The Gonotrophic Cycle of *Aedes albopictus* in the Field

Akio MORI and Yoshito WADA

Department of Medical Zoology, Nagasaki University School of Medicine, Nagasaki, Japan

Abstract: The gonotrophic cycle of *Aedes albopictus* was studied in the field with the average temperature of 25°C using the mark-release-recapture method. From the result, it was made clear that the period from the emergence to the first feeding of *Ae. albopictus* was about 2 days and the duration of one gonotrophic cycle was about 5 days under this condition. These are in agreement with the results by the laboratory experiment.

The adult of *Aedes albopictus* lives in such a place as the thicket or the bamboo grove and is known as a vector of dengue fever in Southeast Asia and of the dog heartworm in Japan. The determination of the duration of a gonotrophic cycle in *Ae. albopictus* is necessary to estimate the survival rate of adult females or to study the epidemiology of the diseases transmitted by this species. To make clear the duration of a gonotrophic cycle of *Ae. albopictus* in nature, the mark-release-recapture experiment was carried out using laboratory-reared adults.

MATERIAL AND METHOD

Three different physiological groups of adult *Aedes albopictus* which had been bred under the condition of 25°C with 16 hours daylength were released at 3 : 00 PM on September 26, 1975. The number of released mosquitoes, their physiological conditions and the dyes used for the mark are given in Table 1. Group A consisted of 3000 females and 2100 males which had emerged one day before the release, Group B 2400 females and 500 males which had emerged on the day of release, and Group C 1170 females which had emerged a few days before and engorged with blood of a chiken from 9 : 00 to 11 : 00 AM on the day of release. The marking of mosquitoes was made 2 hours before the release by spraying three different kinds of fluorescent dye, so as to distinguish the groups. Just before the release, all mosquitoes sampled from each group were confirmed to be well marked with dyes.

The releasing point was in an about 50m square clump of trees, in which there were some glass bottles and bamboo vases suitable for oviposition. A few dog were chained near the margin of this thicket and were a souce for blood feeding of mosquitoes.

Recapture catches were made every day from September 27 to October 13. Two collectors

Contribution No. 226 from the Department of Medical Zoology, Nagasaki University School of Medicine
Received for publication, June 18, 1977

at a distance of 10m caught females just feeding on them and males swarming around, using a small net and a suction tube from 1:00 to 1:30 PM each day. The temperature and weather during the experiment are given in Table 2.

Collected mosquitoes were placed on filter paper and a drop of 70% ethyl alcohol was put on each mosquito. These mosquitoes were examined for the mark with the aid of the fluorescent detection light. The marked females were dissected for determining the physiological age.

Table 1. Females and males of *Aedes albopictus* released around 3 PM, September 26, 1975

Group	Date of emergence	No. released		Mark
		Females	Males	
A	September 25	3000	2100	0.5 % Blue AFX 0.9 % Whitex BB
B	September 26	2400	500	0.5 % Rohdamine B 0.9 % Whitex BB
C	September 21–22	1170*	0	0.5 % Yellow 8 G 0.9 % Whitex BB

* Engorged with blood of a chicken from 9 to 11 AM on September 26.

