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제주도 활엽수림에 서식하는 초파리의 계절적 변동과 미수직 분포*

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Seasonal Fluctuation and Vertical Microdistribution of Drosophilid Flies Dwelling in the Broad-leaved Forests on Cheju-do (Quelpart Island)

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Abstract

Community organization of the drosophilid flies was investigated with respect to the seasonal variation in species abundance and vertical microdistribution on the basis of the trapped collections in the two natural forests on Cheju-do from May to October 1994. The dominant species were *Drosophila bizonata*, *D. curviceps*, *D. lutescens*, *D. angularis*, *D. pengi*, and *D. immigrans* in the annual collections. The pattern in seasonal changes of the dominant species was similar at the two survey sites. Seasonal fluctuation in the species diversity was more affected by evenness than by species richness (number of species). The seasonal variation of abundance showed an unimodal pattern in all of the dominant species. The seasonal patterns of vertical microdistribution revealed difference in some of the dominant species between the two survey sites. These results suggest that the predominant species in the forest avoid niche overlap by means of seasonal separation of breedings and that the vertical microdistribution is strongly affected by factors associated with season and vertical site in the deep wooded forests.

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INTRODUCTION

Investigations on seasonal fluctuation and vertical microdistribution of the drosophilid flies are very important in order to discuss ecological niche of the species in the community. However, information on ecological structure of the drosophilid flies in the natural forests is still insufficient in Korea. In the past fifteen years, investigations have made some progress into the distributional and ecological feature of *Drosophila* in Cheju Island (Quelpart Is.) (Kim, 1984, 1985; Kim and Ko, 1994; Kwon and Toda, 1981).

The present paper reports some accounts of seasonal fluctuation and vertical microdistribution of the drosophilid flies surveyed from May to October in 1994 in the natural broad-leaved forests at the southern part of Cheju-do (Quelpart Is.).

SITES SURVEYED

Two different sites were selected each from the stream side near Namsŏ-kyo Bridge of (Sundol) and Suak-kyo Bridge of Suak Valley. Namsŏ-kyo Bridge and Suak-kyo Bridge are located about 5 and 15 km northeast of the center of Sŏgwipo City, which is located in the southern slope of Mt. Hallasan. The elevations of the sites are 280 and 520 m above the sea level, respectively. The vegetation of these areas formed a forest of broad-leaved evergreen trees. The undergrowth layers were very sparse, and almost all surface of the ground was covered with fallen decayed leaves in both sites. The species were as follows:

Namsŏ-kyo (NS) : *Castanopsis cuspidata* var. *sieboldii* NAKAI, *Quercus acuta* THUNB., *Q. glauca* THUNB., *Q. serrata* THUNB., *Camellia japonica* L., *Distylium racemosum* S. et Z., *Eurya japonica* THUNB., *Euscaphis japonica* (THUNB.) KANITZ, *Dendropanax morbifera* LEV., *Damnacanthus indicus*

GAERTNER, *Pittosporum tobira* AIT., *Ficus nipponica* FR. et SAV., *Trachelospermum asiaticum* var. *intermedium* NAKAI, *Ardisia crenata* SIMS, *Ardisia japonica* BL., *Rumohra amabilis* (BL.) CHING.

Suak-kyo (SA) : *C. cuspidata* var. *sieboldii* NAKAI, *Q. acuta* THUNB., *Q. glauca* THUNB., *C. japonica* L., *E. japonica* THUNB., *D. morbifera* LEV., *Acer palmatum* THUNB., *Daphniphyllum macropodum* MIQ., *D. racemosum* S. et Z., *Cinnamomum japonicum* SIEB., *Machilus japonica* S. et Z., *T. asiaticum* var. *intermedium* NAKAI, *A. japonica* BL.

METHODS

From the 1st of May through the 22nd of October 1994, forest-dwelling drosophilid flies in the two study sites were investigated twice a month.

Collections were made at one point of each site. Samples were collected with two weeks interval by the "retainer" traps (Toda, 1977) baited with fermenting banana pieces to which water suspension of Baker's yeast was added. At each site, six traps were set at six different heights, 0 m, 1 m, 2 m, 3 m, 4 m, and 5 m above the ground. Five traps were lifted up by a cable hung from a thick branch of one tree (*C. cuspidata* var. *sieboldii* NAKAI). One trap was tied on the heel of the tree. Baited traps were left out for seven days. The trapped specimens were collected to polypropylene bottles containing 70% ethanol.

ANALYSIS

Collections may be classified by difference in season and vertical sites. In each case the contribution made by the particular niche component can be investigated by looking at not only the differences of the relative abundance but also the vertical microdistribution gradient. In order to investigate seasonal assemblage of the communities, the 95% confidence limits of relative percentages of the component species were calculated by using the Sakuma's (1964) formula.

$$\{n/N \pm \sqrt{n(N-n)/N^3}\} \times 100$$

where N is the total number of individuals and n is the number of individual of a species. Next the limits of the mean percentage can be calculated in the same way by using the mean number of individuals ($n = N/S$, where S = the total number of species) instead of n.

