STUDIES ON CONTACT TOXICITY

Part V—Residual activity of DDT applied in admixture with glue dichromate on mud surface

by

R. K. Paul and S. L. Perti

Defence Research Laboratory (Stores), Kanpur

ABSTRACT

Residual activity of DDT applied in admixture with glue-dichromate on mud surface has been investigated against the housefly, *Musca nebulo* Linn. and the mosquito, *Culex fatigans* Wied. It has been found that the addition of glue-dichromate to DDT dispersion in water or DDT emulsion considerably enhances the residual activity of the insecticide against flies and mosquitoes. The practical value of the results has been discussed.

Introduction

In an earlier paper, Cheema *et al*[1] have shown that treatment of cement brick or mud surfaces with a mixture of glue and potassium dichromate prior to the application of DDT considerably enhances the residual activity of the insecticide against the housefly, *Musca nebulo* Linn. and the mosquito, *Culex fatigans* Wied. Haq *et al*[2] reported similar enhancement on cement surface against the flour beetle, *Tribolium castaneum* Herbst.

There have been attempts by several workers to enhance the residual activity of insecticides by incorporating them in a variety of materials and by applying on different surfaces. Hadjinikolan and Busvine[3] found mixture of DDT or lindane in lime washes residually effective against the mosquito, *Aedes aegypti* Linn. These workers confined the insects in cages with treated detachable walls and ceilings of Essex board. Clapp *et al*[4] have shown that incorporation of salt into white washes increased the residual effectiveness of DDT applied on wall paper against the mosquito, *Anopheles quadrimaculatus* Say. Gilmour[5] and Beacher and Parker[6] reported that incorporation of DDT or toxaphene in different types of paints and their application on glass or wood surfaces enhanced the residual activity of the insecticide against *M. domestica*. Reddy and Michelbecher[7] found paint containing DDT residually effective against the rice weevil, *Sitophilus oryzae* Linn. and *T. confusum*. Barnes[8] has shown that DDT incorporated in distemper enhanced the residual effectiveness of the insecticide against the bed bug, *Cimex lectularius* Linn. Block [9] reported that the residual activity of DDT, lindane, chlordane or toxaphene is enhanced when the insecticide is applied admixed with cellulose-acetate lacquers. Reid[10] has shown that urea-formaldehyde resins in admixture with DDT, BHC, aldrin or

dieldrin enhanced the residual activity of the insecticide against the cockroach, *Nauphoeta cinerea* Olive. and *T. destructor*. Sullivan and Hornstein,[11] Hornstein and Sullivan [12] and Hornstein *et al* [13] have reported that incorporation of chlorinated polyphenyls in diazinon or lindane enhanced their residual effectiveness on paper or plywood against *M. domestica*, *T. confusum* and the cockroach, *Periplaneta americana*. Beckel[14] incorporated lindane in liquid floor wax and found the mixture residually effective against the silver fish, *Lepisma saccharina* Linn. Barnes[8] found that residual activity of DDT on cement or wood surface is enhanced against *C. lectularius* by the addition of adhesive agents such as coumarone resins or paraffin wax to the insecticide. Van Tiel [15] reported that addition of coumarone resin to DDT solution in kerosene oil increased the residual activity of the insecticide on cement surface against *M. domestica* and *A. aegypti*. Gerolt[16] has shown that admixture of coumarone resin with dieldrin enhanced the residual activity on mud surface against *M. domestica*. In the present paper, the results of investigations carried out in this laboratory, on the enhancement of residual activity of DDT applied in admixture with glue-dichromate on mud surface against the housefly, *Musca nebulo* Linn. and the mosquito, *Culex fatigans* Wied. have been described and practical value of the results discussed.

Material and Methods

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

DDT formulations—Requisite concentrations of (*a*) aqueous dispersion derived from a 75 per cent DDT water dispersible powder and (*b*) emulsion derived from a 25 per cent DDT emulsifiable concentrate were used

Glue-dichromate—Requisite concentration of 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 also added to the glue-dichromate mixture as a preservative.

DDT-glue-dichromate mixture—Requisite quantities of DDT (water dispersion or emulsion) were added directly to the glue-dichromate solution so as to obtain a deposit of 14 gms. of glue-dichromate per sq. m. (1,300 mgms./sq. ft.) and either 2·15 or 4·30 gms of DDT per sq. m. (200 or 400 mgms/sq. ft.) on the mud surface.

