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Repellent Action of *Cymbopogan martinii martinii* Stapf var. *sofia* Oil Against Mosquitoes

M.A. ANSARI and R.K. RAZDAN

Studies were carried out to evaluate the repellent action of *Cymbopogan martinii martinii* Stapf var. *sofia* (F. Gramineae) against mosquitoes under field conditions. Results revealed that the oil has strong repellent action and provided absolute protection for 12 h against *Anopheles culicifacies*, a principal vector of malaria in the country. Similar degree of protection was evident against *An. annularis* and *An. subpictus*. The protection against *Culex quinquefasciatus*, a pest mosquito was 96.3% for 12 h. Results of evaluation in captivity revealed complete protection against this species for 5 h.

Keywords: Malaria control, Palmarosa, Repellent

INTRODUCTION

Cymbopogan martinii martinii Stapf var. *sofia* (Gramineae) is a wild perennial undershrub, commonly known as palmarosa or rosha grass. It is abundant in scrub forests of Madhya Pradesh, Maharashtra and Andhra Pradesh states of India. Oil extracted from the grass has a sweet floral rose and geraniol like odour and is mainly used in reconstitutional and flavouring of oils in India[1]. Main constituents identified in Indian palmarosa oil

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are geraniol (76.15%), geranyl acetate (9.05%), linalool (3.86%), limonene (1.74%), nerol (1.53%), elemol (1.45%), Y. terpinene (0.94%) and myrcene (0.07%)[2]. These components are also found in citronella oil (*Cymbopogan nardus*), which is well-known for repellent action against houseflies and mosquitoes. Based on this fact a field evaluation of palmarosa oil was carried out to evaluate its repellent action against mosquitoes. Results of this studies are presented in this paper.

MATERIALS AND METHODS

Dhaulana village located on Mussooree and Gulawathi road at a distance of 50 km southeast of Delhi was selected for evaluation. The population of the village is about 10,000 staying in 1200 houses. The village is endemic for malaria and *An. culicifacies* was incriminated as principal vector[3].

Pure oil of var. *sofia* was obtained from Division of Plant Genetic Resources, Indian Agriculture Research Institute, New Delhi. Repellent action was evaluated in outdoor conditions because of sleeping habits of inhabitants in sultry and humid weather. Human volunteers were used as baits. Pure oil (1 ml) without dilution was applied on exposed parts of hands, legs, neck and face of a bait at 1800 hrs and allowed to sit or relax on cot throughout the night. Untreated (control) bait was also allowed to rest in a similar manner at a distance of 5 m. Landing mosquitoes on treated and untreated volunteers were collected throughout the night by trained insect collectors who were changed after an interval of 3 h to avoid slackness or bias.

Mosquitoes collected on baits were identified and reconfirmed with the help of hand lens in the laboratory. Position of treated and untreated baits was changed alternately to rule out site bias. One bait per night was taken as replicate and as such 12 replicates of each treated and untreated baits were made during August to October 1993.

In another experiment 100 unfed female mosquitoes collected from field were kept in each set of experiment. In one cage untreated left arm of the volunteer was allowed for feeding in captivity, while in other 0.25 ml oil was applied on left arm of another volunteer and was asked to place it inside the cage for mosquito feeding.

Feeding in mosquitoes on treated and untreated bait alongwith the time was recorded by the supervisor from dusk to dawn. Man hour density (MHD) was also monitored during study period using handcatch index.

Per cent protection was calculated by substracting total mosquitoes landed on treated bait from the untreated

bait and divided by total collected on untreated bait and multiplied by 100. Average protection time was calculated by taking an average of complete protection time of each species in all replicates.

RESULTS AND DISCUSSION

Man hour density (MHD) of mosquitoes in the study village is shown in Table 1. *An. subpictus* was predominant species followed by *Cx. quinquefasciatus*, *An. culicifacies* and *An. annularis*. During the study period the density of *Cx. quinquefasciatus* ranged between 117 to 267 and *An. culicifacies* from 72 to 191. Highest density 402 of *An. subpictus* was recorded in August followed by decline in subsequent months. Other species *Cx. tritaeniorhynchus*, *Cx. vishnui* group and *An. annularis* were prevalent but in low numbers. Occasionally few specimens of *An. stephensi*, *An. nigerrimus*, *An. pulcherrimus* and *Mansonia* spp were also recorded.

Results of evaluation against different species of mosquitoes are shown in Table 2. In general, landing rate of *An. culicifacies*, *An. subpictus*, *An. annularis* was very low in comparision to *Cx. quinquefasciatus*. Similar observations were also made during the evaluation of insecticide-impregnated rope[5]. Nevertheless, it was clearly revealed that *Cymbopogan martinii martinii* var. *sofia* oil had strong repellent action against mosquitoes. Single application of this oil provided complete protection against *An. culicifacies*, a principal vector of malaria. Similar degree of protection was evident against *An. subpictus* and *An.*

Table 1. Relative density of mosquitoes in a study village

Species	Man hour density (1993)			
	Aug	Sep	Oct	Nov
An. culicifacies	72.2	72.0	82.7	190.7
An. stephensi	0.0	0.0	0.0	0.0
An. annularis	5.7	5.2	11.5	30.7
An. subpictus	402.0	188.0	187.7	267.0
Total anophelines	479.9	265.2	281.9	488.4
Cx. quinquefasciatus	219.0	116.7	140.2	267.2
Cx. tritaeniorhynchus	12.0	5.0	2.7	0.0
Cx. vishnui	1.5	1.5	0.0	0.0
Total mosquitoes	712.4	388.4	424.8	755.6

Table 2. Efficacy of *Cymbopogan martinii martinii* var. *sofia* oil in repelling mosquitoes

Sl. No.	*An. culicifacies*			Total anopheline			*Cx. quinquefasciatus*			Total mosquitoes		
	E	C	%p	E	C	%p	E	C	%p	E	C	%p
1.	0	3	100.0	0	3	100.0	10	140	92.8	10	143	93.0
2.	0	4	100.0	0	4	100.0	8	145	94.4	8	149	94.6
3.	0	3	100.0	0	3	100.0	3	95	97.8	3	98	96.9
4.	0	3	100.0	0	3	100.0	2	94	97.8	2	97	97.9
5.	0	5	100.0	0	5	100.0	2	112	98.2	2	117	98.2
6.	0	7	100.0	0	23	100.0	3	117	97.4	3	140	97.8
7.	0	6	100.0	0	24	100.0	2	124	98.3	2	148	98.6
8.	0	9	100.0	0	11	100.0	5	136	96.3	5	147	96.5
9.	0	5	100.0	0	7	100.0	6	110	94.5	6	117	94.8
10.	0	6	100.0	0	10	100.0	4	105	96.1	4	115	96.5
11.	0	5	100.0	0	9	100.0	6	178	96.6	6	187	96.7
12.	0	4	100.0	0	6	100.0	4	153	97.3	4	159	97.4
Total	0	60	100.0± 0.0	0	108	100.0± 0.0	55	1509	96.3± 1.6	55	1617	96.5± 1.5

E – Bait treated with oil (experimental); C – Untreated bait (control); %p – Per cent protection.

annularis. However, 96.3% protection was obtained against *Cx. quinquefasciatus*, a pest mosquito and also vector of filariasis in the country.

Landing rate of mosquitoes on treated and untreated human volunteers at different time interval is shown in Table 3. Results revealed that protection time varied in anopheline and culicines. Single application of the oil resulted in complete protection from anopheline bite for 12 h in all observations. However, it varied from 7 to 12 h against *Cx. quinquefasciatus*. Average protection time during the field studies against this species was found to be 6 h.

Results of landing rate of females on human volunteers sitting at various distance from treated bait revealed that the repellent action of oil was only restricted to treated bait and oil aroma provides no protection to baits sitting at 1, 3, 5, 7 and 10 m distance away from the treated bait (Fig. 1).

Results of evaluation in captivity against *Cx. quinquefasciatus* is shown

Table 3. Landing rate of mosquitoes on *C. martinii martinii* var. *sofia* oil treated and untreated volunteers from dusk to dawn

Species	Females landed on treated/untreated human baits (hrs)						
	0700	0800	0900	1000	1100	1200	1300
An. culicifacies	0/0	0/3	0/7	0/11	0/5	0/2	0/4
An. annularis	0/0	0/0	0/0	0/0	0/2	0/0	0/0
An. subpictus	0/0	0/3	0/8	0/6	0/5	0/7	0/5
Total anophelines	0/0	0/6	0/15	0/17	0/12	0/9	0/9
Cx. quinquefasciatus	0/71	0/107	0/173	0/147	0/139	0/111	1/99
Total	0/71	0/113	0/188	0/164	0/151	0/120	1/108

Species	Females landed on treated/untreated human baits (hrs)					Total	Complete protection time
	1400	1500	1600	1700	1800		
An. culicifacies	0/6	0/4	0/7	0/7	0/4	0/60	12
An. annularis	0/0	0/0	0/0	0/0	0/0	0/2	12
An. subpictus	0/2	0/0	0/3	0/3	0/4	0/45	12
Total anophelines	0/8	0/4	0/10	0/10	0/8	0/108	12
Cx. quinquefasciatus	7/90	7/101	8/135	1/159	18/177	55/1509	6
Total	7/98	7/105	8/145	14/169	18/185	55/1617	6

Total of 12 replicates.

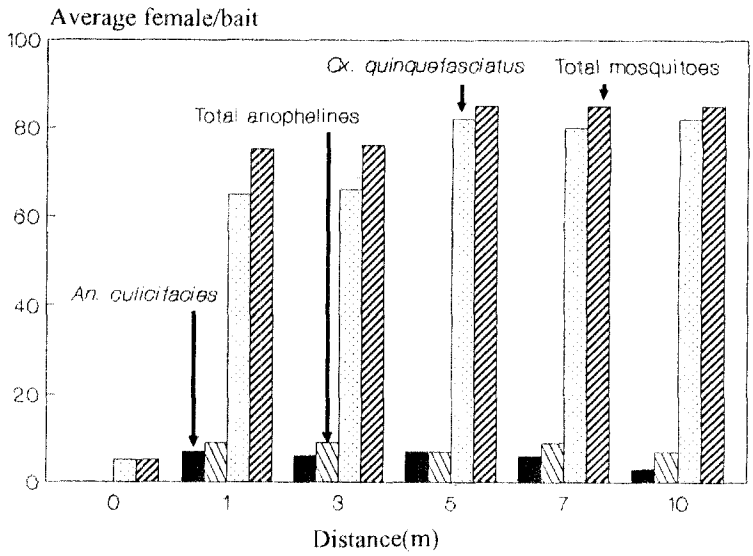

Fig. 1: Landing rate of females on baits sitting at various distances from treated bait

in Table 4. It was interesting to note that feeding in captivity was low. This may be due to light disturbance or reflex action of volunteers at probing time. Nevertheless 35.8% feeding was observed on untreated hand as against 0.4% on treated hand in captivity. The protection time varied from 5 to 10.6 h. This substantiates the earlier findings where 6 h protection time was observed. Unusually high mortality of mosquitoes was recorded in treated cages. This may be either due to starvation of females or vaporised action of oil.