The contribution of microhabitat and season to the diversity of species present in these sites was sought by use of the Shannon-Weaver (1949) function for information or uncertainty:

$$H' = -\sum P_i \log_2 P_i$$

where P_i is the proportion of species i to the total collection. Two components of diversity, namely species richness and evenness of distribution of species abundance patterns, are combined in the Shannon-Wiever function. The species richness was represented by the total number of species in a collection. The evenness was measured by using the following index:

$$E = \frac{e^{H'}}{S}$$

The similarity in the species composition between two collections in different seasons or that in different layers was calculated by using Morisita's index:

$$C_\lambda = \frac{2\sum_{i=0}^{\infty} N_{1i} \cdot N_{2i}}{(\lambda_1 + \lambda_2)}$$

$$\lambda_1 = \frac{\sum_{i=0}^{\infty} n_{1i}(n_{1i}-1)}{N_1(N_1-1)}, \quad \lambda_2 = \frac{\sum_{i=1}^{\infty} n_{2i}(n_{2i}-1)}{N_2(N_2-1)}$$

(Morisita, 1959), where N_1 and N_2 are the total number of individuals occuring in the 1st and 2nd collection, respectively and n_{1i} and n_{2i} are the number of individuals on ith species in each collection. This index varying from 0 to about 1, corresponds in the degree of overlapping in the species composition between the two collections.

Vertical microdistribution gradient index (g) was given by the followin g formula (Toda, 1973b).

$$g = \sum_{i=1}^{5} \frac{f_{i+1} - f_i}{h_{i+1} - h_i} \quad (-1 \leq g \leq 1)$$

where, f_i is the percentage ratio of the specimens collected at the height, h_i.

RESULTS AND DISCUSSION

Species composition and relative abundance of drosophilid flies

A total of 72,751 flies was collected, which was represented by 29 species belonging to 7 genera (Table 1). The drosophilid community of the site **NS** was composed of a total of 42,683 flies belonging to 29 species of 7 genera and that of the site **SA** was composed of a total of 30,068 flies belonging to 25 species of 6 genera. The abundant species were *Drosophila lutescens*, *D. triauraria*, *D. angularis*, *D. bizonata*, and *D. curviceps* at the site **NS**. They accounted for about 90% of the total annual collection. At the **SA** site, however, *D. lutescens*, *D. angularis*, *D. bizonata*, *D. curviceps*, *D. immigrans*, and *D. pengi* were the abundant species among the whole collection. These six species accounted for about 89% of the total annual collection. *Drosophila bizonata* was the predominant species at both sites. These patterns of species composition might have been related to the collection method. Most of the rare species in trapped populations have been known to be collected by the use of net sweeping (Suzuki, 1955; Momma, 1965; Kimura, 1976).

Table 1. Temporal variation of the freguency(%) and the relative abundance* of the forest dwelling drosophilid flies.

