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VILLAGE TRIAL OF CARBARYL AGAINST ANOPHELES ALBIMANUS IN EL SALVADOR, CENTRAL AMERICA[1]

by

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ABSTRACT

Carbaryl was tested in El Salvador against Anopheles albimanus as a residual insecticide in several types of rural houses. At 2 g/m^2 mosquitos confined to treated surfaces were killed for 15 weeks after application. However, mortalities of naturally entering and departing female mosquitos were too low and, therefore, the material was judged to be unsatisfactory for malaria control under the conditions of these tests.

Alternate insecticides for DDT for use in residual spraying for malaria eradication have been sought, but few have arrived at the stage of field testing in problem areas. A village trial with one such candidate insecticide, a carbamate compound, carbaryl (1-naphthyl N-methylcarbamate, OMS-29) was carried out by the insecticide testing unit of the World Health Organization (WHO) near Lagos, Nigeria, in 1963. Bar-Zeev & Bracha (1965) reported that carbaryl reduced the indoor anopheline densities for two months but that by the third month the density rose again, approaching that of the control village.

In 1969 the Central America Malaria Research Station (CAMRS) carried out a small scale trial of carbaryl in the village of El Progreso which is located in the eastern part of El Salvador. The village is situated on a low rise along the margin of the Lagoon San Juan at an altitude of 73 metres. The houses are very scattered in the area and are mainly of the loose or open type construction prevalent in the rural lowlands of El Salvador. Wall surfaces may be, and often are, constructed of several different materials, but pole walls were found to be predominant in both the treated and control villages. The roofs were mainly of grass-thatch or tile.

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There is extensive cotton growing around the test village. The principal mosquito breeding source is the Lagoon San Juan, including the swamps around it, situated to the south of the village. Mosquito breeding is mainly of the rainy season type. The rainy season, with a range of 1725 to 2570 mm of rain yearly, is generally from May through October in this part of El Salvador. When the rains stop the non-permanent breeding sites tend to dry up rapidly. The yearly temperature in the area ranges from 19.3°C to 37.2°C.

Playa Grande, used as a comparison village, is situated approximately 10 kilometres south-east from El Progreso in a valley near a small lagoon, at an altitude of 62 metres. The houses in both villages had been routinely treated previously by the Campaña Nacional Anti-Palúdica (CNAP) (National Malaria Eradication Programme) with DDT at 2 g/m^2. This comparison village, Playa Grande, was treated routinely during the study by CNAP with DDT in June and November 1969. The country is in the attack phase of malaria eradication and there are said to be no untreated villages to use for comparison purposes. Due to the high DDT resistance of the principal malaria vector Anopheles albimanus, no appreciable effectiveness of the DDT treatments was observed with the entomological evaluations employed.

MATERIALS AND METHODS

Insecticide treatments. The test village was treated with carbaryl first on 26 June 1969 and then again on 20 October by 8 CNAP spraymen utilizing conventional hand-operated compression sprayers equipped with fixed pressure regulators. The carbaryl used was an 85% water dispersible powder and the amount applied was calculated to give a target dose of 2 g/m^2 of technical material. In the first test 60 houses were treated with total inside coverage, and in the second test 70 houses were treated. There was practically no odour from the insecticide and there were no complaints from the inhabitants during the spraying.

Resting and biting counts. Ten "fixed point" houses were selected in each village which were searched weekly or fortnightly by two men to a house using aspirators and flashlights. The approximate time spent was 15 minutes to each house, beginning at 0600 hours. The live A. albimanus encountered were held for 24 hours to observe mortality and the females were grouped into blood-fed, gravid and unfed.

Exit trap densities and mortalities. Collapsible wall traps made of marquisette and metal frames were placed over as many of the openings as possible on one pole-type house in each village. For the fortnightly tests, the traps were fixed into position before 1800 hours and the house searched and any live and dead mosquitos that might already be inside were removed. The following morning at 0600 hours the traps were searched for live and dead mosquitos and then a similar search was made inside the house. The live mosquitos collected were held for 24-hour mortality observations.

