

and actual residues recovered from test plot water (not exceeding 0.0022 ppm at the highest dosage), the controlled-release formulation of chlorpyrifos is considered superior to those larvicide formulations presently available.

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## SUSCEPTIBILITY OF *ANOPHELES MACULIPENNIS* TO INSECTICIDES IN NORTHERN IRAN, 1974<sup>1</sup>

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**ABSTRACT.** Susceptibility tests were performed in different localities of northern Iran, which had been treated with DDT for malaria control inside houses, 6-13 rounds once a year, and for agricultural pest control on cotton plantations. These tests showed that in localities where the application of DDT for malaria control has

been withdrawn since 1968, the application of this insecticide on cotton plantations has led to the emergence of DDT resistance in *A. maculipennis*. Tests against malathion and dieldrin showed that the discriminating concentration that killed 100% of the mosquitoes tested was 3.2% and 0.8% respectively.

*A. maculipennis* is a vector of malaria in the northern part of Iran, an area with high infection rates. Malariometric surveys undertaken in Rasht and Bandar Pahlavi, Gilan Province, in January 1921, showed 57.4% splenic and 19.2% parasitic indices (Latishev, 1921). Another study made by Amidzadeh in 1925, in Azarbaijan and along the southern bank of the Aras River in northwest Iran, showed a 53.5% splenic index. Records from dispensaries of the Ministry of Health showed 40% malaria mortality in the infested area of Mazandaran in 1944.

In 1949, a pilot project using DDT as a

residual insecticide was begun in the northern part of Iran, and eventually malaria control was started in 1950 and converted to malaria eradication in 1956. After 3 years of DDT spraying, a comprehensive malariometric survey conducted in a number of villages in Gilan and Mazandaran by the Institute of Public Health Research showed a 91% decrease in the infection rate, and by 1956 the area had been cleared of malaria. Insecticide spraying was withdrawn from the area in 1956. In 1965, the area was resprayed with DDT, and after 1968, no more treatments were made.

The resurgence of malaria in some of the consolidation phase areas has highlighted the importance of having effective remedial measures in readiness. Because anti-malaria operations rely heavily on residual insecticides, knowledge of the susceptibility level of anopheline fauna at this

<sup>1</sup>This study was supported in part by the School of Public Health and Institute of Public Health Research, University of Teheran, and partly by the Public Health Research Project of the Ministry of Health and Plan Organization.

stage is as important as it is in the early stages of malaria control programs. During the past 5 years, susceptibility tests made in northern Iran, (Azarbaijan, Gilan, Mazandaran and Khorassan Provinces) which are in the consolidation phase, showed that, in spite of the withdrawal of DDT spraying from inside houses for malaria control, its use for agricultural pest control has resulted in the emergence of DDT resistance in *A. maculipennis*. The resistance of *A. maculipennis* to insecticides has been fully summarized by Brown and Pal (1971), who mentioned that this species is resistant to DDT in Greece and Romania, and to dieldrin in Bulgaria and Romania. Ramsdale (1973) reported double resistance to DDT and dieldrin from Turkey. Resistance of *A. maculipennis* was observed in Isfahan Province, central Iran, in 1954, but this resistance had not affected the malaria eradication program in this province (Manouchehri et al., 1963).

**MATERIAL AND METHODS.** The methods used in testing were developed by WHO

(1970), and described in our previous paper (Manouchehri et al., 1974). Paper impregnated with malathion, DDT and dieldrin was provided by WHO. All observed mortalities were corrected by Abbott's formula when necessary. (Abbott, 1925). The mosquitoes tested were blood-fed *A. maculipennis*, which had been collected from human and animal shelters in rural areas of Azarbaijan, Gilan, Mazandaran and Khorassan. In each test there were 4 replicates and the number of mosquitoes per replicate was 20-25. These tests were made during June, July, and August, when the weather was hot and there was no sign of hibernation.

**RESULTS.** As table 1 shows, 10 villages in Gilan, Mazandaran and Khorassan, which had been treated with DDT at the rate of 2 g/m<sup>2</sup> once a year for 6-13 rounds, were checked during the last 5 years. Susceptibility tests showed that the mortality rates with 4% DDT, 1 hr exposure and 24 hr recovery, were between 35-90. When the exposure time was increased to 2 hr, the mortality increased to 84-90%.

