EFFECTIVENESS OF DIFFERENT DICHLORVOS FORMULATIONS AS RESIDUAL FUMIGANTS [1]

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Various studies have shown that dichlorvos-wax formulations are capable of producing sufficient vapor to give satisfactory kills of caged adult mosquitoes for periods up to 16 weeks (Schoof *et al.*, 1963, and Mathis *et al.*, 1963). These investigations indicated a need for development of improved dichlorvos vapor dispensers which would have more uniform vapor emission rates and a longer useful life. This paper describes comparative studies on formulations of different composition and of different surface areas.

All evaluations were run in houses of 1,000 cubic feet each at Savannah, Georgia (Schoof *et al.*, 1963). Huts were built entirely of plywood, or of bamboo or mud walls with thatched roofs. Dispensers were suspended from the roof peak rafter, approximately 9 feet above the ground.

Efficacy of the treatment was measured by exposing caged, dieldrin-resistant *Anopheles quadrimaculatus* at 2′, 6′, and 9′ levels at the midline of one wall and at the 2′ level in each of the 4 corners. Fifty to 100 mosquitoes were contained in each of the 7 cages. During the warm part of the season, the exposure period was from 8:00 p.m. to 8:00 a.m. When the heaters were in operation during the cool months, the exposure time was 4 hours and the tests were made during the day. After exposure, the caged mosquitoes were placed in a noncontaminated room (temperature 80° F., 70 percent relative humidity), supplied with food, and held for 24-hour female mortality determinations.

The dichlorvos formulations tested were: [2]

(a) 25 percent dichlorvos in a base of 25 percent dibutyl phthalate and 75 percent Montan wax as pellets (½″ diameter x ½″ long) or cylinders (6″ long, 1.5″ diameter)
(b) 25 percent dichlorvos in a base of 12.5 percent ethyl acetate and 12.5 percent dibutyl phthalate, 75 percent Montan wax, cylinder (6″ long, 1.5″ diameter)
(c) 50 percent dichlorvos in a base of 25 percent dibutyl phthalate and 75 percent Montan wax cylinder (6″ long, 1.5″ diameter)
(d) 30 percent dichlorvos-resin tube,[3] 5¼″ long x 1¼″ outside diameter, ¼″ wall thickness
(e) 10 percent or 20 percent dichlorvos-resin strips,[3] each 10″ x 2.5″ x 0.22″
(f) 20 percent dichlorvos-resin strand,[3] ⅛″ diameter
(g) 70 percent dichlorvos liquid dispenser,[4] a plastic unit consisting of a vapor-proof reservoir (2¾″ long, 1″ diameter) and vapor permeable tube insert (4″ long, 0.5″ diameter)

RESULTS. The initial comparison test included four dichlorvos-Montan wax formulations (3 as cylinders and 1 in pellet form) and one dichlorvos-resin dispenser in huts with eave ventilation only. The dichlorvos-Montan wax units for the first 6 weeks gave essentially 100 percent kills. When 4-hour exposures were used, the 25 percent dichlorvos-wax-dibutyl phthalate

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[2] Use of commercial products in this study does not constitute endorsement by the Public Health Service.

[3] Furnished by the Shell Chemical Company, New York City, New York.

[4] Manufactured by CIBA, Switzerland, and provided through the courtesy of the World Health Organization, Geneva, Switzerland.

TABLE 1.—Mortalities of caged *A. quadrimaculatus* at various periods after installation of one dispenser/plywood hut on 3/26/63, eave ventilation.

Dispenser Age (Weeks)	Temp. °F.	Exposure (Hours)	% Kill with Formulation			
			A	B	C	D
7	86	4	100	98	100	96
8	81	4	90	64	96	61
9	90	4	99	89	99	69
10[1]	82	4	62	43	68	30
11	70–72	12	100	100	100	100
12	72–75	12	100	98	100	55
13	74–78	12	100	100	100	90
14	74–78	12	100	99	16	8
15	76–82	12	95	24	59	5
16	74–84	12	98	49	..	..

