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Further Observations on Butterfly Phenology at Jozankei (Sapporo): Comparisons of the Results in Two Successive Years

By

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(With 6 Text-figures and 3 Tables)

Following a previous paper (Yamamoto 1974) on a butterfly phenology surveyed once per month at Jozankei, comparisons of the results obtained in two successive years are dealt with in the present paper, based upon more detailed surveys made three times per month, together with some notes on the rational census schedules which make the comparison of similar but less intensive results possible.

Before going further, I wish to express my sincere thanks to Prof. Mayumi Yamada, Dr. Shôichi F. Sakagami and Dr. Hiromi Fukuda, Zoological Institute, Hokkaido University, for their kind guidance to the present study.

Method

Area studied: The surveyed area is the same to that reported previously, the roadsides at Jozankei in the suburbs of Sapporo City, the ecological and topographical conditions of which were described in Yamamoto (*op. cit.*). At about 500 m upstream of point C of the census route, the construction of Hôheikyo Dam was started in 1967 and completed in 1972. This did not visibly affect vegetation and topography of the census route. But an intense traffic of lorries for construction might influence the butterfly fauna to some degree.

Census method: The belt census once or twice per ten days was made 25 times from May to October in 1972 and 34 times from mid April to October in 1973. As in a previous survey, any individuals of any species on the wing or at rest found within 10 m wide of both sides of the road were registered without collecting. Certain species difficult to identify at distance were captured and soon liberated after identification (*Pieris napi*, *P. melete*, *P. rapae* and some small lycaenid species of the genus *Favonius*). The details on the faunal makeup is consulted for Yamamoto (1974, 1975). New additions to previous results are *Argynnis anadyomene midas* Butler, *Neptis aceris intermedia* W.B. Pryer (Nymphalidae) and *Araragi enthea* (Janson), *Wagimo signata* (Butler) (Lycaenidae).

Results and Discussions

Results are divided into three parts, 1) seasonal succession in the appearance

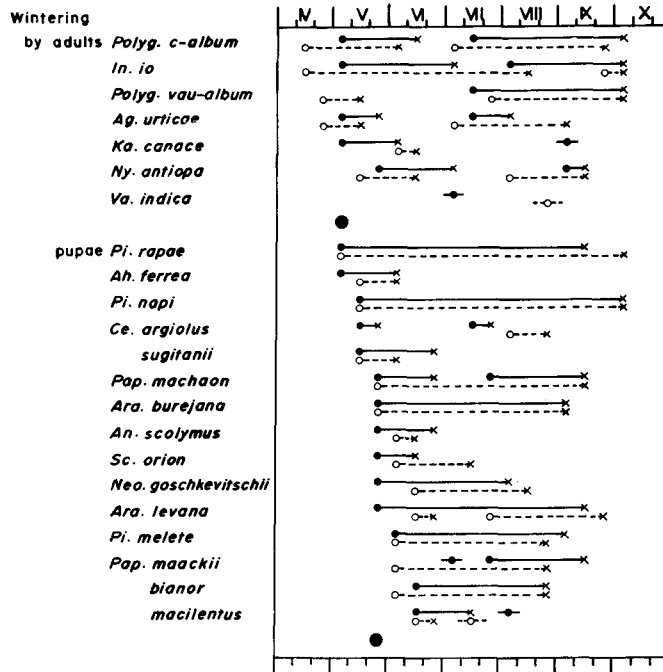
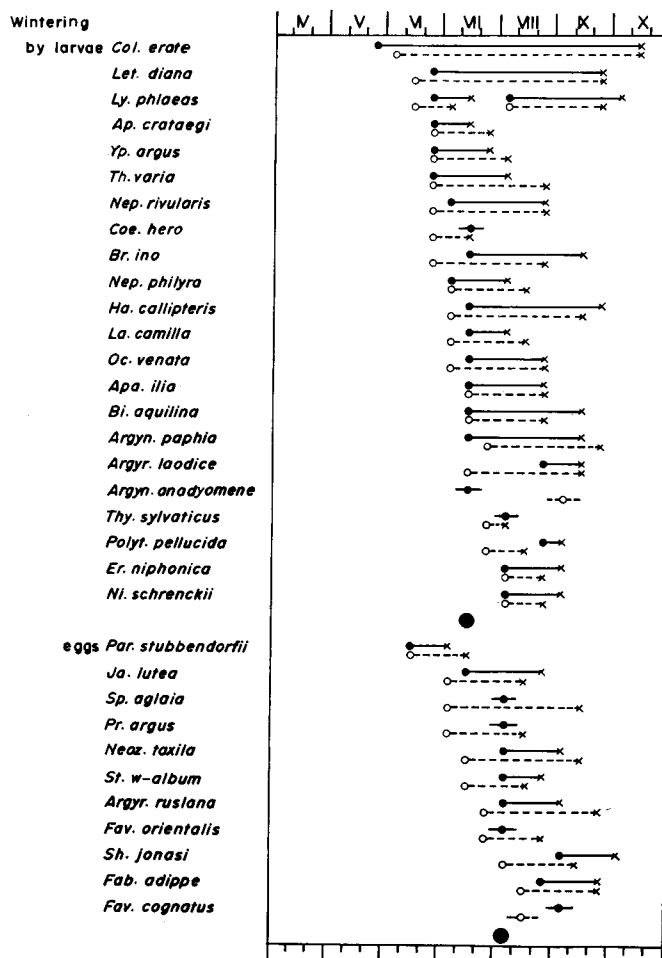


Fig. 1. (Continued to the opposite page) Period of adult appearance in 1972 and 1973 in relation to the wintering stages. Large solid circles are mean time of appearance in each wintering types. Generic names shown by the first two or three letters. Further explanations in text.

of adults, 2) seasonal change of species and individual numbers and phenologies of predominant species and 3) relation between census interval and number of species registered.

