STUDIES ON CONTACT TOXICITY—PART IV

Influance of Pretreatmcnt on the Residual activity of D.D.T. on various surfaces against Mosquitoes and flies

by

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ABSTRACT

The use of starch and a mixture of glue and potassium dichromate as pretreatments for the enhancement of the residual activity of DDT has been investigated using mosquitoes, *Culex fatigans* Wied. and flies, *Musca nebulo* Linn. The DDT deposits were derived either from an emulsifiable concentrate or a water dispersible powder concentrate. As substrate, cement, brick and mud surfaces were investigated both as they were and in the lime-washed condition. Pretreatment with glue-dichromate considerably enhanced the residual activity of DDT against both the species of insects on all the three surfaces and proved very much superior to pre-treatment with starch. The deposits derived from DDT emulsion showed residual activity for a longer period than those derived from DDT water dispersible powder on mud surfaces pretreated with glue-dichromate.

Introduction

With the increased use of DDT in diverse spheres for controlling a wide variety of insect pests it has become important to increase the efficacy of application of the insecticide to obtain a maximum return for the minimum dosage. It is well known that DDT films deposited on certain building materials rapidly lose their toxicity[1,2,3]. This phenomenon is accentuated in the case of mud surface due to its greater porosity. Parkin and Hewlett[3], Hewlett and Parkin[4] and Hewlett[5] have reported that pre-treatment of cement or brick surfaces with size, or starch or gelatin enhanced the residual activity of DDT or pyrethrins against the flour beetle, *Tribolium castaneum* Herbst.

In an earlier paper, Haq, Misra and Ranganathan[6] had shown that treatment of cement surfaces with a mixture of glue and potassium dichromate prior to the application of DDT enhances the residual activity of the insecticide against the flour beetle, *Tribolium castaneum* Herbst. It was of interest to test the effect with certain insect vectors of diseases and accordingly the above pre-treatment has now been investigated against the house-fly, *M. nebulo* Linn. and the mosquito, *C. fatigans* Wied. In view of the encouraging results reported with starch[5] this material has been assessed side by side with glue-dichromate mixture. In addition to cement surfaces, those of brick and mud have been investigated.

Materials and Methods

Building Materials:—The following building materials were used in these investigations.

Cement—Cement plates (15 × 15 × 1·3 cms) were prepared from cement and Ganga sand mixed in the ratio of 1 : 3.

Bricks—Bricks (23 × 11 × 8 cms), were supplied by a local manufacturer.

Mud—Mud plates (15 × 15 × 1·3 cms) were prepared from clay and rice husk mixed in the ratio of 12 : 1. After drying, the surface of plates was rendered smooth.

Lime-washing of surfaces—The substrates were placed together so as to form a compact block. Two coats of lime were applied with a brush. In the first coat, a 33 per cent dispersion of lime in water was applied at the rate of 12 pints per 100 sq. ft. (7·3 litres/10 sqm.). In the second coat 20 per cent dispersion was used, the rate of application remaining the same.

Pre-treatment with glue-potassium dichromate—A 6·0 per cent (W/V) solution of hide glue was prepared in water to which potassium dichromate (0·5 per cent) was added. Salicylic acid (0·5 per cent on the weight of glue) was added to the glue solution as a preservative. This solution was uniformly applied on the surfaces by means of a camel hair brush so as to leave a dry deposit of 17 gms of glue-dichromate per sq. metre of surface. The surfaces were dried in air and subsequently stored for a week in the laboratory prior to the application of the insecticide.

Pre-treatment with starch—A 6·0 per cent (W/V) solution of starch was prepared in boiling water and salicylic acid (0·5 per cent on the weight of starch) was added to it. Details and dosage of application were the same as for glue-dichromate described above. On brick surfaces, the films of starch tended to peel off at places. On lime-washed mud surfaces they peeled off completely on drying and therefore, the pre-treatment of lime-washed mud plates with search had to be excluded from these investigations.

