THE EFFECT OF SURFACE MATERIAL, RETREATMENT AND FORMULATION ON THE RESIDUAL ACTIVITY OF SEVERAL INSECTICIDES [1]

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Malaria eradication programs continue to rely upon residual treatment of homes as the principal means of interrupting the transmission cycle. Although DDT, dieldrin, and BHC are used for this purpose, the first named remains the insecticide of choice in most countries. In some areas where the vector has developed resistance to these chlorinated hydrocarbon toxicants, malathion and Baytex have been used. However, neither of these compounds possesses the residual qualities of DDT or dieldrin and both are usually more sensitive to breakdown when applied to certain surfaces.

To evaluate the effect of surface and other factors on the potential of new organophosphorus and carbamate insecticides as residual treatments, studies similar to those previously reported (Schoof *et al.*, 1962) were continued at Savannah, Georgia, in 1962.

METHODS. The compounds were tested under an outdoor shed in the manner previously reported (Schoof *et al.*, 1962) except for a reduction in the number of surfaces from 10 to 9 by discarding two types of bamboo and adding whitewashed clay. The test surfaces included clay, whitewashed clay, thatch, galvanized metal, plywood, whitewashed plywood, bambo, cement plaster, and brick. Panels from 1961 that were retreated in 1962 contained the same surfaces tested in the previous year. In the tests with synergized formulations, only cement plaster, brick, and plywood surfaces were used.

All panels were treated in vertical position under the shed using a 1-gallon compression sprayer equipped with an 8004 nozzle. Plywood inserted on both sides of the panel under treatment protected the adjacent panels from contamination during the spraying operation. The following toxicants and dosages were tested as suspensions:

Compound [2]	Percent active ingredient	g./sq.m.
1. Sevin	50 or 85	1, 2
2. Sevin:DDT	50:75	2:0.5
3. DDT	75	0.5
4. Bayer 39007 [3]	50	1, 2
5. Bayer 39007:Sevin	50:50	1:1
6. Bayer 39007:DDT	50:75	2:0.5
7. Bayer 39007: Piperonyl butoxide	12.5:12.5	1:1
8. Bayer 39007: Piperonyl butoxide	8.3:16.7	1:2
9. Hercules 9699	50	0.25, 0.5, 1
10. Bayer 39731 [4]	50	0.5, 1, 2
11. Bayer 41831 [5]	40	0.5, 1, 2
12. Bayer 47940 [6]	25	0.5, 1, 2
13. Bayer 46676 [7]	25	0.5, 1, 2
14. Bayer 37344 [8]	50	0.5, 1, 2
15. Malathion	25	1

[2] The use of trade names and sources of supply is for identification only and does not constitute endorsement by the Public Health Service.

[3] o-isopropoxyphenyl methylcarbamate.

[4] 2-isopropylphenyl N-methylcarbamate.

[5] O,O-dimethyl O-4-nitro-3-methylphenyl-phosphorothioate.

[6] O,O-dimethyl-O-(3-chloro-4-cyanphenyl)-thionophosphate.

[7] Ethyl-O-ethyl-O-(2-oxy-4-methyl-6-ethyl-pyrimidinyl)-thionophosphonate.

[8] 4-(methylthio)-3,5-xylyl methylcarbamate.

Panels treated in 1961 with Sevin or Bayer 39007 at 1 or 2 g./sq. m. were retreated at the same rate in 1962. In addition, panels made with bamboo from Indonesia, Thailand, Viet-Nam, and the Philippines were retreated in 1962 with Sevin at 1 g./sq. m.

Evaluation of the treatments was by ex-

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posure of dieldrin-resistant *Anopheles quadrimaculatus* females to the deposits for 1 hour beneath a plastic cone. (Fig. 1). Three replicates were made on each surface with 10 females in each cone. Tests were at 2-week intervals. Different sites were employed each time. After exposure, the specimens were held at 80° F. and 70 percent relative humidity for 24 hours, at which time the percent mortality was determined.