Test insects—The housefly, *Musca nebulo* Linn. and the mosquito, *Culex fatigans* Wied. drawn from laboratory cultures were used as test insects.

M. nebulo—The method of rearing the insect in the laboratory was as described by Basden[17] for *M. domestica*. Adult female flies, 4-5 days old, were used in the assay.

C. fatigans—The method of rearing the insect in the laboratory was as described by Newman *et al*[18]. Adult female mosquitoes, 2-3 days old, were used in the assay.

Treatment of mud panels—Each mud panel was separately treated by spraying requisite concentration of DDT or a mixture of DDT and glue-dichromate solution. For spraying, the panel was supported in the centre of a wooden frame (46 cms. ×46 cms.) inclined at an angle of 45° to the horizontal. The entire area (including that of the wooden frame) was sprayed with 25 ml of the material by means of an 'Aerograph' paints gun, fitted with nozzle No. 3, from a distance of approximately 45 cms. and at a pressure of 1·76 kg per sq. cm. (25 lbs per sq. in.). The amount of DDT deposit was estimated by hydrolysable chlorine method[19] from filter papers similarly treated with the insecticide alone or with the insecticide in admixture with glue-dichromate. The quantity of glue-dichromate deposited was ascertained by the difference in weight of the treated (and subsequently dried for 48 hours) and untreated filter papers, giving allowance for DDT deposited on the surface. The treated panels were allowed to dry for 48 hours before exposure to the insects.

Assessment of toxicity—The insects were confined on the treated mud panels simultaneously in (*a*) 'exposure chambers' (12·7 cms. diam., 0·5 cm. height) described by Pal[20] and (*b*) under inverted glass funnels (7·5 cms. diam). Twenty insects were used in each experiment and there were three replicates for each assay. Periods of exposure of insects to treated mud plates are shown in Tables I and II. After the exposure the insects were transferred on filter papers under 'glass chimneys' and observations on the mortality recorded 24 hours thereafter. Subsequent exposures of the insects on the treated mud panels were carried out at intervals and discontinued when the mortality effected in two successive exposures was below 20 per cent. The temperature and humidity during the investigations were 23-33°C and 32-91 per cent respectively.

Results

The results obtained in the various experiments are presented in Tables I and II and Figures 1 to 8. Table III summarises the periods for which 50 and 20 per cent mortalities were recorded on the treated surfaces and also the index of enhancement in each case. The index of enhancement of the residual activity of the insecticide is the ratio of periods for which DDT-glue-dichromate treated surface and DDT-treated surface effect a particular level of mortality.

Discussion

It is observed from the results presented in Tables I to III and Figures 1 to 8 that admixture of glue-dichromate with DDT considerably enhances the residual activity of the insecticide against *M. nebulo* and *C. fatigans* irrespective of the formulation used (water dispersion or emulsion) and irrespective of the technique of bioassay employed.

Enhancement of residual activity at 50 per cent mortality level—It is noted from Table III that when DDT water dispersible powder is mixed with glue-dichromate, the index of enhancement of residual activity due to glue-dichromate is 2·5 and 6·2 against *C. fatigans* and *M. nebulo* respectively when insects

are exposed by the 'exposure chamber' technique. By the glass funnel technique the index of enhancement is 4·2 and 2·4 against *C. fatigans* and *M. nebulo* respectively.

When DDT emulsion is mixed with glue-dichromate, the index of enhancement could not be gauged against *M. nebulo* and *C. fatigans* by the 'exposure chamber' technique and against *C. fatigans* by the glass funnel technique. In these cases DDT emulsion even in the dosage of 4·47 gms per sq. m. effected only 25 and 23 per cent initial mortality of *C. fatigans* and M. *nebulo* respectively (Table I) by the 'exposure chamber' technique and 17 per cent initial mortality of *C. fatigans* (Table II) by the glass funnel technique. The advantage of incorporating glue-dichromate with the insecticide is, however, quite clear. The mixture effected more than 50 per cent mortality for 228 and 125 days against *C. fatigans* and *M. nebulo* respectively by the 'exposure chamber' technique and 109 days against *C. fatigans* by the glass funnel technique. Against *M. nebulo* the index of enhancement is 5·4 by the glass funnel technique when DDT (emulsion) is mixed with glue-dichromate, in the dosage of 5·48 gms per sq. m.

