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Seasonal Change in Abundance of Mosquitoes in Sapporo¹⁾

By

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(With 4 Text-figures)

As to the seasonal variation in abundance of mosquitoes, there have been published a fair number of reports in Japan. Especially, the results of extensive investigation of the problem prepared by the 207th Malaria Survey Detachment, the 406th Medical General Laboratory and the Japan Society of Sanitary Zoology have been successively reported since 1949. In those reports, seasonal prevalence of mosquitoes in various areas in Japan is summarized. So far as the present author is aware, however, there are few papers on the distribution of mosquitoes in Hokkaido (Takahasi, 1946; Shogaki, 1950), and data on the seasonal prevalence have not yet been reported. After having been studying the seasonal prevalence of mosquitoes in Sapporo since 1953, the author proposes to publish here a part of these observations.

Before proceeding further, the author wishes to express his cordial thanks to Professor Tohru Uchida for his instructive guidance and his kindness in reading through the manuscript.

Localities and methods of investigation

In this study two localities were chosen for observation: a horse-stable and a tract of woods.

Two large horse-stables facing each other about 50 m apart in the farm attached to the university, have 12 and 11 small compartments. One stable (21.2 × 10 m²) used for observation is divided into two parts by a middle corridor (about 2.5 m wide), each half having 6 compartments. Except 3 compartments stored with hay, eight each harboured a single horse and one contained 3 mules. In the immediate neighbourhood of the stables there are various breeding places for mosquito larvae, such as a remnant of toilet pool, cesspools, an artificial water tank, and paddy-fields. The patch of woods on the campus of the university is chiefly made up of tall elms and thickets of bamboo-grass. A temporary pool of standing water in the bamboo thickets is inhabited by species of *Aedes* and *Anopheles*. About 100 m away from the woody tract, there stands a large dormitory of the university, in the neighbourhood of which there are a ditch and open barrels which breed the larvae of *Culex pipiens pallens*.

1) Contribution No. 368 from the Zoological Institute, Faculty of Science, Hokkaido University, Sapporo, Japan.

Jour. Fac. Sci. Hokkaido Univ. Ser. VI, Zool. 12, 1956.

The catch of mosquitoes was made once weekly in 1953, but since 1954 occasionally throughout the year. In the horse-stable, as many mosquitoes were captured as possible during the period 10.00-11.00 a. m. For catching them, a glass tube (inside diam. 2.5 cm) was used; the glass tube has a funnel (diam. 3 cm) at one end, and at the opposite end, a bit of narrow glass tube covered with bolting cloth and with a long rubber tube, so that mosquitoes can be captured by inhaling at the end of the rubber tube. In the woody tract, one hour sweeping with a funnel-shaped net (diam. 36 cm; 100 cm in length) was done usually between 3 and 4 p.m.

Results and discussion

The results obtained in 1955 will be stated in the following.

1. Results obtained in the woods

Sampling was taken 16 times from April 27th to September 15th. Among the specimens captured were found 6 species, including *Aedes vexans nipponii*, *Culex pipiens pallens*, *Culex orientalis*, *Aedes esoensis*, *Aedes excrucians* and *Aedes galloisi* (Table 1). In addition to these species, one specimen each of *Aedes dorsalis* and *Aedes japonicus* was collected in 1954. Thus specimens of 8 species of mosquitoes have been obtained in the woody tract.

Table 1.

| Species | Males | Females | Total | % |
|------------------------------|-------|---------|-------|-------|
| <i>Aedes vexans nipponii</i> | 136 | 127 | 263 | 63.4 |
| <i>Culex pipiens pallens</i> | 16 | 48 | 64 | 15.4 |
| <i>Culex orientalis</i> | 51 | 11 | 62 | 14.9 |
| <i>Aedes esoensis</i> | 1 | 21 | 22 | 5.3 |
| <i>Aedes excrucians</i> | 3 | 0 | 3 | 0.7 |
| <i>Aedes galloisi</i> | 1 | 0 | 1 | 0.3 |
| Total | 208 | 207 | 415 | 100.0 |

a) Seasonal prevalence of the most prominent species

Aedes vexans nipponii: As seen in Figure 1, a few females were captured on June 9th and they increased rapidly in number to form a peak on June 16th. Then, they decreased gradually and disappeared temporarily from the end of July to the end of August. In September, they appeared again in considerable number and disappeared completely during October. The seasonal prevalence of males was only slightly different from that of the females but the period of appearance was a little shorter than in the females. Thus the species prevailed markedly in June and in September. Since 1953 such two peaks have been observed every year without change in the season of appearance.

