BITING ACTIVITY OF MOSQUITOS (DIPTERA: CULICIDAE) AT A MALARIOUS SITE IN PALAWAN, REPUBLIC OF THE PHILIPPINES

George W Schultz
US Naval Medical Research Unit No. 2 Detachment, APO AP 96440, San Lazaro Hospital Compound, Santa Cruz, 1003 Manila, Philippines.

Abstract. Fifty-one species of mosquitos were collected at a malarious site in western Palawan, Philippines. *Anopheles flavirostris,* which is the primary malaria vector, was mildly exophagic and zoophilic, and had a peak biting activity from 0030-0130 hours. *An. balabacensis,* a secondary vector, was endophagic, anthropophilic, and was primarily active between 2000-0030. Of the 3 main genera, *Culex* were the most zoophilic, *Aedes* were the most anthropophilic, and *Anopheles* had species in both extremes. *An. annularis, Ae. vexans,* and *Cx. vishnui* showed similar biting activity patterns during both the rainy or dry seasons.

INTRODUCTION

In the Republic of the Philippines, 5 *Anopheles* species have been recognized as malaria vectors (Catangui, 1985; Catangui *et al,* 1985; Cabrera and Arambulo, 1977). *Anopheles flavirostris* (Ludlow) is considered the primary malaria vector throughout most of the Philippines. It breeds in slightly-shaded, slow-flowing, clear streams. *An. balabacensis* Baisas is a secondary vector found primarily in the forests of Palawan. *An. litoralis* King breeds in brackish water of rock pools and lagoons. Although widely distributed throughout the Philippines, it is classified as a vector only in the southernmost islands. *An. mangyanus* (Banks) was once considered a secondary vector on the island of Mindoro; however, because of ecological disturbances by man, its importance has greatly diminished. *An. maculatus* Theobald has a widespread distribution and is capable of breeding in stagnant streams and ditches.

All 5 of these vectors were present at a malarious site in western Palawan. The objectives of this study were: 1) to determine the primary and secondary vector(s) of malaria, 2) to determine their biting rates, biting activity rhythms, indoor/outdoor feeding pattern, host selection and seasonal abundance, and 3) to compare and contrast their behavioral characteristics with other mosquito species abundantly found at this site.

MATERIALS AND METHODS

Man-biting collections were conducted during 5 trips to the village of Sto Nino, 32 km west of Puerto Princesa, Palawan. The first trip, totaling 12 nights, was from 25 July - 5 August 1987 during the rainy season, and the last 4 trips, totaling 30 nights, occurred on 30 January - 7 February, 17-24 February, 16-23 March and 12-21 April 1988 during the dry season.

Mosquitos attracted to human bait were collected each night by 2 teams of 6 men; team 1 collected from 1800-0000 and team 2 from 0000-0630. Each team of 6 was divided into 2 subgrounds – 1 for indoor collections and the other for outdoor collections. On each succeeding night, each team was rotated between early and late collection periods and indoor and outdoor locations in order to reduce sampling bias. Each man collected mosquitos from his own exposed legs using oral aspirators and red-filtered flashlights. Mosquitos

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were placed into carton cages which were replaced every 30 minutes. The following day all mosquitos were identified, and during the dry season all *Anopheles* were dissected and examined for sporozoites in their salivary glands.

Mosquitos also were collected using a carabao-baited trap (water buffalo). The carabao was secured in the center of a fine-mesh tent 3.9 m × 3.9 m and 1.8 m high. The tent had one door, measuring 1.5 m wide and 1.8 m high, which could be sealed. The tent was protected by a tarp 6.9 × 6.9 m which was elevated over the tent. The door was opened for 20 minutes each hour, beginning from 1830-1850 and ending from 0430-0450. After each 20-minute interval, collectors would enter the tent, and with the door closed, use mechanical aspirators to capture all mosquitos present. Mosquitos were frozen for later identification.

RESULTS AND DISCUSSION

Fifty-one species in 10 genera were collected biting man and carabao at Sto Nino (Table 1). Only *An. flavirostris, An. annularis* (Van Der Wulp), *Ae. vexans* (Meigen), and *Cx. vishnui* (Theobald) were commonly collected from man. Man biting rates were higher during the rainy season than during the dry season with the exception of *An. peditaeniatus* (Leicester), *An. litoralis, Cx. whitmorei* (Giles), and *Ma. uniformis* (Theobald). Man-biting species were exophagic to some degree with the exception of *Armigeres subalbatus* (Coquillett), *An. balabacensis,* and *Ae. albopictus* (Skuse). *An. flavirostris* was weakly exophagic with 68% collected outdoors in the rainy season and 66% outdoors in the dry season.

