Environ. Sci. Hokkaido	8 (2)	185~194	Dec. 1985

Effects of the 1977 Eruption of Mt. Usu on Drosophilid Flies

II. August, 1984[1)]

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Abstract

Fruit-trap and sweeping collections were made at four stations on and near Mt. Usu in August, 1984, to survey the situations of drosophilid communities in the crater-basin area and the surrounding forests at the stage of seven years after the 1977 eruption. At Yosomiyama on the foot of Mt. Usu, where the forest vegetation was slightly damaged by the eruption, the structure of vertical habitat stratification in the drosophilid community has recovered completely from the initial disturbance. The crater-basin drosophilid community is regarded as situating at transition from grassland phase to shrub phase in the process of succession.

Key Words: Drosophilid community, effects of eruption, Mt. Usu, niche dimensionality, succession, *vertical habitat stratification.*

1. Introduction

The first paper of this series (Toda 1985) reported the initial impact of forest destruction by volcanic ash-fall on drosophilid communities, based on the data obtained one year after the eruption. According to that report, interspecific vertical habitat segregation became more obscure in the forest which was damaged more intensively. However, in spite of the absolute damage of forest vegetation in the crater-basin area, a number of silvicolous species, both canopy and floor dwellers, persisted still at that initial phase.

Thereafter, invasion of plants and revegetation proceeded in the crater-basin area (Rivière 1982, Ito and Haruki 1984), and the surrounding forests which were damaged only slightly at the initial phase recovered the structure of vegetational stratification (Fujimoto pers. comm.). These vegetational changes should be reflected by the changes in drosophilid communities living there. The present paper reports the situations of drosophilid communities in the crater-basin area and the surrounding forests at the stage of seven years after the eruption.

1) Entomological and ecological surveys on Mt. Usu in 1984. III.

2. Methods

Fruit-trap collections were made at the same four stations as in 1978 (Toda 1985), using "retainer type-I" traps (Toda 1977 a) baited with banana fermented by Baker's yeast. At Stations I and II, four traps were set vertically from the ground to the canopy. The upper two traps were suspended by a rope hung from a bough of the canopy. For each station, the location, vegetation, trap heights (T. H.) and collection period (C. P.) are described separately below.

Station I: Nakajima; broad-leaved forest (tree tops: 10–15 m), undamaged by the 1977 eruption, undergrowth vegetation recently heavily destroyed by intense browsing of Sika deers, *Cervus nippon yesoensis* (Kaji, *et al.* 1984); T. H.—12.5, 7.0, 1.0, 0.1 m; C. P.—August 1 to 8.

Station II: Yosomiyama; broad-leaved forest (tree tops: 20–25 m), lightly damaged by the eruption; T. H.—14.5, 8.0, 1.0, 0.1 m; C. P.—August 2 to 9.

Station III (Photo 1): Inner wall of northern somma of Mt. Usu; two traps set in shrub vegetation dominated by *Populus maximowiczii* (vegetation height; 2–3 m), broad-leaved forest vegetation, which was heavily damaged by the eruption but still remaining at the stage of 1978, completely destroyed afterwards by considerable topographic changes caused by the underground volcanic activity; T. H.—both 1.0 m; C. P.—August 3 to 10.

Station IV (Photo 2): Crater-basin of Mt. Usu; two traps set in tall herbaceous vegetation dominated by *Polygonum sachalinense* and *Petasites japonicus* var. *giganteus* with admixture of poplar shrubs (vegetation height: ca. 2 m); T. H.—both 0.5 m; C. P.—August 3 to 10.

In this paper, the data of sweeping collections, which were made on herbaceous plants at the four stations in August, 1978 and 1984, were also used to examine successional faunal changes in drosophilid species seldom or never attracted to fruit baits of traps.

The degree of vertical habitat segregation among component species in a drosophilid community was evaluated by the same method of niche dimensionality analysis as in Toda (1985). Total diversity (H'_T) and inter-trap diversity (H'_{inter}), i. e., the diversity due to differences among four trap samples, were calculated by the formulae given in Toda (1985). When used as a measure of relative importance of the vertical habitat dimension, H'_{inter} was expressed as a percentage of H'_T. Furthermore, this value was divided by the height of the top trap to standardize the range covered by the vertical collection. The average height of fly distribution was calculated by the formula also given in Toda (1985).