Table 1. Results of DDT susceptibility tests on *A. maculipennis* (1970-1974) in northern Iran with 4% DDT.

Locality & Area	Spray Cycle	% Mortality after 1 hr exposure & 24 hrs recovery			
		1970	1972	1973	1974
Hassan Abad (Chalous)	10 DDT	51 (95)	65.5	58 (89)	52 (105)
Lulman (Rasht)	9 DDT	84 (86)	90 (110)	85.7 (98)	80 (101)
Zardab					
Mahalah (Lahijan)	8 DDT	..	74.7 (99)	72	71.5 (109)
Balankah (Roodsar)	13 DDT	58 (90)	59 (113)	65.9 (88)	68 (111)
Mohamad Abad (Amol)	7 DDT	90 (44)	91 (78)	83 (72)	82 (108)
Lazoorah (Gonbad)	14 DDT	72 (83)	83.6 (98)	..	35.5 (104)
Kalate Naderi (Mashad)	12 DDT	..	74.5 (75)	..	69 (110)
Soltan Abad (Mashad)	12 DDT	..	98 (105)	..	56 (108)
Bijarbin (Astara)	6 DDT	94 (84)	..	91	90 (109)
Shirood (Shahsavari)	10 DDT	53 (85)	83 (80)	55.6 (88)	55 (107)

The figures in parentheses represent the number of mosquitoes tested.

Table 2. Result of dieldrin susceptibility test on *A. maculipennis* in Northern Iran, 1974

Locality	Date	Spraying cycle	temp.		R.H.% *	Control	% Mortality after one-hour exposure, 24 hours recovery				
			Min-max				0.1	0.2	0.4	0.8	LC 50
Bijarbin (Astara)	July 74	6 D.D.T	28-23	*	76-78	0	22.3 (103)	67.6 (105)	100 (109)	100 (108)	
Shileh-Sar (Bandar Pahlavi)	"	8 D.D.T	26-22		68-70	0	28.4 (102)	67.5 (111)	100 (105)	100 (110)	
Luleman (Rasht)	"	9 D.D.T	24-20		72-75	0	21.2 (113)	66.3 (107)	99 (105)	100 (108)	0.16
Zardab Mahalah (Lahijan)	"	8 D.D.T	26-21		70-72	0	22.2 (106)	73.7 (103)	100 (105)	100 (108)	
Balanganh (Roodsar)	"	14 D.D.T	26-22		71-73	0	19.2 (104)	62.6 (107)	97 (103)	100 (105)	0.17
Shirood (Shahsavar)	"	10 D.D.T I.D.L.	27-24		67-71	0.8 (112)	20.9 (110)	58.2 (103)	95.1 (104)	100 (108)	0.18
Hassan Abad (Chalus)	"	10 D.D.T	28-23		73-83	0	17 (107)	59.6 (114)	94.3 (106)	100 (109)	0.17
Khormakola (shahi)	"	3 D.D.T	28-24		67-72	0	15.7 (103)	58 (112)	92.5 (107)	100 (104)	0.18
Mohammad-abad	August 74	7 D.D.T	30-25		71-78	1	16.5 (109)	61.6 (112)	92.4 (106)	100 (104)	0.17
Gavankola (Babol)	"	9 D.D.T	31-25		67-72	0	21.1 (107)	58 (105)	100 (109)	100 (103)	
Ab-Bandan-Kesh (Sari)	"	12 D.D.T	30-25		70-75	0	25.8 (112)	65.4 (107)	97.1 (104)	100 (108)	
Sanghand (Sari)	"	8 D.D.T I.D.L.	30-25		75-77	0	11.1 (108)	58 (100)	93 (101)	100 (107)	

\* R.H.=Relative humidity.

The figures in parentheses represent the number of mosquitoes tested.

