

Effects of Temperatures on the Oviposition and Hatching of Eggs in *Culex pipiens molestus* and *Culex pipiens quinquefasciatus*

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Abstract: In Japan, the mosquito of *Culex pipiens molestus*, a member of *Culex pipiens* complex, distributes in parts of Japan lying the northern part of Kagoshima, but not in the more southern parts such as Okinawa. However, in the latter parts there is the mosquito of *Cx. p. quinquefasciatus*, another member of the same complex as *Cx. p. molestus*. To make clear the factors limiting the distribution of *Cx. p. molestus* in Japan, oviposition and hatching of eggs were examined with the females of *Cx. p. molestus* and *Cx. p. quinquefasciatus* which had been bred from the 1st instar larvae at various temperatures. In *Cx. p. molestus*, oviposition rate of autogenous females at the high temperature of 30 C was not high, and hatching rate of eggs was very low, but in *Cx. p. quinquefasciatus*, oviposition rate of fed females was high and hatching rate was also high even at 30 C. Therefore, high temperature seems to be one of the factors inhibiting the mosquito of *Cx. p. molestus* to invade the southern parts of Japan.

INTRODUCTION

The mosquitoes of the *Culex pipiens* complex of Japan are composed of the following three members, *Culex pipiens molestus*, *Cx. p. pallens* and *Cx. p. quinquefasciatus*. The larva of *molestus* occurs generally in under-ground water, such as cesspools in buildings and the adult female reproduces usually by autogeny, i. e. first oviposition without taking blood meal (Ikuzawa, 1955; Ishii, 1975; Kamura, 1959; Omori et al., 1955; Wada and Ofuji, 1962). *Pallens* and *quinquefasciatus* larvae occur in the above-ground water such as drains and the adults lay their eggs always after taking blood meal. *Molestus* distributes together with *pallens* in the parts of Japan lying north of Kagoshima, but not in more southern parts, such as Okinawa, in which *quinquefa-*

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sciatus is found (Ishii, 1975; Tanaka et al., 1979). However, few studies have been attempted on the environmental factors limiting the distribution of *molestus* in Japan.

In Nagasaki, Oda and Ueda (1979) reported that *molestus* commonly oviposits in the above-ground water and this activity is high in spring and autumn, but it is low in summer, on the other hand, the activity of egg laying in *pallens* is low in spring and autumn, but it is high in summer.

These facts suggested that the reproductive activity of *molestus* is more strongly suppressed by high temperatures than the activity of *pallens* and *quinquefasciatus*, and therefore, high temperature seems to be at least one factor limiting the distribution of *molestus*. With this suggestion, observations were started to compare the effects of temperatures on the oviposition and hatching of eggs between *molestus* and *quinquefasciatus*. These results are reported in the present paper.

MATERIALS AND METHODS

In this experiment, the mosquitoes of *molestus* of Nagasaki strain and *quinquefasciatus* of Okinawa strain were used. One hundred newly hatched larvae of each mosquito species were put into a pan containing 800 ml tap water. These larvae were reared to the adult stage in 4 insectaria with temperatures of 21, 25, 28, and 30 C respectively and with the relative humidity of 80 %.

About 30 females and 30 males were kept with 2 % sugar solution for 3 to 6 days after emergence in a cage of 20 X 20 X 30 cm, in which they easily copulated. Females of *quinquefasciatus* were given a mouse for one night at the same temperature. Each autogenous female of *molestus* and fed female of *quinquefasciatus* was placed individually into a small plastic bottle, containing 30 ml tap water, in which each mosquito was allowed to lay eggs.

After most of the females had finished their oviposition, the hatching rates of eggs and the developmental states of unhatched eggs in egg-rafts laid by the fertilized females of *molestus* and *quinquefasciatus* were examined. Besides these observations, follicular development was examined in the females which did not deposit any eggs.

RESULTS

1. Oviposition rates of unfed females and hatchabilities of eggs in *molestus* at various temperatures

Table 1 shows the rates of *molestus* females which autogenously laid eggs at various temperatures.

At temperatures from 21 to 28 C, most of the females laid eggs, however, at the higher temperature of 30 C, the rate of ovipositing females decreased markedly, and when the females without oviposition activity at 30 C were dissected, about a half of them

Table 1. Rates of ovipositing females* of *Culex pipiens molestus* which were reared from the 1st instar larvae at various temperatures

Temp. (C)	Rate of ovipositing females		
	No. of females (A)	No. ovipositing females (B)	Rate (B/A X 100)
21	30	30	100.0
25	30	30	100.0
28	30	29	96.7
30	92	29	31.5

*Females were allowed to lay eggs without blood feeding.

did not have mature eggs. Therefore, the fall of this rate at 30 C is considered to have been caused mainly by the increase of females of which eggs did not mature,

Hatching rates of eggs in egg-rafts at various temperatures in the experiments in Table 1 were examined, and the developmental state of embryos in unhatched eggs was observed. These results are shown in Table 2.

At 21 and 25 C, most of eggs hatched, however, at 28 and 30 C, hatching rates of eggs became lower, as temperatures rose higher. At 30 C, it was found that most of the unhatched eggs did not contain any embryos, however, the reasons for this phenomenon are unknown to us.

