion

The data obtained in this survey are shown in Table 8 and Fig. 3-H. In TF the total collected individuals are fewer, with occasional visits of the following forest species, *D. bifasciata*, *D. coracina* and *D. testacea*, like as in open environments near forests at other localities mentioned above. As for other closed environments (SC. 1969, NF, SF), no remarkable difference in assemblage structure is noticed, with *D. bifasciata* and *D. moriwakii* being significantly abundant. Therefore, the influence by selective cut in 1969 probably nearly disappeared after three years, except for the abundance of *D. moriwakii* in selective cut area and the neighbouring forest.

Table 8. Flies collected at Osashima.

Vegetation	TF		SC. 1969		NF		SF		TOTAL
	N	%RF	N	%RF	N	%RF	N	%RF	
L. quinquemaculipennis	—	—	2	1.0	—	—	1	0.3	3
A. variegata	4	6.7	2	1.0	1	0.9	—	—	7
D. confusa	—	—	3	1.5	—	—	1	0.3	4
D. busckii	—	—	—	—	—	—	1	0.3	1
D. coracina	15	25.0	24	12.1	12	10.3	9	3.1	60
D. bifasciata	31	51.7	69	34.7	36	30.8	120	40.7	256
D. imaii	2	3.3	16	8.0	5	4.3	14	4.7	37
D. auraria	—	—	—	—	1	0.9	—	—	1
D. testacea	6	10.0	27	13.6	6	5.1	18	6.1	57
D. nigromaculata	1	1.7	7	3.5	10	8.5	2	0.7	20
D. histrio	1	1.7	4	2.0	6	5.1	5	1.7	16
D. immigrans	—	—	10	5.0	3	2.6	5	1.7	18
D. virilis	—	—	—	—	—	—	1	0.3	1
D. ezoana	—	—	—	—	—	—	9	3.1	9
D. lacertosa	—	—	1	0.5	4	3.4	16	5.4	21
D. moriwakii	—	—	33	16.6	33	28.2	92	31.2	158
D. okadai	—	—	1	0.5	—	—	—	—	1
D. pengi	—	—	—	—	—	—	1	0.3	1
TOTAL	60		199		117		295		671

7. Kami-Otoineppu

An experimental area for BIOLLEY's "Kontrollmethode" is settled in natural mixed forest mainly composed of Saghalien fir, Akaezo spruce (*Picea Glehni*) fir and broad-leaved trees. In this area damaged and wolf trees have been selectively (10~15%) cut year by year since 1967, together with supplementary planting with Saghlien fir seedling at open land by BIOLLEY's method.

Survey (1)

Collection was made five times (5 : 00~17 : 00) per day on August 5 and 6, 1972, in selecitve cut area in 1971 (SC. 1971), its neighbouring meadow (M) and natural forest (NF), in each of which two traps were set up (in total six traps).

Results

The assemblage structure in SC. 1971 and NF shows a similar predominance of *D. coracina*, *D. testacea* and *D. bifasciata* (Table 9 and Fig. 3–I). *D. moriwakii* is more abundant (21 specimens, 6.8%) in SC. 1971 than (3, 10%) in NF, while *D. confusa vice versa* (41, 14.0% in the latter, 9, 2.9% in the former). The small sample obtained in M shows the predominance of the following occasional visitors from forest: *D. bifasciata* (42.1%), *D. coracina* (36.8%) and *D. testacea* (10.5%).

Table 9. Flies collected in Survey (1) at Kami-Otoineppu.

Vegetation	M		SC. 1971		NF		TOTAL
	N	%RF	N	%RF	N	%RF	
L. quinquemaculipennis	—	—	2	0.6	2	0.7	4
A. variegata	—	—	—	—	1	0.3	1
D. confusa	—	—	9	2.9	41	14.0	50
D. coracina	28	36.8	104	33.7	88	30.0	220
D. rufifrons	1	1.3	1	0.3	—	—	2
D. bifasciata	32	42.1	68	22.0	57	19.5	157
D. imaii	2	2.6	12	3.9	5	1.7	19
D. suzukii	1	1.3	—	—	—	—	1
D. triauraria	4	5.3	—	—	—	—	4
D. testacea	8	10.5	81	26.2	78	26.6	167
D. nigromaculata	—	—	1	0.3	1	0.3	2
D. histrio	—	—	6	1.9	12	4.1	18
D. immigrans	—	—	1	0.3	3	1.0	4
D. moriwakii	—	—	21	6.8	3	1.0	24
D. pengi	—	—	3	1.0	2	0.7	5
TOTAL	76		309		293		678

Survey (2)

Flies were collected five times (5 : 00~17 : 00) per day on August 8 and 9, 1972, in each selective cut area from 1967 to 1970: selective cut area in 1970 (SC. 1970), SC. 1969, SC. 1968, SC. 1967, and streamside forest in SC. 1970 (SF. 1970) and in SC. 1969 (SF. 1969). Two traps were set in each vegetation except the last two, where in each only one was set up.

