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Seasonal fluctuation of moth community in Tomakomai Experiment Forest of Hokkaido University*

By

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北海道大学苫小牧地方演習林における
蛾類群集の季節的変動

吉田国吉**

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I. Introduction

There are many reports on the light-trap survey of moths for the purpose of programming the control in orchards and plantations (OATMAN 1964, GLICK et al 1965, THURSTON 1965, BANERJEE 1967, KAMRAN 1968, STEWART et al 1969, GENTRY et al 1971, MITCHELL et al 1972, HIENTON 1974, BUCHANAN 1977, etc), but only a few analyzing the community structure in field (PRESTON 1948, WILLIAMS 1953, YAMASHITA et al 1970, HOLLOWAY 1977, 1979, KIMOTO and AZUMA 1979). YOSHIDA (1976) recorded about 450 species of the moths belonging to 18 families from Tomakomai Experiment Forest of Hokkaido University. Since then he has performed light-trap surveys to obtain ecological information on the faunal make-up, habitat preference, vertical stratification, phenology and daily activity in the area. Among these aspects, the present paper deals with only an outline on the seasonal fluctuation of the moth community.

II. Area surveyed and flora of sampling sites

Tomakomai Experiment Forest of Hokkaido University, 2,719 ha, is situated in an undulatory lowland 5-90 m above sea-level (lat. 42°40'N. and log. 141°31'E.,

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苫小牧市青少年科学センター

Fig. 1). The climatic conditions from May to October in 1978 are given in Fig. 2, based on the data obtained at the forest observation tower of the Experiment Forest. The Forest is composed of broad-leaved forests (64% in area) and conifer afforestations (31%) (mainly *Larix leptolepis* and *Abies sachalinensis*).

The collections were made at four different stands, at each of which two traps were set, one at the inside and the other at the edge of the forest (Fig. 1). The outline of the flora at each sampling site is as follows :

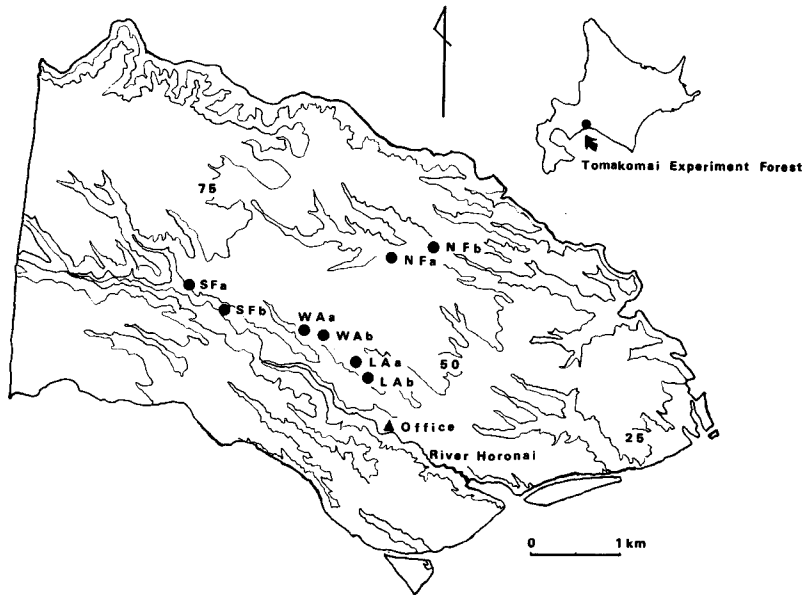


Fig. 1. Location and topography of the area surveyed. Closed circles show trap sites. NF: natural forest, SF: secondary forest, WA: white fir afforestation, LA: larch afforestation. a: forest inside, b: forest edge, numerals: altitude.

Natural forest (NF a, b): Dominated by *Quercus mongolica* var. *grosseserrata*, *Kalopanax pictus*, *Cercidiphyllum japonicum*, *Acer* spp, *Betula* spp, with some young trees (*Sorbus alnifolia*, *Carpinus cordata*, *Acer palmatum* var. *matsumurae*, *Magnolia kobus* var. *borealis*, *Tilia japonica* and others). Inside undergrowth mostly *Pachysandra terminalis* and *Dryopteris crassirhizoma* with some other herbs, while at the edge mainly *Dryopteris crassirhizoma*, *Phryma leptostachya* var. *asiatica* and some grasses.