Culex pipiens pallens: When room temperature rose to 17°C or so, females appeared indoors in January, and increased gradually in number towards March. Although outdoor flying is seen usually during April, blood-sucking does not yet

occur in this season. A fair number of females including blood-sucking individuals were captured at the end of May and in the middle of June. The male was first recorded to appear on June 16th. From June 23rd to August 25th both males and females diminished remarkably in number. Such a decrease of population has not been seen in the summer season of an ordinary year. As to the reason why the population decreased, the following facts seem to be related. As unusual hot days

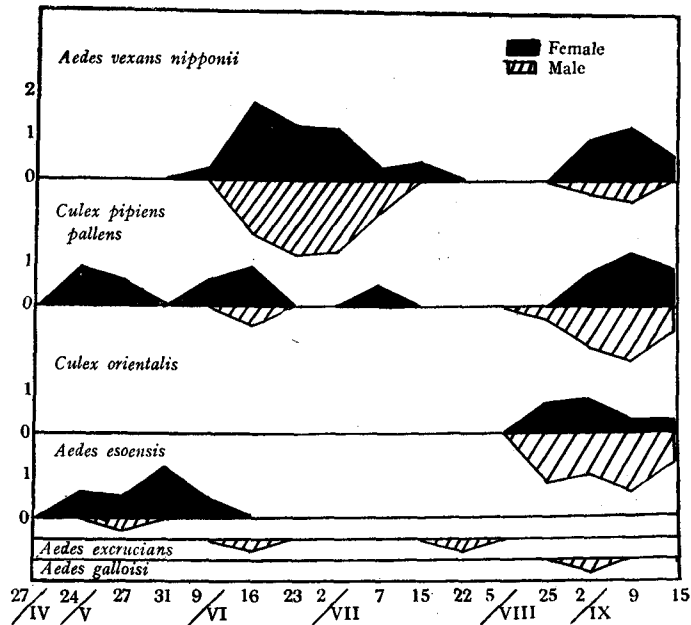


Fig. 1. Seasonal prevalence of each species occurred in woods.
Ordinate: individual numbers after $\log(n+1)$.

(* above 30°C) continued in July and August, the larval habitats of the mosquito in the neighbourhood of the dormitory dried up. Moreover, from the middle of July to the last part of August, the larvae of the species could not be found in the pool of standing water in the woods. At the beginning of September, the mosquitoes were again exceedingly prevalent. Especially, males increased remarkably in number. Splendid swarming was done in the calm evenings and was seen till the end of October. The last swarming was observed on October 27th. After November the mosquitoes were scarcely found outdoors. The seasonal activity described above, seems to differ fairly from that observed by Hosoi (1954). In general, the start of various activities (outdoor flying, blood-sucking, appearance

* In Sapporo, the usual air temperature in summer seldom rises to 30°C.

of males and so on) is about a month later in this area and the disappearance of the mosquito is earlier. As one of the main factors inhibiting the activities, low air temperature in March (maximum 12.2°C) and in November (maximum 13.2°C) is suggestive.

Culex orientalis: Males and females appeared together on August 25th and were captured continuously till the middle of September. The earliest appearance observed until the present data was on August 16th in 1954. They disappeared at least during October. From these facts, it seems that in this area the species emerges once a year after August.

Aedes esoensis: The species was captured from the last part of May to the first part of June but no specimen has been captured again since then. They increased to the maximum on May 31st and one blood-sucking female was found on June 9th. Thus this species was the earliest to occur among the mosquitoes in the present area. In Japan Proper, the imagines of the species are usually seen at considerable height (over 1000 m above sea-level; Kurashige, 1950; Tamaboko, 1953), and the larvae are often captured at about 100 m above sea-level (Numata, 1952). From such facts the species is considered to be a resident in the district of comparatively cold climate.