The study revealed that the oil of *Cymbopogan martinii martinii* var. *sofia* could be used to repel mosquitoes in both rural and urban areas. Repellent action of citronella and lemon grass oils (*C. nardus* and *C. citratus*) is well-known and these oils are used in various creams to repel houseflies and mosquitoes[5,6]. Similarly repellent action of other essential oils viz. *Cassia*, Camphor, Wintergreen pine and Eucalyptus have also been reported and several commercial products were developed based on these essential oils. The interest in these oils was diluted with the advent of synthetic compounds diethyl toluamide (DEET)[7]. Recently, research on essential oils is being revived because of growing concern of environmentalists. Use of essential oils may be preferred over synthetic chemical based cream, coil and mats as prolonged use of synthetic chemicals could be harmful[8]. It may

Table 4. Evaluation of *C. martinii martinii* var. *sofia* oil in captivity against *Cx. quinquefasciatus*

Time (hrs)	% feeding		% mortality		% protection
	T	C	T	C	
0700	–	–	–	–	–
0800	0	1.7	21.0	0.4	100.0
0900	0	3.1	16.2	1.2	100.0
1000	0	3.2	15.1	0.6	100.0
1100	0	3.5	10.7	0.0	100.0
1200	0	4.1	9.1	0.6	100.0
1300	0.3	3.5	4.2	0.6	91.4
1400	0.1	3.0	2.7	1.0	96.6
1500	0	3.0	3.4	1.7	100.0
1600	0	3.6	2.0	1.1	100.0
1700	0	3.1	2.8	1.6	100.0
1800	0	3.7	3.4	1.7	100.0
Average	0.4	35.8	91.0	11.3	98.8±2.5

Av. of 9 replicates; 100 field collected unfed females were kept in each treated (T) and control (C) cages.

also be appropriate to bring to notice that chemical based repellents do not provide complete protection and their cost is also prohibitive for low socio-economic groups[4]. Some of them also require uninterrupted power supply which may not be available particularly in inaccessible and remote areas.

The oil of *C. martinii martinii* var. *sofia* is non-sticky with rose like aroma and will easily be socially accepted in both rural and urban areas. Present cost of 1 kg oil is Rs. 250.0 and if 1 ml is used per individual then the cost/night/individual will only be Rs. 0.25 which is affordable even by low socio-economic groups. In India the total production of oil is about 50-60 metric ton per year and its production can be further increased by cultivation of improved varieties developed by plant genetic resources[9]. It is estimated that the wasteland area in the country is about 1053 lakh hectare and if this land could be utilized for cultivation of appropriate high yield varieties of rosha grass, then the production can be further increased[10]. This would further reduce the cost of oil and will improve the economy of tribal population

where highest incidence of malaria is reported. Further studies on relative efficacy of essential oils against sandflies, houseflies and various species of mosquitoes are indicated so that environment friendly chemical free, indigenous plant base oils may be integrated to control programme. Longitudinal studies on dermal toxicity of these oils should also be carried out in view of earlier observations against lemon grass[6].

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REFERENCES

1. Maheshwari, M.L. and J. Mohan (1985). Geranyl formate and other easters in Palmarosa oil. *Pafai J.*, **7**(3): 21-26.

2. Boelesis, M.H. (1994). Sensory and chemical evaluation of tropical grass oils. *Perfumer and Flavorist*, **19**: 29-45.

3. Choudhury, D.S. (1983). Studies on resurgence of malaria in parts of northern India. In *Proceedings of Indo U.K. Workshop on Malaria*, edited by V.P. Sharma (Malaria Research Centre, Delhi): 61-71.

4. Ansari, M.A., V.P. Sharma and R.K. Razdan (1992). Esbiothrin-impregnated ropes as mosquito repellent. *Indian J. Malariol.*, **29**: 203-210.

5. Osmani, Z., I. Anees and M.B. Naidu (1972). Insect repellent cream for essential oils. *Pesticides India*, **6**: 19.

6. Curtis, C.F., J.D. Lines, Lu Baolin and A. Renz (1990). Natural and synthetic repellents. In *Appropriate Technology in Vector Control*. Ed. C.F. Curtis (CRC, Boca Raton, F.L.): 75-92.

7. Liu, W.K., M.H. Wong and Y.L. Mui (1987). Toxic effects of mosquito coil (a mosquito repellent) smoke on rats. Properties of mosquito coil and its smoke. *Toxicological Letter* (Amst.), **39**: 223-230.

8. Ansari, M.A., V.P. Sharma, R.K. Razdan and P.K. Mittal (1990). Evaluation of certain mosquito repellents marketed in India. *Indian J. Malariol.*, **27**: 57-64.

9. Pareek, S.K., M.L. Maheshwari and R. Gupta (1985). Study of palmarosa grass germiplasm, Pt III: Evaluation for high yielding genotypes at Delhi. *Indian Perfum.*, **29**: 209-214.

10. Kothari, S., K.K. Singh, S.P.S. Duhan and D.V. Singh (1987). Cultivation of aromatic grasses for wasteland utilization. *Indian Farmer's Digest*, **20**(1-2): 7-12.

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Resting and Biting Habits of *Anopheles sundaicus* in Car Nicobar Island

ROOP KUMARI and V.P. SHARMA[a]

Resting and biting habits of *An. sundaicus* were studied in Car Nicobar Island. Results of resting behaviour revealed that although substantial numbers of *An. sundaicus* rest outdoor, still the species prefer to rest indoors, and much less in human dwellings. High parity rate (73.38%) in *An. sundaicus* and close contact with man were the factors responsible for high transmission in Car Nicobar. *An. sundaicus* population in Car Nicobar is susceptible to DDT. Indoor man-biting of *An. sundaicus* was significantly higher than outdoors and the species showed bimodal biting activity with first peak between 2130 to 2230 hrs and second between 0130 to 0230 hrs. *An. sundaicus* preferred to feed on people's legs and hands. Due to complex behaviour of *An. sundaicus*, an integrated approach comprising (i) chemical, (ii) bioenvironmental control, and (iii) personal protection methods was suggested to interrupt malaria transmission in Car Nicobar Island.

Keywords: *An. sundaicus*, Bionomics

INTRODUCTION

In Car Nicobar, *Anopheles sundaicus* (Rodenwaldt) is the known malaria vector and maintains high endemicity of malaria[1,2]. According to NMEP report between 1981-1991, API and AFI was 44.6 to 201.9 and 7.0 to

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30.3 respectively. Malaria control is carried out by spraying 3 rounds of DDT (75%), weekly antilarval oiling, thermal malathion fogging, and active and passive surveillance by NMEP. Efforts to curtail malaria for the last three decades are quite unsuccessful.

A review of the literature revealed that *An. sundaicus* was endophilic and endophagic in Andaman and Nicobar[3]. However, it has been reported that it is completely an exophagic and exophilic in Andaman and Great Nicobar Islands because of selection resulting from excito-repellency of DDT spray[4]. In Car Nicobar Island, mosquito survey was carried out by Krishnan and Bhatnagar[2] and they did not find *An. sundaicus* in outdoor resting places. In view of the changed behaviour of *An. sundaicus* in Andaman it was important to study the feeding and resting behaviour of this species in relation to transmission of malaria. Results of the study are reported below.

MATERIALS AND METHODS

Study area

Andaman and Nicobar Islands are situated in the Bay of Bengal. Northern most Island of Nicobar group of Islands is Car Nicobar, situated between 6^0 and 10^0 N latitude. The Island is almost plain and made of coral reefs. It has an area of 127 sq km with a population of 22,000 living in 17 villages. Studies were carried out mainly in four villages viz. Kimios, Kakana, Sawai and Malaka while random mosquito collection was also done in other villages (Fig. 1).

Climate

The humidity and temperature on the Island varies from 60 to 90% and 27 to 32^0C respectively. Rainy season starts from May and continues till December/January. Car Nicobar Island is under the belt of tropical monsoon evergreen forests and receives a total of about 3000 mm/year rainfall from both southwest and northeast monsoon.

Resting collection

Daytime resting collections: Regular fortnightly adult mosquito collections were made from April 1990 onwards for a period of one year from different indoor and outdoor resting shelters. In indoor collections, mosquitoes were collected from human dwellings and cattlesheds and also from abandoned and disused *copra machans*, a small hut made up of bamboo and dry coconut leaves with a perforated platform of split bamboo about 2 to 3 ft above the ground level, used for drying endosperm of coconut fruits (*Coccus nucifera*). When *copra machans* is not in use pigs and goats rest below the platform. Outdoor shel-

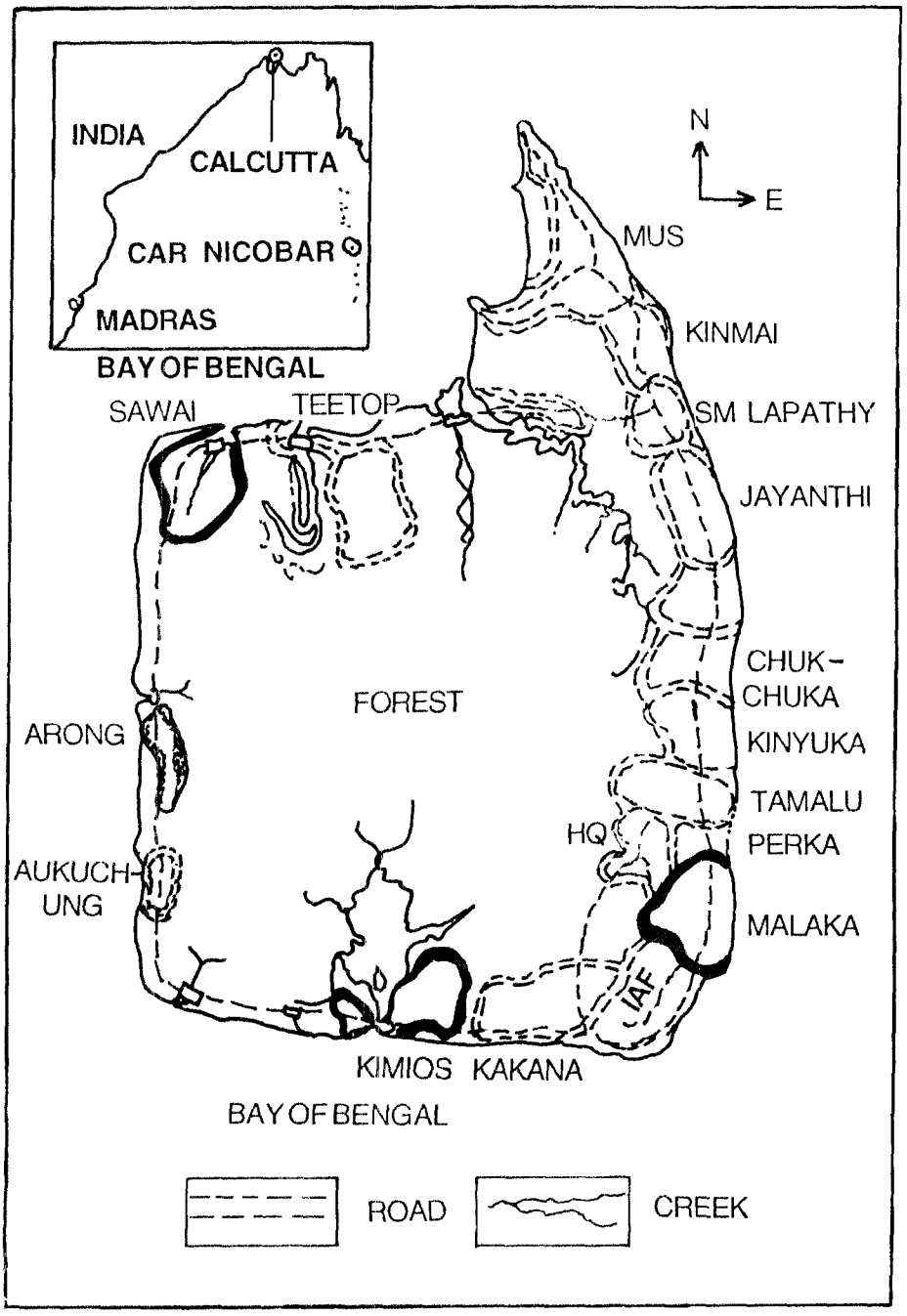

Fig. 1: Map of Car Nicobar showing study villages

ters included bushes, tree holes, coconut shells, dry leaves, pit shelters, concrete bridges, mangrove root, canoe, crab holes and tyres. The searches were made during morning (0500 to 0800 hrs) and daytime by suction tube method. Mosquitoes were also collected from bushes and grass using drop nets.

