THE ECOLOGY OF ANOPHELINE MOSQUITOS IN NORTHWEST COASTAL MALAYSIA : HOST PREFERENCES AND BITING-CYCLES

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Abstract. The host preferences of eight species of anophelines were studied in two coastal Malaysian villages, Kampung Permatang Rawa and Sungai Udang Kecil, by seven 12-hour catches in each village. Collections were made concurrently from a human-baited net trap, a cow-baited net trap and by human-bait landing catches. *Anopheles campestris* was attracted almost equally to man and cow, but *An. lesteri paraliae, An. nigerrimus, An. peditaeniatus, An. sinensis, An. indefinitus, An. subpictus* and *An. vagus* showed a strong preference for the cow bait. The human-bait landing catches were more productive than the human-baited net trap, which attracted very few mosquitos. Seven more all-night catches were made at each village employing only the cow-baited trap, and the combined data were used to plot the biting-cycles of each species at each site. Although the biting-cycles at the two localities were in general agreement, there were notable differences. At Sungai Udang Kecil, where the collection site was relatively sheltered, several species showed a steady decline in numbers from sunset to sunrise. At Kampung Permatang Rawa, on the other hand, where the site was more exposed and close to the sea, the same species showed a bimodal pattern of activity with an early evening peak followed by a decline then a period of increased activity before sunrise rising to a second, lesser peak at 0500 - 0600 hours.

INTRODUCTION

In a related paper (Jaal and Macdonald, 1993) the larval habitats and adult seasonal fluctuations of anophelines in two villages in northwest coastal Malaysia, Kampung Permatang Rawa and Sungai Udang Kecil, were described. A study was also made in the villages of the host preferences and biting-cycles of the mosquitos and the results are described here. General descriptions of the areas have been given previously (Jaal and Macdonald, 1992, 1993) and will not be repeated.

MATERIALS AND METHODS

To compare the host preferences of the different species, seven all-night catches were made in each village using three different methods concurrently- the human-baited net trap, the cow-baited net trap and an outdoors bare-leg landing catch. The human-baited trap consisted of a double mosquito net, the large outer net measuring 2.1 m in length, 2 m in width and 1.8 m in height and the small inner net containing a chair or campbed on which the human bait rested. The outer net was raised 0.3 m above the ground to allow mosquitos to enter. At sunset the bait retired and at the end of each hour until sunrise he rose and collected all the mosquitos trapped between the two nets.

The cow-baited trap was a single large net, 2.4 m long, 2.4 m wide and 1.6 m high, raised 0.3 m above the ground. On one side a 1.2 m wide door was opened and closed by zip fasteners. A cow was tethered inside from sunset to sunrise and at the end of each hour three collectors entered the net and collected resting mosquitos.

Both the human-baited and the cow-baited traps had a tarpaulin stretched above the nets to provide protection from rain.

The bare-leg landing catch was organized in the pattern used by Haddow (1954) in Uganda. A team of five collectors was employed, three working and two resting at any given time. Within the group of three, one man acted as mosquito collector and the other two, with their legs bared, served as bait. At the end of each hour one of the baits went off-duty, the collector became a bait, and a previously off-duty collector caught the mosquitos.

Since the period between sunset and sunrise

did not equal 12 hours, it was divided into 12 equal intervals of approximately one hour.

Using all three methods, collections were made between November 1987 and February 1988. Since only the cow-baited trap yielded good numbers of anophelines, a second series of seven 12-hour catches was made at each village during April to July 1989 employing only this trap. The first series provided information on host preferences and both series provided data on the biting-cycles.

The Williams' mean, described by Haddow (1954, 1960), was calculated for each hourly collection of each species and then plotted as a percentage of the total catch of that species.

RESULTS

Host preferences

Table 1 shows the collections during the first series of 12-hour catches at Kampung Permatang Rawa and Sungai Udang Kacil. It is clear that with the exception of *An. campestris,* which showed no clear host preference, all the species collected showed a pronounced preference for the cow. In a comparable study elsewhere in Malaysia Reid (1961) found that *An. campestris* was attracted to man compared with a calf in a ratio of 3.4 : 1. The zoophily of the other species is in agreement with the results of Reid (1953, 1961, 1968) in Malaysia and Harrison and Scanlon (1975) in Thailand. The human-baited net trap was very ineffective in attracting mosquitos.