Enhancement of residual activity at 20 per cent mortality level—When DDT water dispersible powder is mixed with glue-dichromate and the insects are exposed by the 'exposure chamber' technique the index of enhancement of residual activity is 2·3 and 4·7 against *C. fatigans* and *M. nebulo* respectively. By the glass funnel technique the index of enhancement is 3·2 and 3·4 against *C. fatigans* and *M. nebulo* respectively.

When DDT emulsion is mixed with glue-dichromate and the insects are exposed by the 'exposure chamber' technique the index of residual activity is 26·6 and 31·5 against *C. fatigans* and *M. nebulo* respectively. The index of enhancement by the glass funnel technique could not be gauged against *C. fatigans* since DDT emulsion even in the dosage of 4·47 gms per sq. m. effected only 17 per cent initial mortality, however it is clear from Table II that it is very high. The index of enhancement of residual activity against *M. nebulo*, however, is 4·1 by the glass funnel technique when DDT emulsion is mixed with glue-dichromate in the dosage of 5·48 gms. per sq. m.

Practical value of results—It is noted from the data in Table IV that the index of enhancement of residual activity obtained when DDT is applied in admixture with glue-dichromate is generally no less than the index obtained when the insecticide is deposited on mud surface pretreated with glue-dichromate. Thus there is a definite economic advantage in resorting to the use of mixture of the insecticide with glue-dichromate since it saves labour of operation involved in the two separate treatments. However, glue-dichromate in the mixtures stains the building surfaces and this is a point which will mitigate its wide use.

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TABLE I

Residual activity of DDT against M. nebulo *and* C. fatigans, *when applied mixed with glue-dichromate on mud surface and investigated by the 'exposure chamber' technique*

Test insect*	Insecticidal formulation	Dosage GMS/sq. M† DDT	Dosage GMS/sq. M† Glue-dichromate	Period of Exposure of insects (Hours)	Per cent mortality in successive exposures (The figures within brackets indicate the number of days after treatment of mud panels)											
M. nebulo	DDT dispersion in water ..	2·15 (200)	*Nil*	4	100 (2)	100 (8)	48 (16)	20 (21)	10 (24)							
		2·15 (200)	14·0 (1300)	4	100 (2)	98 (9)	100 (16)	96 (26)	92 (30)	100 (37)	100 (50)	100 (64)	95 (78)	87 (85)	53 (92)	13 (100)	13 (111)
	DDT emulsion ..	4·47 (415)	*Nil*	4	23 (2)	15 (11)	2 (17)									
		4·84 (450)	14·0 (1300)	4 ..	80 (2)	63 (16)	70 (30)	42 (45)	98 (66)	95 (80)	90 (101)	60 (116)	97 (144)	25 (164)	6 (184)	12 (190)	7 (197)
	DDT dispersion in water.	2·15 (200)	*Nil*	3	97 (2)	100 (8)	100 (16)	97 (32)	98 (39)	88 (51)	73 (59)	85 (66)	60 (77)	47 (88)	81 (98)	15 (106)	
		2·15 (200)	14·0 (1300)	3	90 (2)	98 (16)	100 (50)	98 (87)	98 (122)	78 (133)	82 (148)	85 (161)	77 (184)	55 (208)	45 (216)	20 (223)	12 (233)
C. fatigans	DDT emulsion ..	4·47 (414)	*Nil*	3	25 (2)	20 (9)	12 (17)									
		4·84 (450)	14·0 (1300)	3 ..	93 (2)	88 (30)	93 (45)	90 (80)	97 (107)	95 (121)	80 (157)	68 (173)	85 (194)	63 (207)	40 (233)	18 (240)	13 (250)

* There was no mortality of the insects on the untreated (control) panels.

† The figures within brackets indicate the dosage in mgms./sq.ft.

TABLE II

Residual activity of DDT against M. nebulo *and* C. fatigans *when applied mixed with glue-dichromate on mud surface and investigated by the glass funnel technique*

