COMPARATIVE TOXICITY OF DDT TO THREE REPRESENTATIVE SPECIES OF MOSQUITO LARVAE [1]

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In laboratory tests with DDT different species of mosquitoes have shown a variation in their tolerance to this chemical. Different lots of larvae of the same species have also shown a variation in their resistance to DDT poisoning. Field tests (Eide, 1945) have shown that this variation in the susceptibility of different species to DDT is very important. The purpose of this paper is to compare the effectiveness of several DDT treatments against *Anopheles quadrimaculatus* Say, *Aedes aegypti* (L.), and *Culex quinquefasciatus* Say. One experiment was conducted with two suspensions and an emulsion that dispersed the DDT uniformly throughout the water, in which the applications were made on a parts-per-million basis, and another experiment with surface applications of solutions and emulsions containing petroleum oil.

Experimental Procedure. In the first experiment the procedure described by Bushland and King (1943) was followed. Distilled water (250 ml.) was added to each 400-ml. beaker; approximately 25 ml. was poured from this beaker into a 50-ml. beaker; 20 early fourth-instar larvae were also placed in the small beaker. After the proper aliquot of the emulsion or the suspension had been placed in the 400-ml. beaker and thoroughly mixed, the water containing the larvae was added. This method protected the larvae from being immersed suddenly into a high concentration of the toxic material.

One suspension consisted of DDT (twice recrystallized) in acetone solution. Another stable water suspension was made from a concentrate containing 10 percent of DDT, 10 per cent of Nopco 1216 (sulfonated sperm oil), and 80 per cent of Cellosolve (ethylene glycol mono ethyl ether). A stable water emulsion was made from a concentrate composed of 25 per cent of DDT, 10 per cent of Triton X-100 (an aralkyl polyether alcohol), and 65 per cent of xylene. Each of these formulations was diluted to 1 part of DDT in 500,000 parts of water, and the aliquots were applied with pipettes of graduated sizes for the desired parts per million in 250 ml. of water.

The surface applications were made in an 8 by 8-foot spray chamber. The solutions and emulsions were applied to three lots of 20 fourth-instar larvae in paper ice-cream cartons containing distilled water. The three lots of larvae were placed beneath the spray opening in the chamber and were spaced along the arc of a circle having a diameter of 26 inches so that they would not be directly under the sprayer nozzle.

The solutions and emulsions were atomized through a hole in the ceiling of the chamber by means of a sprayer connected to an air compressor delivering 10 pounds pressure.

The dosage was computed on the basis of total area covered by the spray. The amount of material to be sprayed into the chamber was therefore governed by the DDT content and the desired dosage.

Mortality readings were taken at 24- and 48-hour intervals. All the larvae

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were forced to submerge. Larvae of *Anopheles quadrimaculatus* were considered dead if they were unable to come to the surface, and those of *Aedes aegypti* and *Culex quinquefasciatus,* which have different feeding habits, if they failed to react to a fine teasing needle. Feeding habits of the different species do not affect their exposure to DDT when it is in colloidal suspension; therefore, any variation between species is due to differences in susceptibility.

The petroleum oil solutions and emulsions were applied to the surfaces and were not uniformly distributed throughout the media. Those that contained Velsicol NR-70 (chiefly tetramethylnaphthalene) remained on the surface even though the specific gravity was greater than that of water.

Results.—The results in Table 1 show the effect on larvae taken at random from the same population, of various dosages of preparations in which the DDT was uniformly dispersed throughout the media. Table 2 shows results of similar tests when the DDT was applied to surfaces.

Culex quinquefasciatus larvae were much more resistant to the toxic action of DDT, in both parts-per-million and surface applications (Table 2), than were larvae of

TABLE 1. Toxicity to Mosquito Larvae of DDT Suspensions and an Emulsion in which the DDT Was Uniformly Dispersed Throughout the Water. Average of 3 replications.

Treatment	Dosage of DDT	Mean Mortality					
		Culex quinquefasciatus		*Anopheles quadrimaculatus*		*Aedes aegypti*	
		24 hours	48 hours	24 hours	48 hours	24 hours	48 hours
	P.p.m.	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
DDT 10%, Nopco 1216 10%, Cellosolve 80% (stable water suspension)	0.025	85.0	96.6	....	....	....	....
	.0125	31.6	33.3	....	....	....	....
	.01	1.6	1.6	....	....	....	....
	.005	....	....	86.6	96.2	....	....
	.0025	....	....	33.3	59.2	86.6	91.6
	.00166	....	....	11.6	46.2	80.0	86.6
	.00125	....	....	....	....	78.3	86.6
DDT 25%, Triton X-100 10%, xylene 65% (stable water emulsion)	.025	88.3	98.3	....	....	....	....
	.0125	13.3	31.6	....	....	....	....
	.01	0	5.0	....	....	....	....
	.005	....	....	86.6	96.2	....	....
	.0025	....	....	11.6	57.3	91.6	98.3
	.00166	....	....	5.0	27.8	96.6	98.3
	.00125	....	....	....	....	83.3	86.6
DDT acetone-water suspension	.025	76.6	90.0	....	....	....	....
	.0125	10.0	11.6	....	....	....	....
	.01	6.6	15.0	....	....	....	....
	.005	....	....	93.3	98.1	....	....
	.0025	....	....	45.0	75.9	91.6	95.0
	.00166	....	....	1.6	40.7	71.6	86.6
	.00125	....	....	....	....	58.3	73.3

TABLE 2. Toxicity to Mosquito Larvae of DDT Solutions and Emulsions in which the DDT Was Not Uniformly Dispersed Throughout the Water. Average of 3 replications.