No	Species	Month						Total
		May	Jun	Jul	Aug	Sep	Oct.	
1	*Leucophenga orientalis*	0.005±0.009 (±)	–	0.14±0.20 (±)	0.110±0.128 (+)	–	–	0.005±0.005 (±)
2	*L. ornata*	0.009±0.013 (±)	–	–	–	–	0.002±0.005 (±)	0.004±0.005 (±)
3	*Amiota okadai*	0.005±0.009 (±)	–	–	2.210±0.564 (±)	0.910±0.315 (±)	0.039±0.019 (±)	0.151±0.029 (±)
4	*A. stylopyga*	0.023±0.021 (±)	–	–	–	–	0.002±0.005 (±)	0.008±0.007 (±)
5	*Scaptodrosophila coracina*	0.028±0.023 (±)	0.045±0.090 (±)	–	–	–	–	0.010±0.007 (±)
6	*S. subtilis*	0.052±0.031 (+)	0.135±0.156 (±)	–	0.074±0.104 (±)	0.276±0.174 (±)	–	0.036±0.014 (±)
7	*Hirtodrosophila histrioides*	0.169±0.056 (±)	1.439±0.505 (±)	2.219±0.776 (+)	0.110±0.128 (±)	0.303±0.183 (±)	0.166±0.040 (+)	0.252±0.037 (+)
8	*H. quadrivittata*	0.038±0.027 (±)	–	–	–	–	0.005±0.007 (±)	0.014±0.009 (+)
9	*H. sexvittata*	0.005±0.009 (±)	0.045±0.090 (+)	–	–	–	0.002±0.005 (±)	0.004±0.005 (+)
10	*H. trivittata*	0.005±0.009 (±)	–	–	–	–	0.002±0.005 (±)	0.003±0.004 (±)
11	*Mycodrosophila gratiosa*	–	–	–	–	–	0.010±0.010 (±)	0.005±0.005 (±)
12	*Drosophila busckii*	0.023±0.021 (±)	5.353±0.955 (+)	2.982±0.896 (+)	–	–	0.007±0.008 (±)	0.234±0.036 (±)
13	*D. bifasciata*	2.338±0.207 (±)	2.519±0.665 (±)	0.208±0.240 (±)	0.331±0.221 (+)	2.261±0.494 (±)	0.150±0.038 (±)	0.976±0.073 (±)
14	*D. lutescens*	22.717±0.574 (++)	17.184±1.600 (++)	30.166±2.417 (++)	37.532±1.859 (++)	10.232±1.007 (++)	0.113±0.033 (±)	9.750±0.220 (++)
15	*D. melanogaster*	0.784±0.121 (±)	0.315±0.238 (±)	3.051±0.906 (±)	0.700±0.320 (±)	4.826±0.712 (+)	0.104±0.032 (±)	0.625±0.058 (±)
16	*D. suzukii*	0.404±0.087 (±)	0.810±0.380 (±)	0.902±0.498 (±)	0.147±0.147 (±)	1.737±0.434 (±)	0.075±0.027 (±)	0.296±0.040 (±)
17	*D. triauraria*	0.019±0.019 (±)	0.450±0.284 (±)	0.347±0.310 (±)	28.508±1.733 (++)	35.439±1.589 (++)	0.152±0.038 (±)	2.943±0.125 (±)
18	*D. unipectinata*	0.014±0.016 (±)	–	0.069±0.139 (±)	–	0.083±0.095 (±)	–	0.010±0.007 (±)
19	*D. agularis*	0.066±0.035 (±)	0.090±0.127 (±)	0.208±0.240 (±)	0.994±0.381 (±)	1.544±0.410 (±)	12.870±0.329 (++)	7.472±0.195 (++)
20	*D. bizonata*	0.793±0.122 (+)	0.720±0.359 (±)	6.103±1.261 (+)	3.941±0.747 (+)	29.454±1.514 (++)	83.163±0.368 (++)	49.366±0.371 (++)
21	*D. curviceps*	45.510±0.682 (++)	31.309±1.967 (++)	3.121±0.916 (±)	0.295±0.208 (±)	0.607±0.258 (±)	0.608±0.076 (+)	14.731±0.263 (++)
22	*D.* sp. of *curviceps* species-subgroup	–	0.045±0.090 (±)	–	–	–	0010±0.010 (±)	0.007±0.006 (±)
23	*D. histrio*	0.038±0.027 (±)	5.038±0.928 (+)	0.139±0.196 (±)	0.074±0.104 (±)	1.489±0.402 (+)	1.153±0.105 (±)	0.902±0.070 (±)
24	*D. immigrans*	8.605±0.384 (++)	18.983±1.664 (++)	33.773±2.491 (++)	8.029±1.043 (++)	2.179±0.485 (±)	0.311±0.055 (±)	4.355±0.151 (++)
25	*D. lacertosa*	0.258±0.070 (+)	1.709±1.550 (±)	5.479±1.199 (+)	16.059±1.409 (++)	5.212±0.738 (+)	0.302±0.054 (+)	1.267±0.083 (+)
26	*D. pengi*	16.051±0.503 (++)	13.450±1.447 (++)	11.096±1.654 (++)	0.221±0.180 (+)	0.883±0.311 (±)	0.005±0.007 (±)	5.385±0.167 (++)
27	*D. sternopleuralis*	1.638±0.174 (±)	0.315±0.238 (±)	–	0.516±0.275 (±)	2.317±0.500 (±)	0.147±0.038 (±)	0.708±0.062 (+)
28	*D. unispina*	0.404±0.087 (+)	0.045±0.090 (+)	0.139±0.196 (±)	0.110±0.128 (±)	0.221±0.156 (±)	0.601±0.076 (±)	0.480±0.051 (±)
29	*Nesiodrosophila raridentata*	–	–	–	0.037±0.074 (±)	0.028±0.055 (±)	–	0.003±0.004 (±)
	Mean±SD	3.846±0.264	5.000±0.925	6.250±1.275	5.263±0.857	5.263±0.742	4.167±0.196	3.448±0.135
	Total Individual No. (*N*)	21,301	2,223	1,442	2,715	3,626	41,444	72,751
	Species No. (*S*)	26	20	17	19	19	24	29

*Relative abundance of component species was evaluated into three classes, Abundant (++), common(+), and rare (±) according to Kwon and Toda (1983). In comparison beteen the percentage range (95% confidence limit) of each species and that of the mean, the species is regarded to be 'abundant' when the lower limit of the former exceeds the upper limit of the latter, 'common' when the two ranges overlap, and 'rare' when opposite to the case of 'abundant.'

From their relative abundances, association of these species can be represented by seasonal assemblage as follows:

Spring assemblage : *Drosophila curviceps*, *D. lutescens*, *D. immigrans*, *D. pengi*, and *D. bifasciata* at the site **NS** and *D. curviceps*, *D. lutescens*, *D. pengi*, *D. immigrans*, *D. bifasciata*, and *D. sternopleuralis* at the site **SA**.

Summer assemblage : *Drosophila triauraria*, *D. lutescens*, *D. immigrans*, *D. pengi*, *D. curviceps*, *D. busckii*, *D. melanogaster*, *D. bizonata*, *D. angularis* at the site **NS** and *D. lutscens*, *D. curviceps*, *D. immigrans*, *D. lacertosa*, *D. triaurraria*, *D. histrio*, *D. bizonata*, *D. pengi*, *D. bifasciata*, *Hirtodrosophila confusa*, *Amiota okadai*, *D. busckii*, *D. melanogaster*, and *D. suzukii* at the site **SA**.

Autumn assemblage : *Drosophila bizonata*, *D. triauraria*, *D. angularis*, *D. lutescens*, *D. suzukii*, *D. melanogaster*, *D. sternopleuralis*, *D. immigrans*, and *D. histrio* at the site **NS** and *D. bizonata*, *D. angularis*, *D. lutescens*, *D. lacertosa*, *D. melanogaster*, *D. triauraria*, *D. bifasciata*, *D. sternopleuralis*, *D. immigrans*, *D. histrio*, *D. unispina*, *D. pengi*, *Amiota okadai*, and *D. curviceps* at the site **SA**.