A = 25 percent dichlorvos (Montan wax-dibutyl phthalate) as cylinder.
B = 25 percent dichlorvos (Montan wax-ethyl acetate) cylinder.
C = 25 percent dichlorvos (Montan wax-dibutyl phthalate) as pellets.
D = 50 percent dichlorvos (Montan wax-dibutyl phthalate) cylinder.
[1] Huts artificially heated weeks 1–10.

formulations gave superior results through week 9 (Table 1). On week 10 the mortalities with all wax formulations were below 70 percent. When the exposure period was increased to 12 hours on week 11, the wax formulations produced complete mortalities. Only the standard 25 percent dichlorvos-wax cylinder continued to give 95 to 100 percent kills through week 16 and this formulation was definitely superior to the other three. Subsequent tests with larger pellets again indicated that this formulation was not as effective as the wax cylinder.

The dichlorvos-resin tubes installed on 3/26/63 gave erratic results during the first 3 weeks and were replaced with new units on April 12, 1963. The latter gave 16 weeks of effective kills and were equivalent in activity to the standard wax unit.

A further test with the 30 percent dichlorvos-resin tube (5¼" long, 1¼" in diameter) during the May-August period indicated that it was less effective than an equivalent dosage of 20 percent dichlorvos-resin strand, 1/8" in diameter (Table 2). The tube gave 11 weeks of effective kills in the door-eave ventilated plywood hut as compared to 16 weeks in a similarly ventilated hut treated with strand.

TABLE 2.—Mortalities of caged *A. quadrimaculatus* at various periods after installation of one dichlorvos-resin dispenser/plywood hut on 5/29/63, maximum ventilation, 12-hour exposure.

Dispenser Age (Weeks)	Temp. °F.	30% Dichlorvos Resin Tube	20% Dichlorvos XP-596 Resin Strand
1–9	...	99–100	100
10	76–86	86	100
11	74–84	71	75
12	74–80	12	100
13	76–82	18	100[1]

[1] 98 to 100 percent through week 16; 63 and 11 percent on weeks 17 and 18.

Comparative tests of the standard dichlorvos-Montan wax cylinder, dichlorvos-resin tube, and dichlorvos-liquid dispenser were conducted in the bamboo and mud huts using three units per hut. Each hut had door-eave-window ventilation. Results indicated 3 to 5 weeks general effectiveness for the 3 types but the weekly kills were too erratic to permit any valid conclusion as to individual superiority.

On September 25 one unit each of 3 types of dichlorvos-resin strips (XP-606, 622, 623), 10" x 2.5" x 0.22", one each of two types of dichlorvos-resin strands (XP-596, 620), 1/8" in diameter, and a standard dichlorvos-Montan wax dispenser

TABLE 3.—Mortalities of caged *A. quadrimaculatus* at various periods after installation of one dispenser per plywood hut on 9/25/63, eave ventilation only.

Disp. Age (Wks.)	Temp.° F.	Exposure (Hours)	% Kill with Formulations					
			XP-596[1]	XP-620[1]	XP-606[2]	XP-622[2]	XP-623[2]	25%-C[3]
1	70–77	12	100	100	100	100	100	100
2	69–72	12	100	100	100	100	99	100
3	62–72	12	98	100	100	100	63	43
4	66–72	12	70	100	99	100	62	75
5	50–69	12	19	71	32	49	4	11
6	80	4[4]	100	100	33	100	100	100
7	70–80	4	83	100	57	100	62	86
8	75–79	4	4	91	34	73	15	27
9	75–80	4	49	100	91	100	71	100
11	75–80	4	65	99	49	96	30	48
13	75–79	4	..	98	..	94	..	..

[1] 20 percent dichlorvos-resin strand. Total dichlorvos 30 g.
[2] 20 percent dichlorvos-resin strip. Total dichlorvos 20 g.
[3] 25 percent dichlorvos-Montan wax standard cylinder. Total dichlorvos 50 g.
[4] Artificial heat used to maintain temperature.

were installed in plywood huts with eave ventilation only. Temperature levels permitted 5 weeks of overnight exposures.