All collected mosquitoes were identified and processed for parity, oocyst, sporozoite rate and gonotrophic status of *An. sundaicus* population.

Night hour resting collections: During the study period (April 1990 to January 1991), ten whole night mosquito collections were made from different indoor and outdoor resting places for 15 min from 1700 to 0600 hrs. All field collected mosquitoes were kept in test tubes at each hour to observe the abdominal condition of vector species.

Biting collections

Indoor and outdoor biting collections were made fortnightly in study villages between October 1989 and November 1990, monthly from 1990 to 1991. In biting collections, two sets of insect collectors, one for outdoor and other for indoor were present. In each set, two men each were made to sit opposite each other, one served as a bait by exposing his hands and lower parts of the legs and the other with a torch light and a suction tube to catch the mosqutoes landing or probing on bait. Mosquitoes collected in each hour were kept separately with proper marking on the test tubes and brought to the laboratory for species identification. 19 whole night collections with two human baits were performed to study the biting preference of *An. sundaicus* on different parts of the body viz. hand, leg, back, belly, shoulder, face and chest.

Susceptibility test

Susceptibility of *An. sundaicus* collected from Car Nicobar Island was tested against 4% DDT and 5% malathion impregnated papers according to the WHO standard test procedure[5].

RESULTS

Resting habits

Table 1 shows the total numbers of *An. sundaicus* collected from different resting habitats in Car Nicobar Island. Out of 2194 *An. sundaicus*, 1672 (76.21%) were collected from indoor resting shelters, whereas only 522 (23.79%) were collected from outdoor resting shelters. Amongst the indoor resting shelters, during day time, man hour density (MHD) of *An. sundaicus* was higher in *copra machans* (MHD 44.13) followed by cattlesheds (MHD 32.92) as compared to human dwellings (MHD 2.66). In-

Table 1. Daytime resting of *An. sundaicus* in Car Nicobar

Sl. No.	Type of structure searched	Sites checked	No. of *An. sundaicus*	Man hour density
	Indoor resting			
1.	*Copra machans*	60	662	44.13
2.	Cattlesheds	112	922	32.92
3.	Human dwellings	132	88	2.66
	Total	304	1672	26.57
	Outdoor resting			Density per shelter
1.	Creek bank (linear)	16 km	22	1.37
2.	Pundanus bushes	390	289	0.74
3.	Bamboo and other bushes	390	61	0.15
4.	Dry grasses	48 m^2	13	0.27
5.	Canoe	74	15	0.20
6.	Pit shelters	44	8	0.18
7.	Mangrove root	220	22	0.10
8.	Coconut dry leaves	840	92	0.10
9.	Coconut tree and coconut shells	1514	0	0
10.	Tree and crab holes	1352	0	0
11.	Concrete culverts and bridge	28	0	0
12.	Tyres and cement tanks	64	0	0
	Total	4916	522	0.106

side the *copra machans* and cattlesheds, 80 per cent *An. sundaicus* were caught from dry coconut leaves hanging down from their roofs while in human dwellings most of them were collected from spider webs, clothes, shaded corners in between bamboo splits etc.

In outdoor natural shelters, density per shelter (DPS) of *An. sundaicus* was higher in creek bank (DPS 1.37) followed by Pandanus bushes (DPS 0.74), dry grasses (DPS 0.27), canoe (DPS 0.20), pit shelters (DPS 0.18), Bamboo and other bushes (DPS 0.15), mangrove root (DPS 0.10)

and dry coconut leaves (DPS 0.10) (Table 1).

Results of whole night hourly collection of *An. sundaicus* from different resting places are given in Table 2. Results revealed that whole night average man hour density was higher in cattlesheds followed by *copra machans* (8.76), outdoor structure (4.133) and human dwellings (3.00). Vector density was significantly low in human dwellings than cattlesheds (t = 6.169; $p < 0.001$) or *copra machans* (t = 3.817; $p < 0.01$). Similarly average vector density in outdoor shelters was significantly low as compared to indoor dwellings viz. cattlesheds (t = 5.066; $p < 0.001$) and *copra machans* (t = 1.693, $p < 0.01$), while insignificant in human dwellings (t = 1.33; $p > 0.05$). In cattlesheds and in *copra machans* the average vector density was high be-

Table 2. Whole night collection of *An. sundaicus* from different resting* places in Car Nicobar

Collection time 15 min/hrs	Cattlesheds (CS) Av. ± SE	*Copra machans* (CM) Av. ± SE	Human dwellings (HD) Av. ± SE	Outdoor structure (OS) Av. ± SE
1700-1800	2.5±0.792	1.8±0.489	1.2±1.200	2.3±0.366
1800-1900	1.6±0.733	1.8±1.072	0.2±0.130	1.2±0.291
1900-2000	1.5±0.687	2.9±0.982	0.5±0.223	0.5±0.166
2000-2100	2.8±3.293	3.0±0.988	1.2±0.388	0.7±0.260
2100-2200	5.7±1.003	5.0±1.192	1.2±0.359	1.2±0.290
2200-2300	4.4±1.765	3.0±0.988	0.7±0.266	2.1±0.348
2300-2400	3.0±0.919	1.0±0.322	0.6±0.221	0.8±0.200
2400-0100	2.6±1.077	1.2±0.326	0.5±0.223	0.7±0.213
0100-0200	2.9±1.286	1.1±0.348	0.8±0.290	1.1±0.378
0200-0300	2.5±1.439	3.3±1.317	1.3±0.442	1.0±0.333
0300-0400	4.2±1.340	1.5±0.452	0.7±0.260	0.5±0.234
0400-0500	2.4±0.777	0.7±0.221	0.1±0.100	0.3±0.142
MHD	11.66	8.76	3.00	4.133
Av. nos. per night ± SE	30.08±3.81	21.91±3.992	7.5±1.275	10.33±1.780

*Catches during night were made either in the pre-biting or post-biting resting phase, not directly on baits; t values: HD vs CS: 6.16, $p < 0.001$; HD vs CM: 3.81, $p < 0.01$; HD vs OS : 1.33, $p > 0.05$; CS vs CM : 1.625, $p < 0.1$; OS vs CM: 1.693, $p < 0.1$; OS vs CS : 5.066, $p < 0.001$.

tween 2100 and 2200 hrs, while in human dwellings there were two peaks of density, one was between 2000 to 2100 hrs and another from 0200 to 0300 hrs.

Gonotrophic studies: Gonotrophic relation of day time resting *An. sundaicus* was also observed which provided additional information on the degree of outdoor resting. Results of this study are given in Table 3. Percentage composition of semi-gravid was higher in total vector population and their percentage composition in outdoor and indoor collections were almost equal.

Parity rate: The proportion of multiparous and nulliparous *An. sundaicus* was estimated (Table 3). Among 1176 females dissected, 863 were multiparous with a parity rate of 73.38 per cent and none was found positive for sporozoites or oocyst.

Biting habits

Results of man biting activity of *An. sundaicus* are summarized in Table 4. A total of 1850 *An. sundaicus* were collected on human baits, i.e. 1291 (69.78%) on indoor biting and 559 (30.22%) on outdoor biting. Feeding activity of *An. sundaicus* was very high during the second and third quarter of the night. A bimodal biting behaviour was observed for *An. sundaicus* with a predominant peak between 2130 and 2230 hrs and a slight increase between 0130 and 0230 hrs.

Seasonal variation in biting activity of *An. sundaicus* is given in Table 5. Biting per night increased from May

Table 3. Abdominal condition of *An. sundaicus* in the indoor and outdoor daytime resting collections

Habitat	Mosquitoes collected		Abdominal condition				No. dissected	Nulli-parous	Parous	Gut/gland positive	Parity rate
	M	F	UF	FF	SG	G					
Outdoor	47	75	10	15	41	9	48	17	31	0	64.58
	(38.5)	(61.5)	(13.3)	(20)	(54.7)	(12)					
Indoor	269	1403	50	294	824	235	1128	296	832	0	73.75
	(16.1)	(83.9)	(3.6)	(20.9)	(53.7)	(16.8)					
Total	316	1478	60	309	865	244	1176	313	863	0	73.38
	(17.6)	(82.4)	(4.1)	(20.9)	(58.5)	(16.5)					

M – Male; F– Female; UF – Unfed; FF – Fully fed; SG – Semi-gravid; G – Gravid; Figures in parentheses are in per cent.

Table 4. Man biting rate of *An. sundaicus* in Car Nicboar*

Time (hrs)	Indoor biting		Outdoor biting	
	No. of mosquitoes	%	No. of mosquitoes	%
1730-1830	54	55.67	43	44.33
1830-1930	80	70.17	34	29.83
1930-2030	132	73.33	48	26.67
2030-2130	145	68.27	66	31.73
2130-2230	208	77.32	61	22.68
2230-2330	135	65.53	71	34.47
2330-2430	118	69.41	52	30.59
2430-0130	111	65.68	58	34.32
0130-0230	142	73.58	51	26.42
0230-0330	109	71.24	44	28.76
0330-0430	39	62.90	23	37.10
0430-0530	18	69.23	8	30.77
Bite/man/night	33.97	69.78	14.71	30.22

*Pooled collection for 38 nights.

Table 5. Seasonal prevalence of *An. sundaicus* collected on human bait

Months	Indoor	Outdoor	Total
	Bite/man/night (%)	Bite/man/night (%)	Bite/man/night
Jan	33.00 (63.46)	19.00 (36.54)	26.00
Feb	3.00 (60.00)	2.00 (40.00)	2.5
Mar	9.33 (71.82)	3.66 (28.18)	6.49
Apr	15.50 (67.40)	7.50 (32.60)	11.50
May	18.50 (72.55)	7.00 (27.45)	12.75
Jun	20.50 (58.86)	14.33 (41.14)	17.40
Jul	313.00 (90.99)	31.00 (9.01)	172.00
Aug	32.00 (41.86)	44.44 (58.14)	38.22
Sep	25.66 (56.20)	20.00 (43.80)	22.83
Oct	46.22 (60.40)	30.30 (39.60)	38.26
Nov	25.00 (62.50)	15.00 (37.50)	20.00
Dec	55.66 (79.90)	14.00 (20.10)	34.83

to June and reached its peak in July and it was quite low during January-February and April-May (dry season). Outdoor biting percentage varies from 27.45 to 58.14% except in the month of July (9.01%) and December (20.10%) which may be due to inclement weather.

During monsoon, indoor biting significantly increased in one of the study villages (Kimios) due to heavy rainfall in July 1991, 97.35% indoor biting on man was observed.

Table 6 gives the results of feeding preference of *An. sundaicus* on human bait. Results revealed that out of 1850 *An. sundaicus*, 1136 (61.42%) were found biting on legs and 470 (25.41%) on hands, while few were collected from the back (7.13%), shoulder (2.59%), face (2.10%), belly (1.13%) and chest (0.22%).

Mortality of *An. sundaicus* on 4% DDT and 5% malathion impregnated papers was 87.72 and 99.08% respectively.

DISCUSSION

Resting habits

76.2 and 23.79% adult *An. sundaicus* were caught from indoor and outdoor shelters respectively with equal proportion of semi-graivd and gravid female in indoor and outdoor collections. These results suggest that *An. sundaicus* rest both in indoor and outdoor shelters. *An. sundaicus* was reported endophilic and endophagic in Andaman and Nicobar Islands by Covell[3] while Krishnan and Bhatnagar[2] found no *An. sundaicus* from outdoor structures in the Car Nicobar Island. Exophilic population of *An. sundaicus* was reported from Sipighat (South Andaman) and Campbell Bay (Great Nicobar) of Andaman and Nicobar Islands by Kalra[4]. It is interesting to note that in natural outdoor shelters *An. sundaicus* prefers to rest inside the dry leafy bushes of Pandanus plant (a plant of commercial value), which is very common in Car Nicobar. Resting of *An. sundaicus* was also found in creek bank, bamboo bushes, pit shel-

Table 6. Biting sites of *An. sundaicus* on human bait

Total captured	No. collected from						
	Face	Shoulder	Chest	Belly	Back	Hand	Legs
1850	39	48	4	21	132	470	1136
	(2.10)	(2.59)	(0.22)	(1.13)	(7.13)	(25.41)	(61.42)

Figures in parentheses are in per cent.

ter, coconut dry leaves, mangrove root and grasses. It may be noted that searches were also made in trees, coconut shells, tree holes, outside cemented tank, crab holes, tyres, concrete culverts and bridges and no specimen of *An. sundaicus* were observed. The above behaviour implies that humidity plays an important role in resting of *An. sundaicus*.