Secondary forest (SF a, b): Mainly dominated by *Quercus mongolica* var. *grosseserrata*, *Ulmus davidiana* var. *japonica*, *Fraxinus mandshurica* var. *japonica* and *Betula* spp, with some young trees (*Acer palmatum* var. *matsumurae*, *Prunus maximowiczii*, *Syringa reticulata*, *Carpinus cordata*, *Acer mono* and others). Inside undergrowth mainly *Carex* sp., *Dryopteris crassirhizoma*, *Phryma leptostachya* var. *asiatica*, *Senecio cannabifolius* and others, at the edge mainly *Carex* sp., *Aruncus dioicus* var. *kamtschaticus*.

White fir afforestation (WF a, b): Dominated by *Abies sachalinensis* (48 years old), with some young trees (*Aralia elata*, *Morus bombycis*, *Acer mono*, *Acer palmatum* var. *matsumurae*, *Tilia japonica* and others). Inside undergrowth mainly *Dryopteris crassirhizoma*, *Athyrium filix-femina* var. *longipes*, at the edge mainly *Aruncus dioicus* var. *kamtschaticus*, *Dryopteris crassirhizoma* and some other herbs.

Larch afforestation (LA a, b): Mainly *Larix leptolepis* (22 years old), with some young trees (*Acer palmatum* var. *matsumurae*, *Quercus mongolica* var. *grosseserrata*, *Fraxinus lanuginosa*, *Morus bombycis*, *Magnolia obovata* and others). Inside undergrowth mainly *Sasa nipponica*, *Pachysandra terminalis*, *Schisandra chinensis* and *Dryopteris crassirhizoma*, at the edge *Pachysandra terminalis* and *Oenothera erythrosepala*.

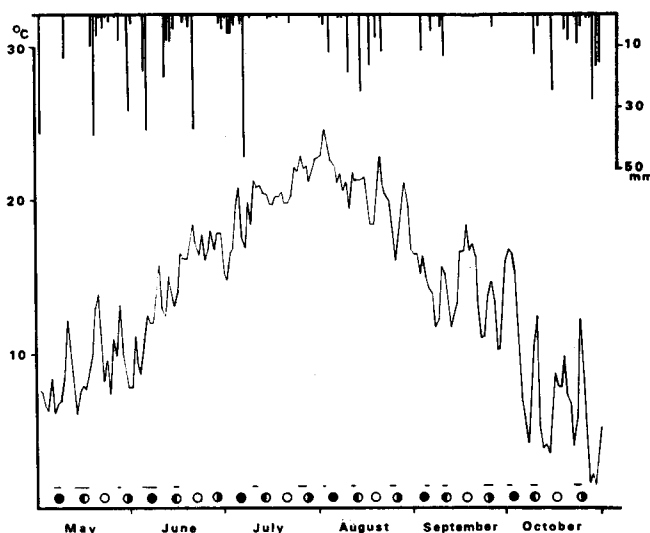


Fig. 2. Climatic conditions of the area surveyed from early May to late October in 1978. Top: precipitation, middle: daily mean temperature, bottom: surveyed periods and moon phase.

III. Methods

The samplings were made for 1 to 5 nights per ten days from early May to late October in 1978, resulting in a total of 43 night collections. The traps employed for this survey are omnidirectional-design light traps: Lamp, a 6 W fluorescent black light tube; electric power supplied with 12 V battery; trap chamber, a cylindrical type made from resin (90 cm × 45 cm); baffle and funnel, an American standard model (HIENTON 1974) partly altered from the portable light trap, Model YI-2 (YAMASHITA and ISHII 1970). The moths trapped were sifted through two different screen sieves in trap chamber to facilitate identification of the species. They were killed with ethyl ether and removed from the traps in the next morning. Samples in late June and early July could not be obtained for the accident on the operation of the light trap. This lack should be supplied in future.

