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# Nocturnal Flight Activity of Moths

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**Abstract**

Nocturnal flight activity of macrolepidopterous moths was observed in Nopporo Forest Park and on Mt. Usu, Hokkaido, northern Japan. Air temperature seemed to be one of the crucial factors controlling their flight activity, because the number of flying moths rapidly declined at about 10°C or less in the autumn and at about 5°C or less in early winter. The flight activity of many species could be grouped into five types on the basis of full-flight time: pre-midnight, midnight, post-midnight, bimodal, and peakless types, though some species showed seasonally or sexually different flight patterns. Although congeneric species tended to have similar flight patterns, the flight activity within each family was not always homogenous. As suggested by Miyata (1983) concerning the moths on Kyushu Island, southern Japan, the ratio of bimodal and peakless types was higher in openland moths than in forest ones.

**Key Words**: Moths, Nocturnal flight, Mt. Usu, Nopporo Forest Park

## 1. Introduction

Studies on nocturnal flight activities of moths have frequently been conducted on agricultural pests such as *Chilo simplex* (Kaburaki and Kamito, 1929), *Crambus trisectus*, *C. teterrellus* and *C. mutabilis* (Banerjee, 1967), *Laspeyresia pomonella* (Pristavka, 1969), *Grapholitha molesta* (Rothschild and Minks, 1974), *Ostrinia nubilalis* (Showers et al., 1976) and *Melissopus latiferreanus* (AliNiazee, 1983). Kaburaki and Kamito (1929), Banerjee (1967), and Showers et al. (1976) reported that each species of moths had its specific flight time controlled by intrinsic factors such as mating urge, oviposition urge, and pheromone response. In addition to these factors, Pristavka (1969), Rothschild and Minks (1974), and AliNiazee (1983) stressed the importance of the influence of temperature and wind velocity.

In contrast to the research on agricultural pests, there have been few surveys dealing with moths collected in natural environment, except for the research of Williams (1939, 1940) in Rothamsted, England, and of Miyata (1983) on Kyushu Island, southern Japan. In the present survey, therefore, we analyze the nocturnal flight activity of moths inhabiting central Hokkaido, northern Japan, in relation to the influence of weather conditions and phylogenetic inertia, as a follow-up to previous reports of the faunal makeup of moths collected in Nopporo Forest Park

(Sato and Fukuda, 1985) and on Mt. Usu (Sato et al., 1985).

## 2. Study Areas and Methods

Surveys were made mainly in Nopporo Forest Park near the city of Sapporo, and on Mt. Usu, an active volcano on which vegetation was damaged by eruptions in 1977-78 (Ota and Ito, 1980; Ito and Haruki, 1984). In Nopporo Forest Park, of which vegetation is composed of coniferous forests, summer-green broad-leaved forests and mixed forests (Tatewaki and Igarashi, 1973), the sampling was made within a mixed stand dominated by *Abies sachalinensis, Magnolia obovata, Fraxinus lanuginosa*, and *Sorbus commixta*, on July 1-3, August 3-6, September 3-6, October 3-6, and November 3-6, 1982 (Sato and Fukuda, 1985). On Mt. Usu, which is located 48 km southwest of Nopporo Forest Park, moths were collected in the crater basin deforested by the most recent eruptions and in a nearly intact forest on Yosomiyama on June 15-17, July 31-August 1, September 8-9, and October 29-31, 1984. The crater basin is in the exposed ground partly covered with artificially sown herbs and grasses, while the natural forest on Yosomiyama is composed of *Populus maximowizii, Alnus hirsuta, Betula ermanii*, and *Ulmus davidiana* var. *japonica* (Sato et al., 1985).

The flight activity of the following 16 families was examined in the present survey: Hepialidae, Limacodidae, Thyrididae, Drepanidae, Thyatiridae, Geometridae, Epiplemidae, Lasiocampidae, Bombycidae, Saturniidae, Sphingidae, Notodontidae, Lymantriidae, Arctiidae, Nolidae, and Noctuidae. In all sampling stations, moths lured to two fluorescent black lamps and one mercury light were captured from sunset to sunrise (Sato and Fukuda, 1985), with hourly records of air temperature, general weather conditions (fair, cloudy, foggy or rainy) and wind force using Beaufort's wind scale.

