AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523
BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY
Batch 72

1. SUBJECT CLASSIFICATION
A. PRIMARY: Health — NS00-0000-0000
B. SECONDARY: Tropical diseases

2. TITLE AND SUBTITLE
Organophosphorus compounds as residual treatments for adult mosquito control

3. AUTHOR(S)
Mathis,Willis; Schoof,H.F.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1959	5p.	ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
HEW/PHS/CDC

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(In Am.j.of tropical medicine and hygiene,v.8,no.1,p.1-4)

9. ABSTRACT

10. CONTROL NUMBER
PN-RAB-664

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Insecticides
Residues
Mosquitoes

13. PROJECT NUMBER

14. CONTRACT NUMBER
PASA 5903-7 Res.

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

PASA 5903-7 Res
HEW/PHS/CDC
PN-RAB-664

REPRINT NUMBER
Copy 2 of 3
252

Reprinted from AMERICAN JOURNAL OF TROPICAL MEDICINE AND HYGIENE
Vol. 8, No. 1, January, 1959
Printed in U.S.A.

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

ORGANOPHOSPHORUS COMPOUNDS AS RESIDUAL TREATMENTS FOR ADULT MOSQUITO CONTROL[1]

W. MATHIS AND H. F. SCHOOF

Resistance to DDT or dieldrin residual applications by malaria vectors throughout the world is a handicap of increasing importance to malaria control and eradication programs. Because of this situation, studies to evaluate other insecticides as potential residual treatments against anopheline vectors were included in a contractual agreement between the Communicable Disease Center and the International Cooperation Administration.

Preliminary laboratory tests of various commercial pesticides[2] on plywood panels against susceptible adult female *Anopheles quadrimaculatus* at exposure periods of 30 minutes indicated that at 100 mg/sq. ft., Parathion, Malathion, DDT, EPN, endrin, and dieldrin were the superior toxicants, giving satisfactory kills for extended periods. In general, residues from suspensions were superior to those from emulsions, only dieldrin and Parathion being effective with either type of formulation.

In subsequent laboratory tests, dosages of EPN suspensions at 12.5, 25, or 50 mg/sq. ft., combined with 100 mg of DDT/sq. ft. were superior to either compound used alone at these dosages. Malathion suspensions at dosages of 25, 50, or 100 mg/sq. ft., alone, were effective only at the highest dosage. Similar dosages of Malathion in combination with 100 mg of DDT/sq. ft. gave satisfactory kills only at levels of 50 or 100 mg of Malathion/sq. ft., while Parathion at dosages of 12.5, 25, or 50 mg/sq. ft. was effective at the two higher dosages. In combination with 100 mg of DDT/sq. ft., all three dosages of Parathion gave satisfactory results. Against field-collected dieldrin-resistant *A. quadrimaculatus* (Mathis *et al.*, 1956), satisfactory results were obtained with suspensions of Parathion at dosages of 12.5, 25, and 50 mg/sq. ft.; of Malathion at 100 mg/sq. ft.; and of EPN at 50 mg/sq. ft. Dosages of EPN at 12.5 and 25 mg/sq. ft. and of Malathion at 12.5, 25, and 50 mg/sq. ft. produced unsatisfactory results. Residues which produced mortalities of at least 90 per cent with 30-minute exposures for at least 10 weeks were considered as "satisfactory."

As a result of these laboratory evaluations, further tests with Malathion, Parathion, and EPN were conducted under simulated field conditions using dieldrin-resistant and susceptible strains of *A. quadrimaculatus*.

METHODS

In 1956, two shed-type huts, approximately 8 feet × 8 feet × 8 feet, were constructed in a wooded area adjacent to irrigated rice fields near Savannah, Georgia. Under the rear overhang of the roof, an opening (1 inch) was left so that wild mosquitoes could enter. On either side, a window (3 feet × 3 feet) was constructed with V-shaped louvers equipped with 1-inch openings in such a manner that mosquitoes could readily leave the hut but would have difficulty in re-entering it. Screen traps were placed over the window to capture the mosquitoes leaving the hut. The inside of the hut was fitted with removable plywood panels which were sprayed with water-wettable Malathion at the rate of 100 mg/sq. ft. Two domestic rabbits, placed in each hut prior to operation at night, served as an attractant and a source of blood.

