EFFICACY OF LIGHT-TRAPS IN SAMPLING MALARIA VECTORS IN DIFFERENT ECOLOGICAL ZONES IN CENTRAL INDIA

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Abstract. This preliminary field study was designed chiefly to test the efficiency of the light-trap as a tool for sampling malaria vectors, in tribal villages located in different ecological settings in comparison with indoor resting collections as an alternative method.

Anopheles culicifacies, a known malaria vector, was the most prevalent species in the study villages and more than 80% of trap catches were obtained before midnight with peak activity during dusk. Reproductive status of trapped specimens revealed proportional representations of unfed, freshly fed, and gravid females. Another vector, *An. fluviatilis* was found in small numbers by both the methods. Thus the trap could give a reliable and unbiased sample of vector population.

Seven species were abundant in the light-trap catches while only four in the indoor resting collections indicates the usefulness of the light-trap for sampling exophilic species. The study revealed that light-traps did not have any bias in favor of any particular species. The method may be useful for assessing the night time densities of different species or the fluctuation of a species at different dates and village to village variations. Light-traps could be used for sampling both endophilic and exophilic anophelines.

INTRODUCTION

Sampling mosquitos is a prerequisite in malaria vector control trials. A number of sampling techniques have been used to measure the impact of intervention measures on anopheline mosquitos, *ie* indoor resting collection, pyrethrum spray collection, bait catches and light-traps. Several studies have shown the usefulness of light-traps in sampling mosquito species in Africa (Odetoyinbo, 1969, Chandler *et al*, 1975, Garrett-Jones and Magayuka, 1975; Lines *et al*, 1991), while light-traps were found to be inefficient compared to other methods in Nigeria (Shidrawi *et al*, 1973). Efficacy of these traps has been found to depend on the ecological zones and the dispersal pattern of the vector population within the zone (Kalra, 1991). In India the use of light-traps for sampling and surveying malaria vectors had not been properly evaluated (Singh *et al*, 1993). In view of this, the present preliminary field study, was aimed to evaluate the efficacy of light-traps in sampling malaria vectors in four highly malarious villages which are located in ecologically different zones in comparison with indoor resting collections.

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MATERIAL AND METHODS

Study area

The study was carried out for one year (1993-1994) in two ecological zones of Central India (Jabalpur and Narsingpur). A total of four villages were selected, two from a broken-forest system and two from a cleared forest irrigated ecosysem. All the study villages are within a radius of 85 km from the laboratory of Malaria Research Centre (MRC), Jabalpur. The rural areas of Jabalpur is under regular BHC spray while the villages of Narsingpur is under regular DDT spray.

Cleared forest irrigated ecosystem

Village 1 (Dabhola): This is a typical road side rural village, about 25 km from MRC Jabalpur, thinly populated (population 284, scheduled caste 50% : scheduled tribe 50%) and on the bank of main Bargi irrigation canal. There is a very good network of irrigation canals, minor canals and water supply for irrigation is excellent. Houses are made of cement, bricks, electrified and ventilated. Soil is red brown and sandy. The main crops are rice, maize and wheat. This village is highly malarious and annual parasite incidence (API) was 440 during the study period.

Village 2 (Manakwara): This village belongs to Narsingpur district (Pop 600, scheduled caste 50% : scheduled tribe 50%), and about 25 km from Dabhola. Irrigation facilities and a network of irrigation canals exists though not as good as in Dabhola. The main crop is soybean followed by wheat. The soil is black and very fertile. Malaria was less prevalent than in Dabhola (API, 75).

Broken forest ecosystem

Village 3 (Mukanwara): Typical tribal village (population 600 : 98% Gond tribe) about 20 km from MRC and having patches of mixed forests. Houses are scattered in agricultural fields. They are small, made of mud, bamboo, thatch and without ventilation. A perennial stream is characterized by the presence of rocky pools, pits and seepages with grassy margins. The soil is laterite (it does not retain moisture and bakes under the sun and becomes hard as brick). Agriculture is monsoon dependent and rice is the main crop grown in small holdings. The terrain is undulating and there are innumerous stone quarries. There is no transport facility in the absence of any road and the village is approachable only on foot (API, 180).

