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On the Gonotrophic Dissociation in *Culex tritaeniorhynchus summorosus* Females under Various Conditions*

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Abstract

In order to understand the ecological significance for the gonotrophic dissociation in *Culex tritaeniorhynchus summorosus* females, the development of follicles, the activity of blood feeding and the incidence of gonotrophic dissociation were examined with the females which had been reared as adults under the outdoor natural or indoor experimental conditions and with those which had been caught at cowsheds. From the results obtained, it was indicated that under the conditions of the short day-length the gonotrophic dissociation occurs commonly, however the feeding rate is very low and accordingly the number itself of the females showing this phenomenon is very small. Therefore, it can be said that the gonotrophic dissociation in this species does not play the important role on the overwintering ecology.

Introduction

Culex tritaeniorhynchus summorosus is well known to play an important role as the vector of Japanese encephalitis during the epidemic period, but it is not clear whether during winter this mosquito reserves the virus of the disease in the body. In early spring most of the females caught in the field were found to be nulliparous (Harada et al., 1967), there-

fore it would be supposed that the possibility of overwintering of the pathogen in the mosquitoes is very low. However, if the females that took the blood-meal and did not develop mature eggs (gonotrophic dissociation) form a greater part of the nulliparous females of the overwintering population, then the possibility would be higher. In other words, for investigat-

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ing the possibility of hibernation of the virus in the mosquito it is necessary to know the rate of gonotrophic dissociation in nature. Thus, it was reported with this mosquito that there occurs the gonotrophic dissociation under some experimental or natural conditions (Harada et al., 1968, 1970; Ito et al., 1968; Kawai, 1969; Takahashi, 1970). However, the actual role of the gonotrophic dissociation played

in the field on the overwintering of this mosquito as well as of the virus was not conclusively given. The present paper deals with the results of experiments to understand the real situation in nature of the gonotrophic dissociation, in connection with the follicular development and the feeding activity in *C. t. summosus* females.

Material and method

The females of *Culex tritaeniorhynchus summosus* which had been bred from the 1st instar larvae of the laboratory colony (Nagasaki strain) were examined for follicular development, feeding activity and gonotrophic dissociation rate. The larvae were bred with equally mixed powder of Ebios (brewer's yeast) and mouse pellets, and the followed adults were kept in a cage with 2% sugar solution, at an outdoor insectarium under natural air conditions, and at indoor insectaria with constant temperatures and alternate light and darkness. The follicu-

lar development was observed under binocular stereoscope and microscope. The stages of follicles were described after Kawai (1969). The females were exposed to a chicken for a night to observe the feeding activity, and the gonotrophic dissociation was examined with the fed females 7-10 days thereafter. Besides the females of the laboratory colony mentioned above, the fed females which had been caught at cowsheds and pigsties and then kept under outdoor conditions were also examined for the occurrence of the gonotrophic dissociation.

Results

Follicular development, feeding activity and gonotrophic dissociation rate were examined with the females which had been reared from the 1st instar larvae under outdoor conditions from September to October. The results are given in Table 1.

Table 1 shows that the follicles of the females which had emerged in early September were large in size and well-developed in stage, but they became smaller and less-developed as the emer-

gence time of females became later in season. The feeding activity also dropped with time, approximately in parallel with the trend of the change in follicular development. As for the gonotrophic dissociation, the seasonal change was not clear, since the females which had emerged in and after early October did not feed on blood at all, however the rate of the occurrence in September seemed not very high.

To make these clearer, our results

Table 1. Follicular development, feeding activity and gonotrophic dissociation in the females of *Culex tritaeniorhynchus summorosus* reared from the 1st instar larvae under outdoor conditions, 1972.