RESULTS. The maximum number of weeks that each toxicant gave a mortality of 90 percent or more was used to determine the priority sequence of the nine surfaces. For the 1 g./sq. m. treatment the total number of weeks possible was 132. The data (Table 1) for treatments of nine toxicants (Sevin, Bayer 39007, 39731, 41831, 46676, 47940, 37344, malathion, and Hercules 9699) at 1 g./sq. m. clearly indicate that deposits on thatch and plywood showed the greatest longevity. Each gave 90 percent kills for 124 out of the maximum of 132 weeks. Residues on clay, whitewashed clay, and cement plaster were the least effective while deposits on bamboo, metal, whitewashed plywood, and brick were intermediate in their longevity.

When a dosage of 2 g./sq. m. was used, residues on thatch were slightly superior to

TABLE 1.—Relative order of effectiveness of deposits of nine toxicants on nine surfaces at 1 g./sq. m. based on number of weeks the surface showed 90 percent kill of *Anopheles quadrimaculatus*. Maximum weeks possible 132.

Surface	Total weeks
Thatch	124
Plywood	124
Metal	102
W. plywood	88
Bamboo	88
Brick	76
Cement plaster	59
W. clay	34
Clay	16

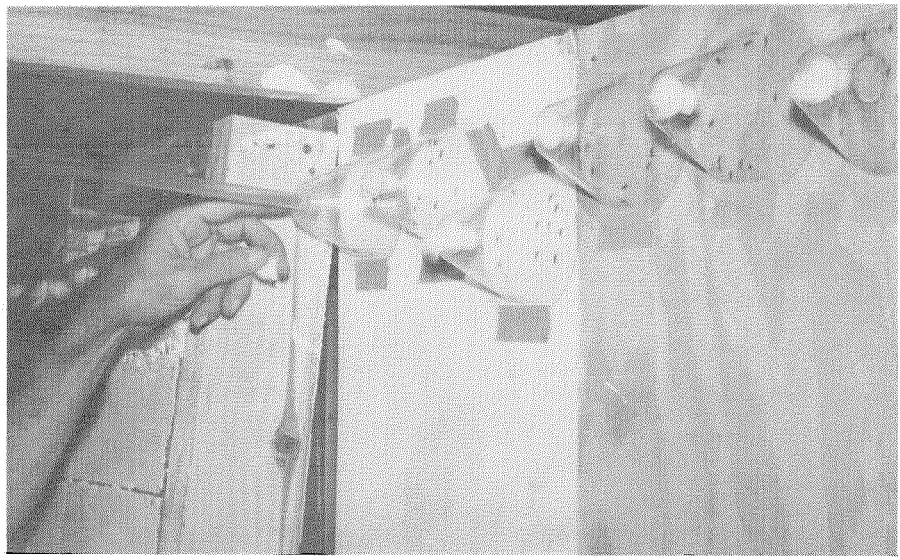

FIG. 1.—Mosquitoes exposed to treated surfaces beneath plastic cones.

those on plywood, deposits on it producing 110 weeks of kills above 90 percent, the maximum number possible. Plywood had a total of 104. Although the general groupings remained the same, deposits on metal gave the longest period of effectiveness in the intermediate group and the sequence of cement plaster and whitewashed clay was reversed in the least effective group. However, the data show that the increase in dosage of B-39731, B-41831, and B-47940 from 1 to 2 g./sq. m. improved their effectiveness on whitewashed clay, cement plaster, and whitewashed clay, respectively (Table 2). On whitewashed clay, 1 g./sq. m. of B-39731 gave only 58

TABLE 2.—Number of weeks that various surfaces treated with various insecticides gave mortalities of 90 percent or more of dieldrin-resistant *A. quadrimaculatus* females exposed for 1 hour. Plus sign indicates weather terminated tests.

