A TRIAL OF ULTRALOW VOLUME PYRETHRIN SPRAYING AS A MALARIA CONTROL MEASURE IN EL SALVADOR

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ABSTRACT. A field trial of ultralow volume spraying of synergized pyrethrins was carried out in a malarious coastal locality of El Salvador during the main transmission season of 1974. The spray was applied with ground equipment, and the insecticide used was a 5 percent solution of pyrethrins synergized with 15 percent piperonyl butoxide. Entomological evaluation of the spraying using mosquitoes in cages placed in and near houses, showed that the spraying caused high mortalities in these mosquitoes. Light trap studies in the sprayed and control localities showed a depression of the natural population of the vector *Anopheles albimanus* in the sprayed area. Malaria surveillance indicated that the ULV spraying had a marked impact on transmission of the disease during the main transmission season.

INTRODUCTION

During the malaria transmission season of 1974, the Central America Research Station (CARS) conducted a field trial of the ground application of ULV pyrethrins in a coastal area of El Salvador, with entomologic and epidemiologic assessment.

The periodic use of pyrethrin sprays as a malaria control measure in and around houses was a well-known procedure prior to the introduction of DDT. Their value on a large scale was first reported from South Africa by Park-Ross (1935), who showed that malaria could be controlled by pyrethrin spraying of houses in Natal and Zululand. Covell et al. (1938) used spray killing in India. Swellengrebel and de Buck (1938) reported good results in the Netherlands, by spraying houses five times during each August-September peak transmission period. Russell et al. (1943) carried out spray-killing experiments for several years in South India where the vector was *Anopheles culicifacies*. They reported success in reducing malaria transmission by weekly application of the spray to houses and animal sheds, even in villages where the houses were of open mud and thatch construction. In these early trials, the sprays were kerosene extracts of pyrethrum flowers usually containing about 0.1 percent natural pyrethrins, and were delivered by hand sprayers. With the appearance of DDT and other long-acting insecticides in the 1940's, the use of pyrethrins in malaria control declined, since malaria workers found these newer insecticides more convenient and economical to use. Pyrethrins were still found useful in the disinsectization of aircraft and in epidemic situations where a rapid knock-down of mosquitoes was required.

In recent years there has been a renewal of interest and experimentation in the use of pyrethrins for the control of pest and vector mosquitoes, since some species have developed physiologic resistance to the organochlorine, organophosphorus, and carbamate insecticides. In Middle America, and specifically in certain areas of El Salvador, *Anopheles albimanus*, the vector of malaria, is moderately to highly resistant to DDT, dieldrin, malathion, and propoxur. Georghiou (1972) has studied and reported these resistance levels in *A. albimanus* collected in Pacific coastal areas and has correlated this resistance with the widespread aerial application of insecticides for the control of cotton pests. This resistance has been considered to be an important contributing factor to the failure of domiciliary applications of re-

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sidual sprays to control malaria in coastal "problem areas" of El Salvador. Rachou et al. (1965) found that DDT house spraying had little impact on malaria transmission in areas of high vector resistance and exito-repellency to DDT. Hobbs and Mason (1974) found that spraying of houses every 5 weeks with propoxur in one of these "problem areas" did not prevent the initiation of a sharp outbreak of *P. falciparum* malaria. Relatively high levels of propoxur resistance were found in the vector anopheline populations of the area at this time.

Mount et al. (1968) reported on a technique for dispersing ultralow volumes (ULV) of undiluted insecticides as nonthermal aerosols using truck-mounted equipment. In the past few years ground application of ULV sprays has been successfully employed by many mosquito control organizations in the United States and in other countries. Mount and Pierce (1972) have shown ground application of ULV synergized pyrethrins to be effective against caged female *Aedes taeniorhynchus* (Wiedemann). Space spraying as a modern malaria control measure has often been mentioned as an alternative to house spraying but has been rarely employed except for aerially applied sprays such as those of malathion reported in Haiti by Eliason et al. (1975). The study reported here was carried out to test the effectiveness of pyrethrins applied as ULV ground sprays against *Anopheles albimanus.*

MATERIALS AND METHODS

STUDY AREA. One of the CARS study areas (District 13) is a 100 square km tract of coastal plain east of the port city of La Libertad. In the area there is intensive production of cotton, sugarcane, and beef cattle. The resident population of about 6,000 is concentrated in villages at the margins of 5 large haciendas. One of these villages, Cangrejera, was selected for the ULV spray testing since most of the houses were accessible to roads. A nearby village, Melara, selected as the control village, has similar housing, agricultural practices, and anopheline densities.