Village 4 (Kunda): Forest fringe village of district Narsingpur, about 60 km from Mukanwara, without irrigation and having a population consisting of 80% of the Gond tribe (API, 100). All the houses are in one forest clearing (population 400). Soil of the area is yellowish black, sandy and fertile. The main crop is soybean followed by wheat. The stream is clear, flowing without any pool or pits and with grassy margins.

Mosquito sampling

Mosquito were collected once in a month at each village by light-trap and by hand catch (indoor resting) for one year. Trap was always fixed at a constant height of 1.67 metres in fixed houses inside in human dwellings and outside near the human dwellings to check whether light-trap could be used for determining indoor/outdoor prevalence of a species. The trap was operated from 18.00 to 06.00 hours and manually emptied at hourly intervals until morning. All mosquitos collected were placed in separate cups and labeled according to where they were collected. The catch house had been treated with residual insecticide. The eaves were not screened and the doors were left open throughout the night in all catches. All the houses were occupied during the nights of trap collection. Hourly humidity, temperature, wind, cloud cover and moon phase were recorded on the site of collection.

Indoor resting collections (per man hour) were also carried out simultaneously in the morning (06.00 to 08.00 hours) from the surrounding localities using standard entomological techniques (WHO, 1975), to compare light-trap samples with the indoor resting density, and to determine whether the relative sampling efficiency of the two techniques differed according to, (i) mosquito species (ii) mosquito population density and (iii) seasonal variations in species prevalence.

All adult mosquitos collected by both the methods were identified morphologically using standard keys (Christophers, 1933). For data analysis the species considered was *An. culicifacies*, of which sufficient numbers were collected throughout the year. *An. fluviatilis* prevalence was occasional without any trends. *Anopheles* were classified to reproductive state (unfed, freshly fed, and gravid by external examination). Parity was determined using the Detinova method (1962).

RESULTS

Performance of the light-traps in different ecosystems

Table 1 summarizes the number of anophelines caught at each location in all seasons (indoor/outdoor) by light-traps. In villages in cleared forest, 1,375 and 349 anophelines representing 11 species were caught by light-traps, of which 755 (55%) and 166 (47.6%) were *An. culicifacies* in Dabhola and Manakwara, respectively. While in the broken forest ecosystem, a total of 411 and 378 *Anopheles* were collected comprising of 13 species, of which *An. culicifacies* were 273 (66.4) and 185 (49%) respectively in Mukanwara and Kunda. The second most prevalent species was *An. annularis* in Dabhola, *An. subpictus* in Manakwara and Mukanwara while *An. theobaldi* in Kunda. *An.*

Table 1

Light trap catches[a] (indoor/outdoor) in study villages.