## 3. Results

In Nopporo Forest Park 12,843 specimens of 430 species were collected. Figure 1 shows nocturnal fluctuation of their flight activity, the oscillation of air temperature, wind force and weather on each sampling date. The greatest number of moths was collected in July (early summer) and August (mid summer), with unimodal and bimodal fluctuations respectively. Thereafter, the number of moths gradually decreased with a small peak before midnight in September (early autumn) and October (mid autumn), and finally they nearly disappeared in November (early winter) with no clear peak. The moths collected on Mt. Usu totaled to 3,847 specimens of 263 species in the crater basin and 900 specimens of 191 species on Yosomiyama. Although the fluctuation pattern of flight activity in each season was similar to that of Nopporo Forest Park, the seasonal sample size per day was relatively small (Figure 2), except in the summer in the crater basin, probably because of the faunal and vegetational damage by the 1977-78 eruptions.

There was almost no correlation between the flight activity of moths and the oscillation of the air temperature from mid June to early August (Figures 1 and 2). In September, however, they became inactive at low temperatures, particularly at about 10°C or less. In October and November, the winter moths, such as *Alsophila japonensis*, *Operophtera brumata*, *Larerannis orthogrammaria* and *Ptilophora nohirae*, flew (Sato and Fukuda, 1985) even around 10°C, but they also became inactive at about 5°C or less. Cloudiness and drizzling rain appeared to neither inhibit nor accelerate their flight activity. However, the influence of fog may be a factor, because an extremely large number of moths were collected on a foggy day, July 31, in the crater basin of Mt. Usu. Although breezes had no effect on the moth activity, strong wind (class 3 on Beaufort's scale) restrained their flight, as on September 8–9, in the crater basin.

The sample size was enough for the flight activity pattern of 85 species to be examined. Based on the full-flight time of each species (Figure 3), the nocturnal activity could be grouped into five types: 1) pre-midnight type (hereafter PR), showing a flight peak before 23:00, e.g. *Austrapoda dentata*, *Tyloptera bella*, *Scionomia mendica*, and *Cifuna locuples*; 2) midnight type (MI), with a peak between 23:00 and 1:00, e.g. *Parapsestis argenteopicta*, *Mimopsestis basalis*, *Geometra diekmanni*, and *Rhyparioides nebulosus*; 3) post-midnight type (PO), with a peak after 1:00, e.g. *Hypomecis punctinalis*, *Larerannis orthogrammaria*, *Ennomos autumnaria* and *Lymantria monacha*; 4) bimodal type (BI), with two peaks, e.g. *Aethalura nanaria*, *Lobogonodes erectaria*, *Milthocrista miniata*, and *Sineugraphe exusta*; 5) peakless type (PL), which flew anytime with no clear peak, e.g. *Callidrepana palleola*, *Ecliptopera umbrosaria*, *Viminia rumicis*, and *Amphipyra pyramidea*. In the species *Electrophaes coryrata*, females flew in full-scale before midnight but males after midnight. The females might fly for egg-laying and the males for mate-seeking, as shown in *Chilo simplex* (Kaburaki and Kamito, 1929), *Crambus* spp. (Banerjee, 1967) and *Abraxas miranda* (Honda and Tamura, 1977). Moreover, following five species showed seasonally different flight patterns: *Deileptenia ribeata*, *Ourapteryx maculicaudaria*, *Chasminodes* spp., *Amphipoea ussuriensis* and *Abraxas* spp.. The first four of these species showed PO or BI in August but PR in September, probably due to the sharp drop in temperature after midnight (Figure 1). Another form, *Abraxas* spp., belonged to PL on July but PO on August, probably because this form seemed to involve multiple species which could barely be distinguished from one another morphologically.

Five species were common to Nopporo Forest Park and Mt. Usu. Out of them, the following four species did not show the locally different flight types: *Ecliptopera umbrosaria* (PL), *Perizoma saxeum* (PR), *Miltochrista miniata* (BI), *Chasminodes* spp. (PL). Although another species, *Dimorphicosmia variegata*, flew in full-scale before midnight at Nopporo but around midnight on Mt. Usu, this difference was too small to be regarded as the local varieties of flight activity.