Test insect*	Insecticidal formulation	Dosage GMS/Sq. M.† DDT	Dosage GMS/Sq. M.† Glue-dichromate	Period of exposure of insects (Hours)	Per cent mortality in successive exposures (The figures within brackets indicate the number of days after treatment of mud panels)												
M. nebulo	DDT dispersion in water	2·15 (200)	*Nil*	6	100 (2)	88 (8)	13 (16)	5 (21)	5 (24)								
		2·15 (200)	14·0 (1300)	6	100 (2)	100 (9)	88 (19)	76 (26)	32 (30)	45 (37)	23 (50)	5 (56)	5 (64)				
	DDT emulsion	5·38 (500)	*Nil*	6	73 (2)	58 (7)	52 (14)	15 (22)	23 (30)	0 (37)	3 (44)						
		5·48 (510)	10·76 (1000)	6	100 (2)	100 (16)	100 (30)	90 (37)	88 (44)	65 (51)	97 (58)	72 (65)	87 (72)	78 (79)	17 (86)	2 (90)	
C. fatigans	DDT dispersion in water	2·15 (200)	*Nil*	2	98 (2)	98 (8)	97 (16)	100 (24)	30 (32)	28 (40)	12 (51)	7 (59)					
		2·15 (200)	14·0 (1300)	2	88 (2)	98 (16)	90 (30)	98 (58)	93 (76)	77 (99)	53 (104)	55 (119)	37 (133)	33 (140)	23 (145)	3 (153)	5 (158)
	DDT emulsion	4·47 (415)	*Nil*	2	17 (2)	10 (9)											
		4·84 (415)	14·0 (1300)	2	95 (2)	97 (8)	82 (15)	100 (22)	92 (45)	92 (64)	83 (72)	72 (80)	58 (107)	40 (112)	20 (121)	13 (128)	

* There was no mortality of the insects on the untreated (control) panels.

† The figures within brackets indicate the dosage in mgms/sq. ft.

TABLE III

Index of enhancement of residual activity of DDT arising from Tables I and II (and Figures 1 to 8)

Method of assessment of toxicity	Insecticidal formulation	*M. nebulo* Dosage GMS/Sq. M. DDT	Glue-dichromate	Period upto which 50% mortality was recorded (days)	Period upto which 20% mortality was recorded (days)	Index of enhancement at 50% mortality level	Index of enhancement at 20% mortality level	*C. fatigans* Dosage GMS/Sq. M. DDT	Glue-Dichromate	Period up to which 50% mortality was recorded (days)	Period upto which 20% Mortality was recorded (days)	Index of enhancement at 50% mortality level	at 20% mortality level
Exposure Chamber Technique	DDT dispersion in water	2·15	*Nil*	15	21	6·2	4·7	2·15	*Nil*	86	95	2·5	2·3
		2·15	14·0	93	99			2·15	14·0	212	223		
	DDT emulsion	4·47	*Nil*	0	5	*	31·5	4·47	*Nil*	0	9	*	26·6
		4·84	14·0	185	189			4·84	14·0	228	239		
Glass Funnel Technique	DDT dispersion in water	2·15	*Nil*	12	15	2·4	3·4	2·15	*Nil*	29	46	4·2	3·2
		2·5	14·0	29	51			2·15	14·00	123	146		
	DDT emulsion	5·38	*Nil*	15	21	5·4	4·1	4·47	*Nil*	0	0	*	*
		5·48	10·76	82	86			4·86	14·0	109	121		

* Index of enhancement was not calculated since the specified mortality levels on mud panels treated with DDT alone were not obtained. It has been observed that very often DDT emulsion applied on mud surface effected low initial mortality as compared to that produced by DDT dispersion in water.

TABLE IV

Comparison between the indices of enhancement of residual activity obtained when DDT is applied in admixture with glue-dichromate and when the insecticide is applied on surface pretreated with glue-dichromate

