# A Butterfly Phenology at Jozankei (Sapporo), Northern Japan

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(*With 4 Text-figures and 2 Tables*)

The present paper is an outcome of a butterfly census undertaken at Jozankei near Sapporo City, to obtain the basic information on faunal makeup and phenology in the area. The results are described and discussed in comparison with those obtained by Morisita (1967) in Kyoto, adopting the procedures developed by him.

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## Methods

The census was made at Jozankei about 320~480 m alt. and 30 km south of Sapporo City, along the road running from Hôsuibashi to Hôheikyo (Fig. 1 A~B~C). Any individuals of any species on the wing or at rest within 10 m width of both sides of the road were registered without collecting. Certain species difficult to identiy at distance were

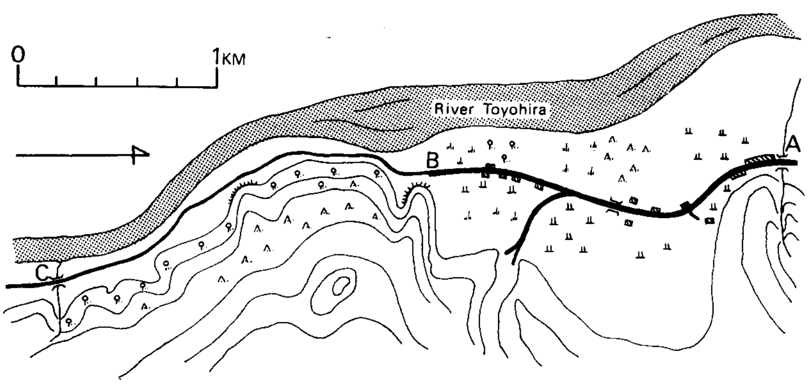


Fig. 1. Map showing the area surveyed. Census was made along the course A~B~C.

captured and liberated after identification. These species are *Pieris napi*, *Pieris melete* (Hasegawa, 1967, 1968, 1970), *Pieris rapae*, and some small lycaenid species of the genus *Favonius*.

The census belt is divided into two sections. One, X (A～B), is 2.0 km long, penetrating intermingling crop fields, paddy fields and human habitation, the other, Y(B～C), is 2.5 km long, running across secondary forests consisting of *Picea jezoensis*, *Abies sachalinensis*, larch trees, white birches and some other deciduous trees. The observation was continued from late April to late October in 1972. Although the census was made several times per month, only two trials were selected about every fifteenth day in each month to facilitate the comparison with the results obtained in Kyoto by Morisita (*op. cit.*).

## Results and Discussions

The species censused are as follows (Subspecific names are omitted in subsequent citations):

Papilionidae *Parnassius stubbendorfii hoenei* Schweitzer, *Papilio machaon hippocrates* C. et R. Felder, *Papilio macilentus* Janson, *Papilio bianor dehaani* C. et R. Felder, *Papilio maackii tutanus* Fenton.

Pieridae *Aporia crataegi adherbal* Fruhstorfer, *Colias erate poliographus* Motschulsky, *Pieris napi nesis* Fruhstorfer, *Pieris melete* Ménétriès, *Pieris rapae crucivora* Boisduval.

Satylidae *Ypthima argus* Butler, *Erebia niphonica* Janson, *Coenonympha hero neoperseis* Fruhstorfer, *Lethe diana* Butler, *Harima callipteris* (Butler), *Ninguta schrenckii menalcas* (Fruhstorfer), *Neope goschkevitschii* (Ménétriès).

Nymphalidae *Apatura ilia substituta* Butler, *Neptis philyra excellens* Butler, *Ladoga camilla japonica* (Ménétriès), *Neptis rivularis insularum* Fruhstorfer, *Araschnia burejana strigosa* Butler, *Araschnia levana obscura* Fenton, *Polygonia c-album hamigera* Butler, *Polygonia c-aureum* (Linnaeus), *Polygonia vau-album samurai* (Fruhstorfer), *Vanessa indica* (Herbst), *Nymphalis antiopa asopos* (Fruhstorfer), *Inachis io geisha* (Stichel), *Kaniska canace no-japonicum* (von Siebold), *Aglais urticae connexa* (Butler), *Fabriciana adippe pallescens* (Butler), *Argyronome laodice japonica* (Ménétriès), *Argynnis paphia geisha* Hemming, *Speyeria aglaia fortuna* (Janson), *Argyronome ruslana lysippe* (Janson), *Brenthis ino tigroides* (Fruhstorfer).