3. Results and Discussion

In Table 1, several items of community characteristics are compared between the two years, 1978 and 1984, for Stations I and II. The samples obtained at the two stations in 1984 were nearly the same in both numbers of species and individuals. For these two items, the values in 1984 decreased from those in 1978, slightly at Station I and considerably at Station II. The total diversity changed in the opposite directions between the two stations : it increased at Station I, but decreased at Station II. On the other hand, the inter-trap diversity and its per-

Table 1. Comparison of drosophilid community characteristics, particularly for the relative importance of vertical habitat dimension, between 1978 and 1984 at Stations I and II

Station:	I		II	
Year:	1978	1984	1978	1984
Number of species	22	20	31	23
Number of individuals	1,693	1,213	2,095	1,320
Total diversity (H'_T)	1.806	2.052	2.244	1.960
Inter-trap diversity (H'_{inter})	0.179	0.246	0.235	0.265
Percentage contribution to H'_T	9.91	11.96	10.47	13.53
Standardized value (% per 1 m)	1.01	0.96	0.78	0.93

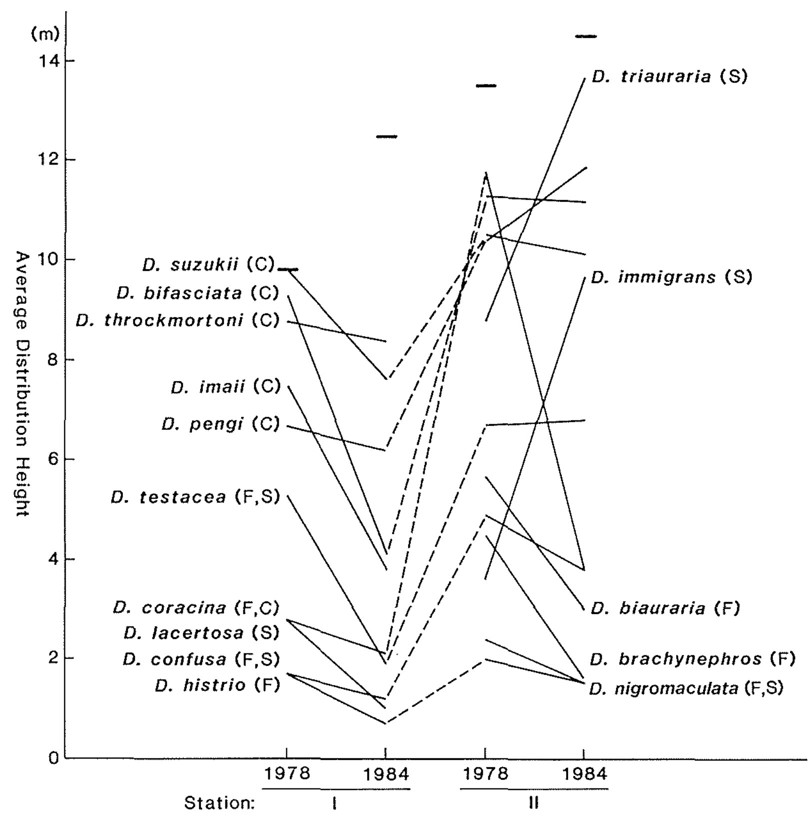

Figure 1. Changes in the average distribution heights of ten and twelve drosophilid species at Stations I and II, respectively, between 1978 and 1984. Horizontal thick bars indicate the heights of the top traps.

centage contribution to the total diversity increased at both stations, especially at Station II for the latter item. As a result, the standardized values of the latter item, which are considered to be more meaningful for indicating the relative importance of vertical habitat dimension, were nearly the same between the two