Results

D. coracina and *D. bifasciata* are significantly abundant in all samples of SC from 1967 to 1970 (Table 10 and Fig. 3-J), showing a quite stable structure, except for the small percentage ratio of *D. bifasciata* in 1969. On the other hand, the small samples in two streamside forests show very different assemblage structure for one another, in both of which *D. nigromaculata* is the unique common predominant species. It is noticeable that 14 specimens of *D. moriwakii* were collected in SF. 1970, while this species was fewer in selective cut areas, in combination only 6 specimens collected.

Discussion

From the comparison of the assemblages in selective cut areas during 1967~1971 and adjacent natural forest, it is concluded that selective cutting at 10~15% ratio is too small to produce a detectable influence upon faunal make-up. The

Table 10. Flies collected in Survey (2) at Kami-Otoineppu.

Vegetation	SC. 1970		SC. 1969		SC. 1968		SC. 1967		SF. 1970		SF. 1969		TOTAL
	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	N	%RF	
L. quinque-maculipennis	—	—	—	—	2	1.0	1	0.7	—	—	—	—	3
A. variegata	2	0.9	1	0.4	1	0.5	1	0.7	—	—	—	—	5
D. confusa	4	1.9	20	8.3	5	2.5	1	0.7	—	—	1	3.0	31
D. coracina	92	43.4	124	51.7	93	46.0	62	44.6	17	25.4	5	15.2	393
D. rufifrons	3	1.4	1	0.4	1	0.5	—	—	—	—	—	—	5
D. bifasciata	72	34.0	56	23.3	75	37.1	54	38.8	6	9.0	11	33.3	274
D. imaii	14	6.6	11	4.6	7	3.5	6	4.3	1	1.5	—	—	39
D. biauraria	—	—	—	—	—	—	—	—	1	1.5	—	—	1
D. testacea	5	2.4	10	4.2	9	4.5	8	5.8	5	7.5	1	3.0	38
D. nigromaculata	1	0.5	—	—	1	0.5	—	—	11	16.4	8	24.2	21
D. histrio	1	0.5	7	2.9	2	1.0	1	0.7	1	1.5	1	3.0	13
D. immigrans	7	3.3	6	2.5	3	1.5	2	1.4	3	4.5	2	6.1	23
D. lacertosa	2	0.9	—	—	—	—	—	—	5	7.5	2	6.1	9
D. moriwakii	5	2.4	—	—	—	—	1	0.7	14	20.9	—	—	20
D. okadai	1	0.5	—	—	—	—	—	—	2	3.0	1	3.0	4
D. neokadai	—	—	—	—	—	—	—	—	1	1.5	—	—	1
D. multispina	1	0.5	—	—	—	—	—	—	—	—	—	—	1
D. pengi	2	0.9	4	1.7	3	1.5	2	1.4	—	—	1	1.7	12
TOTAL	212		240		202		139		67		33		893

tendency of withdrawal in *D. confusa* and increase in *D. moriwakii* in SC. 1970 might suggest an influence by felling, but such slight effect must disappear even after one year.

Concluding Remarks

The results described in the present paper are not conclusive to show the allogenic succession of drosophilid assemblages occurring in the course of vegetational change, artificially started by clear or selective cutting. In the present study, the actual change between the situations before and after felling was not traced at one and the same area, but mainly inferred from the difference in habitats corresponding to these states. The precise comparison was usually impossible because of daily and seasonal fluctuation of activities, which cannot exactly be controlled. Further, in no case the gradual change of assemblage structure was continuously traced throughout a sufficiently long period covering successive phases of vegetational change. In spite of these defects, some results obtained appear to be fruitful for a closer analyses in future.

The first marked change of drosophilid assemblage soon after felling is that some stenotopic forest species decrease or even totally disappear. Such species

are, in the descending order of resistance to felling, arranged as follows: *D. bifasciata*≒*D. coracina*≫*D. testacea*>*D. sordidula*≫*D. histrio*>*D. confusa*. Among these species, *D. confusa* and *D. histrio* nearly totally disappear, withdrawing in forest areas nearby, but some ones, *D. bifasciata*, *D. coracina*, *D. sordidula* and *D. testacea*, still persist, if cutting is not too intensive, and *D. bifasciata*, *D. coracina* and *D. testacea* occasionally visit clear cut areas for its eurytopic activities. On the contrary, *D. moriwakii* increases by felling, and thereafter *D. auraria* does in the course of grassing.