Dissection of *Anopheles* collected from man showed 2 species to be vectors of malaria in the Sto Nino area (Table 2). Most infective mosquitos (127 of 132) were *An. flavirostris.* Although the sporozoite rate of *An. balabacensis* was high (29.4%), its low man-biting rate made this species a secondary vector.

Both species diversity and abundance were usually much higher from the carabao-baited trap than from man, even though the trap was open only 3 hours 40 minutes each night. As with man-baited collections, almost all species were much more abundant in carabao-baited traps during the rainy season. In addition to having high dry season biting rates on man, *An. peditaeniatus, An. litoralis, Cx. whitmorei,* and *Ma. uniformis,* along with *An. vagus* (Doenitz) also showed a high biting rate on carabao during the dry season.

The ratio of mosquitos collected from man and from the carabao-baited trap indicates the relative anthropophilicity or zoophilicity of each species (Reid, 1961). The most anthropophilic species was *An. balabacensis* (Table 3). During the rainy season, for every *An. balabacensis* attracted to man only 1.5 were collected on carabao. During the dry season, 2.5 *An. balabacensis* were collected on man for every one on carabao. In Malaysia this species also has been described as generally anthropophilic (Hii, 1985). *An. flavirostris* also had a low man-to-carabao ratio in both the rainy and the dry season. This finding contrasted the strongly zoophilic pattern historically attributed to *An. flavirostris* (Russell *et al,* 1963). The few carabao present in our study area may have influenced blood feeding patterns. There appeared to be little behavioral change in seasonal feeding preference for all of the species collected. Of the 3 major genera, *Culex* was the most zoophilic with all 6 species ranking near the bottom of the list. *Aedes* appears as the more anthropophilic genus with all 4 species near the top of this list. *Anopheles* is the most diverse group with representatives at both extremes.

During daylight hours mosquitos were almost never observed biting man. The only exceptions were in forested areas where *Ae. albopictus* would bite when disturbed. Although *Armigeres* species often began biting as early as 1700 hours, most species' biting activity occurred between 1800 and 0630. When comparing the biting activity of the 8 most common man-biters, *An. flavirostris* showed a unique pattern with a peak activity between 0030-0130 and with no significant peaks at either dusk or dawn (Fig 1). Seasonal and indoor/outdoor activity patterns showed very little difference. A small peak from 1830-1900 was present consistently during the dry season. Biting activity continued into the dawn hours with 23 collected from 0600-0630 during the dry season. Thus, the period of risk from this malaria vector ranged from 1830-0630, with highest risk during 2100-0500. The small number of *An. balabacensis* (75) collected resulted in an irregular biting pattern with most activity between 2000-0030. In Malaysia this vec-

Table 1

Mosquitos collected biting man and carabao at Sto Nino, Palawan, comparing indoor-outdoor preference and seasonality.