Seasonal variation of species diversity

The seasonal fluctuation of species diversity is represented in Fig. 1. The species diversities at both sites were stable throughout the seasons, although they showed a weak bimodality with two peaks in June or July and September. The fluctuation depended more evenness than species richness. However, both components of species diversity compensated each other in August at the site **SA** and in September at the site NA.

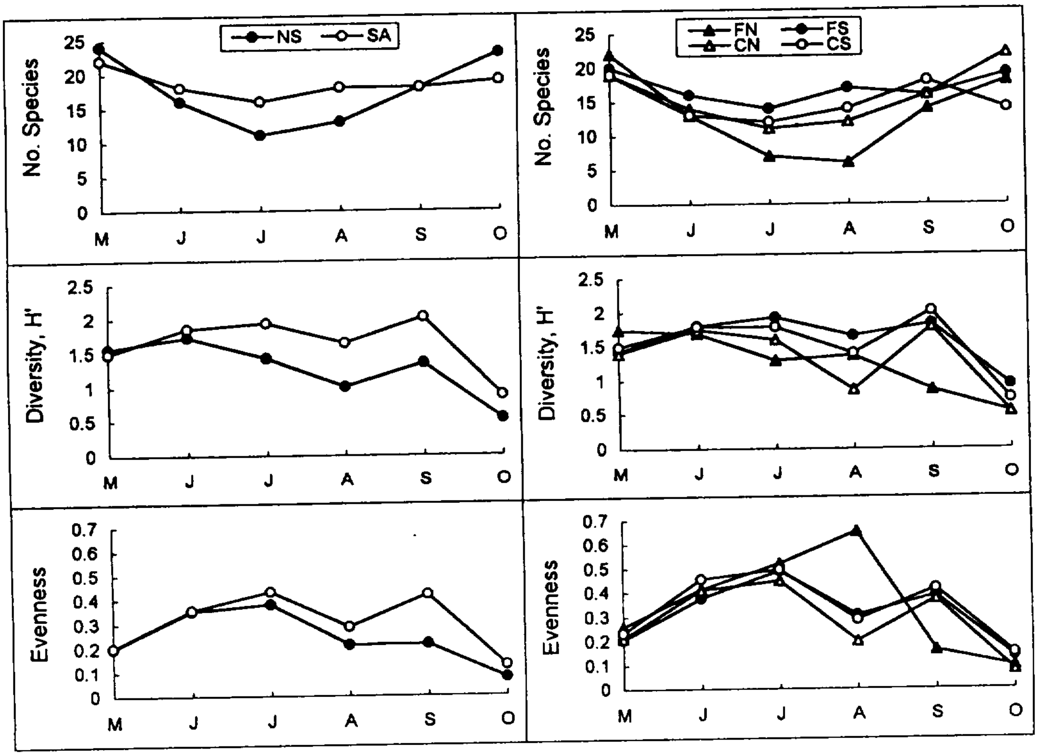

Fig. 1. Seasonal fluctuation in the species diversity of the forest-dwelling drosophilid flies. The legends represent the site Namso-kyo (NS) and the site site Suak-kyo (SA) in the left column, and the floor (NF) and cnopy (NC) collections at NS and the floor (SF) and canopy (SC) collections at SA in the right column.

The species diversity peaked in June and September at the site NS and SA, respectively. And the community structure was more diverse at the site SA than at the site NS. These differences of community structure might be related to the climatic conditions and tree phenology due to the elevational difference. The difference of elevation between two sites is about 300 m.

A few species critically influenced the seasonal pattern of species diversity due to their relative abundance. An increase in the relative abundances of *Drosophila curviceps*, *D. lutescens*, *D. pengi*, and *D. immigrans* in May and *D. bizomata*, and *D. angularis* in October resulted in a remarkable decrease in the evenness. At the site SA the sharp decrese of the evenness in August was due to an increase in the relative abundances of *D. lutescens*, *D. lacertosa*, *D. immigrans*, and *D. triauraria*. The dominancy of *D. lutescens* from May to August at the site NS and to September at the site SA appeared to contribute to the stable species diversity.