Table 2. Temperature and weather during the experiment, 1975

Date	Days after release	Air temperature °C			Weather	
		Mean	Max.	Min.	6 AM – 6 PM	6 PM – 6 AM (of the following day)
September 26	0	25.5	28.5	23.9	Cloudy, occasional rain	Cloudy, occasional rain
27	1	23.8	25.8	22.9	Cloudy, occasional rain	Cloudy, occasional rain
28	2	24.6	28.9	22.0	Cloudy	Cloudy, occasional rain
29	3	24.3	27.9	22.5	Cloudy	Cloudy
30	4	24.2	28.1	21.8	Cloudy	Cloudy
October 1	5	24.9	29.9	20.6	Cloudy	Cloudy
2	6	25.8	30.1	22.1	Cloudy	Rain
3	7	25.5	28.9	22.4	Intermittent heavy rain	Cloudy
4	8	24.8	27.9	21.8	Cloudy, occasional rain	Cloudy
5	9	23.4	26.0	19.2	Cloudy	Cloudy
6	10	22.0	26.6	17.1	Clear	Cloudy, occasional rain
7	11	22.3	27.8	19.8	Heavy rain	Cloudy, occasional rain
8	12	20.1	23.0	15.3	Clear	Cloudy
9	13	18.4	23.8	13.7	Clear	Cloudy
10	14	19.6	25.7	14.9	Clear	Cloudy
11	15	22.2	25.2	17.5	Cloudy, brief rain	Heavy rain
12	16	21.0	24.1	18.3	Rain	Rain
13	17	19.8	22.4	18.5	Rain	Cloudy, occasional rain

Obtained from the Nagasaki Marine Observatory.

RESULTS

The numbers of females and males collected during 15 days after release are given in Table 3. One day after the release, about one third of released females of Group A were recaptured. This shows that the majority of the females of this group fed on animals 2 days after emergence, because this group had been kept for 1 day in the laboratory from emergence to release. In Group B, the females were recaptured from 1 day after release, but the average time of recapture was 2 days after release. The number of recaptured mosquitoes in these two groups decreased rapidly from day to day after the release. This quick decrease was due to the removal of recaptured mosquitoes and to the natural mortality, and also because the females which had succeeded to feed on blood were usually not attracted until oviposition.

The recapture rates of females were different among the groups. It seems that this difference was due to the different physiological states as to feeding at time of release, because the recapture rates of males were not different among the groups. More non-marked females and males were collected 1 day after release than in the following days. This may be because some released mosquitoes were discolored and not detected as marked.

The physiological ages of recaptured females were given in Table 4. Though only a part of the females recaptured during 2 days after release were examined, all of them were nulliparous. All recaptured 3 days after release were nulliparous, too. Nine females recaptured during 2 days after release in Group C were identified as nulliparous, because they still had old blood. Uni-parous females were recaptured from 4 to 10 days after in Group A, and from 5 to 10 days

Table 3. Number of females (and males) of *Aedes albopictus* collected

Days after release	Total No. collected	Group A	Group B	Group C	Without mark
1	1180 (608)	921 (463)	189 (55)	9	61 (90)
2	391 (93)	162 (64)	209 (20)	3	17 (9)
3	148 (27)	29 (19)	86 (4)	2	31 (7)
4	51 (55)	7 (33)	15 (13)	11	18 (9)
5	42 (69)	5 (25)	10 (16)	4	23 (28)
6	42 (24)	9 (8)	10 (6)	2	21 (10)
7	17 (10)	4 (4)	(1)		13 (5)
8	9 (10)	1 (2)	1	1	6 (8)
9	5			1	4
10	14 (10)	3 (2)	4 (3)		7 (5)
11	*				
12	2 (3)	(1)	(1)		2 (1)
13	2 (1)				2 (1)
14	6 (1)				6 (1)
15	9 (3)	1			8 (3)
Total	1918 (914)	1142 (618)	524 (119)	33	219 (177)
% to No. released		38.1(29.4)	21.8(23.8)	2.8	

* Could not be collected due to heavy rain.

after in Group B. The number of 1-parous females caught were largest 6 days after release in both groups. Uni-parous females in Group C were caught from 3 to 8 days after release and the peak of the recapture of this physiological age group was observed 4 days after release. Ten days after release, 1-parouse females with old blood were found in Group A and B. One 2-parous female was caught 10 days after the release and another one 15 days after in Group A (the latter could not be exactly determined, and may have been 3-parous), and one 2-parous females in Group C was caught 9 days after release.

