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PHLEBOTOMINE SAND FLY (DIPTERA: PSYCHODIDAE) CONTROL USING A RESIDUAL PYRETHROID INSECTICIDE[1]

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ABSTRACT. Cyfluthrin was evaluated in the field as a residual insecticide to develop a new strategy for control of Old World phlebotomine sand fly vectors of leishmaniasis, which live and rest inside termite mounds and animal burrows. This insecticide was evaluated as a residual spray in Baringo District, Kenya, during 1993. Termite mounds and animal burrows were treated with a cyfluthrin/corn oil mixture (1.5% AI) using an 8-liter hand-pumped sprayer. Treatment of animal burrows and termite mounds with cyfluthrin provided control of sand flies inside these structures for 12 wk. Numbers of sand fly adults collected in light traps were reduced by up to 90% for 2 wk following treatment. This indicates that cyfluthrin provides short-term area control of adult sand flies when applied to termite mounds and animal burrows.

INTRODUCTION

Visceral leishmaniasis, a fatal endemic disease of East Africa, is vectored by the phlebotomine sand fly *Phlebotomus martini* Parrot in the Baringo District, Kenya (Perkins et al. 1988). Termite mounds and animal burrows have been reported as the primary larval habitat and adult diurnal resting sites for *P. martini* in this area (Mutinga and Kamau 1986).

No vaccine or prophylaxis against visceral leishmaniasis is presently available. Currently, only vector control shows potential for reducing the incidence of this disease. Ward (1985) found that the problem with leishmaniasis control is not insecticide resistance of sand flies, but is because each of the leishmanial epidemiologies is unique in some respect and therefore different specialized control strategies are required. Marinkelle (1980) in his World Health Organization (WHO) review on control of leishmaniasis vectors stated that the only way of controlling sand flies is by proper application of insecticides. In addition, he made the recommendation that ventilation shafts of termite mounds that are close to human settlements be sprayed with insecticide for control of visceral leishmaniasis in East Africa.

The objective of this study was to evaluate residual pyrethroid insecticide spraying of termite mounds and animal burrows in Baringo District, Kenya, for the control of sand fly populations.

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MATERIALS AND METHODS

Two study sites, designated as Rabai-South and Rabai-North in the area of Rabai settlement, were located approximately 2 km south of Marigat, Baringo District, Kenya. This area is approximately 250 km NW of Nairobi (0°28′N, 35°58′E) at an altitude of 1,050 m. The rainy season is March to June and annual rainfall amounts average 510 mm. This area is characterized by rolling hills covered with various succulents and *Acacia* spp. Numerous termite mounds built by *Macrotermes subhyalinus* Rambur, the dominant mound-building termite species found in the area, are present. Also, numerous animal burrows built by the unstriped ground squirrel (*Xerus rutilus* Ehrenberg) are widely distributed.

The untreated control site (Rabai-South) and the treatment site (Rabai-North) were separated by approximately 1.5 km. Each study site, covering approximately 3 ha, contained 6 termite mounds and numerous (>15) animal burrows. Two occupied, wooden human domiciles were within each study site.

Six termite mounds and 6 animal burrows were randomly selected in each study site to monitor sand fly populations. In addition, 6 Solid State Army Miniature (SSAM) light traps were used to monitor sand fly populations within each site. Exit–entrance traps (Yuval and Schlein 1986) were used to monitor adult sand fly movement into and out of termite mounds and animal burrows. These traps consist of an empty 1.5-liter plastic water bottle with both ends cut out. The plastic cylinders (23 cm long × 9 cm diam), open at both ends, are divided in the middle by a fine-mesh partition. Paper sheets (34 × 11 cm) coated with castor oil cover the inside surface of each half of the trap to provide the trapping surface.

The trap seals off the termite mound or animal burrow when inserted into the opening. Flies

Table 1. Phlebotomine sand fly species collected at the treatment (Rabai-North) and control (Rabai-South) sites.

Species	Treatment site		Control site	
	n	(%)	*n*	(%)
Phlebotomus duboscqi	18	0.9	36	1.7
Phlebotomus martini	273	14.3	419	20.1
Sergentomyia adleri	106	5.5	92	4.4
Sergentomyia africana	40	2.1	60	2.9
Sergentomyia affinis	2	0.1	0	0.0
Sergentomyia antennata	404	21.0	704	33.7
Sergentomyia bedfordi	268	13.9	179	8.6
Sergentomyia clydei	199	10.3	139	6.7
Sergentomyia inermis	2	0.1	3	0.1
Sergentomyia schwetzi	565	29.4	429	20.4
Sergentomyia squamipleuris	43	2.2	18	0.9
Unknown/damaged	3	0.2	10	0.5
Total collected	1,923	100.0	2,089	100.0

emerging from the structure are caught on the inner half of the trap, and flies originating elsewhere and attempting to enter the structure are trapped on the outer half. The fine-mesh screen dividing the trap into halves allows free movement of air in and out of the structure. This design allows for the determination of whether the flies are entering or leaving the termite mound or animal burrow.

