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Susceptibility of *Culex quinquefasciatus*, the Vector of Lymphatic Filariasis, to Few Conventional and Newer Insecticides in Different Parts of Rajasthan

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Abstract: Studies on the current insecticide susceptibility status of *Culex quinquefasciatus* against few conventional insecticides, i.e., DDT and Dieldrin, and more potent ones, i.e., malathion, fenitrothion, propoxur and permethrin, were carried out in three desert districts (Barmer, Jodhpur and Pali) and three non-desert districts (Ajmer, Kota and Udaipur) in Rajasthan. The results of the investigations revealed that this vector species was no longer susceptible to any of the tested insecticides. In desert districts, the species exhibited resistance to DDT, dieldrin and malathion (mortalities <80%) and intermediate resistance to fenitrothion, propoxur and permethrin (mortalities 80-98%). However, in non-desert districts, the species, besides resistance to DDT, dieldrin and malathion, had also developed resistance to propoxur (mortalities <80%), but it exhibited intermediate resistance to fenitrothion and permethrin (mortalities 80-98%).

Key words: Insecticide, susceptibility, resistance, *Culex quinquefasciatus,* filariasis.

In India, lymphatic filariasis is considered a major health problem next to malaria among the vector-borne diseases (Rao *et al.*, 1976). In non-endemic states, the presence of microfilarae (*mf*) in migratory laborers and army personnel in Rajasthan and Jammu and Kashmir, respectively (Sharma *et al.*, 1986; Raina *et al.*, 1985) has enhanced the risk of transmission of disease to local inhabitants, whenever congenial environmental conditions develop (Singh and Bansal, 1995). Keeping this in mind, it was decided to determine the current insecticide-susceptibility/resistance status of *Culex quinquefasciatus,* the vector of lymphatic filariasis, to some conventional and more potent insecticides in different parts of Rajasthan. The information gathered could be utilized in formulating vector control measures for the prevention of disease.

Materials and Methods

The study was carried out in 3 desert districts, viz., Barmer, Jodhpur and Pali, and 3 non-desert districts, viz., Ajmer, Kota and Udaipur, selected on the basis of settlement of army personnel, except Pali, which was chosen due to the presence of migratory laborers. The mosquitoes were collected from the localities/situations, which were either adjoining the army residential areas or where the army personnel/migratory laborers were residing along with local inhabitants. Freshly-fed females of *Culex quiquefasciatus* were collected during dawn hours from indoor locations, using WHO-aspirator tube and focus lights. After collections the females were kept in Burraud cages and were provided with glucose pads (10%) and resin

Table 1. Efficacy of organochlorine compounds against Cx. quinquefasciatus in studied areas.

District/Insecticide	Diagnostic dose (%)	Exposure time (h)	% mortality	S/R** status	Lethal concentrations (%)*	
					LC_{50}	LC_{95}
Barmer						
DDT	4.0	4	24.1	R	9.5	19.1
Dieldrin	4.0	1	48.5	R	4.1	8.8
Jodhpur						
DDT	4.0	4	35.1	R	5.8	11.7
Dieldrin	4.0	1	53.0	R	3.5	7.3
Pali						
DDT	4.0	4	33.9	R	5.9	11.7
Dieldrin	4.0	1	63.8	R	3.0	6.1
Ajmer						
DDT	4.0	4	53.3	R	3.8	7.2
Dieldrin	4.0	1	63.9	R	2.9	6.4
Kota						
DDT	4.0	4	46.8	R	4.2	7.9
Dieldrin	4.0	1	54.5	R	3.3	6.9
Udaipur						
DDT	4.0	4	57.4	R	3.3	6.1
Dieldrin	4.0	1	63.9	R	2.9	6.2

* LC_{50}-Concentration required to obtain 50% mortality; LC_{95}-Concentration required to obtain 95% mortality.
**S/R- Susceptibility/resistance status, R-Resistant.

and candy, during the holding periods (WHO, 1981a).