Evaluations were made at weekly intervals for 5 weeks after treatment using the natural population of *A. quadrimaculatus*. The mosquitoes entering the huts during the night were collected from the interior of the huts or the window traps the following morning by 9:00 a.m. After the numbers of mosquitoes entering the hut were insufficient for satisfactory tests, 100 laboratory-reared female *A. quadrimaculatus* were released at weekly intervals in the hut and left for 1 hour. After this exposure, they were

[1] From the Communicable Disease Center, Bureau of State Services, Public Health Service, U. S. Department of Health, Education, and Welfare, Savannah, Georgia.

[2] Compounds tested included aldrin, American Cyanamid Compound 4124, Bayer 21/199, BHC, chlordane, Chlorthion, DDT, Diazinon, dieldrin, Dipterex, endrin, EPN, heptachlor, isodrin, lindane, Malathion, methoxychlor, Parathion, Perthane, Strobane, TDE, and toxaphene.

collected, fed honey water, and held for 24 hours at 80° F and 70 per cent relative humidity for mortality determination.

In 1957, similarly equipped huts (6 feet × 6 feet × 6 feet) with smaller windows (2 feet × 2 feet) were used. As laboratory-reared mosquitoes were employed, an entrance cage (2 feet × 1 feet × 1 feet) was attached to the rear of the hut at window level (2 feet above floor) with an opening (1 inch × 20 inches) to permit the mosquitoes to enter the hut. The removable plywood panels were treated prior to installation as follows: (a) DDT (200 mg/sq. ft.), (b) dieldrin (25 or 50 mg/sq. ft.), (c) Malathion (100 or 200 mg/sq. ft.), (d) Malathion: DDT (200:100 or 100:200 mg/sq. ft.), (e) Malathion:dieldrin (100:25 or 100:50 mg/sq. ft.), (f) Parathion (12.5 mg/sq. ft.), (g) Parathion: DDT (12.5:200 mg/sq. ft.), and (h) EPN:DDT (25:200 mg/sq. ft.). All applications were made at 40 psi with a hand sprayer equipped with an "8004" nozzle, certain of the higher dosages being applied prior to the tests and the panels stored in a well-ventilated room for aging. With the panels installed, all the inner resting surfaces of the hut were treated except for the floor and the window louvers. After each test, the treated panels were removed and placed in storage. The huts were located in a shaded, woody area in close proximity to each other. Temperatures ranged from 62° to 91° F during the test periods.

Each test began at 4:00 p.m., when one domestic rabbit was placed in the hut and the mosquitoes were transferred to the entrance cage. At that time, the entrance slot at the rear was opened and remained so until the following morning, when it was closed, the rabbit removed, and the dead and living mosquitoes collected from the hut and window traps. The living mosquitoes were placed in screen holding cages, fed, and held for a 24-hour mortality determination.

Three-day-old laboratory-reared females of a dieldrin-resistant strain and of a susceptible strain of *A. quadrimaculatus* were used in the tests, the former being obtained from eggs from field-collected females in Mississippi. Tests were made with each formulation against the dieldrin-resistant strain at 2-week intervals and against the susceptible strain as time permitted. Approximately 50 to 150 females were used in each test, the number available fluctuating because of seasonal variations in the natural abundance of the wild mosquitoes. Experiments were conducted with the dieldrin-resistant strain from June 25 to October 3. For comparative purposes, one untreated hut was operated during each test night.

