STATUS OF MOSQUITO AND FLY INSECTICIDE SUSCEPTIBILITY IN TURKEY

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The chlorinated hydrocarbon insecticides, DDT, dieldrin and BHC have been used in agriculture and public health control work in Turkey since 1947. The organophosphorous chemicals, malathion and diazinon have been used since 1952, particularly in the southern cotton and rice growing regions. Resistance of the malaria vector *Anopheles sacharovi* to DDT has been reported by de Zulueta (1959), Perry (1959), Gokberk (1959) and Holstein (1960). However, such resistance has been restricted mostly to the Adna-Maras area in southern Turkey, and apparently has not followed the trend of resistance experienced in nearby Greece and reported by Hadjinicolaou (1952), Lividas (1955) and Belios (1956–1960). This latter resistance is distinguished by a high level of resistance to both DDT and dieldrin.

A total of 181 insecticide susceptibility tests were made during the period May-November 1960 by members of the United States military forces on the adult and immature forms of four species of medically important mosquitoes and flies, from four selected localities in Turkey. The LD_{50} values for the species were established on the basis of these tests.

Tests were completed on the larvae of the pest mosquitoes *Culex pipiens, C. vagans,* and the primary malaria vector, *Anopheles sacharovi;* and on the adults of *Culex pipiens* and *Musca domestica.* Specimens were collected and tested in Izmir, Samsun, Incirlik (Adana province) and Diyarbakir. These localities represent the major geographical regions of the country with the exception of the high mountain area of far eastern Turkey. The data on *Culex pipiens* were plotted on a probit logarithmic graph (Figure 1) to achieve the LD_{50} (Table 4), and to establish the dosage mortality lines for this important pest species against insecticides in two localities. The slope, shape and position of these dosage-mortality lines are of value in the interpretation of future testing. LD_{50} values less than that of the lowest concentration of the insecticide tested were not referred to the graph and are simply stated as being less than the lowest concentration (Table 4).

The mosquito tests were performed in accordance with the instructions of the World Health Organization (1959–1960) with equipment and chemicals supplied by the WHO, Geneva, Switzerland. The instructions of the Armed Forces Pest Control Board (1959) were followed for completion of the fly tests, and the chemical for these latter tests were supplied by the U. S. Army Environmental Health Laboratory, Edgewood, Maryland.

Each test employed a minimum of twenty individuals, and all tests were supported by control groups of the same numbers of insects. In the mosquito larval series any emerging pupae were discarded during the 24 hour observation period. It was also necessary to discard 17 tests because of a control mortality in excess of 20 percent. In addition, where the control mortality was between 5 and 20 percent, the percentage mortalities were corrected by Abbott's formula:

$$\frac{\%\ \text{test mortality} - \%\ \text{control mortality}}{100\%\ \text{control mortality}} \times 100$$

A series of five tests of adult *Culex pipiens* in Izmir were also discarded because only 5 percent kill was achieved at 4 percent DDT. Although no fatalities occurred in the controls, it is believed that

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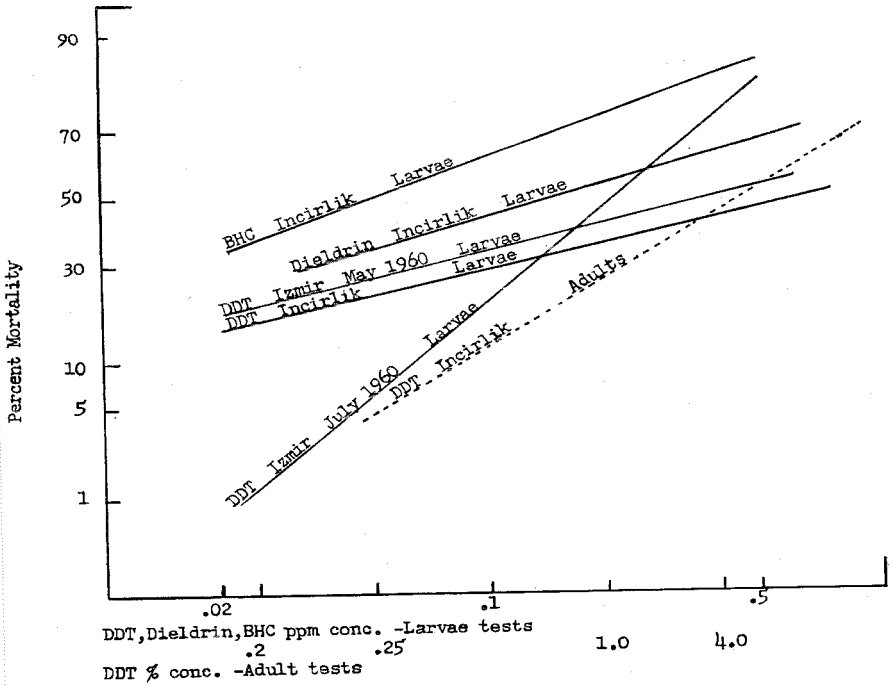

