Notes

Some Effects of Formulation on the Initial Contact Toxicity of Insecticides to Adult Mosquitos *

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Previous work has frequently shown that the physical properties of the formulation of an insecticide and of the material to which it is applied have a considerable influence on the availability of the active ingredient to insects. This aspect of the action of insecticides is now further emphasized by comparison of the initial contact toxicity to adult mosquitos of wettable powder and emulsion formulations of solid and liquid insecticides applied to two types of material, one relatively non-porous, the other very porous.

Materials and methods

Test insects. *Anopheles stephensi* and *Aëdes aegypti* were reared by standard methods at 25° C and 70%-80% relative humidity; and 2-3-day-old, blood-fed females were used in all experiments.

Insecticides. The insecticides used were: 75% DDT wettable powder; 50% dieldrin wettable powder; 30% malathion wettable powder; 40% fenthion wettable powder; 25% w/v DDT or dieldrin emulsion concentrate; and 50% w/v malathion or fenthion emulsion concentrate.

Wettable powders were from commercial sources but the emulsion concentrates were prepared in the laboratory according to a standard formula: 1.25 g or 2.50 g of insecticide, according to concentration, were dissolved in 1 ml of a xylene solution containing 0.5 g of mixed emulsifier and the volume made up to 5 ml with xylene. The emulsifiers were a mixture of ethylene BCP and BSE in equal proportions. The final concentrate therefore contained 25% or 50% w/v of insecticide and 10% w/v of emulsifiers in xylene.

Test surface. Plywood was taken as an example of a relatively non-porous material. Dried mud bricks made from Taveta soil as described by Hadaway & Barlow [a] were taken as an example of a very porous material. Materials were sprayed in a Potter tower, and were tested a few hours after treatment.

Exposure methods. Female *Anopheles stephensi* were exposed in Perspex chambers on vertical treated surfaces as described by Hadaway & Barlow.[a] Female *Aëdes aegypti* were exposed under Perspex funnels on horizontal treated surfaces by the method described by Hadaway & Barlow.[b] Mortality counts were made after 24 hours.

Results and discussion

The results obtained with DDT are shown in Table 1, with dieldrin in Table 2, with malathion in Table 3 and with fenthion in Table 4.

The wettable powder formulation of the two solid insecticides, DDT and dieldrin, had a higher initial contact toxicity to mosquitos on dried mud bricks than on plywood. These results are in accord with previous experience. A likely explanation is that the wetting agent solution cannot penetrate so readily into plywood as it can into porous mud bricks and, as the water evaporates, more residue remains to hold the insecticide particles to the surface. In other words, the ratio of insect-insecticide adhesion to insecticide-surface adhesion is reduced. Plywood has properties which seem to be intermediate between very porous and non-porous surfaces. Earlier experiments have shown that when a non-porous surface such as glass is used the dried residue shows maximum insecticide-surface adhesion and an insecticide such as DDT has greatly reduced availability to resting insects. Dieldrin, having a greater intrinsic toxicity, is less influenced by these availability factors and the present results suggest that

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[a] See the article on page 55 of this issue.

[b] Hadaway, A. B. & Barlow, F. (1951) *Bull. ent. Res.*, **41**, 603.

TABLE 1
CONTACT TOXICITY OF DDT

Formulation	Material sprayed	Dosage (g/m^2)	Mean kill (%) after contact time shown									
			2 min.	5 min.	10 min.	15 min.	25 min.	30 min.	60 min.	120 min.	180 min.	240 min.
Anopheles stephensi												
Wettable powder	Plywood	2		5		67		100				
		1		5		48		81				
		0.5				18		29	88			
Wettable powder	Dried mud	2	58	87		100						
		1	26	60		100						
		0.5	12	39		95						
Emulsion	Plywood	2				0		4	43			
		1				0		0	4	61		
Emulsion	Dried mud	1							0	0		0
Aëdes aegypti												
Wettable powder	Plywood	1		100								
		0.5		100								
		0.25		8	60	92						
Wettable powder	Dried mud	0.25	100									
		0.125	85	100								
		0.06	97	100								
		0.03	5	70	95							
Emulsion	Plywood	1			10	20	75					
Emulsion	Dried mud									5	15	65

the change from mud to plywood test surfaces has less effect with this insecticide than with DDT.

The two liquid insecticides, malathion and fenthion, showed the opposite effect in that the wettable powders were more effective on plywood than on the mud bricks. Again an explanation can be supplied from past investigations. Liquid insecticides can be displaced from the carrier and emulsified when the powder is suspended before spraying and consequently they are absorbed into porous substrates with the suspending liquid. Alternatively, if they do stay on the carrier in suspension they can very rapidly diffuse into the substrate because they are liquids. In either case the superficial deposits are very low even shortly after spraying. Solid insecticides, on the other hand, remain as particles on the surface and are potentially available to insects unless loss by adsorption occurs subsequently. Adsorption, however, is slow compared with absorption even on the more active substrates and does not influence the initial contact toxicities. Plywood, on the other hand, consists of coarse fibres which are individually of low porosity. Spray deposit on the fibres consequently still contains the liquid insecticide and surface deposits are greater on plywood than on mud. This explanation is complementary to that given for the reduced effectiveness of solids on plywood.