The results of night collections indicate that feeding activity is generally confined to the final resting sites. However, outdoor day time sample was not found to commensurate to night activity under outdoor conditions. This may be due to difficulty of sampling under outdoor conditions, because of inaccessibility. Besides human dwellings and cattlesheds, freshly fully fed *An. sundaicus* were also collected throughout the night from *copra machans* (FF 73.76%) and from outdoor structure (FF 50.46%) indicating that this mosquito rests in these structures after feeding on either man or animals. Throughout the study it was found that *copra machans* provided the most suitable habitat for resting of *An. sundaicus*. This excito-repellency may be the result of DDT spraying in houses. Although *An. sundaicus* resting populations were higher in cattlesheds than human dwellings, apparent lack of excito-repellent was the result of poor and often not sprayed resting places like the bamboo splits and hanging dry coconut leaves of the cattlesheds. In Car Nicboar a high parity rate of 73.38% of *An. sundaicus* suggested extended longevity which in turn maintains high transmission.

Breakup of the physiological stages indicate that both indoor and outdoor semi-gravid percentage is higher than unfed, fully fed and gravid percentages (Table 3). High percentage of semi-gravid indicate that the species tend to leave the resting site and come to surface in preparation to leave out while lower percentage of fully gravid show that the species do not complete the gonotrophic cycle indoor and tend to leave the indoor shelter at semi-gravid stage.

Biting habits

Results of biting collections revealed that indoor man biting by *An. sundaicus* was significantly higher than outdoor man biting ($t = 4.598$; $p < 0.001$). Biting activity of *An. sundaicus* was found to be very high during the second and third quarter of the night with a bimodal biting peak. Similar biting behaviour was observed in Indonesia[6], Kamorta and Great Nicboar[7]. In night resting collections, two peaks of resting mosquitoes were observed in every resting shelter in the study villages.

Seasonal variation in biting activity of *An. sundaicus* was observed in Car

Nicboar, a higher rate of bite per man density was noticed during May to December (Table 5) when temperature and humidity were most favourable for mosquito multiplication. Most preferred feeding sites of *An. sundaicus* on human bait was ankle, legs and hands.

Our study clearly shows that *An. sundaicus* of Island ecosystem are hygrophilic species, as per the description of Kalra[8]. This species have adapted to higher threshold of humidity and are indescriminate feeders. They prefer domestic animals[9] but easily bite man also. The species is found to rest in both indoors as well as outdoors which are influenced by the environment. Excophilic nature of *An. sundaicus* poses a great problem to interrupt transmission by residual inseciticide.

Since *copra machans* provide most suitable resting shelters to indoor dwelling *An. sundaicus*, it should also be included for spraying to produce impact on malaria transmission. Proper cleaning of Pandanus, bamboo and other bushes, dry grasses and coconut garden should be performed through the involvement of community participation[10] to lessen exophilic population. Presence of 38.5 and 16.1% males in the outdoor and indoor resting collections respectively indicate proximity of breeding sites which should be eliminated by using biological control and environmental methods[11]. Our study clearly reveals that *An. sundaicus* is highly endophagic with two biting peaks and preferred to bite on legs and hands as compared to other parts of the body, therefore the use of personal protection methods like repellents, insecticide-impregnated bednets and mats could be useful to reduce infective bites particularly during the peak biting period. It may be noted that due to the complex behaviour of *An. sundaicus* in Car Nicobar Island, an integrated approach with the use of chemial insecticides, bioenvironmental control and personal protection methods coupled with prompt case detection and treatment should be used to interrupt malaria transmission.

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REFERENCES

1. Basu, P.C. (1958). A note on malaria and filariasis in Andaman and Nicobar, *Bull. Nat. Soc. Ind. Mal. Mosq. Dis.*, **6:** 193-206.
2. Krishnan, K.S. and V.N. Bhatnagar (1968). A note on Anophelines of Car Nicobar Islands (India). *Bull. Ind. Soc. Mal. Com. Dis.*, **5:** 97-101.

3. Covell, G. (1927). Report of an enquiry into malaria conditions in the Andamans. (Government Press, Delhi).

4. Kalra, N.L. (1980). Emergence of malaria zoonosis of simian origin as natural phenomenon in Greater Nicobar, Andaman and Nicobar Islands — A preliminary note. *J. Com. Dis.*, **12:** 49-54.

5. WHO (1975). *Manual on Practical Entomology in Malaria.* Pt II. In *Methods and Techniques* (WHO, Geneva): 141-147.

6. Sundararaman, S., R.M. Soeroto and M. Siram (1957). Vector of malaria in mid-Java. *Indian J. Malariol.*, **11:** 321-338.

7. Das, S.C., D.R. Nath, M. Bhuyan, N.G. Das, I. Baruah and P.K. Talukdar (1989). Studies on malaria and filariasis vectors in Kamorta and Great Nicobar Islands. *Indian J. Malariol.*, **26:** 153-157.

8. Kalra, N.L. (1991). Forest malaria vectors in India: Ecological characteristics and epidemiological implications. *Forest Malaria in Southeast Asia.* In *Proceedings of Informal Consultative Meeting WHO/MRC.* Eds. V.P. Sharma and A.V. Kondrashin (Malaria Research Centre, Delhi): 93-114.

9. Kumari, Roop, Hema Joshi, A. Giri and V.P. Sharma (1993). Feeding preferences of *Anopheles sundaicus* in Car Nicobar Islands. *Indian J. Malariol.*, **30:** 201-206.

10. Sharma, V.P. (1994). Malaria Control: Bioenvironmental methods and community participation. In *Community Participation in Malaria Control,* edited by V.P. Sharma (Malaria Research Centre, Delhi): 1-42.

11. Sharma, V.P. (1987). Community based malaria control in India. *Parasitol. Today,* **3:** 222-226.

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Distribution and Relative Prevalence of Anophelines in District South 24-Parganas, West Bengal, India

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The anopheline survey of district South 24-Parganas revealed presence of sixteen species including *Anopheles annularis*, *An. subpictus*, *An. fluviatilis*, *An. varuna*, *An. culicifacies* and *An. sundaicus* known to be associated with malaria transmission in the country. A total of 14, 12 and 8 species were encountered in cattlesheds (CS) in contrast to 7, 5 and 4 species in human dwellings (HD) during monsoon, winter and summer respectively. The population density of anophelines in CS was significantly higher than in HD in all the three seasons.

Keywords: *Anopheles*, Anopheline fauna

INTRODUCTION

Apart from a preliminary report on the mosquito fauna of district South 24-Parganas[1,2], all other investigations on the distribution of the anophelines and incrimination of the various vector species in the study area were conducted in the early part of the century[3-6]. In view of the resurgence of malaria in the study area, it was deemed necessary that the anopheline fauna of the said area be re-explored with special reference

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to the distribution, prevalence, density of vector species and their bionomics in the light of changed ecological conditions. The present investigation incorporates the findings of the study organised during 1991-92.

Study area

District 24-Parganas is situated in the southeast corner of West Bengal and is the largest district of the State. Nearly one third of its southern part is covered by dense Sundarban forest, through which flow big and small creeks. The longer creeks Matla, Gausaba, Haraibhanga and a few others form the mouths of the Ganga. River Hugli flows on the west of Sundarbans, with Sagar Island on the east of estuary. The central portion of the district is marshy, while the northern part is fertile and densely populated. The chief crop is paddy, although some oil seeds and pulses are also grown. Reclamation of forests is in progress in the southern part of the district, which is very fertile.

Of the 29 blocks in district South 24-Parganas, Canning, Kakdwip, Diamond Harbour and Lakshmikantpur are small ports. The houses in the villages are mainly made of mud walls with thatched roofs; only 5% houses had brick walls plastered with mud and thatched roofs. The human cattle ratio was 6.5:2.

The temperature and humidity in summer ranged between 32-36.5°C and 60-65%; in winter 10-18.5°C and 42-45.3%; and in monsoon 28-31°C and 72-77% respectively.

METHODOLOGY

An anopheline survey was conducted in 22 blocks (seven blocks of the district have two parts) of district South 24-Parganas during monsoon (July-October 1991). The 22 blocks of district South 24-Parganas were classified into northern region consisting of eight blocks (Maheshtaia, Baj Baj, Bishnupur, Falta, Sonarpur, Bhangar, Baruipur and Canning), a central region, consisting of five blocks (Diamond Harbour, Mograhat, Mandirbazar, Joynagar, Thakurpukur) and a southern region, consisting of nine blocks (Kulpi, Mathurapur, Kultali, Basanti, Kakdwip, Sagar, Namkhana, Patharpratima, Gosaba) respectively. Collection of mosquitoes was done from fixed number of cattlesheds (CS) and equal number of human dwellings (HD) in each of the three regions of district South 24-Parganas for 10 min in each habitat with a view to compare the distribution and prevalence of the anopheline species in the northern, central and southern areas of district South 24-Parganas.

Survey in eleven representative blocks namely Sagar, Kakdwip, Kulpi, Diamond Harbour, Thakurpukur, Mogra-

hat, Joynagar, Baruipur, Canning Maheshtala and Sonarpur was also conducted for a period of one year from July 91 to June 92 to study and compare the relative prevalence and density of indoor resting anopheline species in monsoon, winter and summer respectively.

Outdoor resting sites such as bushes, shrubs, bark of trees, outer surface of walls of human dwellings and cattlesheds were also searched for outdoor resting anophelines.

RESULTS

A total of 19,988 anophelines (CS 83.91%, HD 16.08%) distributed over 14 species were collected during monsoon (Jul-Oct 1991) in a survey conducted indoors in 22 blocks (divided into northern, central and southern zone) of district South 24-Parganas (Table 1).

The data revealed that density of anophelines in cattlesheds (in all the three zones) was significantly higher

Table 1. Distribution and relative prevalence of anopheline species in southern, central and northern blocks of District South 24-Parganas during monsoon (July 1991 to October 1991).

Sl. No.	Species	Southern zone MHD		Central zone MHD		Northern zone MHD	
		CS	HD	CS	HD	CS	HD
1.	*An. hyrcanus* gr.	11.3	3.50	11.91	1.75	8.3	3.83
2.	*An. barbirostris*	11.06	1.13	6.5	0.91	5.0	0.91
3.	*An. vagus*	3.28	4.87	0.52	1.83	6.5	8.0
4.	*An. subpictus**	2.53	0.87	1.41	0.41	1.08	0.6
5.	*An. annularis**	11.62	0.08	5.0	0.83	23.0	0.16
6.	*An. culicifacies**	0.84	0.08	0.4	0.58	0.16	–
7.	*An. aconitus*	1.43	0.04	0.5	1.16	0.33	–
8.	*An. varuna**	0.03	0.12	–	–	0.33	–
9.	*An. tessellatus*	0.34	–	–	–	0.66	–
10.	*An. pseudojamesi*	6.72	–	–	–	–	–
11.	*An. jamesii*	2.21	–	0.83	–	–	–
12.	*An. pulcherrimus*	3.59	0.04	1.0	–	0.75	–
13.	*An. sundaicus**	1.75	–	–	–	–	–
14.	*An. fluviatilis**	1.43	–	3.5	–	–	–

*Vector species.

than in human dwellings of the corresponding zones respectively. In cattlesheds of the southern zone all the fourteen species were encountered in contrast to 10 species each in CS of central and northern zones respectively. In human dwellings of southern, central and northern blocks of the study area, 9,7 and 5 anopheline species were found respectively. Six and 4 vector species respectively were encountred in CS and HD of the southern zone, in contrast to 4 and 3 vector species each in CS and HD in the central and 4 and 2 vector species in the CS and HD of northern zone of district South 24-Parganas respectively.