1. Seasonal succession in the appearance of adults

The survey carried out twice per day (10:30~12:30 and 12:30~14:00) for each census, and once or twice per ten days from May to October in 1972 and from April to October in 1973. The results in both years are discussed after being corrected as surveyed once per ten days. The occurrence period (from the first to the last observation) of each species is shown in Fig. 1, the result in 1972 and 1973 given respectively at the upper solid and lower broken lines and the wintering stage mentioned at lefthand. Only the earlier part of the occurrence is concerned in this section. The order of appearance of adults must be controlled by diverse factors, e.g., number of generations per year, appearance of larval foods and other species-specific responses to the season. But the most important factor seems



the wintering stages. For instance, for the species wintering by adult stages, only the activation from diapause is necessary for their appearance. On the other hand, those wintering by eggs, the adults appear only after accomplishing the sequence of hatching - growth - pupation - emergence. The species wintering by pupae or larvae stay between these two extremes.

Table 1 gives the species first observed in the respective period, arranged in the order of appearance for each period.

Snow melting starts in early March at the center of Sapporo City but it delays considerably in the surveyed area. In mid April, some exposed soil patches appear and grow on the snow cover at the route A but the route B, shaded with

Table 1. Order of appearance in the species observed in both years, arranged in months (April~August) and for each period also by the order of appearance.
E: early. M: mid, L: late.

	1972	1973
4M) Not observed	<i>Polygonia c-album</i> , <i>Inachis io</i>
L		<i>Polygonia vau-album</i> , <i>Aglais urticae</i>
5E	<i>Polygonia c-album</i> , <i>Inachis io</i> , <i>Kaniska canace</i> , <i>Aglais urticae</i> , <i>Pieris rapae</i> , <i>Ahlbergia ferrea</i>	<i>Pieris rapae</i>
M	<i>Pieris napi</i> , <i>Celastrina sugitanii</i> , <i>C. argiolus</i>	<i>Nymphalis antiopa</i> , <i>Ahlbergia ferrea</i> , <i>Pieris napi</i> , <i>Celastrina sugitanii</i>
L	<i>Nymphalis antiopa</i> , <i>Papilio machaon</i> , <i>Araschnia burejana</i> , <i>A. levana</i> , <i>Anthocalis scolymus</i> , <i>Colias erate</i> , <i>Neope goschkevitschii</i> , <i>Scolytantides orion</i>	<i>Araschnia burejana</i> , <i>Papilio machaon</i>
6E	<i>Pieris melete</i> , <i>Papilio maackii</i>	<i>Kaniska canace</i> , <i>Papilio bianor</i> , <i>Anthocalis scolymus</i> , <i>Pieris melete</i> , <i>Scolytantides orion</i> , <i>Colias erate</i>
M	<i>Papilio macilentus</i> , <i>P. bianor</i> , <i>Parnassius stubbendorfi</i>	<i>Papilio macilentus</i> , <i>Araschnia levana</i> , <i>Lethe diana</i> , <i>Lycaena phlaeas</i> , <i>Parnassius stubbendorfi</i> , <i>Neope goschkevitschii</i>
L	<i>Aporia crataegi</i> , <i>Ypthima argus</i> , <i>Lycaena phlaeas</i> , <i>Thoressa varia</i> , <i>Lethe diana</i>	<i>Neptis rivularis</i> , <i>Aporia crataegi</i> , <i>Coenonympha hero</i> , <i>Brenthis ino</i> , <i>Thoressa varia</i> , <i>Ypthima argus</i>
7E	<i>Vanessa indica</i> , <i>Neptis philyra</i> , <i>N. rivularis</i>	<i>Papilio maackii</i> , <i>Harima callipteris</i> , <i>Neptis philyra</i> , <i>Fabriciana adippe</i> , <i>Ladoga camilla</i> , <i>Ochlodes venata</i> , <i>Speyeria aglaia</i> , <i>Japonica lutea</i> , <i>Prebejus argus</i>
M	<i>Polygonia vau-album</i> , <i>Brenthis ino</i> , <i>Coenonympha hero</i> , <i>Argynnis paphia</i> , <i>Harima callipteris</i> , <i>Apatura ilia</i> , <i>Ladoga camilla</i> , <i>Argynnis anadyomene</i> , <i>Bibasis aquilina</i> , <i>Ochlodes venata</i> , <i>Japonica lutea</i>	<i>Apatura ilia</i> , <i>Argyronome laodice</i> , <i>Bibasis aquilina</i> , <i>Strymonidia w-album</i> , <i>Neozephyrus taxila</i>
L		<i>Argynnis paphia</i> , <i>Thymelicus sylvaticus</i> , <i>Polytremis pellucida</i> , <i>Argyronome ruslana</i> , <i>Favonius orientalis</i>
8E	<i>Ninguta schrenckii</i> , <i>Erebia nipponica</i> , <i>Thymelicus sylvaticus</i> , <i>Speyeria algaia</i> , <i>Argyronome ruslana</i> , <i>Neozephyrus taxila</i> , <i>Favonius orientalis</i> , <i>Strymonidia w-album</i> , <i>Prebejus argus</i>	<i>Celastrina argiolus</i> , <i>Erebia nipponica</i> , <i>Ninguta schrenckii</i> , <i>Shirozua jonasi</i>
M		<i>Favonius cognatus</i>
L	<i>Argyronome laodice</i> , <i>Polytremis pellucida</i> , <i>Fabriciana adippe</i>	<i>Vanessa indica</i>
9E	<i>Shirozua jonasi</i> , <i>Favonius cognatus</i>	<i>Argynnis anadyomene</i>

woods, is still thickly covered with snow (1 m). Under a good insolation, some species, *Polygonia c-album*, *Inachis io*, *Polygonia vau-album* and *Aglais urticae*, all wintering by adults, begin to fly about slowly or rest on the snow cover despite the absence of nectariferous plants. In late April, snow melting is accelerated by

