INSECTICIDE RESISTANCE OF *ANOPHELES CULICIFACIES* IN THE PROVINCE OF HELMAND, SOUTHWEST AFGHANISTAN, 1976[1]

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ABSTRACT. After the initiation of residual house spraying with DDT in 1953, populations of *Anopheles culicifacies* Giles in the province of Helmand decreased and remained at a low level for ca. 15 yr. In 1968 and the following years the number of cases of malaria increased considerably, and epidemics appeared in 1970. Susceptibility tests showed that *An. culicifacies* is resistant to DDT but susceptible to dieldrin and malathion in Helmand.

INTRODUCTION

Anopheles culicifacies Giles is one of the most important vectors of malaria in the plains of peninsular and north-western India, Pakistan and Sri Lanka (Ceylon). It is widely distributed throughout Burma, Thailand, Indo-China and mainland China. It is also a vector of malaria in southeastern Iran and southern Afghanistan.

The susceptibility status of *An. culicifacies* has been very fully summarized by Brown and Pal (1971). At the present time this species is resistant to DDT in India (Samson et al. 1974), Pakistan, Nepal, Burma, Afghanistan (Clarke et al. 1974 W.H.O., unpublished) and eastern Iran (Janbakhsh et al. 1976).

Early control measures using DDT residual spraying were begun in the province of Helmand in 1953. Malaria control continued until 1958 when, on the basis of the excellent results obtained, it was decided to embark on a Malaria Eradication Programme. Under the impact of the attack measures implemented during the first years of the Malaria Eradication Programme, the epidemiological situation evolved very favorably, to such an extent that in 1962 some areas were transferred into the consolidation phase. In 1968 and the following years the number of positive cases increased considerably, and epidemics finally appeared, in the south and southwest, 1970.

Susceptibility tests were performed from three different localities of southwestern Afghanistan in 1976. These areas had been treated by residual spraying with DDT 75% w.d.p., 1.5 g/m^2, 18 rounds, once a year during 1953–74, and one round of malathion 50% w.d.p., 2g/m^2 in 1975, for malaria control.

MATERIALS AND METHODS

Susceptibility tests were conducted on *An. culicifacies* from Bost, Luchmin, and Khanishin, in the Lashgargah area, province of Helmand (Fig. 1). All tests were carried out using a field population of adult females collected from indoor resting places between 06.00 and 08.00 hr. The mosquitoes used were blood-fed and caught by aspirator tube.

The method used in testing is that developed by the World Health Organization (WHO, 1970). Standard WHO impregnated papers were used at the following concentrations: 4.0% DDT; 0.05, 0.1, 0.2, 0.4 and 0.8% dieldrin; and 3.2 and 5.0% malathion, together with the corresponding control papers. Mosquitoes were held for 24 hr after exposure, when mor-

[1] These studies were conducted under the auspices of the World Health Organization.

talities were recorded. No mortality corrections were necessary as control mortalities were always less than 5%. LC50 and LT50's were estimated by plotting the dosage-mortality lines.

RESULTS AND DISCUSSION

Susceptibility tests already carried out on *An. culicifacies* during 1970–75 in different localities in Afghanistan showed that this species is resistant to DDT (Table 1).

In 1976, a series of susceptibility tests was performed on *An. culicifacies* in 3 different localities of Bost, Luchmin and Khanishin in Lashgargah area. The average mortality rate for 4.0% DDT after 1 hr exposure and 24 hr recovery was between

MAP SHOWING THE STUDY SITES OF INSECTICIDE RESISTANCE ON ANOPHELES CULICIFACIES IN THE PROVINCE OF HELMAND, SOUTH WEST AFGHANISTAN

