Frequency of Actual Mosquito Attacks during the Summer Season in Central Japan: a Monitored Investigation.

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Abstract: Weekly records of mosquito attacks in the usual life of voluntary monitors were analyzed to evaluate the realistic frequency of mosquito attacks. *Culex pipiens pallens, Cx. tritaeniorhynchus,* and *Aedes albopictus* were equally incriminatory species. The male monitors who engaged in outdoor activities such as cleaning, repairing and gardening experienced more attacks than the others whose main outdoor activities were shopping, strolling and visiting other places. More attacks were reported from June to August than in other months, and the number of attacks per man-day was consistently around 0.3 during this period, although the predominant species shifted from *Cx. pipiens pallens* to *Cx. tritaeniothynchus* and *Ae. albopictus.* The attacks were most frequent at dusk. Seasonal change in the density examined by UV-light trap did not always reflect the seasonal tendency of attacks.

Key words: mosquito attack record, monitored investigation

INTRODUCTION

Analyzing records of attacks or bites by mosquitoes on human is a good measure to evaluate the mosquito problem in every day life, because the severity of mosquito attacks is not only a main concern of the people who live in a given community but also one of key parameters in epidemiology of mosquito-borne diseases. Human bait collection has been the most popular measure so far, but still has limitations in representing the actual risk of mosquito bites, because data are usually obtained by examiners who sit continuously and are solely engaged in collecting mosquitoes at a certain fixed point without performing normal activities. Another approach has been made through questionnaires and/or interview to residents. In this way, Hatch *et al.* (1973), Robinson and Atkins (1983), and John *et al.* (1987) successfully evaluated the mosquito-related problems in large-scale societies in the USA. This method was also adopted by Kanjanapan (1983) and Butraporn *et al.* (1986) in epidemiological surveys of malaria in Thailand. The third approach was made by Reuben and Panicker (1979) in India. They collected mosquitoes from villagers who behaved freely, and confirmed differences in the risk for the mosquito bites in relation to their daily mode of behavior.

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The author fortunately met seven volunteers, all of whom had a good background of knowledge about mosquitoes, and who agreed to report all attacks by mosquitoes in their daily lives using diary-like timetables of activities during a summer season. To analyze the weekly reports made by those volunteers and to evaluate rough but real situation of mosquito attacks in daily life of civil people in Central Japan are main objectives of this report.

Materials and Methods

A total of seven monitors were selected. An hourly timetable was distributed to the monitors, and they were asked to fill one out every day and to submit it to the author weekly. The information to be recorded on the sheet included: in what activity they were engaged at what time and place (indoor or outdoor), the type of clothing (long or short sleeves, long or short pants, etc.), whether or not doors and glass or mesh windows were open, and the time and frequency of mosquito attacks. Mosquitoes that attacked the monitors were hand-caught as far as that was possible, and submitted to the author for identification. Number of attacks was counted as a total number of mosquitoes caught plus mosquitoes escaped and flied away from monitors before or after bithng. Therefore some double counting is inevitable if a mosquito, which attacked a monitor and flied away once, attacked the monitor again after a while.

Four 6W UV-light traps with a suction fan were operated every night from 18 : 30 for 12 hours under the roof of the premises of two monitors (MS and YS) and outside of an office building where four monitors (MS, YS, KT and SR) routinely worked in the daytime. Samples collected by these light traps were taken back to identify the species, and to examine whether they were engorged or not.

The survey was made in Tsu City, located in the central part of Japan, from May to September, 1980. The premises of MS, YS, and KY and KN were located just outside of the suburbs where dwellings were rather scattered in a paddy area, and were surrounded small private yards with storehouses and garages. The house of MS was neighbored by KY and KN. The other two monitors, KT and SR, lived on the second and the fifth floors of flats situated in the suburban area. The office building, in which MS, YS, KT and SR were worked, was located at the north end of the urban area, approximately 300 m away from the nearest rice field, 300 m from the seashore, and sparsely surrounded by any other concrete buidings.

Results and Discussion

Lifestyle of the monitors

The main everyday activities of the monitors are illustrated in Table 1. Among the seven monitors, MS, YS, KT and SR mainly spent their time at two places, at the office or at their premises, while the other three, KY, KN and MY, usually stayed and worked at home whole day. The usual sleeping and waking schedules in descending order from the

Table 1. Variety and frequency of daily activities of monitors.