spring shower, the route B changing temporarily to a small stream. The flowers of *Lysichiton camtschatense*, *Corydalis ambigua* and *Petasites japonicus* begin to bloom. In this period, *Aglais urticae* is often observed to visit nectariferous flowers of *Petasites*. For the species wintering by adults on open place like the census road seems to be important as mating site rather than feeding site. In early May, the small white butterfly wintering by pupae, *Pieris rapae*, already appears before *Nymphalis antiopa* wintering by adults. Delayed appearance of *Nymphalis antiopa* was also reported by Fujioka (1975). Possibly this relates with the higher thermal threshold of this species to start flight activity. One month from mid May till mid June is the season of appearance of the species wintering by pupae with two exceptions, *Colias erate* (wintering by larvae) and *Parnassius stubbendorffi* (by eggs). Succession among these species is not clear, though *Pieris rapae* appears first, followed by *Ahlbergia ferrea*, *Pieris napi* and *Celastrina sugitanii*. Generally multivoltine species and flower feeders appear earlier, which is obviously adaptive to the seasonal shift. The same can be held for a multivoltine species, *Colias erate*. Other species wintering by larvae following *Colias erate* are characteristic of early summer from late June to mid July, forming the so-called early summer assemblage (Morisita 1964), together with the first generation of the species wintering by adults and the second generation of those wintering by pupae. The order of adult succession in the larvally wintering species is likely to be determined by the larval instar entering diapause before winter. *Aporia crataegi*, *Ypthima argus* and *Lethe diana* wintering by later instars appear earlier than *Argyronome laodice* and *Argynnis paphia* wintering by the first instar, partly even by eggs. The species wintering by eggs begin to fly since about early July except *Parnassius stubbendorffi* mentioned above. In and after July, the species wintering by eggs do not always show a marked delay of appearance than larvally wintering species, resulting in a mixed succession of the species wintering by larvae or by eggs after early July. In spring, the appearance of adults may be determined mainly by air temperature and insolation. Consequently, the species wintering by adults appear distinctly earlier than those wintering by pupae. But the species wintering by larvae and eggs are affected not only by weather but also by sprouting of their food plants. The sprouting period itself must be controlled by diverse environmental conditions as well as species-specific life cycles of the plants. This complex of conditions may allow earlier appearance of some species wintering by eggs than those by larvae, as especially conspicuous in 1973. The former group involves *Japonica lutea*, *Prebejus argus*, *Argyronome laodice*, *Strymonidia w-album* and *Neozephyrus taxila* in 1973. Based upon the results and inference given above, seasonal succession of the appearance of adults is ordered for each wintering type as follows (the asterisked species showed a marked difference between two years).

- 1) Wintering by adults: *Polygonia c-album*=*Inachis io*>*Polygonia vau-album*=*Aglais urticae*>*Kaniska canace*>*Nymphalis antiopa*
- 2) Wintering by pupae: *Pieris rapae*=*Ahlbergia ferrea*>*Pieris napi*=*Celastrina*

argiolus=*C. sugitani*>*Papilio machaon*=*Araschnia burejana*=*Anthocalis scolymus*
 =*Pieris melete*=*Neope goschkevitschii**=*Araschnia levana*=*Scolytantides orion*>
Papilio maackii=*P. bianor*>*P. macilentus*

- 3) Wintering by larvae: *Colias erate*»*Lethe diana*>*Lycaena phlaeas*>*Aporia crataegi*
 =*Ypthima argus*=*Thoressa varia*>*Neptis rivularis*>*Brenthis ino**>*Coenonympha*
hero>*Harima callipteris*=*Neptis philyra*=*Ladoga camilla*=*Ochlodes venata*>*Apatura*
ilia=*Argynnis paphia*=*A. anadyomene**=*Bibasis aquilina*>*Argyronome laodice**>
Thymelicus sylvaticus>*Ninguta schrenckii*=*Erebia nipponica*>*Polytremsis pellucida**
- 4) Wintering by eggs: *Parnassius stubbendrofii*»*Japonica lutea*>*Speyeria aglaia**
 =*Prebejus argus*>*Strymonidia w-album*=*Neozephyrus taxila*>*Argyronome rulsana*
 =*Favonius orientalis*>*Shirozua jonasi**>*Fabriciana adippe**=*Favonius cognatus*

Nextly the differences between two years are referred to. Most species, especially those wintering by adults or pupae, appeared within the same ten days interval in both years (Fig. 1). The time of appearance is fairly predictable for such species, but some species showed marked differences of more than two intervals between two years, making a prediction of its appearance difficult. Among them there are two abundant species, *Polygonia c-album* and *Inachis io*, in which the difference was probably caused by the delayed start of the survey in 1972. As to the following species, the observational errors due to the scarcity of individuals is probably responsible for deviations: *Kaniska canace*, *Vanessa indica*, *Celastrina argiolus*, *Coenonympha hero*, *Argynnis anadyomene*, *Argyronome laodice*, *Polytremsis pellucida*, *Shirozua jonasi*, *Strymonidia w-album*, *Plebejus argus* and *Favonius cognatus*. The other species, *Polygonia vau-album*, *Papilio maackii*, *Araschnia levana*, *Fabriciana adippe* and *Brenthis ino*, seem to show a real difference between two years, affected by some environmental conditions.