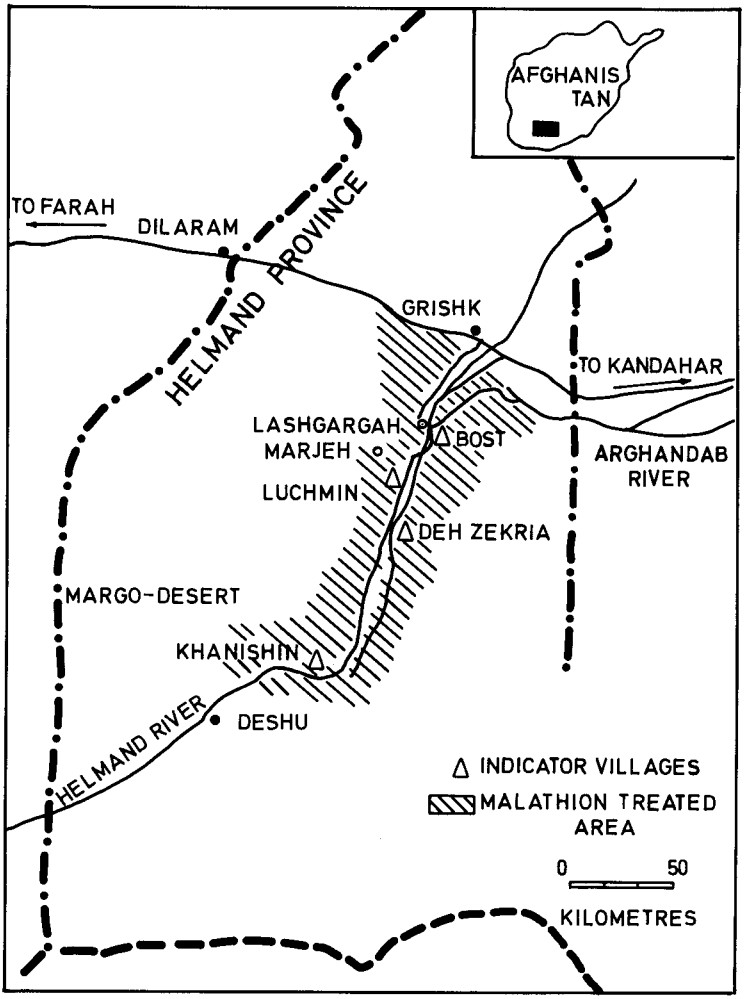

FIGURE 1.

Table 1. Results of susceptibility tests on *An. culicifacies* (1970–1975) in Afghanistan. Figures in parentheses are numbers of females tested.

Year	Area	% Mortality after 1 hr exposure, 24 hr recovery		
		DDT 4.0%	Malathion 3.2%	Propoxur 0.1%
1970	Khost (E)	34.4 (26)		
1971	Laghman (E)	39.4 (38)		
1972	Helmand (SW)	10.3 (29)		
1973	Khost (E)		100 (123)	100 (171)
1974	Helmand (SW)		100 (56)	
1974	Khost (E)		100 (40)	
1975	Nimroz (SW)	21.4 (70)	100 (215)	
1975	Jalalabad (E)		100 (378)	

Table 2. Results of DDT susceptibility tests on *An. culicifacies* (1976) in Helmand province. Figures in paraentheses are the number of females tested.

Locality	Date	Spraying cycle	Exposure time (hr)	% Mortality after 24 hr recovery	
				Control	4.0
Bost	July 76	18. DDT 1. MAL.	1	1 (98)	3.1 (96)
"	"	"	4	1 (97)	50 (100)
Luchmin	July 76	18. DDT	1	0 (83)	12.3 (81)
"	"	"	4	0 (83)	65.1 (86)
Khanishin	July 76	18. DDT 1. MAL.	1	0 (91)	26.8 (97)
"	"	"	4	0 (91)	55.5 (90)

3.1 and 26.8%. When the time of exposure was increased to 4 hr, the mortality rate was between 50 and 65.1% (Table 2).

Susceptibility tests with 0.5, 0.1, 0.2, 0.4 and 0.8% dieldrin concentrations at 1 hr exposure revealed the mortality range of 2.1–26.3%, 40.2–70.3%, 84.2–92.6%, 98.6–100% and 100%, respectively. The LC50 was observed to be between 0.08–0.11% (Table 3.).