Time of emergence*	Days after emergence to dissection or feeding	No. with the 1st follicles of the indicated size**							Follicular stage	Feeding			Gonotrophic dissociation			
		3-	4-	5-	6-	7-	8-	9-		Total	No. exposed	No. fed	%	No. fed***	No. showing	%
Sep. E	10				2	4	4		10	Ib	30	15	50.0	15	2	13.3
Sep. M	20	2	1	2	0	1	1		7	N-Ib	20	6	30.0	6	2	33.0
Sep. L	20	1	2	5	0	1			9	N	20	8	40.0	8	0	0.0
Oct. E	10	1	3	3					7	N	50	0	0.0	—	—	—
Oct. M	40	4	6						10	N	100	0	0.0	—	—	—
Oct. L	25		7	3					10	No2,N	40	0	0.0	—	—	—

* E, M and L show the early, middle and late part of the month respectively.

** One unit = 10 μ

*** The fed females were dissected 7 to 10 days after feeding.

shown in Table 1 were plotted together with the data by Kawai (1969) in Fig. 1. It is apparent from Fig. 1 that the seasonal changes of the follicular development and the feeding activity are in accordance with those mentioned above. The females which had emerged as adults from early August to middle September had the developed follicles and their feeding rates were generally high, but when the females emerged after that, particularly in October, the follicles were small-sized and the feeding rates were very low. It seems that the rate of the females showing gonotrophic dissociation is low from early August to middle or late September, but becomes high thereafter. Although in middle October all of the six females which had fed on blood showed the gonotrophic dissociation, it should be noted that the feeding rate was very low and therefore the number itself of the females showing this phenomenon was small.

The above results seem to indicate the decreases in the size of follicles and in the feeding activity, and the increase of the occurrence of gonotrophic dissociation,

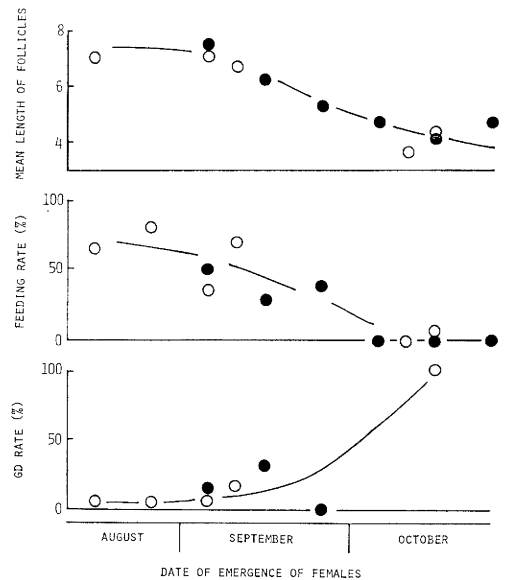


Fig. 1. Follicular size, feeding activity and gonotrophic dissociation in the females of *Culex tritaeniorhynchus summorosus* reared from the 1st instar larvae under outdoor conditions. Black and white circles were drawn from Table 1 and Kawai (1969) respectively. As for the follicular size, see** in Table 1. GD: Gonotrophic dissociation

in the females, as the season becomes later from summer to autumn. To know the possible role of the day-length in such

changes, developmental states of follicles, feeding activity and gonotrophic dissociation were examined with the females which had been reared as adults from the 1st instar larvae under the experimental conditions with photoperiods ranging from

11:30 to 16:00 hours at temperatures of 21–25°C. These results are represented in Table 2 and Fig. 2. In the latter, the data of Kawai (1969) were again shown together with ours.

These results showed that when day-length was longer than 13.5 hours, the females had the well-developed follicles and fed on the chicken actively, and the gonotrophic dissociation rate was generally very low. On the other hand, when day-length was shorter than 13.5 hours, the females had mostly the undeveloped

Table 2. Follicular development, feeding activity and gonotrophic dissociation in the females of *Culex tritaeniorhynchus summorosus* reared from the 1st instar larvae under the combined conditions with various photoperiods and temperatures.