Table 2. Number of drosophilid flies collected by fruit-traps

Station	I				
Trap Height (m)	12.5	7.0	1.0	0.1	Total
Amiota stylopyga	—	—	—	—	—
A. albilabris	—	—	—	—	—
Drosophila funebris	—	—	—	—	—
D. triauraria	—	—	—	—	—
D. auraria	1	—	—	—	1
A. trifurcata	—	—	—	—	—
D. pengi	136	76	138	34	384
D. bifasciata	3	5	13	—	21
D. suzukii	86	42	45	13	186
D. immigrans	—	—	1	—	1
D. melanogaster	2	—	1	—	3
D. throckmortoni	7	5	3	—	15
D. moriwakii	—	—	1	—	1
D. biauraria	—	1	—	—	1
D. testacea	1	2	18	3	24
D. multispina	1	—	1	—	2
D. brachynephros	1	—	2	—	3
D. imaii	18	22	76	3	119
D. coracina	13	9	60	55	137
D. confusa	2	3	99	15	119
A. conifera takadai	—	1	2	—	3
D. histrio	—	—	5	2	7
D. nigromaculata	—	—	—	—	—
D. curvispina	—	1	20	5	26
D. lacertosa	—	—	10	—	10
D. unispina	—	—	58	92	150
D. hydei	—	—	—	—	—
A. dispina	—	—	—	—	—
A. sp.	—	—	—	—	—
Leucophenga maculata	—	—	—	—	—
L. quinquemaculipennis	—	—	—	—	—
D. busckii	—	—	—	—	—
Total No. of Individuals	271	167	553	222	1,213
Total No. of Species	12	11	18	9	20

stations in 1984. In 1978, however, this value was smaller at Station II where the forest vegetation was slightly damaged than at Station I where the vegetation was intact, indicating the disturbance of vertical habitat segregation among drosophilid species. The present results, i. e., nealy the same values of the last item and less

at four stations on and near Mt. Usu in August, 1984

II					III			IV		
14.5	8.0	1.0	0.1	Total	1.0	1.0	Total	0.5	0.5	Total
1	—	—	—	1	8	32	40	11	18	29
1	—	—	—	1	—	—	—	—	—	—
1	—	—	—	1	—	—	—	—	—	—
7	1	—	—	8	8	15	23	4	7	11
4	2	4	3	13	4	5	9	6	4	10
2	1	—	—	3	1	—	1	2	—	2
16	11	—	—	27	—	1	1	—	—	—
7	4	1	—	12	359	284	643	135	53	188
261	147	57	34	499	2,832	5,401	8,233	2,728	3,303	6,031
6	6	1	1	14	7	7	14	1	2	3
3	10	1	1	15	21	28	49	18	26	44
—	—	—	—	—	—	—	—	—	—	—
—	1	—	—	1	—	1	1	—	1	1
5	6	21	15	47	6	7	13	1	4	5
48	93	60	21	222	79	235	314	58	115	173
—	—	—	—	—	—	—	—	—	—	—
2	11	30	55	98	43	125	168	64	82	146
—	—	—	—	—	—	1	1	—	—	—
1	2	3	3	9	—	—	—	—	—	—
3	25	28	16	72	6	25	31	3	3	6
—	—	—	—	—	2	2	4	2	1	3
7	19	92	117	235	92	192	284	53	66	119
2	—	14	14	30	33	42	75	49	109	158
—	—	2	5	7	6	44	50	19	53	72
—	—	1	—	1	4	—	4	—	2	2
—	—	1	2	3	3	6	9	1	1	2
—	—	—	1	1	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	1	1
—	—	—	—	—	1	—	1	—	—	—
—	—	—	—	—	4	18	22	1	—	1
—	—	—	—	—	—	3	3	—	—	—
—	—	—	—	—	1	—	1	—	—	—
377	339	316	288	1,320	3,520	6,474	9,994	3,156	3,851	7,007
18	15	15	14	23	20	21	24	18	19	21

variation in other items between the two stations, indicate the recovery of vertical habitat stratification in the silvicolous drosophilid community at Station II from the disturbance at the initial phase. From the last item's values observed at Station I in 1978 and 1984 and at Station II in 1984, it can be speculated that this value in an intact natural broad-leaved forest in this area ranges from about 0.9 to 1.0.