Biting cycles

Anopheles campestris: Low numbers of *An. campestris* were caught at both sites and the biting-cycles are not in close agreement (Fig 1). At Kampung Permatang Rawa there was irregular activity throughout the night with most biting between 2200 hours and 0200 hours, whereas at Sungai Udang Kecil, where fewer numbers were collected, there was a sharp rise from 2100 hours to 2400 hours then a steady decline to sunrise. Moorhouse and Wharton (1965) recorded an irregular biting pattern with a broad band of increased activity from 2000 hours to 0200 hours and Thevasagayam *et al* (1979) also observed biting throughout the night with an indoor peak at 0200 - 0400 hours and an outdoor peak at 2200 - 2400 hours.

Anopheles lesteri paraliae: Very good numbers of *An.l.paraliae* were collected at Sungai Udang Kecil, but not at Kampung Permatang Rawa. In the former, there was a clear pattern with peak activity in the hour after sunset followed by a steady decline until 2300 hours. Thereafter there was a low level of biting with a slight rise at 0400 - 0600 hours (Fig 2). At Kampung Permatang Rawa the early evening peak was not pronounced and from 2100 hours there was steady activity throughout the night with a slight increase before sunrise. In

Table 1

The numbers of *Anopheles* caught during 14 12-hour catches with alternative baits at Kampung Permatang Rawa (KPR) and Sungai Udang Kecil (SUK).

Species	KPR			SUK		
	HBT	CBT	BLC	HBT	CBT	BLC
An. campestris	0	19	5	3	30	43
An. lesteri paraliae	0	6	0	0	1,624	64
An. nigerrimus	0	4	0	0	85	12
An. peditaeniatus	0	726	1	0	6	0
An. sinensis	0	886	125	0	2,094	151
An. subpictus	0	166	14	0	438	5
An. vagus	0	130	3	0	18	0

HBT - Human-baited trap
CBT - Cow-baited trap
BLC - Bare-leg landing catch

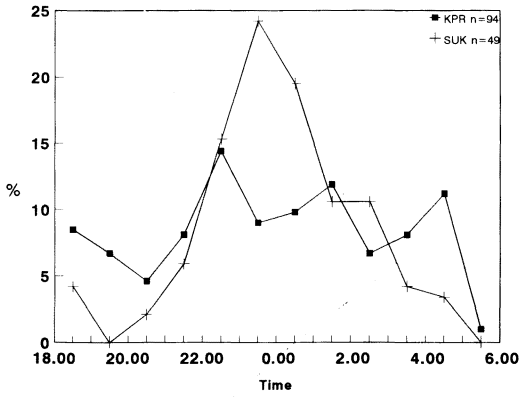

Fig 1—The biting-cycle of *An. campestris* at Kampung Permatang Rawa and Sungai Udang Kecil.

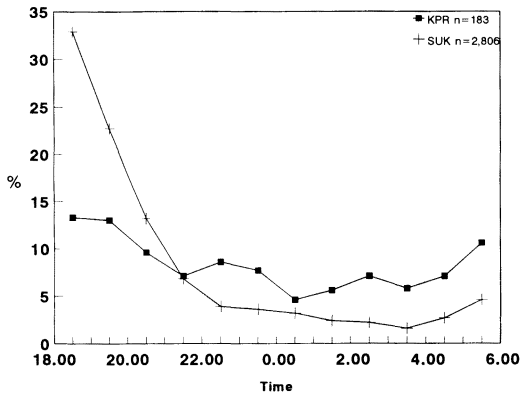

Fig 2—The biting-cycle of *An.l.paraliae* at Kampung Permatang Rawa and Sungai Udang Kecil.

China Ho *et al* (1962) studied *An.l.lesteri,* which preferred man to cattle as a source of blood-meals, and observed most biting in the latter part of the night, whereas in Japan Otsuru and Ohmori (1960) reported that biting was mainly during the hours up to midnight.

Anopheles nigerrimus: The numbers of *An. nigerrimus* collected were not large but the patterns of activity at both sites were broadly similar (Fig 3). There was peak activity during the first two hours of the night followed by lesser, irregular biting throughout the night with a sharp fall in the hour before sunrise. In Pakistan Aslamkhan and Salman (1969) recorded a similar pattern with maximum activity between 1800 - 1900 hours and thereafter minor fluctuations during the rest of the night.

Anopheles peditaeniatus: Low numbers of *An. peditaeniatus* were collected at Sungai Udang Kecil and the biting pattern was irregular, with most activity between 1800 - 2100 hours (Fig 4). At Kampung Permatang Rawa, where numbers were high, there was a bimodal pattern with steady activity during 1800 - 2200 hours, a fall in activity during 2200 - 0200 hours, then a rise during the remainder of the night with a marked peak in the hour before sunrise.