FIG. 1.—Dosage mortality lines of DDT, dieldrin and gamma-BHC against *Culex pipiens* larvae and adults in dispersed locations in Turkey.

the DDT impregnated test papers may have deteriorated to allow such a low mortality.

Larvae of *Culex pipiens,* the most common pest species throughout Turkey, and of *Culex vagans,* a very prevalent pest species in the western part of the country were tested in Izmir against DDT during May 1960. *C. pipiens* was tested again in July of the same year. Larvae of *C. vagans* were subjected to DDT concentrations of 0.004, 0.10, and 0.25 ppm. Air temperature during the tests ranged from 78° F. in May to 85° F. in July. A 100 percent mortality was achieved at 0.10 ppm DDT while 0.004 ppm suspensions gave an 80 percent kill. In the *C. pipiens* series where a wider range of test chemical concentrations were used, 100 percent mortality was attained with 2.50 ppm DDT in May but this mortality could not be achieved in July. This latter concentration in July gave only a 70 percent kill. Thus the LD_{50} for *C. pipiens* increased 50 percent (from 2.8 to .42 ppm) within the period of three months.

Similar but more extensive tests of *Culex pipiens* larvae were made at Incirlik in southern Turkey during July 1960. In this locality the larvae were tested against DDT, BHC and dieldrin at concentrations of 0.004, 0.02, 0.10, 0.50 and 2.50 ppm. The temperature ranged from 75° F. to 90° F. during the tests. One hundred percent mortality was achieved only with BHC at the concentration of 2.50

TABLE 1.—Susceptibility levels of *Anopheles sacharovi* and *Culex pipiens* larvae from Diyarbakir, Turkey, to DDT and dieldrin, after 24 hours. June 1960. Temperature during tests, 75°–80° F.

Concentration of insecticide in test suspensions	Total No. of larvae used		Total No. of dead and moribund larvae		Percent mortality	
	A. sacharovi DDT-dieldrin	*C. pipiens* DDT-dieldrin	*A. sacharovi* DDT-dieldrin	*C. pipiens* DDT-dieldrin	*A. sacharovi* DDT-dieldrin	*C. pipiens* DDT-dieldrin
.008 ppm	.. 20	.. ..	.. 20	.. ..	.. 100	.. ..
.004 ppm	40 ..	40 ..	39 ..	38 ..	97 ..	95 ..
.02 ppm	.. ..	40 ..	.. ..	39 ..	.. ..	97 ..
.10 ppm	40 20	.. ..	40 20	.. ..	100 100	.. ..
.50 ppm	.. ..	40 ..	.. ..	40 ..	.. ..	100 ..
2.50 ppm	40 20	.. ..	40 20	.. ..	100 100	.. ..
Control	40 40	40 ..	4 4	6 ..	10 10	15 ..

ppm. DDT gave 71 percent and dieldrin 94 percent mortality at this latter concentration.

The results of other tests on *C. pipiens* at Diyarbakir in southeastern Turkey and on adult specimens at Incirlik are given in Tables 1 and 2. A total of 2,870 *C. pipiens* larvae and 100 adults were utilized in all tests. These numbers do not include the insects in the control groups.

TABLE 2.—Susceptibility levels of one day old, female, non-blooded *Culex pipiens* adults, from Incirlik (Adana Province) Turkey, to DDT after 24 hours. Exposure period, 1 hour. Temperature during exposure period 77° F. and relative humidity 64 percent. Total of 20 specimens used for each test.