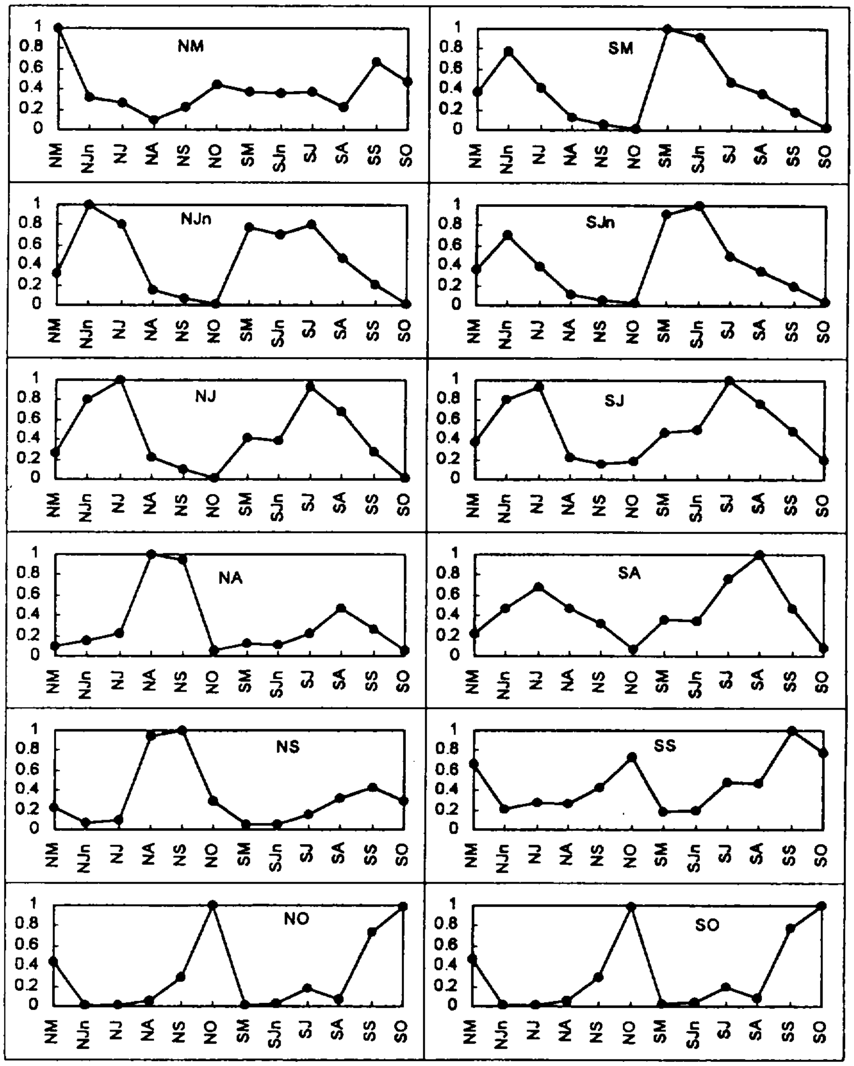

Fig. 2. Seasonal changes in species composition of forest-dwelling drosophilid flies. The similarity indices between every two collections taken in different seasons and sites were calculated. Each curve represents a set of similarity indices against the collection shown by dark circles. When the species compositions are similar to each other, the curves also show a similar pattern. Abbreviations represent the collections taken in different seasons and sites, i.e., NM, May at the site NS and Sjn, June at the site SA, etc.

The seasonal succession of drosophilid flies was apparent (Fig. 2). The species compositions (similarity) of both sites was closely superimposed on each other in May, July and October. However, they showed great difference each other in August and September. This phenomena appeared to be mainly affected by the abundance of the commonest species. The seasonal changes in numbers of the eight commonest *Drosophila* species are shown in Fig. 3. There is a marked increase in the numbers of *D. curviceps*, *D. pengi*, *D. immigrans*, and *D. lutescens* in May coincident with the appearance in forests of fungi and rotten nuts which provide a breeding site for these species. The numbers showed a sharp decrease in June and remain at this low level until October, when there is a marked increase in the numbers of *D. bizonata* and *D. angularis*. It was noted that there is a marked increase in the number of *D. triauraria* in August and peaked in September at the site **NS**. However, there is a marked increase in the numbers of *D. lacertosa* in August at the site **SA**. Among the commonest species *D. lutescens* only showed a bimodality in the seasonal distribution with a large peak in May and a smaller one in August at the site **SA**.

The distributional pattern in some species of *Drosophila* in Cheju-do appeared to be different from that in Hokkaido, Japan. According to the regular autumn burst in forest near human habitations (Wakahama, 1957; Kaneko, 1960; Kaneko and Tokumitsu, 1963; Toda, 1973a), it has been postulated that *D. immigrans* increases its population from spring to summer in and near human habitations, then invades into neighboring forest, there a homogeneous and well mixed population from late summer to autumn (Toda, 1974). The previous study on the seasonal activity of this species in Cheju-do revealed that this species increases its population from spring to summer far from human habitations (Kim, 1985). It has

