

## CONCURRENT CONTROL OF MOSQUITOES AND DOMESTIC PESTS BY USE OF DELTAMETHRIN-TREATED CURTAINS IN THE NEW DELHI MUNICIPAL COMMITTEE, INDIA

M. A. ANSARI AND R. K. RAZDAN

*Malaria Research Centre, 20, Madhuban, Vikas Marg, Delhi-110092, India*

**ABSTRACT.** A field trial was conducted in Block F of the Moti Bagh area of New Delhi Municipal Committee to demonstrate composite control of *Anopheles stephensi* and *Aedes aegypti* by spraying deltamethrin at 100 mg/m<sup>2</sup> on window and door curtains of habitations. Results revealed drastic reduction (87.9–93.7%,  $P < 0.05$ ) of target species in the experimental area. The impact of deltamethrin-treated curtains was also evident against nontarget species (67.9–85.7%,  $P < 0.05$ ). Treated curtains provided 100% kill of *An. stephensi* and *Ae. aegypti* for 3–4 months, followed by a gradual decline in successive months. Use of deltamethrin-treated curtains resulted in 92.0 reduction in slide positivity rate and 95.4% reduction in malaria cases per thousand population. The cost of deltamethrin treatment was Rs 41.15 (<\$1 U.S.) per house per annum. Insecticide-treated mosquito window and door curtains, along with legislative measures, may provide cost-effective concurrent control of mosquitoes and other domestic pests.

**KEY WORDS** *Anopheles stephensi*, *Aedes aegypti*, *Culex quinquefasciatus*, deltamethrin, insecticide-treated mosquito window and door curtains, malaria, dengue, domestic pest control

### INTRODUCTION

Insecticide-treated mosquito nets and insecticide-treated mosquito window and door curtains (ITMWDC) have recently received considerable attention as means of malaria and mosquito control in several tropical and subtropical countries (Majori et al. 1987, Snow et al. 1987, Rozendaal and Curtis 1989, Bermejo and Veecken 1992, Jana-Kara et al. 1995, Poopathi and Raghunatha Rao 1995). Insecticide-treated mosquito window and door curtains have provided effective control in urban areas because these curtains are invariably used in every household for protection from sunlight and for privacy. These curtains also are socially acceptable, because they provide control of household pests as well as of *Aedes aegypti* (L.), which bites during the daytime and is a vector of the virus causing dengue and dengue hemorrhagic fever (DHF) (Ansari 1997, Ansari et al. 1998). In view of the periodic epidemics of malaria and other vector-borne diseases in Delhi, India, a field trial was carried out to evaluate the operational feasibility and efficacy of deltamethrin-treated curtains for the concurrent control of *Anopheles stephensi* Liston (a malaria vector), *Ae. aegypti*, and domestic arthropod pests. This paper reports the results of a 1-year study.

### MATERIALS AND METHODS

An ex-gratia sample of deltamethrin (2.5% emulsifiable concentrate) formulation was obtained through the courtesy of Hoechst AgroEvo India Ltd. (Mumbai, India) for treatment of curtains. The experiment was carried out in the Central Public Works Department's 2-room apartments located in Moti Bagh, Block F, Circle No. 2, of the New Delhi

Municipal Committee. This area has about 204 middle-income group flats accommodating a population of 992. Block E, with a population of 750 and situated in the same locality, was used as a control area. All inhabitants of both experimental and control areas were using their own curtains of cotton fabric; the color, design and quality of fabric was variable. Temperature and relative humidity were variable in each season. In summer, temperatures ranged from 35 to 45°C with 40–60% relative humidity. The temperature was 25–35°C during the monsoon season with relative humidity of 80–90%. In winter, temperatures are extremely low (i.e., 3–20°C) with 60–70% relative humidity. The inhabitants were all educated, and were engaged in government service. Before the impregnation of curtains, health camps were organized to brief the occupants of blocks F and E about the new technique and they were also requested to cover their windows and doors with treated curtains for about 1 h during dusk and dawn. The total area of the curtains installed on doors and windows was measured to be about 1,200 m<sup>2</sup>. Deltamethrin was sprayed with a stirrup pump at 100 mg/m<sup>2</sup> on both sides of curtains, as described earlier (Ansari et al. 1998). The 1st impregnation was made from July 5 through 8, 1994, and the 2nd impregnation was done from April 22 through 26, 1995.

