DAY-TIME INDOOR RESTING ANOPHELINES OF THE DELTA REGION OF VIETNAM [1]

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The collection of adult anopheline mosquitoes from their day-time resting places inside habitations is one of the techniques used to survey the possible vectors of human malaria. Prior to an increase in military activity in the Republic of Vietnam (RVN) this method was used to study the anophelines of this country (Hien, 1968). A decrease in hostilities in the Delta region (Region 4), south of Saigon, permitted the resumption of this mosquito survey technique.

This writer was assigned as an advisor to the Region 4 malaria program to organize and conduct an anopheline mosquito survey. The emphasis was on the training of Vietnamese civilian and military personnel in techniques of malaria entomology. In conjunction with this training, a survey was initiated to determine the geographical distribution of the indoor resting species of anopheline mosquitoes.

DESCRIPTION OF THE AREA STUDIED. The 16 provinces south of Saigon comprise the Delta region of the Republic of Vietnam. This is an area of low elevation, coastal mangrove swamps, inland rice fields and an isolated mountainous area along the Cambodian border. The Mekong River and its numerous tributaries form the major drainage system. The climatic conditions can be divided into the dry and rainy seasons, each of 6 months duration. The annual rainfall is approximately 2000 mm and the mean temperature is 25° C. The land becomes flooded during the rainy season (Hien, 1968). The Delta is the most heavily populated region of RVN with nearly six million inhabitants; fishing and rice farming are their primary occupations.

MATERIALS AND METHODS. Collections inside human habitations were made with flashlights and small glass vials with cotton plugs. The survey was restricted primarily to rural villages with dwellings having dirt floors and thatched walls and roofs. Sleeping areas (walls, bed netting, clothing, etc.) were routinely examined between 0900–1200 and/or 1400–1700 hours. Identifications were based on female adult specimens and were confirmed by Mrs. Rampa Rattanarithikul, taxonomist, Department of Medical Entomology, U.S. Army Medical Component, SEATO, Bangkok, Thailand.

RESULTS AND DISCUSSION. During the period of 27 April to 1 December 1971, 114 villages representing locations from all 16 provinces of Region 4 were surveyed for daytime indoor resting species of anopheline mosquitoes. Of the 11 species collected, *Anopheles vagus* was by far the most abundant (Table 1). Although the walls of the dwellings were routinely examined, bed netting and/or human clothing hanging in the sleeping area were preferred daytime resting places. Irregular collection patterns prohibited the accurate calculation of density and seasonal distribution. However, the results of morning and afternoon collections on the same day were generally similar except during periods of indoor cooking when the smoke apparently caused the mosquitoes to move outside. Windy conditions, particularly common along the coast generally resulted in the collection of fewer specimens. Geographical distribution records are not extensive enough to conclude that a species does not occur in a province where it was not collected.

Previous studies indicate that *A. vagus*

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Table 1.—Geographical distribution of daytime indoor resting species of female anopheline mosquitoes from the Delta region, Republic of Vietnam (April–December 1971).

Province	*Anopheles* species											Total No. Locations
	aconitus	*barbirostris*	*campestris*	*lesteri*	*nigerrimus*	*peditaeniatus*	*sinensis*	*subpictus*	*sundaicus*	*tessellatus*	*vagus*	
An Giang	..	1	4	..	..	..	16	..	..	1	166	4
An Xuyen	..	..	..	..	..	..	4	6	1	..	1	3
Ba Xuyen	..	..	2	1	..	..	1	54	..	..	115	4
Bac Lieu	..	..	..	..	..	..	..	8	..	..	3	3
Chau Doc	1	..	..	..	..	5	..	19	..	..	1473	14
Chuong Thien	..	..	..	..	..	..	26	2	..	..	4	3
Dinh Tuong	..	..	6	..	..	..	..	..	..	..	1302	28
Go C ng	..	..	..	..	..	..	..	..	2	..	45	4
Kien Giang	..	..	1	..	..	..	1	..	..	1	96	7
Kien Hoa	3	..	2	..	1	..	1	14	..	..	240	6
Kien Phong	..	..	..	..	..	..	..	2	..	..	193	13
Kien Tuong	..	..	1	..	..	8	..	1	..	..	40	4
Phong Dinh	..	..	..	13	..	..	..	..	..	1	33	5
Sa Dec	..	..	..	..	..	..	..	..	..	..	207	1
Vinh Binh	1	..	..	..	..	..	..	13	..	..	147	9
Vinh Long	..	..	..	..	..	..	..	25	..	..	244	6
Totals	5	1	16	14	1	13	49	144	3	3	4309	114

is the most abundant species of anopheline mosquito throughout RVN with its greatest densities from the middle of the rainy season (July) to the end of the dry season (February) (Hien, 1968). Females have a zoophilic feeding preference and can successfully oviposit in a wide variety of aquatic habitats (Hien, 1968). It is the only anopheline in RVN to have shown a resistance to chlorinated hydrocarbon insecticides (Quy, 1966a).

