Journal of the American Mosquito Control Association, 20(3):317–318, 2004

SCIENTIFIC NOTE

RESTING BEHAVIOR AND MALARIA VECTOR INCRIMINATION OF *ANOPHELES STEPHENSI* IN GOA, INDIA

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ABSTRACT. Malaria in Goa, India, has been endemic ever since an outbreak occurred in 1986. *Anopheles stephensi* Liston has always been suspected as a malaria vector in this area. Due to lack of knowledge on its resting behavior, sufficient adult females could not be collected and incriminated as vectors in the past. In this study mosquito collections were conducted in three endemic urban and suburban areas of Goa. In well-built houses, 67 h of collections did not yield a single *An. stephensi* mosquito, although other species were encountered. However, collections in construction sites and workers' huts for 151 h yielded, besides other mosquito species, 38 *An. stephensi* females resting in 15 types of sites at a height varying from 30 cm to 2.4 m. Of the 37 of these mosquitoes tested for the presence of circumsporozoite protein (CSP) by an ELISA technique, 1 was found to be *Plasmodium falciparum* CSP positive.

KEY WORDS *Anopheles stephensi*, resting behavior, incrimination, Goa, India

Since an outbreak in the town of Panaji in 1986, malaria has been a major problem in urban and periurban Goa, India (Kumar et al. 1991, 1998). *Anopheles stephensi* Liston is widely distributed in India and is considered a principal malaria vector in urban areas, where it transmits malaria either alone or together with *Anopheles culicifacies* Giles, usually in the periphery of the towns (Kumar 1997). The species is presumed to be a major malaria vector in Goa, although it has not been incriminated from this area previously (Nagpal and Sharma 1995). *Anopheles stephensi* breeds in a variety of manmade habitats in Goa, India, where rampant construction activity has led to excessive standing water and an increase in vectors followed by active malaria transmission in migrant rural workers from the neighboring states (Kumar et al. 1991, Kumar and Thavaselvam 1992). Due to scarcity of adult females in routinely collected samples, sporozoite-positive *An. stephensi* have not so far been found in Goa (Nagpal and Sharma 1995). As observed elsewhere by earlier authors in India, collection of adult females of this important vector species has been difficult using routine indoor hand collections of resting individuals because of insufficient knowledge on its resting behavior (Hati et al. 1987, Bhatt et al. 1989). However, Kumar et al. (1995) were able to collect them during whole-night collections on human bait in Goa. This study was conducted to gather information on the resting behavior of *An. stephensi* to facilitate the detection of sporozoites and to ascertain the feasibility of applying an adulticiding strategy for its control.

This study was conducted from March 1998 to July 1999 in 3 malaria-endemic coastal towns of Goa, India, viz., Panaji, Porvorim, and Calangute. Various probable resting sites were examined between 0600 and 1200 h inside local houses and at outdoor resting sites, such as open construction sites and workers' huts near construction sites. These resting sites were visited randomly throughout the period of study. Mosquitoes were collected using aspirators and flashlights. The heights of the resting site above either the ground level or water level were measured, and the gonotrophic status of females was recorded. The collected mosquitoes were dried and stored individually in plastic vials containing dried silica gel under cold conditions (0–4°C) until September 1999, when head and thorax portions of the specimens were tested by the Sandwich ELISA method of Burkot et al. (1984) using antibodies to circumsporozoite proteins of *Plasmodium falciparum, Plasmodium vivax*-210 and *P. vivax*-240. Endpoint results were read visually and confirmed at 450 nm using a Vmax kinetic microplate reader manufactured by Molecular Devices Corporation (Sunnyvale, CA).

Collections in well-built permanent local houses and likely outdoor resting sites for 67 h did not yield a single *An. stephensi,* although 12 adult female of *An. subpictus* Grassi, 208 of *Culex quinquefasciatus* Say, 18 of *Aedes aegypti* L., and 21 of *Armigeres subalbatus* Coquillett were collected from these dwellings. However, collections in construction sites and workers huts for 151 h yielded 38 female adult *An. stephensi,* 105 *An. subpictus,* 12 *An. vagus* Doenitz, 1069 *Cx. quinquefasciatus,* 60 *Ae. aegypti,* and 35 *Ar. subalbatus* (Table 1).

Anopheles stephensi female mosquitoes were found resting 0.3–2.4 m above ground/water level, and 34 of the 38 specimens were found resting more than 1.2 m above the surface. Resting sites were classified into one of 5 types as follows (with

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Table 1. Other mosquito species collected from construction sites, labor huts, and local houses in Goa, India.