2. Seasonal change of species and individual numbers and phenologies of predominant species

Nextly the differences in the numbers of species and individuals between two years are described and discussed. Dealing with only 10:30 census, in total, 57 species and 1,685.5 corrected individuals were counted in 1972, while 61 and 1,722.0 in 1973 except some unidentified species. Fifty five species were common in both years while nine species counted only in one year. A higher number of species in 1973 may depend upon the higher number of censuses realized. Four species observed only in 1973 are all scarce and small sized: *Araragi enthea*, *Antigius attilia*, *Wagimo signata* and *Erynnis montanus*. Small species are generally difficult to be detected (Yamamoto 1975). Their discoveries may be an outcome of an increased chance, though *Ussuriana stygiana* was observed only in 1972. On the other hand, the other four species, being large or abundant, *Sasakia charonda*, *Nymphalis xanthomelas*, *Neptis aceris* and *Everes argiades*, suggest an actual difference between both years. *Sasakia charonda* should be an occasional migrant from its restricted breeding habitat in Mt. Hakken. The absence of *Nymphalis xanthomelas* and *Everes argiades* in 1972 may be caused by a high

annual fluctuation characteristic of these species, as is also confirmed by Kyoto (cf. Morisita 1964), rather than any environmental changes due to dam construction.

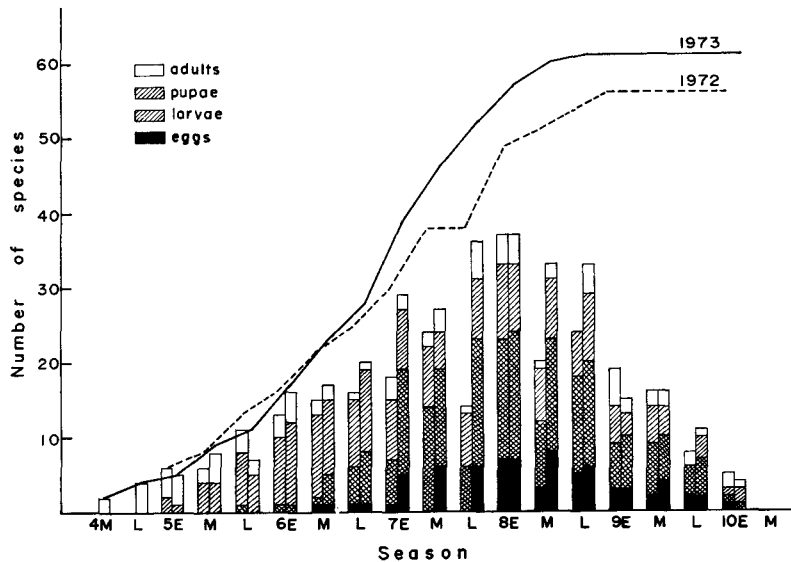


Fig. 2. Seasonal changes of the species number for four wintering types (left: 1972, right: 1973), and cumulative species number (broken line: 1972, solid: 1973).

The number of species (Fig. 2) steadily increases until reaching the peak in early August, followed by a rapid decline. This peak is formed by a combination of four peaks of four wintering types. The cumulative number of newly observed species linearly and moderately increases in spring until early (1973) or mid July (1972) when the increase becomes steeper by the appearance of the species wintering by larvae and eggs in a rapid successions. Thereafter, the number of newly observed species decreases gradually until reaching the asymptote in mid August (1973) or early September (1972).

Concerning the total corrected individual number except some unidentified species, two figures, 1,685.5 individuals in 1972 and 1,722.0 individuals in 1973, are fairly similar for each other. The seasonal changes of the total corrected individual number are shown in Fig. 3 (upper: 1972, lower: 1973), together with the predominant species (12 in 1972, 13 in 1973) i.e. the species, the total corrected individual number of which exceeds the average corrected individual number (total corrected individual number/number of species; 30.25 in 1972, 28.62 in 1973). Two graphs in Fig. 3 are basically similar for each other. If the survey in 1972 was started since April, the first peak in 1973 by the species wintering by adults is expected in 1972, too. Small drops in 7L and 8M in 1972 were brought by a low number of censuses, which could not compensate decreased individual number

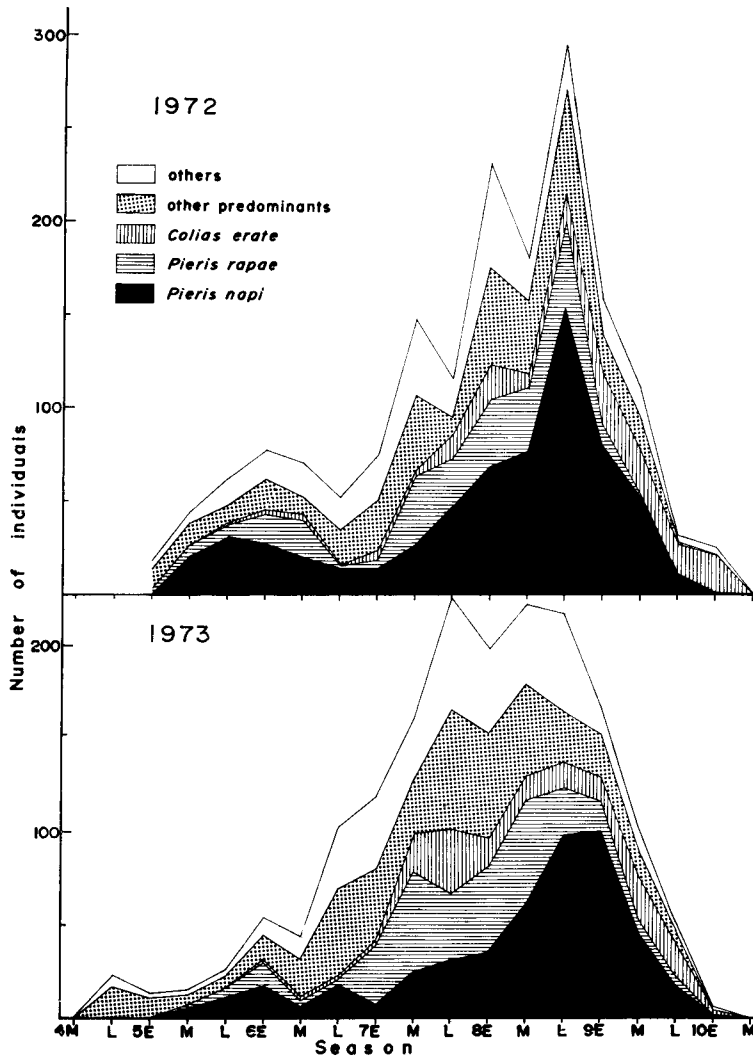


Fig. 3. Seasonal change of the total corrected individual number and of predominant species in 1972 and 1973.

caused by unfavored environmental conditions (wind class, 3~5 in 7L and 8M, 1972). The first small peak in late April, the second mild peak in early June and the third conspicuous peak in mid July to late August are recognized from Fig. 3.