Bioassays of inside surfaces. Bioassays of the main indoor surfaces were made using the WHO (1963) method with the variation that CO_2 gas was used when the test mosquitos were removed from the chambers. There were 10 to 15 blood-fed females per chamber and three chambers per surface in two different houses. Modified test chambers were used for the bioassays on such curved surfaces as roof tiles and pole walls. Also a special holding device was developed to hold the WHO chamber on surfaces such as thatch and palm to help prevent insecticide falling into the test chamber and holding cups.

The A. albimanus used for the bioassay tests were collected from the local corral the night before the test, or from the El Jocotal Corral where there existed a high density of DDT-resistant A. albimanus. The bioassay tests began at 0600 hours and the test specimens were held with cotton pads soaked with sugar water for 24 hours at which time the mortality was calculated. The exposure period in all tests was 60 minutes.

RESULTS

Resting and biting counts. In two pretreatment captures there was an average of 1.5 and 3.8 live A. albimanus females captured per house in El Progreso. The post-treatment captures yielded a mean of 1.3 and 1.0 live females per house during weeks 1 and 2, respectively. There was then a marked increase above pretreatment levels on subsequent captures until the general density decline in week 11 (Table 1). The number dying in 24 hours and the number found dead in this first test represented less than 50% of the total number recovered at all times.

In Playa Grande, the comparison village, similar captures in 10 "fixed point" houses indicated higher house-resting densities (Table 2) Interestingly, but not unexpected, even after the routine DDT treatments the house-resting density remained the same or increased.

At the time of the second carbaryl application on 20 October, unfortunately, the mosquito density had declined markedly in the area. It was interesting, however, that by week 3 a few live A. albimanus were encountered in the treated houses indicating results similar to those obtained in the first test (Table 1).

Indoor and outdoor human night-biting counts and corral counts were made in both villages. These counts indicated that carbaryl had no effect in reducing the number of mosquitos entering the treated houses and biting the occupants. The counts also showed a general mosquito population increase in the areas from early June to late August with a sharp decline thereafter.

Exit trap densities and mortalities. It will be noted that there was an 18% mortality in the capture made prior to the initial carbaryl treatment whereas in that made in the same house two weeks following treatment it was only 42% (Table 3). In two subsequent captures at four and six weeks after treatment the mortalities were 33% and 31%, respectively. The rate of exit into the traps was very high, ranging from 67% to 96%.

Following the second application of carbaryl on 20 October, the density of the mosquitos entering the houses was very low, which may have tended to exaggerate some of the mortality percentages. However, consideration of only the mortalitiy among the blood-fed mosquitos, which is considered to be a more accurate evaluation, shows the mortalities much lower (25% and 18% on weeks four and six, respectively). The exits into the traps during the second test were about the same as those observed in the first test. Similar tests with wall-traps were carried out in the comparison village of Playa Grande approximately three weeks after those in the test village (Table 4). Although there were fewer tests run, there were lower overall mortalities, ranging from 0% to 12%. High exit numbers were also encountered, with 73% to 100% of the total number of mosquitos being taken in the traps.

Bioassays. The bioassays following the first carbaryl treatment showed satisfactory kills (above 70% mortality) up to 13 weeks on wood, nine weeks on thatch, three weeks on mud, 11 weeks on poles (but variable), three weeks on adobe and unsatisfactory results on tile as early as the first test on week three (Table 5). Following the second treatment on 20 October, there was an increase in the duration of effectiveness on wood which gave 91% mortality up to 17 weeks when the bioassays were discontinued. The residues on thatch, although variable on weeks 13 and 15, did give 78% mortality on week 17. Mortalities on mud were poor following the bioassays on week two and on adobe were fair up to week six. The residues on tile were again unsatisfactory from the first bioassays on week two. Mortalities on the pole surfaces were good up to week 17, with 89% mortality being recorded at that time. There was a decline in mortalities, however, on this surface in week 13 to 55% mortality. There appeared to be some additive effect from the second treatment at least on wood, poles and thatch, although this was not reflected in the effect on the mosquitos naturally entering and leaving the treated houses.

