DEVELOPMENT OF NONWETTABLE DDT DUSTS FOR USE AGAINST ANOPHELINE LARVAE[1]

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The first tests of DDT against mosquito larvae at the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine, were made in 1943 with a commercially prepared dust. At that time tests were under way to prepare anopheline larvicides containing arsenicals in forms that would resist wetting and, if possible, remain floating on water surfaces. Extensive tests of a similar nature were therefore initiated early in 1943 with DDT. Various coating agents and diluents were tested in an effort to develop a practical, nonwettable DDT dust. An insecticidal preparation employing combinations of DDT with stearic acid and other waxy solids is described in a patent by Deonier and Jones (1944). The data given in this patent constitute the first published report on the use of DDT against mosquito larvae.

The preparation and use of DDT larvicidal dusts has been discussed briefly by Deonier *et al.* (1945) and Jones *et al.* (1945). The present article gives more details of biological results with some of the numerous preparations made during the development of these dusts.

Technique. The preparation of dusts that would remain effective on water surfaces for long periods of time required a long and laborious biological test procedure. To reduce the time required as much as possible, a rather severe laboratory test was developed. A rain machine was used in which water was dropped as individual large drops from a height of 6 feet. With this machine an artificial rain of 6 inches in 3 minutes could be obtained.

A battery jar 6 inches in diameter was used for these tests. The jar was filled with about 1 inch of water, and the preparation to be tested was dusted over the water surface at a calculated dosage. The initial artificial rain was then given, bringing the water level to a mark on the jar 6 inches above the lower level.

Twenty early fourth-instar larvae of *Anopheles quadrimaculatus* Say were introduced into each jar. Mortality readings were made after 24 and 48 hours. Larvae unable to come to the surface after the rain had penetrated the dust were considered to be dead. If the mortality after 48 hours was 80 per cent or above, the rain tests were repeated at 48-hour intervals with new lots of larvae until the mortality was less than 80 per cent. In later tests a mortality of 90 per cent in 48 hours was used as a criterion. Just prior to each artificial rain the water was siphoned from the test jar until the 1-inch level was reached. The siphon was so manipulated as to remove the dead larvae from the bottom of the jar but not to remove any of the toxic material which might be present on the surface. Because of the time and effort involved in making these tests, they were not replicated extensively.

Preparations Studied. The first tests to decrease the wettability of DDT dusts were made by mixing the original commercial dust with stearic acid. Later, several series of dusts containing different proportions of DDT and stearic acid were prepared by various methods. One of these mixtures, on which a large number of tests were made, comprised 1 part of DDT and 4 parts of stearic acid. Other waxy solids tested were palmitic acid, stearyl alcohol, cetyl alcohol, glyceryl

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monostearate, and hydrogenated cottonseed oil (Cotoflakes). The methods used in making these preparations have been described by Jones *et al.* (1945). Most of the materials were prepared by use of a mutual solvent.

In subsequent tests, mixtures of micronized DDT with metallic stearates were found to possess marked resistance to wetting. The solvent method of preparation was first used, but later formulations were made by mechanical mixing. Calcium stearate was used in most of the preparations, but copper and zinc stearates were also tried. The dusting qualities of the DDT-stearic acid preparation (1:4) were improved when calcium stearate was mixed with it.

A number of preparations were also made of DDT mechanically mixed with talc. Micronized DDT was used in many of the early preparations, and various proportions of talc were tried. In all these tests the dusts were applied at the rate of 0.5 pound of DDT per acre and the criterion of effectiveness was a larval mortality of at least 80 per cent in 48 hours.

Comparisons were also made of the wettability of seven commercial 10 per cent DDT dusts made with talc and with pyrophyllite. In these preparations technical DDT and the diluent were milled together in an ordinary hammer or other type mill. The dusts were applied at the rate of 0.1 pound of DDT per acre, and the criterion of effectiveness was a larval mortality of at least 90 per cent in 48 hours.

Results. The resistance to artificial rain of the dust preparations applied at a dosage of 0.5 pound of DDT per acre is shown in Table 1. No significance is attached to the results when the duration of effectiveness differs by only a few days.

Micronized DDT alone (surface mean diameter by air permeation 6 microns) was resistant to wetting. This material, however, was difficult to prepare, tended to form lumps, and did not dust readily. The preparation containing 20 per cent of DDT and 80 per cent of stearic acid, and which had passed a 200-mesh sieve showed a marked resistance to rain Coarser particles of this mixture, however were much less resistant to the rain. The addition of talc or calcium stearate to this preparation greatly improved its dusting qualities. The talc reduced the rain-resistance of the preparation, whereas the calcium stearate apparently did not.

Mixtures of micronized DDT with calcium stearate also showed marked resistance to rain. Mechanical mixtures appeared equally as good in this respect as those made by use of a solvent, and they were more easily prepared. Material passing a 100-mesh screen appeared about as resistant to rain as that passing a 200-mesh.

Mechanical mixtures of DDT and talc were resistant to the action of rain but not quite so long lasting as preparations containing high proportions of stearic acid or calcium stearate. The latter mixtures, however, did not appear to have sufficiently greater water resistance to warrant the added cost and difficulty of manufacture. Dusts in which the DDT was impregnated on the talc by means of a volatile solvent were not so resistant to rain as the mechanical mixtures.

A brief study was made of the relation between particle size and rain resistance of DDT dust without a diluent. In these tests micronized DDT was effective (80 per cent mortality in 48 hours) through 84 inches of rain. DDT passed through a 200-mesh sieve was effective after only 18 inches of rain, whereas 100- to 200-mesh, and 60- to 100-mesh fractions were toxic through only 12 inches of rain This indicated that the finer particles of DDT were more resistant to rain.