A survey conducted for a period of one year (July 91 to June 92) in district South 24-Parganas revealed that indoor resting anopheline fauna comprised 16 species including six known to be associated with malaria transmission (Table 2). Anophelines collected from outdoor resting habitats consisted of six species only.

Analysis of data reveals that the density of anophelines in cattlesheds (CS) was significantly higher than in human dwellings (HD) in each of the three areas during monsoon, winter and summer. Of the six vector species encountered in the study area, 3 (*An. subpictus*, *An. culicifacies*, *An. annularis*) were found in HD in monsoons, and only 1 each in winter (*An. annularis*) and summer (*An. subpictus*) respectively. *An. varuna*, *An. sundaicus* and *An. fluviatilis* were found in CS only. It is also evident from the data that vector densities (MHD) in CS and HD were almost equally low, except with respect to *An. annularis*, in CS in monsoon and winter respectively (Table 2).

DISCUSSION

An. annularis and *An. subpictus* were most prevalent amongst vector species, being found in cattlesheds and human dwellings in all the blocks of the study area. *An. culicifacies* though encountered in CS of northern, central and southern blocks were found in HD of southern and central blocks only. *An. varuna* on the other hand, was encountered in CS and HD in southern zone, and in CS of the northern zone only. *An. sundaicus* was found only in CS of southern zone and *An. fluviatilis* in CS of southern and central zone respectively. The MHD of each species is shown in Table 1.

It is worth pointing out that *An. culicifacies* was found both in CS (MHD 0.18) and HD (MHD 0.32) in monsoons only. *An. fluviatilis* and *An. sundaicus* were found in CS; the former in all the three seasons but the latter in monsoon and winter only (Table 2).

Earlier studies reveal that *An. varuna*, *An. sundaicus*, *An. philippinensis* and

Table 2. Relative prevalence and man hour density (MHD) of anopheline species in 11 representative blocks of district South 24-Parganas in monsoon, winter and summer (July 1991 to June 1992)

Sl. No.	Species	Monsoon (Jul 91 - Oct 91) MHD		Winter (Nov 91 - Feb 92) MHD		Summer (Mar 92 - Jun 92) MHD	
		CS	HD	CS	HD	CS	HD
1.	*An. hyrcanus* gr.	10.91	3.68	23.86	2.0	5.86	0.55
2.	*An. barbirostris*	11.09	1.68	15.87	0.09	6.27	0.36
3.	*An. vagus*	1.23	5.55	1.86	5.5	6.17	3.27
4.	*An. subpictus**	1.82	0.91	4.69	–	2.68	0.27
5.	*An. aconitus*	1.73	0.77	6.5	0.13	0.36	–
6.	*An. varuna**	0.18	–	0.22	–	–	–
7.	*An. culicifacies**	0.18	0.32	–	–	–	–
8.	*An. sundaicus**	1.68	–	0.68	–	–	–
9.	*An. annularis**	21.14	0.09	21.22	0.22	3.18	–
10.	*An. fluviatilis**	3.36	–	2.31	–	0.55	–
11.	*An. pseudojamesi*	3.27	–	1.59	–	–	–
12.	*An. jamesii*	1.86	–	–	–	–	–
13.	*An. theobaldi*	–	–	6.22	–	–	–
14.	*An. pulcherrimus*	2.95	–	–	–	–	–
15.	*An. tessellatus*	0.31	–	0.86	–	–	–
16.	*An. jeyporiensis*	–	–	–	–	6.45	–

*Vector species.

An. annularis[3,4,7] were found infected in nature, though Ganguli[8] observed otherwise with respect to *An. annularis*. During the course of the present investigation, *An. varuna* and *An. sundaicus* were found only in cattlesheds in monsoon and winter. In summer, however, the two species were not encountered in either habitat.

It is also to be pointed out that *An. philippinensis* was not found in the study area during the course of the present investigation. Disappearance of *An. philippinensis* from rural Bengal has already been reported[7], though its presence in one endemic area was reported later[9].

An. annularis which has been incriminated as the vector of malaria in rural Bengal[10], was found in significantly large numbers in cattlesheds but strikingly low numbers in human dwellings during monsoon

and winter. In summer, however, the species was found in low numbers in cattlesheds and not at all in human shelters (Table 2).

It is evident from the study that the anopheline fauna of different blocks of the district differed from each other. The deltaic blocks were richer both with regard to diversity and density of the anopheline species including the vector species.

It is also worth pointing out that collection of *An. sundaicus* from the deltaic blocks is noteworthy, specially when claims of disapperance of the species had been made[11].

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REFERENCES

1. Mahapatra, Mita S., Sukumar Das and Neelam Tandon (1991). Mosquito fauna of certain areas of deltaic West Bengal – A preliminary report. *Indian J. Malariol.*, **28:** 45-50.
2. Bhattacharya, S., I. Sen and N. Tandon (1992). Preliminary observation on the distribution of anopheline species in deltaic zone of the West Bengal. In *Proceedings of the Zoological Society, Calcutta. Symposium on Zoological Research in Relation to Man and Environment*, March 1-4, **45**(Suppl A): 331-334.
3. Iyengar, M.O.T. (1931). The distribution of *An. ludlowi* in Bengal and its importance in malaria epidemiology. *Indian J. Med. Res.*, **19:** 499-539.
4. Iyengar, M.O.T. (1940). Further observations on the vectors of malaria in Bengal and notes on the seasonal infectivity of *Anopheles*. *J. Mal. Inst. India*, **3:** 115-123.
5. Iyengar, M.O.T. (1942). Studies on malaria in the deltaic region of Bengal. *J. Mal. Inst. India*, **4:** 435-446.
6. Sen, P. (1937). The relative prevalence of Anophelines in houses and cattlesheds in deltaic Bengal. *Rec. Mal. Surv. India*, **7:** 147-153.
7. Anon. (1970). Report of the in depth evaluation of National Malaria Eradication Programme, Pt III (Directorate of National Malaria Eradication Programme, New Delhi): 6.
8. Ganguli, N. (1947). Preliminary note on the investigations of malaria in Bengal – Orissa border, south of Khargpur. *Indian J. Malariol.*, **1:** 289-300.
9. Hati, A.K. (1980). Distribution of *Plasmodium falciparum* in West Bengal. *Trans. R. Soc. Trop. Med. Hyg.*, **74:** 420.
10. Ghosh, K.K., S. Chakraborty, S. Bhattacharya, A. Palit, Neelam Tandon and A.K. Hati (1985). *Anopheles annularis* as a vector of malaria in rural West Bengal. *Indian J. Malariol.*, **22:** 65-69.

11. Basu, Mallik, K.C. (1989). *Malaria in West Bengal.* First ed. (Sri Kanta Basu Mallik, P-185, C.I.T. Scheme, VI-M, Calcutta-54): 55.

SHORT NOTES

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Field Evaluation of Mosquito Repellent Action of Neem Oil

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Keywords: *Azadirachta indica*, Mosquitoes, Neem oil, Repellent

The neem tree (*Azadirachta indica*) products were well-known for insect repellent and antifeedant properties long before the advent of synthetic insecticides. In recent years neem has received worldwide attention for its usefulness in insect control. Neem is characterised by multiple mechanism of action on insects, and use of its several constituents in agriculture have already been reported[1-3]. Various parts of the tree are being used in India for several millennia for medicinal purposes, and Ayurveda regards the tree as *sarva roga nivarni* (cure for all diseases).

Malaria control is beset with multifaceted problems[4] and requires simple non-toxic and cost-effective remedies. In view of this an attempt was made to evaluate the repellent action of neem oil against mosquitoes with particular emphasis on vectors of human diseases. Larvicidal action of different fractions of neem on *An. stephensi*, *Cx. quinquefasciatus* and *Ae. aegypti* is well documented[5-7].

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To test the efficacy of neem oil as mosquito repellent, all night man-biting collections were carried out in Galteshwar (a hamlet of village Sarnal in Thasra taluka), Lingda and Kanjari villages of Kheda district in Gujarat during the months of March and April 1993. Galteshwar (pop. 252) is situated on the bank of the perennial river Mahi and on the basis of pretest collections, the malaria vector *An. culicifacies* was found to be the predominant mosquito species. Lingda (pop. 3758) in Anand taluka is situated in irrigated area and rice is the main crop, cultivated twice a year. Mosquito fauna comprises various anopheline and culicine species in different proportions. Kanjari (pop. 11000) is a semi-urban locality in Nadiad taluka and the mosquito fauna is dominated by *Cx. quinquefasciatus*.

Neem oil (marketed by M/s. Shree Baidyanath Ayurved Pvt. Ltd., Nagpur) was mixed at 0.5, 1 and 2% strength (v/v) in coconut oil (Parachute brand). Five ml oil was applied on face, arms and legs of three different volunteers. Similarly, 5 ml coconut oil was applied on one volunteer to serve as control. Volunteers were allowed to sit or relax under a shelter from 1900 to 0600 hrs. Mosquitoes landing on the exposed body parts were collected with the help of a suction tube and a torch, and transferred into a plastic cup properly covered by net cloth. Mosquitoes caught on each bait were anaesthetised and identified using the keys of Christophers[8] and Barraud[9] and an hourly record was kept. During 10 nights (atleast three in each village) mosquitoes landing on untreated human baits were also caught to know the fauna of biting mosquitoes. Data of the 12 night collections (4 nights in each of the three village) for each replica was pooled and per cent protection was calculated using the formula: $[(Nc - Nt)/Nc] \times 100$, where *Nc* and *Nt* are the number of mosquitoes collected on coconut oil and neem oil applied baits, respectively.

A total of 1682 mosquitoes were collected biting on untreated human volunteers. Maximum biting was caused by the *Culex* spp of mosquitoes (61.2%) followed by anophelines (22.02%), *Mansonia* spp (12.24%), *Aedes* spp (4.27%) and *Armigeres* spp (0.17%). Total collection of mosquitoes was represented by 18 different species. *An. tessellatus*, *Cx. quinquefasciatus*, *Ae. taeniorhynchoides* and *Ma. uniformis* were predominant species among respective groups. Average man biting rate of mosquitoes on human volunteers applied with three different concentrations of neem oil and coconut oil is given in Table 1. It was found that man biting on volunteers treated with different concentrations of neem oil remained low in comparison to control and it was minimum on application of 2% neem oil for all the mosquito species. How-

Table 1. Man biting rate of mosquitoes on human volunteers applied with neem and coconut oil

Mosquito species	Concentrations of neem oil			Coconut oil (control)
	0.5%	1%	2%	
An. culicifacies	0.83 ± 1.75[a]	0.17 ± 0.39[a]	0.08 ± 0.29[a]	4.08 ± 4.68
An. fluviatilis	0.42 ± 1.16	0.25 ± 0.62[a]	0.08 ± 0.29[a]	0.75 ± 1.05
Cx. quinquefasciatus	30.50 ± 49.56	20.67 ± 27.28	12.67 ± 18.37	53.83 ± 148.50
Cx. vishnui gr.	1.58 ± 5.18	1.17 ± 3.74	0.58 ± 1.08	2.92 ± 4.85
Ae. taeniorhynchoides	2.42 ± 6.04	0.92 ± 1.56	0.92 ± 1.56	6.50 ± 14.57
Ma. uniformis	3.83 ± 6.86	3.33 ± 4.87	1.17 ± 2.04	9.25 ± 15.70
Total anophelines	7.17 ± 14.87	5.00 ± 14.53	4.75 ± 8.64[a]	15.17 ± 17.54
Total culicines	39.50 ± 58.50	26.58 ± 27.77	15.33 ± 19.08	73.58 ± 148.06

Mean mosquitoes/man/night ± SD based on the collections for 12 nights on one bait each. Means were compared with control using *t*-test (df = 11); [a]Significant difference ($p < 0.05$).