Among nine genera, each containing two or three congeners, the flight pattern did not conform in only two genera, i.e. *Amphipyra* (PL and MI) and *Catocala*

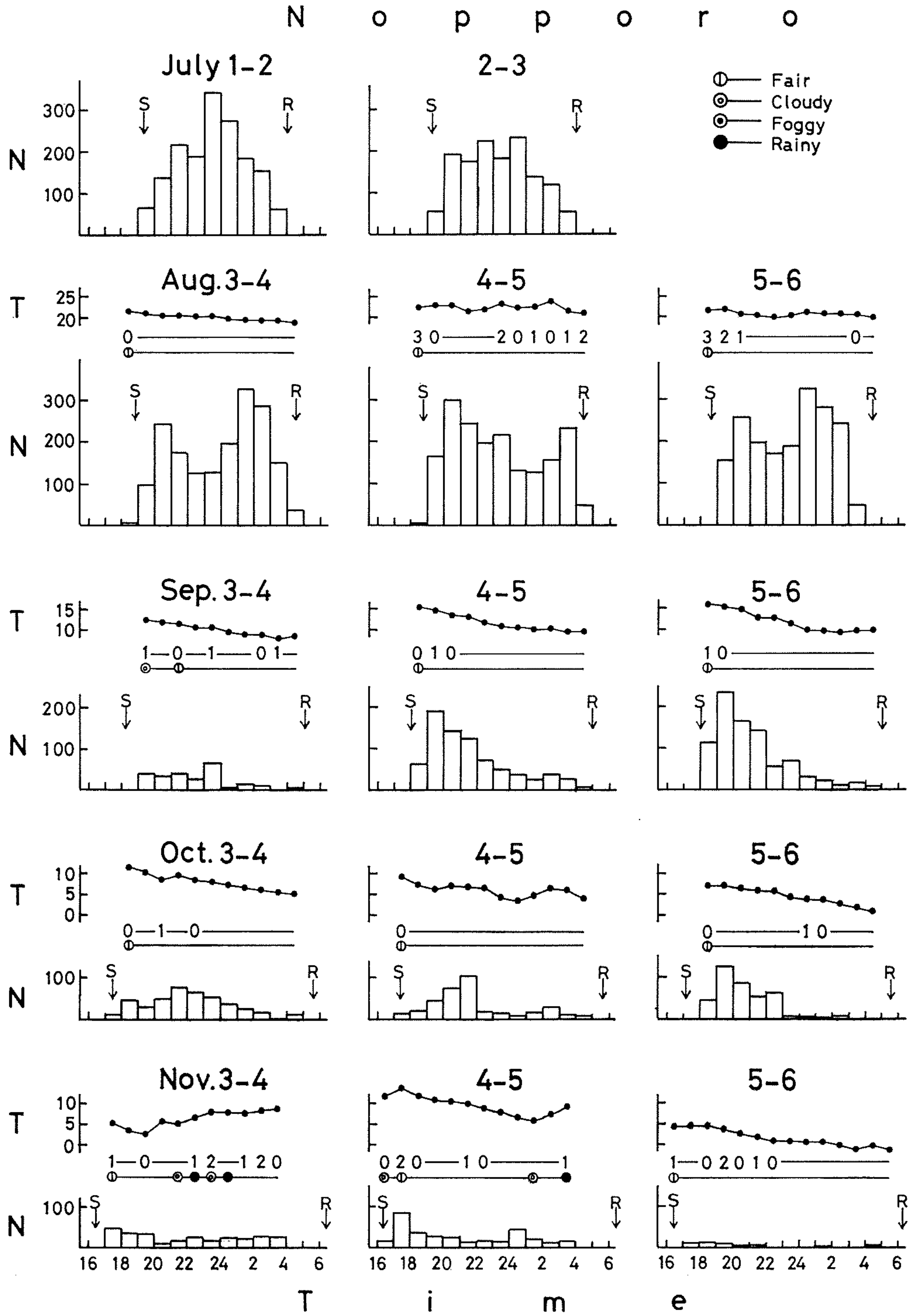



**Figure 1.** Fluctuation of nocturnal flight activity of moths in Nopporo Forest Park, with the changes of weather conditions. N, T, S, and R represent the number of specimens, air temperature (°C), sunset and sunrise, respectively. Wind force is also given by using Beaufort's scale.