With respect to the other two species, it is difficult to deduce any conclusions about the seasonal prevalence because of scantiness of materials.

b) Seasonal change of mosquito association in the woody tract

For a study of this topics, the numerical constitution of various species in each association was analysed using "the graph of occurrence probability", which was used by Kato and his colleagues (1952). Thus the confidence intervals of occurrence-probability of all species were calculated at the significant level of 90% (Figure 2). According to Kato et al., it is concluded that, when the confidence interval of two species overlaps each other, they are balanced in number. They

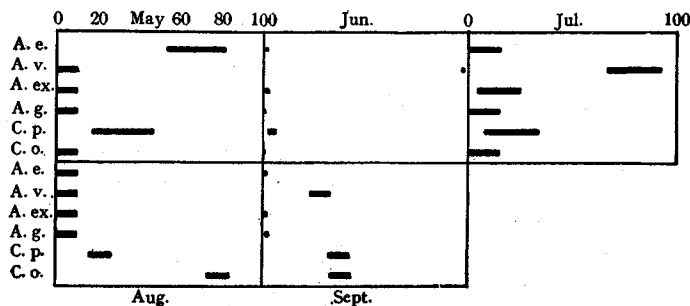


Fig. 2. Seasonal change of mosquito association in woods. A. e.: *Aedes esoensis*, A. v.: *Aedes vexans nipponii*, A. ex.: *Aedes excrucians*, A. g.: *Aedes galloisi*, C. p.: *Culex pipiens pallens*, C. o.: *Culex orientalis*.

confirmed further that, when the confidence interval of a given association is narrower, the population density of the association becomes higher. As seen in Fig. 2, the superior-inferior relation of constituent species in each association is clear-cut except in September. That is to say, in May *Aedes esoensis* was more numerous than *Culex pipiens pallens*. In June and July, *Aedes vexans nipponii* was clearly the dominant species. But in June, as the confidence interval of each species is fairly narrower than in July, it is understood that the population density of June is much higher than that of July. In August, *Culex orientalis* was highest in number and *Culex pipiens pallens* was next. The structure of each association stated above was comparatively simple, the dominant species being always clear. However, in September the situation was slightly different from the above, and the constitution of the association was complex. The confidence interval of three species, *Culex orientalis*, *C. pipiens pallens* and *Aedes vexans nipponii* overlapped one another. Moreover, these three species each was numerically superior to the other constituent species, *Aedes galloisi*. It is therefore, concluded that between the former three species, superiority or inferiority in number did not exist and all of them were the dominant species in this season. Thus the seasonal change of mosquito association in the woods was as follows:

Aedes esoensis association → *Aedes vexans nipponii* association → *Culex orientalis* association → *Culex orientalis*-*C. pipiens pallens*-*Aedes vexans nipponii* association.

2. Results obtained in the horse-stable

Eighteen investigations were undertaken between June 20th and November 10th, 1955. During that period, three species, *Culex pipiens pallens*, *Aedes vexans nipponii*, and *Anopheles hyrcanus sinensis* occurred. The former two species were overwhelmingly abundant (Table 2).

Table 2.

| Species | Males | Females | Total | % |
|------------------------------------|-------|---------|-------|--------|
| <i>Culex pipiens pallens</i> | 474 | 755 | 1229 | 86.1 |
| <i>Aedes vexans nipponii</i> | 0 | 195 | 195 | 13.7 |
| <i>Anopheles hyrcanus sinensis</i> | 0 | 3 | 3 | 0.02 |
| Total | 474 | 953 | 1427 | 100.00 |

a) Seasonal prevalence of each species

Culex pipiens pallens: As is clear in Figure 3, both males and females appeared first on July 2nd. Prior to this, on June 20th, they had already emerged one after another in a cesspool near the horse-stable, but they were not found in the stable. As *Aedes vexans nipponii* prevailed markedly in the stable at that time, it is considerable that *Culex pipiens pallens* could not invade. On this point, the results of investigations will be reported elsewhere. The catch of the mosquito

increased steadily after June 8th and reached the maximum on August 10th. They decreased slightly in number towards the end of August but were still abundant till the middle of September. In the middle of October, a sudden fall of appearance occurred and they disappeared at the end of the month. The seasonal activity stated above, did not always coincide with the observations made in Japan Proper (Omori, 1951 ; Kitaoka et al. 1953 ; Narita, 1953 ; Ori & Shimogama, 1953).