Toxicant	g/m²	Clay	W clay	Thatch	Metal	Ply-wood	W. plywood	Bamboo	Cement plaster	Brick
B-39731	0.5	0	0	2	0	2	2	2	0	0
	1.0	0	0	6	2	6	6	6	0	6
	2.0	2	12	12	6	12	12	6	0	12
B-41831	0.5	0	0	10	4	10	6	2	0	4
	1.0	0	4	12	6	12	14+	6	4	6
	2.0	0	6	14+	12	14+	14+	12	12	12
B-46676	0.5	0	0	0	2	2	2	2	0	0
	1.0	0	0	6	4	4	8+	4	0	0
	2.0	0	4	10	8	8	8	8	6	8
B-47940	0.5	0	0	4	2	8+	8+	4	2	4
	1.0	0	0	10+	4	8	8	4	2	4
	2.0	0	8	12+	8	12+	8	8	4	8
B-37344	0.5	0	0	16+	16+	16+	12	12	0	12
	1.0	0	10	16	20+	20+	16	16	14	20+
	2.0	4	16	20+	20+	16	20+	20+	16	20+
B-39007	1.0	10	6	20+	16	20+	10	20+	8	16
	2.0	6	14	20+	16	20+	16	20+	12	20+
(B-39007: (Sevin	1.0: 1.0	0	12	20+	16	20+	20+	20+	20+	20+
(B-39007: (DDT	2.0: 0.5	8	20+	20+	12	20+	20+	20+	16	20+
DDT	0.5	4	8	10	12	8	8	0	8	12
(Sevin: (DDT	2.0: 0.5	12	12[1]	20+	20+	20+	20+	20+	20+	20+
Sevin [2]	1.0	0	0	18+	16	16	16	0	16	16
	2.0	0	22+	22+	22+	22+	22+	22+	22+	22+
Sevin [3]	1.0	4	10	22+	22+	22+	18	14	18	10
	2.0	8	22+	22+	22+	22+	22+	22+	22+	22+
H-9699	0.25	8	0	10	4	0	0	0	0	0
	0.5	0	0	14+	10	12	0	2	0	2
	1.0	2	0	16+	12	16+	4	10	0	10
Malathion	1.0	0	4	16	16	16	4	8	8	4

[1] 81 percent mortality at week 20.
[2] Suspension from 85 percent wettable powder.
[3] Suspension from 50 percent wettable powder.

percent kill at week 2 but at 2 g./sq. m. the same toxicant gave 12 weeks of 90 percent or better kills. On cement plaster, the same dosage increase with B-41831 produced 8 additional weeks of effectiveness. Sevin at 2 g./sq. m. (from 85 percent WW) gave kills above 90 percent at week 22 on whitwashed clay and bamboo even though deposits on either surface at 1 g./sq. m. did not produce a similar kill at the initial inspection on week 4. It also was apparent that some compounds (e.g. H-9699 and B-39731) were ineffective on certain surfaces (i.e. cement plaster) regardless of dosage.

Sevin at 1 g./sq. m. was used in 1961 and in 1962 to treat bamboo from Thailand, Indochina, Philippine Islands (two types), and Indonesia. The bamboo from the Philippine Islands and from Thailand was evaluated on both the outside and inside surfaces. All surfaces gave similar satisfactory results through the 16-week period of study.

Formulations of piperonyl butoxide and Bayer 39007 at 1:1 and 2:1 ratios and of B-39007 alone were tested on cement plaster, brick, and plywood. At 1 g. of B-39007/sq. m. kills of 90 percent were obtained on cement plaster for 2 weeks only with the piperonyl butoxide:B-39007 formulations and for 8 weeks with B-39007 alone. On the brick and plywood surfaces tested, the three formulations gave similar results for the 14 weeks tested except the 1:1 formulation that was ineffective on brick.

The combination of B-39007:Sevin at 1:1 g./sq. m. proved less effective than either compound at 2 g./sq. m. on clay and whitewashed clay (Table 2). The combination treatment was superior to B-39007 (2 g./sq. m.) and equivalent to Sevin (2 g./sq. m.) on cement plaster and whitewashed plywood. On the brick, plywood, thatch, and bamboo, similar effective results were obtained with the three formulations.

Results from the Sevin:DDT at 2:0.5 g./sq. m. showed that the combination formulation was equivalent in effectiveness to Sevin at 2 g./sq. m. on all surfaces except clay and whitewashed clay (Table 2). On clay, the Sevin:DDT deposits gave 12 weeks of kills above 90 percent as compared to 8 weeks with Sevin alone. On this same criterion, Sevin alone gave 22 weeks effectiveness on whitewashed clay versus 12 weeks for the Sevin:DDT treatment. However, when the criterion was related to kills above 80 percent both treatments on whitewashed clay gave similar results. Treatment with DDT at 0.5 g./sq. m. did not give effective kills for more than 12 weeks on any surface.

A formulation of B-39007:DDT at 2:0.5 g./sq. m. gave 8, 20, 20, and 16 weeks of kills above 90 percent on clay, whitewashed clay, whitewashed plywood, and cement plaster, respectively, as compared to 6, 14, 16, and 12 weeks, respectively, for B-39007 alone on the same surfaces (Table 2). On metal, the combination formulation was slightly less effective than B-39007 alone and on thatch, plywood, brick, and bamboo, the two formulations gave similar results.

