FIELD EFFICACY OF "MOSBAR" MOSQUITO REPELLENT SOAP AGAINST VECTORS OF BANCROFTIAN FILARIASIS AND JAPANESE ENCEPHALITIS IN SOUTHERN INDIA

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ABSTRACT. Deet-permethrin "Mosbar" soap was field tested for repellency against mosquitoes by volunteers in urban and rural localities in southern India. Eighty-nine to 100% reduction in man-vector contact was recorded for 8 mosquito species, including *Culex quinquefasciatus* and recognized vectors of Japanese encephalitis. The soap was highly acceptable to the community.

INTRODUCTION

Personal protection by the use of mosquito repellents is potentially an important component of integrated disease vector control. There is a need to develop appropriate tools and methods for vector control at individual as well as community levels. Effectiveness of the mosquito repellent deet formulated with permethrin as a soap against mosquitoes biting man outdoors was demonstrated in Malaysia (Yap 1986) and in Australia (Frances 1987). For the present study, evaluation of "Mosbar" mosquito repellent soap containing 20% deet and 0.5% permethrin was made in the city of Madurai against *Culex quinquefasciatus* Say, the vector of bancroftian filariasis. Also tested were species of the *Cx. vishnui* subgroup (comprising *Cx. tritaeniorhynchus* Giles, *Cx. vishnui* Theobald and *Cx. pseudovishnui* Colless, all incriminated vectors of Japanese encephalitis in southern India) in Alankottaram village, about 25 km from Madurai.

MATERIALS AND METHODS

Collections of mosquitoes were made hourly using aspirators, on volunteers in a shed with thatched roof and open sides from 1800 to 0600 hours. Observations were repeated thrice in each locality. In all, 18 male volunteer subjects, 10 in Madurai and 8 in the village Alankottaram, aged 11–15 yr, were treated with mosquito repellent soap and used as human baits. Informed consent of the parents of the subjects was obtained. An untreated volunteer was a control in each replicate. In addition, a volunteer was treated with plain carbolic soap in Alankottaram village to compare the effect, if any, on mosquito biting. An additional 67 villagers were treated with mosquito repellent soap (8 of them on 2 occasions) to test for side effects and acceptability. No mosquito collections were made on these persons, but they were asked to report their reactions next morning.

Immediately before each observation, i.e., before 1800 h, repellent soap was applied on clean wet skin of arms, legs (below the knees), neck and face of treated subjects. The soap was rubbed thoroughly on the skin to obtain a good lather and then allowed to dry. The repellent soap was weighed before and after each application to obtain the mean quantity of repellent soap used on each person. Collections were made of all mosquitoes biting or landing on the skin and clothes of the subjects. No distinction was made between mosquitoes actually captured biting and those captured before they could start probing, since it was assumed that they would have done so. Mosquitoes captured on treated subjects were stored in individual test tubes to ascertain the time of first biting of each species of mosquito. "Protection time" is the time from treatment until the first bite is recorded (Granett 1938). Average protection time was calculated, based on the time from treatment to first bite on each treated subject.

Hourly captures on the untreated control were kept in 15 × 15 × 15 cm cloth cages. Captures were identified to species the next morning. Man Biting Rates (MBR), i.e., mean bites received/person/night, and percentage repellency (percentage reduction in biting rates) for each species were calculated, following Mehr et al. (1985):

$$\frac{\text{Mean no. on control} - \text{Mean no. on treated}}{\text{Mean no. on control}} \times 100$$

The paired t-test (Snedecor and Cochran 1967) was applied to the data, using the formula $t = \frac{\bar{d}}{s/\sqrt{n}}$ where d_i = difference between paired means of hourly readings on treated and control subjects. $\bar{d} = \frac{1}{n} \Sigma d_i$ and $s^2 = \frac{1}{n-1} \Sigma (d_i - \bar{d})^2$. There were 11 degrees of freedom.

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RESULTS AND DISCUSSION

In the studies carried out in Madurai, 11 species of mosquitoes belonging to 4 genera were collected. These included 6 species of *Culex*, 3 of *Aedes* and one each of *Armigeres* and *Anopheles*. The most abundant was *Cx. quinquefasciatus*, followed by *Cx. vishnui*, *Cx. tritaeniorhynchus* and *Ar. subalbatus* (Coquillett).