2. Oviposition rates of fed females and hatchabilities of eggs in *quinquefasciatus* at various temperatures

Oviposition rates of the fed females of *quinquefasciatus* at various temperatures were observed and these results are shown in Table 3. Most of the females deposited egg-rafts regardless of the rearing temperature.

Hatching rates of eggs laid by the fertilized females of *quinquefasciatus* at various

Table 2. Hatching of the eggs produced by the fertilized females of *Culex pipiens molestus* which were reared from the 1st instar larvae at various temperatures

Temp. (C)	No. egg-rafts examined	Total no. eggs (A)	Hatched eggs		Unhatched eggs			
			No. (B)	(B/A X 100) %	No. with embryo (C)	(C/A X 100) %	No. without embryo (D)	(D/A X 100) %
21	30	3472	2849	82.1	204	5.9	419	12.1
25	30	3314	3088	93.2	66	2.0	160	4.8
28	26	1714	849	49.5	273	15.9	592	34.5
30	23	983	73	7.4	95	9.7	815	82.9

temperatures in Table 3 were examined, and the results are indicated in Table 4. From this table, it is clear that eggs usually hatched at any temperatures.

From these results mentioned above, it will be said that oviposition and egg-hatching in *quinquefasciatus* are scarcely influenced by high temperature, such as 30 C, however, in *molestus*, high temperatures have damaging effects on follicular development and oviposition as well as egg-hatching.

Table 3. Oviposition rates of the fed females of *Culex pipiens quinquefasciatus* which were reared from the 1st instar larvae at various temperatures and allowed to feed on a mouse

Temp. (C)	Oviposition rate		
	No. fed females (A)	No. females laid eggs (B)	Rate (B/A X 100)
21	21	21	100.0
25	27	26	96.3
28	—	—	—
30	20	18	90.0

Table 4. Hatching of eggs produced by the fertilized females of *Culex pipiens quinquefasciatus* which were reared from the 1st instar larvae at various temperatures and allowed to feed on a mouse

Temp. (C)	No. egg-rafts examined	Total no. eggs (A)	Hatched eggs		Unhatched eggs			
			No. (B)	(B/A X 100) %	No. with embryo (C)	(C/A X 100) %	No. without embryo (D)	(D/A X 100) %
21	21	5802	5565	95.9	35	0.6	202	3.5
25	25	7081	6158	87.0	97	1.6	826	11.7
28	—	—	—	—	—	—	—	—
30	16	3837	3620	94.3	68	1.8	149	3.9

DISCUSSION

These results showed that the autogenous females of *molestus* oviposited at a moderate rate and the eggs hatched at a low rate when females were bred from the 1st instar larvae at 30 C. Similar results on the rate of the autogenous females with oviposition were obtained by Ikuzawa (1955). On the other hand, Dobrotworsky (1954) reported that at 31 C the autogeny rate of *molestus* was very high and the hatching rate of eggs was medium, and Sasa et al. (1967) showed the results that at 30 C rates of autogeny and

egg-hatching were very high. Their results were obtained with the females of *molestus* that were exposed to high temperatures of 31 C or 30 C after emergence. The disagreement between our results and those by Dobrotowsky (1954) and Sasa et al. (1967) may be due to the difference in the period of exposure to high temperatures in the developmental stages of *molestus*, and to the difference in strains of *molestus* used, however, further examinations are needed to find the reason for this marked difference.

In *molestus*, it is reported that the numbers of egg-rafts and larvae in the above-ground water are found to be large in spring and autumn, but in summer they decrease (Oda and Ueda, 1979; Yonemoto, 1971). The decrease of immature populations in summer may have a relation with inhibition of oviposition activity and egg-hatching at high temperatures in this season.

In the present experiment, oviposition rates of females and hatchabilities of eggs in *quinquefasciatus* were very high even at the high temperature of 30 C. Ikeshoji (1965) reported with this mosquito that eggs hatched at high rates in both rainy and dry seasons in Burma. This is consistent with our experimental results.

From the facts mentioned above, it will be concluded that follicular development and oviposition as well as egg-hatching in *molestus* are more strongly inhibited by high temperatures than in *quinquefasciatus*, and that high temperatures may be at least one of the factors inhibiting the mosquito of *molestus* to invade the southern parts of Japan.

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チカイエカとネッタイエカの産卵と卵の孵化に及ぼす温度の影響

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我国においてアカイエカ群の一員であるチカイエカは鹿児島以北に分布しているが、沖縄のようなより南の地方では未だ発見されておらず、そこには同じアカイエカ群のもう一つの構成員であるネッタイエカが棲息している。チカイエカの分布要因を明らかにするための研究の一環として、これらの蚊について1令幼虫から種々の温度下で飼育羽化させた雌に産卵させて、産卵雌率と受精した雌から生まれた卵の孵化率を調べた。チカイエカでは温度が30°Cの高温になると、無吸血状態の雌の産卵率が低下し、卵の孵化率も著しく減少した。これに対してネッタイエカの場合は30°C下でも吸血した雌は高率に産卵し、卵の孵化率も高かった。したがって高温はチカイエカの沖縄のような南の地方への侵入を抑制する要因の一つとなりうると思われる。

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