Change of the pattern of these graphs is virtually determined by the predominant species, especially *Pieris napi*, *P. rapae* and *Colias erate*. But the composi-

Table 2. Predominant species expressed by the corrected individual number (N) in 1972 and 1973.

1972		1973	
Species	N	Species	N
<i>Pieris napi</i>	642.0	<i>Pieris napi</i>	479.0
<i>P. rapae</i>	251.0	<i>P. rapae</i>	301.5
<i>Colias erate</i>	155.5	<i>Colias erate</i>	161.0
<i>Harima callipteris</i>	61.5	<i>Araschnia burejana</i>	60.5
<i>Inachis io</i>	53.0	<i>Brenthis ino</i>	58.5
<i>Lethe diana</i>	51.5	<i>Lycaena phlaeas</i>	55.0
<i>Araschnia levana</i>	43.5	<i>Papilio machaon</i>	54.5
<i>Lycaena phlaeas</i>	33.5	<i>Aglais urticae</i>	53.5
<i>Thoressa varia</i>	33.0	<i>Everes argiades</i>	38.0
<i>Bibasis aquilina</i>	32.5	<i>Inachis io</i>	34.5
<i>Araschnia burejana</i>	30.5	<i>Thoressa varia</i>	34.5
<i>Papilio machaon</i>	28.5	<i>Argyronome rustlana</i>	29.5
		<i>Ochlodes venata</i>	27.5
Total	1,416.0		1,387.5
%	83.6		79.5

tion of predominant species was somewhat different between two years (Table 2). The predominant species occupying higher ranks in both years are: *Pieris napi*, *P. rapae*, *Colias erate*, *Lycaena phlaeas*, *Araschnia burejana* and *Inachis io*. *Harima callipteris* (rank 7→23), *Lethe diana* (5→12), *Araschnia levana* (7→29) and *Bibasis aquilina* (11→26) were high ranked in 1972 but dropped in 1973, while *Brenthis ino* (22→5), *Papilio machaon* (12→7), *Aglais urticae* (13→8) and *Argyronome rustlana* (37→11) behaved oppositely. *Everes argiades* was not observed at all in 1972 but was one of the predominant species in 1973 by the reason referred to later. Rank discrepancy between two years in these species is always accompanied with a marked difference of the individual number. Unevenness of abundance between two years measured with 95% fiducial limits of percentage ratio was found in 17 out of all 63 species, as arranged below (*=predominant).

1972>1973

Pieris napi (642.0*/479.0*)
Harima callipteris (61.5*/16.0)
Lethe diana (51.5*/24.5)
Araschnia levana (43.5*/8.5)
Bibasis aquilina (32.5*/9.5)
Ahlbergia ferrea (10.0/1.0)

1972<1973

Pieris rapae (251.0*/301.5*)
Araschnia burejana (30.5*/60.5*)
Brenthis ino (8.0/58.5*)
Papilio machaon (28.5*/54.5*)
Aglais urticae (24.0/53.5*)
Everes argiades (0.0/38.0*)
Argyronome rustlana (2.5/29.5*)
Parnassius stubbendorfii (10.0/26.0)
Speyeria aglaia (1.5/23.5)
Papilio maackii (5.5/22.0)
Argynnis paphia (3.5/19.0)

Three top ranked species, *Pieris napi*, *P. rapae* and *Colias erate*, were very stable as predominant species in spite of fluctuated individual numbers. The other predominant species, especially of Satyridae and Argynninae were less stable and their ranks changed one another.

Phenologies of the predominant species are outlined for each species from the results in two years, arranged in the decreasing order of individuals summed up two years (Fig. 4) (A, P, L, E=wintering stage). Some species showed a burst in one of two years, the causes of which are unknown unless particularly mentioned.

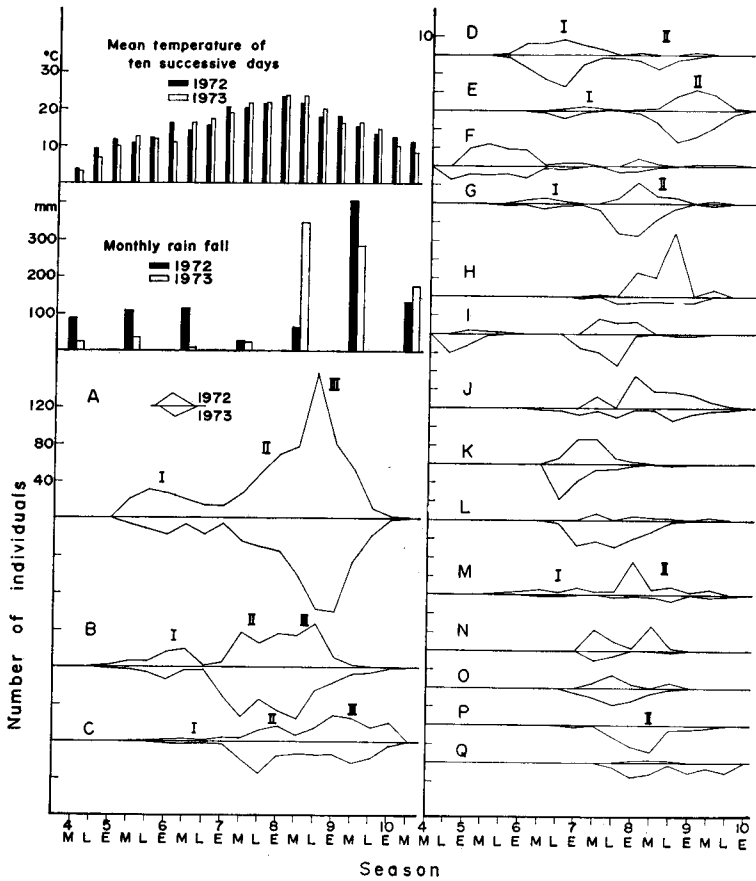


Fig. 4. Phenology of the predominant species observed in two years.

