THE BITING AND RESTING BEHAVIOR OF *ANOPHELES ALBIMANUS* IN NORTHERN HAITI[1]

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ABSTRACT. A one-year study of the biting and resting habits of the malaria vector *Anopheles albimanus* was carried out in four rural villages of northern Haiti. Man-biting rates and nightly biting cycles were determined by the use of all-night man-biting captures inside and outside houses. Seasonal changes in density and behavior were determined by repeating the captures on a bimonthly basis throughout one year. Exophily was demonstrated in these anopheline populations by a comparison of inside-biting with inside-resting densities. These behavior characteristics are discussed in relation to malaria transmission and to the choice of malaria control methods.

INTRODUCTION

Anopheles albimanus Wiedemann is mainly a tropical lowland species found from the lower Rio Grande Valley through Mexico and Central America and along the coast of Colombia to the Paria Peninsula in Venezuela and on some of the Caribbean islands. On the Pacific side of the mainland the mosquito extends from Baja California, Mexico, to northern Peru. In several Central American and Caribbean countries, this species is an important, and sometimes the only, vector of human malaria.

Because of its medical importance, the bionomics of *An. albimanus* has been extensively observed and studied, and a large body of information is available about this vector species throughout its range. Muirhead-Thomson and Mercier (1952) studied the various factors influencing malaria transmission by *An. albimanus* in Jamaica. Rachou et al. (1965) conducted epidemiological studies of malaria in El Salvador, and included a large entomological component. Elliott (1968) reported on his studies of man-vector contact in some malarious areas of Colombia, and Breeland (1972) studied the ecology of *An. albimanus* in El Salvador. In Haiti, Taylor (1966) carried out studies of seasonal density changes and biting and resting behavior of the species in relation to houses.

The Republic of Haiti and the Dominican Republic are located on the island of Hispaniola, one of the Greater Antilles in the Caribbean Sea. In Haiti, malaria continues to be a public health problem in spite of more than 30 years of efforts to control or eradicate the disease by a combination of methods, including house spraying with residual insecticides, mass distribution of anti-malarial drugs and a few limited drainage projects. Transmission of the infection continues at a relatively high level in some rural areas. The World Health Organization (1983) reported 46,703 slide-confirmed, positive cases in 1981, in an estimated population at risk of 4.34 million people. From that year to the present, the annual number of reported cases has not changed appreciably.

This continuing high level of malaria transmission in recent years and the need to find explanations and solutions for the problems, has prompted a reexamination of the basic epidemiology of malaria in Haiti by the Service National des Endemies Majeures (SNEM), with the collaboration of the Malaria Branch, Centers for Disease Control (CDC), U.S. Public Health Service. One part of these investigations was a one-year study from September 1983 to September 1984 in four villages of northern Haiti to determine man-vector contact, seasonal density changes, and resting habits of *An. albimanus* as related to the epidemiology and control of malaria. The findings of this study are presented here.

MATERIALS AND METHODS

STUDY AREAS. Four villages, Morne Anglais, Belle Hotesse, La Fond and St. Michel, were chosen as study sites. All are located near the port city of Cap Hatien. They were selected on the basis of year-round accessibility, a history of malaria cases in the past few years (according to SNEM records), and proximity to known anopheline breeding places. The majority of the houses in these villages are small, have mud plastered walls and corrugated metal or thatch roofs. The type of construction provides easy access of mosquitoes to the inside of houses through open spaces between walls and eaves. The houses have not been sprayed with residual insecticides by SNEM in the past five years. The total population of the four villages was 1,898. A blood slide survey in March 1984 showed parasite rates ranging from 9.3 to 29.8% in the four localities. The parasites were all identified as *Plasmodium falciparum*.

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MAN-VECTOR CONTACT. Man-biting rates were determined by stationing collectors inside and immediately outside houses and having them record the number of *An. albimanus* collected while attempting to bite the bared lower legs of the collectors. Identification of *An. albimanus* under these conditions is not difficult, since this species is the only Haitian anopheline with the hindtarsal segments mostly covered with white scales. The biting captures were performed from sundown to sunrise in at least four houses of each study village, on a bimonthly basis. The collectors were given a weekly dose of chloroquine, 300 mg/base, as malaria prophylaxis. The information derived from these captures was used to determine the nightly biting cycle, man-biting rates, indoor compared with outdoor biting, and seasonal changes in the density of biting *An. albimanus*.