Monitor	Age	Sex	Activity								
			Sleeping		Cleaning & repairing outside, gardening etc.			Shopping, strolling, visit neibors etc.			Miscellaneous
			Time(from)	(to)	Time(from)	(to)	Frequency	Time(from)	(to)	Frequency	
KY	70	m	20:00–22:00	4:00– 6:00	6:00– 7:00 15:00–16:00	10:00–11:00 18:00–19:00	nearly every days	10:00	12:00	rarely	fishing once/4.4days
MS	35	m	0:00– 2:00	8:00– 8:30	18:00–19:00	20:00–22:00	once/4.8days	15:00	19:00	rarely	fishing once/15.0days
YS	37	m	22:00– 0:00	7:00– 8:00	13:00–13:00 17:00–18:00	15:00–16:00 19:00–19:30	once/5.1days	10:00–11:00 13:00	11:00–12:00 16:00	once/6.5days	
SR	55	m	22:00–23:00	5:00– 7:00	5:00– 6:00 9:00–11:00	6:30– 7:30 12:00–17:00	once/3.8days	no report			
KT	35	m	22:00–23:00	6:30– 7:30	10:00	12:00	once/23.8days	10:00	12:00	once/4.0days	fishing once/21.0days
KN	65	f	20:00–22:00	4:00– 6:00	6:00– 7:00	10:00–11:00	rarely	10:00	11:30	nearly every days	
MY	63	f	23:00– 0:00	7:00– 8:00	9:00 17:00	10:00 18:00	rarely	14:00	17:00	occasionally	

MS, YS, SR and KT worked in an office in the day time.
If an activity was interrupted for several hours and then continued, it was counted twice even if it was performed in one day.

earliest were for KY and KN, followed by SR, KT, and YS, and then by MY and MS.

During the daytime, long sleeve shirts were changed to short sleeves in the beginning of June by all monitors irrespecitive of sex, and after late June, almost of all the male monitors were shorts instead of long pants after their business hours when they relaxed in their homes.

Mesh windows were furnished in all premises of monitors from early June, although a mosquqito net was not used. Until that time, the glass windows were usually closed even during the daytime. The status of the windows was recorded in detail for only two premises (MS, and KY and KN). After installation of the mesh windows, these were usually shut at dusk (around 19 : 00), and the glass windows were also shut before midnight. Both windows were fully opened in the daytime unless it rained. This pattern of window use continued until late September when the monitoring was terminated. Air-conditioners in the premises were operated just occasionally.

Mosquito coils were used by all monitors almost every night from early July. The last record of using mosquito coils in that year was on August 24 in KS/KN's premises and on September 12 in MS's premises. Spray-type insecticides were also available to all monitors, but were seldom used.

Attacks by mosquitoes

The number and the seasonal tendency of attacks by mosquitoes are summarized in Table 2. A total of 204 attacks was recorded by seven monitors during the study period, and the average attack density (the average number of attacks per man per day) was 0.216, or more than one bite every five days. However, the attack density differed greatly from

Table 2. Half-monthly total of attacks by mosquitoes on monitors

Monitor	Month										Total	No. bites /man•day
	May(f)	May(l)	Jun(f)	Jun(l)	Jul(f)	Jul(l)	Aug(f)	Aug(l)	Sep(f)	Sep(l)		
MS	0	2	19	21	20	16	14	11	6	1	110	0.733
YS	0	3	9	8	7	6	—	—	—	—	33	0.367
SR	0	3	1	2	6	0	—	—	—	—	12	0.133
KT	0	1	0	0	0	1	2	0	0	0	4	0.027
KS	0	0	2	1	5	10	6	12	4	0	40	0.267
KN	0	0	1	0	1	0	0	1	0	0	3	0.020
MY	0	0	0	0	0	2	0	0	0	0	2	0.013
Total	0	9	32	32	39	35	22	24	10	1	204	1.560
No. bites /man•day	0.000	0.086	0.305	0.305	0.371	0.333	0.293	0.320	0.133	0.013	1.943	0.216

(f): the first half of a month, (l): the latter half of a month.

monitor to monitor. The attack density for MS (0.733), who was attacked the most frequently, was more than 56 times that of MY, who was attacked the least frequently (0.013), even though they lived in the same premises. One of reasons for the high attack density for MS was that he was freqently attacked outdoors during gardening and cleaning for a long period. As shown in Table 1, he spent from 1.5 to 4.0 hours (average, 2.3 hours) on these activities once every 4.8 days, mainly in the evening, throughout the monitoring period. This tendency is strongly confirmed by the fact that KY, who experienced the third highest attack density, also spent much time outdoors. He engaged in gardening and/or cleaning and repairing a house for 3 or 4 hour almost every day in the early morning, and returned to these activities for another 3 or 4 hours in late afternoon. The same situation was true for YS and SR in whom the attack densities were 0.367 and 0.133, respectively; YS engaged in gardening and/or cleaning for 2.2 hours, mainly in the afternoon, once every 5.1 days, while SR participated in these activities for 5.0 hours in the morning once in every 3.8 days.

