

Indian Journal of Malariology, 12, 4, December 1958.

Furnished by
Communicable Disease Center
Technical Development Laboratories
P. O. Box 769, Savannah, Ga.

FIELD EFFECTIVENESS OF MALATHION DEPOSITS AGAINST DIELDRIN-RESISTANT *ANOPHELES QUADRIMACULATUS*.

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[November 29, 1958]

IN tests conducted under simulated field conditions in 1957 against dieldrin-resistant *Anopheles quadrimaculatus*; malathion suspensions applied at rates of 100 or 200 mg. per square foot were found to give essentially 100 per cent kill of adult females for four to five months (Mathis and Schoof, 1959). In 1958, the studies were continued and expanded to include treatment of both vacant and occupied houses in the State of Mississippi, U.S.A.

METHODS.

The treated removable plywood panels used in the 1957 experiment at Savannah, Georgia, U.S.A., were subjected to further evaluation in the same shed-type huts (6' x 6' with a 7' front) (Mathis and Schoof, 1959). The huts were equipped with window traps on two sides and were fitted with an entrance cage (2' x 1' x 1') at the rear wall of the hut two feet above the floor level. An opening (1" x 20") permitted the mosquitoes to enter the hut, which contained a domestic rabbit as an attractant and a source of food. The panels had been sprayed in 1957 with the following treatments: (a) D.D.T. (200 mg./sq. ft.); (b) dieldrin (25 or 50 mg./sq. ft.); (c) malathion (100 or 200 mg./sq. ft.); (d) malathion: D.D.T. (200:100 or 100:200 mg./sq. ft.); (e) malathion:dieldrin (100:25 or 50 mg./sq. ft.); (f) parathion (12.5 mg./sq. ft.); (g) parathion: D.D.T. (12.5:200 mg./sq. ft.); and (h) EPN:DDT (25:200 mg./sq. ft.).

In the vacant house treatments in Mississippi, the rooms were lined with cardboard prior to the experiment to insure an insecticide-free pre-treatment surface

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and to mosquito-proof the rooms. Treatments were applied to the cardboard-lined walls and ceiling, using a hand sprayer equipped with a nozzle calibrated to deliver 0.4 gal./min. (type 8004). After treatment, the floors were covered with wrapping paper to aid in the recovery of dead mosquitoes. In each room, two windows were screened and allowed to remain open constantly for ventilation. Each formulation was tested in two rooms, with a third untreated room serving as a check. Treatments were applied on March 26 and 27, 1958, and included toxicants and dosages as follows: (a) malathion (50, 100, and 200 mg./sq. ft.), (b) D.D.T. (200 mg./sq. ft.) and (c) malathion:D.D.T. (50:100 and 100:100 mg./sq. ft.). Two rooms were treated with each formulation. The suspensions used were prepared from 25 per cent malathion and 75 per cent D.D.T. wettable powders.

The occupied homes were the residences of rural families, each dwelling being treated by an operational spray crew* which used a power sprayer equipped with an 8004 nozzle. With the exception of the dosage of 200 mg. of malathion/sq. ft., each of the same dosages applied to unoccupied houses also was applied to five occupied homes (total of 25 houses treated).

The appraisal of the effectiveness of the treatments in the huts at Savannah, Georgia, was conducted at monthly intervals by introducing 100 specimens of dieldrin-resistant or susceptible *A. quadrimaculatus* females into the entrance cage at 4.00 p.m. and removing the dead and living specimens from the house and window traps from 8 to 9 a.m. the following morning. The live adults were collected and held for 24 hours for mortality determinations.

The vacant room treatments were evaluated by the release of 100 field-collected female *A. quadrimaculatus* in each room at four-week intervals beginning June 1 and continuing until October. The specimens were liberated in the rooms at 7.00 p.m. and recovered at 8.00 a.m. the following day. Specimens recovered alive were held 24 hours for mortality determinations.

For additional evaluation in the unoccupied houses, wall cage tests were made using polished transparent plastic funnel-shaped cones† (8.5 cm. in diameter at the base and 5.5 cm. high) in which the stem of the funnel had an aperture 1.0 cm. in diameter. The base of the funnel had a circular flange 1.5 cm. in width to which an adhesive type tape could be fitted which would permit the cone to be attached to uneven surfaces. An aspirator with an angular tip (135°) was used to introduce and remove the specimens from the cones‡. In each room, five cones (each with ten females) were attached to the walls at five different locations for a 30-minute exposure period. After exposure, the specimens were removed and held for a 24-hour mortality count. Both release and wall cage tests were made during the same week.

* The Bolivar County Health Department, Cleveland, Mississippi, U.S.A., kindly provided the services of one of their regular spray crews which was treating approximately 6,000 homes on country-wide basis using a malathion : DDT spray.

† These cones were furnished through the courtesy of Mr. James W. Wright, Division of Environmental Sanitation, World Health Organization, Geneva, Switzerland.

‡ To prevent contamination of the aspirator by the malathion deposits, a separate aspirator was used for exposing adults in the untreated rooms. Both the cones and the aspirator, used for the treated surfaces tests, were decontaminated between successive evaluations by washing them in soapy water.

In the occupied houses, evaluation of the treatments was limited to use of the plastic cones. Five sites were tested in each of three houses treated with a given formulation, beginning one week after treatment and continuing at four- to five-week intervals until October.

RESULTS.