Treatment with DDT emulsion—5·0 per cent emulsion derived from a 25 per cent emulsifiable concentrate was used on cement, brick and mud surfaces. Before the insecticide was applied on the different surfaces, filter papers of the same area as that of the surfaces to be treated were placed on the floor of a glass chamber (35×30×50 cms). Known volumes of the 5·0 per cent emulsion were sprayed from the top of the chamber with Aerograph, Artist Air Brush at a pressure of 25 lbs/sq. in. (1·76 kgms/sq. cms). The papers were removed two minutes after spraying and the deposits on the filter papers were estimated chemically. The relationship between volume sprayed and the estimated deposit was established and this was made use of in obtaining requisite deposits on the various surfaces. The treated surfaces were dried in air and used 2 days after treatment.

Treatment with DDT water dispersible powder—5·0 per cent aqueous dispersion derived from a 75 per cent DDT water dispersible powder concentrate was used on mud surfaces. Filter papers of areas same as those of the surfaces to be treated were held vertically and sprayed with known volumes of the 5·0

per cent dispersion with Aerograph C.A. gun fitted with No. 3 nozzle at 15 lbs/sq. in. (1·05 kgm/sq. cm.) from a distance of 46 cms. The DDT deposits on the filter papers were estimated chemically. The relationship between volume sprayed and the estimated deposit was established and this was made use of in obtaining requisite deposits on mud surfaces.

Assessment of toxicity—This was carried out in a room in which temperature and humidity were recorded during the course of investigations. While the variations in temperature and humidity on successive days or successive weeks were not appreciable they were so in different months of the year. The maximum and minimum temperatures and the humidity recorded during the course of each experiment are given in Figs 1–14.

Laboratory-bred, 40–60 hours old, adult female mosquitoes, *C. fatigans*[7] and 4-5 days old adult female houseflies, *M. nebulo*[8] were the test insects. At each exposure three batches of 20 insects of each species were separately confined on treated and untreated (control) surfaces under glass funnels, 7·5 cm diameter. The period of exposure of the mosquitoes and the flies was 2 and 6 hours respectively. After the exposure the insects were transferred to glass bottles (6 cm. diam. × 12 cm.). With mosquitoes, a few raisins soaked in water were kept in the bottles to serve as food. For flies, cotton pads soaked in milk were provided. Observations on mortality of the insects were recorded 24 hours after their transfer to the bottles.

For assessing the residual activity of insecticidal deposits, the insects were exposed at frequent intervals on the treated and untreated (control) surfaces. Tables 1 & 2 *inter-alia* summarise the details of surfaces, nature of pre-treatments, formulation of insecticide, rate of application and test insects used.

Results

The results obtained in the various experiments are presented graphically in Figs 1–14 in which the toxicity as assessed by per cent mortality of insect has been plotted against the period in days after treatment. Under the conditions of the experiment the insects exposed on untreated (control) surfaces did not suffer mortality.

Tables 1 and 2 summarise the information on the periods for which not less than 50 per cent mortality was registered on the surfaces and also the index of enhancement. The index of enhancement of the residual activity of the insecticide is the ratio of periods for which pretreated surface and control surface effect not less than 50 per cent mortality.

Discussion

Nature of surface—Among the three surfaces investigated with DDT emulsion but without any pre-treatment, the cement surfaces recorded the highest residual activity whereas the mud surfaces showed the lowest residual activity (Figs 1–12 and Tables 1 & 2). This difference in the residual activity may be due to the difference in the porosity of these surfaces. The loss of insecticide on the surfaces can be due to (*a*) rapid physical adsorption of DDT crystals into the surfaces [9,10] and (*b*) chemical decomposition of the insecticide catalysed by the presence of certain metallic salts and alkalinity[11].

Lime-washing of surfaces—Lime-wash on cement and mud surfaces tends in general to lower the residual activity of DDT (Figs 1–4 and 9–12). On brick surfaces, lime-wash has not produced any appreciable difference in residual activity (Figs 5–8). The cause of the difference is not clear. According to Hadaway and Barlow[12] DDT gets absorbed in lime-washed surface and loses its toxicity. Parkin and Hewlett[3] observed that the toxicity of DDT film on lime-washed wood surface in warehouses was for a shorter duration than on unlime-washed wood surface.