All termite mounds and animal burrows within the treatment site were treated with TEMPO 2® (cyfluthrin) (Miles Inc., Kansas City, MO) mixed with a corn oil carrier using an 8-liter hand-pumped compression sprayer. The spray solution contained 500 ml of 24% cyfluthrin mixed with 7.5 liters of corn oil (1.5% AI). The termite mounds were completely covered with spray outside and inside to a depth of 0.5 m. Animal burrows were sprayed around the outside opening and inside the tunnel to a depth of

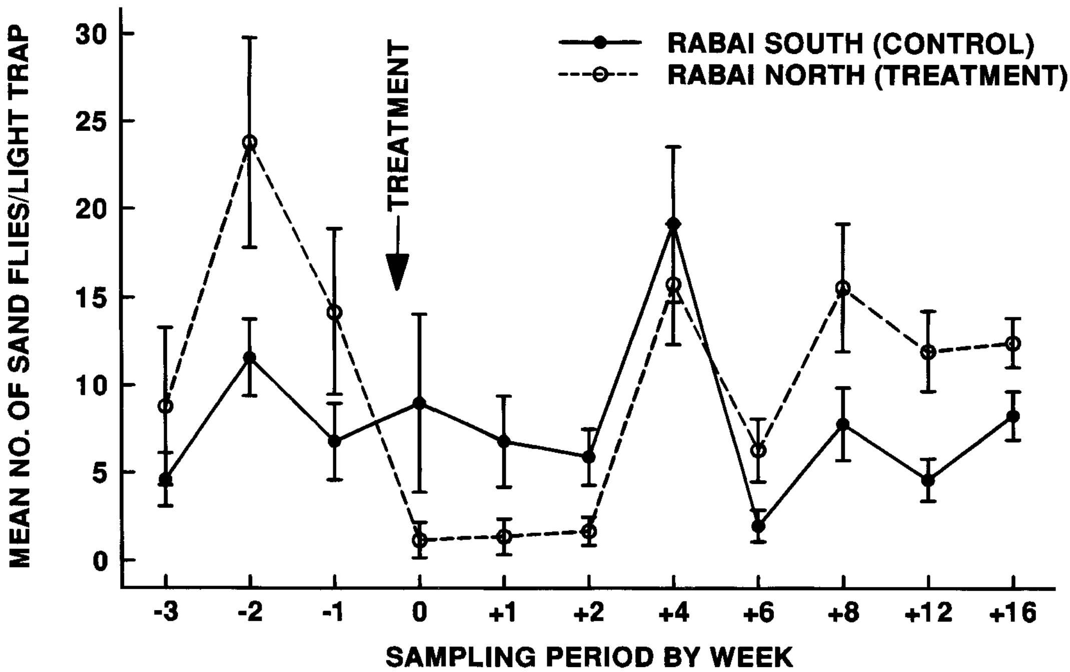

Fig. 1. Mean numbers of adult phlebotomine sand flies collected from light traps during the sampling period.

