WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTE

WHO/Mal/313
1 September 1961

ORIGINAL: ENGLISH

THE EFFECTS OF MIXTURES OF DDT AND MALATHION ON MOSQUITO ACTIVITY AND MORTALITY

by

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INTRODUCTION

Some effects of mixtures of insecticides on mosquitos were explored by Elliott (1960), using larvae of Culex fatigans, and it was concluded that both economically and biologically there may be a case for the employment of mixtures in malaria eradication. It was pointed out in the paper, and emphasized editorially, that the results of larval reactions cannot give direct information as to the possible utility of mixtures in adult control, since the larval tests are based on continuous exposure, while in adult tests short exposures are commonly used, and in the field irritability to such a chemical as DDT might well shorten the exposure time to another chemical associated with it. It may be added that most tests of adult reactions to mixtures, such as those described by Macdonald (1959), also leave out of account the factor of irritability, since the exposures are carried out at a fixed time interval.

The susceptibility-testing methods for adults so far devised fail to take the irritability factor into account; moreover, methods for the measurement of irritability deal only with the immediate effects of exposure to chemicals, but not with its after-effects. The most important point from a practical standpoint is probably the intensity and duration of the extra activity stimulated by insecticidal contact, and the introduction of a means of measuring this appears to be necessary.

Brown et al. (1960) describe an apparatus comprising a series of boxes connected by funnels for measuring the activity of flies in different states of nutrition. By reducing the size of the apparatus, replacing the funnels by baffles, and taking

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the observations over a longer period, Elliott (1961) has shown that the intensity and duration of activity induced by exposure to different insecticides can be measured in mosquitos; the following observations refer to the use of the same apparatus to evaluate the effects of mixtures of DDT and malathion.

1. THE APPARATUS

A wooden box was subdivided by cardboard partitions into four compartments, each 15 cm high and 12 x 12 cm in area, closed by a perspex lid with a hole for loading, the whole being covered by a brown paper hood. The 15 x 12 cm partitions carried each a baffle narrowing from 7.5 x 5 cm to 6 x 0.6 cm.

The effect of this is that random movement of mosquitos placed in box 1 tends to carry them towards box 4, passages "forward" being about three times as frequent as passages "in reverse". Thus, after a time interval, the number of mosquitos in the further boxes gives a measure of the amount of activity in the period. The formula

$$\frac{(n_2 + 2n_3 + 3n_4) \times 100}{(n_1 + n_2 + n_3 + n_4) \times 3}$$

indicates the percentage of activity shown as compared with the total possible activity, n_1, n_2 etc. being the number of mosquitos found in box 1, box 2, etc. at the end of the period. Mortality can also be measured, as well as the different degrees of activity shown by survivors and the moribund.

The apparatus was used for three types of experiment: exposure of the mosquitos to WHO-type insecticide-impregnated papers in box 1; exposure to these for an hour in the WHO susceptibility apparatus followed by transfer to box 1 of an untreated apparatus; similar exposure followed by an interval before transfer. The experiments here described were all of the first type (Elliott, 1961).

2. THE BIOLOGICAL MATERIAL

Fed female Anopheles gambiae of the Lagos strain were used at 3-5 days old. The colony cages were kept in darkness and fed on guinea-pig between 9 a.m. and noon; the experiments being conducted from 2 p.m. onwards with final observations at 8 a.m. on the following morning. The physiological state of the mosquitos was therefore 12 hours out of phase with that of "wild" mosquitos, but their reactions over the experimental period probably approximate to those of the post-feeding resting segment of the gonotrophic cycle.

3. RESULTS WITH CHEMICALS USED SINGLY

The effect of DDT was to stimulate an immediate increase in activity, as compared with untreated controls. By about 13 hours after removal from contact this activity gradually died down to a normal or subnormal level. Malathion, on the contrary, appeared to cause an initial decrease in activity. This passed off after about five hours, and was followed by a longer period of increased activity, which, however, never rose to the level stimulated by DDT. The question at once arose as to what combined effects the two insecticides would have and in particular whether their apparently reciprocal action might lead to longer exposure and higher mortality due to the DDT component of the mixture. A series of 15 x 12 cm test papers were made up from the same stock solutions of DDT/risella oil and malathion/olive oil solutions, in order to test this point, and the mosquitos were exposed to the test papers which lined three sides of box 1.