Anopheles sinensis: Although large collections of *An. sinensis* were made at both study sites, the biting patterns were not in good agreement (Fig 5). At Kampung Permatang Rawa there was steady but irregular activity throughout the night, whereas at Sungai Udang Kecil there was high activity from 1800 - 2000 hours then a decline to a reduced but steady level and a sharp drop at 0500 - 0600 hours. Elsewhere in Malaysia Chiang *et al* (1986) recorded peak activity from 1900 to 2100 hours and in China Ho *et al* (1962) also reported most biting activity in the early evening.

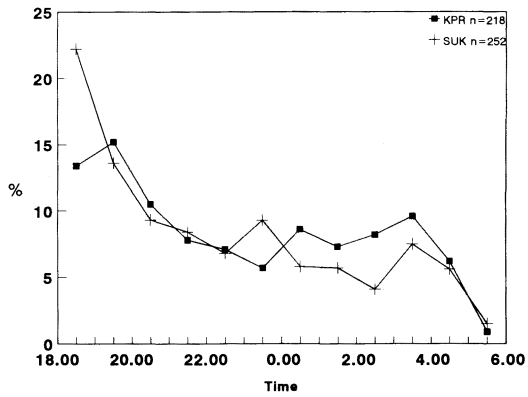

Fig 3—The biting-cycle of *An. nigerrimus* at Kampung Permatang Rawa and Sungai Udang Kecil.

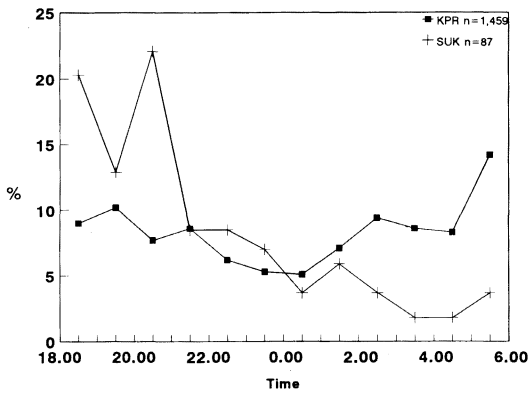

Fig 4—The biting-cycle of *An. peditaeniatus* at Kampung Permatang Rawa and Sungai Udang Kecil.

Anopheles indefinitus: An. indefinitus was most abundant in Sungai Udang Kecil where peak biting was in the hour following sunset. Thereafter there was a steady decline until sunrise (Fig 6). At Kampung Permatang Rawa the pattern was essentially similar except that lowest activity was recorded at 0200 - 0300 hours after which there was an apparent increase in the hours before sunrise. However, the numbers collected were low and the data for Sungai Udang Kecil are more reliable.

Anopheles subpictus: An. subpictus had a very similar biting pattern to that of *An. indefinitus* (Fig 7). At both study sites there was high activity in the hour or two after 1800 hours then a fairly steady decline throughout the night. At Kampung Permatang Rawa, as in the case of *An. indefinitus,* there was a small rise in activity during the three or four hours before sunrise. In Pakistan Reisen and Aslamkhan (1978) recorded that the biting-cycle of *An. subpictus* was usually bimodal, with well-defined peaks during the early evening and before sunrise, but in India Reuben (1971) described a steady increase after sunset for 3 - 4 hours, then a gradual fall until sunrise.

Anopheles vagus: The activity pattern of *An. vagus* (Fig 8) was very similar to those of *An. indefinitus* and *An. subpictus.* Once again, the population at Sungai Udang Kecil fell steadily from the hour after sunset until sunrise, whereas at Kampung Permatang Rawa there was a clear bimodal pattern with peaks in the early evening and before sunrise.

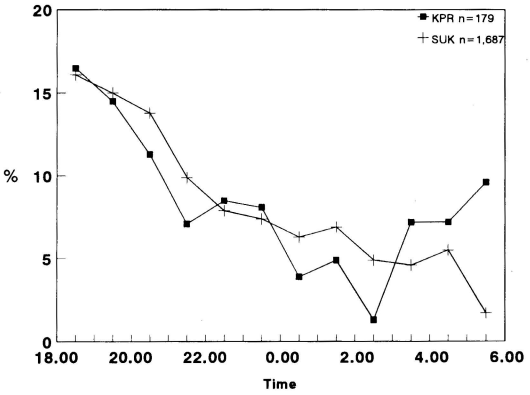

Fig 6—The biting-cycle of *An. indefinitus* at Kampung Permatang Rawa and Sungai Udang Kecil.