Treatment	Dosage of DDT [3]	Mean Mortality					
		Culex quinquefasciatus		*Anopheles quadrimaculatus*		*Aedes aegypti*	
		24 hours	48 hours	24 hours	48 hours	24 hours	48 hours
	Pound per acre	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
DDT (%) in No. 2 fuel oil:							
5	0.05	98.6	98.6	....	....	....	....
	.025	78.3	80.0	....	....	83.3	92.7
1	.02	....	....	....	....	95.0	98.6
	.015	3.3	6.6	....	....	90.0	96.6
	.01	....	....	....	....	60.0	93.3
	.005	....	....	....	....	43.3	70.0
0.5 [1]	.0025	....	....	60.0	66.8	....	....
	.0025	....	....	66.3	83.1	....	....
DDT (%) in Velsicol NR-70:							
5	.05	95.0	95.0	....	....	....	....
	.025	80.0	81.6	....	....	....	....
0.5	.01	11.6	23.3	....	....	5.0	8.3
	.005	11.6	20.0	....	....	0	8.3
	.0025	0	8.3	52.9	70.5	1.6	5.0
DDT emulsion:							
5% [2]	.05	100.0	....	....	....	....	....
	.025	93.3	93.3	....	....	....	....
1% [2]	.015	13.3	18.3	....	....	....	....
5% [3]	.05	100	....	....	....	....	....
	.025	96.6	96.6	....	....	....	....
1% [3]	.015	58.3	61.6	....	....	....	....
Xylene (0.5%) emulsion	0.0025	....	....	35.0	43.15	....	....
No. 2 fuel oil	....	5.0	11.6	....	....	5.0	6.6
Velsicol NR-70	....	18.3	30.0	....	....	3.3	8.3

[1] 80% No. 2 fuel oil, 20% S.A.E. No. 30 lube oil.
[2] Made from 25% DDT concentrate in PD-544-C (an aromatic petroleum fraction).
[3] Made from 20% DDT concentrate in Velsicol NR-70.

Anopheles quandrimaculatus and *Aedes aegypti*. This is evident from the much higher concentration required for a minimum lethal dosage, and the greater amount of material necessary to obtain the desired results with surface applications. *Anopheles* and *Aedes* larvae were both affected by the lower dosages, *Aedes* being more susceptible when the DDT was diffused throughout the media and much less susceptible when it was applied to the surface.

The difference in susceptibility between *Anopheles quadrimaculatus* and *Aedes aegypti* may have been due to a difference in their feeding habits. Since the *Anopheles* larvae are primarily surface feeders, they are easily affected by either type of application, whereas the *Aedes* larvae, which are habitually bottom feeders, are less susceptible to surface applications.

The greater resistance of *Culex* larvae to the DDT applications at all dosages cannot be explained on the basis of feeding habits, and can be accounted for only by assuming that this species possesses an inherent resistance to the toxic material.

When dusts containing DDT were ap-

plied to the surface of water containing these three species of mosquito larvae, they were effective against *Anopheles* but ineffective against *Aedes* and *Culex*. Again this may be explained on the basis of feeding habits, since only the larvae of *Anopheles* would actually feed on the surface and be affected by small dosages. As shown in Table 1, however, materials dispersed throughout the water control all three species.

Summary.—Great variation in susceptibility to the toxic action of various DDT emulsions, suspensions, and solutions, applied so that the DDT was diffused throughout the media or to the surface only, was shown among larvae of *Culex quinquefasciatus* Say, *Anopheles quadrimaculatus* Say, and *Aedes aegypti* (L.). The *Culex* larvae were highly resistant to DDT regardless of how it was applied, and required a much higher concentration for a minimum lethal dosage than did the *Anopheles* or the *Aedes* larvae. Against *Aedes aegypti* the treatments in which the DDT was diffused throughout the media gave high mortality at much lower dosages than did the surface applications. This variation between treatments might be due to a difference in the feeding habits of the mosquitoes, since *Anopheles quadrimaculatus,* which is primarily a surface feeder, required a lower dosage of DDT in the surface applications than did *Aedes aegypti,* which is habitually a bottom feeder. The greater resistance of *Culex* larvae to the DDT at all dosages cannot be explained on the basis of feeding habits, and can be accounted for only by assuming that this species possesses an inherent resistance to the toxic material.

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