

Ecology of Vector Mosquitoes of Japanese Encephalitis,  
Especially of *Culex tritaeniorhynchus* 3. Seasonal changes  
in the time of being attracted to dry ice in the females of  
*Culex tritaeniorhynchus*\*

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### Abstract

The time of being attracted to dry ice of *Culex tritaeniorhynchus* females in the evening roughly depends on the sunset time. Strictly speaking, however, the former time much fluctuates seasonally than the latter time. In spring, the starting time of being attracted to dry ice is usually over half an hour earlier than the sunset time, and the peak time appears around the sunset time. With the progress in season, the time in relation to the sunset time becomes later gradually and in summer and autumn the starting time, and consequently the peak time, becomes in most cases, later than the sunset time. In other words, the illumination in Lux at the time of being attracted to dry ice is much higher in spring than in the other seasons.

### Introduction

A dry-ice-trap is a very efficient tool for collecting the gonoactive females of *Culex tritaeniorhynchus* (Omori *et al.*, 1965). In our Department the collection of *C. tritaeniorhynchus* has been continued by this method for sever-

al years in relation to the epidemiology of Japanese encephalitis. As we took care to cover the peak time of being attracted to dry ice in the evening in the collection, it was necessary to change the time of collection.

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seasonally. In this paper the seasonal changes in the time of being attracted to dry ice of *C. tritaeniorhynchus* females in the evening are

examined in relation to air temperature and illumination in Lux.

### Methods

The collection of *Culex tritaeniorhynchus* females was made from March to November for five years from 1965 to 1969 by using dry-ice-traps in many villages near or in Nagasaki City, i. e., Nunomaki, Tomachi, Kawabira Koebaru, Hotachime, Kobasaki, Fukuda, Nishiyama, Mogi, Kaizu and Aino. In all the villages paddy-fields were developed to a greater or lesser extent. By the paddy-fields a mosquito-net was set tucking up at least one side. Usually in the mosquito-net about two kilograms of dry ice were used to generate CO<sub>2</sub> gas continuously by being thrown

into hot water for about two hours before and after the sunset time. Mosquitoes were collected when coming about to or entering the mosquito-net by aspirator or hand net.

The starting time of *C. tritaeniorhynchus* females to be attracted to CO<sub>2</sub> gas, the peak time or the time of reaching maximum in number, and the decreased time (or the end time) in number were recorded in relation to the sunset time. In summer and autumn, the peak and especially the decreased time were observed using the electric hand light because the times usually come after dark.

### Results of observations

The time of being attracted to dry ice of *Culex tritaeniorhynchus* females in five years from 1965 to 1969 are presented in Fig. 1, with the sunset time and the time of becoming dark. It is seen from Fig. 1 that the time of being attracted to dry ice changes gradually with the progress in season. In spring the starting time is about 6:30 p. m. or earlier, and the decreased time is around 7:30 p. m. or earlier. While in July the starting time becomes as late as 7:30 p. m. and the decreased time appears about 8:30 p. m.. Thereafter the time becomes earlier gradually. These changes in the time of being attracted to dry ice roughly depend on the change in the sunset time. Strictly speaking, however, the former time much fluctuates than the latter time. In spring, the starting time is usually over half an hour earlier than the sunset time, and the peak time appears around the sunset time.

With the progress in season, the time in relation to the sunset time delays gradually, so in summer and autumn the starting time, and consequently the peak time, becomes in most cases, later than the sunset time.

The mean times of being attracted to dry ice in early, middle and late parts of each month in five years from 1965 to 1969 are presented in Fig. 2, showing more clearly the tendency observed in Fig. 1. This figure offers the useful information for the collection of *C. tritaeniorhynchus* females by dry-ice-traps in Nagasaki. It is recommended that the collection is started about one hour before the sunset time in March and April and continued for one hour so as to cover the peak time; the collection period is gradually delayed with the progress in season; and in or after July the collection is made for one hour from about a quarter past the sunset time.

