EVALUATION OF PROPOXUR SPRAYING IN HOUSES AS A MALARIA CONTROL MEASURE IN EL SALVADOR

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ABSTRACT. An extensive malaria surveillance system already in operation and an entomological surveillance system were used to evaluate the effect of propoxur application in houses every 5 weeks in a highly malarious coastal area of El Salvador. The spraying of houses with this insecticide did not prevent the initiation of malaria transmission and the development of a sharp *Plasmodium falciparum* outbreak in the area. High levels of resistance to propoxur in the *Anopheles albimanus* populations could be a contributing factor to the failure of propoxur to interrupt transmission of the disease.

INTRODUCTION

The emergence of resistance of malaria vectors to DDT, dieldrin and HCH in certain parts of the world has seriously modified progress, and in some situations has become one of the major obstacles to achieving the goal of malaria eradication. This has led to an intensive search for alternative insecticides for use in malaria control programs. The World Health Organization collaborative program for the evaluation and testing of insecticides is based on newly-developed insecticides submitted to WHO. The testing procedure has been described in detail by Wright, *et. al.* (1969).

One compound to pass successfully from preliminary laboratory tests through operational field trials is the carbamate ortho-iso-propoxyphenyl methylcarbamate, also known as propoxur, OMS-33 and Baygon®. Large scale trials of propoxur were carried out in three areas in 1966-67: southern Iran, northern Nigeria and El Salvador. In these areas DDT is ineffective for the interruption of malaria transmission for a number of reasons, including vector resistance to the compound. Propoxur proved to be an effective substitute insecticide in these trials, as reported by Wright, *et. al.* (1969). When sprayed at 2 gm/m^2 propoxur continued to give satisfactory kills of the anopheline vectors up to 12 weeks after spraying. Another significant finding during these trials was that the insecticide has an airborne phase which is effective in killing mosquitoes at some distance from the sprayed surface.

Additional field trials of propoxur using a partial spraying technique were conducted in El Salvador during 1971 and 1972, and the results were reported by Lassen *et. al.* (1972). An application of 60 grams per house on selected inside surfaces was considered to be an effective and economical way to use this insecticide. This partial spray control measure was introduced in 1972 by the National Antimalaria Campaign (CNAP) in an area where the Central America Research Station (CARS) was carrying out basic studies on the epidemiology of malaria, and it was possible to evaluate the effects of the insecticide using the surveillance system already in operation.

Many factors of vector physiology and behavior as well as human behavior may contribute to malaria transmission. We were aware that a certain amount of propoxur resistance was present in the vector anopheline populations of the study area prior to the propoxur spraying, since this was reported by Georghiou (1972) in *Anopheles albimanus* Wiedemann collected from this same area. We did not know what operational implications this might have, since resistance levels were thought to be low in most of the localities of the study area. It was believed that well-executed cycles of spray-

ing might have some measurable impact on malaria transmission.

MATERIALS AND METHODS

DESCRIPTION OF THE STUDY AREA. The CARS coastal study area, known as District 13, is a 100 square kilometer tract of low lying land 20 kilometers east of the port city of La Libertad. The area is mainly an agricultural one, with 5 large haciendas engaged in cotton cultivation and cattle production. The area has a population of approximately 6,000 people living in 1,200 houses. Malaria is endemic, and incidence of the disease was relatively high during 1971.

HOUSE SPRAYING. Area-wide spraying was started on March 15, 1972, with all houses being sprayed every 5 weeks through November, 1972. A target dosage of 60 gms of propoxur 70 percent water dispersible powder was applied to the interior of each house, using two 1-meter wide swaths around the interior walls of the house. The spraymen were CNAP employees supervised by CARS field personnel. The coverage of houses was 95 percent or higher in each 5-week cycle.

ENTOMOLOGICAL EVALUATION. The effect of the propoxur spraying was tested entomologically by making house captures of resting *A. albimanus* during the late morning hours. Searches were made weekly in 64 houses of 4 different localities. The spray application was considered to be ineffective when live mosquitoes were found resting on inside walls of sprayed houses during the late morning hours.

Susceptibility tests were carried out in March, May, and June 1972, with *A. albimanus* captured in 4 different localities of the district. The WHO technique for testing the susceptibility of adult mosquitoes was used, and the mosquitoes were exposed for 1 hour to 0.1 percent propoxur-impregnated papers. Parallel tests were run using known propoxur susceptible *A. albimanus* from a CARS laboratory colony for comparison with tests of the wild-caught specimens.

EPIDEMIOLOGICAL EVALUATION. Malaria surveillance was carried out during the entire year by house-to-house fever surveys conducted every 2 weeks. Blood slides were collected from all actual and recent fever cases and examined in our laboratories. Two mass surveys were done, one in February before the main transmission season and one in August during the transmission season. In addition, 14 voluntary collaborator posts were maintained at different points in the district where people with fever could receive free medication in exchange for a blood slide.