Concentration of DDT	No. dead	% Mortality
0.25%	0	0
0.5%	1	5
1.0%	2	10
2.0%	6	30
4.0%	9	45
Control	0	0

Tests were also made on the larvae of *Anopheles sacharovi* at Diyarbakir (Table 1) and at Samsun on the Black Sea coast. The tests at Samsun were made in August 1960 when the temperature ranged from 70° F. to 80° F. These tests, as also experienced at Diyarbakir, revealed a high sensitivity to both DDT and dieldrin. One hundred percent mortality was achieved at 0.004 ppm DDT and 0.008 ppm dieldrin; the lowest available concentrations. In this series 520 specimens were used against DDT and 280 against dieldrin. One hundred larvae were utilized as controls for both chemicals.

The tests on the house flies revealed a twofold increase of tolerance to both DDT and lindane as compared to the LD_{50} of a susceptible strain of *Musca domestica* maintained by the Orlando, Fla. Laboratory of the U. S. Department of Agriculture. This constitutes the emergence of tolerance, while resistance is confirmed at a 3- or 4-fold increase. Attempts were made to test house flies from the Adana and Istanbul areas but too great a mortality occurred while the specimens were in transit from the collection sites.

The insecticide susceptibility situation in Turkey presents various problems, the major one being that of caution. The above tests summarized as LD_{50} values in Table 4 would appear to demonstrate a fairly high level of tolerance if not actual resistance, particularly in the case of *C. pipiens* in the western part of the country. However it is to be remembered that all such tests are merely indicators and should not be considered apart from control experience in the field. Good control is now being attained with normally low concentrations of DDT in various locations. Thus the LD_{50} of .28 ppm DDT for this species in Izmir may be considered as a base line reference peculiar to the physiology of the tested strain. The increase of

TABLE 3.—Susceptibility levels of *Musca domestica* to DDT and lindane, from Izmir, Turkey. 24 hours observation. 15 minutes exposure

Percent concentration of test solutions	No. of flies used		No. of flies dead		Percent dead	
	DDT	Lindane	DDT	Lindane	DDT	Lindane
.005	..	20	..	5	..	25
.01	..	20	..	13	..	65
.05	40	20	40	15	100	75
.1	60	..	54	..	90	..
.5	120	..	114	..	95	..
1.0	60	..	60	..	100	..
2.5	20	..	20	..	100	..
Control	20	20	1	0	5	0

TABLE 4.—LD_{50} values of several insecticides against mosquitoes and house flies in four locations in Turkey

IZMIR —			
Culex pipiens	— Larvae	0.28 ppm DDT	— May 1960
Culex pipiens	— Larvae	0.42 ppm DDT	— July 1960
Culex vaguns	— Larvae	<0.004 ppm DDT	
Musca domestica	— Adults	0.1% DDT	
INCIRLIK —			
Culex pipiens	— Larvae	0.7 ppm DDT	
Culex pipiens	— Larvae	0.15 ppm Dieldrin	
Culex pipiens	— Larvae	0.051 ppm BHC	
Culex pipiens	— Adults	4.5% DDT	
DIYARBAKIR —			
Culex pipiens	— Larvae	<.004 ppm DDT	
Anopheles sacharovi	— Larvae	<.004 ppm DDT	
Culex pipiens	— Larvae	<.004 ppm Dieldrin	
Anopheles sachurovi	— Larvae	<.0008 ppm Dieldrin	
SAMSUN —			
Anopheles sacharovi	— Larvae	<.004 ppm DDT	
Anopheles sachurovi	— Larvae	<.0008 ppm Dieldrin	

the LD_{50} to .42 ppm DDT by mid-summer is perhaps only behavioristic tolerance and not a demonstration of resistance. Such increases of tolerance during the control season are commonly encountered in field work.

In the Adana area, the problem is somewhat complicated. It is here that *C. pipiens* tolerance approaches a critical LD_{50} whereby true resistance may be suspected. It is in this area also that de Zulueta (1959) found a strain of *A. sacharovi* to be highly DDT-resistant but of normal dieldrin susceptibility. Proper control of these two domestic species will necessitate continual surveillance. Nevertheless, this situation does not invalidate the judicious use of the chlorinated hydrocarbon chemicals.

ACKNOWLEDGMENTS. The author wishes to acknowledge the extensive work of Airmen Robert O. Barry and Jerry Tisdale of the 4th Epidemiological Flight, U. S. Air Force.

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