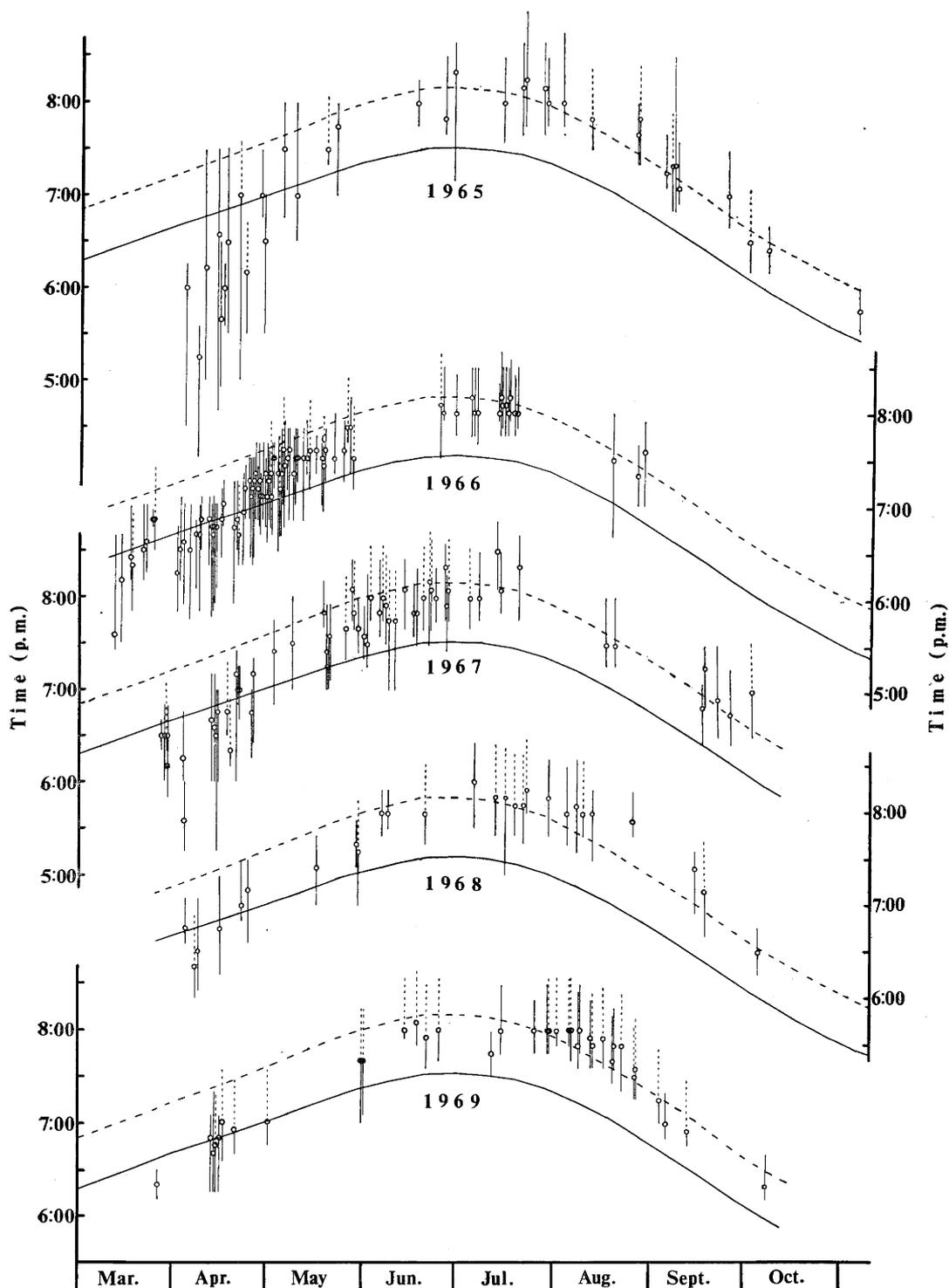


Fig. 1. Seasonal changes in the time of being attracted to dry ice in the females of *Culex tritaeniorhynchus*, observed around Nagasaki City in five years from 1965 to 1969. Solid curved line shows the sunset time; dotted one is the time of becoming dark. Vertical solid line and circle shows the duration and the peak in time of being attracted to dry ice, respectively. The part given by the dotted line on the duration line shows the case when the decreased time was not observed.