In Figure 1, changes in the average distribution heights of component species between the two years are demonstrated for ten and twelve species, which exceeded four specimens in sample size in both years, at Stations I and II, respectively. The vertical distribution types observed in a natural broad-leaved forest at Misumai (Toda 1977 b) are shown with symbols (C : canopy type, S : subarboreal layer type, F : floor type) in parentheses. At Station I, in spite of the increased height of the top trap, the distribution heights of component species generally decreased, especially in some of canopy dwellers, e. g., *Drosophila bifasciata* and *D. imaii*. This change may be due to the heavy destruction of undergrowth vegetation by intense browsing of Sika deers, although the proximate causal factors, e. g., changes in light or food conditions, are unknown. At Station II, relatively large changes were observed in some species of the S group and *D. coracina*. However, these changes are considered to be ecologically meaningless, because the vertical distribution patterns of these species are changeable temporally and locally as mentioned by Toda (1985). Ecologically, more meaningful changes were observed in floor dwellers. Their average distribution heights decreased, considerably in *D. biauraria* and *D. brachynephros*. These changes may be due to the recovery of ground vegetation, which was considerably buried with ash at the time of the previous survey in 1978.

The results of collections at Stations III and IV are presented in Table 2 along with the data of the actual number of individuals collected at Stations I and II. It is immediately noticed that the numbers of individuals of *D. suzukii* collected at Stations III and IV were extraordinarily great, probably representing a state of its population outbreak in and near the crater-basin area. In addition to *D. suzukii*, the sample sizes of some other species, e. g., *Amiota stylopyga*, *D. triauraria*, *D. bifasciata*, *D. melanogaster*, *D. brachynephros*, *D. nigromaculata*, *D. curvispina* and *Leucophenga maculata*, were also remarkably larger at Stations III and IV than at Stations I and II. At the present, it is unknown what environmental factors facilitated the population outbreak or abundance of these species. However, to examine ecological features of these species gives suggestive information for characterizing the community in and near the crater-basin area. Consulting the results of other studies on habitat preferences of drosophilid species (Toda 1973, 1977 b, Minami *et al.* 1979), these species are regarded as consisting mainly of three elements ; forest canopy dwellers (*A. stylopyga*, *D. bifasciata*, *L. maculata*), domestics or semi-domestics (*D. suzukii*, *D. melanogaster*), and grassland dwellers (*D. triauraria*, *D. brachynephros*, *D. nigromaculata*). *D. curvispina* is a forest floor dweller. Furthermore, it is known that domestic or semi-domestic species are distributed in the foliage layer of forest canopy, shrub vegetation or mantle vegetation at the forest edge together with wild forest canopy species, when they invade wild environments (Toda 1977 b, unpub.). Therefore, the crater-basin drosophilid community at the time of the present survey is characterized primarily by the prosperity of foliage layer elements and grassland ones, including also forest floor species as secondary elements. Toda (1985) predicted that the crater-basin community would be reorganized into a new stable state mainly by grassland species after the initial unbalanced stage. However, nothing can be said as to whether such a prediction was realized, i. e., a pure grassland community was established, or not, unfortunately because of the lack of data during the period between 1978 and 1984. Seemingly, the crater-basin community at the time of the present survey is regarded as situating at a transitional phase from grassland community to shrub one, coinciding with the successional stage of vegetation at the trap stations (cf.