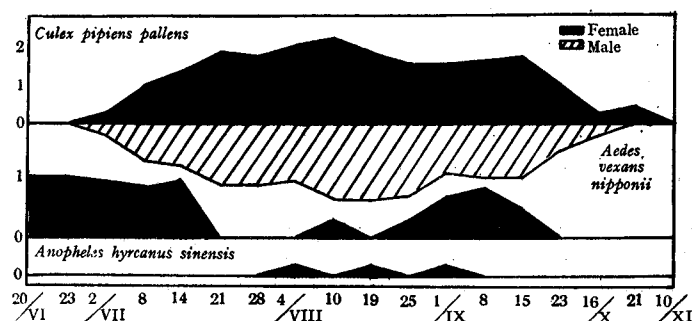


Fig. 3. Seasonal prevalence of each species occurred in horse-stable.
Ordinate : individual numbers after $\log(n+1)$.

As pointed out previously, in this area the duration of appearance of the species seems to be quite short. The period in which the females suck the blood is also short. One blood-sucking female was captured first on July 2nd and the catch increased gradually afterwards. From the middle of July to the end of August, blood-sucking activity was the highest, but it fell off abruptly after September ; their fatness was noticeable. The last blood-sucking females were noticed on September 27th. Thus a sign of hibernation was seen as usual during September. As reported by Hosoi (1954), the causes of hibernation seem to be mainly low air temperature and the remarkable lack of light in September.

Aedes vexans nipponii : This species appeared from June to the middle of September, forming peaks respectively on June 20th and September 8th. During that period, they were not found for a while from the last part of July to the first part of August. Such a sudden disappearance had already been observed in the woods survey. The present author cannot give any explanation for the fact but wishes to call attention to the strong resemblance of air temperature between June and September, in which months the species was extremely prevalent. Next, in respect to this species the following interesting facts are observed every year. Only the females are always seen in the horse-stable and every one of them sucks blood, but the males can never be found in the stable despite the occurrence of*breeding places nearby. These facts seem to suggest that there is a consider-

* Paddy-fields, about 300m distant from the stable.

able difference between the intrinsic behaviour of females and males (chemical sense etc.).

Anopheles hyrcanus sinensis: The species has been first captured since 1953. Only three females were captured separately from the beginning of August to September.

b) Seasonal change of mosquito association in the horse-stable

As was done for the mosquito association in the woody tract, each association was analysed by the occurrence probability method. Figure 4 shows clearly that in the horse-stable the constitution of the associations are very simple. In June *Aedes vexans nipponii* excelled the other species in number, but on the contrary, *Culex pipiens pallens* was the dominant species in the subsequent months. Thus the seasonal change of mosquito association in the horse-stable proceeded as follows:

Aedes vexans nipponii association → *Culex pipiens pallens* association.

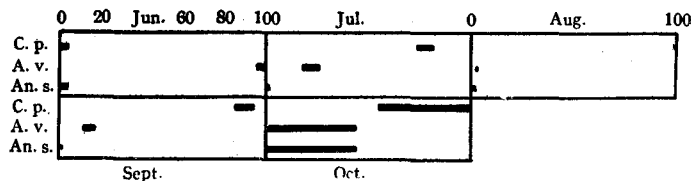


Fig. 4. Seasonal change of mosquito association in horse-stable. C. p.: *Culex pipiens pallens*, A. v.: *Aedes vexans nipponii* An. s.: *Anopheles hyrcanus sinensis*.

