Short Report: Forest Malaria in Central Vietnam

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Abstract. Studies were conducted in a village in central Vietnam to explain the existence of a forest malaria cycle of transmission external to the village. The findings suggested no malaria transmission in the village because of the absence of a suitable vector, but suggested evidence for transmission in villagers when attending garden plots in the forested hills surrounding the village. A sizeable population residing near these garden plots, the presence of Anopheles dirus (a highly efficient vector), and a degree of malaria immunity within the inhabitants created suitable conditions to sustain malaria transmission outside the village.

Anopheles dirus s.l. is the primary vector of malaria in Southeast Asia (Bangladesh, Burma, Thailand, Cambodia, Laos, and Vietnam).1 Its exceptional longevity, anthropophilic nature, and carriage of human malaria parasites make An. dirus an important vector species. Additionally, its exophilic behavior makes it difficult to control by conventional intervention measures such as indoor residual spraying and insecticide-treated nets.2-5 Such characteristics make An. dirus a dangerous vector even at low densities.

This mosquito species is associated with forested hills, which include native rainforests and secondary regrowth or rubber or fruit tree plantations that provide shade for its preferred breeding sites.2,5,6 The combination of An. dirus, Plasmodium spp. parasites, and forested hills defines the term forest malaria, which has been used to describe transmission of malaria in communities living in or near forested hills that provide suitable habitats for An. dirus.4,5 In these communities, stable malaria transmission is more dangerous and difficult to control than in communities not associated with forested areas.7

In Vietnam, the terms internal and external malaria are used to differentiate transmission that occurs in the village (internal) compared with malaria infections that are acquired outside the village (external) and are brought back into the village. This terminology is related to forest malaria because it is believed that persons from the village go into the forest for various activities (food gathering, hunting, crop cultivation, timber cutting, gem mining), become infected with malaria because An. dirus is present in the forest, and bring malaria back into the community.

There is still this association between forest, An. dirus, and malaria, but the original concept of forest malaria has been modified and is now applied to persons who do not live in (or near) the forest but who visit it for various reasons and for varying periods. However, little is known as to how the malaria cycle is maintained in the forest.7 The role of An. dirus is such that any communities that have high levels of malaria transmission should have an association with this species and the forest, but too often there is only a vague association between persons, the forest, malaria, and An. dirus.8 Erhart and others9 associated sleeping overnight in the forest while cutting timber and gardening with a statistically significant increase in the risk of acquiring malaria. However, how these activities, particularly those as transient as timber cutting, provide a stable host population that supports transmission of the parasite is not known.

Because of the lack of any direct evidence demonstrating how malaria transmission can be maintained in populations moving into and out of the forest, we evaluated forest malaria in a village in south central Vietnam.

Dong Thong village in the Phuoc Chien Commune is located in Ninh Thuan Province. The land surrounding the village is largely unsuitable for crop cultivation and is used mainly for grazing cattle and goats. Farmers practice slash-and-burn clearing of the surrounding hill sides to grow staple crops such as corn and cassava. Each of the five villages in the Phuoc Chien Commune has a designated crop-growing area in the surrounding hills. Erhart and others10 showed that villagers in Dong Thong had a high rate of malaria parasite positivity (32.1% in November–December 2003), and villagers who slept overnight in the forested hills while tending their gardens were associated with a significant increase in malaria infection risk. These workers composed 23.3% (1,003 of 4,306) of the study population, which included inhabitants from Dong Thong who spent nights in the forest. The median number of nights spent in the forest was 12 per month (range = 1–30 nights).

This information raises two questions. First, would this situation create sufficient human/vector contact to maintain the malaria cycle? Second, do persons who go into the hills exist as a community or are they scattered in isolated groups throughout the hills? Bearing in mind that the flight range of An. dirus is approximately 1.5 km,6 one would expect that a large human population within close proximity over sufficient time would be needed for malaria transmission to be maintained.

In September–October 2006, we conducted a malaria survey in Dong Thong village (total population = 1,153). The rate of parasite positivity was 15.5% (48 of 310: 8 persons 0–5 years of age, 12 persons 6–14 years of age, and 28 persons > 15 years of age) on the basis of a mass blood survey and thick film microscopy.

We also conducted a night biting mosquito catch (from 6:00 PM to 6:00 AM, with one indoor and two outdoor collectors collecting for 50 minutes each hour) and cattle shed collections in which for five nights anophelines were collected from three cattle sheds (all located within the village) over a
Anopheles dirus was shown to be present at these hillside plots. Similar collections were conducted six months later with another person sitting 15 meters away collecting from one house while another person collected from another house with a 15-meter gap between them. Surveys included four houses on each of the four nights. Surveys collected 149 An. dirus from indoor light traps and 7 An. dirus from indoor light traps. No An. dirus were collected from cattle, of which 362 (95.3%) were An. vagus and the remainder were An. sinensis (n = 5), An. annularis (n = 4), An. minimus s.l. (n = 3), An. aconitus (n = 2), An. petidexiatus (n = 2), An. philippinis (n = 1), and An. kochi (n = 1). Of 13 larval sites, all were positive for An. vagus and of those larvae reared to adults, 92% (253 of 274) were An. vagus. The surveys indicated that An. vagus was the dominant anopheline in Dong Thong village. However, this is a zoophilic species and is not regarded as a vector of malaria in Vietnam. Thus, it would appear that in the absence of any appreciable numbers of an efficient vector, malaria transmission is not occurring within Dong Thong village. These findings imply that transmission must be occurring in the garden plots located in the hills above Dong Thong, the only other location where people from the hamlet stay overnight regularly.