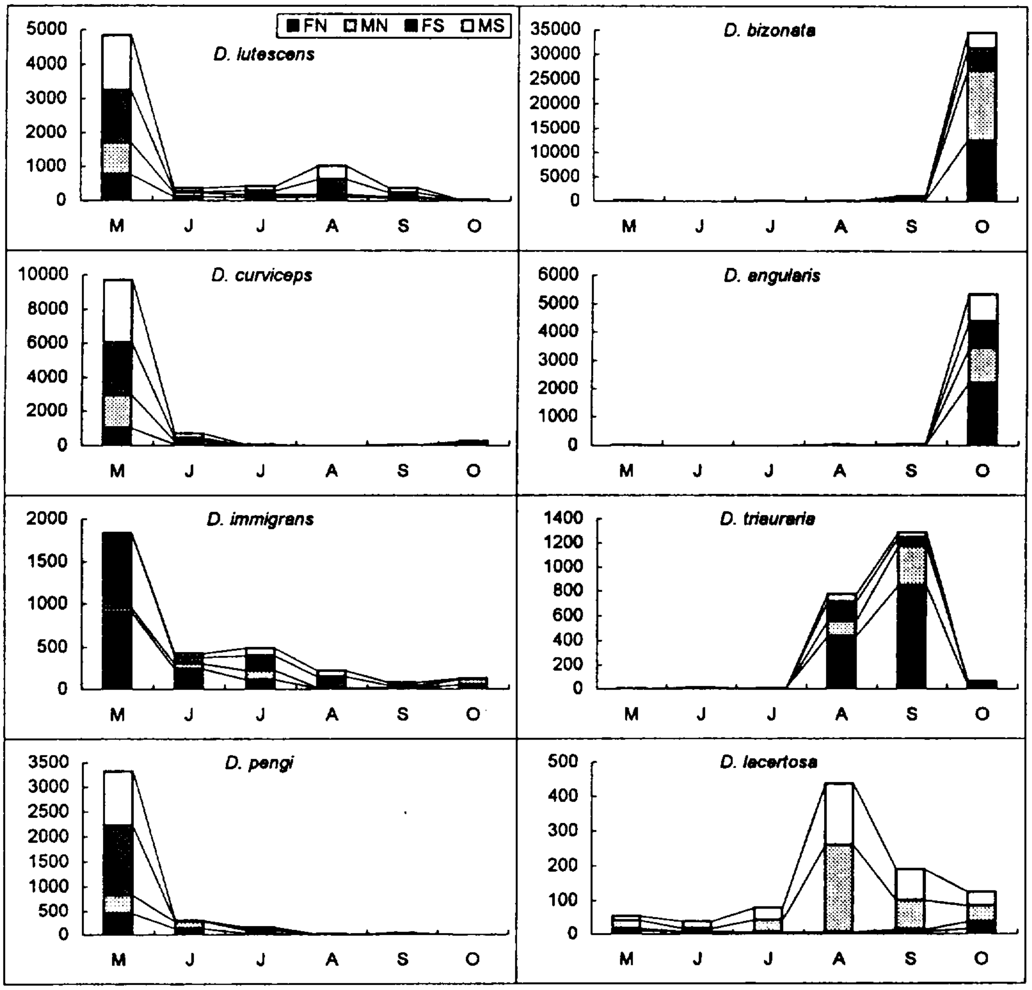

Fig. 3. Seasonal changes in the numbers and sex ratios of the predominant species. FN, MN, FS and MS represent female and male at NS and SA, repectively. Abscissa is month.

been also reported that *D. lutescens* is to be found around human habitations and *D. lacertosa* predominates at lower elevations in southern Hokkaido (Momma, 1957; Kaneko and Tokumitsu, 1963). However, in the present study *D. lutescens* was to be dominant in thick forests far from human habitations from May to September. In addition, *D. lacertosa* showed to be predominant rather at the higher elevation than at the lower, that is, this species predominated only at the site SA in August.

Table 2. Temporal and spatial variations of the vertical microdistribution gradient indedices of the drosophilid species

No	Species	May		Jun		Jul		Aug		Sep		Oct.		Total	
		NS	SA	NS	SA	NS	SA	NS	SA	NS	SA	NS	SA	NS	SA
1	*Leucophenga orientalis*	0						0	0.500					0	0.500
2	*L. ornata*		0.500									1.000		1.000	0.500
3	*Amiota okadai*		1.000					0.667	-0.123	0	-0.133	0.111	-0.286	0.200	-0.126
4	*A. stylopyga*	0.333	0										1.000	0.333	-0.333
5	*Scaptodrosophila coracina*	0	0.200		1.000									0	0.333
6	*S. subtilis*	0	-0.333		1.000				-0.500	0	0			0	-0.294
7	*Hirtodrosophila histrioides*	0.217	0.077	0	-0.452		0.156		0	0	-0.333	0.556	0	0	-0.074
8	*H. quadrivittata*	0										-1.000	-1.000	-0.111	1.000
9	*H. sexvittata*	0		-1.000								1.000		0	
10	*H. trivittata*	-1.000										0		-0.500	
11	*Mycodrosophila gratiosa*											-0.500	-1.000	-0.500	-1.000
12	*Drosophila busckii*	0	0	0.173	0.190	0.150	0.217	0	0			0	-1.000	-0.161	0.174
13	*D. bifasciata*	-0.019	0.059	-0.063	0.491	1.000	0.500	0.396	-0.065	0.500	0.750	0.227	-0.250	0	0.185
14	*D. lutescens*	0.201	0.265	0	0.231	0.021	0.186		0	0.235	0.222	-0.056	-0.069	0.180	0.196
15	*D. melanogaster*	-0.345	0.036	-0.222	0	0.370	0.118	1.000	0	0.131	0.184	0.364	0.200	0.108	0.100
16	*D. suzukii*	0.043	0.383	0	-0.267	1.000	0	0.710	-0.018	-0.016	0	0.217	0	-0.839	0.192
17	*D. triauraria*	0	-0.500	0	-1.000	0	0			0.530	-0.236	-0.048	0	0.270	-0.096
18	*D. unipectinata*	0	0				0	0	0		1.000			-0.333	0.600
19	*D. agularis*	-0.500	0	-0.040	1.000		-0.333	0.226	-0.092	0	-0.625	-0.150	-0.310	-0.152	-0.312
20	*D. bizonata*	-0.149	-0.088	0	-0.250	0.500	-0.071	1.000	-0.400	0.210	-0.324	-0.012	-0.061	-0.008	-0.084
21	*D. curviceps*	0.068	0.101	-0.201	0.117	0	0.045			0	-0.250	-0.135	0.255	0.052	0.052
22	*D.* sp. of *curviceps* species-subgroup			0					0			-0.500		-0.400	
23	*D. histrio*	0	0.200		0.241		-0.500	0.167	-0.250	0.050	-0.647	0.371	-0.379	0.352	-0.349
24	*D. immigrans*	0.024	-0.127	-0.201	-0.479	0.213	-0.102	1.000	-0.026	0.333	-0.109	0.071	0	-0.041	-0.163
25	*D. lacertosa*	0.059	-0.368	0.194	-0.194	0.400	-0.081	1.000	-0.333	0.385	-0.335	-0.108	-0.068	0.118	-0.122
26	*D. pengi*	0.125	-0.020	-0.148	0.286	0.023	0.108		0.071	0	0.154	0		0.058	-0.018
27	*D. sternopleuralis*	0.067	0.003	0					0.667	0.304	0.136	0	0.190	0.120	0.048
28	*D. unispina*	-0.224	0.105	-1.000			-1.000	1.000		0	0	0.536	-0.389	-0.312	-0.368
29	*Nesiodrosophila raridentata*									0				0.500	
	Species No.	24	22	16	18	11	16	13	18	18	23	19	29	25	25