Test Insect	Insecticidal formulation	DDT applied in admixture with glue-dichromate††								DDT applied on surfaces pretreated with glue-dichromate							
		'Chamber' Technique					Glass Funnel Technique				"Chamber" Technique†				Glass Funnel Technique**			
		Dosage GMS/Sq.M.		Exposure period (hrs)	Period for 50 % mortality (days)	Index of Enhancement	Dosage GMS/Sq.M.		Exposure period (hrs)	Period for 50 % mortality (days)	Index of enhancement	Dosage GMS/Sq.M.		Exposure period (hrs)	Period for 50 % mortality (days)	Index of Enhancement	Dosage GMS/Sq.M.		Exposure period (hrs)	Period for 50 % mortality (days)	Index of enhancement
		DDT	Glue-dichromate				DDT	Glue-Dichromate				DDT	Glue-Dichromate				DDT	Glue-Dichromate			
M. nebulo	DDT dispersion in water	2·15	*Nil*	4	15	6·2	2·15	*Nil*	6	12	2·4	1·94	*Nil*	45 mts	8	7·5	1·08	*Nil*	6	12	4·9
		2·15	14·0	4	93		2·15	14·0	6	29		1·94	17·0	45 mts	60		1·08	17·0	6	59	
	DDT emulsion	4·47	*Nil*	4	0	*	5·38	*Nil*	6	15	5·4	4·10	*Nil*	4	11	8·0	1·29	*Nil*	6	0	††
		4·84	14·0	4	185		4·48	10·76	6	82		4.10	17·0	4	88		1·29	17·0	6	62	
C. fatigans	DDT dispersion in water	2·15	*Nil*	3	86	2·5	2·15	*Nil*	2	29	4·2	**1·94**	*Nil*	3	58	2·0	1·08	*Nil*	2	74	1·5
		2·15	14·0	3	212		2·15	14·0	2	123		1·94	17·0	3	106		1·08	17·0	2	113	
	DDT emulsion	4·47	*Nil*	3	0	*	4·47	*Nil*	2	0	*	2·31	*Nil*	3	0	*	1·29	*Nil*	2	0	*
		4·84	14·0	3	228		4·84	14·0	2	109		2·31	17·0	3	19		1·92	17·0	2	438	

* The initial mortality on mud panels treated with DDT alone was less than 50 per cent. Hence the index of enhancement of residual activity has not been shown in the column.

† Unpublished work in this laboratory.

†† The data is from Table III.

** The data is from a paper by Cheema *et al.*

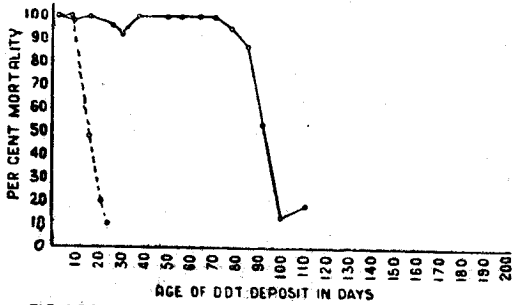

FIG. 1 DDT APPLIED AS WATER DISPERSIBLE POWDER AGAINST *M. NEBULO*

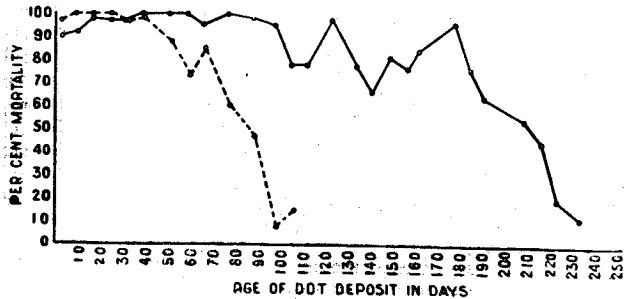

FIG. 2 DDT APPLIED AS WATER DISPERSIBLE POWDER AGAINST *C. FATIGANS*

O----O DDT 2·15 GMS PER SQ.M. WITHOUT GLUE DICHROMATE
O—— O DDT 2·15 GMS PER SQ.M. ADMIXED WITH GLUE DICHROMATE

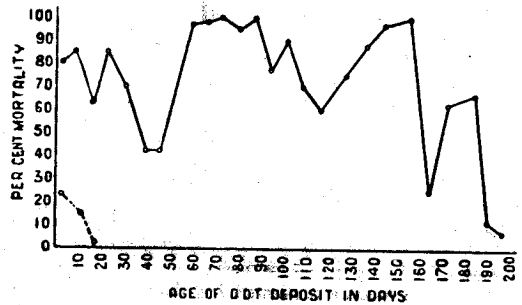

FIG. 3 DDT APPLIED AS EMULSION AGAINST *M. NEBULO*

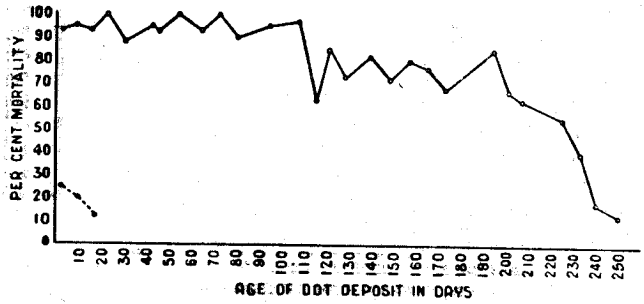

FIG. 4 DDT APPLIED AS EMULSION AGAINST *C. FATIGANS*

O----O DDT 4·47 GMS PER SQ.M. WITHOUT GLUE DICHROMATE
O—— O DDT 4·84 GMS PER SQ.M. ADMIXED WITH GLUE DICHROMATE

FIGS. 1-4—RESIDUAL ACTIVITY OF DDT AGAINST *M. NEBULO* AND *C. FATIGANS* WHEN APPLIED MIXED WITH GLUE–DICHROMATE ON MUD SURFACE AND INVESTIGATED BY THE CHAMBER TECHNIQUE