Lycaenidae *Japonica lutea* (Hewitson), *Shirozua jonasi* (Janson), *Ussuriana stygiana* (Butler), *Neozephyrus taxila regina* (Butler), *Favonius orientalis* (Murray), *Favonius cognatus* (Staudinger), *Ahlbergia ferrea* (Butler), *Lycaena phlaeas daimio* (Seitz), *Scolitantides orion jezoensis* (Matsumura), *Celastrina argiolus ladonides* (de l'Orza), *Celastrina sugitanii* (Matsumura.

Hesperiidae *Bibasis aquilina chrysaeglia* (Butler), *Thymelicus sylvaticus* (Bremer), *Ochlodes venata herculea* (Butler), *Thoressa varia* (Murray).

Monthly corrected individual number ($n_i$) is the sum of the counts in two censuses divided by two. The census result is given in Table 1, in which the species are arranged in the approximately phenologic order, together with distribution types according to Shirôzu (cf. Morisita *op. cit.*). The number of genera and species obtained by the survey belonging to various distribution types are as follows (shown by genera-species). Some species differ subspecifically from the populations in other areas of Japan and ajacent lands, but this difference is ignored here.

Table 1. Species observed with corrected individual number censused in each month. Family name are shown with initial letters (Pa: Papilionidae, Pi: Pieridae, S: Satylidae, N: Nymphalidae, L: Lycaenidae, H: Hesperiidae). D: Distribution type.