Vertical distribution pattern of drosophilid flies

It was observed that there was inconsistency in the vertical microdistribution gradient in almost species temporally and spatially (Table 2). In general, the gradient in vertical microdistribution was downward direction in most predominant species, except *D. lutescens*. The direction was upward in this species, even though it was inversed in

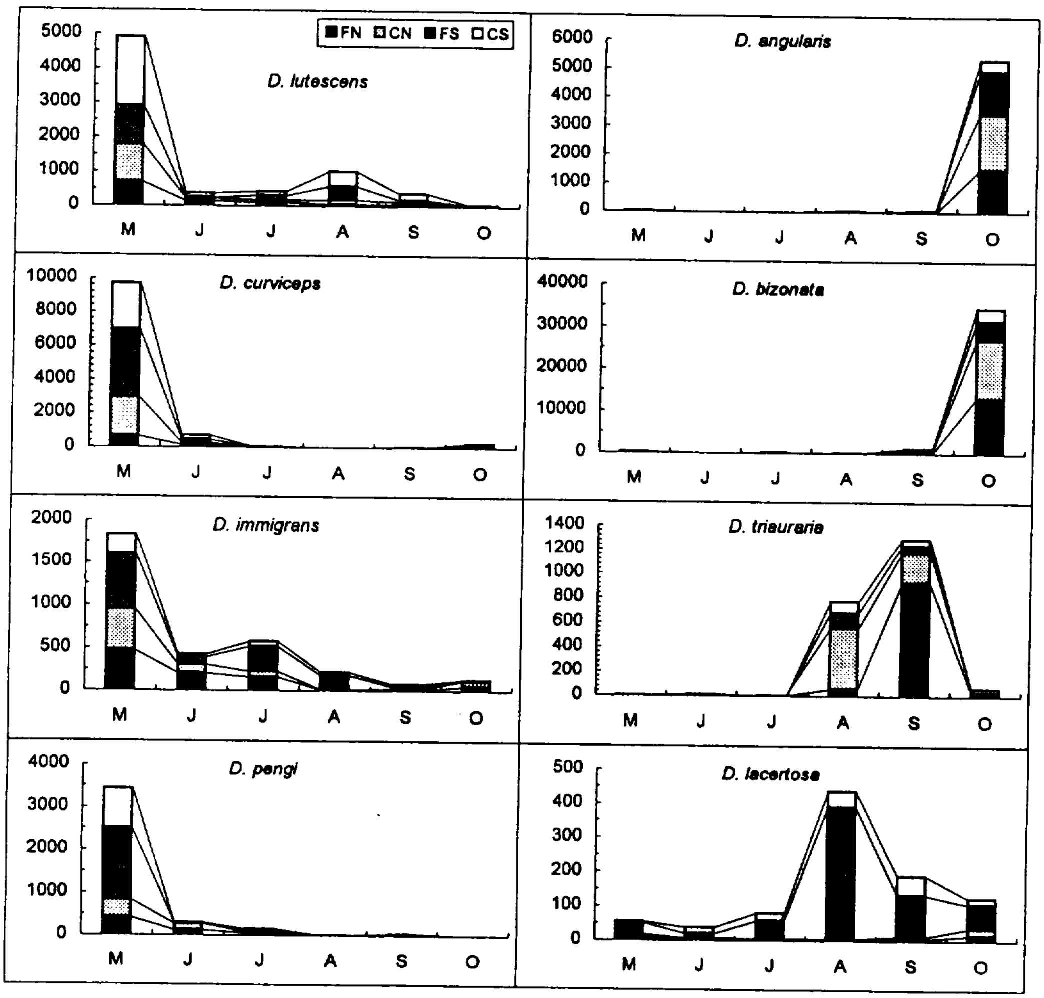

Fig.4. Seasonal changes in vertical microdistributions of the predominant species. In the legend the first letter, F and C, represent the floor and canopy collections, and the second letters, N and S, represent the study site NS and SA, respectively. Abscissa is month.

October at both sites. The gradient in vertical distribution could be affected by the numbers. The extreme case is when only one sepcimen has been catched at 0 or 5 m. Therefore, in order to minimize this effect the collections of six traps were classified two layers, i.e., the canopy layer defined as foliage 3-6 m above the ground and the floor layer 0-2 m above the ground, respectively.