The tests done in Playa Grande, the DDT-treated comparison village, indicated unsatisfactory results on all surfaces using as the test mosquitos the DDT-resistant A. albimanus from Playa Grande and El Jocotal.

CONCLUSIONS

Bioassay tests indicated that when the mosquitos were confined to the treated surfaces in wall cages for one hour, lethal residues of carbaryl remained present on most of the indoor surfaces of treated houses for three to 13 weeks after spraying. However, satisfactory mortalities of the naturally entering and departing A. albimanus were not obtained. Hence, carbaryl was not found to be useful for the residual spraying of houses for malaria eradication in the coastal, DDT-resistant problem area of El Salvador.

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REFERENCES CITED

Bar-Zeev, M. & Bracha, P. (1965) A village-scale trial with the insecticides carbaryl and folithion in Southern Nigeria, Bull. Wld Hlth Org., No. 33, 461-470

World Health Organization (1963) Insecticide resistance and vector control. Thirteenth report of the WHO Expert Committee on Insecticides. Wld Hlth Org. techn. Rep. Ser. No. 265, 227 pp.

TABLE 1. EARLY MORNING CAPTURES OF A. ALBIMANUS INSIDE 10 HOUSES TREATED WITH CARBARYL EL PROGRESO, 1969-70

Date	Week	Number houses positive	A. albimanus females			
			Total		Number per house	
			Alive	Dead	Alive	Dead
27 May 1969	-4	4	15	0	1.5	0
3 Jun	-3	8	38	0	3.8	0
26 Jun	0	Locality treated with carbaryl at 2g/m^2				
2 Jul	1	4	13	9	1.3	0.9
9 Jul	2	4*	9	7	1.0	0.8
24 Jul	4	7	32	15	3.2	1.5
30 Jul	5	8	39	7	3.9	0.7
15 Aug	7	10	60	13	6.0	1.3
27 Aug	9	9	156	24	15.6	2.4
10 Sept	11	4	3	0	0.3	0
24 Sept	13	3	3	0	0.3	0
7 Oct	15	4	8	0	0.8	0
20 Oct	0	Locality treated with carbaryl at 2g/m^2				
28 Oct	1	2	0	8	0	0.8
13 Nov	3	3	2	3	0.2	0.3
27 Nov	5	2	0	3	0	0.3
10 Dec	7	4	4	2	0.4	0.2
23 Dec	9	3	3	0	0.3	0
8 Jan 1970	11	1	1	0	0.1	0
20 Jan	13	0	0	0	0	0
3 Feb	15	0	0	0	0	0
17 Feb	17	0	0	0	0	0

* Nine houses searched only

TABLE 2. EARLY MORNING CAPTURES OF A. ALBIMANUS INSIDE 10 "UNTREATED" HOUSES PLAYA GRANDE, 1969-70

Date	Week	Number houses positive	A. albimanus females			
			Total		Number per house	
			Alive	Dead	Alive	Dead
27 May 1969	25	7	64	0	6.4	0
2 Jun	0		Locality treated with DDT at 2g/m^2			
4 Jun	0	8	78	0	7.8	0
1 Jul	4	9	102	12	10.2	1.2
7 Jul	5	8	106	0	10.6	0
31 Jul	8	10	73	0	7.3	0
14 Aug	10	10	73	0	7.3	0
28 Aug	12	10	38	0	3.8	0
12 Sept	14	8	54	0	5.4	0
25 Sept	16	8	10	0	1.0	0
8 Oct	18	8	18	0	1.8	0
29 Oct	21	10	46	2	4.6	0.2
5 Nov	0		Locality treated with DDT at 2g/m^2			
13 Nov	1	6	42	1	4.2	0.1
27 Nov	3	4	12	0	1.2	0
11 Dec	5	2	3	0	0.3	0
23 Dec	7	3	4	0	0.4	0
8 Jan 1970	9	7	24	1	2.4	0.1
21 Jan	11	2	2	0	0.2	0
4 Feb	13	2	8	0	0.8	0
18 Feb	15	3	4	0	0.4	0