| Fam. | Species | D | Corrected individual number per month | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | V | VI | VII | VIII | IX | X | Total ($N$) |
| N | *Inachis io* | N | 12.5 | 5.5 | 1.0 | 3.5 | 1.5 | | 24.0 |
| L | *Celastrina sugitanii* | N′ | 4.5 | 1.0 | | | | | 5.5 |
| L | *Ahlbergia ferrea* | N′ | 2.0 | 1.5 | | | | | 3.5 |
| N | *Kaniska canace* | S | 0.5 | 0.5 | | | 0.5 | | 1.5 |
| L | *Celastrina argiolus* | N | 1.0 | | 0.5 | | | | 1.5 |
| N | *Polygonia c-aurerium* | N′ | 1.0 | | | | | | 1.0 |
| N | *Araschnia burejana* | N′ | 0.5 | 7.0 | 4.5 | | 0.5 | | 12.5 |
| Pi | *Pieris melete* | N′ | | 4.5 | 1.5 | 2.5 | 0.5 | | 9.0 |
| H | *Bibasis aquilina* | N′ | | | 11.5 | 7.0 | | | 18.5 |
| H | *Thoressa varia* | S′ | | 1.5 | 13.5 | 0.5 | | | 15.5 |
| N | *Aglais urticae* | N | 1.0 | | 7.5 | 4.5 | | | 13.0 |
| Pi | *Aporica crataegi* | N | | 1.0 | 7.0 | | | | 8.0 |
| S | *Neope goschkevitschii* | H | | 1.5 | 4.0 | 2.0 | | | 7.5 |
| H | *Ochlodes venata* | N | | | 3.0 | 1.5 | | | 4.5 |
| N | *Brenthis ino* | N | | | 3.0 | 1.0 | | | 4.0 |
| Pa | *Parnassius stubbendorfii* | N | | 1.5 | 2.5 | | | | 4.0 |
| N | *Ladoga camilla* | N | | | 3.0 | 0.5 | | | 3.5 |
| S | *Ypthima argus* | S′ | | 0.5 | 2.0 | | | | 2.5 |
| L | *Scolitantides orion* | N | | 0.5 | 2.0 | | | | 2.5 |
| N | *Vanessa indica* | N′ | | | 1.0 | | | | 1.0 |
| S | *Coenonympha hero* | N | | | 0.5 | | | | 0.5 |
| Pi | *Pieris napi* | N | 14.0 | 20.5 | 25.0 | 79.5 | 48.0 | 0.5 | 187.5 |
| Pi | *Pieris rapae* | N | 9.5 | 8.5 | 23.5 | 34.0 | 5.5 | | 81.0 |
| S | *Lethe diana* | S′ | | | 5.0 | 14.5 | 4.0 | | 23.5 |
| N | *Araschnia levana* | N | 0.5 | 1.5 | 2.0 | 8.5 | 0.5 | | 13.0 |
| S | *Harima callipteris* | N′ | | | 0.5 | 8.5 | | | 9.0 |
| Pa | *Papilio machaon* | N | | 1.5 | | 4.5 | | | 6.0 |
| N | *Polygonia c-album* | N | 0.5 | | | 2.5 | 2.0 | 0.5 | 5.5 |
| N | *Neptis rivularis* | N | | | 2.0 | 3.0 | | | 5.0 |
| N | *Apatura ilia* | N | | | 1.5 | 3.0 | | | 4.5 |
| Pa | *Papilio bianor* | N′ | | | 1.0 | 2.0 | | | 3.0 |
| S | *Erebia niphonica* | N′ | | | | 2.0 | 0.5 | | 2.5 |
| L | *Japonica lutea* | N′ | | | | 2.0 | | | 2.0 |
| Pa | *Papilio maackii* | N′ | | | 0.5 | 1.5 | | | 2.0 |
| N | *Speyeria aglaia* | N | | | | 1.5 | | | 1.5 |
| L | *Neozephyrus taxila* | N′ | | | | 1.5 | | | 1.5 |
| S | *Ninguta schrenckii* | N′ | | | | 1.0 | | | 1.0 |
| N | *Argyronome laodicae* | N | | | | 1.0 | | | 1.0 |
| N | *Argyronome ruslana* | N′ | | | | 1.0 | | | 1.0 |
| L | *Ussuriana stygiana* | H | | | | 0.5 | | | 0.5 |
| L | *Favonius orientalis* | N′ | | | | 0.5 | | | 0.5 |
| H | *Tymelicus sylvaticus* | N′ | | | | 0.5 | | | 0.5 |
| Pi | *Colias erate* | N′ | 0.5 | 1.5 | 5.5 | 11.5 | 24.0 | 10.5 | 53.5 |
| L | *Lycaena phlaeas* | N | | 0.5 | 2.0 | 1.0 | 6.5 | | 10.0 |
| N | *Nymphalis antiopa* | N | 1.0 | 0.5 | 0.5 | | 2.5 | | 4.5 |

Table 1. (*Continued*)

| Fam. Species | D | V | VI | VII | VIII | IX | X | Total ($N$) |
|---|---|---|---|---|---|---|---|---|
| L *Shirozua jonasi* | N′ | | | | | 2.0 | 0.5 | 2.5 |
| N *Polygonia vau-album* | N | | | 0.5 | 0.5 | 0.5 | 1.0 | 2.5 |
| N *Fabriciana adippe* | N | | | | | 1.5 | | 1.5 |
| N *Argynnis paphia* | N | | | | 0.5 | 1.0 | | 1.5 |
| L *Favonius cognatus* | N′ | | | | | 0.5 | | 0.5 |
| Pa *Papilio macilentus* | N′ | | 0.5 | 0.5 | 0.5 | | | 1.5 |
| N *Neptis philyra* | S′ | | | 0.5 | 0.5 | | | 1.0 |
| ? *Pieris napi* | | 1.5 | 0.5 | | | | | 2.0 |
| ? *Pieris melete* | | 1.0 | 2.5 | | | | | 3.5 |
| Total ($T$) | | 51.5 | 64.5 | 138.5 | 210.5 | 102.0 | 13.0 | 580.0 |

S : Typical Oriental species: 1–1.
S′ : Species distributed in Japan-China-Himalaya district but belonging to higher taxa of Oriental distribution: 4–4.
N : Northern Palaearctic species with southern limits of distribution in Japan: 22–24.
N′: Species distributed in Japan-China-Himalaya district but belonging to higher taxa of Northern Palaearctic distribution: 18–21.
H : Species belonging to higher taxa endemic to Japan-China-Himalaya district: 2–2.
C : Cosmopolitan or widespread species: 0–0.