IV. Results and Discussion

In total 22,476 individuals of 380 species were obtained, which belonged to 13 families, *Sphingidae*, *Saturniidae*, *Brahamaeidae*, *Arctiidae*, *Noctuidae*, *Notodontidae*, *Lymantriidae*, *Lasiocampidae*, *Bombycidae*, *Thyatiridae*, *Drepanidae*, *Geometridae*, and *Heterogeneidae*. The numbers of species and individuals were much more abundant at the natural and secondary forests than at the white fir and larch afforestations. In order to analyze the community structure, the species diversity was examined. Generally, average species diversity is divided into two factors, namely "species richness" measured by number of species in sample, and "equitability" measured by relative diversity indices. H' (SHANNON and WEAVER 1949) and $e^{H'}/S$ (SHELDON 1969) were employed as the indices of average and relative species diversity, respectively, which are expressed by the following formula:

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

where $P_i = n_i/N$, N = total number of individual in each sample, n_i = the number of individuals of species "i", and unit of H' is bit, and

$$E = e^{H'}/S$$

where S = total number of species in each sample, and unit of $e^{H'}/S$ is nit. In the subsequent description, the numbers of individuals and species and the values of H' and $e^{H'}/S$ are represented by daily mean values in each decade of a month.

Sites	Individuals	Species
NF a	5,157	270
NF b	3,924	257
SF a	3,239	235
SF b	3,335	227
WA a	2,098	181
WA b	2,337	240
LA a	1,680	173
LA b	706	145

Natural forest (Fig. 3)

All figures and indices are similar in seasonal patterns between forest inside and edge. The individual numbers showed two large peaks in mid July and early to mid August and two small peaks in mid September and mid October. The values of average species diversity were high from mid July to mid August, increasing slightly again in early October. The seasonal fluctuation of the species numbers was nearly similar to that of average species diversity. In early August at forest edge it decreased distinctly, but the same tendency was also seen at the other stands. The values of relative species diversity was rapidly decreasing from early June to mid July, and underwent a low level till mid August, followed by

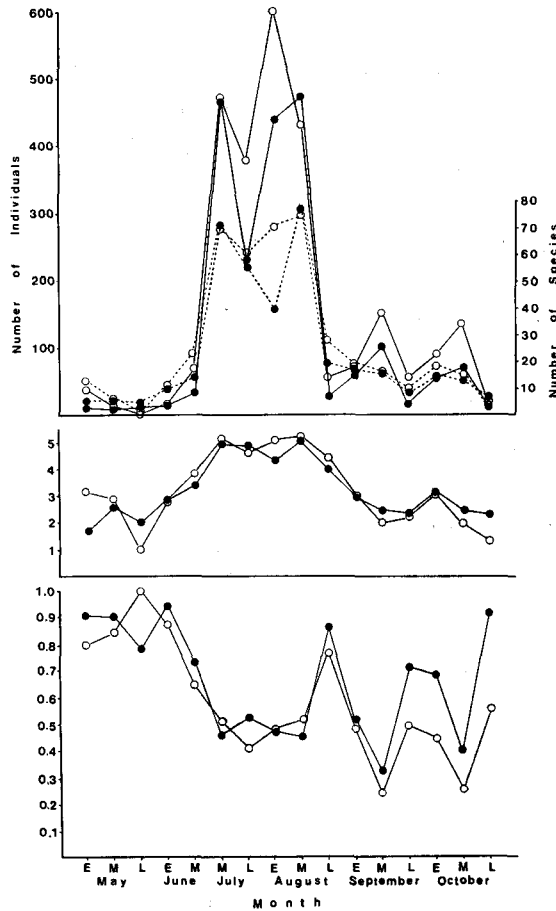


Fig. 3. Seasonal fluctuation of the moths caught by light traps at the natural forest in 1978. In Fig. 3~6, open circles: forest inside, closed circles: forest edge, top: individual numbers (solid line) and species numbers (broken line), middle: average species diversity (H'), bottom: relative species diversity ($e^{H'}/S$).

an amplified fluctuation.