Photo-period (hr: min)	Temp. (°C)	Days after emergence to dissection or feeding	No. with the 1st follicles of the indicated size*												Total	Follicular stage		Feeding		Gonotrophic dissociation	
			3-	4-	5-	6-	7-	8-	9-	10-	11-	12-	No. exposed	% fed		No. fed**	% showing				
16:00	25	12					1	2	2	3				8	Ib-IIa	238	221	92.9	184	0	0.0
13:30	21	7				1	2	11	6				20	Ib-IIa	306	10	3.3	—	—	—	—
13:30	24	5, 7		1	2	5	5	7				20	N-Ib	217	102	47.0	10	2	20.0		
13:00	21	5, 7		13	13	2						28	N	245	48	19.6	6	4	66.7		
13:00	24	7		5	6	2	1	1				15	N-Ib	418	42	10.0	23	5	21.7		
12:00	21	9-11		4	6							10	N	380	0	0.0	—	—	—		
11:30	21	5		6	5							11	N	521	6	1.2	6	6	100.0		

* One unit = 10 μ

** The fed females were dissected 7 to 10 days after feeding

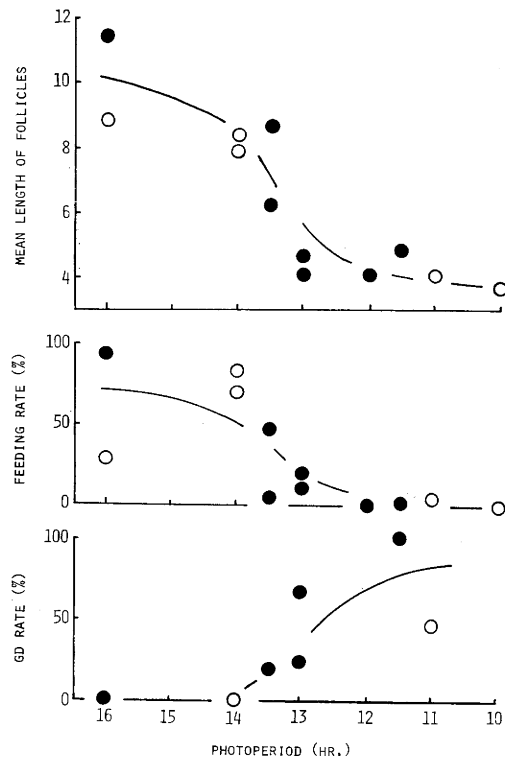


Fig. 2. Follicular size, feeding activity and gonotrophic dissociation in the females of *Culex tritaeniorhynchus summorosus* reared from the 1st instar larvae under various photoperiods at temperature of 21–27°C. Black and white circles were drawn from Table 2 and Kawai (1969) respectively. As for the follicular size, see ** in Table 1. GD: Gonotrophic dissociation

follicles, and the rate of feeding on animals was low and the rate showing gonotrophic dissociation was generally high.

From those results it may be concluded that the females which emerged under the short day-length in the outdoors or the laboratory show the gonotrophic dissociation commonly. Also it seems that the follicular development, feeding activity and gonotrophic dissociation rate in those females are related to each other and

influenced at least by day-length.

To estimate the gonotrophic dissociation rate in nature, it was examined with the fed females which were collected at cowsheds and pigsties in the period from March to October and then kept for 7 to 10 days under the outdoor conditions. These results are given in Table 3, which shows that gonotrophic dissociation in these females was low in rate in spring to summer and became a little high in autumn.

Table 3. Seasonal changes in the rate of gonotrophic dissociation in the fed females of *Culex tritaeniorhynchus summorosus* which were caught at cowsheds and pigsties and thereafter kept under outdoor conditions.

