

STUDIES ON THE DEVELOPMENT OF RESISTANCE TO DDT AND MALATHION IN HOUSE FLIES

G. C. LABRECQUE, H. G. WILSON, M. C. BOWMAN, and J. B. GAHAN—
Entomology Research Division, Agr. Res. Serv., U. S. D. A.¹

Resistance to DDT in house flies (*Musca domestica* L.) is now worldwide. Organophosphorus insecticides have been suitable replacements under most conditions, but resistance to many of these insecticides is also developing (Keiding 1956, Lindquist 1957, LaBrecque *et al.* 1957, 1958, and Kilpatrick *et al.* 1958).

Studies were initiated at the Orlando, Florida, laboratory in 1956 to determine the effect of selection with an organophosphorus insecticide and a chlorinated hydrocarbon when used individually, alternately, and in combination, on the rate of development of resistance.

Four experimental colonies of house flies were started from the regular (susceptible) colony by subjecting the adults of each generation to contact sprays in a wind tunnel by the technique of LaBrecque *et al.* (1957). Colony M was treated with malathion, colony D with DDT, colony DM with a combination of malathion and DDT, and colony DM-A with DDT or malathion alternately in successive generations. Selection was accomplished by exposing 100 to 200 4- to 5-day-old flies of undetermined sex to 0.25 ml. of an odorless kerosene solution of the insecticide. After treatment the flies were held for 24 hours and the mortality was recorded. The survivors were then released in a rearing cage where oviposition medium was available. Twenty-four hours later the eggs were collected and placed in larval medium for rearing of the subsequent generation.

The spray used in selecting the first 12 generations of each colony contained 1% of one or both insecticides, which killed about 90% of the flies. In later generations the concentration of either toxicant was raised only when all those colonies subjected to that toxicant could tolerate the increased concentration. The concentration of DDT was increased to 5% in the 13th generation, to 10% in the 17th, and to 20% in the 29th generation, in selecting the D, DM, and DM-A colonies. The concentration of malathion was increased to 2% in the 29th generation in the M, DM, and DM-A colonies.

As resistance developed its progress was followed by conducting wind-tunnel tests with DDT and malathion against 4- to 5-day-old female flies from the 11th, 15th, 20th, 25th, 30th, 31st, and 32nd generations. The concentration of insecticide was varied with the resistance encountered. After treatment the flies were transferred to screen holding cages and supplied with 10% sugar solution on absorbent cotton pads. Mortality was recorded after 24 hours. Duplicate tests with 20 female flies were run at each concentration of insecticide. An LC-50 was computed from the concentration-mortality data, and the degree of resistance determined from the ratio of this LC-50 to that of flies from the regular colony. The results of these tests are presented in table 1.

After 30 to 32 generations resistance to DDT was lower in the DM-A colony than in the D or DM colonies, but had nevertheless reached a high

¹ C. R. Crittenden and P. H. Adcock assisted in these studies.

TABLE 1.—LC-50's OF DDT AND MALATHION IN WIND-TUNNEL TESTS AGAINST HOUSE FLIES OF FOUR EXPERIMENTAL COLONIES AND THE REGULAR COLONY, AND DEGREE OF RESISTANCE AS INDICATED BY THE RATIO OF THE LC-50 OF EACH EXPERIMENTAL COLONY TO THAT OF THE REGULAR COLONY. (AVERAGE OF 2 TESTS.)

Generation	D Colony			M Colony			DM Colony			DM-A Colony			Regular	
	LC-50	Ratio	LC-50	LC-50	Ratio	LC-50	LC-50	Ratio	LC-50	LC-50	Ratio	LC-50	Ratio	LC-50
11	>40.0	>16.0	—	—	—	>4.0	>4.0	>16.0	>4.0	>4.0	>16.0	>4.0	>16.0	0.25
15	27.0	64.4	4.0	9.6	10.3	10.3	15.8	24.6	15.8	37.7	37.7	15.8	37.7	.42
20	27.2	22.7	15.0	12.5	19.0	19.0	19.0	15.8	15.8	8.3	8.3	10.0	8.3	1.20
25	12.7	14.5	2.1	2.4	41.2	41.2	6.5	47.3	47.3	7.5	7.5	6.5	7.5	.87
30	35.0	53.8	>10.0	>15.4	>40.0	>40.0	24.0	>61.5	24.0	36.9	36.9	24.0	36.9	.65
31, lot a	25.0	92.1	11.0	28.9	>40.0	>40.0	10.5	>105.0	10.5	30.2	30.2	10.5	30.2	.38
lot b	17.5	47.3	4.5	12.2	28.0	28.0	7.1	75.6	7.1	19.2	19.2	7.1	19.2	.37
32	>40.0	>49.4	10.0	12.3	35.0	35.0	22.5	43.2	22.5	27.8	27.8	22.5	27.8	.81
DDT														
11	—	—	1.1	2.2	1.1	1.1	0.6	2.2	1.1	0.6	1.2	0.6	1.2	0.5
15	0.8	<1.0	1.7	1.1	.9	.9	.9	<1.0	<1.0	.9	<1.0	.9	<1.0	1.5
20	1.3	<1.0	1.4	<1.0	1.5	1.5	1.2	<1.0	<1.0	1.2	<1.0	1.2	<1.0	1.9
26	.7	1.3	.4	<1.0	1.7	1.7	.8	3.4	3.4	.8	1.7	.8	1.7	.5
30	.7	1.1	1.3	2.2	3.6	3.6	1.8	6.0	6.0	1.8	3.0	1.8	3.0	.6
31, lot a	.5	1.3	1.4	3.5	2.4	2.4	.7	6.0	6.0	.7	1.8	.7	1.8	.4
lot b	1.5	3.8	1.4	3.5	1.5	1.5	.9	3.8	3.8	.9	2.3	.9	2.3	.4
32	1.8	2.6	1.8	2.6	1.6	1.6	1.2	2.3	2.3	1.2	1.7	1.2	1.7	.7
Malathion														

level, and even the M colony had developed 10- to 30-fold resistance to DDT. Resistance to malathion was much lower than to DDT, and was variable between generations, but the M and DM colonies consistently showed more than 2-fold resistance.

Since resistance to DDT was present in the M colony although the selection was made with malathion, tests were conducted to determine the extent of DDT detoxification to DDE. Adult flies were exposed to residues of 3.5 mg. of *p,p'*-DDT per square foot on glass surfaces for 5 hours. The flies were then analyzed for internal DDT and DDE. The analyses showed an average of 26.2 μ g. of DDT and 89.5 μ g. of DDE per 100 flies, indicating a high rate of detoxification of DDT to DDE in this strain of flies.

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