RESULTS

The 1956 application of Malathion (100 mg/sq. ft.) gave essentially 100 per cent mortality of the wild *A. quadrimaculatus* recovered within the hut for a period of 5 weeks after treatment. In the window traps, the mortality range was from 65 to 100 per cent. The lowest mortality occurred with the first run when 559 females were recovered in the window trap. Based on total numbers recovered in the treated and untreated huts, the Malathion treatment apparently did not repel this strain of mosquito, since a greater number was recovered in the treated than in the untreated hut. The percentage of females obtaining blood meals ranged from 7 to 22 per cent in the untreated hut and from 3 to 15 in the treated hut. Only two of the blood-fed mosquitoes from the treated hut survived for 24 hours after exposure.

The laboratory strain of *A. quadrimaculatus* females used in tests 7, 8, 9, 10, and 13 weeks after treatment gave 24-hour mortalities of 100, 98, 100, 70, and 36 per cent, respectively, with a 60-minute exposure period.

Table 1 gives the monthly mortalities ob-

TABLE 1

Average 24-hour mortalities obtained with dieldrin-resistant Anopheles quadrimaculatus *females in treated animal bait stations (June–October, 1957)*

Toxicant (water-wettable)	Dosage (mg/sq. ft.)	Per cent mortality at months after treatment				
		1	2	3	4	5
DDT	200	—	30	26	54	54
Dieldrin	50	51	47	41	46	
Dieldrin	25	75	36	40		
Malathion	200	—	100	100	100	100
Malathion	100	100	99	100	100	
Malathion:DDT	100:200	—	100	100	100	
Malathion:DDT	200:100	—	100	100	100	
Malathion:dieldrin	100:50	100	100	100	100	
Malathion:dieldrin	100:25	100	100	99		
Parathion	12.5	100	100	100		
Parathion:DDT	12.5:200	—	100	95	99	100
EPN:DDT	25:200	—	96	88	84	

tained in the 1957 tests with dieldrin-resistant *A. quadrimaculatus* females. Although specific exposure times are unknown, limited observations indicate that most mosquitoes entered the hut around 7:00 p.m. These specimens then were collected between 8:00 and 10:00 a.m. the following morning. All formulations containing organic phosphorus compounds alone or in combination with dieldrin or DDT, with the exception of EPN:DDT, gave essentially 100 per cent mortality for the duration of the test (11 to 20 weeks). The EPN:DDT formulation, which was not evaluated during the first 4 weeks after treatment, showed mortalities of 98 to 100 per cent during the following 12 weeks with mosquitoes recovered in the house, but kills in the window traps varied from 27 to 100 per cent. However, this combination still was superior to DDT alone, although inferior to formulations containing Malathion or Parathion. Dieldrin (25 or 50 mg/sq. ft.) gave mortalities of 40 to 75 per cent, while DDT (200 mg/sq. ft.) evaluated the second, third, fourth, and fifth months after treatment, yielded mortalities of only 30, 26, 54, and 54 per cent, respectively.

Against the susceptible laboratory strain, all formulations with the exception of DDT gave essentially 100 per cent mortality During the first 3 months of exposure to DDT, the mortalities of the laboratory strain were higher than those of the dieldrin-resistant strain but little difference was noted during the fourth and fifth months.

The number of females recovered and the mortality occurring in the entrance cage with the various treatments were compared with the same information from the entrance cages attached to the untreated huts. With all treatments, a greater percentage of females remained in the entrance cage than in cages of untreated huts for corresponding nights. Although the numbers recovered varied greatly, no one formulation seemed to repel consistently more than the others.

When DDT, dieldrin, or EPN plus DDT was used as the treatment, the entrance cage mortality was no greater than that of the untreated hut. All other treatments apparently caused considerable mortality in the entrance cage. Malathion in combination with DDT or dieldrin caused the greatest mortality in the entrance cages, in some instances all mosquitoes remaining in the entrance cage were killed. Mortality appeared to be greater on nights of very high humidity.

