only for control tubes) cut to a size of 8.5 × 10 cm and place disc of similarly impregnated paper (2.8 cm diameter) at bottom of tubes.

4. Transfer flies from Borrell tube into exposure tubes by gentle shaking or phototropism.

5. On completion of exposure period (generally 1 hour), transfer flies from exposure tubes to recovery tubes (by gentle shaking) and maintain the tubes in a horizontal position for 24 hours.

6. Count the dead flies and transfer living flies to a normal tube to be etherized and counted.

7. Calculate the correction for control mortality and prepare the mortality curve on log-probit paper. The LD_{50} values are determined graphically.

Conclusions

The authors believe that the method described can be used for *Drosophila* in much the same way as the WHO standard test is used for adult mosquitos, but with certain modifications. For practical reasons the use of the WHO standard impregnated paper, cut to a suitable size, is recommended. While *Drosophila* flies may be exposed to the insecticide in dry tubes, a sufficient degree of humidity must be maintained in the recovery tubes. Banana-agar and molasses-agar are commonly used in *Drosophila* laboratories and are therefore recommended for this purpose, but simple agar-gel or any other material which would maintain a constant humidity could, of course, be used.

Insecticide-Resistance in Bed-bugs and Flies in Zanzibar

by NORMAN G. GRATZ,[a] *Team Leader, WHO Housefly Investigation and Control Project, Monrovia, Liberia*

In November 1959, in the course of an investigation of reported increases in the populations of bed-bugs, fleas, and mites following dieldrin applications in Zanzibar, a resistance survey was carried out on bed-bugs and flies.

Anti-malaria spray programmes were begun on the island by the WHO Malaria Eradication Team with an initial spraying cycle from April to September 1958 and a second one from March to August 1959. In each case dieldrin was applied at a rate of 0.8 g/m². The entire island was sprayed with the exception of one area of Zanzibar town. In addition, DDT has been used for several years by the island Health Department for the control of pests in individual homes. The island's Department of Agriculture has also used substantial quantities of DDT for insect control in agricultural areas close to Zanzibar town. There has been some use of diazinon-impregnated cords for fly control in the markets, and diazinon was sprayed into 28 pit privies (of which there are over 9000 in the African section of the town), but its use was discontinued when it was found that it gave but 10-12 days' control of *Chrysomyia putoria*.

Fly densities were fairly high in rural and municipal areas, with estimated grill counts as high as 175 in one village; bed-bug populations varied considerably from village to village and from hut to hut within villages. A number of very heavy bed-bug infestations were found in Zanzibar town in both the sprayed and unsprayed sections. Only a very small number of fleas were found in the villages, all *Pulex irritans*; and, despite their reported appearance in heavy numbers following the dieldrin spraying, no fowl mites were found in any of the huts in the villages.

Insecticide-resistance tests were carried out on houseflies, on *C. putoria*, and on bed-bugs (*Cimex hemipterus*). Flies were exposed in 21 mm × 71 mm vials to dieldrin and DDT residual deposits from acetone solutions. Exposure was for 30 minutes with dieldrin and for 15 minutes with DDT. Bed-bugs were tested in Petri dishes by a previously described method,[b] with the modification that there was continuous exposure to dieldrin for three days and to DDT for two days.

Results of the tests (Tables 1-3) show a high degree of resistance to dieldrin in houseflies and *C. putoria* taken from Zanzibar town. Houseflies from this

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[b] Gratz, N. G. (1959) *Bull. Wld Hlth Org.*, **20**, 835.

TABLE 1

HOUSEFLY MORTALITIES AFTER EXPOSURE TO DIELDRIN AND DDT [a]

Locality	Insecticide	Control	Percentage concentration of insecticide					
			0.0001 %	0.001 %	0.01 %	0.1 %	1.0 %	2.0 %
Zanzibar town	Dieldrin	0 (60)	—	6 (60)	5 (60)	8 (60)	5 (60)	6 (60)
	DDT	2 (40)	10 (20)	7 (40)	10 (80)	62 (80)	16 (60)	46 (60)
N'Gombe	Dieldrin	10 (20)	—	—	13 (40)	0 (40)	38 (40)	44 (40)
	DDT	0 (20)	—	0 (20)	10 (20)	80 (20)	50 (20)	—
M'kakatoni	Dieldrin	22 (40)	—	4 (20)	6 (40)	10 (40)	0 (40)	32 (40)
	DDT	10 (40)	—	—	0 (40)	11 (40)	18 (40)	34 (40)
Chwaka	Dieldrin	7 (40)	—	5 (40)	0 (40)	5 (40)	16 (40)	10 (40)
	DDT	2 (40)	—	5 (40)	5 (40)	12 (40)	92 (40)	77 (40)

[a] Expressed as the percentage mortality in the controls and the corrected percentage mortality for each concentration of insecticide. The number of flies used in each test is given in parentheses.