Month of collection	Days from collection to dissection	No. dissected	No. with mature eggs	No. showing gonotrophic dissociation	% of gonotrophic dissociation
Mar. 27	7	7	7	0	0.0
Apr. 12	7	49	48	1	2.0
May 25	7	17	17	0	0.0
Jun. 8	7	30	29	1	3.3
Jul. 10, 17	7	46	43	3	6.5
Aug. 2, 26	7	74	69	5	6.8
Sep. 7—Oct. 5*	3—10	31	22	9	29.0
Sep. 10—26	7	72	69	3	4.2
Oct. 8, 18	10	4	3	1	25.0

* Cited from Kawai (1969).

Discussion

In our experiments with *C. tritaeniorhynchus summorosus*, the females which had been bred under the experimental conditions with day-lengths shorter than 13.5 hours and temperatures from 21 to 25°C showed a low feeding rate, and the gonotrophic dissociation in the fed females was demonstrated at a high rate of ca. 50–100%. The similar result was reported by Ito et al. (1968). They indicated that when the females reared as adults

under a short photoperiod at 25°C were allowed to take the blood-meal, only a few females took the blood-meal and most of them showed the gonotrophic dissociation. From those facts, it is supposed that the females in low feeding activity are liable to show the gonotrophic dissociation.

Harada et al. (1968, 1970) found that the gonotrophic dissociation rates were ca. 70–100% in the females which had

emerged after early September under outdoor conditions. Kawai (1969) also observed that the feeding activity was very low in females which had been reared to adults after middle September under outdoor conditions and had mostly the undeveloped follicles, and the gonotrophic dissociation was high in rate. Ito et al. (1968) showed that in the females which had emerged after late September the feeding activity was lower and the gonotrophic dissociation occurred at higher rates (50–70%), if compared with the females of earlier emergence date. Those data generally coincide with ours. Thus, the close association is again seen between the low activity of the blood feeding and the high incidence of the gonotrophic dissociation. Also it is clearly indicated from those results with outdoor-reared females that the gonotrophic dissociation increases in incidence in autumn, perhaps due largely to the shortening of the day-length. With the females which were caught at cowsheds and pigsties in the Nagasaki area and then kept under outdoor conditions, Kawai (1969) obtained the results that the rate of gonotrophic dissociation was about 30% in September and October, and our data showed a similar incidence rate to Kawai's. There-

fore, it is certain that the gonotrophic dissociation does occur also in the field. However, the incidence rate in autumn is generally lower in the females collected in the field than in those reared under outdoor conditions. The reason for this is not clear at present, but it may be partly included for the explanation that the individuals with physiologically low feeding activity, which could feed on animals under experimental conditions, are not attracted to animals in the field.

In the present mosquito, most of the females entering into hibernation in autumn are unfed and nulliparous (Harada et al., 1968; Ito et al., 1968; Kawai, 1969). In fact, the females encountered at animal houses are very small in number in autumn (Wada et al., 1967). Therefore, even if the incidence rate of the gonotrophic dissociation is fairly high in autumn, the number of the females which experienced the gonotrophic dissociation must be extremely small in the overwintering population. Thus, it can be concluded that the gonotrophic dissociation in this species does not play an important role for the overwintering ecology, therefore the possibility of the virus to overwinter in the mosquito is also very small, as far as northern Kyushu areas are concerned.

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種々の条件下でのコガタアカイエカの栄養生殖分離

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摘 要

コガタアカイエカの栄養生殖分離の果す生態学的意義を明らかにするために、夏から秋にかけて屋外の自然条件下で飼育羽化させた雌及び種々の日長と温度とを組み合わせた実験条件下で飼育羽化させた雌について、濾胞の発育状態、吸血率及び栄養生殖分離率を調査し、更に春から秋にかけて牛舎で採集した吸血雌についても栄養生殖分離率を調べた。これらの調査結果から、本種雌の栄養生殖分離は短日条件下で普通に起こるが、吸血率が顕著に低いため、本現象を示す雌の数は極めて少ないことがわかった。したがって、本種の栄養生殖分離が越冬生態の上に重要な役割を果すとは思われない。