With both insecticides the initial toxicities of deposits from wettable powders were greater than those emulsions on a given surface. This is probably due to the greater ease with which an insecticide in emulsion form can penetrate any surface that is not completely non-porous. On mud the concentration of insecticide in the superficial layers will be greater, even when sorption of a liquid has occurred from a wettable powder, compared with the rapid and deep penetration which occurs from a finely dispersed emulsion. Just how effective a given concentration of insecticide on the mud can be will depend, of course, upon intrinsic toxicity (compare dieldrin and

TABLE 2
CONTACT TOXICITY OF DIELDRIN

Formulation	Material sprayed	Dosage (g/m^2)	Mean kill (%) after contact time shown							
			2 min.	5 min.	15 min.	30 min.	60 min.	120 min.	180 min.	240 min.
Anopheles stephensi										
Wettable powder	Plywood	1	91	100						
		0.5	61	95						
		0.25	38	79	100					
Wettable powder	Dried mud	1	100							
		0.5	100							
		0.25	90							
Emulsion	Plywood	1	0	33	100					
Emulsion	Dried mud	1				0	0	40		80
Aëdes aegypti										
Wettable powder	Plywood	1	97	100						
		0.5	88	100						
		0.25	15	95						
Wettable powder	Dried mud	0.5	100							
		0.25	100							
		0.125		26	80					
Emulsion	Plywood	1		17	92					
Emulsion	Dried mud	1					0	0	35	100

TABLE 3
CONTACT TOXICITY OF MALATHION

Formulation	Material sprayed	Dosage (g/m^2)	Mean kill (%) after contact time shown									
			2 min.	5 min.	7 min.	10 min.	15 min.	30 min.	60 min.	90 min.	120 min.	180 min.	240 min.
Anopheles stephensi													
Wettable powder	Plywood	2	0	33			100						
Wettable powder	Dried mud	1					0	0	4				
Emulsion	Plywood	1		4			57	100					
Emulsion	Dried mud	1						0	0		0		
Aëdes aegypti													
Wettable powder	Plywood	1	95	100									
		0.5	71	96		100							
		0.25		15	42	75							
Wettable powder	Dried mud	1				20	65	80	100				
		0.5								10	45	100	
Emulsion	Plywood	1		25	50	91							
Emulsion	Dried mud	1								0	0	0	0

TABLE 4

CONTACT TOXICITY OF FENTHION TO *ANOPHELES STEPHENSI*

Formulation	Material sprayed	Dosage (g/m^2)	Mean kill (%) after contact time shown					
			2 min.	5 min.	15 min.	30 min.	60 min.	120 min.
Wettable powder	Plywood	1	100					
		0.5	98	100				
		0.25	87	100				
Wettable powder	Dried mud	2		96				
		1		21	92			
Emulsion	Plywood	1	37	100				
Emulsion	Dried mud	1				0	0	24

DDT and fenthion and malathion). It is noteworthy that the difference between wettable powder and emulsion of any insecticide is much less on plywood than on dried soils. This feature is again probably connected with the non-porous nature of the individual wood fibres and with the greater retention of any formulation as a superficial deposit compared with the differential effects which occur with different formulations on dried mud.

As emulsions, all the insecticides were more effective on plywood than on the dried mud bricks. The reason for this is almost certainly to be found in the difference mentioned in the previous paragraph between the highly porous microstructure of mud and the lower porosity of the individual wood fibres. This difference will result in greater superficial deposits on wood.

Finally, these experiments have shown once again the differences obtained with two test insects, *Anopheles stephensi* and *Aëdes aegypti*, but it will be seen that the effects are not consistently in one direction. This is because numerous factors are involved, such as intrinsic toxicity, resting behaviour, test method, total dosage of available insecticide and the form in which it is present on a particular surface, and the relative importance of these is likely to vary from one situation to another. The picture is probably clearest with wettable powders on both mud and plywood. *Aëdes aegypti* is killed more readily despite the intrinsic toxicities being either equal or greater for *Anopheles stephensi*. This is probably due to the different resting habits and exposure methods. *Aëdes aegypti* walks about much more than *Anopheles stephensi*, and insects pick up more deposit on a horizontal surface than on a vertical one. With emulsions the relative effectiveness against the two species is variable, even inverted, and factors involving the deposit characteristics are probably brought into play. We know little about the behaviour of emulsions on different substrates and cannot at present provide any explanations based on experimental results.

Treatment of Malaria with Small Daily Doses of Chloroquine Hydroxynaphthoate or Tannate

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In medicated salt schemes the use of chloroquine diphosphate or sulfate has not been altogether satisfactory because of two problems: these soluble compounds tend to leach out of the mixture when it is stored under humid conditions, and their bitter taste becomes objectionable when their concentration exceeds 0.4% of the base.

On the other hand, chloroquine methylene-bis-β-hydroxynaphthoate does not tend to leach and is tasteless, as is another compound, chloroquine