Pieris napi (P, Fig. 4A): Probably trivoltine in and near Sapporo, judging from the results of the censuses of eggs, larvae and adults (Yamamoto unpub.). The adults begin to emerge in early May, and form a peak in late May to early June. The second generation

is shown by an increased individual number from mid July to early August and cannot be separated on the graphs from the third generation showing a burst from mid August on. The curves for two years are very similar except for a slightly higher level of the first generation in 1972 than 1973.

Pieris rapae (P, Fig. 4B): Trivoltinism was clarified by the other survey made at the Campus of Hokkaido University (Yamamoto unpub.). The peak of the first generation is in early June to mid June as in *Pieris napi*, but the peaks of the second and third generations appear earlier, probably caused by the differential thermal sensitivity between the two species. Another aspect worth mentioning is the absence of a burst in the third generation as seen *Pieris napi*. The phenological pattern is similar between two years.

Colias erate (L, Fig. 4C): Probably trivoltine but further evidence is required. This species is observed till the last butterfly season, with two peaks in summer and autumn respectively. A slight difference between two years is recognized: The autumn peak is higher than summer peak in 1972 but *vice versa* in 1973.

Araschnia burejana (P, Fig. 4D): Bivoltine with the first major peak in June and the second one in August. Both spring and summer generations were more abundant in 1973 than in 1972.

Lycaena phlaeas (L, Fig. 4E): Bivoltinism is clearly shown by the bimodal curves. A small peak in early summer, a drop in late July, and a major peak in early autumn were similar in two years.

Inachis io (A, Fig. 4F): The graphs of both years are bimodal and closely similar. Whether this species is univoltine (Miyachi and Homma 1951) or bivoltine (Yokoyama 1970) is yet unsolved.

Papilio machaon (P, Fig. 4G): A bivoltine species. The phenology is quite similar between two years. Spring generation has a small peak in June, while summer one a major peak in late July to early August, especially in 1973.

Harima callipteris (L, Fig. 4H): The phenology is difficult to determine for a highly annual fluctuation, probably requiring successive surveys for about five years. A burst in 1972 is somewhat comparable to that in *Lethe diana* given below and is probably caused by some common factors because they seem to occupy similar niches.

Aglais urticae (A, Fig. 4I): Phenology shows univoltinism. Another aspect worth mentioning is a higher count of post-wintering population than of pre-wintering one. This contradictory result seems to be caused by migration to wintering habitats in pre-wintering population as suggested in *Inachis io* by Hasegawa (1975).

Lethe diana (L, Fig. 4J): The seasonal activity is erratically fluctuating. The active season is the longest in Satyridae. The graphs for two years are quite different as in *Harima callipteris*.

Thoressa varia (L, Fig. 4K): Univoltinism is obvious from the graphs with a peak in mid July, 1972 and in late June, 1973.

Brenthis ino (L, Fig. 4L): Although not clear from the graph, this species is univoltine. Active season of adults is long, from late June to mid September. Such long flight period by one generation is characteristic of some species wintering by larvae, e.g., *Lethe diana*, *Harima callipteris*, *Neptis rivularis* and *Argynnis paphia*, all having the flight period over 50 days. The long flight period may be caused by a long life span of each individual and/or a higher allochronic emergence.

Araschnia levana (P, Fig. 4M): Bivoltine as in its relative, *Araschnia burejana* (Fig. 4D). The spring generation produces a mild peak in June, while the summer generation does a higher peak in August and the curve continues to late September. A burst in 1972 is opposite to the case in *Araschnia burejana*.

Bibasis aquilina (L, Fig. 4N): Although the curves show a bimodality with peaks in

mid July and in August, especially in 1972, this is a univoltine species. The resulted curves may not reflect the real phenology, because of the difficulty to count this species correctly by its habit of gregariously absorbing water (Yamamoto *op. cit.*).

Ochlodes venata (L, Fig. 4, O): Univoltine species. The graphs are similar between two years.

Everes argiades (L, Fig. 4P): This species seems to be bivoltine. At the foot of Mt. Hakken, 8 km south of the area surveyed (Yamamoto unpub.), adults of the spring generation appear from late May and those of the summer generation from mid July. At Jozankei, a burst in summer 1973 corresponds to the second (summer) generation, reflecting an excessive scarcity of the first generation in 1973 as well as both generations in 1972. This does not mean the lasting withdrawal of the population from the area because some individuals were censused in 1969 (Yamamoto unpub.). Such excessive annual change in this species was also reported by Morisita (1967).

Argyrogonome ruslana (E or L, Fig. 4Q): This univoltine species also has a burst in 1973 as in *Brenthis ino* despite of the scarcity in 1972.