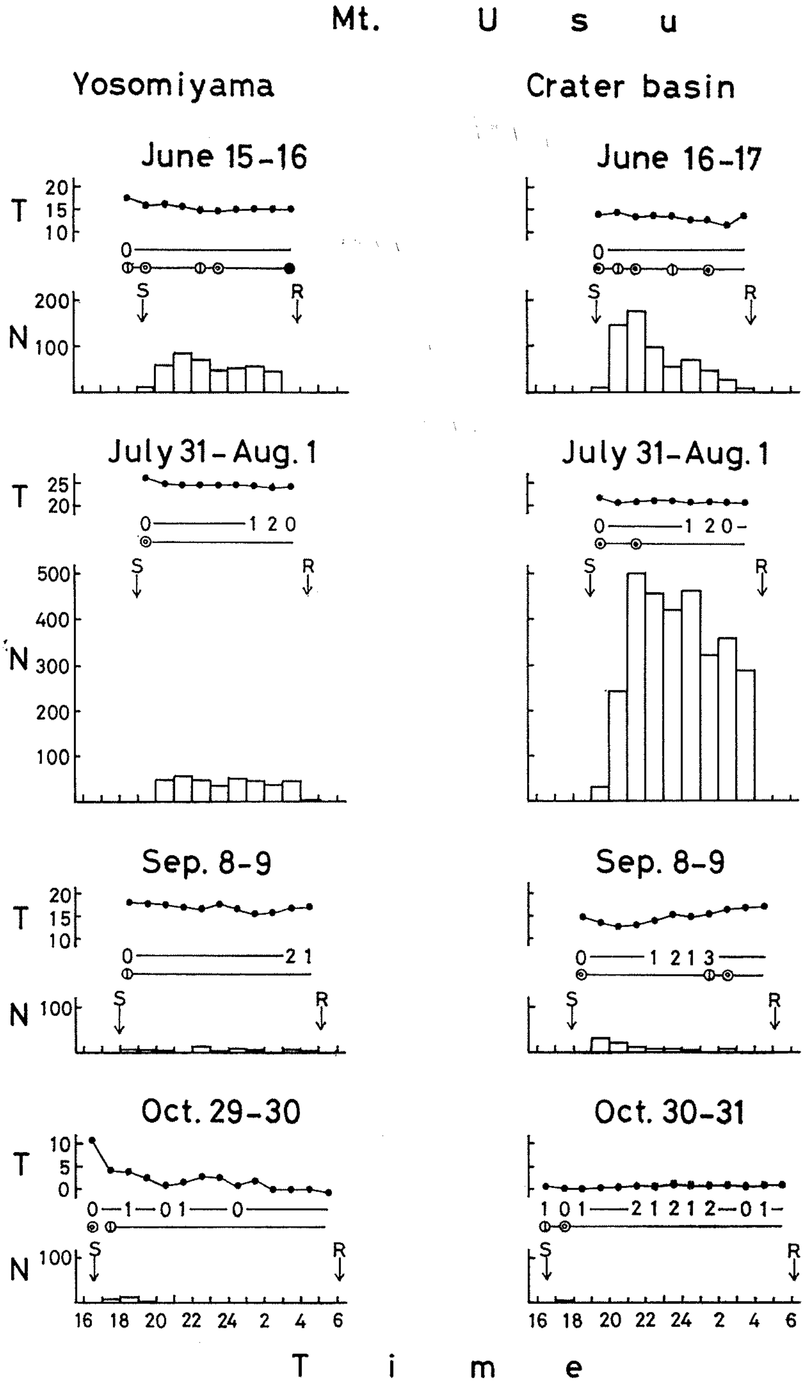



**Figure 2.** Fluctuation of nocturnal flight activity of moths on Mt. Usu. For abbreviations and signs, see Figure 1.

(BI and MI), but did conform in three genera, i. e. *Hypomecis* (PO), *Sineugraphe* (BI) and *Cosmia* (PR), and nearly conformed in four genera, i. e. *Myrteta* (PR and PL), *Lomographa* (PO and MI), *Eilema* (MI and PL) and *Chasminodes* (PL and PR). This means that congeneric species tend to have similar flight activity patterns, as found in three congeneric species of *Crambus* by Banerjee (1967). However, the flight activity within each family was not always homogenous (Table 1). For in-