Table 2. Relative protection provided by neem oil from mosquito bites

Mosquito species	Concentrations of neem oil			Coconut oil (control)
	0.5%	1%	2%	
An. culicifacies	79.65 (10)	96.07 (2)	98.03 (1)	(49)
An. fluviatilis	45.33 (5)	66.67 (3)	89.34 (1)	(9)
Cx. quinquefasciatus	43.34 (366)	61.61 (248)	76.48 (152)	(646)
Cx. vishnui gr.	45.70 (19)	60.13 (14)	80.06 (7)	(35)
Ae. taeniorhynchoides	62.92 (29)	86.00 (11)	86.00 (11)	(78)
Ma. uniformis	58.59 (46)	63.89 (40)	87.45 (14)	(111)
Total anophelines	52.77 (86)	67.01 (60)	68.67 (57)	(182)
Total culicines	46.32 (474)	63.88 (319)	79.16 (184)	(883)
Total mosquitoes	47.41 (560)	64.41 (379)	77.37 (241)	(1065)

Values are per cent protection calculated as : % protection = $[(Nc - Nt)/Nc] \times 100$, where *Nc* and *Nt* are the number of mosquitoes collected of coconut oil and neem oil applied baits respectively. Figures in parentheses are the total specimens collected.

ever, mean values in respect of culicines were not found statistically significant.

Table 2 gives the results of relative protection from the mosquito bites. Neem oil in the concentrations of 0.5, 1 and 2% provided 79.65, 96.07 and 98.03% protection respectively from the principal malaria vector *An. culicifacies*. Neem oil in low concentrations (0.5 and 1%) was found to be less effective (< 67%) against *An. fluviatilis*, whereas 2% neem oil provided about 89% protection from the bites of this species. Neem oil (2%) also provided more than 75% protection from the predominant culicines viz. *Cx. quinquefasciatus*, *Cx. vishnui* gr., *Ae. taeniorhynchoides* and *Ma. uniformis*. Sharma *et al.*[10] have reported complete protection from biting of anophelines and more than 99% protection from *Culex* at same concentrations of neem oil. However lower concentrations were found to be less effective.

In the present context of malaria situation, mosquito repellent properties of neem oil may be very useful as it is indigenous, easily available at low cost, and acceptable to the village communities.

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REFERENCES

1. Mitra, C.R. (1963). *Neem* (Indian Central Oil Seed Committee, Hyderabad): 190
2. Pradhan, S., M.G. Jotwani and B.K. Rai (1962). The neem seed deterrent to locust. *Indian Farming*, **12**(8): 42-44.
3. Patel, H.K., V.C. Patel, M.S. Chari, J.C. Patel and J.R. Patel (1968). Neem seed paste suspension a sure deterrent to hairy catterpillar (*Amsacta moorei* But.). *Madras Agric. J.*, **55**(2): 509-510.
4. Sharma, V.P. and K.N. Mehrotra (1986). Malaria resurgence in India. A critical study. *Soc. Sci. Med.*, **22**(8): 835-845.
5. Chavan, S.R., P.B. Deshmukh and D.M. Renapurkar (1979). Investigation of indigenous plants for larvicidal activity. *Bull. Haff. Inst.*, **7**(2): 23-33.
6. Zebitz, C.P.W. (1984). Effect of some crude and azadirachtin enriched neem (*Azadirachta indica*) seed kernel extracts on larvae of *Ae. aegypti*. *Entomol. Exp. Appl.*, **35**(1): 11-16.
7. Singh, R.P. (1984). Effect of water extracts of deoiled neem kernel on second instar larvae of *Cx. fatigans* Wiedmann. *Neem Newsletter*, **1**(2): 16-17.
8. Christophers, S.R. (1933). *The fauna of British India including Ceylon and Burma*, v. 4 (Taylor and Francis, London).
9. Barraud, P.J. (1934). *The fauna of British India including Ceylon and Burma*, v. 5 (Taylor and Francis, London).
10. Sharma, V.P., M.A. Ansari and R.K. Razdan (1993). Mosquito repellent action of neem (*Azadirachta indica*) oil. *J. Amer. Mosq. Contr. Assoc.*, **9**(3): 359-360.

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Epidemiological Study of Malaria Outbreak in a Hotel Construction Site of Delhi

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Keywords: Construction, Epidemiology, Malaria outbreak

Delhi is situated in the malaria epidemic zone of Indian subcontinent[1]. Focal outbreaks of malaria have been reported in different parts of Delhi as a result of unplanned urbanization and industrialization with aggregation of large migratory labour[2-10]. An in-depth account of prevailing mosquitogenic potential in Delhi and urgent remedial measures for malaria control programme for the capital city have been recommended by Kalra and Sharma in 1987[11]. However, the incidence of malaria is increasing progressively[12] and the other most disturbing feature is the appearance of chloroquine resistant *P. falciparum* and reported resistance to long acting sulphonamide/pyrimethamine combination[13].

An outbreak of febrile illness was detected during October 1992 in a five star hotel construction site in South Delhi. Owing to this an epidemiological investigation was initiated for precise determination of the causative agent of the fever epidemic, estimation of its magnitude, to determine the mechanism of its transmission and consequences. The first report of the fever was recorded on 22 Octo-

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ber 1992 at Malaria Research Centre Clinic. Subsequently, epidemiological investigations were carried out approximately for one month during October-November 1992 in the hutments located within and around the hotel construction site. Information was collected during the epidemiological study pertaining to demography and source of labour immigration, fever morbidity, diagnosis and treatment, mosquito species prevalence and vector incrimination.

The fever morbidity of labour population were recorded by door-to-door surveillance of hutments in and around the construction site and the diagnosis of malaria was made by microscopic examination of blood smears with standard JSB staining. All *P. vivax* positive cases were treated with 900 mg of chloroquine in divided doses, whereas *P. falciparum* positive cases were treated with 1500 mg chloroquine and doses for infants and children were adjusted accordingly.

Adult mosquito collections were carried out both at early morning (0600-0900 hrs) and at night (2100-0100 hrs) by hand collection technique. All water collections in and around the study area were searched for larval breeding. Larvae were collected using laddles and pippets and reared in the laboratory for subsequent species identification. Adult vectors collected from the study site were dissected for detection of oocysts and sporozoites. Eggs from individual progeny of *An. stephensi* were checked for number of ridges in the egg float to identify mysorensis/type form[14,15].

A total of 462 migrant labourer population involved in construction activities hailing from 51 districts belonging to eight states of India and neighbouring country Nepal were screened. They were living with extremely poor community facilities in the basement and sub-basement of the hotel (Figs. 1a, b and c). Out of 462 people surveyed 52% migrants were from Uttar Pradesh, 21% from Bihar, 15% from Orissa, 5% from Rajasthan and rest 7% were from other states of the country. Some of these labourers had paid frequent visits to their native places in the preceding two years. On an average the migrants had stayed at their native places for 8 to 10 weeks.

Results of blood smear examination of fever cases among these labourers and those living in the hutments around the hotel revealed high incidence of malaria. Blood smears from a total of 188 fever cases were examined for the presence of parasitaemia. Out of which 113 cases were found positive. Of these 83 were positive for *P. falciparum*, 27 for *P. vivax* and 3 had mixed infection (Table 1).

Larval surveys revealed the presence of *Culex* spp, *Aedes aegypti* and *An. subpictus* breeding besides *An.*

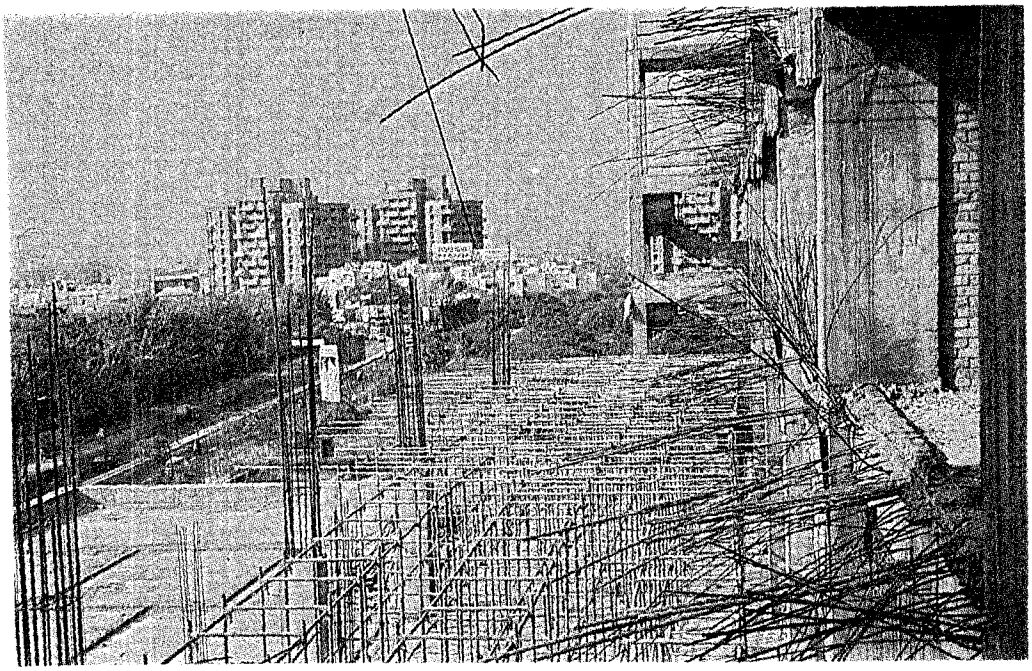

Fig. 1(a): Building construction site

Fig. 1(b): Labour near construction site

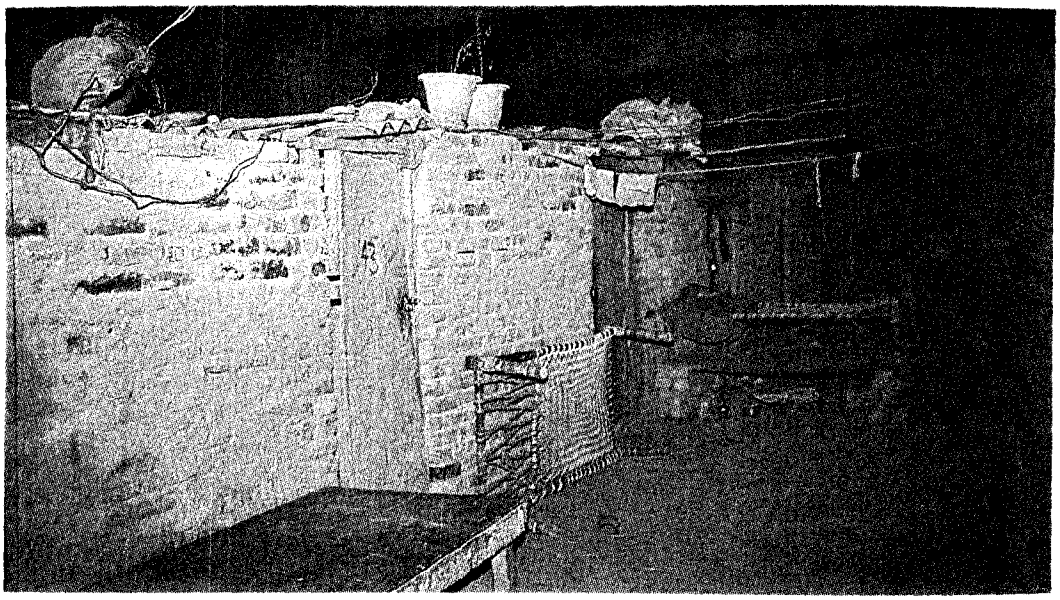

Fig. 1(c): Labour hutments in basement

stephensi, in three types of water collections i.e. curing tanks, stagnant water used for curing of roof and borrow- pits created within the project. Adult mosquito collection included *Culex quinquefasciatus, Aedes aegypti, An. subpictus* and *An. stephensi*. Of these, two *An. stephensi* were incriminated for gland and one for gut infection. Among the two common vector species, *An. culicifacies* and *An. stephensi* prevalent in Delhi, the later has been found to be associated with focal outbreaks particularly in construction sites, due to its high breeding potential[10]. Similarly, in the present epidemic, *An. stephensi* was found to be involved in active transmission even at very low density. It may be mentioned that egg ridge count of the infected mosquito revealed the presence of *An. stephensi* type form (ridge number > 16).