Months	Villages	Light trap[b] location	Total *Anopheles*	*Anopheles* species[c]						
				AC[d]	AF	AN	AS	AT	ANG	ASP
Nov-Jan	Dabhola	In	20.5	3.0	1.0	15,0	1.0	0.0	0.0	0.0
		Out	14.0	2.0	2.0	9,0	0.5	0.0	0.5	0.0
	Manakwara	In	5.5	1.0	0.0	0,0	4.5	0.0	0.0	0.0
		Out	1.0	1.0	0.0	0,0	0.0	0.0	0.0	0.0
	Mukanwara	In	3.5	2.5	0.0	0,5	0.5	0.0	0.0	0.0
		Out	7.0	2.5	0.0	1,0	0.0	0.0	0.0	3.0
	Kunda	In	5.0	2.0	2.0	0,0	0.0	1.0	0.0	0.0
		Out	7.5	4.5	0.0	0,0	0.0	2.5	0.0	0.0
Feb-Apr	Dabhola	In	108.0	6.0	14.0	66,0	1.0	0.0	0.0	20.0
		Out	41.5	3.0	0.0	33,5	2.0	0.5	0.0	2.5
	Manakwara	In	9.0	4.0	0.0	0,0	5.0	0.0	0.0	0.0
		Out	13.0	5.5	0.0	2,0	5.0	0.0	0.0	0.0
	Mukanwara	In	8.0	8.0	0.0	0,0	0.0	0.0	0.0	0.0
		Out	5.0	2.0	0.5	0,5	0.0	0.5	0.0	1.5
	Kunda	In	5.0	2.0	0.0	3,0	0,0	0,0	0.0	0,0
		Out	6.0	4.5	1.0	0.5	0.0	0.0	0.0	0.0
May-Jul	Dabhola	In	116.0	2.0	0.0	108.0	6.0	0.0	0.0	0.0
		Out	18.0	2.0	0.0	13,0	3.0	0.0	0.0	0.0
	Manakwara	In	10.5	2.0	0.0	1,0	8.0	0.0	0.0	0.0
		Out	8.0	4.0	0.0	0,0	4.0	0.0	0.0	0.0
	Mukanwara	In	128.5	98.0	3.5	5,0	17.0	5.0	0.0	0.0
		Out	3.0	1.0	1.0	0,0	1.0	0.0	0.0	0.0
	Kunda	In	9.0	6.0	0.5	0,5	2.0	0.0	0.0	0.0
		Out	15.0	10.0	1.0	3,0	0.0	1.0	0.0	0.0
Aug-Oct	Dabhola	In	41.6	14.3	0.3	15,0	11.0	0.0	0.0	0.0
		Out	838.0	684.0	4.0	30.0	98.0	21.0	0.0	1.0
	Manakwara	In	51.0	23.0	0.0	6.0	21.0	0.0	0.0	0.0
		Out	111.0	58.5	0.0	20.5	30.5	0.0	1.0	0.0
	Mukanwara	In	29.0	14.0	0.0	0.0	15.0	0.0	0.0	0.0
		Out	83.0	40.0	2.0	13.0	9.0	4.0	10.0	1.0
	Kunda	In	31.0	24.6	0.0	1.6	3.6	1.0	0.0	0.0
		Out	107.5	33.5	7.5	5.0	10.5	21.5	11.0	7.0

[a] Nos caught / trap / night

[b] In = Indoors

Out = Outdoors

[c] *An. pallidus*, *An. vagus*, *An. varuna* and *An. tesselatus* were found in small numbers in all the villages. *An. maculatus* and *An. karwari* were recorded only from broken forest villages.

[d] AC = *An. culicifacies*; AT = *An. theobaldi*

AF = *An. fluviatilis*; ANG = *An. nigerrimus*

AN = *An. annularis*; ASP = *An. splendidus*

AS = *An. subpictus*

fluviatilis constituted 1.8, 2.7 and 6% of trap catches in Dabhola, Mukanwara, Kunda but were absent in Manakwara.

An. culicifacies were prevalent throughout the year, but the highest trap catches were found indoor and outdoor in the monsoon and post-monsoon season (August-October). Similarly *An. annularis* and *An. subpictus* were also found in high numbers in trap catches especially in August to October, though very large variations were recorded among villages. In Dabhola the catches of *An. annularis* far exceeded those of *An. culicifacies*, except in August-October.

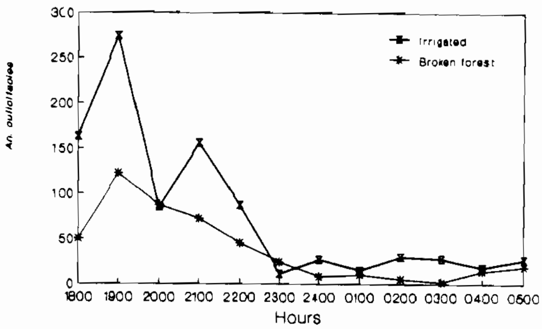

Fig 1 – Hourly trap collection in cleared forest irrigated villages and broken forest villages.

Fig 1 shows that more than 80% of *An. culicifacies* were trapped before midnight in both the group of villages with peak activity from 19.00 - 20.00 hours.