Since insufficient numbers of dieldrin-resistant *A. quadrimaculatus* were available, the tests at Savannah, Georgia, were evaluated chiefly with a susceptible laboratory strain. The results (Table I) show that parathion alone at 12.5 mg./sq. ft. was ineffective at the first test in 1958. In combination with D.D.T., the same dosage of parathion gave essentially equivalent results to D.D.T. alone at 200 mg./sq. ft. at 14 months. Therefore, both parathion formulations were discarded. Malathion at 100 or 200 mg./sq. ft. gave excellent results for 15 months but at 16 months the lower dosage showed signs of failure. Combinations of malathion with either D.D.T. or dieldrin produced complete mortalities at the last tests (15 months). Since the D.D.T. applications gave a much lower kill at this same

TABLE I.

Per cent mortality of susceptible *Anopheles quadrimaculatus* females exposed to residual treatments in animal-baited huts.

Material, water wettable	Dosage (mg./sq.ft.)	PER CENT MORTALITY AT MONTHS AFTER TREATMENT					
		3-5*	12	13	14	15	16
D.D.T.	200‡	68	..	..	74†	57	71§
Dieldrin	50	99	..	95†	85	..	63
Dieldrin	25	100	79†	51	62	12	
Malathion	200	..	..	..	100†	100	100
Malathion	100	..	100†	100	100	91	57
Malathion: D.D.T.	100:200	..	..	100†	89	100	
Malathion: D.D.T.	200:100	..	..	96†	100	100	
Malathion: dieldrin	100:50	100	..	99†	100	100	
Malathion: dieldrin	100:25	..	94†	100	91	100	
Parathion	12.5	100	31†	..	..	..	..
Parathion: D.D.T.	12.5:200	100	..	82†	..	..
EPN : D.D.T.	25:200	98	..	100†	78	99	

* September 1957

† June 1958

‡ Actual dosage estimated as 175 mg./sq. ft.

§ At 17 and 18 months, mortality was 57 and 11 per cent, respectively

time interval, the effectiveness of the combination treatments presumably was due to the malathion component. Dieldrin at 25 mg./sq. ft. showed a definite break in effectiveness after 12 months, and the 50 mg./sq. ft. dosage was ineffective at the last test.

When dieldrin-resistant mosquitoes were available, tests were run against dieldrin (25 and 50 mg./sq. ft.), D.D.T. (200 mg./sq. ft.) and malathion (100 mg./sq. ft.). At four and twelve months, the dieldrin dosages gave kills of 40 and 19 per cent (25 mg./sq. ft.), and 46 and 7 per cent (50 mg./sq. ft.); the D.D.T. gave kills of 54 and 32 per cent; and the malathion 100 and 96 per cent, respectively.

In the unoccupied houses in Mississippi, tests through 25 weeks after treatment resulted in complete mortalities of either released specimens or those exposed in the plastic cone, with the exception of one room which had been treated with malathion at the rate of 50 mg./sq. ft. With released mosquitoes, the mortalities in this room were 80, 87, 93, 92, and 86 per cent at 10, 14, 18, 22, and 25 weeks, respectively, after treatment. With specimens in the cone, the mortalities were 75, 85, 76, 76 and 50 per cent at the same intervals after treatment. As the other room treated with this dosage gave 100 per cent mortality for the duration of the experiment, the reduced kills in the one room were considered a reflection of inadequate treatment. Since the release test at 25 weeks gave essentially the same mortality as in previous tests, the data indicate that an insufficient amount of toxicant was present rather than its deterioration.

In the occupied houses, the cone tests, started in the second week after treatment in June 1958, showed that all formulations gave complete mortalities of dieldrin-resistant *A. quadrimaculatus* for the duration of the experiment (12-16 weeks). In twenty-five houses treated as part of the routine spraying of rural dwellings by the Bolivar County Health Department*, similar tests also gave complete mortalities of female mosquitoes for the entire evaluation period (June-September).

DISCUSSION.

The results of treatments in either occupied or unoccupied houses in Mississippi verify the data from the 1957 Savannah tests in the animal baited huts, which showed that malathion at 100 mg./sq. ft. and malathion:D.D.T. at 100:200 or 200:100 mg./sq. ft. gave 100 per cent kill of dieldrin-resistant *A. quadrimaculatus* for four to five months. The continued evaluation of the plywood panels treated in 1957 revealed that the residues of malathion at 100 mg./sq. ft. gave essentially 100 per cent kill of dieldrin-resistant *A. quadrimaculatus* for 12 months (maximum period tested) and the same kill of a susceptible strain through 15 months with evidence of failure at 16 months.

The 1958 data also indicated that malathion:D.D.T. (50:100 mg./sq. ft.) was equivalent in effectiveness to the malathion treatment of 100 mg./sq. ft. for 25 weeks in the unoccupied houses. Malathion residues from the 50 mg./sq. ft. treatment likewise showed promising results which contrast sharply with earlier laboratory tests in which this dosage was ineffective.

*Treatment at a rate of 50:100 mg. of malathion:DDT per square foot.

In the two years of study, malathion has been shown to be an extremely effective residual insecticide against *A. quadrimaculatus*. The surfaces involved in these tests have included wood (painted and unpainted), cardboard, and paper. How durable the deposits would be on mud surfaces in the field is a question which can be resolved only through field tests inside such structures. The only previous data on such field treatments are from tests against culicine and anopheline adults in India by Krishnan *et al.*, who reported that diazinon (25 mg./sq. ft.) and malathion (25 mg./sq. ft.) gave control for only three weeks in houses with walls of bamboo matting or coconut leaves. Studies involving mud, leaf, and rice-straw surfaces are now being planned in Central America against *Anopheles albimanus*.

ACKNOWLEDGEMENT.

These studies were accomplished as part of a contractual agreement between the Communicable Disease Centre and the International Cooperation Administration.

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