The frequency order is N>N′⋙S′>S>H, showing the predominance of N and N′, sharply contrasting to the results in Kyoto, where S′ occupies the top rank with the order S′>N′>N>S>H>C.

*1. Dominant species*: As a first approach, the dominant species could be determined by the total corrected individual number, $N$, that is, the sums of monthly corrected individual numbers ($n_i$) given in Table 1. Sixteen species with higher values of $N$ are given in the second column of Table 2. However, two species with the same value of $N$ may vary as to the seasonal distribution. For instance, *Lethe diana* and *Inachis io* differ for each other by the concentration in different months, nevertheless the value of $N$ is almost identical (Tables 1 and 2). The degree of seasonal concentration is shown by Morisita's index of seasonal diversity:

$$1/I_\delta = \frac{1}{q \times \dfrac{\sum_{i=1}^{q} n_i(n_i-1)}{N(N-1)}}, \quad \text{conveniently} \quad 1/I_\delta = \frac{1}{q \times \dfrac{\sum_{i=1}^{q} n_i(n_i-0.5)}{N(N-0.5)}}$$

Table 2. Dominant species expressed by three indices.

| | seasonal | | | spatial | |
|---|---|---|---|---|---|
| species \ index | $N$ | $1/I_\delta$ $q=12$ | $N/I_\delta \times 100$ | $1/I_\delta$ $q=2$ | Section preferred |
| *Pieris napi* | 187.5 | 0.299 | 0.560 | 0.996 | XY |
| *P. rapae* | 81.0 | 0.292 | 0.237 | 0.506 | X |
| *Colias erate* | 53.5 | 0.291 | 0.155 | 0.592 | X |
| *Inachis io* | 24.0 | 0.247 | 0.0594 | 0.754 | (X)Y |
| *Lethe diana* | 23.5 | 0.188 | 0.0442 | 0.789 | (X)Y |
| *Bibasis aquilina* | 18.5 | 0.161 | 0.0298 | 0.529 | Y |
| *Thoressa varia* | 15.5 | 0.109 | 0.0170 | 0.738 | (X)Y |
| *Araschnia levana* | 13.0 | 0.187 | 0.0243 | 0.587 | Y |
| *Aglais ulticae* | 13.0 | 0.191 | 0.0248 | 0.587 | Y |
| *Araschnia burejana* | 12.5 | 0.197 | 0.0246 | 0.500 | Y |
| *Lycaena phlaeas* | 10.0 | 0.186 | 0.0186 | 0.683 | X |
| *Pieris melete* | 9.0 | 0.260 | 0.0234 | 1.048 | XY |
| *Harima callipteris* | 9.0 | 0.094 | 0.0084 | 0.559 | Y |
| *Aporia crataegi* | 8.0 | 0.109 | 0.0087 | 0.895 | (X)Y |
| *Neope goschkevitschii* | 7.5 | 0.236 | 0.0177 | 1.071 | XY |
| *Papilio machaon* | 6.5 | 0.141 | 0.0085 | | |

$N$: Total corrected individual number

where $q$ is the number of months (=12), and $n_i$ and $N$ as defined above. The higher value of $1/I_\delta$ indicated, more homogeneous seasonal distribution and *vice versa*. The product of $N$ and $1/I_\delta$, $N/I_\delta \times 100$, Morisita's index of specific prosperity, could be used to detect the dominant species without seasonal bias. As given in the third column of Table 2, the order by index of specific prosperity coincides with that by $N$ in top ranked species but slightly deviates in other low ranked ones. The five dominant species defined by the former are given in the descending order as follows: *Pieris napi, P. rapae, Colias erate, Inachis io* and *Lethe diana.* The phenology of these species is given in Fig. 2, accompanied with seasonal warmth index [$\sum (t-6)$°C, $t$=mean temperature of five successive days]. Five top dominants in Kyoto are *Ypthima argus, Eurema hecabe mandarina* de l'Orza, *Pieris rapae, Neope goschkevitschii* and *Neptis aceris intermedia* W. B. Pryer, that is, only *Pieris rapae* is common to both.