Indoor resting density (pmh) is shown in Table 2. Average density per man hour of collection was 61 and 40 in the irrigated ecosystem of which *An. culicifacies* constituted 37 and 57% respectively in Dabhola and Manakwara. While in the broken forest ecosystem, *An. culicifacies* comprised more than 75% of total anopheline collection in both the villages. A breakdown by village revealed that *An.*

Table 2

Indoor resting collections (pmh) in study villages.

Months	Villages	Average total *Anopheles*	*Anopheles* species[a]			
			AC[b]	AF	AN	AS
Nov-Jan	Dabhola	67.3	2.3	3.0	56.3	1.0
	Manakwara	21.5	6.0	0.0	1.0	14.0
	Mukanwara	16.7	13.0	0.7	1.3	1.0
	Kunda	10.0	6.5	0.0	1.0	0.0
Feb-Apr	Dabhola	75.7	26.0	0.7	48.0	1.0
	Manakwara	37.7	20.3	0.0	4.3	13.0
	Mukanwara	19.0	17.0	0.0	1.0	1.0
	Kunda	13.3	6.7	0.7	0.0	6.0
May-Jul	Dabhola	28.0	14.7	0.0	7.7	5.7
	Manakwara	17.7	10.3	0.0	0.0	7.3
	Mukanwara	34.7	22.3	0.0	1.3	11.0
	Kunda	27.7	21.0	0.0	0.7	6.0
Aug-Oct	Dabhola	74.3	49.0	0.0	12.7	12.0
	Manakwara	76.3	49.0	0.0	3.0	23.7
	Mukanwara	62.0	56.0	0.0	1.0	5.0
	Kunda	55.0	44.0	0.0	0.0	10.0

[a] *An. theobaldi, An. pallidus, An. barbirostris* and *An. splendidus* were recorded in insignificant numbers.
[b] AC = *An. culicifacies*
AF = *An. fluviatilis*
AN = *An. annularis*
AS = *An. subpictus*

culicifacies was the most abundant species in the study villages except Dabhola, where *An. annularis* is the dominant one except in August-October. The second most numerous species was *An. subpictus* in three of the villages and *An. culicifacies* in Dabhola. *An. fluviatilis* was only 1% of its catch in Dabhola, <1% in Mukanwara and Kunda, and it was absent in Manakwara. Eight species were recorded resting indoors in all the villages, though only four were abundant. The peak of seasonal abundance of *An. culicifacies* was in August–October as was the catch for its trap catches.

Abdominal condition of trapped mosquitos

Table 3 shows the abdominal condition of the *An. culicifacies* caught. Females of all stages were trapped in each village, though the proportions of unfed, fed, semigravid and gravid were different in each village. The abdominal condition of indoor resting *An. culicifacies* showed predominance of fed and semigravid females in all the villages.

Sex composition

Percentages of trapped male anophelines and male *An. culicifacies* were fairly high, 21 and 32.5% respectively in irrigated villages, but only 10 and 11.5% respectively in broken forest villages, a difference which was significant statistically (Z test; $p<0.001$).

Parity status

The parity rates among light trapped and resting *An. culicifacies* were all about 60%.

DISCUSSION

Comparing the yield of different collection techniques is of prime importance in mosquito population studies (Service, 1976) but this has not been evaluated for the *An. culicifacies*, a well known vector of malaria in Indian sub-continent (Zaim *et*

Table 3

Blood feeding status of *An. culicifacies* caught by CDC light traps against indoor resting density.

Villages	Locations[a]	Percentage of *An. culicifacies*							
		Trap collection				Resting collection			
		UF[b]	FF	SG	G	UF	F	SG	G
Dabhola	In	21.0 (10)	40.0 (19)	8.5 (4)	30.0 (14)	11.0 (8)	59.0 (41)	23.0 (16)	6.0 (4)
	Out	22.5 (14)	11.0 (7)	24.0 (15)	41.0 (26)				
Manakwara	In	45.0 (13)	21.0 (6)	14.0 (3)	24.0 (7)	12.0 (13)	45.0 (50)	36.0 (40)	7.0 8
	Out	56.0 (53)	14.5 (14)	20.0 (19)	8.5 (8)				
Mukanwara	In	26.0 (5)	47.0 (9)	21.0 (4)	5.0 (1)	8.0 (7)	36.0 (31)	40.2 (35)	16.1 (14)
	Out	50.0 (23)	30.0 (14)	4.0 (2)	15.0 (7)				
Kunda	In	18.0 (15)	18.0 (15)	43.0 (36)	20.5 (17)	7.5 (7)	43.0 (40)	33.3 (31)	16.1 (15)
	Out	18.0 (14)	35.5 (27)	22.0 (17)	24.0 (18)				