Summary

1. Mosquitoes were collected at a horse-stable from June to November, and in a woody tract from April to September 1955. The total number of individuals obtained was 1427 in the horse-stable: *Culex pipiens pallens* (86.1%), *Aedes vexans nipponii* (13.7%), *Anopheles hyrcanus sinensis* (0.02%); it was 415 in the woody tract: *Aedes vexans nipponii* (63.4%), *Culex pipiens pallens* (15.4%), *Culex orientalis* (14.9%), *Aedes esoensis* (5.3%), *Aedes excrucians* (0.7%), *Aedes galloisi* (0.3%).

2. *Culex pipiens pallens*: Females were seen outdoors about the end of April and blood-sucking ones were captured from the end of May. Males occurred from the middle of June. The mosquitoes were captured until the end of October, the maximum was attained towards the beginning of August. Blood-sucking activity of females was the highest from the middle of July to the end of August, and it fell off rapidly at the beginning of September. Then fattened females became extremely abundant.

3. *Aedes vexans nipponii*: Males and females appeared almost simul-

taneously in the middle of June and disappeared late in September. The peak of appearance was attained in June and in the first part of September respectively.

4. *Aedes esoensis*: Both males and females were captured in great numbers late in spring, namely, from the end of May to the beginning of June. They were not seen after the middle of June.

5. *Culex orientalis*: Females and males first appeared in August and a few individuals were continuously captured till the end of October. Among mosquitoes in Sapporo, this species seems to be the latest to appear.

6. The mosquito associations in the wooded tract and in the stable were analysed using the so-called, "graph of occurrence probability". In the wooded tract, the seasonal change of mosquito association occurred somewhat perplexingly, whilst in the stable it passed very simply.

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Localities and methods of investigation

In this study two localities were chosen for observation: a horse-stable and a tract of woods.

Two large horse-stables facing each other about 50 m apart in the farm attached to the university, have 12 and 11 small compartments. One stable (21.2 × 10 m²) used for observation is divided into two parts by a middle corridor (about 2.5 m wide), each half having 6 compartments. Except 3 compartments stored with hay, eight each harboured a single horse and one contained 3 mules. In the immediate neighbourhood of the stables there are various breeding places for mosquito larvae, such as a remnant of toilet pool, cesspools, an artificial water tank, and paddy-fields. The patch of woods on the campus of the university is chiefly made up of tall elms and thickets of bamboo-grass. A temporary pool of standing water in the bamboo thickets is inhabited by species of *Aedes* and *Anopheles*. About 100 m away from the woody tract, there stands a large dormitory of the university, in the neighbourhood of which there are a ditch and open barrels which breed the larvae of *Culex pipiens pallens*.

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Results and discussion

The results obtained in 1955 will be stated in the following.

1. Results obtained in the woods

Sampling was taken 16 times from April 27th to September 15th. Among the specimens captured were found 6 species, including *Aedes vexans nipponii*, *Culex pipiens pallens*, *Culex orientalis*, *Aedes esoensis*, *Aedes excrucians* and *Aedes galloisi* (Table 1). In addition to these species, one specimen each of *Aedes dorsalis* and *Aedes japonicus* was collected in 1954. Thus specimens of 8 species of mosquitoes have been obtained in the woody tract.

Table 1.

| Species | Males | Females | Total | % |
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| <i>Aedes galloisi</i> | 1 | 0 | 1 | 0.3 |
| Total | 208 | 207 | 415 | 100.0 |

a) Seasonal prevalence of the most prominent species

Aedes vexans nipponii: As seen in Figure 1, a few females were captured on June 9th and they increased rapidly in number to form a peak on June 16th. Then, they decreased gradually and disappeared temporarily from the end of July to the end of August. In September, they appeared again in considerable number and disappeared completely during October. The seasonal prevalence of males was only slightly different from that of the females but the period of appearance was a little shorter than in the females. Thus the species prevailed markedly in June and in September. Since 1953 such two peaks have been observed every year without change in the season of appearance.