RESULTS AND DISCUSSION

ENTOMOLOGICAL. Live *A. albimanus* were found resting in sprayed houses during the late morning hours in the locality of Chagüitón as early as 2 days after spraying,

TABLE 1. Live *Anopheles albimanus* found in houses during late morning hours, after propoxur spraying in four localities of District 13, June and July, 1972

Locality	Days Post-Spraying																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Melara (16 houses)	*	—	—	—	—	4	—	—	—	—	—	1	7	—	—	—	—	—	—	4
Toluca (16 houses)	—	—	0	—	—	—	—	—	1	2	—	—	8	—	—	—	—	—	2	2
Chagüitón (16 houses)	—	23	—	—	—	—	—	—	8	—	—	—	—	—	38	—	—	—	—	—
Cangrejera Sur (16 houses)	—	—	—	—	—	0	—	—	—	—	—	—	7	—	—	—	—	—	—	11

* No observations

indicating ineffectiveness of the propoxur application. The other localities examined had resting mosquitoes at 6, 9 and 13 days after spraying, showing that these houses were unprotected by the propoxur during the greater part of the interval between spray cycles. These observations were made in July following the third spray application; findings are summarized in Table 1.

The susceptibility tests showed resistance in the *A. albimanus* collected in the localities of Cangrejera, Cangrejera Sur, Melara and Santa Lucía, when tests of wild caught mosquitoes were compared with tests of the known propoxur susceptible laboratory colony. The resistance was at the highest level in the seaside village of Cangrejera Sur, where 87 percent of the mosquitoes survived the 1-hour exposure to propoxur impregnated papers. Results of these tests are given in Table 2.

EPIDEMIOLOGICAL. A total of 2665 malaria cases were diagnosed during the year, from a total of 19,680 blood slides collected. Of the positive slides, 2132 were *Plasmodium vivax* infections and 533 were *P. falciparum* infections. The *P. falciparum* incidence can be taken alone as an indication of the transmission curve, since there are no relapses to complicate the picture as with *P. vivax*. Although spraying started in March, 1972, more than 500 *P. falciparum* cases were found in the area after the initiation of spraying, as shown in Figure 1. Practically all of the cases were investigated, and it was determined that transmission was occurring in spite of 95 percent coverage of the houses in the area with propoxur every 5 weeks.

One explanation for the persistance of transmission in spite of the propoxur spraying is the presence in the area of *A. albimanus* populations with a high level of resistance to this insecticide. While propoxur itself has not been used for agricultural spraying, other carbamates, as well as a wide range of organophosphate and organochlorine insecticides, have been used and probably have been important in producing a wide spectrum of resistance in *A. albimanus*.

References

Georghiou, G. P. 1972. Studies on resistance to carbamate and organophosphorus insecticides in *Anopheles albimanus*. Amer. Jour. Trop. Med. Hyg. 21(5): 797-806.

Lassen, K., Liu, S. K., Lizarzaburu, C. and Rios R. 1972. Preliminary report on the effect of selective application of propoxur on indoor surfaces in El Salvador. Amer. Jour. Trop. Med. Hyg. 21(5):813-818.

TABLE 2 Results of susceptibility tests of *Anopheles albimanus* one hour exposure to propoxur 0.1% (WHO method)

District 13, 1972

Test Date	Locality	Source		No. of *A. albimanus* Exposed	% Mortality 24 hours
3 Mar.	Cangrejera Sur	Inside Houses	Test	75	13
			Control	25	0
23 May	Melara	Stable	Test	57	41
			Control	60	0
30 May	Santa Lucía	Stable	Test	131	41
			Control	53	3
6 June	Cangrejera	Stable	Test	20	45
			Control	20	0
15 May	CARS Lab. Colony	Colony	Test	302	100
			Control	75	1

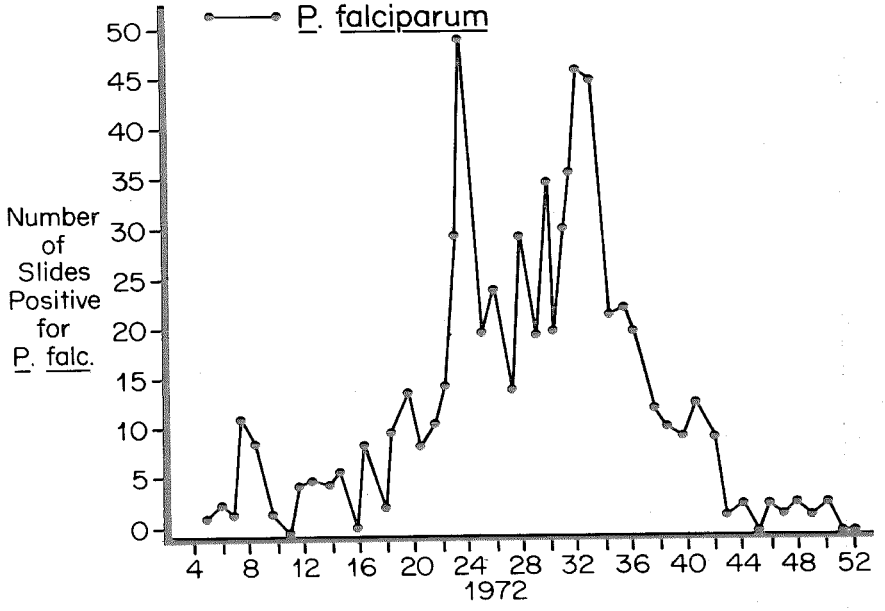

Fig. 1 Blood slides positive for *Plasmodium falciparum*, from all sources except mass surveys, by week, District 13, El Salvador, 1972.

Wright, J. W., Fritz, R., Hocking, K. S., Babione, R., Gratz, N. G., Pal, R., Stiles, A. R. and Vandekar, M. 1969. Ortho-isopropoxyphenyl methylcarbamate (OMS-33) as a residual spray for control of anopheline mosquitoes. WHO Bul. 40:67-90.