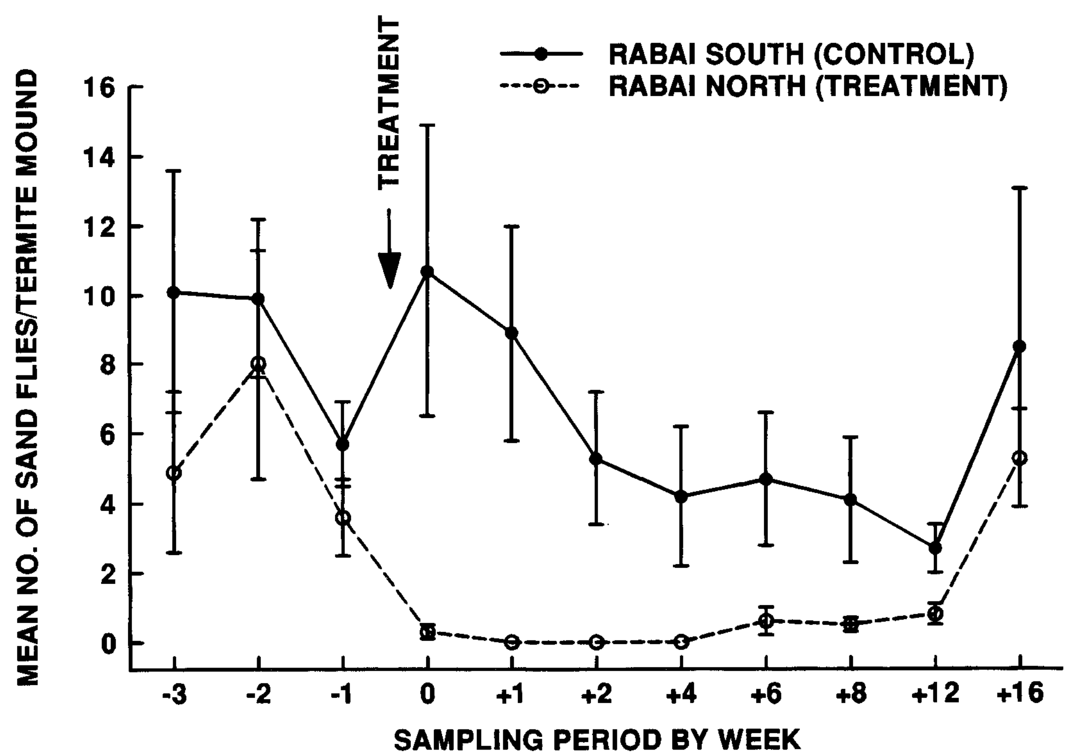

Fig. 2. Mean numbers of adult phlebotomine sand flies collected from termite mounds during the sampling period.

approximately 0.3 m. Adequate spray coverage of mounds and burrows was determined by the wet appearance of treated areas. Termite mounds and animal burrows received an average of 12 ml and 2.5 ml of active ingredient, respectively.

Sand fly trapping was conducted 2 nights per week (Monday and Tuesday nights) during the 3 wk prior to insecticidal treatment and 1, 2, 4, 6, 8, 12, and 16 wk posttreatment. Because a removal sampling technique was used, trapping was conducted only 2 nights per week so that it would have a minimal impact on the sand fly populations inside the termite mounds and animal burrows. Exit–entrance traps were placed in the selected termite mounds and animal burrows, and SSAM traps were set before dusk at 1800 h. All traps were collected at sunrise (*ca.* 0600 h) the following morning. In the field laboratory, trapped flies were counted, sexed, and identified, and direction of travel (exiting or entering) and burrow of origin were recorded.

Two-way analysis of variance was used to compare numbers of sand flies before and after treatment because the same termite mounds, animal burrows, and light trap sites were sampled repeatedly over time (Sokal and Rohlf 1981). This procedure was also used to determine if the sand fly species composition was significantly different between the 2 sites. The termite mounds, animal burrows, and light trap sites are one factor (considered as random and serving as replication) and the time dimension is the second factor, a fixed treatment effect (Statistix II 1987).

RESULTS

A total of 1,923 and 2,089 sand flies, representing 11 species, were captured from the treatment and control sites, respectively (Table 1). *Sergentomyia schwetzi* Adler, Theodor and Parrot, *Sergentomyia antennata* Newstead, *Sergentomyia bedfordi* Newstead, and *P. martini* were the predominate species at both the sites. The species compositions of sand flies collected at the 2 sites were not significantly different.

During the pretreatment period, the number of sand flies collected from animal burrows at the treatment site (333) compared to the control site (54) (df = 17,17; F-value = 3.98; $P = 0.04$) and in light traps at the treatment site (569) and control site (272) (df = 17,17; F-value = 4.27; $P = 0.04$) were significantly different. In contrast, significantly more (df = 17,17; F-value = 6.15; $P = 0.02$) flies were collected from termite