Culex pipiens pallens: When room temperature rose to 17°C or so, females appeared indoors in January, and increased gradually in number towards March. Although outdoor flying is seen usually during April, blood-sucking does not yet

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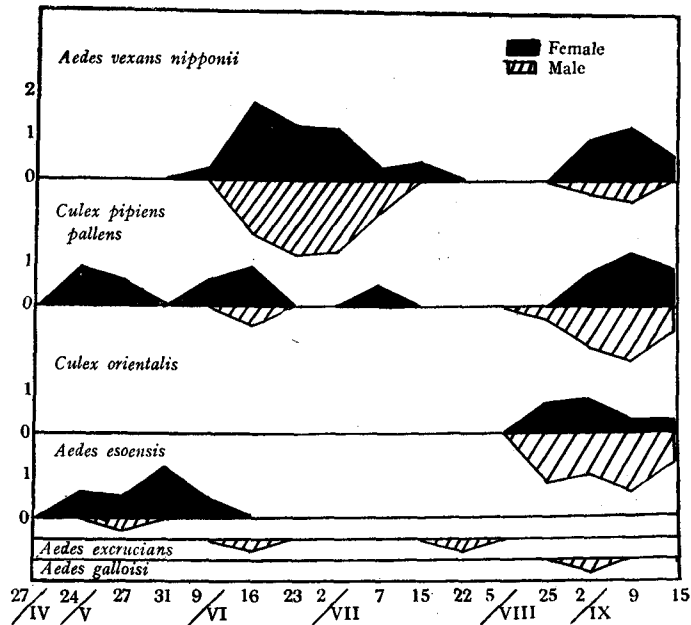


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For a study of this topics, the numerical constitution of various species in each association was analysed using "the graph of occurrence probability", which was used by Kato and his colleagues (1952). Thus the confidence intervals of occurrence-probability of all species were calculated at the significant level of 90% (Figure 2). According to Kato et al., it is concluded that, when the confidence interval of two species overlaps each other, they are balanced in number. They

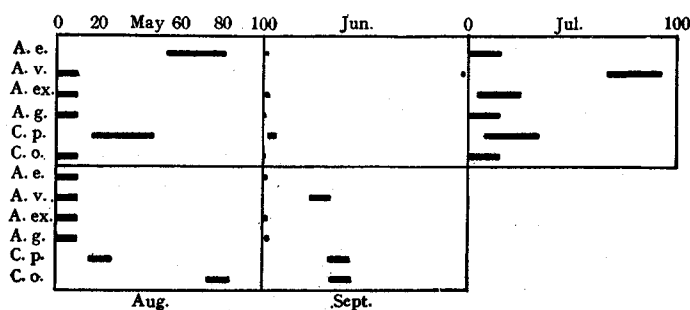


Fig. 2. Seasonal change of mosquito association in woods. A. e.: *Aedes esoensis*, A. v.: *Aedes vexans nipponii*, A. ex.: *Aedes excrucians*, A. g.: *Aedes galloisi*, C. p.: *Culex pipiens pallens*, C. o.: *Culex orientalis*.

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2. Results obtained in the horse-stable

Eighteen investigations were undertaken between June 20th and November 10th, 1955. During that period, three species, *Culex pipiens pallens*, *Aedes vexans nipponii*, and *Anopheles hyrcanus sinensis* occurred. The former two species were overwhelmingly abundant (Table 2).

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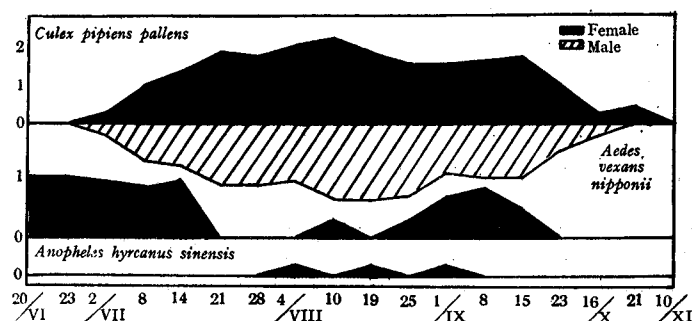


Fig. 3. Seasonal prevalence of each species occurred in horse-stable.
Ordinate : individual numbers after log (n + 1).

