EFFECTIVENESS OF SOME NEW INSECTICIDES ON VARIOUS TYPES OF SURFACES AND IN CLAY-LINED EXPERIMENTAL HUTS AGAINST *ANOPHELES QUADRIMACULATUS*[1]

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Experimental huts were used by Haddow in 1942 and White and Rao in 1943 in developing techniques for study of mosquito habits. Hocking (1947) and Thomson (1948) did work in experimental huts in 1947, including studies on the habits of mosquitoes in treated and untreated huts and evaluations of the effectiveness of DDT in different formulations. Various types of huts have since been used (Smith, 1964) in assessing the toxicity of residual compounds for possible use in the malaria eradication program.

The present paper gives results of tests with *Anopheles quadrimaculatus* females exposed to experimental compounds applied to the interior surfaces of such experimental huts and to panels of various surface materials maintained out-of-doors under sheds (Schoof *et al.*, 1962). Observations were also made on behavior of mosquitoes released under different conditions in the huts.

METHODS. To expose treated panels to the normal fluctuations of temperature and humidity, two sheds 120 feet long containing panels (1 x 4 feet) placed in a vertical position under the center of the peaked roof were constructed. Each section contained panels of clay, whitewashed clay, plywood, thatch, and cement plaster. Panels were treated in position by using a 1-gallon compression sprayer equipped with an 8002 nozzle. Evaluation was by exposure of dieldrin-resistant *A. quadrimaculatus* females to the deposits for 1 hour beneath a plastic cone at weekly intervals. Each test represented 30 females, 10 in each of three cones, per surface. After exposure the specimens were held for 24-hour mortality determination.

The experimental huts were 6 x 6 feet with a 6-foot wall at the back and a 7-foot front. The front had a door 2 feet wide opening onto a screen porch 2.5 x 6 feet. A 2-inch opening between the front and back walls and the ceiling provided additional ventilation. The inner walls were lined with clay blocks 2 inches thick. The ceiling and door were plywood.

Treatments were made at 40 psi with a conventional hand sprayer equipped with an 8002 nozzle. After treatment, the floors were lined with clean paper. Table 1 gives compounds used on the panel sheds and in the huts. Treatments were evaluated by: (1) confining mosquitoes on treated clay and wood surfaces; (2) mos-

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TABLE 1.—Compounds tested against dieldrin-resistant *Anopheles quadrimaculatus* females.

Toxicant	Chemical Composition
BAY 62863	2-methyl-7-cumaranyl-N-methyl-carbamate
BAY 77488	O,O-Diethyl thiophosphoryl O-α-cyanobenzaldoxime
Hercules 9007	M-Isopropylphenyl N-chloroacetyl-N-methylcarbamate
OMS-868	O,O-dimethyl-O-(3-chloro-4-N,N-diethyl sulfamoylphenyl) phosphorothionate
OMS-958	O,O-Dimethyl-S-[5-ethoxy-1,3,4-thiadiazol-2(3H)-on-3-yl-methyl]-dithiophosphate

quitoes released in the hut or on the screen porch; and (3) caged mosquitoes suspended near the center of the hut.

Wall surface tests were made in the same manner as in the panel shed tests, three replicate tests on each surface at weekly intervals. In the tests with free-flying mosquitoes, the specimens were released inside the huts or on the porches to compare the mortalities obtained under each of these conditions and also to determine the location of mosquitoes at the end of the tests. All tests were made with the door between the porch and interior of the hut open. Approximately 60 females were released for each test. The time of release and length of exposure varied. The females collected in the hut and on the porch were held separately for mortality determinations. Caged mosquitoes (25 females per cage) were suspended from the center of the hut to determine possible fumigant action of the treatments. Such tests were limited to the daytime 2-hour tests of the free-flying mosquitoes. All tests were duplicated in an untreated hut.

RESULTS. Panel tests. Table 2 gives results obtained with 60-minute exposure of mosquitoes to candidate compounds. Hercules 9007 at 2 g/m^2 and OMS-868 at 1 and 2 g/m^2 were superior to other compounds tested on clay surfaces. Mortalities were greater than 70 percent at termination of tests due to cold weather 15 weeks after treatment. Although Hercules 9007 at 2 g/m^2 and OMS-868 at 1 g/m^2 were less effective on whitewashed clay than on clay, other treatments gave the same results on the two surfaces or were more effective on whitewashed clay. On plywood and thatch surfaces all materials were giving mortalities greater than 70 percent at termination of tests. OMS-958 and 868 were superior to other compounds on cement plaster.

Hut tests. Table 3 gives results obtained when mosquitoes were exposed to clay or wood surfaces for 1 hour. Hercules 9007 gave 70 percent or greater kills on clay for 13 weeks and OMS-868 for 7 weeks. None of the remaining com-

TABLE 2.—Number of weeks that surfaces on panel shed treated with indicated insecticides gave mortalities of 70 percent or more of dieldrin-resistant *A. quadrimaculatus* females exposed for 1 hour.

