FEEDING PATTERNS OF *ANOPHELES DIRUS*, THE MAJOR VECTOR OF FOREST MALARIA IN NORTH EAST INDIA

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Abstract. The feeding behavior of *Anopheles dirus*, the forest breeding, major malaria vector in northeast India was studied. The analysis of blood meals collected from this mosquito revealed that the species was highly anthropophilic in nature, the anthropophilic index being 90.5. The results of bait collection on human and cattle bait also confirmed its biting preference for human hosts. The species was observed to land on human bait throughout the night, showing prominent biting time at 20.00-21.00, 23.00-24.00 and 02.00-03.00 hours during the study period.

INTRODUCTION

Anopheles dirus Peyton and Harrison is a primary vector of human plasmodia in Southeast Asia. The reports of incrimination of this species as malaria vector from the northeastern region of India, the physiography of which is very similar to neighboring Southeast Asian countries like Myanmar and Thailand, are also available (Sen *et al*, 1973; Rajagopal, 1979; Das and Baruah, 1985; Dutta *et al*, 1989b; Dutta *et al*, 1992). This is characteristically a species of hills and foothills resting and breeding mostly in forest areas (Rao, 1984; Rosenberg, 1982; Dutta *et al*, 1989a). It was observed that the human population residing near the forested foothill areas were prone to malaria infection transmitted by this vector (McArthur, 1947, 1950; Slooff and Verdrager, 1972; Rosenberg and Maheswary, 1982; Dutta *et al*, 1991).

Adequate information regarding the host feeding, biting pattern of *An. dirus* is lacking in this part of the country. A study was therefore undertaken to determine the host feeding pattern of *An. dirus*, in relation to previously published reports.

MATERIALS AND METHODS

Study area

The study was carried out during July-September, 1992 in some highly malarious areas of Tengakhat PHC of Dibrugarh District, Assam which are mainly forest fringes inhabited by tea-garden laborers and villagers.

Bait collection

In an experiment, the whole night collections were made in the study area from 18.00 hours of first day to 06.00 hours of the second day to record the biting densities of the malaria vector, using 3 different bait types: (1) outdoor human bait (2) indoor human bait and (3) a cattle bait. Six complete nights were spent during July-September, 1992 and hourly collected vector mosquitos were kept separately in properly marked test tubes for recording.

Blood meal analysis

Specimens of *An. dirus* were collected from outdoors at night in the resting state from vegetation, bamboo fencing, etc by using suction tube and torchlight. Also, the specimens were collected by operating CDC light traps from dusk to dawn. The gut contents of fullfed mosquitos collected by these methods were squashed on whatman No. 1 filter paper. The sources of blood meals thus kept in filter papers were identified by employing the agarose gel diffusion technique described by Collins *et al* (1986) using antisera to human, bovine, avian, pig. Normal rabbit serum was kept as control. The antisera used were obtained from the office of the serologist to the Government of India, Calcutta.

RESULTS

Feeding pattern

Results of collection of *An. dirus* in 6 whole nights using 3 different bait types revealed that the

collection was more pronounced on human bait. Almost equal prevalence of *An. dirus* using outdoor human bait (46.5%) and in indoor human bait (44.2%) was observed whereas its presence on cattle bait was not so pronounced. The feeding ratio of *An. dirus* with the 3 different bait types was recorded as outdoor human bait : indoor human bait : cattle bait 5 : 4.8 : 1. This finding thus disclosed the human host preference of the vector.

The feeding of *An. dirus* on human bait was observed throughout the night and its biting activity was prominently recorded between 2000-2100, 2300-2400 and 0200-0300 hours. The peak of biting activity was high in between 2000-2100 hours. Another two peaks recorded in between 2300-2400 and 0200-0300 hours were somewhat lower (IST; Fig 1). It was observed that *An. dirus* females just after coming from their day resting places took a rest in outdoor vegetation around catching stations very early in evening. They were found to remain inactive for sometime before seeking a bloodmeal and to start their biting activity from 1900 hours.

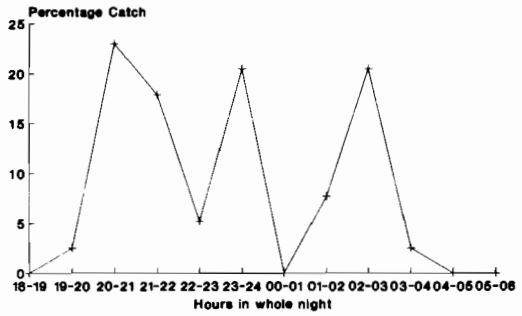

Fig 1–*Anopheles dirus* collection on whole night human bait.

Identification of hosts

A total of 137 samples of bloodmeals were collected from specimens of *An. dirus* from outdoor resting places at night and by operating CDC miniature light-traps for the whole night. These were analysed by the gel diffusion technique. From light-trap collections, 90 samples were tested and out of these 79 were positive for human, 3 for bovine and 2 for avian blood. From the outdoor resting collections, 47 samples were tested and 45 were positive for human blood. From these two sources, 124 (90.5%) samples were positive for human blood, 3 (2.2%) for bovine blood, 2 (1.5%) for avian blood and 8 (5.8%) did not show any reaction (Table 1). It is evident from the results that *An. dirus* prefers human blood. The anthropophilic index was recorded to be 90.5.