Magnitude of malaria morbidity did not show any correlation with the state of immigration in the present epidemic, suggesting that different levels of malaria immunity in the labour population, if existed was not of any protective significance. In the present investigation 13.76% of the total labour population were from 4 hard core districts of Orissa namely Dhenkanal, Sambalpur, Kalahandi and Sundergarh from where *Pf* resistant cases have been reported[16]. In our study two *Pf* resistant cases were suspected suggesting malaria infection being imported to Delhi through these labourers leading to focal outbreak.

Table 1. Results of blood smear examination of fever cases among the labour (October 1992)

Locality	BSE	Total (+ve)	SPR	No. *Pf*	No. *Pv*	Mixed	SfR
Hotel construction site	155	92	59.4	69	21	2	44.5
Settlement colony	22	14	63.6	11	2	1	50.0
Hemkunth labour colony	11	7	63.6	3	4	0	27.3
Total	188	113	60.1	83	27	3	44.1

The epidemiological inferences from the present data, following Boyd[17], reveals that the outbreak was an epidemic, which occurred in the labour population where malaria was either previously absent or persisted at low or moderate endemic level. Alternately, it could also be interpreted as an epidemic outbreak caused by exotic parasite and/or immigrant human host exotic to parasite, which might have nullified the protective effect of strain specific immunity, if any. Beside this the socio-economic status and behaviour of labour population resulted in high man-mosquito contact under favourable transmission season which helped in precipitation of malaria epidemics in labour aggregation[18]. In the absence of any effective vector control measures at the construction site, vector breeding was going on by itself. The preventive and curative malaria care facilities were also completely missing in the building construction site, which not only caused human suffering and loss of valuable man-days, it also resulted in large number of secondary gametocyte carriers sufficient for establishing endemicity in the area. The consequence of such negligence in providing malaria care facility is wrought with the danger of establishment of malaria outbreaks and endemicity in the capital city. This investigation therefore, suggests the need for strict vigilance and to undertake temporary and permanent vector control measures especially in and around all the construction sites with aggregation of labourers.

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REFERENCES

1. Christophers, S.R. (1911). *Malaria in the Punjab.* Scientific Memoirs. Government of India, Ser. No. **46** (Govt. Press, Calcutta).
2. Barker, W.E., T.E. Dampster and H. Yule (1847). Report of a committee assembled to report on the causes of unhealthiness along the Delhi canal (Govt. Press, Calcutta). Reprinted in *Rec. Mal. Sur. India*, **1**(2): 1-68.
3. Hodgson, E.C. (1914). Malaria in the new province of Delhi. *Indian J. Med. Res.*, **2**: 405-455.
4. Christophers, S.R. (1927). *Report of Malaria in Delhi* (Govt. Press, Calcutta).
5. Covell, G. (1939). Antimalaria operations in Delhi, Pt-I. *J. Mal. Inst. India*, **2**: 1-61.
6. Pattanayak, S., S.J. Rehman, K.G. Samnotra and N.L. Kalra (1977). Changing pattern of malaria transmission in urban Delhi. *J. Com. Dis.*, **9**(4): 150-158.
7. Pattanayak, S., R.G. Roy, K.G. Samnotra and M.S. Bendley (1981). Urban malaria scheme of the National Malaria Eradication Programme of India. *Indian J. Malariol.*, **18**(1): 21-27.
8. Choudhury, D.S. (1984). Studies on resurgence of malaria in parts of northern India. In *Proceedings of Indo-UK Workshop on Malaria*, edited by V.P. Sharma (Malaria Research Centre, ICMR, Delhi): 61-71.
9. Covell, G. and Jaswant Singh (1943). Antimalaria operations in Delhi. Pt-IV. *J. Mal. Inst. India*, **5**: 87-106.
10. Dhir, S.L. (1969). A focal outbreak of malaria in Delhi in 1969. *J. Com. Dis.*, **1**(3-4): 195-202 .
11. Kalra, N.L. and G.K. Sharma (1987). Malaria control in Delhi, past, present and future. *J. Com. Dis.*, **19**(2): 91-116.
12. Anon. (1993). *Annual Report* (Malaria Research Centre, ICMR, Delhi).
13. Choudhury, D.S., S. Sinha, S.K. Ghosh, C. Usha Devi and V.P. Sharma (1987). Report of a case of *P. falciparum* malaria resistant to chloroquine and combination of sulfalene pyrimethamine in Delhi. *Indian J. Malariol.*, **24**(1): 95-96.
14. Sweet, W.C. and B.A. Rao (1937). Races of *An. stephensi* type and *An. stephensi* var. mysorensis. *Indian Med. Gaz.*, **72:** 665-674.
15. Subbarao, S.K., K. Vasantha, T. Adak, V.P. Sharma and C.F. Curtis (1987). Egg-float ridge number in *Anopheles stephensi*: Ecological variation and genetic analysis. *Med. Vet. Entomol.*, **1**(3): 265-271.
16. Anon. (1991). *Annual Report* (National Malaria Eradication Programme, Delhi).
17. Boyd, Mark F. (1949). *Malariology.* v. I (W.B. Saunders and Co., Philadelphia, London).
18. V.P. Sharma, H.C. Uprety, P.K. Srivastava and R.K. Chandrahas (1985). Studies on malaria transmission in hutments of Delhi. *Indian J. Malariol.*, **22**(2): 77-84.

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Man Biting Rate of Culicine Mosquitoes in Cochin City

ALEX EAPEN and R.K. CHANDRAHAS

Keywords: Culicines, Man biting rate

Cochin city (Kerala state) is endemic for bancroftian filariasis. According to the stratification of NFCP the city is classified under a microfilarial rate of above 6.0[1]. The principal vector *Culex quinquefasciatus* is one of the predominant species. Open stagnant drains are sites of profuse breeding of this species. During 1991-92 an opportunity was utilized to estimate the man biting rate of culicine mosquitoes in three different seasons; pre-monsoon (March-May), monsoon (June-November) and post-monsoon (December-February). The results of observations made in three different localities of Cochin city namely; Gandhi Nagar, Giri Nagar and Indira Nagar are reported here.

Ten all night man biting collections were made between 1800 and 0600 hrs; 2 collections each in pre-monsoon and post-monsoon seasons and 6 collections during the monsoon season. The adult mosquitoes which were alighting or in the act of biting a human bait indoors lying with legs, chest and hands exposed were picked up by two insect collectors using a suction tube and a torch light. The mosquitoes collected at different hourly intervals were retained separately in test tubes. On reaching the

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laboratory, the mosquitoes were arranged according to hourly intervals, anaesthetized, separated species-wise, counted and recorded.

The indoor man biting collections yielded 2626 culicine mosquitoes represented by 8 species; *Cx. quinquefasciatus* (2512, 95.6%), *Cx. sitiens* (27, 1.0%), *Cx. gelidus* (16, 0.6%), *Cx. vishnui* (1, 0.03%), *Mansonia annulifera* (43, 1.63%), *Ma. uniformis* (9, 0.34%), *Armigeres subalbatus* (17, 0.64%) and *Aedes albopictus* (1, 0.03%). *Cx. quinquefasciatus* was the predominant species.

The man biting activity of culicine mosquitoes is given in Table 1. It is evident that *Cx. quinquefasciatus* exhibited man-mosquito contact from dusk to dawn. Seasonally, the man biting rate was highest in post-monsoon season being 896 bites/man/night followed by pre-monsoon season with 328.5 bites/man/night and the lowest in monsoon season being 10.5 bites/man/night. While peak biting activity occurred from 2200 to 2300 hrs in both pre- and post-monsoon seasons, a shift was conspicuous in monsoon season which centered around 0100 to 0200 hrs. In con-

Table 1. Man biting activity of two species of culicine mosquitoes in Cochin city

Hourly interval (hrs)	Season					
	Pre-monsoon		Monsoon		Post-monsoon	
	Cx. qu.	*Ma. a.*	*Cx. qu.*	*Ma. a.*	*Cx. qu.*	*Ma. a.*
1800-1900	2	0	1	0	21	0
1900-2000	34	0	1	0	74	1
2000-2100	48	0	1	1	120	0
2100-2200	73	0	2	1	166	1
2200-2300	102	1	4	3	295	1
2300-0000	56	0	7	5	254	0
0000-0100	86	1	10	9	197	0
0100-0200	70	0	12	6	198	0
0200-0300	58	0	8	7	162	0
0300-0400	54	0	9	2	133	1
0400-0500	50	0	5	1	89	1
0500-0600	24	0	3	1	83	0
Total	657	2	63	36	1792	5

Number of collections: Pre-monsoon – 2; Post-monsoon – 2; Monsoon – 6; *Cx. qu.* – *Culex quinquefasciatus*; *Ma. a.* – *Mansonia annulifera*.

trast, *Ma. annulifera* exhibited a higher man biting rate in monsoon season. The biting cycle peaked around midnight (0000 to 0100 hrs). However, no such activity was encountered in *Ma. uniformis*. The remaining 5 species of mosquitoes were picked up from human bait in small numbers and maximum biting occurred during the first quarter of the night.

The man biting cycle of *Cx. quinquefasciatus* observed in Cochin is similar to the findings recorded in Pondicherry[2] and elsewhere in Bangkok[3] and Rangoon[4], where the man biting rate peaked either around or soon after midnight. As far as *Mansonia* mosquitoes are concerned, the low catches are insufficient to draw any valid conclusions. However, seasonality in biting behaviour conforms with the studies carried out in Shertallai[5]. In Cochin, drains are one of the major contributors of *Cx. quinquefasciatus*. The contribution of septic tanks to the overall breeding of *Cx. quinquefasciatus* may be limited as the ventilated lids of vent pipes in almost all houses in the study area were closed or provided with pre-fabricated mosquito-proof lids. The flooding of drains during monsoon which records on an average of about 2000-2500 mm rainfall between June and August washes away mosquito larvae resulting in a sharp decline in densities. After the abatement of monsoon the ground level water bodies created become favourable sites of *Cx. quinquefasciatus* breeding and drains get gradually colonized by this species. By February the ground level water bodies dry up and the breeding of *Cx. quinquefasciatus* shifts to drains. This is probably the reason behind high man-mosquito contact encountered in post-monsoon season.

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REFERENCES

1. Rao, C.K. (1977). Current knowledge on selected aspects in the epidemiology of bancroftian filariasis in India. *J. Com. Dis.*, **9**: 185-191.
2. Vanamail, P. and K.D. Ramaiah (1991). Biting periodicity index of *Culex quinquefasciatus* and its relationship with microfilaria periodicity in Pondicherry. *Indian J. Med. Res.*, **93**: 379-383.
3. Sasa, M., T. Kurihara and D. Harinasuta (1965). Studies on mosquitoes and their natural enemies in Bangkok, Pt I. Observations on the bionomics of *Culex pipiens* fatigens Wiedmann. *Japanese J. Exp. Med.*, **35**: 23.
4. Botha, De Meillon and Anthony Sebastian (1967). The biting cycle of

Culex pipiens fatigans on man in Rangoon, Burma and the microfilarial periodicity. *Bull. WHO*, **36:** 174-176.