Seasonal succession of the predominant species: Here the term seasonally predominant species is defined as those, the individual number of which exceeds the mean number of individuals in each ten days period. The phenologies of 29 seasonally predominant species are shown in Fig. 5. A glance at the figure reveals that most of seventeen locally predominant species mentioned in the preceding subsection appear as seasonally predominants in more than two periods with a single exception of *Araschnia levana*. Especially, *Pieris napi* and *P. rapae* are seasonally predominant in nearly all periods, followed by *Colibris erate*, *Inachis io* and *Araschnia burejana* which keep their seasonal predominance for a considerably long season. The other 12 species not involved in the local predominants mostly appear as seasonal predominants in only one period: *Polygonia c-album*, *Celastrina sugitanii*, *Scolytantides orion*, *Aporia crataegi*, *Pieris melete*, *Ypthima argus*, *Speyeria aglaia*, *Japonica lutea*, *Apatura ilia* and *Argynnis paphia*. Exception is *Parnassius stubbendorfi* which prevails for a relatively long time. Some seasonal predominants with a short flight period are to be regarded as seasonal indicators, e.g. *Celastrina sugitanii* in late May (1972), *Parnassius stubbendorfi* in mid June to early July (1973) and in early July (1972), *Aporia crataegi* in early July (1972) and *Ypthima argus* in mid July (1972).

3. Relation between counting interval and number of species

By the different specific phenologies, the faunal makeup obviously cannot be clarified by a single census per year. On the other hand, it is difficult to make frequent periodical censuses at the area remote from the laboratory. In this section, a compromise between these contradictory conditions is sought on the basis of the results obtained. Here, the discussion is given based upon the actually censused data in 1973 alone, for the census frequency is higher in 1973 than in 1972 as mentioned previously. The procedure developed by Sakagami and Fukuda (1973) for wild bees is applied to determine the best season for the census to obtain

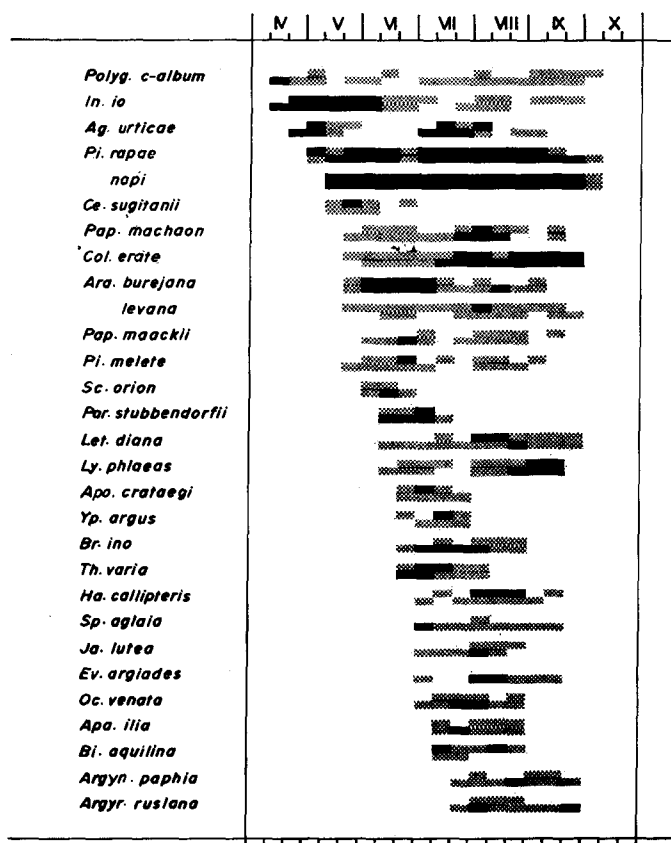


Fig. 5. Phenology of 29 seasonally predominant species. Dotted: recorded, black: predominant, in the respective period. Upper: 1972, bottom: 1973.

as many species as possible. Fig. 6 shows seasonal distributions of the numbers of species and individuals counted in each census period. The late July (VII-24 in the present case) with the highest number of species and individuals could be regarded as the best season, though only about a half of total species actually counted is involved. To seek the other favorable periods based on the species observed in each period, the species not observed in VII-24 were counted for each period and the number was shown in Table 3, column A, together with the individual number occupied by these species. Thereafter, the next favorable period was sought to obtain the highest species number by the combination of two censuses, e.g. one VII-24, another VIII-13 (column B). By the same procedure, some census schedules which may yield as many as possible number of species were arbitrarily selected as follows (cf. Table 3):

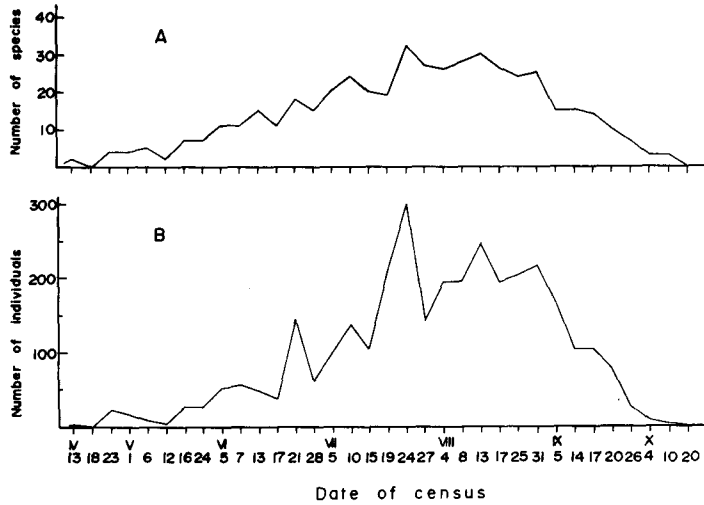


Fig. 6. Number of species (A) and individuals (B) counted in each census period.

- A (one census per year). Late July
- B (2 censuses per year). Late July (cf. A), Mid August (VIII-13)
- C (3). Mid June (VI-13), Late July, Mid August (cf. B)
- D (4). Mid June, Late July, Mid August (cf. C), Late August (VIII-31)
- E (5). Early June (VI-7), Mid June, Late July, Mid August, Late August (cf. D)
- F (6). Early June, Mid June (cf. E), Mid July (VII-15), Late July, Mid August, Late August (cf. E)

Applying these schedules to my results, the corresponding number of species involved and its ratio to the total species number obtained are calculated as follows.