The following conclusions on the structure of moth community in natural forest can be extracted from the results mentioned above. In spring, moth community was low in density, and showed a simple structure characterized by small number of species with similar population sizes. In summer, the density was high, i. e., the individual numbers collected at the forest inside and at the edge from mid July to mid August attained 72% and 80% of the total yield, respectively. Its structure was complex caused by "species richness" not by "equitability". Bursts of many predominant species contributed to both diversity and abundance in this period. In fall, moth community was greatly affected both in its density and in its structure by alternation of predominant species, *Hermonassa arenosa* in mid September (64% at the inside and 58% at the edge) and *Ramobia basifuscaria* in mid October (62% at the inside and 41% at the edge).

Secondary forest (Fig. 4)

The patterns of individual numbers at the forest inside and the edge are similar in spring and fall, showing a conspicuous peak in early October together with a small one in mid September. But a notable difference was observed in summer, two peaks in mid July and early to mid August at the forest inside against only one conspicuous peak in late July at the edge. The patterns of average species diversity at forest inside and forest edge showed gentle fluctuation on the whole, with distinct drops in late July at the forest edge and in early October at both sites. The fluctuation patterns of species number and relative species diversity at both sites were nearly similar to those of natural forest, but relative species diversity showed abrupt decrease in late July at the forest edge and in early October at both sites. These low values of "equitability" possibly affected much the corresponding values of average species diversity.

Consequently the moth community in secondary forest showed seasonal patterns similar to those in natural forest. However, at the forest edge *Eilema nankingica* was extremely predominant in late July (61%), while less abundant at the inside

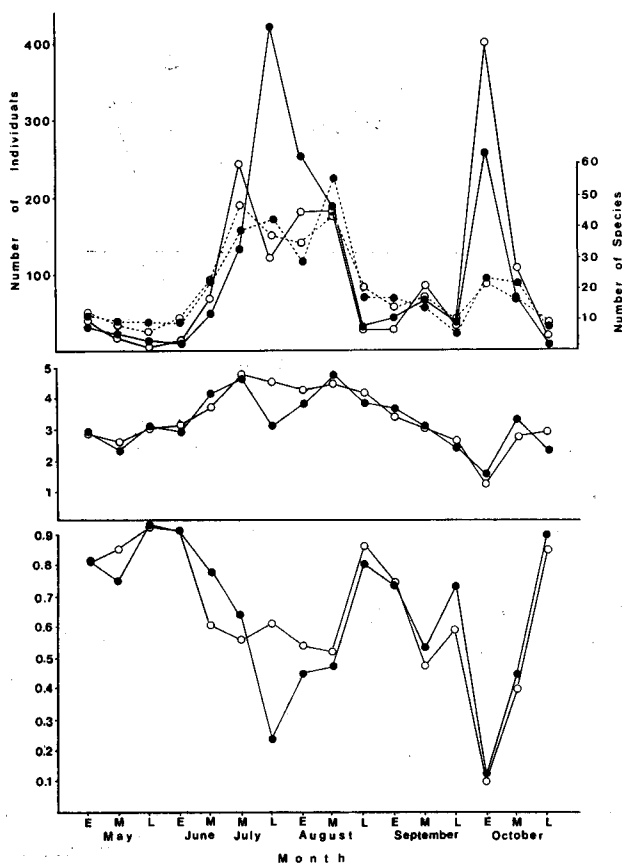


Fig. 4. Seasonal fluctuation of the moths at the secondary forest in 1978.

(19%). As in the natural forest, *Hermonassa arenosa* was frequent in mid September (40% at the inside and 31% at the edge). Against the predominance of *Ramobia basifuscaria* in mid October in natural forest, *Rhodinia fugax diana* was extremely abundant in early October in secondary forest (inside: 78%, edge: 81%), which seemed to cause in part the great difference in the number of moths trapped in this period between the secondary and natural forests.

White fir afforestation (Fig. 5)

At forest inside, the individual number decreased from early May, at start of sampling, to mid May, and thereafter fluctuated moderately to late August. It showed a rapid increase in mid September, followed by decrease in late September and a slight increase in late October. On the other hand, the pattern at forest edge is characterized by four distinct peaks of nearly same height in mid to late July, mid August, mid September and early October. The fluctuations of average species diversity at forest inside and edge tended to show a large peak in summer. The species numbers at both sites were large in summer, showing two distinct peaks in mid to late July and mid August at the forest edge.