5. Sabesan, S., N.P. Kumar, K. Krishnamurthy and K.N. Panicker (1991). Seasonal abundance and biting behaviour of *Mansonia annulifera, Ma. uniformis* and *Ma. indiana* and their relative role in the transmission of Malayan filariasis in Shertallai (Kerala State). *Indian J. Med. Res.*, **93:** 253-258.

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Feasibility Study of Insecticide-impregnated Bednets for Malaria Control in Forested Villages of District Mandla (M.P.)

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Keywords: *An. culicifacies*, Bednets, Impregnated, Forest malaria

Malaria control in tribal areas in the country have proved to be a difficult proposition by conventional methods of insecticidal spray as adopted under NMEP[1]. However, use of impregnated bednets with synthetic pyrethroids has been successfully demonstrated in many parts of the world where conventional methods have failed[2,3]. Therefore, a feasibility study on the use of this technology for control of malaria among 'Gond' tribal communities of Mandla forests of Madhya Pradesh was under taken during 1989-1991.

A total of 5119 impregnated and 1400 plain nylon bednets were distributed in two distinct groups of villages with 6982 and 2295 population respectively. Impregnation of bednets was carried out with deltamethrin (K-othrine, E.C.) @ 25 mg/sq m during 1989 and with Lambdacyhalothrin (ICON, E.C.) @ 25 mg/sq m during 1990. Reimpregnation was carried out at an interval of six months. Assessment was made to determine the (i) degree of acceptability of impregnated bednets by tribals, (ii) impact on vector density, and finally (iii)

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sustainability of large-scale use of bednets as a method of malaria control.

Tribals who are not used to protect themselves from mosquito bites through bednets were exposed to extensive motivational health education for use of bednets. Several meetings were held at PHCs, villages and hamlets involving children, women, health workers, integrated child development scheme (ICDS) workers and school teachers to explain the benefits of bednets in preventing malaria.

Results of per man hour density of *An. culicifacies* for the period 1989-91 in the treated net and plain net villages is included in Figs. 1 and 2. It would appear that in both the areas, *An. culicifacies* population did not show reduction in density except seasonal variations.

A questionnaire based study covering 2000 tribal population on the extent and difficulties faced by them in the use of bednets gave the following analysis.

(i) Majority of the people (83%) sleep on a piece of cloth on floor in verandahs throughout the year; hence, it was difficult to use bednets.

(ii) Ten per cent people complained of suffocation while using bednets,

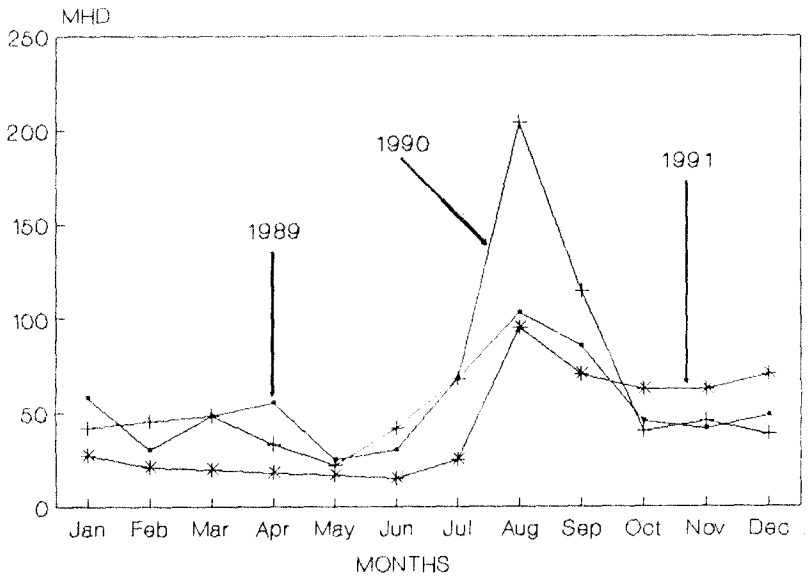

Fig. 1: Man hour density of *An. culicifacies* in villages having treated bednets

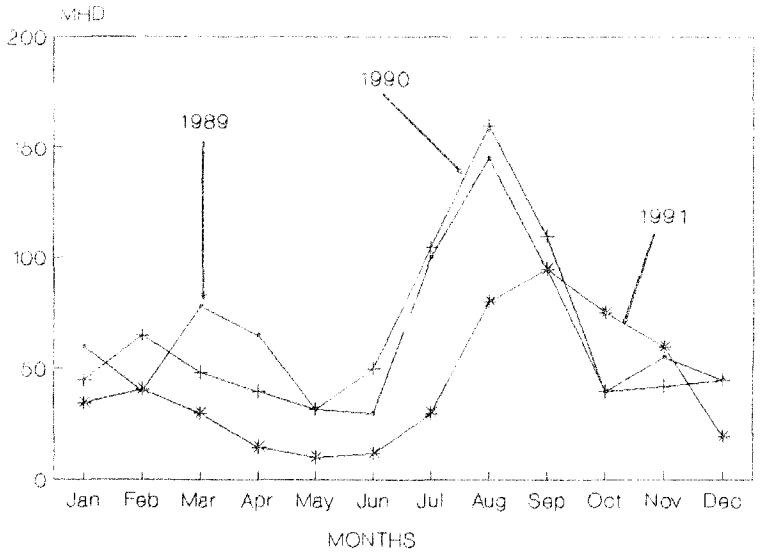

Fig. 2: Man hour density of *An. culicifacies* in villages having plain bednets

especially during hot and humid season. Outdoor sleeping habits further make the use of nets difficult.

(iii) During winter (November-February) people sleep around fire and bednets cannot be used near fire.

(iv) Hard field work results in laziness, and fatigue was the most common reason for irregular use of bednets (58%).

(v) Some people are alcoholic (2%) and usually sleep late. Except few, all are habituated to liquor and will avail themselves of any opportunity to take liquor because of its ritual and social significance. This group of people never used bednets.

(vi) Owing to religious affiliation, often (2-7 days in a month) people remained outdoors up to midnight and beyond. These activities prevented people from using bednets.

(vii) Often, guests are to be accommodated in the bednets and two or more children (neighbouring friends) sleep under one net. Mosquitoes were seen feeding on exposed body parts due to over crowding in the net. A count in 14 villages showed that in 2864 bednets, 3401 people were found sleeping, and 360 nets were hanging unused.

(viii) Those (21%) who experienced advantages of bednets wrapped

bednets around their body while sleeping as impregnated bednets kill head and body lice. Few others wrapped the nets around animals for similar reasons.

(ix) Some enterprising people even found it convenient as 'net' for catching fish from the ponds/streams.

A durability survey based on a sample of 3929 bednets showed that about 20% nets were damaged beyond repair within one year and required replacement. Another 38 per cent need repair. Two per cent were damaged by fire, while 19% were found missing. After 3 years 77% bednets were found damaged.

The success of impregnated bednets as a method of malaria control depends on (i) feeding behaviour of vector, i.e. biting activity should conform to sleep timings of the population in the nets during the night; (ii) acceptance of regular use of impregnated bednets by all members of a family; and (iii) timely reimpregnation of the nets at a given interval as recommended by the public health authorities.

In our experiment the *An. culicifacies* fed throughout the year with a peak feeding during the first quarter of night[4]. It has been observed that early biters are generally freshly emerged females and hence do not pose epidemiological risk.

Regular use of impregnated nets by the tribal communities also depends on their movement for collection of forest produce and their marketing. They usually stay out of their houses. Others, who stay back indulge in drinking, dancing and performing religious functions outdoors till midnight. In our study, in spite of continuing health education, not more than 20% could be motivated to use nets, while those who used these were found not fully covered, which permitted feeding of mosquitoes. Some used these for wrapping around their heads, or on animals for killing lice, while others used these either as pillows or as fishing nets.

We conclude that in Mandla tribal communities the success of impregnated nets, as a method for malaria control is difficult till people switch over to agriculture or some other form of static economy.

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REFERENCES

1. Kalra, N.L. and V.S. Orlov (1994). Status of malaria programmes in countries

of SEA region – update 1992. A ciritcal review (Unpublished report, WHO/ SEARO, New Delhi).

2. Njunwa, K.J., J.D. Lines, S.M. Magesa, A.E.P. Mnzava, T.J. Wilkes, M. Alilio, K. Kivumbi and C.F. Curtis (1991). Trial of pyrethroid-impregnated bednets in area of Tanzania holoendemic for malaria: Pt 1 – Operational methods and acceptability. *Acta Tropica*, **49:** 87-96.

3. Bermejo, A. and H. Veeken (1992). Insecticide-impregnated bednets for malaria control: A review of the field trials. *Bull. WHO*, **70:** 293-296.

4. Singh, Neeru, A.K. Mishra and O.P. Singh (1993). Preliminary observations on mosquito collections by light traps in tribal villages of Madhya Pradesh. *Indian J. Malariol.*, **30:** 103-107.

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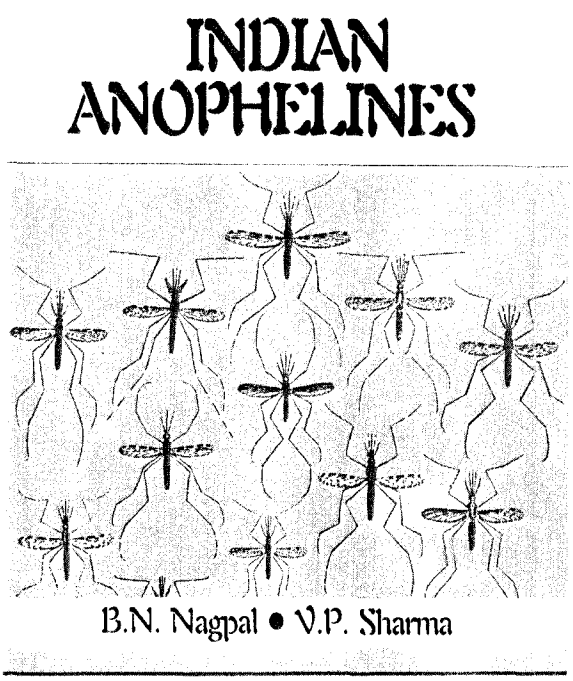

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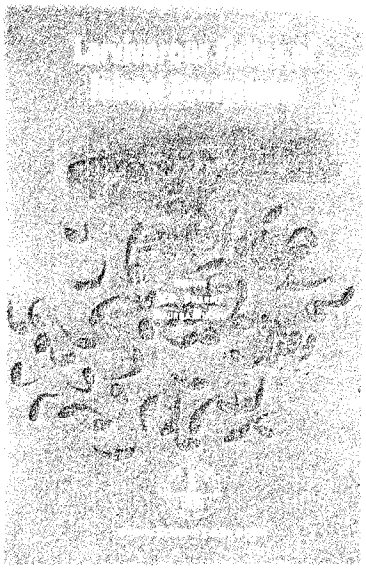

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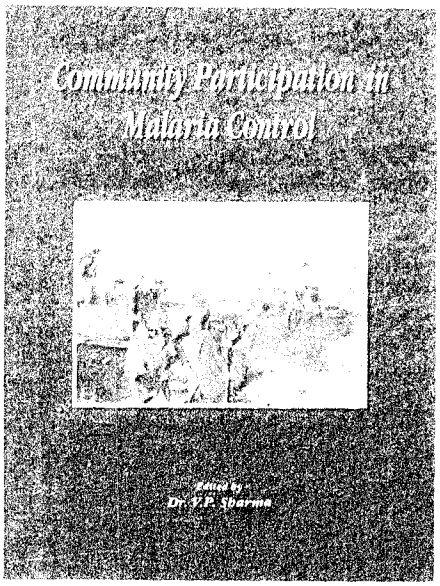

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