DISCUSSION

From the present study, the human to cattle biting ratio of *An. dirus* was recorded to be ~ 5 : 1 and in bloodmeal analysis, the anthropophilic index was recorded to be 90.5, whereas the cattle feeding rate was only 2.2%. In North Borneo, it was estimated that 88-90% of the *A. b. balabacensis* populations fed on human blood (McArthur, 1947,

Table 1

Results of analysis of blood meals of malaria vector *An. dirus* collected from different sources.

Source of collection	No. of samples examined	Blood meal source (%)			No. showing no reaction
		H	B	A	
Light trap (Whole night)	90	79 (87.8)	3 (3.3)	2 (2.2)	6 (6.7)
Outdoor resting (Night)	47	45 (95.7)	0 -	0 -	2 (4.3)
Total	137	124 (90.5)	3 (2.2)	2 (1.5)	8 (5.8)

Figures in parentheses denote the percentage
H = Human, B = Bovine, A = Avian.

1950). In a study in Assam, it was found that even in the presence of numerous cattle, only 22% of the species fed on these and 75.5% fed on man (Ramsay *et al*, 1936). In another study in Cambodia by Eyles *et al* (1964), cattle attracted fewer *A. b. balabacensis*, giving a human to cattle attraction ratio of 5.3 : 1, while in a study in Thailand by Scanlon and Sandhinand (1965), the use of cattle bait was a failure. In a report from Burma, the average catch per bait per hour of this vector species on cattle was much less than that on man (Khin-Muang-Kyi, 1974). A study in Bangladesh by Rahman *et al* (1977) recorded a man to cow ratio of 2.5 : 1, whereas in a precipitin test, the human blood index was around 27%. From all these observations, there is no doubt about the anthropophilic behavior of *An. dirus*.

In the present investigation, the biting activity of *An. dirus* was observed throughout the night showing prominent biting activity at several points between 2000 and 0300 hours. The nightly catches on outdoor and indoor human bait were observed to be of similar type, *ie* 46.5 and 44.2 %, respectively. This uniformity was also recorded in studies conducted in Thailand (Ismail *et al*, 1974) and in Bangladesh (Rosenberg and Maheswary, 1982). In a Borneo study *A. b. balabacensis* was observed to be a late feeder with a peak of activity in the early hours of the morning, however, on individual nights, the peak varied from as early as 2200-2300 hours to as late as 0400-0500 hours (Colless, 1956 a, b). In a study in Thailand by Scanlon and Sandhinand (1965), the peak biting activity of this species was recorded between midnight and 0300 hours. In another study in Thailand, the biting activity of this mosquito was observed only up to midnight between April and May, subsequently feeding decreased, with only one specimen collected after 2300 hours (Wilkinson *et al*, 1970).

In a subsequent study is Northern Thailand by Ismail *et al* (1974), the biting activity of this species was observed to be very scarce in the early hours (1800-1900) and reached its peak between 2300-0200 hours in May-August whereas in September-October, the biting activity started earlier and the peak of biting advanced to between 2200 and 2400 hours. This finding was comparable to the study conducted in Myanmar by Khin-Muang-Kyi (1974). In one night study conducted is Mikir hills of Assam by Rajagopal (1974), the biting catches of this vector on two men in a thatched field hut used for watching the crops at night were recorded to be as follows : before 2200 hours = 6, between 2200-0200 hours = 65, and 0200-0230 hours = 15.

From the foregoing discussion, it is evident that *An. dirus* has a strong inclination to bite humans. Peak biting time may vary from locality to locality and from season to season. The biting activity may change for acclimatization with man-made situations. In Thailand, although the peak biting time of the mosquito was generally observed at midnight, after spraying of DDT the biting activity of the vector advanced towards the earlier hours of night (Ismail *et al*, 1975). It is a highly exophilic species. Therefore, it is concluded that indoor spraying of DDT or any adulticide would not be effective against *An. dirus* in controlling malaria. In a study under a pilot project in Khemer, it was observed that DDT spraying did not interrupt transmission even when supplemented by mass drug administration (Slooff and Verdrager, 1972).

In such a situation, personal protection measures by the use of mosquito nets may be an effective measure in reducing the chances of man-mosquito contact while sleeping, as our observation in Assam revealed that the risk of acquiring malaria by the mosquito net users are five times less than the non bed net users (Dutta *et al*, 1989c). The quality of surveillance should be improved in the endemic areas of this region along with chemoprophylactic measures for the forest workers so as to reduce the parasite reservoir among them. As the people of the backward areas are of lower socio-economic status and are less conscious about maintaining hygienic conditions, the health education will be essential to gaining community participation so that the containment program of malaria through integrated approach can be implemented successfully in this region.