*Entomological evaluation:* Densities of indoor-resting mosquitoes (target species) and domestic pests (nontarget species) were monitored before and after impregnation of curtains. Populations were knocked down with an aerosol spray consisting of allethrin and piperonyl butoxide on a fortnightly basis from 0900 to 1300 h in selected apartments of both experimental and control areas.

Table 1. Cumulative average density of mosquitos per structure in Block F (experimental) and block E (control), Moti Bagh, New Delhi Municipal Committee area.<sup>1</sup>

Species	Preimpregna- tion density		Postimpregnation density and % reduction						Cumulative pre- and postimpregnation density and % reduction		
			1st impregnation (July 8, 1994)			2nd impregnation (April 26, 1995)					
	E	C	E	C	R	E	C	R	E	C	R
	Target										
<i>Anopheles stephensi</i>	96	93	43.4	120.5	96.9	7.5	39.5	82.0	11.5	160	93.1
Total anophelines	96	93	43.4	488.4	91.5	10.7	194.9	94.8	54	683.3	92.5
<i>Aedes aegypti</i>	426	412	12.1	142.5	91.9	3.9	101.1	96.3	16	243.6	93.7
<i>Culex quinquefasciatus</i>	984	816	122.3	573.1	82.6	81.8	799.8	91.7	204.1	1372.9	87.9
	Nontarget										
<i>Musca domestica</i>	456	468	41	47	12.8	86.7	350.5	75.3	127.7	397.5	67.9
<i>Gryllus</i> spp.	111	96	8	7	1.8	52.9	244.1	81.4	60.9	251.1	79.8
<i>Blatta orientalis</i>	60	84	2.2	3.1	0.7	6.5	91.3	90.1	9.7	94.4	85.7
Ants	153	108	28	27	27.5	116.3	537.7	84.9	144.3	564.7	82.2

<sup>1</sup> E, experimental; C, control; R, reduction.

Collected specimens were identified and density of mosquitoes was estimated. The duration of the effectiveness of deltamethrin-impregnated curtains was evaluated weekly by exposing groups of laboratory-reared *Anopheles culicifacies* Giles, *An. stephensi*, *Ae. aegypti* and *Culex quinquefasciatus* Say. Mosquitoes were exposed for 15 min and mortality was recorded after 24 h as per World Health Organization standard procedures. Corrected mortality was calculated with Abbott's formula.

**Epidemiological evaluation:** Epidemiological evaluation was carried out by door-to-door weekly surveillance. Blood smears of all fever cases were prepared on glass microscopic slides and examined microscopically for presence of *Plasmodium* parasites within 2–3 days. All malaria-positive cases were given radical treatment. Spleen surveys of 2- to 12-year-old children were also carried out to measure the endemicity of both control and experimental areas after impregnation of curtains. A social survey of user response was carried out in the study area with the help of a questionnaire prepared for this purpose.

Percent reduction of vector densities and epidemiological indices were calculated with the formula of Mulla (1971): percent reduction =  $100 - (C_1/T_1 \times T_2/C_2) \times 100$ , where  $C_1$  and  $T_1$  are the pretreatment indices and  $C_2$  and  $T_2$  are posttreatment indices. An SPS software package (Wipro India, Mumbai, India) was used to calculate  $P$  values.

## RESULTS AND DISCUSSION

The cumulative average density and structure of target and nontarget species are shown in Table 1. The monthwise density and structure of target species are presented in Fig. 1.