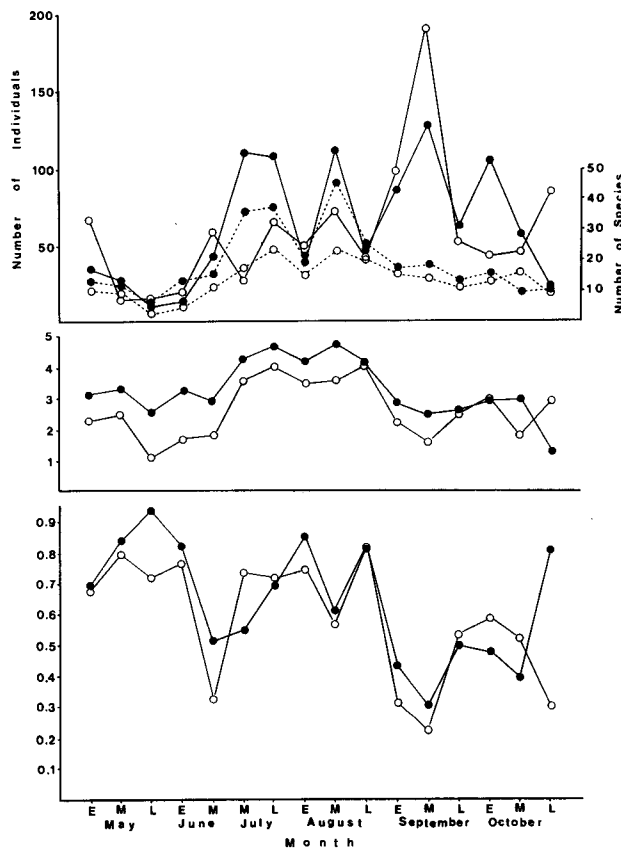


Fig. 5. Seasonal fluctuation of the moths at the white fir afforestation in 1978.

In conclusion the white fir afforestation was less abundant in the number of moths than in the natural and secondary forests, and radically different in the seasonal pattern from the latter. The predominant species at forest inside was *Eupithcia daemionata* (52%) in early May, *Gonodontis bidentata harutai* (70%) in mid June, *Eilema depressa pavescens* (31%) in mid August, *Alcis medialbifera* (67%) in mid September, and *Erannis gigantea* (67%) in late October. The samples at forest edge exceeded mostly those at inside in the individual number, species number and average species diversity, probably due to the closeness of a broad-leaved forest to the trap site.

Larch afforestation (Fig. 6)

At forest inside both numbers of individuals and species were relatively small throughout the season, except for a peak from late July to mid August. The average species diversity showed a peak in late July. In this favorable period the predominant species were *Semiothisa shanghaiaria* (25% in early August and 21% in mid August) and *Eilema depressa pavescens* (17% and 41%, respectively). At the forest edge, the moths were less abundant throughout the whole season except in early May. It seems that the trap light was so markedly screened by thick vegetation surrounding the trap that the trapping efficiency might have been