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REFERENCES

Colless DH. The *Anopheles leucosphyrus* group. *Trans R Ent Soc London* 1956a; 108 : 37-116.

Colless DH. Observations on Anopheline mosquitos of the Akah River, 4th Division, Sarawak. *Bull Entomol Res* 1956b; 47 : 115-23.

Collins RT, Dash BK, Agarwala RS, Dhal KB. An adapation of the gel diffusion technique for identifying the source of mosquito blood meal. *Indian J Malariol* 1986; 23 : 81-9.

Das SC, Baruah I. Incrimination of *Anopheles minimus* Theobald and *Anopheles balabacensis balabacensis* Baisas (*A. dirus*) as malaria vector in Mizoram. *Indian J Malariol* 1985, 2 : 3-55.

Dutta P, Bhattacharyya DR, Sharma CK, Dutta LP. The importance of *Anopheles dirus* (*A. balabacensis*) as a vector of malaria in Northeast India. *Indian J Malariol*1989a; 26 : 95-101.

Dutta P, Bhattacharyya DR, Dutta LP. Incrimination of *Anopheles dirus* (*A. balabacensis*) as a vector of malaria in Dibrugarh district, Assam. *Indian J Malariol* 1989b; 26 : 149-52.

Dutta P, Bhattacharyya DR, Dutta LP. Malaria among bed net users and non users. *Indian J Malariol* 1989c; 26 : 171-2.

Dutta P, Bhattacharyya DR, Dutta LP. Epidemiological observations on malaria in some parts of Tengakhat PHC of Dibrugarh district, Assam. *Indian J Malariol.* 1991; 28 : 121-8.

Dutta P, Bhattacharyya DR, Sharma CK, Dutta LP. Anopheline fauna of some part of Tirap district, Arunachal Pradesh with particular reference to transmission of malaria. *Indian J Med Res* 1992; 95 : 245-9.

Eyles DE, Wharton RH, Cheong WH, Warren M. Studies on Malaria and *Anopheles balabacensis* in Cambodia. *Bull WHO* 1964; 30 : 7-21.

Ismail IAH, Notananda V, Schepens J. Studies on malaria and responses of *Anopheles balabacensis balabacensis* and *Anopheles minimus* to DDT residual spraying in Thailand. Part I. Pre spraying observations. *Acta Tropica* 1974; 31 : 129-64.

Ismail IAH, Notananda V, Schepens J. Studies on malaria and responses of *Anopheles balabacensis balabacensis* and *Anopheles minimus* to DDT residual spraying in Thailand. Part II. Post spraying observations. *Acta Tropica* 1975; 32 : 206-31.

Khin-Muang-Kyi. Further observations on *Anopheles balabacensis balabacensis* and malaria in Burma. *WHO/MAL/74* (Mimeographed document) 1974; 838 : 14pp.

McArthur J. The transmission of malaria in Borneo. *Trans R Soc Trop Med Hyg* 1947; 40 : 537-58.

McArthur J. The importance of Borneo anophelines. *Indian J Malariol* 1950; 4 : 391-447.

Rahman M, Elias MD, Ameen Mahmud-UL. Bionomics of *Anopheles balabacensis balabacensis* Baisas (Diptera: Culicidae) in Bangladesh and its relation to Malaria. *Bangladesh J* Zool 1977; 5 : 1-3.

Rajagopal R. Role of *A. balabacensis* in transmission of malaria. *J Com Dis* 1979, 11 : 71-4.

Ramsay GC, Chandra SN, Lamprell BA. A record of an investigation to determine the anthropophilic in dices of certain anopheline mosquitos collected on tea estates in Assam and Northern Bangal. *Rec Malar Survey India* 1936; 6 : 49-52.

Rao TR. The Anophelines of India. Malaria Research Center, Indian Council of Medical Research, Delhi, 1984.

Rosenberg R. Forest malaria in Bangladesh. III. Breeding habits of *Anopheles dirus. Am J Trop Med Hyg* 1982, 31 : 192-201.

Rosenberg R, Maheswary NP. Forest Malaria in Bangladesh II. Transmission by *Anopheles dirus. Am J Trop Med Hyg* 1982; 31 : 183-91.

Scanlon JE, Sandhinand V. The distribution and biology of *Anopheles balabacensis* in Thailand (Diptera: Culicidae). *J Med Entomol* 1965; 2 : 61-9.

Sen RK, John VM, Krishnan KS, Rajagopal R. Studies on malaria transmission in Tirap district, Arunachal Pradesh (NEFA). *J Com Dis* 1973, 5 : 98-110.

Slooff R, Verdrager J. *Anopheles balabacensis balabacensis* Baisas 1936 and Malaria transmission in South Eastern areas of Asia. *WHO/MAL/72.765* (Mimeographed document) 1972; 26 pp.

Wilkinson RN, Miller TA, Esah G. Anthropophilic mosquito in central Thailand, with notes on *Anopheles balabacensis* Baisas and malaria. *Mosq News* 1970; 30 : 146-8.