EXOPHILY. This term has been defined by The World Health Organization (1963) as the tendency of mosquitoes to rest outdoors, whether by day or night. Mosquitoes which feed on man indoors, but leave the house immediately or shortly after feeding, demonstrate exophily. Malaria vectors showing this behavior could, to some degree, escape lethal contact with residual insecticides sprayed on inside walls of houses.

In these studies, we attempted to measure the tendency toward exophily by comparing the number of mosquitoes captured while biting man throughout the night indoors with the number of freshly blooded *An. albimanus* collected while resting on inside walls in searches carried out for 15 min in every hour throughout the night.

MOSQUITO INFECTION RATES. Dissections were made of a sample of *An. albimanus* from both the biting and inside-resting portions of the population for the presence of *Plasmodium* infections. Examinations were made both of guts for oocysts and salivary glands for sporozoites. Priority was given to mosquitoes biting in the early evening hours outdoors, since we wished to assess the risk of extra-domiciliary transmission, but we also dissected a sample of inside-biting and resting mosquitoes as well. We realized at the outset that the chances of finding natural infections in this species would be small, since this has been a common finding of workers making dissections of wild-caught *An. albimanus*, as pointed out by Warren et al. (1975).

RESULTS AND DISCUSSION

MAN-VECTOR CONTACT. The nightly cycle of biting activity shown in this study is presented graphically (Fig. 1). Biting began at sundown or shortly thereafter and was at the maximum during the first 3 hr after sunset. Biting occurred throughout the night until sunrise, but with 50% of the total bites in the first 2 hr after sunset. More outside than inside biting occurred at all hours of the night. The outside biting after 2100 hr, recorded in these captures, may not have much epidemiological significance, since villagers are generally inside their houses for the night after this hour. Many people are outdoors between the time of sunset and 2100 hr, and are being bitten by *An. albimanus*. This could possibly lead to some outdoor transmission of malaria. These findings show, however, that the total indoor exposures exceeds the early evening outdoor exposures, so house spraying with an appropriate insecticide should reduce transmission, if the mosquitoes come in contact with the insecticide long

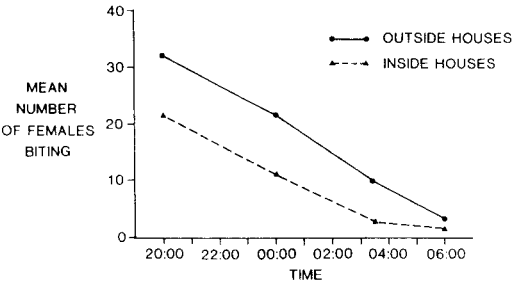

Fig. 1. The biting cycle of *An. albimanus*. Means for all-night catches at four villages in northern Haiti. Total catch = 513, mean per night = 51.

Table 1. Man-vector contact by 12-hour catches (sunset-sunrise) in four villages of rural Haiti, 1983–84.

Month	No. of collectors		Total man-hours		Bites/man/hour	
	Exterior	Interior	Exterior	Interior	Exterior	Interior
Sep. 1983	2	2	70.5	65.3	0.3	0.06
Dec. 1983	2	2	54.0	54.0	8.6	1.4
Feb. 1984	2	2	36.0	36.0	0.33	0.1
May 1984	2	2	36.0	36.0	5.2	4.0
Jul. 1984	2	2	54.0	54.0	5.4	1.4
Sep. 1984	2	2	54.0	54.0	2.2	0.4

enough after consuming the blood meal to be killed. Results of the captures done bimonthly to measure the seasonal fluctuations in biting density are shown (Table 1).

Considerable variation exists in man-biting rates from captures made in different months of the year. The bites per man-hour outside varied from 0.3 in September to 8.6 in December. Indoor biting varied from 0.06 in September to a peak of 4.0 in May. The peaks in outdoor biting came shortly after the two annual rainfall peaks, which occur in late April and early November in northern Haiti. This finding agrees with that of an earlier report from Haiti, in which Paul and Bellerive (1945) stated that *An. albimanus* could be found throughout the year at lower elevations but was most abundant immediately (not clearly defined) following the rainy season.