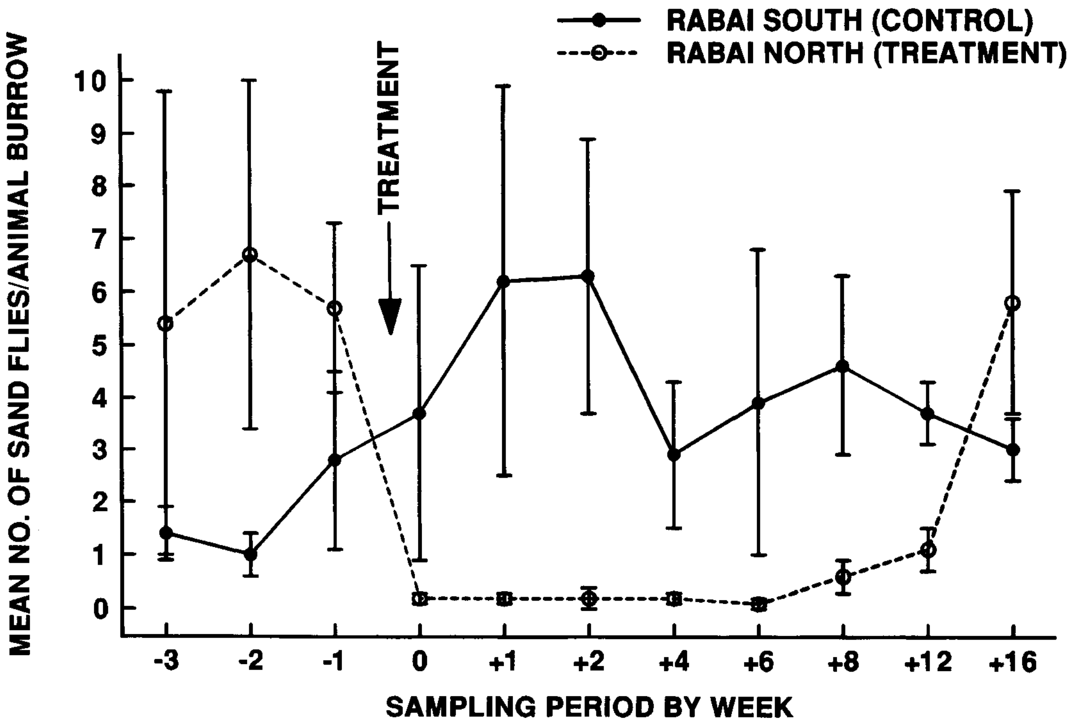

Fig. 3. Mean numbers of adult phlebotomine sand flies collected from animal burrows during the sampling period.

mounds at the control site (454) compared to the treatment site (291) during the pretreatment period.

After insecticidal treatment, cyfluthrin provided a significant (df = 17,17; F-value = 7.28; P = 0.02) 2-wk reduction in the mean number of adult sand flies collected per light trap at the treatment site (36) compared with the pretreatment mean number (190) (Fig. 1). There was a reduction of 92.4, 90.4, and 91.1% in the number of adult sand flies collected in light traps for weeks 0, 1, and 2, respectively. Numbers of sand flies collected in light traps varied during the sampling period, indicating seasonal population variation. However, both sites reflected the same variations, except during weeks 0–2 posttreatment at the treatment site.

After insecticidal treatment, numbers of sand flies collected in exit–entrance traps in animal burrows and termite mounds showed a marked reduction compared with pretreatment numbers. Cyfluthrin treatment provided significant (df = 41,41; F-value = 9.47; P = 0.01) residual control of sand flies for 12 wk in termite mounds (Fig. 2) and animal burrows (df = 41,41; F-value = 8.63; P = 0.01) (Fig. 3). The number of sand flies collected from these sites gradually increased from weeks 6 to 12 until they returned to levels not significantly different from pretreatment levels by week 16.

Rainfall totaled 77.4 mm during the 16-wk posttreatment period. Generally, this occurred as light rains of less than 5 mm accumulation at a time.

DISCUSSION

The species of sand flies collected from termite mounds and animal burrows are consistent with early research in this geographic area (Minter 1964). Eroded termite mounds and animal burrows are favored habitats for many of the common species of sand flies in Baringo District, Kenya (Robert et al. 1995).

Little is known about the effect of insecticidal applications on sand fly populations, especially in relation to leishmaniasis control (Lane 1991). Turner et al. (1965) reported poor control of adult sand flies in the Sudan using malathion and BHC applied as water emulsions for area control. These authors attributed the poor level of control achieved to the considerable and rapid infiltration of biting female sand flies into each test plot.

The reduction of the adult sand fly population after treatment with cyfluthrin in this study is consistent with previous research using various insecticides in Saudi Arabia (Büttiker 1980). Büttiker (1980) reported a considerable reduction of phlebotomine sand fly populations following regular ground application of diazinon and aerial application of iodofenphos insecticides in villages. Corradetti (1968) observed that kala-azar in the Middle East was considerably reduced by residual insecticide spraying in houses and animal dwellings.

Our results indicate that spraying sand fly resting and larval habitats with cyfluthrin, a residual insecticide, can provide short-term (2-wk) control of existing adult sand flies and long-term (12-wk) control of emerging sand flies from animal burrows and termite mounds. As indicated by previous research (Turner et al. 1965) and our observations, there is rapid infiltration of biting female sand flies back into treated areas.

This and previous research indicate that spraying of residual insecticides cannot only reduce numbers of sand flies, but may also serve to reduce the incidence of visceral leishmaniasis by reducing vector populations, as suggested by Corradetti (1968).

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