On the other hand, the species showing lower $1/I_\delta$ in spite of a relatively high value of $N$ could be used as seasonal indicators. The seasonal differentiation at a given locality is better demonstrated by such species than the dominants defined by index of specific prosperity. At Jozankei, such species are:

May: *Inachis io*

July: *Thoressa varia, Bibasis aquilina* and *Aporia crataegi.*

August: *Lethe diana* and *Harima callipteris.*

September: *Lycaena phlaeas.*

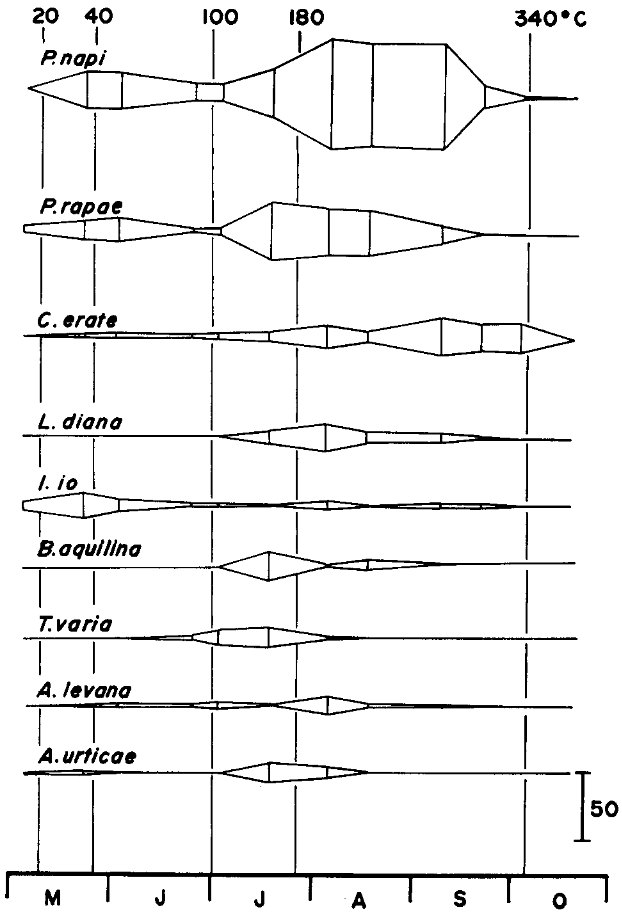


Fig. 2. The seasonal fluctuation of individual numbers in the nine top ranked species.

Nextly, the spatial differentiation between X (A ~ B) and Y (B ~ C) is sought by the same approach. The result is shown in the final column of Table 2. *Pieris napi*, *P. melete* and *Neope goschkevitschii* are dominant both in openland and forests, while *Pieris rapae*, *Colias erate* and *Lycaena phlaeas* are openland indicators and *Lethe diana*, *Bibasis aquilina*, *Aglais urticae* and *Araschnia burejana*, forest indicators.

2. *Community prosperity*: As a measure for community structure, Morisita invented the index of community diversity:

$$\beta = \frac{T(T-1)}{\sum x(x-1)}, \quad \text{conveniently} \ \beta = \frac{T(T-0.5)}{\sum x(x-0.5)}$$

where $x$ is monthly individual number of each species and $T$, $\sum x$. The value of this index approaches 1.0 when the community is simple, that is, most individuals belong to few species, and deviated from 1.0 in opposite instances. In the present study, the community prosperity index, $T\beta$ was used to analyze the phenologic change of butterfly community at Jozankei. For this purpose, the species listed in Table 1 were divided into several distribution types as mentioned previously and the seasonal change of community prosperity index in some types were calculated. Excluding C, analysis was made by adopting two ways of grouping (cf. Fig. 3):

I. $\bar{S}(=S+S')$ : $\bar{N}(=N+N')$ (H excluded) (This grouping was adopted by Morisita.)

II. $\bar{S}$ : $\hat{N}(=N'+H)$ : N

According to Grouping II, phenology of N and $\bar{N}$ is similar, but decline of N in June is probably caused partly by some adult-hibernating species in N, which disappear in June.