SPRAYING OPERATIONS. A truck-mounted LECO® sprayer, Model ULV-HD,[2] was used to deliver the spray. The insecticide used was a 5 percent solution of pyrethrins synergized with 15 percent piperonyl butoxide (Pyrocide®, MKG Co., Minneapolis, Minn.). This solution was sprayed at a discharge rate of 2–2.5 fluid oz. per min. while the truck was moving at 5 mi per hr. The objective was to treat the village with .002 to .0025 lbs per acre of pyrethrins and .010 to .0125 lbs per acre of piperonyl butoxide. The treated area of the test village included approximately 185 acres. The spray swath width was calculated to be about 100 m, and all of the houses of the village were located within this distance from roads. Approximately 150 fluid oz. of the insecticide were expended per application.

The ULV spray was applied once weekly starting the first week of May and ending the last week in August 1974. This period represents the peak malaria transmission season in the study area. The spraying was started at sundown, about 6 pm, and about 1 hr was required to spray both sides of every road in the village. During this part of the early evening, *Anopheles albimanus* females were seen moving about, actively seeking blood meals. Breeland (1972) found that the diel resting cycle of females of this species shows a pattern of resting during the daylight hours, followed by several evening hours of activity with no resting.

ENTOMOLOGIC EVALUATION. To measure the immediate knock-down and killing effect of the ULV spray, caged *A. albimanus* were placed in houses and open animal shelters located 30 to 40 meters from roads. The mosquitoes used in exposure cages (15 females per cage), were colony reared, 4-days old, and blood fed

[2] Use of trade names and commercial sources is for identification purposes only and does not constitute endorsement by the Public Health Service or by the U.S. Department of Health, Education, and Welfare.

on the day of exposure. Beginning with spraying operations on June 13 and continuing through the last week in August, 4 to 6 cages were exposed during the weekly spraying; these tests were repeated 8 times during the trial period. Knock-downs in these cages were recorded 1 hr after completion of the spray application. Control cages were exposed in similar situations, for a comparable period of time, in the unsprayed village of Melara.

To measure the natural *A. albimanus* population densities, and to compare these densities in the sprayed and unsprayed villages, New Jersey light traps were installed in Cangrejera and Melara. These traps operated 1 night a week, from sunset to sunrise during the entire 4 months of the trial period. The night chosen for trap operations was the night before the weekly ULV spray application, so as to separate in time as much as possible the trapping night from the spraying night.

EPIDEMIOLOGIC EVALUATION. Malaria surveillance information for the transmission seasons of 1973 and 1974 in the villages of Cangrejera and Melara was available through the voluntary collaborator post located in the center of each of the villages. The voluntary collaborator posts are part of the surveillance system of District 13; persons with fever may report to these posts, located throughout the District, where a blood slide is taken and free antimalaria drugs dispensed. Slides are examined for parasites in the CARS laboratory, and results used for calculations of malaria rates in different localities of the study area by month. Experience has shown that these posts provide a sensitive measure of malaria incidence in the small villages of the area (Mason and Hobbs, in press).

RESULTS AND DISCUSSION

ENTOMOLOGIC. The ULV spray application was effective in knocking down caged *A. albimanus* females placed in and near houses. Knock-downs after 1 hr ranged from 81.5 to 100 percent during 8 weekly trials (Table 1). Most of the houses in the study area are of relatively open construction, with open spaces around the eaves and spaces between the boards and poles used in wall construction. People living in this area are generally inside or immediately outside their houses during the hour following sunset. Since this is a peak hour of blood-seeking activity by *A. albimanus*, an effective space spray application at this hour could be expected to kill infective mosquitoes.