### Impact on target species

Estimates of density of both target and nontarget species were comparable before treatment of cur-

tains ( $P > 0.05$ ). Deltamethrin-treated curtains were shown to significantly reduce the indoor resting density of *An. stephensi*, *Ae. aegypti*, and *Cx. quinquefasciatus* ( $P < 0.05$ ). The sharp increase in density of *Cx. quinquefasciatus*, particularly during March–April 1995, may be due to the influx of this species with the onset of summer and also because of the decay of the insecticidal effect (Table 2 and Fig. 1). The reduction in densities of target species ranged between 82.6 and 96.9% and 82 and 96.3% during the 1st and 2nd impregnations, respectively. The cumulative reduction of both the 1st and 2nd impregnations varied from 87.9 to 93.7%. The reduction in adult densities was more pronounced for *An. stephensi* and *Ae. aegypti*, and less so for *Cx. quinquefasciatus*.

### Impact on nontarget species

Treatment of curtains with deltamethrin also resulted in reduction of densities of nontarget species, although this was not as evident in the 1st treatment as in the 2nd treatment. Nevertheless, the cumulative reduction ranged from 67.9 to 82.2% ( $P < 0.05$ ). The highest reduction (85.7%) was in cockroaches followed by that in ants (82.2%), crickets (79.8%), and houseflies (67.9%). These results agree with earlier findings (Ansari et al. 1998).

### Persistence of deltamethrin on treated curtains

Bioassay results revealed that curtains treated with deltamethrin at 100 mg/m<sup>2</sup> remained effective against *An. stephensi* and *Ae. aegypti* for 3 months after the 1st impregnation and for 5 months after the 2nd impregnation. However, treatments were effective against *Cx. quinquefasciatus* for only 2 months and 3 months after the 1st and 2nd impregnations, respectively. Treatment effectiveness was gradually reduced in successive months. Nevertheless, a mortality of 20.0–98.7% was obtained in all