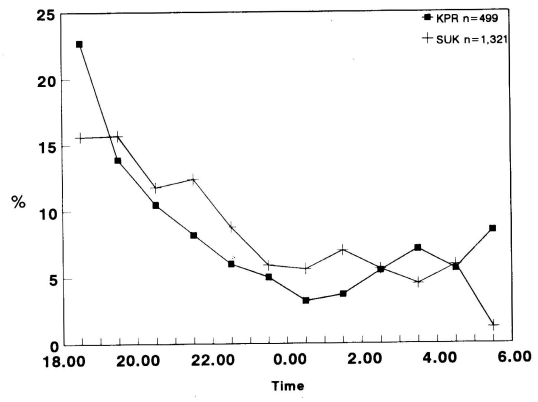

Fig 7—The biting-cycle of *An. subpictus* at Kampung Permatang Rawa and Sungai Udang Kecil.

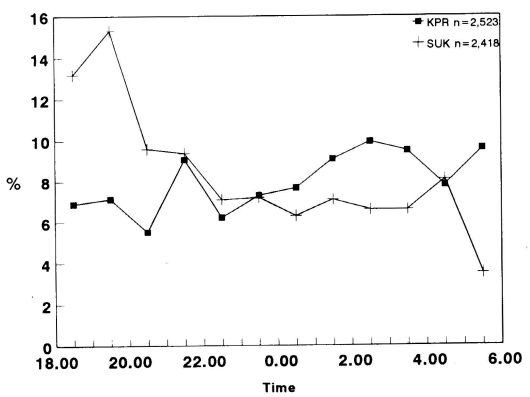

Fig 5—The biting-cycle of *An. sinensis* at Kampung Permatang Rawa and Sungai Udang Kecil.

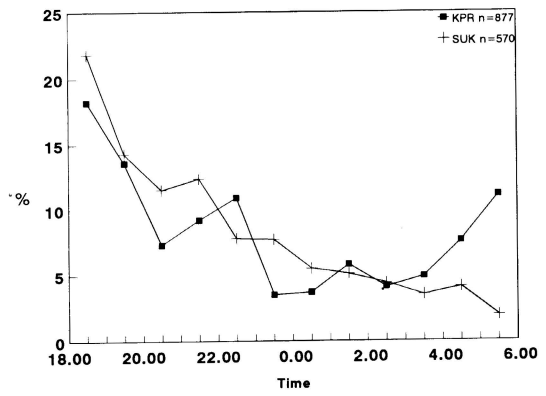

Fig 8—The biting-cycle of *An. vagus* at Kampung Permatang Rawa and Sungai Udang Kecil.

DISCUSSION

There are clearly similarities between the biting-cycles in the two localities of each of the eight species, but there are also notable differences. Some of the differences may be the result of the small sample size in some collections, but others seem to be related to the collection sites. The small samples of *An. campestris* do not allow a final conclusion on the biting pattern. All that can be said is that there is irregular activity throughout the night with a sharp drop after 0500 hours. Because the numbers collected at Sungai Udang Kecil were so low, no great weight can be given to the apparently well-defined cycle. In the case of *An.l.paraliae,* the smooth curve at Sungai Udang Kechil, based on a very large collection, is most likely an accurate representation of the biting-cycle. The moderate numbers of *An. nigerrimus* collected at each site have a broadly similar pattern. Both *An. peditaeniatus* and *An. sinensis* show ill-defined patterns with no consistent peaks of activity. However, at Kampung Permatang Rawa both show more activity during the latter part of the night with a marked increase at 0500 - 0600 hours. In contrast, at Sungai Udang Kecil *An. sinensis* in particular, and *An. peditaeniatus* with much fewer numbers, shows high early evening activity and a marked fall at 0500 - 0600 hours.

The differences between the collection sites in pre-sunrise collections are most marked with *An. indefinitus, An. subpictus* and *An. vagus.* At Sungai Udang Kecil all three species show a more or less steady decline in activity from sunset to sunrise with the lowest numbers being caught at 0500 - 0600 hours. At Kampung Permatang Rawa, on the other hand, each species shows a bimodal pattern with increasing activity during the 3 - 4 hours before sunrise and a peak at 0500 - 0600 hours.

There is no obvious explanation for these differences, but the collection site at Kampung Permatang Rawa was only about 0.5 km from the sea and it was much more exposed than the site at Sungai Udang Kecil, which lay 2-3 km from the coastline and was relatively sheltered by houses and trees. Differences in wind movements may well have influenced the activity patterns of the mosquitos.

ACKNOWLEDGEMENTS

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