Light-trap results show lower densities of the natural populations of *A. albimanus* in the sprayed village of Cangrejera than in the control village of Melara during the spray period (Figure 1). The studies of previous years have shown that none of the localities of the study area are exactly equivalent in anopheline densities, as measured by light-trap studies. Melara, in 1973, had slightly higher densities than Cangrejera. During the ULV spray pe-

Table 1. Knock-down of caged *Anopheles albimanus* exposed in houses during ULV prethrin spraying June–August 1974, District 13, El Salvador

	CANGREJERA (sprayed)		MELARA (unsprayed)	
Date	Caged Mosquitos Exposed	Knock Down After 1 hr.	Caged Mosquitos Exposed	Knock Down After 1 hr.
13 June	83	98.8	45	15.6
18 June	60	81.5	45	9.0
20 June	60	86.5	45	4.0
23 July	60	86.5	30	10.0
31 July	55	100.0	39	3.0
15 Aug.	60	100.0	30	0.0
21 Aug.	60	90.0	30	0.0
28 Aug.	57	86.7	30	3.5

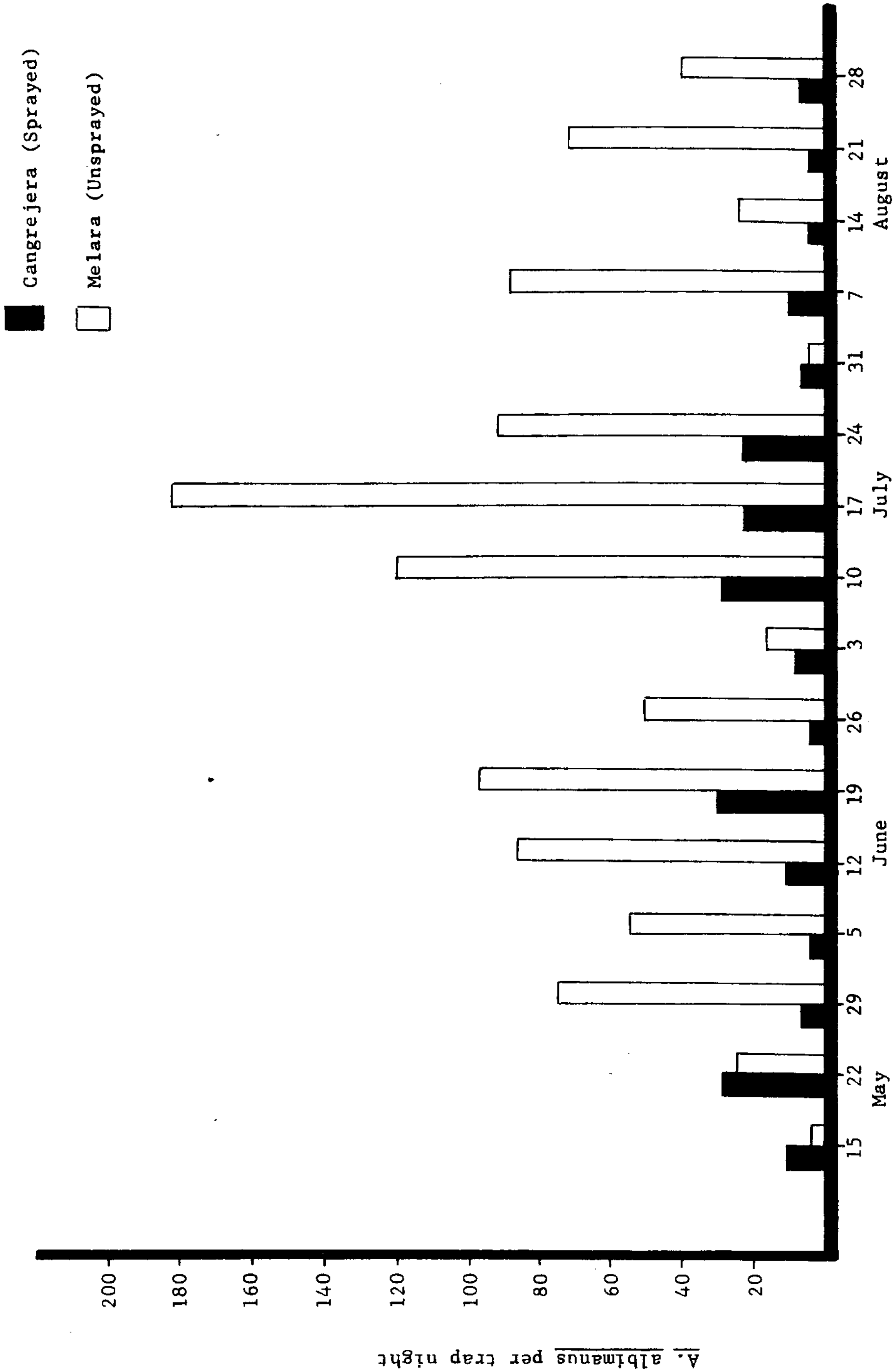

Fig. 1. New Jersey Light Trap Catches in Cangrejera (Sprayed) and Melara (Unsprayed) by Week, District 13, 1974

riod of 1974, however, the vector population in the test village was markedly depressed. In these villages, which are separated by 3 km, the main rainy season larval habitats are near the houses and blood sources. It seems unlikely that large scale migrations of new mosquitoes from village to village take place frequently. Although aerosols of pyrethrins have no residual effectiveness, it appears that the weekly killing of gravid and potentially gravid females with these insecticides can bring about a measure of control of local *A. albimanus* populations.

EPIDEMIOLOGIC. Malariometric data from the volunteer collaborator posts in Cangrejera and Melara were analyzed for the period 15 June to 15 September 1973 and 1974. A comparison was then made between the 2 villages in terms of cases of *Plasmodium falciparum* malaria and *falciparum* attack rates per 100 population (Table 2). Attack rates are shown for *falciparum* malaria only; the total number of malaria cases includes an immeasurable number of *Plasmodium vivax* relapses and, therefore, does not clearly reflect current transmission.