On the other hand, KT and two female monitors (KN and MY) were only occasionally attacked by mosquitoes. They did not spend much time in gardening, cleaning, or repairing. Their main outdoor activities consisted of shopping, strolling and visiting neighbors, all of which were less risky in terms of mosquito attack.

The seasonal trend of the attack density was analyzed on a half-monthly basis. During the first half of May, no monitor experienced any attacks. However, by the end of this month, four of the seven monitors reported the first attack of the year. The first attacks happened on May 19 for MS, on May 25 for YS, on May 30 for KT, and on May 31 for SR. A total of 9 attacks were recorded in the latter half of May. During the following 3 months, June, July and August, the attack density was prominently higher than in other periods. Thus, the densities from June to August were continuously over 0.3 per man per day. The highest attack density of 0.371 per man per day was recorded in the first half of July. These results suggest that people in this area will be attacked by a mosquito at least once every 3 days during these periods. The attack density quickly decreased in September, and ended toward the end of that month.

Among the 204 recorded attacks, 112 undamaged mosquitoes were identified to the species. The results are illustrated in Table 3. Seven species, namely *Culex pipiens pallens, Cx. tritaeniorhynchus, Cx. bitaeniorhynchus, Aedes albopictus, Ae. togoi, Anopheles sinensis,* and *Armigeres subalbatus,* all of which were common species in the area, were collected. As to the species composition, *Cx. p. pallens, Cx. tritaeniorhynchus* and *Ae. albopictus* were predominant in the overall average throughout the season. The attack densities of these 3 species were nearly equal, and more than 90% of all attacks was caused by these three species. Only a few occasional attacks were by other species. For example, all of the four attacks by *Ae. togoi* occurred at local wharves when the monitors were enjoying fishing.

Although the attack densities of the above 3 species were nearly equal in the overall seasonal average, their seasonal distribution was clearly different from species to species. As shown in Table 3, *Cx. p. pallens* was solely predominant as an attacker in the first-half of June. However, this species quickly fell off toward July. In turn, *Cx. tritaeniorhynchus*

became the dominant species in the latter-half of June. Then, in the following first-half of July. *Ae. albopictus* accounted for more than 70% of the attacks. From the latter-half of July onward, both *Cx. tritaeniorhynchus* and *Ae. albpictus* accounted for an equal number of the attacks for 1 month, although *Cx. p. pallens* played an equivalent role again in the first-half of August.

Table 3. Seasonal change of the number of mosquitoes that attacked monitors

Species	Month										Total (%)
	May(f)	May(l)	Jun(f)	Jun(l)	Jul(f)	Jul(l)	Aug(f)	Aug(l)	Sep(f)	Sep(l)	
Cx.p.p.	0	1	14	10	1	1	6	2	0	0	35 (31.3)
Cx.tri.	0	1	1	11	5	7	4	0	2	0	31 (27.7)
Cx.bit.	0	0	0	0	0	1	0	0	0	0	1 (0.9)
Ae.alb.	0	3	1	2	19	8	4	0	1	0	38 (33.9)
Ae.tog.	0	0	0	0	0	4	0	0	0	0	4 (3.6)
An.sin.	0	0	0	0	1	0	0	0	0	0	1 (0.9)
Ar.sub.	0	0	0	0	0	0	2	0	0	0	2 (1.8)
total	0	5	16	23	26	21	16	2	3	0	112 (100.0)

(f) : the first half of a month, (l) : the latter half of a month.
Cx.p.p. : *Cx. pipiens pallens, Cx.tri.*: *Cx. tritaeniorhynchus, Cx.bit.* : *Cx. bitaeniorhynchus*
Ae.alb. : *Ae. albopictus, Ae. tog.* : *Ae. togoi, An. sin.* : *An. sinensis, Ar. sub.* : *Ar. subalbatus*