Alive = Survived 24 hours after capture
Dead = Found dead, or captured alive and died within 24 hours

TABLE 3. EARLY MORNING CAPTURES OF A. ALBIMANUS INSIDE CARBARYL-TREATED HOUSES AND IN EXIT TRAPS EL PROGRESO, 1969

Date	Week	House number	A. albimanus females		
			Total	% Mort.	% in traps
20 June	-1	27B	53	18	93
26 June	0	Locality treated with carbaryl at 2g/m^2			
8 Jul	2	27B	31	42	68
22 Jul	4	27B	18	33	67
6 Aug	6	27B	26	31	96
20 Oct	0	Locality treated with carbaryl at 2g/m^2			
5 Nov	2	27B	4	100	100
19 Nov	4	27C	10	90	90
3 Dec	6	30A	37	13	68
10 Dec	7	30A	68	25	94

TABLE 4. EARLY MORNING CAPTURES OF A. ALBIMANUS INSIDE "UNTREATED" HOUSES AND IN EXIT TRAPS PLAYA GRANDE, 1969-1970

Date	Week	House number	A. albimanus females		
			Total	% Mort.	% in traps
2 Jul 1969	4	34A	95	3	73
9 Jul	5	34A	125	1	84
31 Jul	8	34A	26	0	100
21 Aug	11	34A	25	12	96
5 Nov	0	Locality treated with DDT-2g/m^2			
21 Jan 1970	11	355	13	0	100

[a] Weeks after treatment with DDT.

TABLE 5. PER CENT. MORTALITY OF FIELD COLLECTED A. ALBIMANUS FEMALES 24 HOURS AFTER EXPOSURE TO CARBARYL AND DDT RESIDUES EL PROGRESO (CARBARYL) AND PLAYA GRANDE (DDT), 1969-70

Week after carbaryl	Insecticide	Surface							
		Wood	Thatch	Mud	Poles	Tile	Palm	Adobe	Control
First treatment (June 1969)									
0	Carbaryl	15	6	2	10	19	-	0	0
	DDT	8	3	3	4	1	3	-	1
3	Carbaryl	100	100	97	99	31	-	73	1
	DDT	-	-	-	-	-	-	-	-
5	Carbaryl	100	93	44	67	9	-	31	0
	DDT	25	3	5	4	3	7	-	1
7	Carbaryl	97	72	52	59	1	-	3	5
	DDT	17	7	6	5	4	18	-	2
9	Carbaryl	86	76	3	72	1	-	11	0
	DDT	3	2	6	1	0	8	-	1
11	Carbaryl	91	65	21	78	1	-	1	4
	DDT	-	-	-	-	-	-	-	-
13	Carbaryl	77	69	-	68	-	-	-	5
	DDT	3	1	4	1	2	8	-	1
15	Carbaryl	51	57	30	46	0	-	7	0
	DDT	17	0	4	0	1	5	-	1
Second treatment (November 1969)									
2	Carbaryl	100	100	86	94	12	-	90	0
	DDT	25	2	9	12	0	13	-	0
4	Carbaryl	100	99	45	93	0	-	67	0
	DDT	23	3	6	7	3	10	-	1
6	Carbaryl	98	98	12	93	2	-	73	0
	DDT	34	11	10	23	1	50	-	0
8	Carbaryl	90	100	3	73	11	-	1	2
	DDT	-	-	-	-	-	-	-	-
11	Carbaryl	80	93	-	77	-	-	16	0
	DDT	29	2	-	8	-	-	-	0
13	Carbaryl	87	64	-	55	-	-	-	0
	DDT	14	2	-	4	-	-	-	1
15	Carbaryl	89	64	-	84	-	-	-	2
	DDT	12	4	-	7	-	-	-	0
17	Carbaryl	91	78	-	89	-	-	-	0
	DDT	14	6	-	13	-	-	-	0