With regard to the 3.2 and 5.0% malathion papers, the study was made as baseline data just prior to starting the second round malathion spraying in July 1976 (the first having been in 1975). In susceptibility tests carried out with 3.2% malathion papers with exposure times of 10, 15, 30 and 60 min, the LT50 was observed between 10.5–16.5 min.

Tests made with 5.0% malathion paper, with similar exposure times, the LT50 was observed to be between 6–7 min. The discriminating dosage that killed 100% of this species was 3.2% malathion for 1 hr exposure or 5.0% malathion for 0.5 hr exposure, 24 hr recovery respectively (Table 4).

To sum up, susceptibility tests performed on *An. culicifacies* showed that this

Table 3. Results of dieldrin susceptibility tests on *An. culicifacies* (1976) in Helmand province. Figures in parentheses are numbers of females tested.

Locality	Date	Spraying cycle	% Mortality after 1 hr exposure, 24 hr recovery						
			Control	0.05	0.1	0.2	0.4	0.8	LC50
Bost	July 76	18. DDT 1. MAL.	0 (98)	26.3 (95)	65 (83)	90.7 (97)	100 (77)	100 (84)	0.08
Luchmin	"	18. DDT	0 (83)	16.2 (80)	70.3 (91)	92.6 (82)	100 (77)	100 (84)	0.08
Khanishin	"	18. DDT 1. MAL.	0 (69)	2.1 (75)	40.2 (72)	84.2 (76)	98.6 (72)	100 (69)	0.11

Table 4. Results of malathion susceptibility tests on *An. culicifacies* (1976) in Helmand province. Figures in parentheses represent numbers of females tested.

Locality	Date	Spraying cycle	Concentration (%)	% Mortality after 24 hr recovery Exposure period (min)						
				Control	5	10	15	30	60	LT50
Bost	July 76	18. DDT 1. MAL.	3.2	0 (96)	—	42 (88)	65.2 (95)	85.3 (89)	100 (92)	13.5
Luchmin	"	18. DDT	"	2.1 (92)	—	39.2 (98)	75.7 (95)	98.9 (93)	100 (90)	10.5
Khanishin	"	18. DDT 1. MAL.	"	0 (69)	—	12.3 (73)	34.3 (67)	96 (75)	100 (70)	16.5
Bost	July 76	18. DDT 1. MAL.	5.0	0 (71)	21.7 (69)	88.5 (70)	97.1 (70)	100 (74)	100 (69)	7.0
Luchmin	"	18. DDT	"	2.1 (92)	29 (93)	88.4 (95)	97.8 (93)	100 (91)	—	6.5
Khanishin	"	18. DDT 1.MAL.	"	0 (69)	33.3 (72)	89.1 (74)	98.5 (68)	100 (69)	—	6.0

species is resistant to DDT but susceptible to dieldrin and malathion in the province of Helmand.

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ANNOTATED LIST OF THE MOSQUITOES OF WEST VIRGINIA[1]

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ABSTRACT. A list of mosquitoes collected or reported to be collected, in West Virginia is presented. Twenty-four species have been found to date, of which seven are reported in this paper as new state records: *Anopheles quadrimaculatus, Coquillettidia perturbans, Culex erraticus, Cx. salinarius, Culiseta inornata, Orthopodomyia signifera* and *Uranotaenia sapphirina.*

The first specific study of mosquitoes of West Virginia was provided by Lowell W. Fletcher (1957). Other records of mosquitoes from the state were provided by Dyar (1922, 1928), Carpenter (1950), and Zavortink (1972).

During the present study, mosquitoes were found in small to moderate numbers in isolated and scattered areas of the state. The physiography of West Virginia provides few extensive breeding areas, and most reforested regions consist of relatively young trees with few tree holes. Marshes, bogs, lakes, and other permanent bodies of water are usually located distant to most of the populated areas. The more suitable mosquito habitats are found in the flood plains of the streams and rivers in the state.

For each species listed, information (if known) is provided for seasonal range, initial county record, date of collection, col-

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