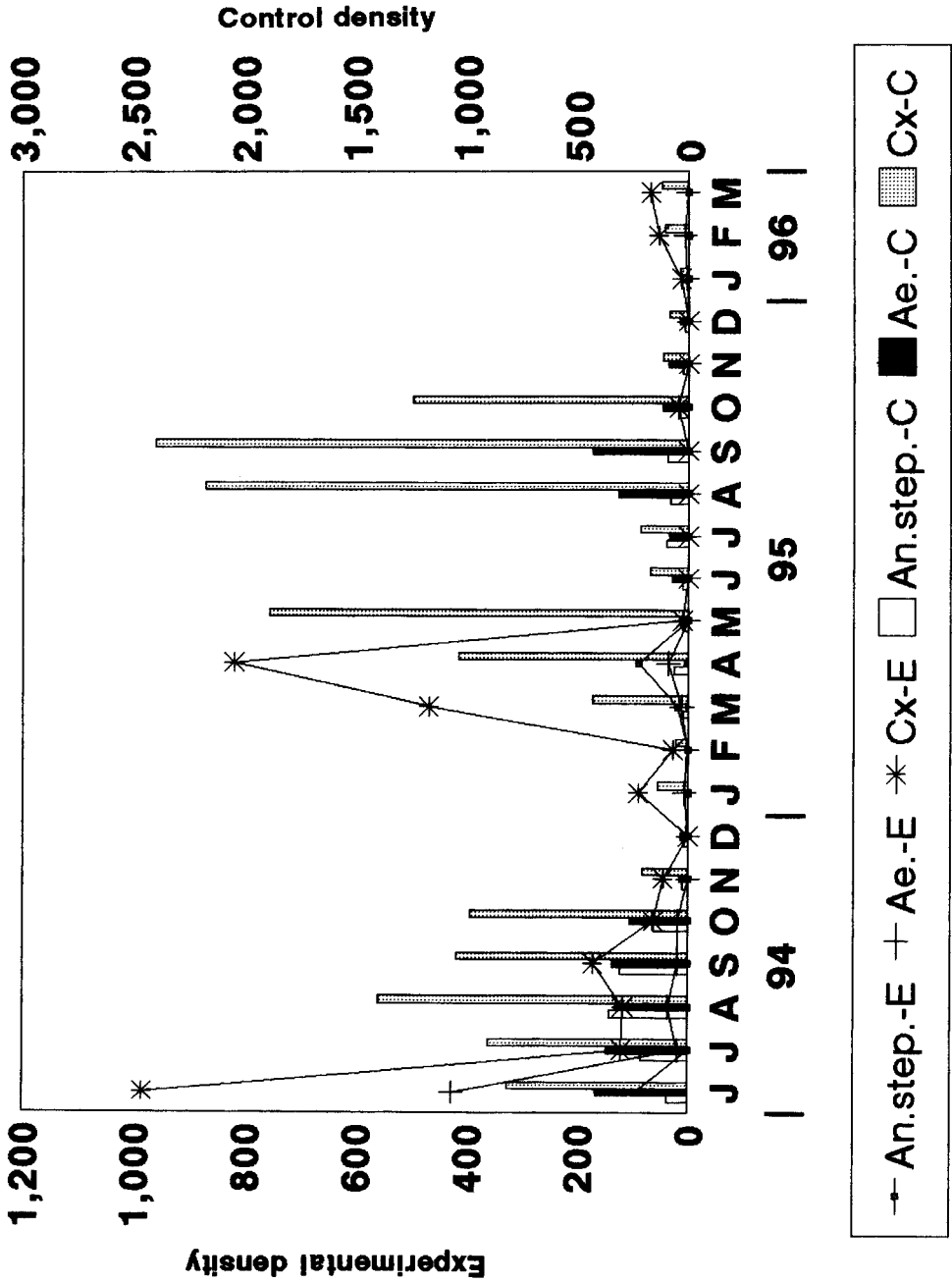


Fig. 1. Monthwise density and structure of *Anopheles stephensi*, *Aedes aegypti*, and *Culex quinquefasciatus*. E, experimental; C, control.

Table 2. Results of bioassay tests on deltamethrin-treated curtains in Block F of Moti Bagh, New Delhi Municipal Committee area.<sup>1</sup>

1st impregnation (July 8, 1994)	% corrected mortality			2nd impregnation (April 26, 1995)	% corrected mortality		
	<i>An. stephensi</i>	<i>Ae. aegypti</i>	<i>Cx. quinquefasciatus</i>		<i>An. stephensi</i>	<i>Ae. aegypti</i>	<i>Cx. quinquefasciatus</i>
July 1994	100	100	100	April 1995	100	100	100
August	100	100	100	May	100	100	100
September	100	100	98.7	June	100	100	100
October	96.2	96.2	93.7	July	100	100	95.0
November	91.2	92.5	90.0	August	100	100	91.0
December	86.2	86.2	78.7	September	91.0	90.0	88.0
January 1995	50.0	80.0	72.5	October	80.0	77.0	75.0
February	36.2	52.5	38.7	November	47.0	41.0	69.0
March	10.0	32.5	20.0	December	35.0	30.0	34.0

<sup>1</sup> *An.*, *Anopheles*; *Ae.*, *Aedes*; *Cx.*, *Culex*.

species of laboratory-reared mosquitoes up to 6 months after the 1st impregnation and a mortality of 34–95% was obtained after the 2nd impregnation (Table 2). Because malaria and dengue are transmitted during the monsoon and postmonsoon periods in northern India, a single impregnation in early July may effectively control transmission of both diseases. However, in southern and northeastern states, 2 treatments at an interval of 6 months may be required to cover the transmission season.