Comparative evaluation of the durability of residues from the nine compounds tested at 1 g./sq. m. (Table 2) revealed that B-39731, B-41831, B-46676, and B-47940 were inferior in effectiveness to malathion. At the same dosage, malathion was inferior to H-9699 on brick, clay, and bamboo but superior on metal, whitewashed clay, and cement plaster.

Deposits of B-37344, Sevin, and B-39007 at 1 g./sq. m. were superior to those of malathion. On brick, B-37344 residues lasted 20 weeks as compared to 10 and 16 weeks for deposits of Sevin and B-39007. Sevin was the most effective toxicant on cement plaster and whitewashed plywood, while B-39007 gave superior results on bamboo and clay. On whitewashed clay, Sevin and B-37344 each produced 10 weeks of effective kills versus 6 for B-39007.

When B-37344, Sevin, and B-39007 are compared at 2 g./sq. m., Sevin was the most effective toxicant. On all surfaces, it showed a period of activity equal to or greater than either of the other two compounds.

Formulations of Sevin derived from

50 percent and 85 percent wettable powders indicate that on all surfaces except clay, the treatments at 2 g./sq. m. were equal in effectiveness (Table 2). On clay, finished spray from the 50 percent formulation gave 8 weeks of 90 percent kills as compared to 0 weeks for the treatment derived from the 85 percent powder. At 1 g./sq. m. the treatment with the 85 percent powder was less effective than that derived from the 50 percent powder on all surfaces except brick and thatch.

The sections treated in 1961 and 1962 with Sevin at 1 and 2 g./sq. m. showed essentially similar results to panels treated only in 1962. On clay, the panel treated in 1962 gave better results than those that received two applications. The opposite was true for the 1 g./sq. m. treatment on brick. With B-39007 the panels treated only in 1962 showed greater effectiveness of the deposits at 1 g./sq. m. on brick, metal, bamboo, and clay. However, on whitewashed plywood the panel receiving treatment both years gave 90 percent kills for 20 weeks versus 10 weeks for the single 1961 application. At 2 g./sq. m., the same was true. However, on six of the remaining seven surfaces no differences existed in the periods of effectiveness of the two types of treatment with B-39007.

DISCUSSION. The foregoing data again revealed that the type of surface treated has a profound effect upon the biological life of the chemical deposits thereon. Clay, whitewashed clay, and cement plaster are most detrimental to the residues while thatch and plywood appear to be most conducive to prolonged activity. Metal, bamboo, brick, and whitewashed plywood are intermediate in their effect on the life of the deposits. With the possible exception of clay, the detrimental influence of a surface can be overcome by using different toxicants or by increasing the dosage applied. Thus B-39731 and H-9699 at 2 g./sq. m. are ineffective on cement plaster in contrast to Sevin and B-37344. On the same surface, B-41831 at 0.5 g./sq. m. produced no kills above 90 percent but at 1 and 2 g./sq. m. yielded 4 and 12 weeks effectiveness.

Although the application of whitewash to a surface has been considered a detriment to the efficacy of insecticide treatment, the data for all compounds except H-9699 show that deposits on whitewashed clay were more effective than those on clay alone. This effect was most obvious with B-39731, B-41831, B-47940, B-37344, and Sevin at 2 g./sq. m.

Carbamate insecticides are usually degraded by alkaline media but whitewash applied to surfaces rapidly changes from calcium hydroxide to calcium carbonate. Apparently the latter does not have a marked effect upon the longevity of the deposits as indicated by the extended action of Sevin, B-37344, and B-39007 at 2 g./sq. m. Chemical analysis of the whitewash mix prior to use and of the applied whitewash 20 weeks after application indicated the calcium carbonate content to be 51.8 and 52.8 percent, respectively.

The tests reveal that three compounds, B-39007, B-37344, and Sevin, have potential as residual treatments against anopheline mosquitoes, with Sevin showing the greatest promise. The superiority of the results from a 50 percent wettable powder over those from an 85 percent powder again indicates that toxicant alone is not the only factor in a formulation that influences the longevity of the residues.

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Reference

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