Toxicant	g/m^2	Clay	W.W. Clay	Plywood	Thatch	Cement
Hercules 9007	1	2	2	>15[a]	>10[a]	6
Hercules 9007	2	>15[a, b]	9[b]	>15[a]	>15[a, b]	8
OMS-958	1	0	>15[a, b]	>15[a]	>15[a]	>15[a, b]
OMS-958	2	3[b]	3[b]	>15[a]	>15[a]	>15[a]
OMS-868	1	>15[a]	9[b]	>15[a, b]	>15[a]	>15[a]
OMS-868	2	>15[a]	>15[a, b]	>15[a]	>15[a]	>15[a]
BAY 77488	1	3[b]	1	>10[a]	>10[a]	4
BAY 77488	2	5	>10[a, b]	>10[a]	>10[a]	6
BAY 62863	0.25	3	>8[a, b]	>8[a]	>8[a]	0
BAY 62863	0.50	5[b]	>8[a]	>8[a]	>8[a]	0
BAY 62863	1	3	3	>8[a]	>8[a]	1

[a] Indicates weather terminated tests.
[b] Indicates mortality fell below 70 percent during test.

TABLE 3.—Number of weeks that surfaces in experimental huts treated with indicated insecticides gave mortalities of 70 percent or more of dieldrin-resistant *A. quadrimaculatus* females exposed for 1 hour.

Toxicant	g/m²	Clay	Wood
Hercules 9007	2	13	>15[a]
OMS-958	2	2	>15[a]
OMS-868	2	7[b]	13
BAY 77488	1	1	>11[a]
BAY 77488	2	3	>11[a]
BAY 62863	1	0	>8[a]
BAY 62863	2	1	>8[a]

[a] Indicates weather terminated tests.
[b] 35 percent mortality on week 3.

pounds were effective (70 percent) for more than 3 weeks. With the exception of OMS-868, all compounds were giving kills greater than 70 percent on wood at termination of tests. OMS-868 was effective for 13 weeks.

Results obtained with mosquitoes released inside the huts during the day for a period of 2 hours are given in Table 4. Mortalities were calculated from total mosquitoes recovered (hut and porch). Hercules 9007 at 2 g/m², BAY 77488 and BAY 62863 at 1 and 2 g/m² were giving mortalities greater than 70 percent at termination of tests. OMS-958 and OMS-868 at 2 g/m² and DDT at 1 g/m² gave mortalities of 70 percent or greater for 1 to 4 weeks.

TABLE 4.—Number of weeks that adobe-lined plywood huts treated with indicated insecticides gave mortalities of 70 percent or more of dieldrin-resistant *A. quadrimaculatus* females released inside huts and exposed for 2 hours.

Toxicant	g/m²	Weeks with 70% or greater mortality
Hercules 9007	2	>15[a]
OMS-958	2	4
OMS-868	2	1
BAY 77488	1	>11[a, b]
BAY 77488	2	>11[a, b]
BAY 62863	1	>8[a]
BAY 62863	2	>8[a]
DDT	1	4[c]

[a] Indicates weather terminated tests.
[b] 61 percent mortality on week 9.
[c] 33 percent mortality on week 2.

Table 5 gives a summation of the location of collected mosquitoes in the 2-hour exposure tests during the 5-week interval following treatment and in the untreated control hut for all tests conducted. With 23 replicates in the untreated hut 98 percent of the mosquitoes were collected inside the hut. In the hut treated with DDT, only 48 percent were collected inside. The percent collected in huts treated with experimental compounds was less than in the untreated hut. The lowest recovery (83 percent) was in the hut treated with 1 g/m² of BAY 62863.

The data for releases made on three different nights (residue age 2, 3, and 4 weeks) in huts treated with Hercules 9007, OMS-868, OMS-958, and in the untreated hut at sunset with the specimens remaining for 2 hours showed that the average recovery inside the huts was 97, 47, 46, and 48 percent, respectively. The high percent recovery inside the hut treated with Hercules 9007 was probably caused by the rapid knockdown of this material, since all mosquitoes were killed in each test and most were dead when collected at the end of the exposure period. Mortalities ranged from 40 to 67 percent with OMS-958 and from 10 to 45 percent with OMS-868.

Results of 12-hour overnight exposures in huts treated with OMS-868, OMS-958, DDT, and the untreated hut are given in Table 6. The percent recovered inside the hut treated with OMS-868 was essentially the same as in the control but lower with OMS-958 and DDT. The mortalities in huts treated with OMS-958 and DDT were 70 percent or greater for the 7-week test period with this exposure but little increase in effectiveness was noted with OMS-868 over mortalities obtained with 2-hour exposure.

Table 7 summarizes the data for the releases made on the porches of huts treated with BAY 77488 and 62863 (1 and 2 g/m²) and the untreated hut during the day with the mosquitoes collected 2 hours later. Eighty-seven percent of the mosquitoes collected in the untreated hut were taken inside the hut while 74

TABLE 5.—Influence of insecticides on movement of dieldrin-resistant *A. quadrimaculatus* females released inside clay-lined plywood huts and exposed for 2 hours.

