MULTIPLE RESISTANCE IN *ANOPHELES CULICIFACIES* GILES

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ABSTRACT. A population of *Anopheles culicifacies* from Maharashtra State, India, showed a broad spectrum of organophosphate resistance when compared with populations of the same species from Sri Lanka and Pakistan. Of significance is the resistance to a number of organophosphates considered potential candidate alternatives for vector control in public health programmes. All 3 populations were susceptible to fenthion and the carbamate, propoxur. DDT resistance was common to all 3 populations. Dieldrin resistance was confined to the two populations from India and Pakistan.

Organochlorine resistance is already widespread in *Anopheles culicifacies*. According to WHO (1980) DDT resistance is present in Afghanistan, Burma, India, Iran, Nepal, Pakistan and Sri Lanka while dieldrin resistance has been recorded in Afghanistan, India, Nepal, Oman and Pakistan. Malathion resistance in *An. culicifacies* was first detected in Gujarat State in India in 1973 (Rajagopal 1977). It is now apparently present also in the Warangal District of Andhra Pradesh according to data provided by Rao (1979). In addition Herath et al. (1981) have now demonstrated fenitrothion resistance in this species from both the Maharashtra and Gujarat States of India.

This paper compares the response shown by 3 populations of *An. culicifacies* from Sri Lanka, Pakistan and India to a number of insecticides including organochlorines, organophosphates and carbamates.

MATERIALS AND METHODS

The *Anopheles culicifacies* populations used were:-

CUL/SRL—a population derived from eggs received from Attanagalla, Kirindiwela, Sri Lanka, and supplied by the Anti-Malaria Campaign in 1976.

CUL/PA—a population provided by the Pakistan Medical Research Centre, Lahore, and derived from the village of Sattoki near Lahore from females collected in 1975.

CUL/IND—a population derived from eggs received from Wadawali Village, Palghar Unit, Thana District, Maharashtra State, India, and supplied by the National Malaria Eradication Programme in 1976.

Standard impregnated papers as supplied by the World Health Organization for their adult mosquito susceptibility test were used in the case of the insecticides DDT, dieldrin, malathion, fenitrothion, fenthion and propoxur. Pure or near-pure samples of malaoxon, chlorphoxim and pirimiphos-methyl dissolved in dioctyl phthalate were used to prepare papers locally, employing acetone as the volatile solvent.

Rearing, maintenance of mosquito populations and the testing procedure were all carried out in the Ross Institute insectaries in the London School of Hygiene and Tropical Medicine where controlled temperatures of 25–28°C, a relative humidity of 70–80% and a 12 hr photoperiod existed. Standard procedures of anopheline rearing were followed. Larvae were bred at water temperatures of 28–30°C and were fed on ground Farex, a proprietary cereal baby

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food. Quantities of food were carefully adjusted according to the larval density and stage of development so as to ensure the production of uniform-sized larvae, pupae and emerging adults. Adult males had access to approximately 20% glucose solution while the females were fed on blood in addition. Feeding was mainly on human volunteers as most were reluctant to feed on the normal animal host provided, the guinea-pig. Both the Sri Lankan and Indian populations had to be propagated by the artificial mating technique as neither mated naturally in cages. The Pakistan population was the cage-adapted one reported by Ainsley (1976).

Susceptibilities to the insecticides were determined by the standard WHO adult susceptibility test using less than 1 day old males and unfed females. One hr exposures, followed by 24 hr recovery periods, were made to concentrations considered to discriminate susceptibility from resistance though, as will be seen, some of these concentrations were imperfect in this respect.

RESULTS AND DISCUSSION

Mortalities after exposure to the organochlorines, 8 organophosphates and 1 carbamate are given in Table 1. All 3 populations are highly resistant to DDT, but while the Pakistan and Indian populations show dieldrin and HCH resistance, the Sri Lankan one remains susceptible to these insecticides. All 3 populations seem equally susceptible to fenthion and propoxur. When comparisons are made with mortalities in the Sri Lankan and Pakistan populations it would seem that resistance to malathion, malaoxon, fenitrothion, chlorthion, chlorphoxim, iodephenophos and pirimiphos-methyl is present in the Indian population.

This resistance to almost all the candidate organophosphate insecticides shown by the Indian population could be of serious practical significance. What needs to be established with some urgency is the level, extent, and operational implications of these resistances. From the susceptibility tests carried out so far it would seem that propoxur remains a suitable alternative if needed. Fenthion is not now considered suitable for house-spraying because of its high mammalian toxicity.

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Table 1. Percentage mortalities at discriminating dosages of various insecticides (all after one hour's exposure) in 3 populations of *Anopheles culicifacies* from Sri Lanka (CUL/SRL), Pakistan (CUL/PA) and India (CUL/IND).
(The actual numbers tested are given in parentheses).

	CUL/SRL	CUL/PA	CUL/IND
5% malathion	99 (81)	95 (92)	2 (215)
5% malaoxon	100 (87)	100 (16)	33 (36)
1% fenitrothion	95 (38)	96 (110)	7 (214)
0.1% chlorthion	92 (152)	—	37 (27)
4% chlorphoxim	97 (89)	100 (140)	37 (65)
10% iodophenphos	100 (17)	—	50 (22)
1% pirimiphos-methyl	90 (94)	95 (42)	4 (119)
2.5% fenthion	95 (38)	100 (34)	90 (114)
0.1% propoxur	100 (28)	100 (44)	100 (63)
4% DDT	12 (445)	0 (72)	7 (90)
4% dieldrin	*100 (39)	0 (16)	0 (6)

* CUL/SRL was exposed to 0.4% dieldrin.

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ENGINEERING EVALUATION OF COMMERCIAL BACKPACK SPRAYER/DUSTERS[1]

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ABSTRACT. Engineering evaluation of 9 commercial backpack sprayer/dusters was conducted by the U.S. Army in view of determining suitability to meet military needs. Important items included in the testing were reliability and ease of maintenance of the individual units, and determination of the pesticide dispersal rates. The most desirable characteristics of the sprayer/duster are also presented.

Disease vector control requires the use of a variety of liquid and solid insecticide formulations. These insecticides often must be dispersed effectively in small areas inaccessible to vehicle-mounted equipment. One means of accomplishing this is by small, motor-driven, backpack insecticide dispersal units. The U.S. Government emphasizes the use of available commercial units to meet the needs of the Army, rather than the development of unique items at Government laboratories. The selection of commercial units which meet the requirements of the Army is essential to this effort. An analytical tool for this determination is engineering evaluation of various commercial units to test relative suitability for military use.

[1] *Disclaimer*—The findings in this report are not to be construed as an official Department of the Army position unless so designated by other authorized documents. Use of trademarked names does not imply endorsement by the US Army, but is used only to assist in identification of a specific product.

Sixteen characteristics of 9 commercial backpack sprayer/dusters manufactured and/or distributed in the U.S. were evaluated. Units incapable of dispersal of both liquid and solid formulations were not included in this evaluation. Prior to testing units were weighed both with and without insecticides and fuel. Operating and storage dimensions were taken to determine the effect the addition of the item to the inventory would have on organizational mobility. After these pre-operative checks, units were operated and maintained in accordance with their instruction manuals for 250 hr. During this time, fuel consumption was determined. Insecticide tank capacity for liquid and solid formulations was measured. Flow rates and dispersal capabilities for each formulation were also determined. During the 250 hours of reliability testing, the number and type of failures were recorded. All maintenance time, both for routine services and malfunction repair, was recorded. At the end of testing a