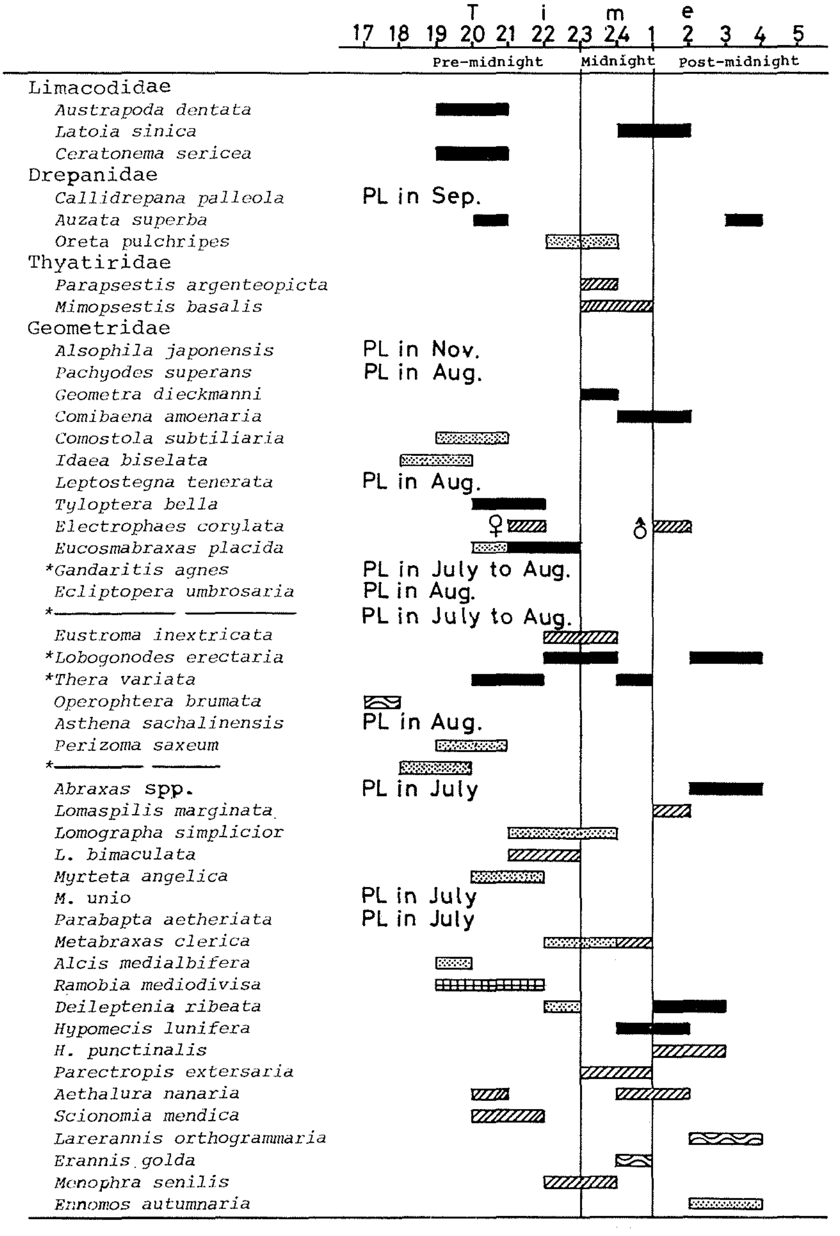
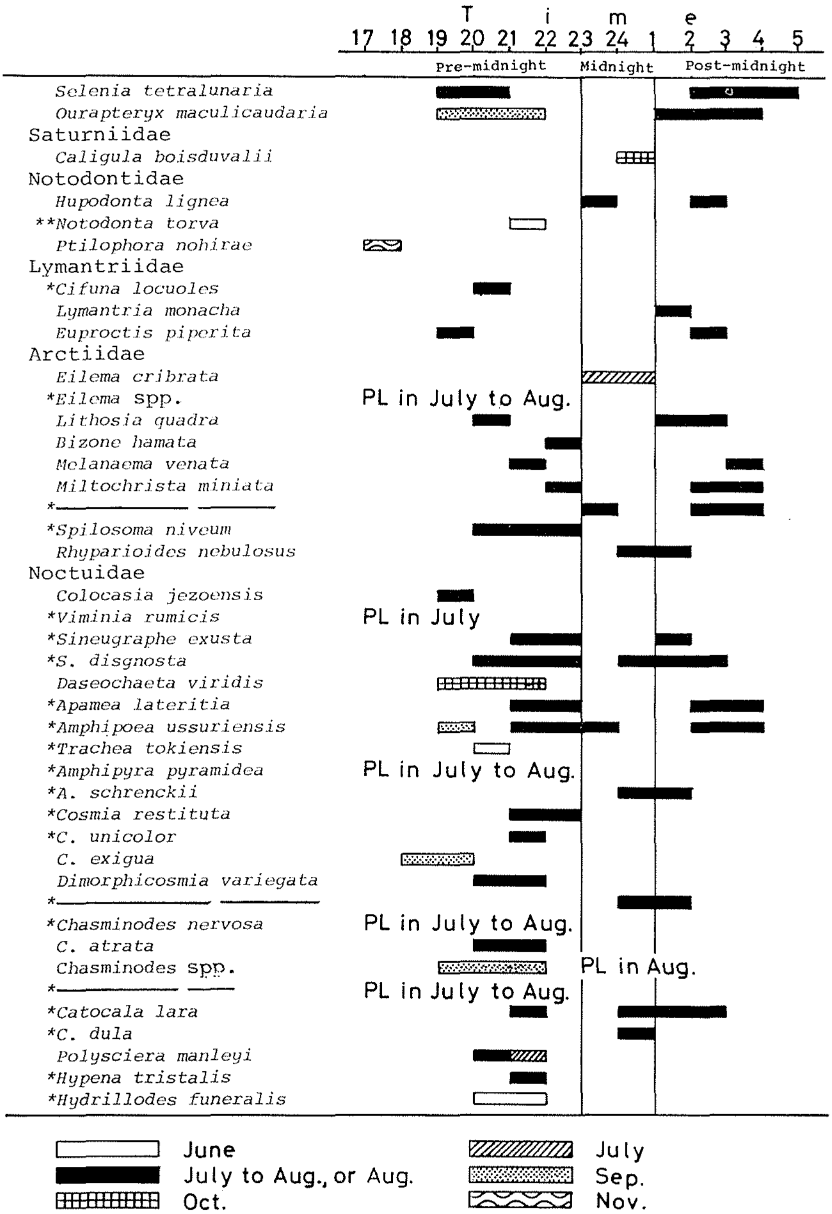