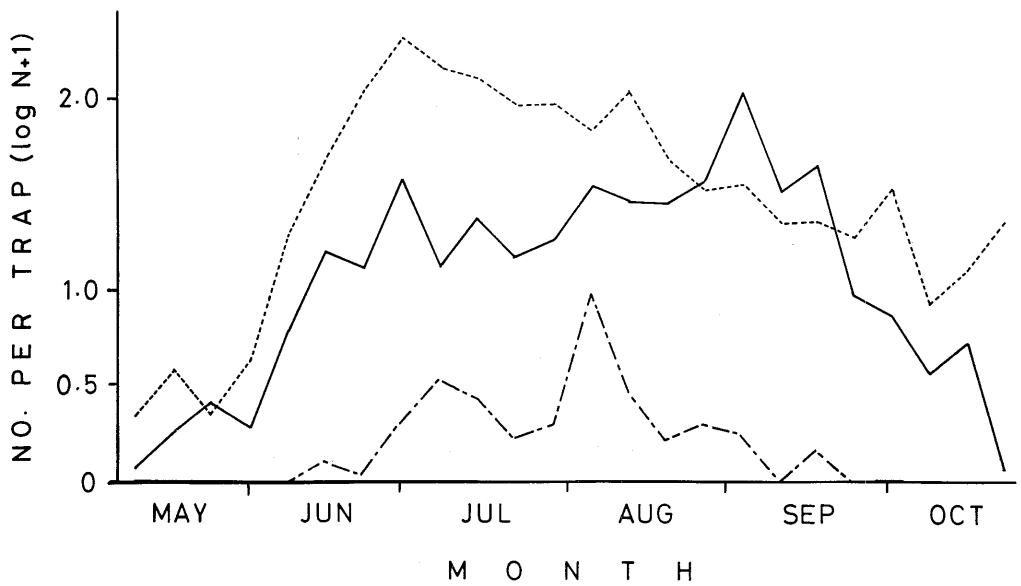

Fig. 1. Seasonal change of the number of females per UV−light trap. Solid line; *Cx. tritaeniorhynchus,* dotted line; *Cx. p. pallens,* and broken line; *An. sinensis.*

Adult collection using four UV-light traps set at 3 stations (the premises of MS and YS, and an office) revealed the seasonal abundance of mosquitoes of night-time biters (Figure 1). Seven species were collected from May 12 to October 18. Among them only *Cx. p. pallens* and *Cx. tritaeniorhynchus* were abundantly collected at every station. *Cx. p. pallens* increased toward the first-half of July, and slowly decreased thereafter. *Cx. tritaeniorhynchus* also increased toward the beginning of July. After reaching a peak in density, the species maintained that level until the end of August, and formed another peak in early September. These seasonal trends were similar for all light traps.

The seasonal trends of *Cx. p. pallens* and *Cx. tritaeniorhynchus* obtained by light traps were compared with the seasonal tendency in attack density. It was found that in *Cx. p. pallens,* the highest frequency of the attacks concided with the increased phase of the light-trapped population during June, and that in *Cx. tritaeniorhynchus,* it coincided with the light-trapped density by the first-half of August, but these conformities were not maintained afterward. The decrease in the proportion of engorged females in the light-trapped population suggested that seasonal changes in the age of the natural population might result in this unconformity.

Table 4 shows the overall average light-trapped densities (number/trap·night), the proportion, and the percentage of 3 species of the blood-fed females collected at 3 stations. The density and the species composition were different from station to station, although the seasonal trends were similar to each other. *Cx. p. pallens* was quite abundant at the premises of MS, and *Cx. tritaeniorhynchus* was rather more at MS and YS. The species compositions were similar to each other in the traps at the office and the premises of MS. The percentage of engorged females at MS was apparently higher than at the other stations, except for *An. sinensis.* These different situation in terms of the prevalence of mosquitoes might cause differences in the frequency of attacks on monitors in such a way that MS and KY, a neighbor of MS, were attacked by more mosquitoes, that more than 94% of all attacks by *Cx. p. pallens* were on MS, that only MS experienced an attack by *An. sinensis,* and that YS was not attacked by mosquitoes other than *Cx. tritaeniorhynchus.* Another likely reason for the higher density and higher proportion of engorged females at the premises of MS was the presence of three dogs which were being reared outside during the study.

The place of attack (outdoor of indoor) is listed in Table 5. Of all the recorded attacks,

Table 4. Number per trap, percentage of engorged, and proportion of 3 night biting mosquitoes caught by UV-light traps

Station	*Cx. tritaeniorhynchus*			*Cx. pipiens pallens*			*An. sinensis*		
	No./trap	% engorged	proportion	No./trap	% engorged	proportion	No./trap	% engorged	proportion
MS	19.6	29.3	26.5	53.6	10.4	72.4	0.8	1.0	1.1
YS	17.3	1.7	67.0	7.5	5.5	29.1	1.0	0.0	3.9
Office	7.3	2.3	32.0	15.1	3.8	66.6	0.3	2.9	1.4