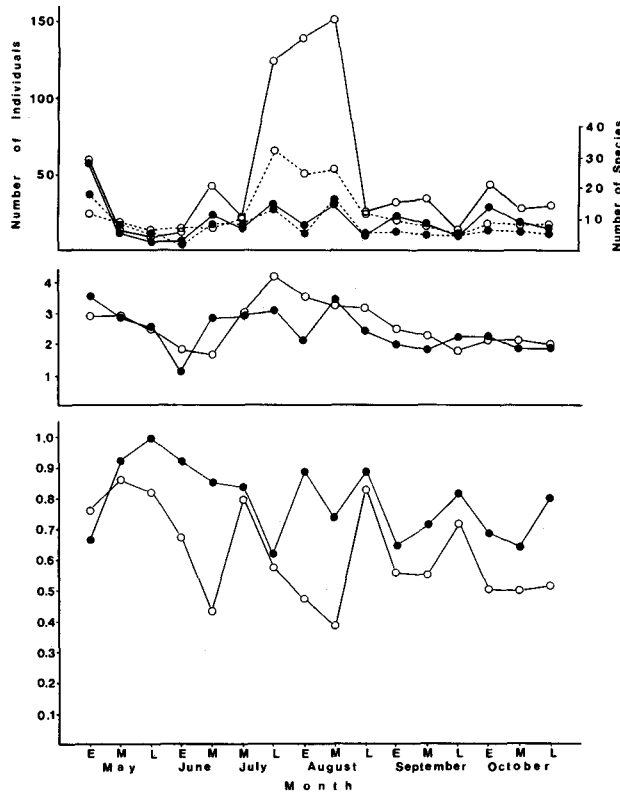


Fig. 6. Seasonal fluctuation of the moths at the larch afforestation in 1978.

decreased.

From the analyses on seasonal changes of species diversity in several communities, KIMOTO and AZUMA (1979) concluded that the average diversities by $e^{H'}$ and H' are more correlative with "species richness" by number of species in sample (S) than "equitability" by $e^{H'}/S$. The average diversity measured by these indices are theoretically given in form of the product or the sum of the species richness and the equitability. In large multispecies population, the species richness by S takes a larger value comparing with that of equitability. This would result in a high correlation between average species diversity and species richness. The results obtained in the present survey agreed approximately with their conclusion. It is, however, note worthy that the average species diversity was more correlative with "equitability" than "species richness" in several cases, e. g., in late July at the forest edge and in early October forest inside and edge in the secondary forest. In such cases the conspicuous predominancy of single species would play an important role for the depression of species diversity. On the other hand, the total individual number is another aspect of community structure. Its seasonal pattern was entirely reverse to that of the "equitability", in other words, parallel with the predominancy at every stand. It can be, therefore, concluded that the seasonal fluctuation of total individual number of the moth community at each stand is much affected by a small number of predominant species not by many common species.

V. Summary

The light-trap survey was carried out to obtain some ecological information on the moths of Tomakomai Experiment Forest at four different stands from early May to late October in 1978.

1) In total, 22,476 individuals of 380 species belonging to 13 families, *Sphingidae*, *Saturniidae*, *Brahamaeidae*, *Arctiidae*, *Noctuidae*, *Notodontidae*, *Lymantriidae*, *Lasiocampidae*, *Bombycidae*, *Thyatiridae*, *Drepanidae*, *Geometridae*, and *Heterogeneidae* were obtained.

2) The seasonal fluctuation of the moth community and the predominant species were compared among the four different stands.

VI. Acknowledgements

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VIII. 摘 要

1978年5月上旬～10月下旬に、北海道大学苫小牧地方演習林の広葉樹天然林、広葉樹2次林、トドマツ林およびカラマツ林の4つの異なる林相で蛾類群集の季節的変動を把握するためにライト・トラップ調査を行なった。

1) 全体で、スズメガ科 (*Sphingidae*)、ヤマヤユガ科 (*Saturniidae*)、イボタガ科 (*Brahmaeidae*)、ヒトリガ科 (*Arctiidae*)、ヤガ科 (*Noctuidae*)、シャチホコガ科 (*Notodontidae*)、ドクガ科 (*Lymantriidae*)、カレハガ科 (*Lasiocampidae*)、カイコガ科 (*Bombycidae*)、トガリバガ科 (*Thyatiridae*)、カギバガ科 (*Drepanidae*)、シャクガ科 (*Geometridae*)、イラガ科 (*Heterogeidae*) の13科に属する380種、22,476個体が採集された。

2) 天然林と2次林における蛾類群集の季節的変動はそれぞれに、類似したパターンを示した。すなわち、春は低密度で単純な群集、夏は高密度で著しく複雑な群集、秋は高密度で比較的単純な群集であった。しかしながら、トドマツ林、カラマツ林はこれら2林相とかなり異なる変動パターンを示した。

3) 蛾類群集において1種のきわだった優占性が種多様性の下降の上で重要な役割を演じていると思われる。

4) 個体数の季節的変動は、多くの普通種ではなく少数の優占種によって大きく影響されている。