A	B	C	D	E	F
32(52.5%)	41(67.2)	47(77.0)	52(85.2)	55(90.2)	57(93.4)

Periodical census schedule can be planned when surveys are carried out from April to October as follows:

- F* (one month interval). F₁* (1st to 5th of each month, V-1, VI-5, VII-5, VIII-4, IX-5, X-4), F₂* (6th to 10th, V-6, VI-7, VII-10, VIII-8, X-10 except September), F₃* (11th to 15th, IV-13, V-12, VI-13, VII-15, VIII-13, IX-14), F₄* (16th to 20th, IV-18, V-16, VI-17, VII-19, VIII-17, IX-17), F₅* (21th to 25th, IV-23, V-24, VI-21, VII-24, VIII-25 except September), F₆* (26th to 30th or 31th, VI-28, VII-27, VIII-31, IX-26 except April and May)
- G (15 days interval). G₁ (F₁*+F₄*), G₂ (F₂*+F₅*), G₃ (F₃*+F₆*)
- H (10 days interval). H₁ (F₁*+F₃*+F₅*), H₂ (F₂*+F₄*+F₆*)

Numbers of species obtained by those census schedules are:

Table 3. The number of species (Sp) and individuals (In) not observed in the census schedules, A~F. Further explanations in text.

	A		B		C		D		E		F		
	Sp	In	Sp	In	Sp	In	Sp	In	Sp	In	Sp	In	
IV-13	0	0	0	0	0	0	0	0	0	0	0	0	
18	0	0	0	0	0	0	0	0	0	0	0	0	
23	0	0	0	0	0	0	0	0	0	0	0	0	
V-1	0	0	0	0	0	0	0	0	0	0	0	0	
6	0	0	0	0	0	0	0	0	0	0	0	0	
12	0	0	0	0	0	0	0	0	0	0	0	0	
16	3	4	3	4	2	3	2	3	1	2	1	2) <i>Celastrina sugitani</i>
24	1	3	1	3	1	3	1	3	1	3	1	3	
VI-5	3	4	3	4	1	1	1	1	1	1	1	1	
7	4	5	4	5	3	3	3	3	-	-	-	-	
13	7	13	6	12	-	-	-	-	-	-	-	-	
17	4	16	3	15	1	1	1	1	0	0	0	0	
21	6	25	5	19	1	1	1	1	1	1	1	1) <i>Coenonympha hero</i>
28	4	16	3	14	1	1	1	1	1	1	1	1	
VII-5	3	10	2	9	1	2	1	2	1	2	1	2	
10	5	13	3	11	0	0	0	0	0	0	0	0	
15	5	6	3	4	2	2	2	2	2	2	-	-	
19	0	0	0	0	0	0	0	0	0	0	0	0	
24	-	-	-	-	-	-	-	-	-	-	-	-	
27	4	9	1	1	1	1	1	1	1	1	1	1) <i>Antigius attilia</i>
VIII-4	5	16	3	4	2	2	0	0	0	0	0	0	
8	9	19	5	6	5	6	1	1	1	1	0	0	
13	9	34	-	-	-	-	-	-	-	-	-	-	
17	8	17	3	3	2	2	1	1	1	1	1	1) <i>Wagimo signata</i>
25	6	24	3	7	2	6	0	0	0	0	0	0	
31	9	39	5	7	5	7	-	-	-	-	-	-	
IX-5	4	22	1	1	1	1	0	0	0	0	0	0	
14	5	15	1	1	1	1	0	0	0	0	0	0	
17	5	18	1	1	0	0	0	0	0	0	0	0	
20	3	13	0	0	0	0	0	0	0	0	0	0	
26	3	4	0	0	0	0	0	0	0	0	0	0	
X-4	0	0	0	0	0	0	0	0	0	0	0	0	
10	0	0	0	0	0	0	0	0	0	0	0	0	

F ₁ *	F ₂ *	F ₃ *	F ₄ *	F ₅ *	F ₆ *	G ₁	G ₂	G ₃	H ₁	H ₂
39	43	44	43	43	44	49	52	53	54	56
average			42.7			51.3			55	
number of			(69.9%)			(84.1%)			(90.2%)	
species										

The efficiency of the periodical census schedule so far adopted to appreciate the faunal makeup is not necessarily high, because the number of species obtained by the periodical census schedule, F* (6 times per year), is less than that from the selective census schedule, C (3 times per year). In the selective census schedules, A~F, all the census dates concentrate upon three months, June, July and August.

For these three months, the schedule C is regarded as monthly census and F is equivalent to two censuses per month. From this relation the concentrated census in these three months, during which all 61 observed species in 1973 were found to fly, is recommended to yield the highest number of species in the area surveyed with the minimum effort. However, some additional censuses in the other four months, April, May, September and October are recommended to make the phenological survey complete. This schedule may be applied to the lowland and hilly areas of Western Hokkaido excluding Oshima Peninsula.

Summary

Butterfly phenologies at Jozankei were reported based upon the belt transect census made three times per month at the interval of ten days from May to October in 1972 and from April to October in 1973. Main results are:

1) In total, 57 species and 1,685.6 corrected individuals were counted in 1972, while 61 species, 1,722.0 corrected individuals in 1973 except some unidentified species.

2) The order of the appearance of adults is mainly determined by the wintering types and stable between two years in most species.

3) Three species, *Pieris napi*, *P. rapae* and *Cobias erate* were stably top ranked in both years. The other predominant species, especially those of Satyridae and Argynninae, were relatively unstable with shift of ranks between years.

4) The periodical census made twice or thrice per month with more increased census frequency in June to August was recommended to obtain the highest number of the species with the minimum effort in the surveyed route and possibly in the adjacent areas.

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