Table 2. *Plasmodium falciparum* attack rates (per 100 pop.) in Melara and Cangrejera main transmission seasons of 1973 and 1974

Transmission Season	Melara (Control) total malaria cases	Pop = 485 *P. falciparum* cases	Pop = 485 *P. falciparum* cases per 100 pop.	Cangrejera (Sprayed) total malaria cases	Pop = 408 *P. falciparum* cases	Pop = 408 *P. falciparum* cases per 100 pop.
15 June–15 Sept. 1973	25	9	1.8	118	63	15.4
15 June–15 Sept. 1974	101	35	7.2	69	21	5.1

Total number of cases in Cangrejera, the sprayed village, decreased from 118 in 1973 to 69 in 1974 for the months under study and total *falciparum* cases decreased from 63 to 21. *Falciparum* attack rates decreased from 15.4 per 100 population to 5.1 per 100 population. In the control village of Melara, on the other hand, total cases increased from 25 in 1973 to 101 in 1974, while *falciparum* cases increased from 9 to 35. *Falciparum* attack rates in the control village increased from 1.8 per hundred in 1973 to 7.2 per hundred in 1974. This shows that the once weekly application of ULV pyrethrins had a measurable impact on malaria transmission in Cangrejera during the transmission season of 1974.

Even though the present cost of synergized pyrethrins is high, the ground application of ULV sprays is operationally simple, and manpower costs are low. The degree of protection afforded by this strategy is, of course, difficult to assess from this single trial. This control method might be considered in other malarious localities where conventional house spraying has failed to achieve control due to insecticide resistance of the vector or peridomicilliary transmission of the disease.

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