Pre-treatment with starch—Hewlett[5] has shown that pre-treatment of brick, and cement—sand surfaces with starch increases the toxicity of DDT films against the flour beetle, *T. castaneum*. The present experiments with mosquitoes and flies support this finding generally.

From Table 2 it is observed that the index of enhancement of residual activity due to pre-treatment with starch is 1·4 to 1·5 and 2·3 to 3·3 on cement and brick surfaces respectively against mosquitoes. Against flies, however, there is no enhancement of residual activity on cement surfaces but on brick surfaces the index of enhancement of residual activity is 4·8 and 1·6 on unlime-washed and lime-washed surfaces respectively (Table 1). On mud surfaces which are not lime-washed a dosage of 1·3 gms/sq. m. DDT effected 30 per cent initial kill against flies (Fig.11) and zero per cent kill against mosquitoes (Fig 12). When starch was used for pre-treatment a similar deposit of DDT effected 50 per cent kill in flies for 84 days (Fig. 11 and Table 1) and in mosquitoes for 193 days (Fig.12 and Table 2).

Pre-treatment with glue-potassium dichromate :—

DDT derived from emulsion—The results shown in Tables 1, 2 and Figs. 1–14 show that the pre-treatment of surfaces with glue-potassium dichromate prior to the application of DDT enhances the residual activity of DDT irrespective of the nature of surface and the formulation of insecticide investigated. In respect of flies, the index of enhancement of the residual activity of DDT films derived from DDT emulsion is 2·9, 6·9 and 1·3 on lime-washed cement, brick and mud surfaces respectively and 2·5 and 3·7 on cement and brick surfaces respectively which were not lime-washed (Table 1).

Against mosquitoes the index of enhancement is 14·9 and 3·2 on cement and brick surfaces respectively which were not lime-washed and 2·3 and 6·3 on lime-washed cement and brick surfaces respectively (Table 2).

DDT derived from water dispersible powder—With this formulation and with pre-treatment with glue-dichromate the index of enhancement on mud surfaces is 4·9 with flies (Fig. 13, Table 1) and 1·5 with mosquitoes (Fig. 14 Table 2).

Insecticidal formulations—It will be seen from Figs. 11–14 that on mud surfaces without pre-treatment DDT water dispersible powder effects 100 per cent kill of flies and mosquitoes initially while DDT emulsion for almost the same deposit (1·1 gms/sq.m.) effects only 30 and zero per cent kill of flies and mosquitoes respectively (Fig 11–12). However, the residual activity of DDT water dispersible powder on pre-treated mud surfaces is of shorter duration (59 and 113 days against flies and mosquitoes respectively) as compared to that with DDT emulsion (62 and 438 days against flies and mosquitoes respectively) Tables 1 and 2.

Insects—The general trend of results with flies and mosquitoes is similar in that the enhancement of residual activity is shown against both the species of insects.

Practical value of results—The results described above are of considerable importance particularly in the control of Culicines and Anophelines. The residual activity of DDT can be considerably enhanced even with reduced dosages, if surfaces on which it is applied are pre-treated with glue-dichromate. A direct result of this will be the reduction in the frequency of application of the insecticide on various building materials. The added cost of glue-dichromate treatment may be expected to more than compensate the expenses involved in repeated applications of the insecticide which will be otherwise necessary. In this context it may be worth while to examine the effect of lesser quantities of glue on the residual activity of the insecticide so as to reduce further the cost of pre-treatment. Since the pre-treatment with starch is inferior to pre-treatment with glue-dichromate and its tenacity as a film is poor on lime-washed mud surfaces, it is not recommended for practical application.