Table 5 summarizes from Table 4 the range, peak and mean of days from the release to the recapture of each age group females. Table 6 shows the periods from the emergence

Table 4. Physiological age of *Aedes albopictus* females recaptured

Days after release	Group A				Group B			Group C			
	No. examined	0-par.	1-par.	2-par.	No. examined	0-par.	1-par.	No. examined	0-par.	1-par.	2-par.
1	37[a]	37			11[a]	11		8[d]	8		
2	19[a]	19			11[a]	11		1[d]	1		
3	29	29			86	86		2		2	
4	7	5	2		15	15		11		11	
5	5	1	4		10	6	4	4		4	
6	9	1	8		10	3	7	2		2	
7	4		4								
8	1		1		1		1	1		1	
9								1			1
10	3		2[b]	1	4		4[b]				
11											
12											
13											
14											
15	1			1[c]							

a) A part of the females collected were examined.
b) One female had old blood.
c) Considered 2-parous, but may be 3-parous.
d) Not dissected, but considered nulliparous due to old blood.

Table 5. Days from release to recapture of each age-group of *Aedes albopictus*

Group		0 - par.	1 - par.	2 - par.
A	range	1 - 6	4 - 10	10 - 15
	peak	1	6	-
	mean	1.22	6.29	12.50
B	range	1 - 6	5 - 10	
	peak	2	6	
	mean	1.92	6.88	
C	range		3 - 8	9
	peak		4	9
	mean		4.50	9.00

Table 6. Mean duration in days of a gonotrophic cycle of *Aedes albopictus*

Group	From emergence to lst feeding	From lst feeding to 2nd feeding	From 2nd feeding to 3rd feeding
A	2.2*	5.1	6.2
B	1.9	5.0	
C		4.5	4.5
Mean	2.1	4.9	5.4

* One day was added to the figure of Table 5 ; see text for further explanation.

to the first feeding and between successive feedings, calculated from Table 5. The period from the emergence to the first feeding of Group A is added by one day for which the mosquitoes were kept in the laboratry before release. From this table, it is seen that the emergence to the first feeding was 2.1 days, the first to the second feeding was 4.9 days and the second to the third was 5.4 days. Therefore, it may be said that the majority of females take the first blood meal 2 days after the emergence and the mean duration of a gonotrophic cycle is about 5 days in the season of the present experiment.

DISCUSSION

The results of dissection of *Ae. albopictus* collected by a man-biting catch in another experiment show that about a half of the parous females had normal-sized dilatations and a remaining half had sac-like or shrinking ovarioles. Shrinking ovarioles were found in *Anopheles gambiae* (Gillies and Wilkes, 1965), *An. sinensis* (Taketomi, 1967) and *Culex tritaeniorhynchus* (Kawai, 1969). But the speed of shrinking of ovarioles after oviposition is different in species, e.g., in a considerable proportion is *An. sinensis* the shrinking dose not complete even 4 days after oviposition, while the majority of *Cx. tritaeniorhynchus* have normal-sized dilatations in all ovarioles by 24 hours after oviposition. In the case of *Ae. albopictus*, the shrinking of ovarioles finishes within 24 hours, therefore at least about a half of females seem to feed again within 24 hours after oviposition. This indicates that probably there are great feeding chances for *Ae. albopictus* in the field.

Davidson (1955) said that the duration of a gonotrophic cycle was one of essentials for culculating the survival rate of adult mosquitoes. For calculating the survival rate, the duration of the cycle must be obtained in the field, but only a few observations have been done. They are with *An. gambiae* in Tanzania (Gillies and Wilkes, 1965), *Ae. aegypti* in Bangkok (Pant and Yasuno, 1970) and *Cx. fatigans* in Ceylon (Samarawickrema, 1967) and in India (Singh and Yasuno, 1972). The duration of gonotrophic cycle in these species is generally similar to that under the room condition. From the present data, it was demonstrated that a gonotrophic cycle of *Ae. albopictus* is about 5 days in the field with the average temperature of 25°C. Some authors showed that the period from feeding to oviposition in this species was about 3-5 days at 25-26°C in the laboratory experiment (Matsuzawa and Kitahara, 1966; Gubler and Bhattacharya, 1971 ; Hien, 1976). Considering the necessity of a few time from oviposition to the next feeding, the present result is in agreement with these results.