Table 3. Results of malathion susceptibility tests on *A. maculipennis* in Northern Iran, 1974

Locality	Date	Spraying cycle	temp.		R.H.*	Control	% Mortality after one-hour exposure, 24 hours recovery		
			Min	Max			0.5	3.2	5.0
Bijarbin (Astara)	July 74	6 D.D.T	26	22	68-74	0 (100)	0 (111)	100 (109)	107 (107)
Shileh-Sar (Bandar Pahlavi)	"	8.D.D.T	26	22	71-78	0 (108)	0.9 (106)	100 (102)	100 (106)
Luleman (Rasht)	"	9.D.D.T	24	21	72-75	0.9 (103)	1.8 (109)	100 (110)	100 (106)
Zardab Mahalah (Lahijan)	"	8.D.D.T	26	22	70-72	0 (106)	0.9 (105)	99 (110)	100 (108)
Balanganh (Roodsar)	"	13.D.D.T	26	22	71-73	0 (104)	2.8 (104)	100 (103)	100 (108)
Shirood (Shahsavar)	"	10.D.D.T 1.D.L	27	24	67-71	0 (111)	3.7 (108)	100 (117)	100 (103)
Hassan Abad (Chalus)	"	10.D.D.T	27	23	73-80	0 (105)	0.9 (108)	99 (113)	100 (109)
Khormakola (Shahi)	"	3.D.D.T	28	24	67-72	0 (107)	8.6 (104)	100 (105)	100 (100)
Cavankola (Babol)	August 74	9.D.D.T	31	25	67-72	0 (106)	4.9 (101)	100 (105)	100 (102)
Mohammad Abad (Amol)	"	7.D.D.T	30	25	71-78	0 (104)	1.9 (102)	100 (107)	100 (107)
Lazooreh (Gonbad)	"	14.D.D.T	31	24	68-72	0 (102)	0 (104)	100 (108)	100 (105)
Sangband (Sari)	"	8.D.D.T	30	25	75-77	0 (105)	0 (107)	100 (104)	100 (101)
Ab Bandan, Kesh (Sari)	"	12.D.D.T	29	25	70-75	0 (106)	5.5 (108)	100 (105)	100 (107)

\* R.H.=Relative humidity.

The figures in parentheses represent the number of mosquitoes tested.

Besides these 10 fixed villages that were checked during the last 5 years, in an additional 6 and 10 villages susceptibility tests were conducted in 1973 and 1974. In these villages the mortality rates were between 81–100% after 1 hr exposure.

Although the application of DDT for malaria control has been withdrawn from the Gorgan area since 1958, the application of this insecticide on cotton plantations has led to the emergence of DDT resistance in *A. maculipennis*. Tests carried out in 1963 showed that in Gorgan, a cotton plantation area, 4% DDT killed 94% of *A. maculipennis* tested, whereas the same concentration in 1974 killed only 35.5% of the mosquitoes tested.

When *A. maculipennis* was tested against malathion and dieldrin in 13 villages in 1974, it was observed that this species is susceptible to both insecticides. The discriminating concentration that killed 100% of the mosquitoes tested was 0.8% and 3.2% of dieldrin and malathion respectively (Tables 2 and 3). Tests carried out in 1963 showed that 0.8% of dieldrin killed 100% of the mosquitoes tested. The same concentration killed 100% of *A. maculipennis* tested and the

LC<sub>50</sub> in 1974 remained at the same level that it was in 1963 (0.15–0.19%).

These studies show that *A. maculipennis* is resistant to DDT in northern Iran (Table 1) but susceptible to dieldrin and malathion (Tables 2 and 3).

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## ERRATA

### Vol. 35, No. 3, September 1975

- P. 414, col. 1, l. 10: for "Train" read "he."  
 P. 414, col. 2, l. 27: for "recommended" read "stated."  
 P. 418, col. 1, l. 22: for "cause" read "course."  
 P. 418, col. 1, l. 24: for "various" read "valuable."  
 P. 418, col. 1, l. 37: for "are not included" read "are included."  
 P. 418, col. 2, l. 11: for "correctors" read "converters."

### Vol. 35, No. 4, December 1975

- PP. 556 and 558. Figures 1 and 2. The legends for these figures were transposed.  
 P. 577, Table 1, col. heading "Total." For fourth listing "5" read "52."