The present status of the transmission of malaria in Region 4, RVN requires further studies to clarify the conflicting opinions which currently exists. Stojanovich and Scott (1966) list *A. sinensis, A. sundaicus,* and *A. vagus* as the primary vectors of malaria in the delta and coastal regions of RVN. However, they offer no critical analysis to support these contentions. Hien (1968) states that *A. sundaicus* is the only important vector-species in the Delta. This is based on a positive sporozoite index of 0.18 percent (1/550) and this species' nocturnal and diurnal anthropophilic feeding habits. The geographical distribution of this species is limited by a brackish water breeding requirement and therefore this fails to explain the transmission of malaria outside of its natural range.

Although no vector extrapolations can be made from the present study, the obvious abundance of *A. vagus* would seem to warrant consideration as a potential vector-species.

Hien (1968) does not consider *A. vagus* a vector of malaria in RVN because of its zoophilic feeding preference and a negative sporozoite index (0/25319). Quy (1966b) states that *A. vagus* is an important vector in North Vietnam and Spinu *et al.* (1961) report a positive sporozoite index of 0.06 percent (total number examined not indicated) of this species in RVN. In Cochin-China (now RVN, Region 4) Robin and Toumanoff (1934) experimentally infected *A. vagus* with *Plasmodium falciparum*. In the absence of natural infections they concluded that the vector capabilities of this species are limited by behavioral characteristics (feeding on animals other than man) rather than by physiological reasons. The results of Sandosham (1959) tend to support these observations. He reports that in Malaya several species of anophelines were successfully infected with local strains of *P. falciparum* and *P. vivax*. Of these, *A. vagus* proved to be the most efficient vector under laboratory conditions with a sporozoite index of 54.7 percent (144/261). He also comments on the relatively poor information obtained from laboratory infections in terms of assessing the vector ability of this species since he found no dissections positive for natural infections (0/9399).

The above discussion indicates that *A. vagus* could be potentially important in the transmission of malaria under natural conditions if its feeding habits change and its population numbers are high. This may have been the situation present in the study of Hockmeyer *et al.* (1967) at the Ba Xoai Special Forces camp in Chau Doc province (along the Cambodian border, Region 4, RVN). From 12 April to 31 August 1967 *A. vagus* was the principal man-biting species representing 75.2 percent (1253/1667) of the total anophelines and 68.4 percent (1253/1832) of the total mosquitoes collected. A corresponding malaria parasitemia of 48.7 percent was recorded. In late October 1967 they observed 2 *A. vagus* (2/1867) positive for oocysts. No sporozoites were found.

Further studies are needed in Region 4, RVN to clarify the status of the transmission of malaria. *Anopheles vagus* merits further consideration but its role in malarious areas should be regarded with caution since it is abundant in many areas of Southeast Asia where there is no malaria. Control of this species also requires consideration since it has shown a resistance to insecticides and indoors it seldom rests on walls where insecticides are applied.

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national uncertainty are developing programs concerned with human welfare. I would particularly like to acknowledge the personnel of the Region 4 malaria program for the contributions they have made. This program will eventually serve as a model for malaria control for the rest of the country. Mr. H. J. Jankowski, USAID malaria advisor, has been instrumental in the development of this endeavor. The technical assistance of Mr. C. H. Nam, Sanitarian, Region 4 Korean Preventive Medicine Team and the administrative support of Dr. J. Ely and Mr. J. Stivers are gratefully acknowledged. Dr. G. Carner and Dr. R. Noblet of the Department of Entomology and Economic Zoology, Clemson University, Clemson, S.C. and members of the parasitology group at the University of Alberta, Edmonton, Alberta, Canada reviewed the manuscript.

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INSECTICIDE BAITS FOR ANOPHELINE LARVAE[1]

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The use of stomach poisons, applied as sprays or dust to natural food materials or incorporated into artificial baits, is an insect control method which antedates by a century today's contact insecticides. Because of their mode of entry via the alimentary canal, stomach poisons, notably arsenic and fluorine compounds, have been employed mainly against chewing insects important as pests of agricultural crops and stored food products. Their application in the control of disease vectors has been limited to the use of paris green against mosquito larvae. The feasibility of killing surface-feeding anopheline larvae with this arsenical, applied as a floating dust, was first demonstrated by Barber and Hayne in 1921. Use of paris green against anophelines became widespread during the 1920's and 1930's (Pal and Gratz, 1968) and it has been credited with eradication of *Anopheles gambiae* from Brazil and Egypt in the 1940's (Soper, 1966). Formulated as a non-floating preparation, paris green has

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