### Epidemiological impact

Cumulative data of epidemiological indicators are presented in Table 3 and monthwise data are shown in Fig. 2. Analysis of results revealed that deltamethrin-treated curtains have a substantial impact on slide positivity rate (SPR), slide *falciparum* rate, malaria cases per thousand population, and *Plasmodium falciparum* malaria cases (*Pf*) per thousand population. The SPR in deltamethrin treated localities was reduced to 91.3 and 93.7 after the 1st and 2nd impregnations, respectively, giving a cumulative reduction of 92.0%. Similarly, cases per thousand were reduced to 93.0 and 98.7%, yielding a cumulative reduction of 95.4%. Substantial reduction in *Pf* cases was also observed but percent reduction could not be calculated, because *Pf* cases were not recorded in the preexperiment

period in both experimental and control localities. Results of the spleen survey ( $n = 80$ ) during November 1994 revealed the difference in endemicity of disease. The average enlarged spleen was 0.0 in the experimental area compared to 1.5 in the control area. Thus, this study has clearly demonstrated the efficacy of deltamethrin-treated curtains in reducing malaria transmission in the experimental area.

The urban malaria scheme (UMS) was implemented in 1971–1972 to reverse the increasing trend of malaria in towns and cities of India. Under this scheme, 131 towns in 18 states and union territories with a population of about 74 million had been covered out of a total of 3,768 towns. The strategy of urban malaria control is based on anti-mosquito larval methods, occasionally supplemented by thermal malathion fogging. This strategy has not provided any reduction of the rising trend of urban malaria. The disease has emerged and re-emerged in epidemic form in Mumbai (Maharashtra), Panjim (Goa), Chennai (Tamilnadu), and Calcutta (West Bengal). In Tamilnadu, Chennai City alone contributes about 60% of the total malaria cases in the state (Poopathe and Raghunatha Rao 1995). Periodic epidemics of dengue and DHF have also occurred in metropolitan cities. A recent epidemic of DHF in 1995 resulted in 400 deaths (Ansari 1997).

Table 3. Cumulative epidemiological data of Block F (experimental) and Block E (control), Moti Bagh, New Delhi Municipal Committee area.<sup>1</sup>

	Preimpregnation		Postimpregnation						Cumulative % reduction
			1st impregnation		2nd impregnation				
	E	C	E	C	R	E	C	R	
SPR	5.76	3.1	3.9	22.3	91.3	2.3	19.6	93.7	92.0
SfR	0.0	0.0	0.5	4.8	0.0	2.3	6.8	—	—
Cases/1,000	3.25	1.3	7.5	42.6	93.0	1.0	30.6	98.7	95.4
<i>Pf</i> /1,000	0.0	0.0	1.0	9.3	—	1.0	10.6	—	—

<sup>1</sup> E, experimental; C, control; R, % reduction; SPR, slide positivity rate; SfR, slide *falciparum* rate; cases/1,000, malaria cases per thousand population; *Pf*/1,000, *Plasmodium falciparum* malaria cases per thousand population.