In the comparative tests of DDT dusts made with talc and with pyrophyllite, four dusts made with talc were effective after 60, 27, 30, and 54 inches of rain, whereas three dusts made with pyrophyllite were effective after 18, 24, and 48 inches. This wide variation with the same diluent depended on the sample used and on the method of milling, the material ground to a finer size apparently being more

TABLE 1. Resistance of fourth-instar larvae of *Anopheles quadrimaculatus* to DDT dusts exposed to artificial rain. Dosage: 0.5 pound of DDT per acre.

DDT (per cent)	Diluent	Method of Preparation	Number of Tests	Total Inches of Rain After Which Dust Remained Effective
100	None	Micronized	2	78
20	Stearic acid	Volatile solvent; through 200-mesh sieve	2	129
25	" "	" " " "	2	39
33.3	" "	" " " "	2	63
50	" "	" " " "	2	54
66.6	" "	" " " "	1	18
80	" "	" " " "	1	18
90	" "	" " " "	2	18
20	" "	Volatile solvent; through 100-mesh sieve	2	51
	" "	Volatile solvent; through 60-mesh sieve	1	48
	" "	Volatile solvent; unscreened	1	12
10	Stearic acid 40% plus calcium stearate 50%	Volatile solvent; calcium stearate added by mechanical mixing	1	108[1]
	Stearic acid 40% plus talc 50%	Volatile solvent; talc added by mechanical mixing	1	54
50	Stearyl alcohol	Volatile solvent; through 200-mesh sieve	1	12
	Glyceryl monostearate	" " " "	1	12
	Cotoflakes	" " " "	2	21
20	Calcium stearate	" " " "	2	108
50	" "	" " " "	2	54
90	" "	" " " "	2	33
10	" "	Mechanical mixing; not screened	2	120[2]
50	" "	" " " "	2	108
20	" "	Mechanical mixing; through 200-mesh screen	2	78[2]
50	" "	" " " "	2	69
66.6	" "	" " " "	1	48
80	" "	" " " "	2	45
90	" "	" " " "	1	24
95	" "	" " " "	2	45
98	" "	" " " "	1	30
20	" "	Mechanical mixing; through 100-mesh sieve	2	78[2]
10	Zinc stearate	Mechanical mixing; not screened	2	99
50	" "	" " " "	2	105
20	Copper stearate	Volatile solvent; through 200-mesh sieve	2	57
50	" "	" " " "	1	30
90	" "	" " " "	2	30
20	Talc	Mechanical mixing; not screened	2	90
50	"	" " " "	1	96
10	"	Volatile solvent; ground but not screened	2	42
20	"	" " " "	2	42

[1] Test terminated before material became ineffective.
[2] One test terminated before material became ineffective.

resistant. The DDT-talc sample resisting 54 inches of rain was micronized. Although the DDT-talc dusts were slightly superior to the pyrophyllite dusts, the differences were not great and the two diluents may be used interchangeably. In the louse powder recommended for use by the armed forces pyrophyllite was used as a diluent for the DDT (Bushland *et al.* 1945).

Discussion and Summary. The first work on DDT dusts for control of anopheline larvae was directed toward the development of products that would not readily be wet and sunk by rain. Dusts containing large proportions of stearic acid or calcium stearate were highly resistant to artificial rain in the laboratory. For use by the armed forces, however, resistance to rain was eventually found to be a factor of comparatively minor importance. A nonwettable dust was subject to wind and wave action, and remained effective for long periods in the field only when the breeding area was protected by thick vegetation. In general, therefore, DDT dusts could only be recommended for control of anopheline larvae for short periods. Dusts using talc as a diluent were therefore recommended as anopheline larvicides for use by the Army and Navy DDT-talc dusts, although slightly less rain-resistant than those made with stearic acid and calcium stearate, are less difficult to manufacture and may be dusted more readily.

Differences between resistance to rain of talc and pyrophyllite dusts were not great, and for anopheline larvicide purposes the two diluents may be used interchangeably.

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"USE OF DDT IN PLAGUE CONTROL AT CASABLANCA"

(Copied from Bulletin of the Army Medical Department, Vol. IV, No. 6 (Dec., 1945), p. 633, as reported by the Tropical Disease Control Division, Surgeon General's Office.)

"Plague was reported as the cause of death of a civilian worker in the port warehouse area of Casablanca, French Morocco, on 21 July 1945, and within a few days several additional civilian cases occurred in the same part of the city. For the protection of American and Italian service units and French military, naval and civilian personnel employed in the area, a meeting was held to plan a program for control of the outbreak. In addition to invoking the international anti-plague measures for ports, restriction of the area to essential personnel, and immunization of individuals likely to be exposed, it was decided to precede the rodent destruction program with applications of DDT in the area to kill any fleas that might leave dead rats.

"A malaria survey detachment experienced in the use of DDT was selected to do the work. A 5 per cent solution of DDT in kerosene was applied with knapsack sprayers to floors and the lower portion of walls in barracks, offices, warehouses, trucks, and two cargo ships moored to the dock. A 10 per cent DDT dust was applied to the clothing of personnel required to enter the area. With a rotary blower, dust was applied to places inaccessible to spray, such as under buildings and in rodent burrows. Local personnel were trained in methods of application of DDT so that they might be prepared to repeat the applications if necessary.

"It is not possible to evaluate accurately the part played by DDT, but, according to latest reports, the plague control program as a whole was completely effective, since no further cases occurred."