In the untreated hut, the total mortalities, with few exceptions, were less than 10 per cent. Comparisons were made on the behavior of the two strains under untreated conditions. Of the 3,700 females of the dieldrin-resistant strain introduced into the entrance cage, 80 per cent entered the house and of these 58 per cent remained until collected the following morning. Only five females were noted with blood meals. With the susceptible laboratory strain, 85 per cent of the 1,345 females introduced entered the house and 88 per cent of this number remained until collected the following morning. Twelve per cent of the number entering the house obtained a blood meal. Thus, the percentage of mosquitoes that entered the house was essentially the same with the two strains. However, the number which remained in the house varied 30 percentage points in favor of the laboratory strain but since the dieldrin-resistant strain showed a lesser inclination to feed on the rabbit, the lack of an attractive host may have influenced their behavior.

The lowered mortality rates obtained with certain treatments was partially a reflection of the escape response which presumably reduced the exposure period of specimens recovered in the window traps. With DDT, the range in mortality of dieldrin-resistant specimens collected in the hut was between 25 and 71 per cent, with dieldrin between 53 and 70 per cent, and with EPN:DDT between 98 and 100 per cent. In the window trap, the per cent mortalities for the same three treatments were 16 to 41, 22 to 41, and 45 to 86, respectively. However, in all treatments with Malathion (alone or combined with DDT or dieldrin) or with Parathion, 98 to 100 per cent mortalities were obtained regardless of the site of collection. The data for Malathion and Parathion presumably are the result of the greater toxicity of these insecticides to the mosquitoes, since the average percentages of mosquitoes which entered the window traps with the DDT, dieldrin, Malathion, or Parathion treatments fell in the range of 36 to 49 per cent. Contrary to expectation, the percentages of mosquitoes for the DDT or dieldrin applications were essentially the same (46 versus 49%). Against the susceptible strain, window trap and hut mortalities with all compounds

were in the same general range, the majority of the specimens being recovered in the hut.

DISCUSSION

These results indicate Malathion residues to have a much longer activity against mosquitoes than would be assumed from the short-term effectiveness this toxicant exhibits against house flies. Although the residues on the plywood panels in the huts did not receive the type of exposure to air and dust encountered in an inhabited dwelling, the biweekly removal, storage, and reinstallation of the panels subjected the deposits to handling abuse. The influence of occupied dwellings on the residual action of Malathion residues should be evaluated in future studies.

Of particular interest were the essentially complete kills achieved with Malathion and Parathion against the dieldrin-resistant strain as compared with the 26 to 54 per cent mortalities obtained with DDT. Also of interest was the fact that the dieldrin-resistant strain succumbed to dieldrin residues at mortality levels similar to those of DDT.

SUMMARY

The residual action of Malathion and Parathion deposits against laboratory-reared adult *Anopheles quadrimaculatus* was evaluated in animal-baited huts under simulated field conditions near Savannah, Georgia. Malathion at 100 and 200 mg/sq. ft., Malathion:DDT at 100:200 or 200:100 mg/sq. ft., Malathion:dieldrin at 100:25 or 100:50 mg/sq. ft., Parathion at 12.5 mg/sq. ft. and Parathion:DDT at 12.5:200 mg/sq. ft. produced essentially 100 per cent mortalities of dieldrin-resistant females for the entire 4- to 5-month observation period. Dieldrin at 25 or 50 mg/sq. ft. and DDT at 200 mg/sq. ft. yielded mortalities of 26 to 54 and 36 to 75%, respectively, over the same time interval. Dieldrin-resistant and susceptible strains of *A. quadrimaculatus* moved into untreated huts from attached entrance cages in similar numbers but 42 per cent of the resistant specimens escaped into window traps as compared to 12 per cent of the susceptible strain.

REFERENCES

Mathis, W., Schoof, H. F., Quarterman, K. D., and Fay, R. W., 1956. Insecticide resistance of *A. quadrimaculatus* in Bolivar County, Mississippi. *Pub. Health Rep.*, **74**: 876–878.