Average protection time provided by the repellent soap against bites of *Cx. quinquefasciatus* was 6.7 hours. The average man-biting rate for *Cx. quinquefasciatus* on treated subjects was 4.8 ± 1.5 (range 0–14) as compared with 1,649.0 ± 691.8 (range 517–2,904) recorded on untreated controls. Hourly biting rates were analyzed and the differences were significant ($P < 0.01$), as shown in Table 1. Percentage reduction of biting for *Cx. quinquefasciatus* remained high throughout the night, ranging from 99.96% recorded in the 1st h post-treatment to 98.8% recorded in the 11th h post-treatment (Table 2). The percentage reduction in biting density of *Ar. subalbatus* was 98.4% (Table 1).

In the village Alankottaram, 18 species of mosquitoes belonging to 3 genera were collected. These were comprised of 8 species of *Culex*, 5 of *Aedes* and 5 of *Anopheles*. The *Cx. vishnui* subgroup constituted about 77 and 68% of the total catch on repellent soap treated and untreated control subjects, respectively.

Average protection time provided by the repellent soap against bites of the *Cx. vishnui* subgroup was 2.7 hours. Average man-biting rate for mosquitoes of this subgroup on the treated subjects was 18.4 ± 4.9 (range 2–43) as compared with 400.0 ± 83.9 (range 274–559) for the untreated controls. Percentage reduction of biting for the *Cx. vishnui* subgroup remained high throughout the night, ranging from 100% observed in the 1st h after treatment to 86.3% observed 11 h after treatment (Table 2). Hourly biting rates were analyzed for individual species of the *Cx. vishnui* subgroup (*Cx. tritaeniorhynchus*, *Cx. vishnui* and *Cx. pseudovishnui*) as well as for *Cx. infula* Theobald, *C. bitaeniorhynchus* Giles, *Cx. fuscocephala* Theobald, *Aedes pseudomediofasciatus* (Theobald) and *Ar. subalbatus*. In every case the differences were found to be significant (Table 1).

Experiments with carbolic soap showed no effect on the biting rates of mosquitoes; a mean number of 609.3 mosquitoes per night were captured on soap-treated individuals as compared with 589.3 caught on untreated controls.

On an average, 1.75 g of repellent soap was used on each treated subject, so a 40 g cake used daily would last about 3 weeks. The cost of a cake weighing 70 g was U.S. $0.25 (Frances 1987) or about Rs. 5.

During the course of the study in the village Alankottaram, mosquito repellent soap was applied on 67 village volunteers. The villagers readily accepted the repellent soap after education on its use. There were no complaints of side effects except for one girl aged 15 yr who reported itching for about an hour after application. However, it was found that this girl was suffering from a skin ailment at the time. There was increasing demand for the soap during the second and third trials, and all the people reported noticeable relief from mosquito bites throughout the night.

In the present study the protection time as defined by Granett (1938) provided by the repellent soap was relatively low (2.7 h in the case of vectors of Japanese encephalitis). However, Travis (1947) pointed out that the number of

Table 1. Effect of repellent soap on man biting rate.

Species	Mean no./person/night*		t (d.f.11)	Percentage repellency
	Untreated control	Treated bait		
Cx. quinquefasciatus	1,649.0	4.8	8.73***	99.7
Cx. vishnui	346.0	13.9	3.32**	96.0
Cx. infula	103.3	2.5	3.39**	97.6
Cx. tritaeniorhynchus	32.3	3.4	37.00***	89.6
Cx. pseudovishnui	21.7	1.1	3.28**	94.8
Cx. bitaeniorhynchus	20.7	1.9	3.13**	90.9
Cx. fuscocephala	12.0	0.0	3.17**	100.0
Ae. pseudomediofasciatus	6.3	0.6	3.10**	90.1
Ar. subalbatus	19.0	0.3	3.41**	98.4

* Based on 2–4 treated and 1 control subjects, 12 readings per night and 3 nights each at Madurai and Alankottaram, respectively. Data for *Cx. quinquefasciatus* and *Ar. subalbatus* from Madurai and all other species from Alankottaram.