Therefore, it seems that the duration of a gonotrophic cycle obtained from the laboratory experiment can usually be used to calculate the survival rate of mosquitoes.

Gubler and Bhattacharya (1971) reported that some *Ae. albopictus* required two blood meals for one oviposition, and the same phenomenon was recognized in the present data under the field condition. However, it occurs in a very low rate, therefore the duration of a gonotrophic cycle can be calculated in disregard of this phenomenon, as in the pesent paper.

ACKNOWLEDGEMENT

The authors are indebted to Mr. J. P. Joshi of WHO/VRCRU-Subunit, Semarang, Indonesia for his kind help in the field work.

REFERENCES

1) Davidson, G. (1955) : Further studies on the basic factor concerned in the transmission of malaria. Trans. roy. Soc. trop. Med. Hyg., 49, 339-350.
2) Gillies, M. T., & Wilkes, T. J. (1965) : A study of the age-composition of populations of *Anopheles gambiae* Giles and *A. funestus* Giles in north-eastern Tanzania. Bull. ent. Res., 56, 237-262.
3) Gubler, D. J. & Bhattacharya, N. C. (1971) : Observation on the reproductive history of *Aedes (Stegomyia) albopictus* in the laboratory. Mosquito News, 31 (3), 356-359.
4) Hien, D. S. (1976) : Biology of *Aedes aegypti* (L., 1762) and *Aedes albopictus* (Skuse, 1895) (*Diptera, Culicidae*). V. The gonotrophic cycle and oviposition. Acta Parasitol. Pol., 24 (6), 37-55.
5) Kawai, S. (1969) : Studies on the follicular development and feeding activity of the females of *Culex tritaeniorynchus* with special reference to those in autumn. Trop. Med. 11 (3), 145-169.
6) Matsuzawa, H. & Kitahara, N. (1966) : Some knowledge on the biology of *Aedes albopictus* Skuse. Jap. J. Sanit. Zool., 17 (4), 232-235 (In Japanese with English summary).
7) Pant, C. P. & Yasuno, M. (1970) : Field studies on the gonotrophic cycle of *Aedes aegypti* the vector of dengue haemorrhagic fever in Bangkok, Thailand. WHO/VBC 70. 242.
8) Samarawickrema, W. A. (1967) : A study of the age-composition of natural populations of *Culex pipiens fatigans* Wiedemann in relation to the transmission of filariasis due to *Wuchereria bancrofti* (Cobbold) in Ceylon. Bull. Wld Hlth Org., 37, 117-137.
9) Singh, N. & Yasuno, M. (1972) : The gonotrophic cycle of *Culex pipiens fatigans* in nature. WHO/VBC 72. 380.
10) Taketomi, M. (1967): Ovariole and age change in *Anopheles sinensis* Wiedmann, with special reference to the relation to temperature and season. Endem. Dis. Bull. Nagasaki Univ., 8 (4), 170-190.

野外におけるヒトスジシマカの gonotrophic cycle

森　章夫，和田義人（長崎大学医学部医動物学教室）

記号放逐法を用いてヒトスジシマカの gonotrophic cycle を平均 25°C の野外で観察した．その結果，この条件下ではヒトスジシマカの羽化から第1回の吸血までは約2日，1回の gonotrophic cycle は約5日であることが明らかとなった．これは室内実験の結果と一致しているので，本種の生存率を計算するとき，室内実験で得られた gonotrophic cycle の期間を野外の gonotrophic cycle の期間の代りに用いても差しつかえないと思われる．

熱帯医学　第19巻　第3・4号　141－146頁，1977年12月