Table 3. Seasonal comparison and significance (κ -square test) of numbers trapped in floor and canopy traps for the commonest species

Species	Site[a]	Layer	Month					
			May	Jun	Jul	Aug	Sep	Oct
D. lutescens	NS	Floor	704***	135**	117***	55***	53*	5
		Canopy	1,006	87	71	132	79	13
	SA	Floor	1,120***	32***	114	401	45***	7**
		Canopy	2,009	128	133	431	194	22
D. triauraria	NS	Floor	2	6	2	55***	925***	27
		Canopy	0	3	1	501	250	35
	SA	Floor	1	1	1	125*	57	1
		Canopy	1	0	1	93	53	0
D. angularis	NS	Floor	3	1	0	9	8	1,498***
		Canopy	1	0	0	5	16	1,945
	SA	Floor	9	1	3	3*	27***	1,488***
		Canopy	1	0	0	10	5	403
D. bizonata	NS	Floor	32	2	11	13	94***	13,062***
		Canopy	35	2	3	18	277	13,866
	SA	Floor	71***	6	40	31	385**	4,523***
		Canopy	31	6	44	45	312	3,015
D. curviceps	NS	Floor	650***	136	0	0	0	61**
		Canopy	2,291	115	1	3	2	93
	SA	Floor	3,997***	203*	36***	5*	15*	53
		Canopy	2,756	242	8	0	5	45
D. immigrans	NS	Floor	469	202***	157***	12	9	52
		Canopy	479	101	64	6	15	60
	SA	Floor	642***	86***	205***	159***	27	5
		Canopy	243	33	61	41	28	12
D. lacertosa	NS	Floor	9	5	0*	0*	5	16
		Canopy	8	2	5	6	8	21
	SA	Floor	33***	12	52***	383***	119***	69***
		Canopy	5	19	22	47	57	19
D. pengi	NS	Floor	414	128	58**	0	1	0
		Canopy	415	143	28	3	5	2
	SA	Floor	1,664***	8*	62***	3	9	0
		Canopy	926	20	12	0	17	0

[a]NS, Namsŏ-kyo and SA, Suak-kyo.

$^{*}P<0.05$, $^{**}P<0.01$, and $^{***}P<0.001$

The temporal and/or spatial differences were also observed in the seasonal pattern of vertical microdistribution with respect to the two layers in many predominant species (Fig. 4 and Table 3). In *D. lutescens*, the direction of vertical microdistribution was variable by month to month at the site NS, nevertheless it showed consistent unward direction at the site SA. In comparison of the cases that the direction of vertical microdistribution was significantly different at both sites, there are many cases that the directions are inverse between the two sites. Such difference would not be expected if the relative importance of the factors concerned is the same between the two sites. It is plausible that difference of the physical factors such as wind induced different responses at the two sites. In general there were many days with strong wind at the site SA, even though wind velocity was not recorded. There are some reports that wind has markedly influenced on flying insects (Rudolfs, 1923). Hachiya (1952) observed that the *Drosophila* showed a very low activity all day in which wind retained strong, sometimes as far as over 10 m/sec., except a dawn calm and an evening calm. Ishihara (1955) described that the diurnal activity of *Drosophila* was affected by wind of more than 5 m/sec.

Kimura (1976) suggested that the decaying season of plants affects the breeding season and the seasonal fluctuation of the drosophilid flies dwelling among undergrowth plants, referring to several reports on breeding sites of some drosophilid species (Frost, 1924; Heed, 1968; Momma, 1965; Pipkin, 1965; Spencer, 1942). From the analysis of the distribution and abundance of woodland species of British *Drosophila*, it has been concluded that factors associated with season and vertical site are the most important components of the adult *Drosophila* niche (Shorrocks, 1975). As mentioned above, four species of *Drosophila*, *D. curviceps*, *D. pengi*, *D. lutescens*, and *D. immigrans*, were dominant in

May. However, the predominant species were *D. triauraria* (at the site NS) and *D. lacertosa* (at the site SA) in August and September, and *D. bizonata* and *D. angularis* in October. These results suggest that the predominant species in the forest avoid niche overlap by means of seasonal separation of breedings, nevertheless the decaying season of plants also may affect the breeding season. Futhermore, the vertical microdistribution of the flies seemed to be not affected only the breeding sites but also physical factors in the deep wooded forests. According to observation of differences in the seasonal patterns of vertical microdistribution between the two survey sites, it is suggested that the vertical microdistribution is strongly affected by factors associated with season and vertical site in the deep wooded forests.

요 약

제주도의 자연림에 서식하는 초파리 군집구조를 파악하기 위하여 1994년 5월부터 10월까지 두 곳의 자연림에서 초파리를 채집하고, 이들의 종 수도와 미수직분포의 계절적 변이를 조사하였다. 전체적으로 우점종은 *Drosophila bizonata, D. curviceps, D. lutescens, D. angularis, D. pengi, D. immigrans* 등 6종이었다. 이들 우점종의 계절적 변화 양상은 두 조사지에서 유사하였다. 종다양성의 계절적 변동은 종풍부도(종수)보다는 균등도의 영향을 더 받는 것으로 나타났으며, 모든 우점종의 수도에서 계절적 변동은 단일 정점을 갖는 양상을 보였다. 우점종의 일부는 미수직 분포에서 두 조사지간에 차이를 나타냈다. 이러한 결과들은 수림에 서식하는 우점종들이 생식 시기를 달리함으로써 생태학적 지위의 중복을 피하며, 이들의 미수직분포는 계절과 고도차에 따른 요인에 많은 영향을 받고 있음을 암시한다.

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