Toxicant	g/m²	Number of Tests[a]	Total Mosquitoes Collected	Number in Hut	Percent
Hercules 9007	2	4[b]	163	151	93
OMS-958	2	5	236	227	96
BAY 77488	1	4[c]	193	172	89
BAY 77488	2	4[c]	238	213	89
BAY 62863	1	5	235	194	83
BAY 62863	2	5	227	197	87
DDT	1	5	233	113	48
Control	..	23	1296	1270	98

[a] Tests made during first 5 weeks after treatment.
[b] No test on week 3.
[c] No test on week 2.

TABLE 6.—Influence of insecticides on movement of dieldrin-resistant *A. quadrimaculatus* females released inside clay-lined plywood huts and exposed overnight for 12 hours.

Toxicant	g/m²	Number of Tests	Total Mosquitoes Collected	Number in Hut	Percent
OMS-868	2	4	166	148	89
OMS-958	2	4	221	158	71
DDT	1	5	143	90	64
Control	..	10	560	507	91

TABLE 7.—Influence of insecticides on movement of dieldrin-resistant *A. quadrimaculatus* females released on porch of clay-lined plywood huts and exposed for 2 hours.

Toxicant	g/m²	Number of Tests	Total Mosquitoes Collected	Number in Hut	Percent
BAY 77488	1	9	483	386	80
BAY 77488	2	9	464	358	77
BAY 62863	1	8	366	271	74
BAY 62863	2	8	358	286	80
Control	..	11	599	523	87

to 80 percent were captured inside the treated huts. Table 8 gives results of mortalities obtained with these releases. BAY 62863 at 1 or 2 g/m² and BAY 77488 at 2 g/m² gave mortalities above 70 percent for the duration of the tests. At 1 g/m² BAY 77488 was effective for 10 weeks.

In the screen cage tests, Hercules 9007 gave mortalities above 70 percent for 13 weeks and BAY 77488 at 1 and 2 g/m² for 8 weeks. None of the other materials gave mortalities above 70 percent for more than 3 weeks.

TABLE 8.—Number of weeks that adobe-lined plywood huts treated with indicated insecticides gave mortalities of 70 percent or more of dieldrin-resistant *A. quadrimaculatus* females released on porches and collected 2 hours later.

Toxicant	g/m²	Weeks with 70% or greater mortality
BAY 77488	1	10[a]
BAY 77488	2	>11[b]
BAY 62863	1	>8[b]
BAY 62863	2	>8[b, c]

[a] 66 percent mortality on week 8.
[b] Indicates weather terminated tests.
[c] 69 percent mortality on week 6.

DISCUSSION. Results obtained in panel shed tests on different surfaces indicated that OMS-868 was the most effective material tested, followed by Hercules 9007. With the same type of tests on clay and wood in the experimental huts, Hercules 9007 was superior. When mosquitoes were released in the huts for 2 hours OMS-868 gave the lowest mortality of any material tested. Hercules 9007 and BAY 77488 and 62863 were still effective at the termination of tests, but the test period for the Bayer compounds was only 8 weeks as compared to 15 weeks for Hercules 9007. Based on all types of tests, Hercules 9007 was the most effective material tested.

In the study of influence of release position and time on the location of mosquitoes at the end of a 2-hour test it was found that in 23 tests, an average of 98 percent (92–100 percent range) would be found inside the untreated hut when the release was made during the day. Limited mosquito releases (3 replicates) at sunset for a period of 2 hours indicated that only 48 percent (35–56 percent range) remained inside the hut. However, with a 12-hour test (8:00 p.m.–8:00 a.m.) 91 percent (81–100 percent range) of the specimens were collected inside the hut at morning collection time. These data indicate that *A. quadrimaculatus* prefer to rest during the day inside of such huts under these conditions but will try to leave at sunset. If they remain in the porch cage overnight, most of those will re-enter the hut before 8:00 a.m. the following morning. With releases made on the porch during the day and left for 2 hours, 87 percent (72–100 percent range) were recovered inside the hut. From these tests in an untreated hut it is evident that both the time and location of releases may influence mortalities that would be obtained in treated huts, since the behavior of the mosquitoes was different in each type of test and the actual period of contact with the toxicant therefore also differed.

SUMMARY. Experimental huts with clay-lined walls and panels constructed from various materials were treated with residues of BAY 62863, BAY 77488, Hercules 9007, OMS-868, and OMS-958. Wall cage bioassay tests were made, using dieldrin-resistant *A. quadrimaculatus,* in the huts and on the panels. Mosquitoes were released in the huts and mortality determined. Observations were also made on the location of released mosquitoes at the end of each exposure period.

Based on all types of tests, Hercules 9007 was the most effective material tested. In the untreated hut, 98 percent of the mosquitoes were collected inside the hut when tests were made during the day. The percent recovered inside the treated huts varied but was less than in the untreated hut. Releases made at sundown indicated that approximately 50 percent of the mosquitoes would leave the hut. If left overnight, most would return inside the hut by 8:00 a.m. the following morning.

ACKNOWLEDGMENTS. The authors wish to express their appreciation to Mr. Fred Freeman, Biological Technician, Technical Development Laboratories, for his assistance in these studies.

These studies were accomplished as part of a contractual agreement of the National Communicable Disease Center with the Agency for International Development.

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