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TABLE—1

Effect of pre-treatment on residual Activity of DDT applied on variously pre-treated surfaces against flies

Type of Surface	Lime-washed or without lime-wash	Nature of pre-treatment	Dosage of pre-treatment (gms/sqm)	Insecticidal formulation	Dosage of insecticide (gms/sq. m)	Period for which not less than 50% mortality was recorded (in days)	Index of enhancement of residual activity	Reference to figures
Cement	Lime-washed	Nil	—	DDT emulsion	1·3	32	—	1
		Starch	17	,,	1·3	36	1·1	
		Glue-dichromate ..	17	,,	1·3	92	2·9	
	Without Lime-wash ..	Nil	—	,,	1·3	67	—	3
		Starch	17	,,	1·3	38	—	
		Glue-dichromate ..	17	,,	1·3	170	2·5	
Brick ..	Lime-washed	Nil	—	,,	1·3	13	—	5
		Starch	17	,,	1·3	21	1·6	
		Glue-dichromate ..	17	,,	1·3	90	6·9	
	Without Lime-wash ..	Nil	—	,,	1·3	20	—	7
		Starch	17	,,	1·3	96	4·8	
		Glue-dichromate ..	17	,,	1·3	74	3·7	
Mud ..	Lime-washed	Nil	—	,,	1·3	20	—	9
		Glue-dichromate ..	17	,,	1·3	26	1·3	
Mud ..	Without Lime-wash ..	Nil	—	..	3·3	9		11
		Nil	—	..	1·3	0	*	
		Starch	17	..	1·3	84		
		Glue-dichromate ..	17	..	1·3	62		
Mud ..	Without Lime-wash ..	Nil	—	DDT Water	4·2	37	—	13
		Nil	—	dispersible	1·1	12	—	
		Glue-dichromate ..	17	powder	1·1	59	4·9	

*On unpre-treated surfaces with a deposit of 1·3 gms/sq.m the initial mortality was less than 50%. Hence the index of enhancement of residual activity has not been shown in this column.

TABLE—2

Effect of pre-treatment on residual activity of DDT applied on variously pre-treated surfaces against mosquitoes

Type of Surface	Lime-washed or without lime-wash	Nature of pre-treatment	Dosage of pre-treatment (gms/sq. m)	Insecticidal formulation	Dosage of insecticide (gms/sq. m)	Period for which not less than 50% mortality was recorded (in days)	Index of enhancement of residual activity	Reference to figures
Cement	Lime-washed	Nil	—	DDT emulsion	1·3	39	—	2
		Starch	17	,,	1·3	55	1·4	
		Glue-dichromate ..	17	,,	1·3	88	2·1	
	Without Lime-wash ..	Nil	—	,,	1·3	55	—	4
		Starch	17	,,	1·3	80	1·5	
		Glue-dichromate ..	17	,,	1·3	816	14·9	
Bricks ..	Lime-washed	Nil	—	,,	1·3	17	—	6
		Starch	17	,,	1·3	56	3·3	
		Glue-dichromate ..	17	,,	1·3	108	6·3	
	Without Lime-wash ..	Nil	—	,,	1·3	16	—	8
		Starch	17	,,	1·3	37	2·3	
		Glue-dichromate ..	17	,,	1·3	51	3·2	
Mud ..	Lime-washed	Nil	—	,,	1·3	0		10
		Glue-dichromate ..	17	,,	1·3	55	*	
	Without Lime-wash ..	Nil	—	,,	5·0	228		12
		Nil	—	,,	1·3	0	*	
		Starch	17	,,	1·3	193		
		Glue-dichromate ..	17	,,	1·3	438		
Mud ..	Without Lime-wash ..	Nil	—	DDT water dispersible powder	4·2	106	—	14
		Nil	—		1·1	74	—	
		Glue-dichromate ..	17		1·1	113	1·5	

* On unpre-treated surfaces with a deposit of 1·3 gms/sq.m the initial mortality was less than 50% hence the index of enhancement of residual activity has not been shown in this column.