Site no.	Mosquito species collected in resting places	No. collected (%)			
		Construction sites	Labor huts	Local houses	Total
1	*Culex quinquefaciatus*	734 (83%)	335 (84%)	208 (80%)	1,277 (82.9%)
2	*Anopheles subpictus*	63 (7.1%)	42 (10.5%)	12 (4.6%)	117 (7.6%)
3	*Anopheles vagus*	12 (1.%)	0	0	12 (0.8%)
4	*Armigeres subalbus*	27 (3.0%)	8 (2%)	21 (8.1%)	56 (3.6%)
5	*Aedes aegypti*	48 (5.4%)	12 (3%)	18 (6.94%)	78 (5%)
	Total	884	397	259	1,540

Table 2. Female *Anopheles stephensi* collected from various places in construction sites and labor huts in Goa, India.

Site no.	Collection site; surface features and material	No. of occasions	No. of specimens collected[1]
1	Unplastered surfaces	7	11 (UF:6, FF:4, G:1)
2	Plastered surface	4	5 (FF:3, SG:2)
3	Bamboo or wood surfaces	4	5 (FF:3, SG:1, G:1)
4	Metal surfaces	3	12 (UF:4, FF:1, SG:5, G:2)
5	Others	4	5 (UF:1, FF:4)
	Total	22	38 (UF:11, FF:15, SG:8, G:4)

[1] UF, unfred; FF, fully fed; SG, semigravid, and G, gravid.

numbers collected): unplastered surfaces (11), plastered surfaces (5), bamboo or wood surfaces (5), metal surfaces (12), and others (5) (Table 2). Most of the mosquitoes were collected from galvanized iron sheets and from unplastered brick walls. Overall, it may be concluded that *An. stephensi* showed considerable diversity of resting places in Goa but was not found in well-built permanent houses. Similar observations were made earlier by Hati et al. (1987) in Calcutta, India.

Examination of the gonotrophic status of these adults showed that 11 (28.9%) were unfed, 15 (39.5%) were freshly blood fed, 8 were semigravid (21.1%), and 4 (10.5%) were gravid. Thirty-seven of the specimens were processed for CSP by the ELISA technique. One of the semigravid specimens was found to contain *Plasmodium falciparum* CSP. Though *An. stephensi* has been incriminated as a malaria vector on 36 occasions from various parts of India (Burkot et al. 1984), this was the first such report for this species in Goa.

Because no *An. stephensi* were collected resting indoors in flats and traditional houses in both urban and periurban areas during 67 h of hand collections, it is concluded that vector control through indoor residual spraying of such dwellings would prove futile. Adulticide spraying of construction sites and temporary workers' huts in which *An. stephensi* were found would probably not be cost effective because its surfaces and building materials are likely to be plastered, painted, or moved within days or weeks of such spraying. This study affirms that, in this area, the control of *An. stephensi* through source reduction, selective larviciding, and utilizing larvivorous fish for immature control is the only practical proposition.

The authors are grateful to the staff of Malaria Research Centre, Goa, India, and Malaria Research Centre, Nadiad, Gujarat, India, for their assistance. The authors are also grateful to Christopher F. Curtis of London School of Hygiene and Tropical Medicine for the valuable comments and advice.

REFERENCES CITED

Bhatt RM, Sharma RC, Yadav RS, Sharma VP. 1989. Resting of mosquitoes in outdoor pit shelters in Kheda District, Gujarat. *Indian J Malariol* 26(2):75–81.

Burkot TR, Williams JL, Schneider I. 1984. Identification of *Plasmodium falciparum*-infected mosquitoes by a double antibody enzyme-linked immunosorbent assay. *Am J Trop Med Hyg* 33:783–788.

Hati AK, Chatterjee KK, Biswas D. 1987. Daytime resting habits of *Anopheles stephensi* in an area of Calcutta. *Ind J Malariol* 24(1):85–87.

Kumar A, Thavaselvam D. 1992. Breeding habitats and their contribution to *Anopheles stephensi* in Panaji. *Ind J Malariol* 29(1):35–40.

Kumar A. 1997. Urban malaria and its control in India. *J Parasitic Dis* 21(2):83–88.

Kumar A, Sharma VP, Sumodan PK, Thavaselvam D. 1998. Field trials of biolarvicide *Bacillus thuringiensis* var. *israelensis* strain 164 and the larvivorous fish *Aplocheilus blockii* against *Anopheles stephensi* for malaria control in Goa, India. *J Am Mosq Contl Assoc* 14: 457–462.

Kumar A, Sharma VP, Thavaselvam D. 1991. Malaria related to constructions in Panaji, Goa. *Ind J Malariol* 28(4):219–225.

Kumar A, Thavaselvam D, Sharma VP. 1995. Biting behaviour of disease vectors in Goa. *J Parasitic Dis* 19(1): 73–76.

Nagpal BN, Sharma VP. 1995. *Indian anophelines* New Delhi, India: Oxford and IBH Publishing Co. Pvt. Ltd.