Comparing the results from Jozankei and Kyoto in Grouping I, the phenology of both $\bar{S}$ and $\bar{N}$, especially the former, is obviously much contracted in Jozankei,

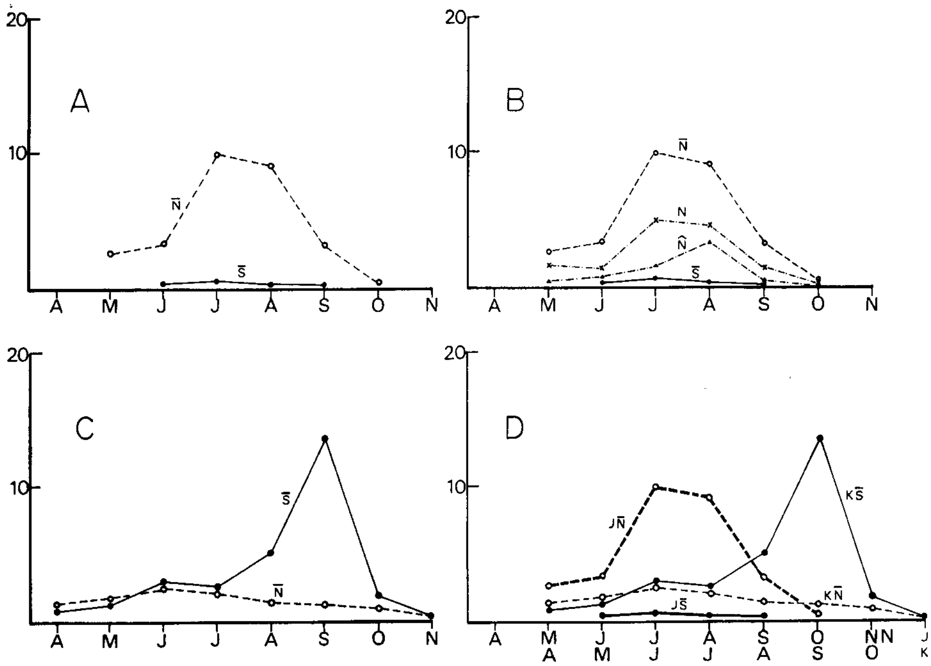


Fig. 3. The fluctuation of community prosperity index ($T\beta$) in Jozankei (A by Grouping I, B by Grouping II) and in Kyoto (C). D compares the difference between Jozankei (J) and Kyoto (K) after eliminating climatic difference.

and the relative height of $\bar{S}$ is distinctly higher in Kyoto while that of $\bar{N}$ in Jozankei. Moreover $\bar{S}$ is obscurely bimodal in Kyoto but not in Jozankei.

The graph D in Fig. 3 compares the difference between two areas after eliminating the seasonal delay in Jozankei. By arranging the warmth index as starting from 20°C, the calender dates of both areas were slided for a month. After this calibration, phenologic trends of both areas become similar except the absence of the second peak in Jozankei. This is understood by the difference of warmth index between two areas. At the second peak of $\bar{S}$ in Kyoto (September), the warmth index reaches 400°C there, which is seldom realized in Jozenkei, where the butterfly season approaches the decline in October with the value of warmth index about 340°C. Therefore, the difference between two areas is caused mainly by the reversed relative prevailence of $\bar{S}$ and $\bar{N}$ groups together with the difference in climatic conditions.