An important question, and one not directly addressed in these studies, is the relationship between vector density levels and the actual malaria transmission period(s). Information from SNEM indicates the peak of reported malaria cases occurs 3–4 months after the rainfall peaks or approximately 2 months after the mosquito density peaks. The actual peak of transmission is probably much closer to the peak of mosquito density as there is usually a minimum of 14–20 days before the parasite is detected in the blood. We believe that the transmission season is short, since the density peaks are sharp, but this requires verification. In the past, the classic method of delimiting the transmission season has been by the results of infant parasite surveys. If the transmission period is known, and is indeed short, then malaria control options might be increased such as short-term mass drug distribution or adulticiding by space spraying with appropriate insecticides.

EXOPHILY. Although Table 2 shows a comparison of indoor biting and indoor resting of *An. albimanus*, these observations suggest that inside biting mosquitoes are not resting on inside surfaces for long periods after taking a blood meal, but are leaving the house after a relatively short time to find outdoor resting places. The disproportion of biting and resting is even greater when one considers that the houses where these observations were made were occupied by their normal residents in addition to the collectors we purposely stationed in the houses. These normal residents, at least four in each house, were also being bitten during the night by *An. albimanus*. Much higher numbers of blooded mosquitoes should have been found resting on inside walls if the mosquitoes did not have this tendency to escape from the house soon after feeding.

Table 2. Comparison of *Anopheles albimanus* indoor biting with indoor resting.

Month	Number/house Inside biting	Number/house Inside biting
Sep. 1983	0.5	0.4
Dec. 1983	12.9	7.2
Feb. 1984	1.3	0.3
May 1984	36.0	11.5
Jul. 1984	12.2	1.8
Sep. 1984	3.8	1.1

It is not known whether this degree of exophily has been present for a long time in Haitian populations of *An. albimanus*, or whether this behavior is a result of selection pressure after many years of spraying inside walls of houses with insecticides. Unfortunately, we have no prespray observations for comparison. We do know that some of these populations are at present exophilic and that this behavior could decrease the effectiveness of house spraying. The Entomology Section of SNEM is continuing to investigate the exophilic behavior of *An. albimanus* by the use of exit window traps in sprayed and unsprayed houses and through the use of the spray sheet method. These additional efforts are important as Muirhead-Thomson and Mercier (1952) indicated hand collection of indoor resting mosquitoes produces results that indicate fewer mosquitoes are present than actually are and this could lead one to think the mosquitoes are exophilic. Yet, these authors also did find with the pyrethrum spray sheet method that 90% of those mosquitoes feeding inside left before daylight and only 10% remained in the homes during the day. Future efforts of SNEM will more clearly define *An. albimanus* exophilic behavior.

MOSQUITO INFECTIONS. A total of 1,219 midguts and 102 salivary glands were examined during this study for the presence of *Plasmodium* infections; none were found positive. This is not an unexpected finding, since *An. albimanus* is known to be a zoophilic species and malaria transmission depends on high vector density.

It may be worthwhile to continue looking for natural infections, either by the classic methods of dissections during high-density periods or the more recently developed immunological methods for detecting sporozoites in pooled mosquitoes (Burkot et al. 1984). Information on mosquito infections could be quite useful in determining the actual transmission season(s). There are reasons to believe that the transmission period is short, and a more precise knowledge of the transmission season in Haiti would

be important in the choice and timing of malaria control operations.

When comparing the biting behavior of *An. albimanus* from northern Haiti with the reported behavior of this species from other parts of the range, some differences can be seen. In Colombia, as reported by Elliott (1968), this anopheline shows a peak of biting in the hour before midnight instead of the early evening peak we observed in Haiti. The nightly biting activity that we observed in the present study closely resembles the cycle described by Rachou et al. (1965) in El Salvador, by Muirhead-Thomson et al. (1952) in Jamaica, and by Taylor (1966) in an earlier study in Haiti. The seasonal density peaks, their relationship to high rainfall periods, and the man-biting rates we found in Haiti are closely comparable to this same type of information reported from Central America and Jamaica. The exophilic behavior seen in our studies of these Haitian populations of *An. albimanus* could decrease the efficiency of future malaria control efforts such as house spray programs.

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