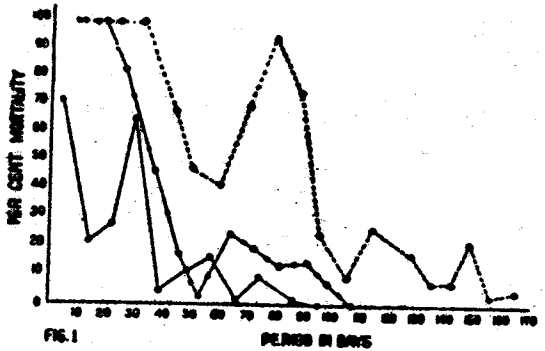

FIG. 1

o—o DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o··o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o-X-o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON STARCH.

TEMP. 20°—28°C.
R. H. 63—91%

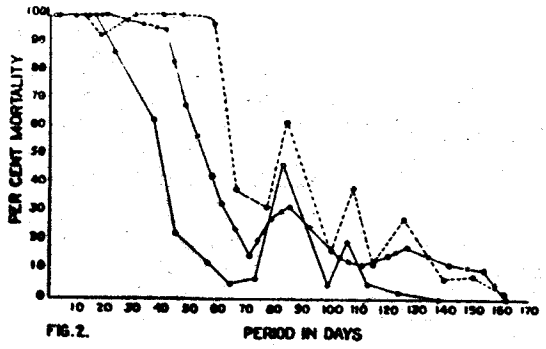

FIG. 2.

o—o DDT. 1·3. GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o··o DDT. 1·3. GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o-X-o DDT. 1·3. GMS. PER SQ. M. SUPPORTED ON STARCH.

TEMP. 27°—33°C.
R. H. 45—92%

o—o DDT. 1·3. GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o··o DDT. 1·3. GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o-X-o DDT. 1·3. GMS. PER SQ. M. SUPPORTED ON STARCH.

TEMP. 20°—33°C.
R. H. 49—92%

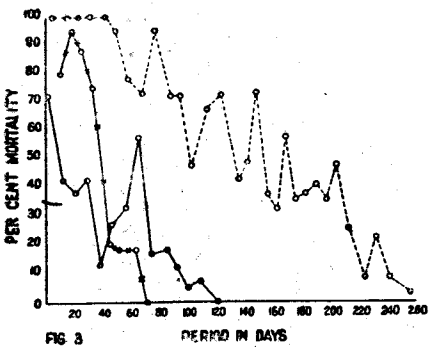

FIG. 3

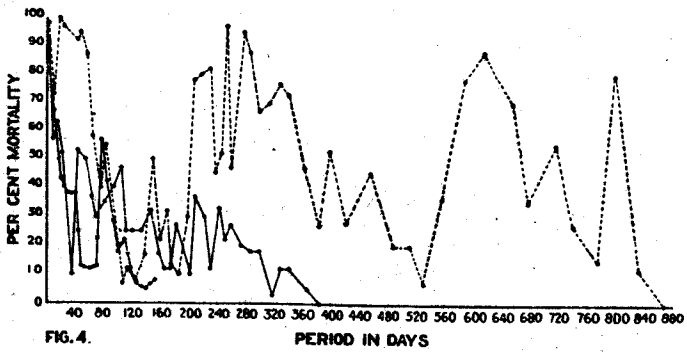

FIG. 4.

o—o DDT. 1·3. GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o··o DDT. 1·3. GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o-X-o DDT. 1·3. GMS. PER SQ. M. SUPPORTED ON STARCH.

TEMP. 27°—33°C.
R. H. 45—92%

THE INFLUENCE OF PRE-TREATMENT OF SURFACES ON THE RESIDUAL ACTIVITY OF DDT APPLIED AS EMULSION

FIG. 1. Lime-washed cement surfaces against the house fly.
FIG. 2. Lime-washed cement surfaces against the mosquito.
FIG. 3. Cement surfaces against the house fly.
FIG. 4. Cement surfaces against the mosquito.