Accordingly, entomologic surveys were conducted in the hills surrounding Dong Thong. These garden plots are approximately 2 km from Dong Thong village at an altitude of approximately 600 meters. Although the two-hour climb to the village is arduous, entire families commute between the two locations on a regular basis. Throughout the year families spend considerable time at these garden plots preparing the land and growing and harvesting their crops. Much of the area has been deforested for cultivation. However, remnants of native forest still remain in patches along creek lines and in regions too steep for cultivation. While in the area, we conducted a census of the surrounding houses and current population.

Entomologic surveys consisted of outdoor human biting collections (from 6:00 PM to 6:00 AM within 10 meters of an occupied house) conducted by three collectors over four nights with CDC light traps (without dry ice) positioned inside four houses on each of the four nights. Surveys collected 5 An. dirus and 19 An. maculatus from human biting and 14 An. dirus, 1 An. vagus, and 35 An. maculatus from indoor light traps. Similar collections were conducted six months later (April–May 2007) in the dry season and collected 123 An. dirus and 14 An. maculatus indoors from traps and 7 An. dirus and 5 An. maculatus from human biting.

The head/prothorax of these 149 anophelines was tested for Plasmodium spp. antigen by an enzyme-linked immunosorbent assay; one An. dirus was positive for P. falciparum. Further surveys were conducted in the dry season of 2008 where over a three-week period 48 CDC light traps were set in houses in the village and at the garden plots. No anophelines were collected in the traps set in houses in the village and 58 anophelines (36 An. dirus and 22 An. maculatus) were collected in the traps set in the houses on the hillsides. This direct comparison further confirms the absence of a malaria vector in Dong Thong village.

Anopheles dirus was shown to be present at these hillside garden plots biting humans and entering houses. We also observed that there were 22 houses associated with these garden plots within an area of 28 hectares (700 meters × 400 meters). At the time the survey was done, 21 dwellings had 65 occupants. The houses were constructed of woven bamboo walls and iron sheeting roofs. Windows and doors were small and the overall construction of the houses was tight. Bed nets are not used because there is no problem with pest mosquitoes. Indoor residual spraying was not carried out in these remote garden plots.

Other factors in Dong Thong were noted during our surveys that could support malaria transmission with low host numbers and limited human/vector contact. The residents of Dong Thong showed few febrile symptoms despite carrying malaria parasites for long periods. Many of the cases of malaria recorded in our mass blood survey were asymptomatic, similar to the findings reported by Erhart and others. We detected 48 malaria cases in 310 people surveyed, but only 12 symptomatic cases in Dong Thong village came to the commune Health Station over the same period. Many of the cases (37 [88%] of 42) detected by mass blood survey were afebrile.

This apparent immunity may be promoted by suppressive antimalarial drugs. The standard treatment for malaria in Vietnam is a seven-day course of artesunate (8 × 50-mg tablet), which is provided by the commune Health Station. Two tablets are given at the time of diagnosis and over the next six days the patient is required to self-medicate with one tablet each day. Because artesunate has the ability to rapidly reduce the parasite load and fever clearance times are short (24–48 hours), the incentive for the villager to complete the entire treatment course is low. This lack of incentive leads to poor compliance and an increased chance of recrudescence, which can be as high as 25–30% if the drug is taken for only 3–5 days.

In conclusion, to state that malaria transmission occurs in the forest simply because An. dirus is present is unsupportable unless it can be substantiated how the transmission cycle can be sustained. These preliminary observations describe a combination of factors that give a plausible explanation as to how a forest malaria cycle of transmission external to the village can be maintained in Vietnam and possibly elsewhere in Southeast Asia.

Received November 21, 2007. Accepted for publication August 13, 2008.

Acknowledgments: We thank Ngo Thi Huong, Nguyen Xuan Thien, Pham Phu Trong, Huynh Trong Dao, and Le Dinh Vinh (Institute of Malariaology Parasitology and Entomology, Qui Nhon); Nguyen Van Minh (Military Preventive Medicine Centre); and Nguyen Chinh Phong (Military Institute of Hygiene and Epidemiology) for their support; and Drs. M. Edstein, K. Rieckmann, and D. Shanks (Australia Army Malaria Institute) for reviewing the manuscript.

Financial Support: This study was supported by the International Policy Division, Australian Defence Force.

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