

Dichlorvos as a Residual Fumigant in Mud, Plywood and Bamboo Huts *

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In experiments conducted at Savannah, Ga., dichlorvos dispensers of montan (lignite) wax installed at a rate of six units per 1000 cubic feet (28 m³) in huts with mud or bamboo walls and with thatched roofs produced kills of caged Anopheles quadrimaculatus (12 hours' exposure) at or above 95% for 5-6 weeks. The doors, windows, and eaves of the huts were open for maximum ventilation. In a non-ventilated plywood hut, a single dispenser gave effective kills for 7 months but in a non-ventilated mud hut the period was 5 months. Air concentrations of dichlorvos in the mud hut were shown to be definitely lower than those in a plywood hut at the same dosage level.

Preliminary reports on the use of the residual fumigant technique against adult mosquitos were made by Mathis et al.⁴ and Mathis & Maddock.⁵ Mathis et al.⁶ discussed the relationship of ventilation to the number of dispensers required to provide effective mosquito kills for 12-16 weeks in plywood houses of 1000 cubic feet (28 m³) capacity. This report describes studies in which a new solid formulation of dichlorvos (DDVP; O,O-dimethyl-2,2-dichlorovinyl phosphate) was evaluated in plywood, mud, and bamboo shelters.

METHODS

All tests were conducted at Savannah, Ga., in houses of 1000 cubic feet (28 m³) each, except for two shelters with a capacity of 728 cubic feet (approx. 20 m³) each. The degree of ventilation varied with the individual test and ranged from houses without

ventilation to those that had windows, eaves, and doors open at all times.⁷

Two huts were approximately 10 feet × 11 feet (3 m × 3.3 m) with a flat roof at the 6-foot (1.8 m) level; one had mud walls and roof, the second was entirely of plywood; both were insulated for use during cool weather. The remaining huts were 11 feet × 12 feet × 6 feet (3.3 m × 3.6 m × 1.8 m) with gabled roof to 10 feet (3 m). Two of these huts were built with mud walls and two with bamboo walls. The roof of each was thatch. One bamboo hut, of bamboo from Indonesia, was at ground level; the other, of Philippine bamboo, was supported by posts with the floor 4 feet (1.2 m) above ground (see the figure). The floor of each hut was earthen except that of the elevated bamboo hut, which was composed of bamboo poles.⁸ The mud used was locally obtained clay pressed into blocks (2 feet × 4 inches × 4 inches; 60 cm × 10 cm × 10 cm). Thatch was prepared from native broom sedge.

The dichlorvos solid formulation consisted of 25% dichlorvos in a base of dibutyl phthalate (25%) and montan (lignite) wax No. 16⁹ (75%). These dispensers (each 6 inches, 15 cm, long; 1.5 inch, 3.7 cm, diameter) were installed at ceiling level or in the corners at 6-foot (1.8 m) heights. In addition, a

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⁴ Mathis, W., Fay, R. W., Schoof, H. F. & Quarterman, K. D. (1959) *Publ. Hlth Rep. (Wash.)*, **74**, 379.

⁵ Mathis, W. & Maddock, D. R. (1961) *Mosquito News*, **21**, 86.

⁶ Mathis, W., Miles, J. W. & Schoof, H. F. (1961) *Bull. Wld Hlth Org.*, **24**, 646.

⁷ Except where otherwise indicated, the door of the hut was closed during the period of insect exposure.

⁸ Secured through the courtesy of the US Department of Agriculture, Plant Introduction Station, Savannah, Ga.

⁹ From the American Lignite Products Co., Ione, Calif. The mention of commercial products is for identification purposes only and does not constitute endorsement by the Public Health Service.

ELEVATED AND GROUND-LEVEL BAMBOO, THATCHED-ROOF HUTS



plastic device containing 50% liquid dichlorvos was employed in two plywood huts. The device¹ consisted of a sealed reservoir containing the dichlorvos formulation and a plastic tube 4½ inches (10.5 cm) long and ½ inch (12 mm) in diameter. The seal in the neck of the reservoir was readily broken by pressing and the liquid dichlorvos then ran into the plastic tube from the reservoir. The plastic tube is permeable to dichlorvos vapours and thus acts as a vapour dispenser.

Evaluation was generally made by exposure of caged, dieldrin-resistant *Anopheles quadrimaculatus* females. Cages contained approximately 50 females each and were suspended at 14 sites within the hut at heights of 2, 6, and, where possible, 9 feet (0.6, 1.0 and 2.7 m). After exposure, the specimens were removed to clean cages and held for the 24-hour determination of female mortality. During the period March-June 1960, the mosquitos were exposed during the day for four hours. In such tests, cage sites were limited to two positions (2-foot and 6-foot levels). All exposures in the June-October periods were for 12 hours beginning at 8.00 p.m.