Table 3. Number of drosophilid flies collected by net-sweeping at four stations on and near Mt. Usu in August, 1978 and 1984

Station:	I		II		III	IV	
Year:	'78	'84	'78	'84	'78	'78	'84*
Drosophila nigromaculata	76	2	89	18	15	8	1
D. collinella	51	46	51	29	—	—	3
Scaptomyza pallida	10	23	17	2	8	24	89
D. biauraria	17	2	46	8	4	—	—
D. nipponica	1	4	29	2	1	—	21
D. tenuicauda	9	—	15	1	—	—	—
D. brachynephros	—	1	10	5	3	1	1
Sc. consimilis	—	3	1	1	12	—	2
D. magnipectinata	—	2	5	2	—	1	8
D. testacea	—	—	—	4	7	1	—
D. suzukii	—	1	—	5	—	—	—
D. mommai	1	—	3	1	—	—	—
D. triauraria	—	—	—	—	2	2	—
Sc. graminum	—	—	—	—	—	4	—
Sc. polygonia	—	—	1	—	—	3	—
D. auraria	—	4	—	—	—	—	—
D. immigrans	—	—	1	—	1	—	—
D. alboralis	—	—	—	2	—	—	—
Nesiodrosophila raridentata	1	—	—	—	—	—	—
Sc. elmoi	—	—	—	—	—	1	—
Amiota elongata	—	1	—	—	—	—	—
Leucophenga orientalis	—	—	—	1	—	—	—
Mycodrosophila poecilogastra	—	—	—	1	—	—	—
Microdrosophila purpurata	—	—	—	—	—	—	1
Total	166	89	268	82	53	45	126

* Sweeping was made at an artificial herbaceous stand sown with exotic species

Ito and Haruki 1984). It is unknown whether the secondary elements (forest floor species) have persisted in the community since the initial phase, having done so at least until August, 1978, or recently reinvaded from the surrounding forests.

To examine the effects of the eruption and the subsequent changes in drosophilid species which depend exclusively on herbaceous plants for breeding and are seldom or never attracted to fruit baits of traps, the results of sweeping collections made in August, 1978 and 1984, are presented in Table 3. At Stations I and II, herbage feeding drosophilid communities are generally characterized by the predominance of *D. nigromaculata*, *D. collinella* and *Scaptomyza pallida*, including also *D. nipponica*, *D. tenuicauda*, *Sc. consimilis*, *D. magnipectinata* and *D. mommai* as secondary or minor components. Judging from the results of collections at Stations III and IV in 1978, the eruption had a great impact on some of these species, which prefer relatively humid habitats, e. g., *D. collinella*, *D. tenuicauda* and *D. mommai* (cf. Toda *et al.* 1984). The crater-basin community of herbage feeding drosophilids at this stage was predominated by *D. nigromaculata* and *Sc. pallida* preferring open grasslands. It is noteworthy that four *Scaptomyza* species, *consimilis*, *graminum*, *polygonia* and *elmoi*, occurred frequently or exclusively in this community. The collection in the crater-basin area in 1984 was made at an artificial herbaceous stand sown with exotic species such as *Trifolium repens* and *Artemisia vulgaris* and at the border between this artificial stand and tall herbaceous grassland dominated by *Petasites japonicus* var. *giganteus*. The obtained sample, which was composed mainly of *Sc. pallida* and *D. nipponica*, indicated that an open grassland community predominated at the surveyed stand. In addition, some species which prefer more humid habitats, e. g., *D. collinella* and *D. magnipectinata*, recolonized the crater-basin area, although the most hygrophilous species such as *D. tenuicauda* and *D. mommai* were still lacking from the area. This may reflect the establishment of some habitats like as forest edge herbage stand, which are intermediate on the gradient of habitat humidity.

Consulting the results of trap and sweeping collections, the following can be inferred. At the stage of seven years after the eruption, the drosophilid community at Yosomiyama on the foot of Mt. Usu, which was slightly affected by the eruption, has recovered completely from the initial disturbance. On the other hand, a succession of the drosophilid community in the crater-basin area is progressive in accordance with vegetational succession there, and at this stage the community is situating in transition from grassland phase to shrub phase.

Acknowledgements

We wish to express our sincere thanks to Dr. S. Fujimoto, Laboratory of Silviculture, Department of Forestry, Faculty of Agriculture, Hokkaido University, for valuable comments based on his unpublished data, and also to the Usu Volcano Observatory, Hokkaido University, for the permission to use its facilities.

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(Received 4 Sept. 1985)

Photo 1. Station III (August, 1984, photo by Toda).

Photo 2. Station IV (August, 1984, photo by Toda).