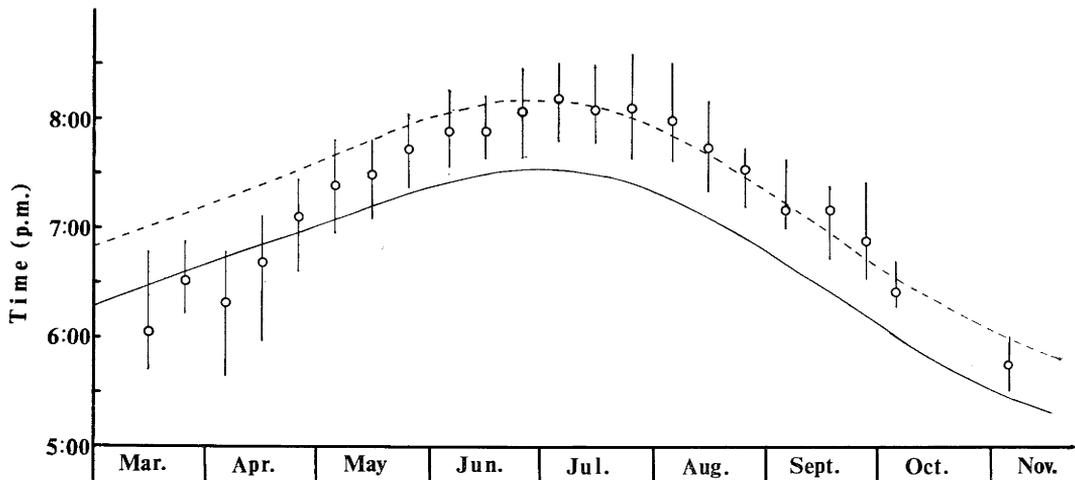


Fig. 2. Seasonal changes of the respective means for the starting, peak, and decreased times, by early, middle, and late parts of a month, based on the data given in Fig. 1. In this Fig. the data of three time points which were observed on the same days were only used.

In Fig. 3 the seasonal changes in the illumination in Lux at the starting time of being attracted to dry ice are given, as it seems from Fig. 1 and 2 that the illumination in Lux at the time of being attracted to dry ice changes seasonally. As expected, the illumination in Lux at the starting time is much higher in spring than in summer and autumn. In spring it is usually above 200 Lux, but in summer and autumn mostly below 150 Lux. One possible explanation of such difference in the illumination in Lux at the time of being attracted to dry ice is that the threshold illumination to begin a flight activity differs in different air temperature, and the other is that the threshold illumination to begin a flight activity differs between the populations of *C. tritaeniorhynchus* females in different seasons, i. e., the reaction to illumination in Lux differs in the mosquitoes in different seasons. For analysing this point, the relation between the time of being attracted to dry ice and the air temperature in the evening is examined in every two months. The air temperature in the evening

is calculated as the mean of maximum temperature on that day and minimum temperature on the next day. The results are shown in Fig. 4. It is seen from Fig. 4 that the time of being attracted to dry ice becomes earlier as the air temperature becomes lower. The tendency is more clearly seen when the air temperature is below 20°C. In April of 1965 the time of being attracted to dry ice was generally earlier than in April of the other four years, as seen in Fig. 1. It may be because the air temperature in April of 1965 was lower than that of the other four years in Nagasaki. It seems also from Fig. 4 that the time of being attracted to dry ice of *C. tritaeniorhynchus* females is not always the same in different seasons, even when the air temperature in the evening is the same. Especially the time in March and April is earlier than the time in the other seasons, i. e., the mosquitoes in March and April begin a flight activity at higher illumination in Lux than the mosquitoes in the other seasons, even when the air temperature is the same. It may be because *C. tritaeniorhynchus* females in March

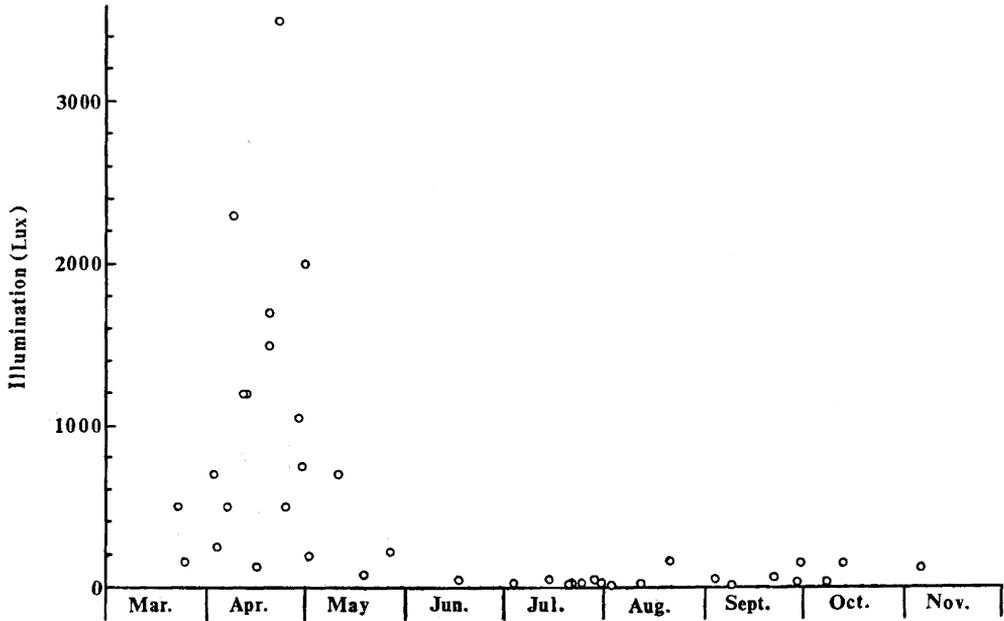


Fig. 3. Seasonal changes of the illumination in Lux at the starting time of being attracted to dry ice in the females of *Culex tritaeniorhynchus*, observed around Nagasaki City in 1965 and 1966.