The tests were conducted in the field as per the WHO methods (WHO, 1981b), mainly during March-April and July-August months. During the tests the temperature ranged from 25-30°C and RH 40-65%. Batches of 20-25 females were exposed to different diagnostic doses (WHO,1992) of DDT, dieldrin (organo-chlorines), malathion, fenitrothion (organophosphates), propoxur (carbamate) and permethrin (synthetic pyrethroid). The diagnostic dose of an insecticide can be defined as the dose, which is initially required to cause 100% mortality in a susceptible strain of an individual species. Three concentrations, each of DDT (1, 2 and 4%) and dieldrin (0.1, 0.2 and 4.0%), were used to obtain a concentration-mortality data for determining the lethal concentrations (LC), whereas in case of organophosphates, carbamate and synthetic pyrethroid, their diagnostic doses were used for different exposure times, i.e., 30, 60 and 120 minutes (in case of permethrin 180 min. also), to obtain exposure time–mortality data for determining their lethal exposure time, LT (WHO, 1981b).

The diagnostic doses of malathion, fenitrothion, propoxur and permethrin were 5.0, 1.0 and 0.1 and 0.25%, respectively. Depending upon the graded mortalities obtained in different doses (DDT and

Table 2. Efficacies of organophosphate, carbamate and synthetic pyrethroid compounds against Cx. quinquefasciatus, based on exposure time mortality response in studied areas

District/Insecticide	Diagnostic dose (%)	Exposure time (h)	% mortality	S/R** Status	Lethal exposure time (min)*	
					LT_{50}	LT95
Barmer						
Malathion	5.00	1	68.6	R	53.0	105.6
Fenitrothion	1.00	2	84.6	IR	60.2	108.6
Propoxur	0.10	2	82.9	IR	76.5	133.0
Permethrin	0.25	3	94.4	IR	39.6	95.5
Jodhpur						
Malathion	5.00	1	72.0	R	46.9	104.7
Fenitrothion	1.00	2	85.0	IR	54.8	107.4
Propoxur	0.10	2	84.0	IR	75.9	132.6
Permethrin	0.25	3	96.0	IR	38.7	93.4
Pali						
Malathion	5.00	1	43.0	R	76.1	102.0
Fenitrothion	1.00	2	58.9	IR	88.5	111.3
Propoxur	0.10	2	77.5	IR	81.7	136.5
Permethrin	0.25	3	97.3	IR	37.7	95.8
Ajmer						
Malathion	5.00	1	76.2	R	45.9	101.8
Fenitrothion	1.00	2	83.0	IR	61.8	108.1
Propoxur	0.10	2	71.2	R	89.6	153.8
Permethrin	0.25	3	93.2	IR	35.6	113.0
Kota						
Malathion	5.00	1	61.1	R	57.3	109.2
Fenitrothion	1.00	2	81.3	IR	64.4	110.7
Propoxur	0.10	2	70.0	R	88.8	154.9
Permethrin	0.25	3	91.9	IR	39.4	106.2
Udaipur						
Malathion	5.00	1	69.0	R	55.4	104.7
Fenitrothion	1.00	2	81.4	IR	61.9	108.2
Propoxur	0.10	2	71.4	R	88.3	153.9
Permethrin	0.25	3	95.6	IR	38.4	105.4

* LT_{50}-Exposure time required to obtain 50% mortality; LT_{95}-exposure time required to obtain 95% mortality, **S/R-Susceptibility/resistance status, R-Resistant, IR-Intermediate resistance.

dieldrin) and exposure times (malathion, fenitrothion, propoxur and permethrin), the mortalities at 50% (LC_{50} and LT_{50}) and 95% (LC_{95} and LT_{95}) levels, were determined. For each dose/exposure time, depending upon the availability of adequate number of mosquitoes, 4-5 replicates were used along with the controls. The mortality counts were made after 24 hours. The control mortalities were adjusted using Abbott's formula. For the determination of insecticide resistance the WHO criteria- the percent mortalities >98% susceptible, 80-98% intermediate resistant, <80% resistant, was considered in the study (WHO, 1992).