Species[c]	Man-biting rates[a]				Carabao-biting rates[b]	
	Rainy season		Dry season		Rainy season	Dry season
	Indoor	Outdoor	Indoor	Outdoor		
An. flavirostris	75.9	162.7	15.2	28.9	489.7	130.3
An. balabacensis	1.4	0.6	0.1	0.1	1.6	< 0.1
An. annularis	0.7	21.7	0.2	3.7	929.2	391.0
An. subpictus	< 0.1	0.2	< 0.1	0.2	652.9	170.8
An. kochi	< 0.1	0.0	0.0	0.0	91.8	63.8
An. tesselatus	0.0	0.4	< 0.1	0.3	61.4	24.5
An. maculatus	0.0	0.4	0.0	0.1	18.1	5.3
An. peditaeniatus	0.0	0.1	< 0.1	0.5	1.2	15.7
An. ludlowae	0.0	0.1	< 0.1	< 0.1	2.0	3.8
An. franciscoi	0.0	< 0.1	0.0	0.0	5.9	10.0
An. litoralis	0.0	0.0	0.1	0.2	0.2	11.8
An. philippinensis	0.0	0.0	0.0	< 0.1	4.5	5.6
An. pseudobarbirostris	0.0	0.0	0.0	< 0.1	0.4	2.1
An. vagus	0.0	0.0	0.0	0.0	22.2	69.0
An. indefinitus	0.0	0.0	0.0	0.0	1.7	5.1
Ae. vexans	17.5	67.7	1.6	8.4	1,343.9	192.0
Ae. albopictus	3.0	1.2	0.1	0.1	4.3	0.2
Ae. longirostris	1.0	3.1	0.1	0.4	5.8	1.2
Ae. poicilius	< 0.1	0.1	< 0.1	0.1	4.5	4.4
Ae. pampangensis	< 0.1	0.1	0.0	< 0.1	3.8	1.7
Ae. lineatopennis	0.0	3.1	0.1	1.6	31.9	17.2
Cx. vishnui	2.5	10.9	3.0	10.0	1,847.7	644.3
Cx. whitmorei	0.1	0.3	0.1	1.8	20.2	65.6
Cx. quinquefasciatus	0.1	0.0	0.3	< 0.1	0.9	1.1
Cx. sitiens	< 0.1	0.1	< 0.1	0.2	0.2	1.1
Cx. bitaeniorhynchus	< 0.1	< 0.1	< 0.1	0.0	1.2	0.3
Cx. gelidus	0.0	0.2	< 0.1	0.3	407.3	245.4
Cx. fuscocephala	0.0	0.1	0.0	0.1	336.3	187.2
Cx. pseudovishnui	0.0	0.0	0.0	< 0.1	27.7	10.1
Cx. tritaeniorhynchus	0.0	0.0	0.0	0.0	21.2	21.9
Cx. nigropunctatus	0.0	0.0	0.0	0.0	4.6	2.0
Cx. fuscanus	0.0	0.0	0.0	0.0	2.9	0.2
Ar. subalbatus	2.2	0.4	1.0	0.2	4.9	2.8
Ar. flavus	0.8	0.2	< 0.1	0.1	17.5	6.9
Ma. uniformis	0.0	< 0.1	0.8	1.4	0.4	5.9
Total	105.2	273.2	22.7	58.7	6,370.00	2,320.1

[a]Number of mosquitos collected/man/night (1800-0630).

[b]Number of mosquitos collected/trap/night (doors open 3 hours 40 minutes).

[c]Species collected at rates of less than 1/night for both man and carabao included: *An. karwari, An. pseudosinensis, An. mangyanus, Ae. flavipennis, Ae. gardnerii, Ae. alcasidi, Cx. sinensis, Cx. Uranotaenia heiseri, Ur. mendiolai, Ur. pylei,* and *Hodgesia malayi.*

Table 2

Man-biting *Anopheles* examined for sporozoites at Sto Nino, Palawan, from 30 January to 21 April 1988.

Species*	No. dissected	No. infective	Sporozoite rate
An. flavirostris	10,414	127	1.2
An. balabacensis	17	5	29.4
An. annularis	235	0	0
An. peditaeniatus	57	0	0
An. litoralis	54	0	0
An. subpictus	51	0	0
An. tesselatus	40	0	0
An. maculatus	12	0	0

*Less than 10 dissected and found to be negative were: *An. philippinensis, An. kochi, An. franciscoi, An. karwani,* and *An. ludlowae*

Table 3

Ratio of man-biting rate (MBR) to carabao-biting rate (CBR) comparing rainy and dry seasons. Arranged from most anthropophilic (top) to most zoophilic (bottom).

Rainy season		Dry season	
Species	MBR : CBR	Species	MBR : CBR
An. balabacensis	1 : 1.5	*An. balabacensis*	2.5 : 1
Ae. albopictus	1 : 2.1	*Ae. albopictus*	1 : 1.6
Ae. longirostris	1 : 2.8	*Ae. longirostris*	1 : 5.0
Ar. subalbatus	1 : 3.8	*Ar. subalbatus*	1 : 5.0
An. flavirostris	1 : 4.1	*An. flavirostris*	1 : 5.9
Ae. lineatopennis	1 : 21.3	*Ae. lineatopennis*	1 : 20.0
Ae. vexans	1 : 32.3	*Ae. vexans*	1 : 38.1
Ar. flavus	1 : 35.0	*Cx. whitmorei*	1 : 67.9
An. annularis	1 : 83.0	*Cx. vishnui*	1 : 99.0
An. maculatus	1 : 90.5	*Ar. flavus*	1 : 103.9
Cx. whitmorei	1 : 101.0	*An. maculatus*	1 : 106.7
Cx. vishnui	1 : 275.8	*An. tesselatus*	1 : 176.4
An. tesselatus	1 : 307.0	*An. annularis*	1 : 199.9
Cx. gelidus	1 : 4073.0	*Cx. pseudovishnui*	1 : 602.8
An. subpictus	1 : 6529.0	*An. subpictus*	1 : 1281.3
An. kochi	1 : 6604.3	*Cx. gelidus*	1 : 1577.1
Cx. fuscocephala	1 : 6726.0	*Cx. fuscocephala*	1 : 3743.3
An. vagus	>1 : 10000	*An. kochi*	>1 : 10000
Cx. pseudovishnui	>1 : 10000	*An. vagus*	>1 : 10000
Cx. tritaeniorhynchus	>1 : 10000	*Cx. tritaeniorhynchus*	>1 : 10000