Figure in parenthesis indicates numbers.
[a] In = Indoor; Out = Outdoor
[b] UF = Unfed; FF = Freshly fed; F = Fed; SG = Semi Gravid; G = Gravid

al, 1995). The most common and practical method of *An. culicifacies* density determination is indoor resting collection (Akiyama, 1974; Reisen *et al*, 1976) expressed as per man hour (pmh). But a good proportion of *An. culicifacies* adults was also found resting outdoors in Central India (Senior White, 1946 and Saxena *et al*, 1992) and the exact proportions have not been determined (Rao, 1984). Therefore, the evaluation of light-traps was carried out (outdoor/indoors) along with indoor resting collections. Simultaneous sampling by light-trap and hand catch have allowed a comparison of the two methods and their limitations.

The fact that seven anopheline species were abundant in the trap catches, while only four in the indoor resting collections, indicates the potential value of the light-trap for sampling exophilic species. The outdoor abundance of *Anopheles* is of importance from a malaria control stand point, because these species may avoid contact with residual insecticide sprayed inside houses. Further, the traps used without bednets did not have any bias in favour of unfed females unlike the study of Lines *et al* (1991) where the trap were used besides nets because of earlier demonstration by Garrett – Jones and Magayaka (1975) that this greatly increased their efficiency. Our data showed no bias in favour of any particular species as reported by Coz *et al* (1971) and by Carnevale and Lepont (1973). Thus light-traps could give reliable and unbiased samples of vector populations as reported by Lines *et al* (1991) who correlated catches of light-traps with human biting catches.

Although the method of hand catch index is simple and convenient, it may miss species which prefer resting places above 2 meters or species which are secretive, often resting deep in thatch (Reuben, 1983). Furthermore, the method will miss females which have left the hut during the night because of natural exophilic behaviour or because of the presence of irritant residual insecticide (Odetoyinbo, 1969). An important advantage of the light-trap is its convenience in outdoor catches especially because outdoor sleeping is very common among tribal people throughout the year (Singh *et al*, 1994). In forest/broken forest areas, it is difficult to capture outdoor resting mosquitos because they are scattered over wide areas and in many type of shelters such as stream banks, underculverts, vegetation, tree buttresses, stone quarries, cracks in the ground and pits for plantations etc. No meaningful comparison can be made between the numbers collected in houses with those actually collected outdoors. The effort required is disproportionally large in outdoor shelters (Rao, 1984). In order to assess whether a substitute sampling method can be relied on to provide an unbiased measure of the density of mosquitos, this study evaluated light-traps as a sampling method for estimating human exposure to host seeking anopheline mosquitos. In the case of African vector species the correlation of human biting and light-trap catches shows that the later method can give reliable indexes of the incidence of attack on man (Lines *et al*, 1991). The trapped anophelines can also be tested for sporozoites by the ELISA method. To test the efficiency of sampling the biting population of *An. culicifacies* by light-traps a correlation of human biting and light-trap catches will be necessary. Suleman *et al* (1977), also recommended light-traps as additional tools for sampling mosquitos in Pakistan, although less productive than buffalo bait catches. Thus we conclude that light-traps can be used for assessing the night time prevalence of different *Anopheles* species, their outdoor and indoor preference, seasonal fluctuations and village to village variations due to different ecological conditions in Central India. However, further studies are required to determine the influence of species-specific variation in the sizes and age structure of collections because such variations can affect the epidemiological interpretation of the data.

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