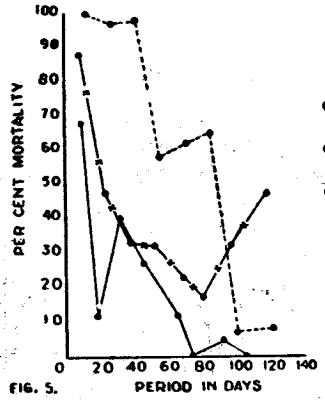

FIG. 5.

o—o DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o....o DDT. 1·3 GMS, PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o—x—o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON STARCH.
TEMP. 29°—33°C.
R. H. 77—92%

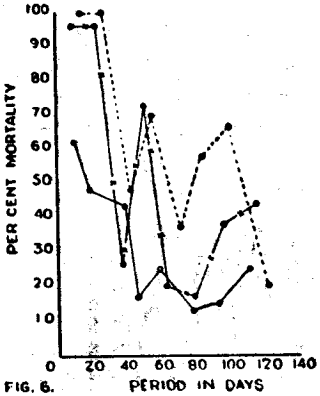

FIG. 6.

o—o DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o.....o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o-x-o DDT. 1·3 GMS. PER SQ.M. SUPPORTED ON STARCH.
TEMP. 29°—33°C.
R. H. 77—92%

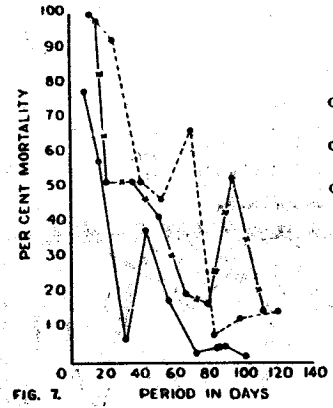

FIG. 7.

o—o DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o.....o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o-x-o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON STARCH.
TEMP. 29°—33°C.
R. H. 77—92%

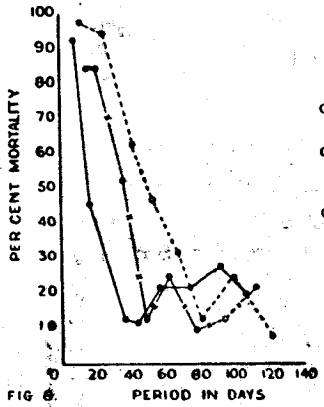

FIG 8.

o—o DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.
o....o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.
o-x-o DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON STARCH.
TEMP. 29°—33°C.
R. H. 77—92%

THE INFLUENCE OF PRE-TREATMENT OF SURFACES ON THE RESIDUAL ACTIVITY OF DDT APPLIED AS EMULSION

FIG. 5 Lime-washed brick surfaces against the house fly.
FIG. 6 Lime-washed brick surfaces against the mosquito.
FIG. 7 Brick surfaces against the house fly.
FIG. 8 Brick surfaces against the mosquito.

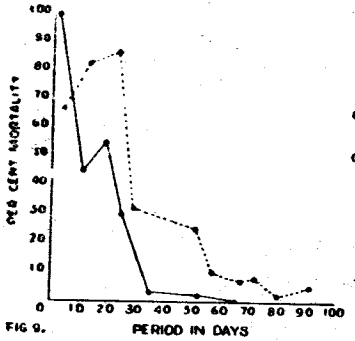

FIG 9.

O—O DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

O....O DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.

TEMP 19°—30°C.
R. H. 56—88%

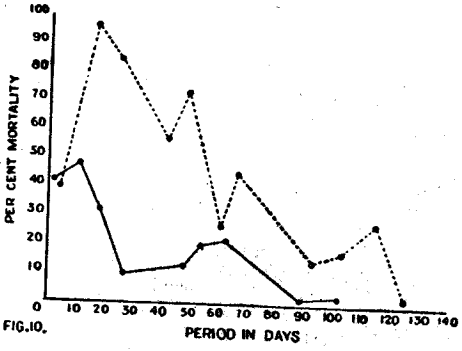

FIG.10.

O—O DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

O....O DDT 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.