¹ Manufactured by Ciba, Switzerland, and provided through the courtesy of the World Health Organization.

RESULTS

A single dispenser of the montan wax formula installed in a non-ventilated mud hut (728 cubic feet, or approx. 20 m³) on 23 January 1961 gave 90%-100% female kills for slightly more than five months. One dispenser installed in late March in a plywood hut of similar size produced 100% kills for seven months. At the final observation (18 October) the mortality was 89%.

Plywood huts No. 15 and No. 7 were treated with one and three dispensers, respectively, in late March. In hut No. 15, with door (D) ventilation only, the single unit gave 100% kills for 22 weeks but failed thereafter. With door-eave-window (DEW) ventilation, the three units in hut No. 7 gave 93%-100% mortalities through 19 weeks but then failed.

Two other plywood huts (No. 3 and No. 14) were treated with two dispensers each on 20 June. With door-eave (DE) ventilation, 98%-100% mortalities were recorded for both huts through week 12, after which the kills were unsatisfactory.

Two dispensers installed in late June in a mud-walled, thatch-roofed hut with DEW ventilation gave ineffective kills within one week. The addition of four more dispensers produced 100% mortalities

TABLE 1
AVERAGE MORTALITIES OF CAGED FEMALE
A. QUADRIMACULATUS AT 14 SITES IN BAMBOO HUTS
WITH THATCHED ROOFS TREATED WITH 6 DICHLORVOS
DISPENSERS^a

Hut position	Door position during exposure	Mortality (%)				
		Week 5	Week 6	Week 7	Week 8	Week 9
On ground	Closed ^b	100	100	99	84	31
	Open ^b	100	99	100	93	42
	Open ^c	100	100	100	78	78
On 4-foot (1.2 m) posts	Closed ^b	100	100	52	95	16
	Open ^b	100	96	89	100	21
	Open ^c	100	100	82	59	40

^a 12 hours' exposure; door-eave-window ventilation.

^b Dispensers at ceiling level.

^c Two dispensers at ceiling level, one in each of four corners, 3 feet (90 cm) up.

for approximately three weeks. In the ground-level bamboo hut (DEW), two dispensers produced mortalities between 50% and 100% for three weeks but the kill dropped to 26% at 5 weeks. In the elevated bamboo hut, two dispensers failed at one week but six units produced satisfactory mortalities for three weeks.

The relatively short-lived effectiveness of the dispensers in mud or bamboo huts was considered

TABLE 2
AVERAGE MORTALITIES OF CAGED FEMALE
A. QUADRIMACULATUS AT 14 SITES IN MUD HUTS WITH
THATCHED ROOFS TREATED WITH 6 DICHLORVOS
DISPENSERS^a

Hut No	Door position during exposure	Mortality (%)				
		Week 5	Week 6	Week 7	Week 8	Week 9
11	Closed ^b	100	97	73	45	15
	Open ^b	100	100	100	79	15
	Closed ^c	100	100	93	52	39
12	Open ^b	95	91	61	28	25
	Closed ^b	100	83	36	97	19
	Open ^c	100	100	91	53	19

^a 12 hours' exposure; door-eave-window ventilation.

^b Dispensers at ceiling level.

^c Two dispensers at ceiling level, one in each of four corners, 3 feet (90 cm) up.

as possibly arising from the age of the dispensers, which had been formulated four months previously. In subsequent tests in these huts with dispensers prepared in July, the results (Tables 1 and 2) were far superior to those obtained in the initial tests.

In the mud and the bamboo huts, three types of test were run each week: (a) six dispensers attached to ceiling, door open during exposure period; (b) similar conditions to those in (a) except that the door was closed; and (c) door open, two dispensers at ceiling level and one in each corner at 6 feet (1.8 m). As the data in Tables 1 and 2 show, these variables exerted little influence on the duration of effectiveness. Kills at or above 95% were obtained for six and five weeks in the bamboo and the mud huts, respectively. Satisfactory mortalities (70%) persisted for one to two weeks longer, but at nine weeks only one of 12 tests run in the four huts gave greater than 42% kill (the ground-level bamboo hut showed 78% kill).

A single liquid dichlorvos dispenser¹ in a plywood hut (DE) gave average kills of 91%-100% for nine weeks except at week 7 (56%) when night temperatures dropped below 67°F (19.5°C). In a similar type of hut, two dispensers gave 99%-100% mortalities over the same period. At week 11, the kill dropped to 57%.

DISCUSSION

The vapour concentration data for the non-ventilated mud and plywood huts clearly showed that the dichlorvos vapour dissipates more rapidly when the surfaces are of mud. At weeks 1 and 2, vapour levels in the mud hut were 0.067 and 0.065 μg per litre of air, respectively, whereas those in the plywood hut were 0.536 and 0.368 μg per litre of air, respectively. At this point the dispensers in the two huts were exchanged. Three samples taken 1, 7, and 14 days later showed the dichlorvos levels to be 0.022, 0.088, and 0.079 μg per litre, respectively, in the mud hut; in the plywood hut the levels were 0.370, 0.214, and 0.096 μg per litre, respectively.