**Figure 3.** Full-flight time of 85 dominant species. One asterisk indicates species collected on Yosomiyama and two asterisks indicate

stance, the largest family, Geometridae, contained all flight types without any predominant type, i. e. 11PR, 8PL, 7MI, 6PO, 4BI. However, the second largest family, Noctuidae, seemed rather homogenous, since 10 of the 22 species belonged to PR.

Miyata (1983) suggested that the species which flew anytime of the night, i. e. type PL or BI, were apt to prefer openland habitats to forest habitats. As shown




those collected in the crater basin. Other species were collected in Nopporo Forest Park.

**Table 1.** Number of species in nine families according to flight types. PR, pre-midnight type; MI, midnight type; PO, post-midnight type; BI, bimodal type; PL, peakless type; MX, mixed type which showed sexually, seasonally and locally differet flight types.

| Family | Type of flight activity | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | PR | MI | PO | BI | PL | MX | |
| Limacodidae | 2 | 0 | 1 | 0 | 0 | 0 | 3 |
| Drepanidae | 0 | 1 | 0 | 1 | 1 | 0 | 3 |
| Tyatiridae | 0 | 2 | 0 | 0 | 0 | 0 | 2 |
| Geometridae | 11 | 7 | 6 | 4 | 8 | 4 | 40 |
| Saturniidae | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Notodontidae | 2 | 0 | 0 | 1 | 0 | 0 | 3 |
| Lymantriidae | 1 | 0 | 1 | 1 | 0 | 0 | 3 |
| Arctiidae | 2 | 2 | 0 | 3 | 1 | 0 | 8 |
| Noctuidae | 10 | 2 | 0 | 4 | 3 | 3 | 22 |
| Total | 28 | 15 | 8 | 14 | 13 | 7 | 85 |