TEMP. 19°—31°C.
R. H. 56—91%

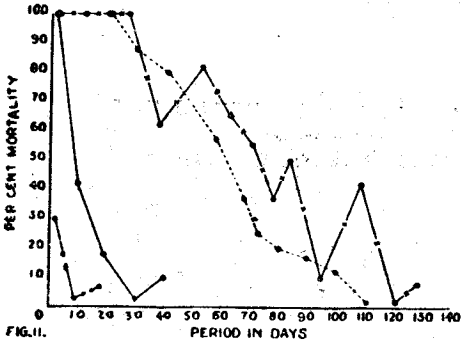

FIG.11.

O—O DDT. 3·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

O>—<O DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

O....O DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.

O-X-O DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON STARCH.

TEMP. 19°—31°C.
R. H. 56—91%

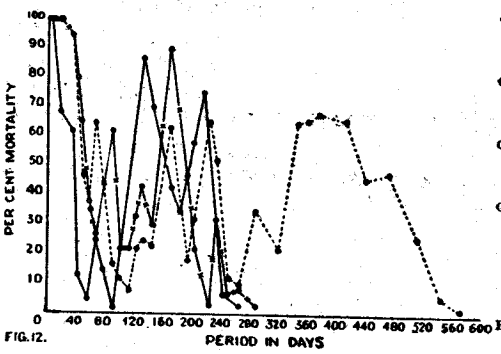

FIG.12.

O—O DDT. 5·0 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

O>—<O DDT. 1·3 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

O....O DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.

O-X-O DDT. 1·3 GMS. PER SQ. M. SUPPORTED ON STARCH.

TEMP. 19°—33°C.
R. H. 56—96%

FIG. 12.

THE INFLUENCE ON PRE-TREATMENT OF SURFACES ON THE RESIDUAL ACTIVITY OF DDT APPLIED AS EMULSION

FIG. 9. Lime-washed mud surfaces against the house fly.
FIG. 10. Lime-washed mud surfaces against the mosquito.
FIG. 11. Mud surfaces against the house fly.
FIG. 12. Mud surfaces against the mosquito.

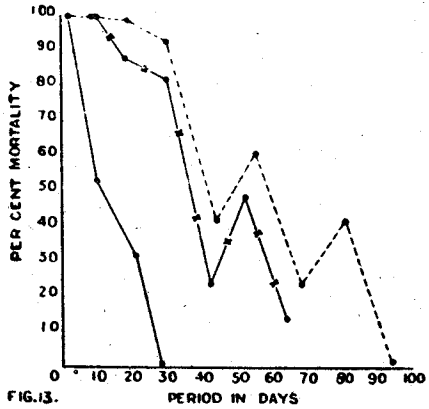

FIG. 13.

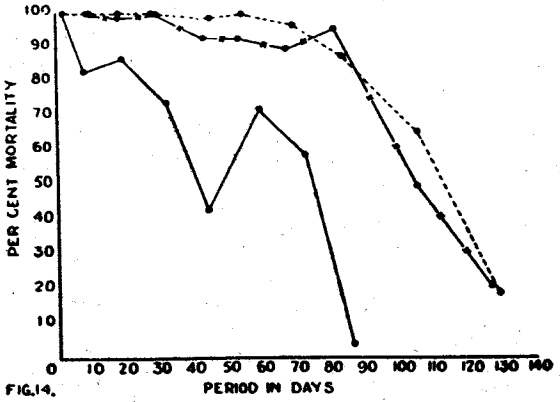

FIG. 14.

THE INFLUENCE OF PRE-TREATMENT OF SURFACES ON THE RESIDUAL ACTIVITY OF DDT APPLIED AS WATER DISPERSIBLE POWDER

FIG. 13. Mud surfaces against the house fly.

FIG. 14. Mud surfaces against the mosquito.

o-X-o DDT. 4·2 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

o—o DDT. 1·1 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

o....o DDT. 1·1 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.

TEMP. 28°—34°C.
R.H. 34—95%

o-X-o DDT. 4·2 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

o—o DDT. 1·1 GMS. PER SQ. M. WITHOUT PRE-TREATMENT.

o....o DDT. 1·1 GMS. PER SQ. M. SUPPORTED ON GLUE-DICHROMATE.

TEMP. 24°—34°C.
R.H. 34°—95%