The increase of *D. moriwakii* after cutting trees is remarkable and widespread, observed at several localities (Misumai, Bannosawa, Hyakumatsuzawa and Nakagawa), and to some degree also at Osashima and in SC. 1971 at Kami-Otoineppu. Some information on its life mode, seemingly important to explain this phenomenon, were obtained at several localities as described below.

Feeding site: At Misumai some individuals feeding on tree sap from cut trunks were found in the clear cut area on June 16, and 14 specimens were collected. At Bannosawa many individuals feeding on sap and slime flux from wounded plant roots on small cliffs along passages of bulldozers (Fig. 4–B) were observed on July 15 and total 70 specimens were collected, together with *D. okadai*, *D. testacea*, and *D. coracina* (each only one specimen). At Nakagawa,

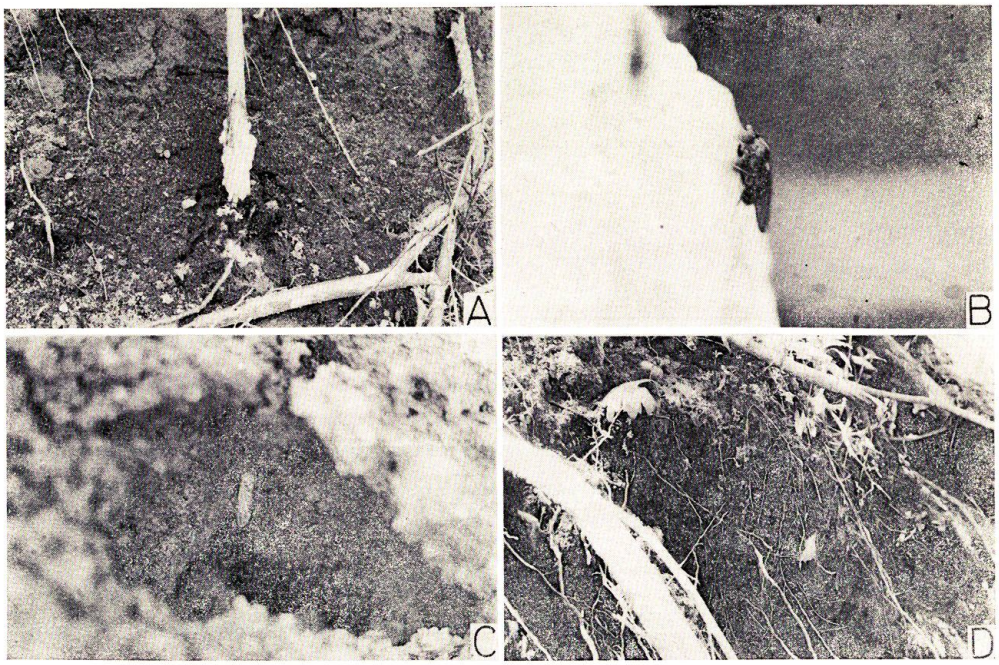

Fig. 4. Feeding, breeding and resting sites of *D. moriwakii* in selective cut area at Bannosawa. A: Slime flux of a wounded root on small cliff. B: A fly feeding on slime flux. C: A young adult staying on the underside of a clod on cliff. D: Plant roots overhang at the top of a cliff used as resting site.

too, four specimens and one *D. neokadai* were collected on sap from wounded plant roots.

Breeding site: A breeding site of this species was found at slime flux of wounded plant roots on small cliff at Bannosawa. Some young adults with wings still unexpanded crawled out from an underground part where sap and slime flux dropped down from the roots. They climbed on the cliff and stayed there in the shade of plant roots overhang at the top of the cliff or on the undersides of pebbles and clods on the cliff, seemingly waiting the complete expansion of wings and hardening of body (Fig. 4–C). Many larvae were found squirming in slime flux and mud where sap and slime flux dropped (Fig. 4–A). Seventeen adult flies emerged from the mud brought back to the laboratory.

Resting site: A stable bimodal crepuscular activity of this species was proved in the present study. In midday when this species scarcely visits traps, many adult flies are found resting in the shade of plant roots overhang at the top of cliffs along passages of bulldozers in diverse cutting areas at several localities (Fig. 4–D). Such resting flies collected by net sweeping or direct sucking with a glass tube were 49 specimens at Bannosawa, 61 at Hyakumatsuzawa, 142 at Nakagawa, 2 at Osashima, and 9 at Kami-Otoineppu. Furthermore, a considerable number of individuals were also resting in the shade of cliffs, tree holes and dense bushes beside a stream, and collected at several localities as follows; 69 at Nakagawa, 38 at Osashima, and 10 at Kami-Otoineppu. Other species were sometimes collected together in these resting sites. It is open for further studies whether such environments are characteristic resting sites only for *D. moriwakii* or common to other species.