**Table 2.** Comparison of flight types between openland species and forest species. For abbreviations, see Table 1.

| Habitat preference | Type of flight activity | | | | | Total |
|---|---|---|---|---|---|---|
| | PR | MI | PO | BI or PL | MX | |
| Openland species | 0 | 0 | 0 | 6 (86%) | 1 (14%) | 7 (100%) |
| Forest species | 4 (40%) | 1 (10%) | 0 | 5 (50%) | 0 | 10 (100%) |
| Unknown | 4 (45%) | 2 (22%) | 0 | 3 (33%) | 0 | 9 (100%) |
| Total | 8 (39%) | 3 (12%) | 0 | 14 (55%) | 1 (4%) | 26 (100%) |

in Table 2, his suggestion was compared with the samples obtained in the crater basin which comprised not only openland species, such as *Ecliptopera umbrosaria*, *Lobogonodes erectaria*, *Spilosoma niveum*, *Viminia rumicis*, *Sineugraphe exusta*, *Apamea lateritia*, and *Amphipoea ussuriensis*, but also forest species, such as *Gandaritis agnes*, *Thera variata*, *Amphipyra pyramidea*, *Cosmia restituta*, *C. unicolor*, *Chasminodes* spp., *C. nervosa*, *Catocala lala*, *C. dula*, and *Hypena tristalis* (Sato et al., 1985). The moths of the types BI and PL reached 86% (6/7) in the openland species but 50% (5/10) in the ten forest species, which may be consistent with the findings of Miyata (1983).

## 4. Discussion

AliNiazee (1983) divided factors regulating the flight activity of moths into intrinsic (endogenous) and extrinsic (exogenous) groups. He enumerated seasonal rhythms, diel rhythms, mating urge, mate searching behavior, oviposition urge and breeding stimuli as intrinsic factors, and light intensity, air temperature, wind velocity, rainfall, and avoidance from predators as extrinsic factors. The present research suggested that the effect of these factors changed according to the season : in the summer the flight activity seemed to be controlled very little by extrinsic factors but more probably by intrinsic factors ; in the autumn and the early winter, however, the extrinsic factors, particularly the air temperature, had a greater effect.

Miyata (1983) collected 656 moth species in Kyushu, southern Japan, and found that flight activity of moths abruptly declined at about 15°C or less, unlike the present results in which the threshold temperature was about 10°C. This may mean that the moths of northern Japan are more tolerant to low temperatures than those of southern Japan. Moreover, Miyata (1983) could determine the flight types of 245 species, and found that Noctuidae was dominated by moths flying in full-scale before midnight. However, Geometridae was dominated by moths of types BI and PL, contrary to the present results. In Rothamsted, England (Williams, 1939), MI predominated in Noctuidae (16 of 27 species) contrary to the present results, while no predominancy of a certain type appeared in Geometridae, being consistent with our results.

Out of 17 species obtained in both the present and Miyata's surveys, the full-flight time of the following nine species was different between the northern and southern areas of Japan : *Latoia sinica* (PO in Hokkaido ; PR in Kyushu), *Auzata superva* (BI ; PO), *Parapsestis argenteopicta* (MI ; PR), *Comostla subtiliaria* (PR ; PL), *Eucosmabraxas placida* (PR ; PL), *Hypomecis lunifera* (PO ; PL), *Selenia tetralunaria* (BI ; PO), *Euproctis piperita* (BI ; PO), and *Daseochaeta viridis* (PR ; PO). Among these species, the local differences in *A. superva*, *P. argenteopicta*, *H. lunifera*, *S. tetralunaria* and *E. piperita* are hardly explained by the non-occurrence of flight peaks which can be attributed to the low temperature in Hokkaido. This may indicate the existence of local varieties of flight activity within Japan.

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