As pointed out previously, in this area the duration of appearance of the species seems to be quite short. The period in which the females suck the blood is also short. One blood-sucking female was captured first on July 2nd and the catch increased gradually afterwards. From the middle of July to the end of August, blood-sucking activity was the highest, but it fell off abruptly after September ; their fatness was noticeable. The last blood-sucking females were noticed on September 27th. Thus a sign of hibernation was seen as usual during September. As reported by Hosoi (1954), the causes of hibernation seem to be mainly low air temperature and the remarkable lack of light in September.

Aedes vexans nipponii : This species appeared from June to the middle of September, forming peaks respectively on June 20th and September 8th. During that period, they were not found for a while from the last part of July to the first part of August. Such a sudden disappearance had already been observed in the woods survey. The present author cannot give any explanation for the fact but wishes to call attention to the strong resemblance of air temperature between June and September, in which months the species was extremely prevalent. Next, in respect to this species the following interesting facts are observed every year. Only the females are always seen in the horse-stable and every one of them sucks blood, but the males can never be found in the stable despite the occurrence of*breeding places nearby. These facts seem to suggest that there is a consider-

* Paddy-fields, about 300m distant from the stable.

able difference between the intrinsic behaviour of females and males (chemical sense etc.).

Anopheles hyrcanus sinensis: The species has been first captured since 1953. Only three females were captured separately from the beginning of August to September.

b) Seasonal change of mosquito association in the horse-stable

As was done for the mosquito association in the woody tract, each association was analysed by the occurrence probability method. Figure 4 shows clearly that in the horse-stable the constitution of the associations are very simple. In June *Aedes vexans nipponii* excelled the other species in number, but on the contrary, *Culex pipiens pallens* was the dominant species in the subsequent months. Thus the seasonal change of mosquito association in the horse-stable proceeded as follows:

Aedes vexans nipponii association → *Culex pipiens pallens* association.

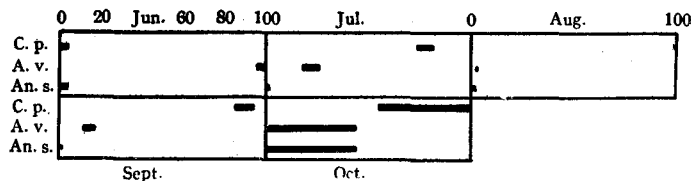


Fig. 4. Seasonal change of mosquito association in horse-stable. C. p.: *Culex pipiens pallens*, A. v.: *Aedes vexans nipponii* An. s.: *Anopheles hyrcanus sinensis*.

Summary

1. Mosquitoes were collected at a horse-stable from June to November, and in a woody tract from April to September 1955. The total number of individuals obtained was 1427 in the horse-stable: *Culex pipiens pallens* (86.1%), *Aedes vexans nipponii* (13.7%), *Anopheles hyrcanus sinensis* (0.02%); it was 415 in the woody tract: *Aedes vexans nipponii* (63.4%), *Culex pipiens pallens* (15.4%), *Culex orientalis* (14.9%), *Aedes esoensis* (5.3%), *Aedes excrucians* (0.7%), *Aedes galloisi* (0.3%).

2. *Culex pipiens pallens*: Females were seen outdoors about the end of April and blood-sucking ones were captured from the end of May. Males occurred from the middle of June. The mosquitoes were captured until the end of October, the maximum was attained towards the beginning of August. Blood-sucking activity of females was the highest from the middle of July to the end of August, and it fell off rapidly at the beginning of September. Then fattened females became extremely abundant.

3. *Aedes vexans nipponii*: Males and females appeared almost simul-

taneously in the middle of June and disappeared late in September. The peak of appearance was attained in June and in the first part of September respectively.

4. *Aedes esoensis*: Both males and females were captured in great numbers late in spring, namely, from the end of May to the beginning of June. They were not seen after the middle of June.

5. *Culex orientalis*: Females and males first appeared in August and a few individuals were continuously captured till the end of October. Among mosquitoes in Sapporo, this species seems to be the latest to appear.

6. The mosquito associations in the wooded tract and in the stable were analysed using the so-called, "graph of occurrence probability". In the wooded tract, the seasonal change of mosquito association occurred somewhat perplexingly, whilst in the stable it passed very simply.

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