As previously reported,² the rapid fall-off in kills, once the concentration dropped to the threshold of effectiveness, was again apparent in these tests. Except where low temperatures were a factor, a decrease in kill below 90% was usually followed by mortalities in the range of 15%-50% whether in

¹ Dripping occurred with all liquid dispensers used and analysis showed the liquid to contain dichlorvos.

² Mathis, W., Miles, J. W. & Schoof, H. F. (1961) *Bull. Wild Hlth Org.*, 24, 646.

TABLE 3
AVERAGE MORTALITIES OF ADULT FEMALE *A. QUADRIMACULATUS* CAGED AT 2, 6, AND 9 FEET
IN THE GROUND-LEVEL BAMBOO HUT

Week	Mortality (%)																
	2 feet (0.6 m) ^a							6 feet (1.8 m) ^a							9 feet (2.7 m) ^b		
	Cages						Average	Cages						Average	Cages	Average	
6	96	91	100	97	100	100	97	100	100	100	100	100	100	100	100	100	100
7	41	96	93	38	70	95	72	100	100	95	92	96	100	97	100	100	100
8	—	4	13	13	8	43	16	13	0	20	10	18	69	22	100	100	100
9	33	10	0	11	30	56	23	100	21	35	26	52	96	55	100	100	100

^a Six sites.

^b Two sites.

plywood, mud, or bamboo huts. As the majority of the data presented represent the average mortalities of the mosquitos at 14 sites within a hut, it is apparent that the high kills (90%-100%) indicated a uniform distribution of the vapour within each hut. When the average mortalities dropped to levels below 50%, sites still remained at which complete mortalities persisted.

Generally, the loss of effectiveness of a treatment was first apparent in the cages at the 2-foot (60-cm) level (Table 3). When average kills at the 2-foot (60-cm) levels were 72%, the cages at 6-foot (1.8-m) and 9-foot (2.7-m) levels still showed excellent mortalities. Usually, high kills were evident the longest in the cages at the 9-foot level. In some instances where the average mortality of mosquitos at the 14 sites was 15%, the mosquitos at the 9-foot levels all succumbed.

While such a marked divergence in kills at the 9-foot *versus* the other levels was not true for every

test, the cages at 9 feet usually gave the highest mortalities whenever the average kill for all sites fell below 75%. This longer period of effective kills at the higher levels would be of marked significance in those areas where the vectors showed a predilection for resting on the ceiling or roof.

Even though the ventilation was greater in the matted bamboo huts than in the mud huts, the period of effectiveness in the former was equal to or better than that in the mud huts. As the elevated bamboo hut had a slat type of flooring, it conceivably should have shown the shortest period of effectiveness. These data suggest that when the ventilation is not excessive the type of interior surface may be more important than the amount of air movement.

Although the effective kills for seven to eight weeks in bamboo huts and mud huts were below those obtained in plywood huts, the results indicated that the residual fumigant has a potential usefulness in huts built of those materials.

RÉSUMÉ

Une étude sur le terrain, exécutée à Savannah, Ga, a permis de préciser les conditions d'application du dichlorvos (DDVP) en fonction du type de construction des abris traités — toits de chaume et parois d'argile pressée, de contre-plaqué ou de bambou. Le nombre des appareils distributeurs à utiliser pour assurer une concentration de vapeurs efficace envers *Anopheles quadrimaculatus* varie avec le degré d'aération du local; à doses de produit équivalentes, le maintien de cette concentration dépend dans une mesure importante du matériau de construction.

Dans les abris en argile ou bambou, six appareils distributeurs constitués de lignite imprégnée de DDVP ont donné, dans un volume de 28 m³, une mortalité égale

ou supérieure à 95% chez les moustiques femelles après exposition de 12 heures; avec ventilation maximum, l'effet s'est maintenu 5 à 6 semaines.

Dans les abris en contre-plaqué à ouvertures tenues fermées, un seul appareil distributeur s'est révélé efficace pendant 7 mois. Dans les mêmes conditions, la période efficace n'était que de 5 mois dans les abris en argile pressée: toutes conditions étant égales d'ailleurs, ces derniers accusaient des concentrations de vapeurs DDVP nettement plus faibles que les abris en contre-plaqué. Ainsi, à la 2^e et 3^e semaine, l'analyse de l'air prélevé a montré dans les locaux à parois d'argile respectivement 0,067 µg/l et 0,065 µg/l de DDVP contre 0,536 µg/l et 0,368 µg/l dans ceux en contre-plaqué.