TABLE 2

BED-BUG MORTALITIES AFTER EXPOSURE TO DIELDRIN AND DDT [a]

Locality	Insecticide	Control	Percentage concentration of insecticide						
			0.0001 %	0.001 %	0.01 %	0.1 %	1.0 %	2.0 %	5.0 %
Zanzibar town	Dieldrin	8 (50)	0 (40)	15 (50)	57 (60)	40 (60)	55 (60)	41 (60)	69 (50)
	DDT	0 (20)	5 (20)	10 (20)	20 (20)	95 (20)	100 (20)	90 (20)	85 (20)
Bububu	Dieldrin	5 (20)	—	20 (30)	23 (30)	20 (30)	26 (30)	13 (30)	36 (30)
	DDT	25 (20)	0 (20)	6 (20)	0 (20)	33 (20)	32 (20)	86 (20)	86 (20)
M'kakatoni	Dieldrin	10 (20)	—	—	16 (20)	16 (20)	16 (20)	44 (20)	—
	DDT	0 (20)	—	15 (20)	20 (20)	55 (20)	85 (20)	80 (20)	85 (20)
Chwaka	Dieldrin	5 (20)	—	—	5 (20)	10 (20)	21 (20)	0 (20)	15 (20)
	DDT	10 (20)	—	—	55 (20)	88 (20)	77 (20)	100 (20)	100 (20)
Zanzibar Prison	Dieldrin	10 (20)	—	—	0 (20)	11 (20)	33 (20)	11 (20)	55 (20)

[a] Expressed as the percentage mortality in the controls and the corrected percentage mortality for each concentration of insecticide. The number of bed-bugs used in each test is given in parentheses.

TABLE 3

CHRYSOMYIA PUTORIA MORTALITIES AFTER EXPOSURE TO DIELDRIN AND DDT [a]

Locality	Insecticide	Control	Percentage concentration of insecticide					
			0.0001 %	0.001 %	0.01 %	0.1 %	1.0 %	2.0 %
Zanzibar town (market)	Dieldrin	16 (30)	—	0 (10)	0 (20)	5 (20)	7 (20)	7 (40)
	DDT	0 (20)	0 (10)	0 (20)	85 (20)	100 (20)	100 (20)	100 (20)

[a] Expressed as the percentage mortality in the controls and the percentage mortality for each concentration of insecticide. The number of flies used in each test is given in parentheses.

municipal area were fairly resistant to DDT but *C. putoria* from the same area were susceptible to DDT. In houseflies tested from several rural areas of the island, there was considerable resistance to both dieldrin and DDT.

Bed-bugs tested from the unsprayed portion of Zanzibar town were moderately resistant to dieldrin and, at most, slightly tolerant to DDT. Bed-bugs from the dieldrin-sprayed rural areas were all highly resistant to dieldrin and slightly more tolerant to DDT. Similar results have been previously recorded elsewhere in East Africa, in Tanganyika,[c] where *C. hemipterus* from the dieldrin-sprayed South Pare region were highly resistant to dieldrin and almost as susceptible as normal bed-bugs to DDT.

Inasmuch as no control area, other than one area in Zanzibar town, was available, no conclusions could be reached as to what had been the effect, if any, of the development of dieldrin-resistance on the fly and bed-bug populations. The density of the housefly populations appeared to vary in accordance with the degree of environmental sanitation in the different places on the island. The bed-bug populations, although frequently heavy, showed considerable variation, even within an individual village, that could not be accounted for by the extent of insecticide-resistance. The substantial *C. putoria* populations result from the ubiquitous breeding of this species in the large number of pit privies in both the urban and rural areas of the island. This condition might be corrected without further use of insecticides by encouraging the introduction of water-seal latrines, which have proved effective against the same species elsewhere in Africa.[d]

* * *

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[c] Smith, A. (1958) *Bull. Wld Hlth Org.*, **19**, 1124.

[d] As reported, for instance, by A. Lebrun at the WHO Symposium on Pesticides held in Brazzaville in 1959.

Toxicity of Diisopropyl 1,2,2,2-Tetrachloroethyl Phosphate and its Vinyl Analogue to Resistant Houseflies *

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The discovery of insecticidal materials appreciably more toxic to insecticide-resistant strains of insects than to susceptible strains, i.e., with a negatively correlated pattern of cross-resistance, could represent a major development in the control of such resistant insects.[a] It was, therefore, with intense interest that we noted the report that a crude preparation of diisopropyl 1,2,2,2-tetrachloroethyl phosphate was from two to six times more toxic to a DDT-resistant strain of houseflies (Orlando-Beltsville) than to a susceptible strain (NAIDM).[b] It has also been further stated on the basis of preliminary information that selection with another crude preparation of this compound for three generations on a DDT-resistant strain containing 5 % of susceptible individuals transformed it into a DDT-susceptible strain.[c]

In order to determine whether the differential activity reported was specifically associated with the diisopropyl compound, since this compound was not purified and similar results were not observed with the corresponding methyl, ethyl, propyl, and butyl esters, we repeated the preparation of diisopropyl 1,2,2,2-tetrachloroethyl phosphate from both the purified and the crude starting product, i.e., diisopropyl 2,2-dichlorovinyl phosphate,[d] and characterized the pure compound. The insecticidal activity of both crude and pure preparations was evaluated to a susceptible strain of *Musca domestica* (NAIDM), to a strain resistant to a chlorinated hydrocarbons (Super Pollard), and to a chlorthion-

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[a] Ascher, K. R. S. (1958) *Bull. Wld Hlth Org.*, **18**, 675.

[b] Mitlin, N., Babers, F. H., & Barthel, W. F. (1956) *J. econ. Ent.*, **49**, 544.

[c] Brown, A. W. A. (1958) *Insecticide resistance in arthropods*, Geneva, p. 152 (*World Health Organization: Monograph Series*, No. 38).

[d] Babers, F. H. & Mitlin, N. (1955) *J. econ. Ent.*, **48**, 430.