Resistance to Dieldrin and DDT and Sensitivity to Malathion in the Bed-bug *Cimex hemipterus* in Malaya

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Early in 1958 reports were received from several plantations and one mental hospital in Malaya that bed-bugs were resistant to the insecticides then in use—DDT, BHC and dieldrin. Most of the complaints were associated with dieldrin. Malathion was recommended and is reported to have given good results.[a] This note records a brief laboratory investigation on one strain of resistant bug obtained from a lowland tea estate.

On this estate, dieldrin at 50 mg per square foot (0.5 g per m^2) had been sprayed four times between March 1956 and March 1958 for the control of malaria. No other residual insecticides were used, and before dieldrin spraying malaria control was by drug prophylaxis. Bed-bug resistance was reported in May 1958 after the fourth dieldrin spraying, but appears to have been evident after the third round of spraying in October 1957. Not until May 1959 was there an opportunity to collect bugs from the estate and to make tests. By this time malathion had been used two or three times, mixed latterly at 0.5% with the dieldrin spray.

The bugs were bred in the laboratory until some were large enough to test using a method modelled on that of Busvine.[b] Recently fed bugs were placed in test-tubes, five per tube, and in each tube was placed a strip of treated paper folded once longitudinally. The bugs climbed onto the paper and did not leave it unless " knocked down " or dead. For the control, and for DDT and dieldrin, the strips were cut from the WHO papers issued with the mosquito testing kit. For malathion, papers were impregnated at about the same rate as the WHO ones (0.7 ml per paper), using liquid paraffin BP containing various concentrations of malathion. The malathion was a commercial 50% emulsifiable concentrate. The dead bed-bugs were recorded daily and the final (5-day) results are shown in the following tabulation with the approximate LT_{50}:

Test paper	*No. bugs dead after 5 days*	*Approx. time in days to 50% kill*
Control	0/30	—
DDT 4%	10/20	5
DDT 8%	18/20	3
Dieldrin 1.6%	1/20	>5
Malathion 0.01%	6/25	>5
Malathion 0.02%	21/25	3½
Malathion 0.05%	25/25	1½
Malathion 0.10%	15/15	1

There was virtually complete resistance to dieldrin, and young bugs, hatching from eggs laid during the test, survived. In all other tubes, except the control, they died if they hatched at all. Busvine gives a normal LC_{50} for *Cimex lectularius* of about 0.07% for dieldrin and about 1.2% for DDT. This strain of bugs had a marked tolerance for DDT, which at 4% killed only 50% in five days, but they were nearly all dead after seven days. Since DDT was not used officially on the estate this tolerance is a little surprising, but perhaps DDT was used sporadically by individuals, especially after the bugs became resistant to dieldrin. The bugs were very sensitive to malathion with an LC_{50} between 0.01% and 0.02%. However, such low concentrations would presumably be too short-lived; for practical use at least 0.5% malathion is generally recommended.

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Since the above was written, my colleague Mr W. H. Cheong has tested a resistant strain of bugs from Kuala Lumpur and compared them with the tea estate strain. He found that the Kuala Lumpur strain was more resistant to DDT and less resistant to dieldrin than the estate strain, but that the former was even more susceptible to malathion (LC_{50} less than 0.01%) than the estate strain. This agrees with the differences in spraying history of the two strains, for the Kuala Lumpur strain came from buildings which have been sprayed a number of times with DDT and seldom with dieldrin, and in

[a] Reid, J. A. & Chee Sinn Lim (1959) *Med. J. Malaya*, **13**, 239

[b] Busvine, J. R. (1958) *Bull. Wld Hlth Org.*, **19**, 1041

which malathion has not yet been used. The estate strain was found to have lost some of its resistance to dieldrin (1.6% concentration killed 25% as against 5% when first tested) following seven months' rearing in the laboratory without further exposure to insecticide.

Inheritance of DDT Resistance in a Philippine Population of *Culex pipiens fatigans* Wied.*

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Culex pipiens fatigans Wiedemann has been shown to be resistant to DDT and other chlorinated hydrocarbons in many areas of the world, presumably as a result of the extensive application of these insecticides for vector and pest control. Yson & Krusé [a] demonstrated that larvae of this species in Manila, Philippines, required heavy concentrations of DDT for effective kill.

In 1957 a colony of *C. p. fatigans* from the Philippines was established in the Laboratories of Medical Entomology, Johns Hopkins University School of Hygiene and Public Health, Baltimore, Md., USA, from material collected near Manila and Angeles by Dr Louis C. LaMotte. A comparison of this colony with a *C. p. fatigans* population originating in Galveston, Texas, showed the larvae of the former to be about 13 times more resistant to DDT at the LC_{50} level, and about 40 times more resistant at the LC_{90} level. A year later another comparative test was made, which showed the larvae of the Philippine population to have an almost identical response to DDT and to be considerably more resistant than the larvae of *C. p. pipiens* and *C. p. molestus* from Baltimore. In comparing the regression lines obtained by plotting the dosage-mortality responses, it appeared that 0.1 part per million (p.p.m.) should be a fairly satisfactory discriminating dose. Philippine *C. p. fatigans* and Baltimore *C. p. pipiens* are interfertile (Rozeboom [b]), and accordingly, a series of crosses between the Philippine *C. p. fatigans* and the Baltimore *C. p. pipiens* were made, and larvae of the several crosses were tested with 0.1 p.p.m. DDT.

The object of this experimentation was to determine whether such a test could be applied to an analysis for resistant genes, and whether the resistance of the Philippine colony was due to a single gene or to several genes. It was also of interest to obtain information as to whether the resistance on the part of the Philippine mosquito was in fact due to selection following the use of DDT, or whether this population was a more vigorous form and hence more tolerant to insecticides.

Materials and methods

The Philippine *C. p. fatigans* was colonized from material collected near Manila and Angeles, and hence probably represents a hybrid of the populations indigenous to these well-separated localities. The *C. p. pipiens* colony had been established some years ago from mosquitos collected on the periphery of Baltimore, and had been maintained continuously in the laboratory.

In setting up a cross, from 50 to 100 or more adults of both sexes were placed in a 1 cubic foot [c] breeding-cage and were kept there until sufficient numbers of egg rafts had been obtained. A chick was placed in each cage as needed for blood feeding. Since it was desirable to run several larvicidal tests simultaneously, the parent adults were maintained for a sufficiently long time for them to produce fresh F_1 eggs at the time that the older F_1 adults from the same parents were producing the F_2 and backcross eggs. However, it was also necessary to add new adults to some cages. Egg production could be regulated by simultaneous feeding of blood to the females. Larvae from these eggs were reared

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[a] Yson, C. O. & Krusé, C. W. (1955) *J. Philipp. med. Ass.*, **31**, 567

[b] Rozeboom, L. E. (1958) *Amer. J. trop. Med. Hyg.*, **7**, 526

[c] 1 cubic foot = 30 dm^3.