4. RESULTS

The first tests tried were a series consisting of DDT 0.5%, DDT 0.25% - malathion 0.25% (mixture), malathion 0.5%, and a control; mosquitos were placed in box 1 lined with these papers at 2 p.m., and results read at 7 p.m. and 8 a.m. the following morning. Results, as shown in Table I, indicate some reduction in activity with both malathion alone and in the mixture, and a mortality from the mixture greater than that from DDT alone. Since the lethal effects of malathion are greater than those of DDT under these conditions, two further series were performed with the following concentrations:

	DDT	Malathion	
Series II.	0.5%	0%	Exposures from 2 p.m. to 8 a.m.
	0.375%	0.0625%	with results at 7 p.m. and
	0.25%	0.125%	8 a.m. (5 hours and 18 hours)
	0.125%	0.1875%	
	0%	0.25%	
Series III.	0.2%	0%	Exposures from 7 p.m. to 8 a.m.
	0.15%	0.025%	with results at 8 a.m.
	0.1%	0.05%	(13 hours)
	0%	0.1%	

Total percentage activities and percentage mortalities are given in Tables II and III. In all cases percentage activity was higher in survivors than in the moribund.

5. CONCLUSIONS

Both series indicate that, although the LD 50 values for DDT and malathion acting on A. gambiae under standard WHO test conditions are approximately the same at about 1% for one hour's exposure, under conditions where the mosquitos are free to move, malathion is more than twice as effective as DDT. Moreover, even a relatively low proportion of malathion in a mixture, down to one-seventh of the total insecticide, materially reduces activity and increases mortality.

It may be concluded therefore that there is a strong case for the trial of a mixture of these two insecticides in combination for malaria eradication purposes, since the mixture may be much more lethal than DDT alone. On highly absorbent surfaces malathion may be expected to lose its efficiency more quickly, and should probably form at least 50% of the mixture; on less active surfaces a lower proportion might suffice. It will be noted that the term "synergism" has not been employed, since the interaction here observed is a rather different matter from the phenomena usually described by this word.

REFERENCES

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TABLE I. MEAN OF 5 REPLICATES OF 20 MOSQUITOS
ACTIVITY AFTER CONTINUOUS CONTACT WITH CHEMICAL

Chemicals	Percentage activity in period		Percentage mortality in period	
	5 hours	18 hours	5 hours	18 hours
DDT 0.5%	31	40	45	74
DDT 0.25% & Malathion 0.25%	13	19	82	97
Malathion 0.5%	18	25	90	96
Control	20	31	7	18

TABLE II. MEAN OF 3 REPLICATES OF 30 MOSQUITOS EACH
ACTIVITY AFTER CONTINUOUS CONTACT WITH CHEMICALS

Chemicals	Percentage activity		Percentage mortality	
	5 hours	18 hours	5 hours	18 hours
DDT 0.5%	50	54	45	48
DDT 0.375% Malathion 0.0625%	38	51	58	82
DDT 0.25% Malathion 0.125%	26	26	69	76
DDT 0.125% Malathion 0.1875%	25	27	59	88
Malathion 0.25%	24	28	69	82
Control	25	36	1	9

TABLE III. MEAN OF 3 REPLICATES OF 30 MOSQUITOS EACH
ACTIVITY AFTER CONTINUOUS CONTACT WITH CHEMICALS

Chemicals	Total activity after 13 hours	Percentage mortality at 13 hours
DDT 0.2%	50	45
DDT 0.15% Malathion 0.025%	39	71
DDT 0.1% Malathion 0.05%	36	71
DDT 0.05% Malathion 0.075%	36	65
Malathion 0.1%	30	77
Control	36	5

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