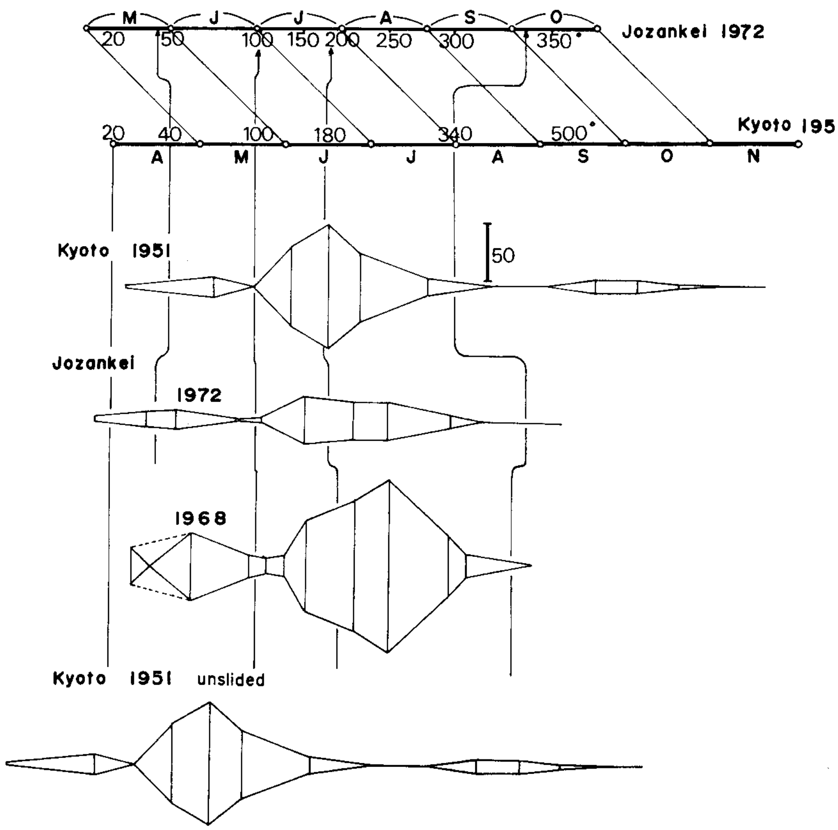


Fig. 4. Comparison of seasonal fluctuation of *Pieris rapae* in Jozankei and Kyoto by sliding the calender date in Kyoto by seasonal warmth index.

A similar procedure was applied to *Pieris rapae*, a predominant species in both areas. As seen in Fig. 4, the sliding for 40 days gives a rather similar phenologic sequence in both areas, except for the prolongation in later months in Kyoto, though it is still premature to conclude the absence of any difference in thermal sensitivity of this species between two areas.

## Summary

Faunal makeup and phenology of butterflies were censused at Jozankei near Sapporo City in comparison with the results obtained in Kyoto. Main results are:

1). In total 52 species were observed, involving counts of 1,160 individuals. The species exhibiting northern distribution pattern occupied 88% of total species.

2). Among predominant species *Pieris napi*, *Pieris rapae* and *Colias erate* are regarded as dominants throughout seasons, while the following species are seasonal indicators: *Inachis io* (spring), *Thoressa varia*, *Bibasis aquilina*, *Aporia crataegi*, *Lethe diana* and *Harima callipteris* (summer), *Lycaena phlaeas* (autumn).

3). *Pieris napi*, *P. melete* and *Neope goschkevitschii* are dominant both in openlands and forests, *Pieris rapae Colias erate* and *Lycaena phlaeas* are openlands indicators while *Lethe diana*, *Bibasis aquilina*, *Aglais urticae* and *Araschnia burejana*, forests indicators.

4). Seasonal change of community prosperity is simple in Jozankei, with a single peak in July to August. The difference in butterfly phenology between Jozankei and Kyoto under different climatic conditions is clearly expressed in a reversed relative prevailence between southern and northern species.

5). As to *Pieris rapae*, a dominant species common to both areas, the seasonal fluctuation takes a similar pattern when compared by means of seasonal warmth index.

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