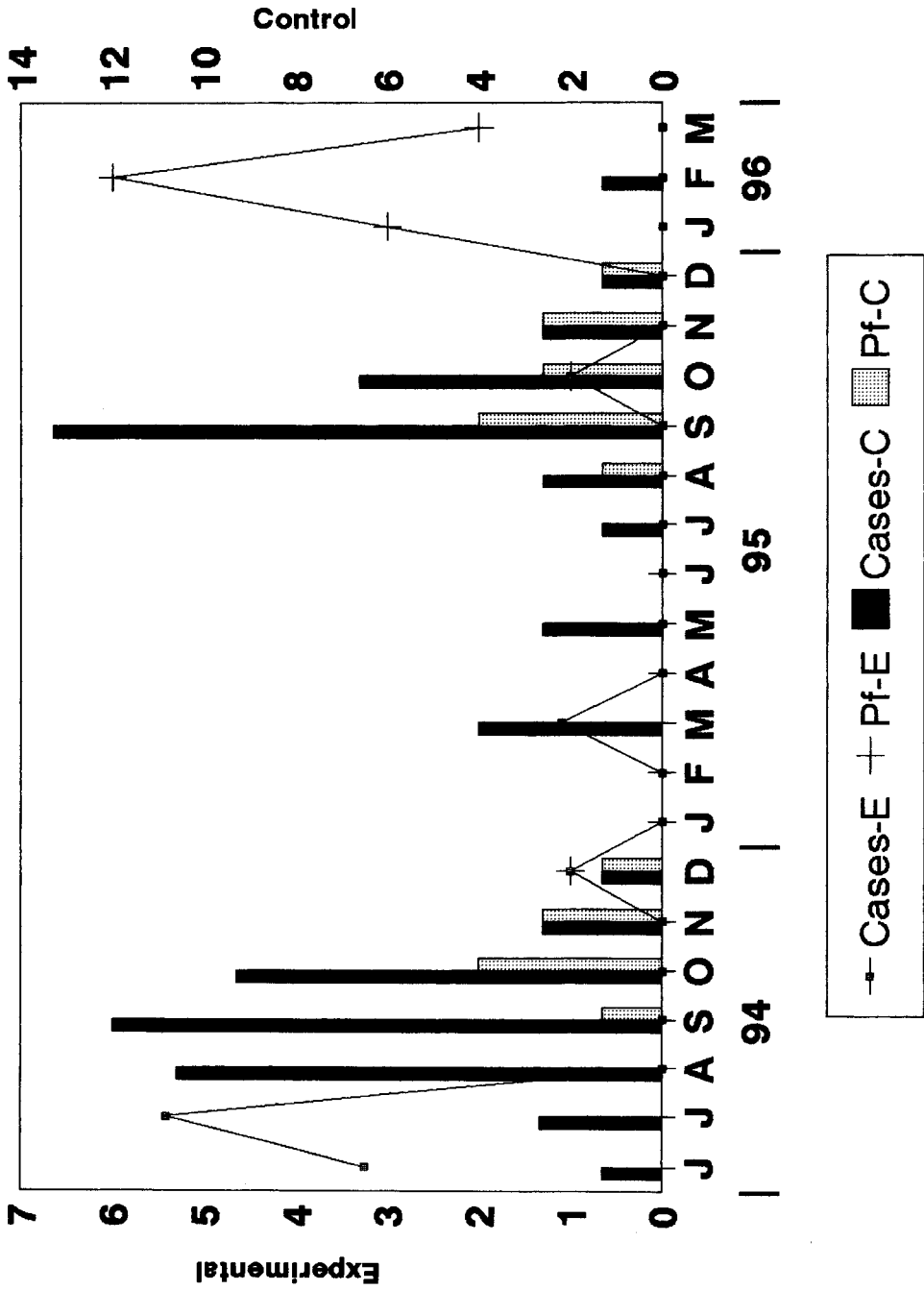


Fig. 2. Monthwise malaria cases (cases) and *Plasmodium falciparum* malaria cases (Pf) per 1,000 population. E, experimental; C, control.

This study demonstrated that deltamethrin-treated curtains reduced the incidence of malaria (particularly *falciparum* malaria), but transmission was not completely interrupted. This may be due to the habit of inhabitants of sleeping on terraces and rooftops, particularly during hot and sultry weather.

Domestic pests such as houseflies, crickets, and cockroaches also are serious problems in urban areas in India. This study has demonstrated the effective control of such pests in addition to control of mosquitoes.

The strategy of using deltamethrin-treated curtains should be incorporated into the UMS, where breeding places of vector species are inaccessible and >80% breeding places are located on domestic premises (Ansari 1993). The use of insecticide-treated curtains along with stringent legislative measures may provide a cost-effective solution for concurrent control of malaria, DHF vectors, and other domestic pests. The social survey conducted during this study showed a high rate of acceptability because of collateral benefits. The cost of treatment of house curtains was Rs 41.15 (<\$1 U.S.) per house per year. This cost is nominal and could be borne easily by inhabitants. Alternatively, government-supplied funds could be used to purchase chemicals and inhabitants could treat curtains themselves.

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