Thus, forest felling presents much food of sap bleeding from cut trunks for *D. moriwakii*. Furthermore, recent mechanization of felling operation with bulldozers breaks mountain slopes in all directions, which offers plentiful resting, feeding and breeding sites as mentioned above. This preparation of environment suitable for breeding and feeding must be a cause of population increase of *D. moriwakii* in cut-over areas. Its explosive increase at streamside cut areas as observed at Bannosawa and Nakagawa may be the combined outcome of its hygrophilous nature and increase of favourable environment induced artificially.

Unfortunately, the information on life mode of other species is still so insufficient that no causal explanation of their increase or decrease by felling is given here.

Further change of drosophilid assemblage may be different according to the change of vegetation. If cut-over areas gradually return to the original situation, the recovery of original forest species populations may take place. The recovery would be faster when cutting in less intensive, or the size of cut area is less extensive, and planting is performed. On the other hand, if the clear cut area is artificially maintained, the ratios occupied by grassland species may increase, and in the area near urban districts the invasion of domestic species, which can live also in grassland conditions, may start, as shown by the invasion of *D. auraria*

at Misumai, which was not seen in Nakagawa Experiment Forest, being remote from urban areas, where some forest species such as *D. bifasciata* and *D. coracina* were sporadically collected.

The invasion of *D. auraria* in the course of grassing after felling is interesting in connection with the mechanism of dispersal of domestic species by artificial facilities. It is supposed that *D. auraria*, one of the most predominant species in Hokkaido, distributed widely in central and southern areas, has extended its distribution accompanied with forest felling started about a century ago, when colonization in Hokkaido began in earnest. The increase of *Scaptomyza pallida* in the course of grassing, mainly collected by sweeping at bushes, was also observed in September at Misumai.

Summary

Drosophilid flies were collected by fruit-traps in diverse cut-over areas at Misumai, Bannosawa and Hyakumatsuzawa in Jozankei mountaneous regions, and at Tenpoku Pass, Nakagawa, Osashima and Kami-Otoineppu in Nakagawa Experiment Forest, Hokkaido University.

The influence of forest felling upon drosophilid fauna was confirmed from the comparison of assemblages in these cut-over areas. Furthermore, the general features of drosophilid succession after forest felling were outlined based upon the results obtained.

Soon after felling *D. moriwakii* increases its population probably by the increase of suitable environments for breeding and inhabitation, for instance, tree sap from cut trunks and wounded roots as food for both adults and larvae, and plant roots overhang at the top on cliffs broken by bulldozer as midday resting sites. On the contrary, stenotopic forest species disappear or decrease in the following descending order of forest confined nature, *D. confusa*, *D. histrio*, *D. sordidula*, *D. testacea*, *D. bifasciata* and *D. coracina*. But if the cutting ratio is small enough, the species low-ranked above are less affected. In clear cut area near the urban area, some domestic species adapted to grassland such as *D. auraria* invade in the course of grassing after clear cutting. On the other hand, in selective cut areas, the retired forest species recover their population densities in the order reverse to that at with-drawal.

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摘　　要

定山渓地方の簾舞，磐の沢，百松沢，及び北大中川地方演習林の天北峠，中川，筬島，上音威子府のいろいろな伐採跡地において，バナナトラップを用いてショウジョウバエの採集を行なった。これらの伐採跡地のショウジョウバエ相を比較することによって，森林伐採がショウジョウバエ相に与える影響が明らかにされた。さらに，これらの結果をもとにして，森林伐採後の植生遷移に伴なって起こるであろうショウジョウバエ相遷移の過程の一般的様相を類推した。つまり，まず伐採直後にキボシショウジョウバエ (*D. moriwakii*) が増加する。これは，本種の成虫，幼虫の餌となる樹液が伐採地の切株や，傷つけられた木の根から分泌され，また，ブルドーザーによってけずられた山はだのがけの上部の植物の根などがたれさがっている部分が成虫の日中の休み場所として利用されたりして，本種の繁殖，及び棲息に好適な環境が伐採

跡地に豊富に準備されるためと考えられる。これに反して，森林棲の種類は伐採によって完全に姿を消したり，あるいは，その個体群密度を減少させる。これらの森林棲種の中にも森林環境への結びつきの程度に差があり，ニセエゾ (*D. confusa*), エゾ (*D. histrio*), オオ (*D. sordidula*), クモマ (*D. testacea*), フタスジ (*D. bifasciata*), クロツヤショウジョウバエ (*D. coracina*) の順により強く森林環境に結びついている。これらの種類の中でも下位の種類は，択伐率がそれ程大きくない時は，影響を受けない。皆伐地において，その後草原化が進むと，*D. auraria* のような草原環境に適応した種類が侵入して来る。一方，択伐地では，いったん退ぞいた森林棲種が退ぞいていった時の逆の順にその個体群密度を回復させる。