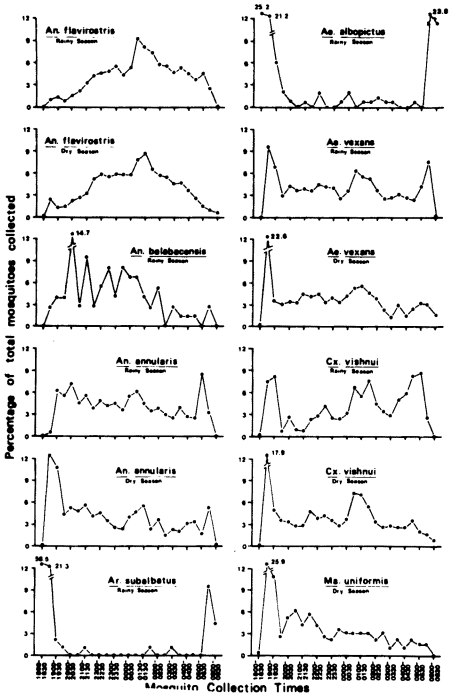

Fig 1—Biting activity of common mosquitos collected biting man at Sto Nino, Palawan, comparing species and seasonal differences.

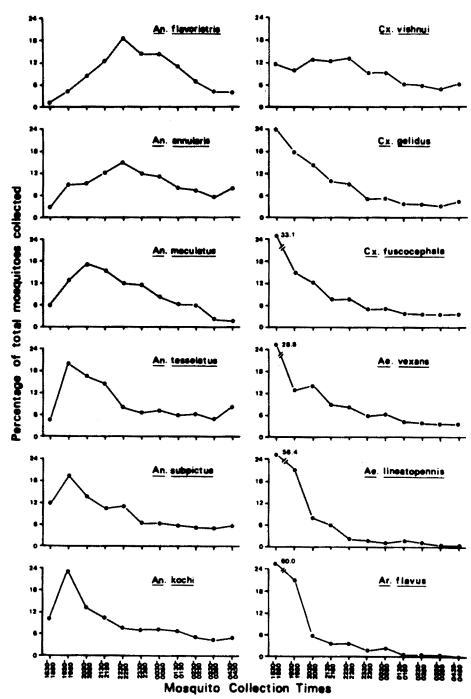

Fig 2—Biting activity of common mosquitos collected in a carabao-baited trap at Sto Nino, Palawan, during the rainy season.

tor had similar peak biting hours from 2100-0100 (Singh, 1985).

The biting activity patterns of *An. annularis, Ae. vexans,* and *Cx. vishnui* were all similar in several ways. During the rainy season all 3 species showed elevated activity during early evening (1830-1930) and pre-dawn (0500-0600) periods, with moderate activity continuing throughout the night. During the dry season these species showed a strong early evening peak from 1830-1900 without a dawn peak. *Ma. uniformis,* which was rarely collected during the rainy season, had a dry season activity pattern very similar to the latter 3 species. *Armigeres subalbatus* and *Ae. albopictus,* which were common only during the rainy season, had patterns similar to each other. *Armigeres subalbatus* had a very strong early evening peak, virtually no activity throughout the night, and a moderate peak at dawn. *Ae. albopictus* had nearly equal dusk and dawn activity with some activity throughout the night.

The carabao-baited trap has several disadvantages in comparison to the man-biting collection when studying mosquito biting activity. First it limits the number of collections during the night; for every 20 minutes that the door is open, it requires 4 men about 30 minutes to collect all the mosquitos in the trap. Fewer collections result in less accurate detection of biting activity patterns. Secondly, mosquitos only rest on the trap walls during hours of darkness, so collections cannot begin until around 1830 and must end around 0500. For example, *Ae. vexans* which during the rainy season had peak man-biting activity from 0530-0600, was completely missed in the animal-baited trap (Fig 2). The advantage of the animal-baited trap is that most species rarely collected from man are often collected in sufficient number from the animal, therefore providing at least a general indication of its biting activity.

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