Results and Discussion

Efficacies of organochlorine compounds against *Cx. quinquefasciatus*, based on concentration-mortality response in different districts have been given in Table 1, whereas the efficacies of organophosphate, carbamate and synthetic pyrethroid compounds have been given in Table 2. The species was not found susceptible to any of the tested insecticides in all the districts. In desert districts, viz., Barmer, Jodhpur and Pali, the species was found resistant to DDT, dieldrin and malathion and exhibited intermediate resistance to fenitrothion, propoxur and permethrin (Tables 1 and 2). In non-desert districts, viz., Ajmer, Kota and Udaipur, the species, besides, DDT, dieldrin and malathion, also exhibited reistance to propoxur. However, against fenitrothion and permethrin, it was found to be partially resistant (Tables 1 and 2). Against DDT, dieldrin, malathion and fenitrothion in desert districts, this species showed highest resistance in Barmer district and in Kota among non-desert districts. Against propoxur the species exhibited highest degree of resistance in Kota among non-desert districts and in Pali among desert districts.

The species exhibited a comparatively low degree of resistance against both DDT and dieldrin in Udaipur (mortalities 57.4 and 65.0%), against malathion in Ajmer (mortality 76.2%), against fenitrothion in Pali (mortality 88.5%), against propoxur in Jodhpur (mortality 84.0%) and against permethrin in Pali (mortality 97.3%).

The results reveal that *Cx. quinquefasciatus* has developed resistance to DDT, dieldrin and malathion, intermediate resistance to fenitrothion and permethrin in all the districts, whereas against propoxur the species was found resistant in non-desert districts and partial resistant in desert districts. This may be due to the cross tolerance to the pesticides being used in agricultural sector in non-desert districts (Georghiou, 1982).

The reports on the development of insecticide resistance have already been published from different parts of the country. Krishnarao *et al.* (1989) reported that the Rajamundary strain of *Cx. quinquefasciatus* was resistant to DDT and dieldrin and susceptible to fenitrothion, malathion, propoxur and deltamethrin. Resistance against DDT and dieldrin has also been recorded from Sundergarh district of Orissa (Chand and Yadav, 1991). Similar findings have been reported against DDT and malathion from the coastal areas of Orissa (Das *et al.*, 1988). Bansal and Singh (1995) reported that the species is resistant to DDT, dieldrin, malathion, fenitrothion and propoxur, but susceptible to permethrin, in Bikaner district. In the present study too, the species exhibited resistance to DDT, dieldrin and malathion in the desert areas, but against fenitrothion, propoxur and permethrin it showed intermediate resistance. In case of permethrin the per cent mortalities indicate that the process of resistance has just started and the resistance is of very low degree.

The development of insecticide resistance, a problem of all insect groups, involves biochemical mechanisms, by which the insecticides become less effective, are similar across all vector taxa, however, each resistance problem is potentially unique. Two types of biochemical resistance are (i) target site resistance, when the insecticide no longer binds to its targets, and (ii) the detoxification enzyme-based resistance, which occurs when enhanced levels of esterases, oxidases or glutathion-s-transferases prevent the insecticide from receiving its site of action (Brogdon and McAllister, 1998). The target of OPs (malathion, fenitrothion) and carbamate (propoxur) is acetylcholinesterases in nerve synapses and the targets of OCs (DDT) and synthetic pyrethroids are the sodium channels of the nerve sheath. DDT-pyrethroid cross-resistance may be produced by single amino acid changes in axonal sodium channel insecticide binding site (Williamson *et al.*, 1996). The enzymes responsible for the detoxification of xenobiotics are transcribed by members of large multigens families of esterases, oxidases and GST and the most common resistance mechanisms in insects are modified levels or activities of esterase detoxification enzymes that metabolize a wide range of insecticides.

The development of resistance against the compounds, which have never been used in the area can be due to the cross-resistance spectrum of the pesticides being used for crop protection (Bansal and Singh, 1995) or due to the industrial effluents/ wastes (Anonymous, 1999). The development of the high resistance against four new compounds in Kota district can be attributed to cross-resistance of the pesticides, being used in agriculture (Wattal *et al.*, 1981; Singh and Bansal, 1996). It is evident from the analysis of the mortality counts made against organochlorines (DDT and dieldrin) in two different areas having DDT- and BHC-spray histories, that if the organochlorine compounds in the spray operations are used alternately, the process of precipitation of insecticide resistance can be prolonged (Bang, 1985).

The findings of the study can be utilized in formulating alternate/emergency vector control strategies through chemical control in study areas.

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