During the first 4 weeks when minimum temperatures were not below 62° F. formulations XP-622, XP-606, XP-620, and XP-596 gave superior results (Table 3). On week 5 when temperatures were between 50–69° F., all formulations except XP-620 gave poor results. Tests during weeks 6 through 13 were limited to 4-hour daytime exposures in heated huts. Formulation XP-620 and XP-622 gave effective kills through week 13 and were definitely superior to the other 4 formulations. The superiority of XP-622 strip over the other 2 strip formulations is correlated with its greater vapor production rate. XP-622, aged 2, 4, 8, and 12 weeks yielded 10, 6.6, 5.4, and 2.6 milligrams of dichlorvos vapor per hour as compared to 5.8, 4.2, 2.8, and 2.3 and 3.0, 2.3, 1.7, and 1.5 milligrams per hour, for XP-606 and XP-623, respectively.[5] Strand XP-620 also had a higher vapor production rate than XP-596. The superiority of the resin over the wax formulation is further reflected in the smaller amounts of dichlorvos in the resin dispenser (*i.e.* 20, 30, and 50 g. per strip, strand, wax dispenser, respectively). However, on the surface area available for vapor emission, the strand had the maximum amount (234 sq. in. versus 55 sq. in. for the strip and 28 sq. in. for the cylinder).

DISCUSSION. The previous data indicate that residual fumigant action can be obtained with dichlorvos in various formulations. Obviously, the type of formulation as well as the amount of vaporizing surface is important to the vapor production rate and, therefore, its biological effectiveness. In these tests, the strip and strand formulations of dichlorvos-resin showed the highest levels of sustained biological activity.

SUMMARY. Residual dispensers formulated with dichlorvos in wax or resin bases or as liquid were evaluated against caged female *Anopheles quadrimaculatus* in plywood, mud or bamboo huts of 1,000 cubic feet capacity at Savannah, Georgia.

A single dispenser containing 25 percent dichlorvos in a wax cylinder was effective in a plywood hut for more than 16 weeks as compared to periods of 13 to 14 weeks for a wax cylinder containing 50 percent dichlorvos or for wax pellets with 25 percent dichlorvos. One 30 percent dichlorvos-resin tube gave effective kills 10

[5] Data provided through courtesy of Shell Chemical Company, 110 W. 51st Street, New York 20, New York.

weeks in a plywood hut versus 16 weeks for an equivalent dosage of 20 percent dichlorvos-resin strand (⅛" diameter). Parallel tests of two strand formulations of 20 percent dichlorvos-resin, three 20 percent dichlorvos-resin strip (10" x 2.5" x 0.22") formulations and a 25 percent dichlorvos-wax dispenser (1.5" diameter x 6") indicated that one strand and one strip formulation produced results superior to those by the dichlorvos-wax dispenser. The results were obtained with a lower total amount of dichlorvos present in both the strip and strand dispensers (20 and 30 g., respectively) than in the wax dispenser (50 g.). Both strip and strand formulations contained a greater surface area than that of the wax dispenser. Vapor emission rates for the superior strand and strip formulations were higher than those of other strand or strip formulations tested.

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RESULTS OF INSECTICIDE RESISTANCE TESTS AGAINST *AEDES AEGYPTI* ADULTS AND LARVAE IN BRITISH GUIANA

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In Georgetown, British Guiana, during February-March 1963, the W.H.O. insecticide resistance testing kits were used in checking possible resistance of *A. aegypti* larvae and adults to various insecticides.

LARVAE. Third and early 4th instar larvae were used in the tests, which were carried out 3 times. Larvae used in test 1 were taken from pit latrines in Georgetown, the East Coast of Demerara County, and from houses along the East Bank of the Demerara River. In tests 2 and 3, the larvae came from Georgetown pit latrines only.

Dieldrin, DDT, and BHC were diluted according to directions, so that 5 concentrations of each resulted: 0.004 p.p.m., 0.02 p.p.m., 0.10 p.p.m., 0.50 p.p.m., and 2.50 p.p.m. Twenty larvae were used in each test. Mortality readings were taken after 3 hours, 7 hours, 20 hours, and 24 hours. A control bowl of 20 larvae in diluted ethanol accompanied each test. The results are shown in Table I.

At 0.004 p.p.m. all three were equally ineffective. At 0.02 p.p.m. dieldrin was the most effective, with complete resistance to DDT. At 0.50 p.p.m., dieldrin and

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