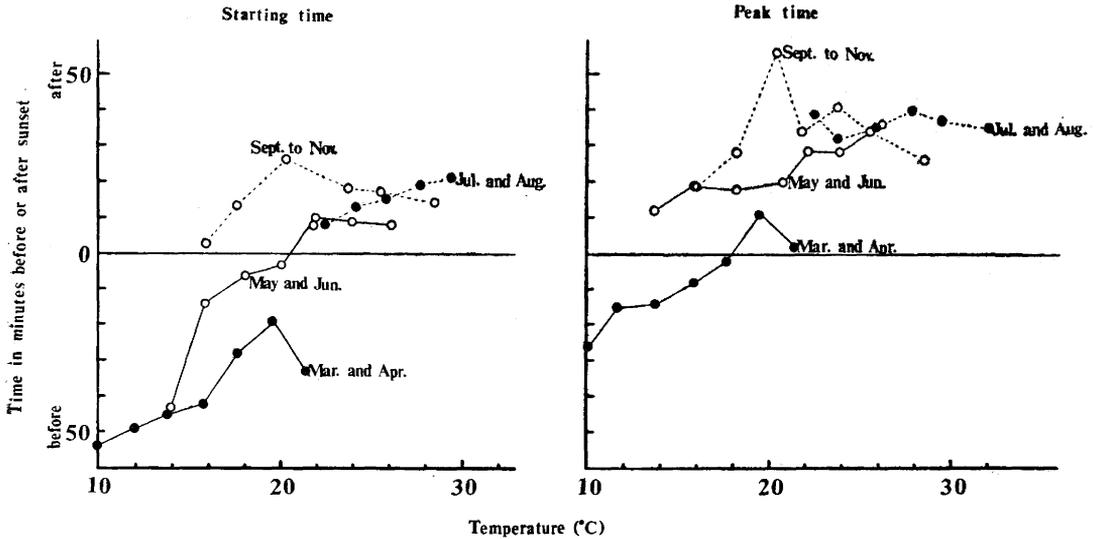


Fig. 4. The relation between the time of being attracted to dry ice in the females of *Culex tritaeniorhynchus* and the air temperature in the evening in every two months, observed around Nagasaki City in five years from 1965 to 1969.

and April collected in Nagasaki are mostly overwintered individuals (Wada *et al.*, 1967). Although the differences between the other three seasons are not so clear, the mosquitoes in May and June may begin a flight activity

at somewhat higher illumination in Lux than the mosquitoes in July to November even when the temperature is the same. From the above results it is concluded that the seasonal changes in the illumination in Lux

at the time of being attracted to dry ice of *C. tritaeniorhynchus* females are probably caused by the difference in the air temperature in the evening and also by the difference, to a lesser extent, in the reaction to illumination in Lux in the mosquitoes in different seasons.

The similar seasonal changes in the time of mosquito activities in relation to the sunset time were observed also in swarming of *C.*

*tritaeniorhynchus* males (Kawai, *et al.*, 1967), in swarming of *Culex pipiens pallens* males (Omori, 1954), and in feeding of *Armigeres subalbatus* females (Bekku, 1954). It is possible that these changes are also caused both by the difference in the air temperature in the evening and by the difference in the reaction to illumination in Lux in the mosquitoes in different seasons.

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### 日本脳炎伝搬蚊、特にコガタアカイエカの生態

### 3. コガタアカイエカがドライアイスに誘引される時刻の季節的变化

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### 摘 要

コガタアカイエカ雌成虫が、夕方、ドライアイスに誘引される時刻は、季節的に、おおそ日没時刻の変化に平行的であるが、厳密に言うと日没時刻よりも早い季節と遅い季節がある。春には、通常、日没の30分以上も前から誘引され始めて、日没頃に最も多く誘引されるが、季節が進むにつれておくれ、夏や秋には日没後に初めて誘引され始めるようになる。すなわち誘引される時刻の照度は、春の方が夏、秋に比べて、一般に、はるかに高い。