** Significant at $P = 0.01$ level.

*** Significant at $P = 0.001$ level.

Table 2. Mean no. of bites of *Culex quinquefasciatus* in Madurai, and the *Culex vishnui* subgroup at Alankottaram on control and treated volunteers.

Hours posttreatment	*Cx. quinquefasciatus*			*Cx. vishnui* subgroup		
	Mean no. bites*			Mean no. bites*		
	Control	Treated	% reduction	Control	Treated	% reduction
0–1	224.3 ± 116.8	0.1 ± 0.1	99.9	30.0 ± 12.0	0.0	100.0
1–2	141.0 ± 75.6	0.1 ± 0.1	99.9	26.7 ± 13.0	0.1 ± 0.1	99.5
2–3	173.0 ± 104.6	0.5 ± 0.3	99.7	27.7 ± 1.9	0.1 ± 0.1	99.5
3–4	66.7 ± 19.9	0.6 ± 0.4	99.1	45.3 ± 9.8	0.8 ± 0.4	98.4
4–5	135.3 ± 73.6	0.4 ± 0.2	99.7	47.0 ± 18.0	0.5 ± 0.3	98.9
5–6	103.7 ± 39.0	0.6 ± 0.3	99.4	24.7 ± 8.7	2.3 ± 0.5	90.9
6–7	103.7 ± 30.8	0.2 ± 0.2	99.8	27.3 ± 6.2	1.4 ± 0.5	95.0
7–8	167.3 ± 63.6	0.6 ± 0.3	99.6	22.0 ± 3.5	2.3 ± 0.9	89.8
8–9	171.3 ± 57.1	0.3 ± 0.2	99.8	32.7 ± 6.8	1.4 ± 0.4	95.8
9–10	205.3 ± 67.0	0.7 ± 0.5	99.7	48.0 ± 23.3	2.6 ± 0.9	93.4
10–11	116.3 ± 50.2	0.2 ± 0.2	99.8	41.3 ± 11.3	3.3 ± 1.4	92.1
11–12	41.0 ± 15.9	0.5 ± 0.4	98.8	27.3 ± 5.2	3.8 ± 1.1	86.3
Mean-biting rate**	1649.0 ± 691.8	4.8 ± 1.5	99.7	400.0 ± 83.9	18.4 ± 4.9	95.4

* Mean of 3 replicates ± SE.
** Mean bites received/person/night.

bites received through time should also be considered to measure repellency, and this view was endorsed by Schreck (1977).

In Malaysia Yap (1986) obtained reduction in biting and landing rates of 5 common man-biting mosquito species ranging from 83.3 to 100% four hours after treatment. Frances (1987) found deet-permethrin soap less effective than liquid deet and suggested this might be due to difficulty in obtaining complete coverage of the skin with the soap. However 90% repellency against day-biting species of *Aedes* was obtained 5 h after treatment and 82.9% seven hours after treatment. A high degree of protection against crepuscular mosquitoes was also observed. He noted that small numbers of mosquitoes came to bite on ears and fingertips that remained untreated. In the present study mosquitoes landed on the untreated toes and shirts of the treated volunteers. Protection up to 6 and 12 h has been reported in studies in Samoa and the Solomon Islands, respectively (Rishikesh 1988).

The prolonged repellency and high acceptability of deet-permethrin soap raises hopes that it can be used as a short-term protective measure for high risk individuals living in highly endemic areas, and may serve to reduce the risk of disease transmission. The Philippines government together with the World Health Organization plan to produce mosquito repellent soap with locally available coconut oil, to use in highly malarious parts of the Philippines (Curtis et al. 1989). The long-term effects of the repellent soap need to be studied before its inclusion into integrated vector control programs. Deet is sold in the United States with a statutory warning that it should not be reapplied on the skin without washing with soap between applications, because skin irritation has been reported in children when this precaution was neglected (Mehr et al. 1990). It is not known how much deet and permethrin will be deposited on the skin by the use of mosquito repellent soap, but it would nevertheless be wise to warn users to wash it off before reapplication. There are still some rural areas where water for domestic purposes has to be carried from some distance away, and under these circumstances washing may often be perfunctory. This was not considered to be a problem in the present study because the observations were not carried out on consecutive days and some trials were timed one week apart.

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