Table 5. Time and place monitors were attacked by mosquitoes

Species	No. of attacks						Attack density per hour and its proportion (%)						Place attacked	
	Dawn	Morning	Afternoon	Dusk	Night	All day	Dawn	Morning	Afternoon	Dusk	Night	All day	Indoor	Outdoor
Cx.p.pal.	0	1	0	1	33	35	0.0 (0.0)	0.1(3.0)	0.0 (0.0)	0.7 (14.2)	4.1 (82.7)	1.5	33	2
Cx.tri.	1	0	1	16	13	31	0.7 (5.1)	0.0(0.0)	0.2 (1.4)	10.7 (81.8)	1.6 (11.7)	1.3	15	16
Cx.bit.	0	0	0	0	1	1	0.0 (0.0)	0.0(0.0)	0.0 (0.0)	0.0 (0.0)	0.1(100.0)	0.0	0	1
Ae.alb.	0	3	21	10	4	38	0.0 (0.0)	0.4(3.8)	3.5 (33.5)	6.7 (58.6)	0.5 (4.1)	1.6	9	29
Ae.tog.	3	1	0	0	0	4	2.0(93.3)	0.1(6.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.2	0	4
An.sin.	0	0	0	1	0	1	0.0 (0.0)	0.0(0.0)	0.0 (0.0)	0.7(100.0)	0.0 (0.0)	0.0	0	1
Ar.sub.	0	0	2	0	0	2	0.0 (0.0)	0.0(0.0)	0.3(100.0)	0.0 (0.0)	0.0 (0.0)	0.1	0	2
not identified	1	13	5	25	48	92	0.7 (2.8)	1.9(5.3)	0.8 (2.6)	16.7 (71.1)	6.0 (18.2)	3.8	46	46
Total	5	18	29	53	99	204	3.3 (5.7)	2.6(4.4)	4.8 (9.1)	26.0 (60.8)	12.4 (20.0)	8.5	1103	101

Cx.p.pal.: Cx.pipiens pallens, Cx.tri.: Cx.tritaeniorhynchus, Cx.bit.: Cx.bitaeniorhynchus, Ae.alb.: Ae.albopictus, Ae.tog.: Ae.togoi, An.sin.: An.sinensis, Ar.sub.: Ar.subalbatus.

50.5% happened indoors. Among the 3 representative species, almost all *Cx. p. pallens* (94.3 %) attacked monitors indoors, while 76.3% of *Ae. albopictus* attacks occurred outdoors, and nearly the same number of female *Cx. tritaeniorhynchus* attacked them indoors and outdoors. This difference might be due to the place where the human hosts were present during the biting time of certain species as well as the species-specific biting habits such as endo- or exo-phagy.

Table 5 also shows the diurnal distribution of the mosquito attacks. The absolute number of attacks was the largest at the night time (19 : 30−3 : 30, 8 hours). Ninety nine attacks, or 48.5% of all attacks, happened during this period. At dusk, from 18 : 00 to 19 : 30, 53 attacks were recorded, and with respect to the severity of these attacks, dusk should be considered as the riskiest time of a day, as all these attacks were concentrated in only 1.5-hour period. The total number of attacks during certain periods of a day was divided by the hourly length of the period in order to evaluate the severity of the attack. The resulting value for dusk was 35.3, while that for night time was 12.4. In period other than these two, dawn (3 : 30−5 : 00), morning (5 : 00−12 : 00) and afternoon (12 : 00−18 : 00), the number of reported attacks was low.

Sixteen *Cx. tritaeniorhynchus* attacks were reported at dusk, and 13 attacks occurred at night. The remaining attacks happened during the dawn and afternoon. With respect to the severity of attack, the calculated values were 10.7, 1.6, 0.7, and 0.2 per hour for the dusk, night, dawn, and afternoon, respectively. Therefore, *Cx. tritaeniorhynchus* must be a dark hours biter with its attack rate being 81.8%, 11.7%, and 5.1%, for the dusk, night, and dawn, respectively. The rate in the afternoon was only 1.4%, and no bites were reported in the morning. *Cx. p. pallens* was also a dark hours biter with a peak of the most annoying attack occurring in the night, not during dusk as in *Cx. tritaeniorhynchus,* because 33 of 35 attacks were recorded during the night, and the rate of attack was 14.2% for dusk and 82.7% for night time. On the other hand, in *Ae. albopictus,* 21 attacks happened in the afternoon for a period of 6 hours, and 10 during for 1.5 hours. The rate was 3.8%, 33.5%, 58.6%, and 4.1% for the morning, afternoon, dusk, and night, respectively. No attacks were experienced at dawn. This species should be classified as a daytime biter with its biting peak occurring at dusk.

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