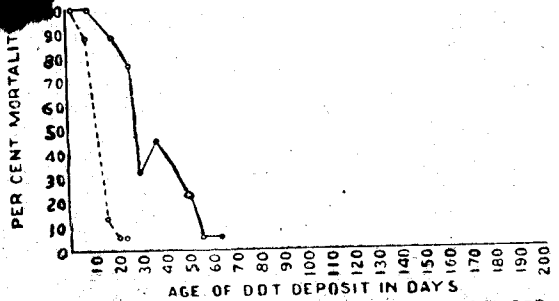

FIG. 5 DDT APPLIED AS WATER DISPERSIBLE POWDER AGAINST *M. NEBULO*

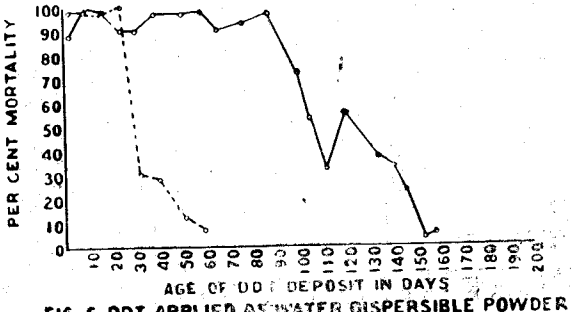

FIG. 6. DDT APPLIED AS WATER DISPERSIBLE POWDER AGAINST *C. FATIGANS*

o- - -o DDT 2·15 GMS PER SQ.M. WITHOUT GLUE-DICHROMATE
o——o DDT 2·15 GMS PER SQ.M. ADMIXED WITH GLUE-DICHROMATE

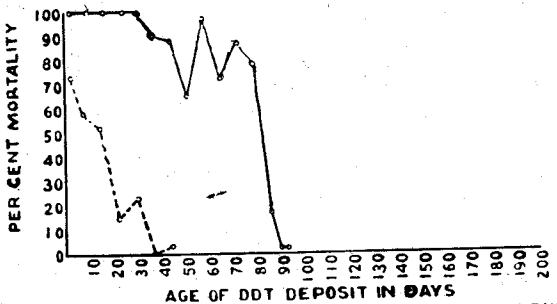

FIG. 7. DDT APPLIED AS EMULSION AGAINST *M. NEBULO*

o- - -o DDT 5·38 GMS PER SQ.M. WITHOUT GLUE-DICHROMATE
o——o DDT 5·48 GMS PER SQ.M. ADMIXED WITH GLUE-DICHROMATE

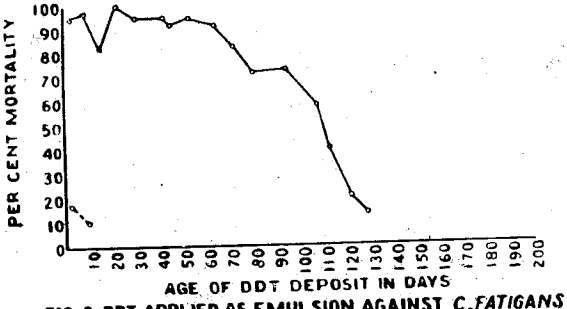

FIG. 8. DDT APPLIED AS EMULSION AGAINST *C. FATIGANS*

o- - -o DDT 4·47 GMS PER SQ.M. WITHOUT GLUE-DICHROMATE
o——o DDT 4·84 GMS PER SQ.M. ADMIXED WITH GLUE-DICHROMATE

FIGS. 5-8:- RESIDUAL ACTIVITY OF DDT AGAINST *M. NEBULO* AND *C. FATIGANS* WHEN APPLIED MIXED WITH GLUE-DICHROMATE ON MUD SURFACE AND INVESTIGATED BY *THE GLASS FUNNEL TECHNIQUE*