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The Chief of the Malaria Section has the honour to communicate hereunder the following note

IMAGOCIDAL METHODS - COMPARATIVE VALUES OF MODERN INSECTICIDES IN RELATION TO TYPE OF SUBSTRATUM

by

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This paper is based on work carried out under the direction of this Unit at Taveta in Kenya by G. Davidson in 1950 and 1951 and by G. F. Burnett since that date on the mosquitos A. gambiae and A. funestus.

Trap huts based on a design of Muirhead-Thompson[8] were used throughout the experiments; they were built with mud and wattle walls, plastered within and without, and thatched roofs. Attracted by the human "bait" sleeping within, mosquitos entered by the very narrow opening under the eaves and rested on the interior surface of the hut before or after feeding. When "irritated" by the insecticide they tended to fly towards the only source of direct light and found their way into the window trap. From here they were collected and kept to determine delayed mortality. Some mosquitos died within the hut and were collected by hand from the floor and total mortality is calculated by summing the floor and window trap catches. Separate control mortalities were found for each period.

With very few exceptions the insecticide deposits were assessed chemically from sample papers exposed at the time of spraying. Nearly all experiments were carried out with suspensions of wettable powders which previous work had shown to be the most effective formulae for use on mud walls.

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Interpretation of the results was confused at times by a marked seasonal variation in the mortalities. There was a regular tendency for the deaths to fall in the dry seasons and rise again in the rains. Experiments were generally discontinued when the level of mortalities fell below 50% for two successive months. This agrees fairly well with Macdonald's theoretical deductions that 65% mortality within a treated shelter meets most conditions, 45% is sometimes sufficient, while 85% will deal with the most severe conditions. 7

DDT

In 1948 Muirhead-Thompson in Dar-es-Salaam found that from a hut treated with DDT, almost all A. gambiae and A. funestus which entered escaped unharmed.[8] This conflicted with practical experience and was not confirmed by Hadaway[4] and Wilkinson[10] in Uganda. However, laboratory work by Hadaway and Barlow in Uganda and the United Kingdom[5] showed very rapid absorption of DDT by mud; its rate depending on particle size, dosage, diluent and type of mud, but was always of the order of a few days.

Davidson repeated Muirhead-Thompson's experiment using the same formulation. He obtained kills that exceeded Muirhead-Thompson's but were still low, but so was the amount of DDT; below 1 g per square metre.[2] Muirhead-Thompson had not estimated his deposit chemically and the formulation he used is now known to have been an exceedingly unsuitable one, and it is likely that the actual amount of DDT on the wall was very small. Davidson repeated the experiment with another formulation at a dosage of 2.3 g per square metre on a wall of mixed mud and gravel with much more encouraging results - a kill of 50% and over for nine months.

Hadaway and Barlow suggested that the increased kill might be due to non-absorption of the DDT where gravel was on the surface of the wall combined with the preference for A. gambiae for settling on the roof which was non-absorbent.

Burnett has repeated the experiment at about the same dosage in a hut plastered with highly active grey mud with results similar to Davidson's. When the roof only was treated the mortality did not approach that obtained when the whole house was treated and it fell off more rapidly with time. There is evidence from these

experiments of greater absorption by a plain mud plaster than by a plaster containing 50% sand but the process took a matter of weeks or months. It seems likely that the continued lethality of the walls was due to the unevenness of the deposit. In some places it was at the rate of many grammes per metre and was only slowly absorbed, particularly from the larger crystals - and absorption was further decreased by the presence of inert diluent.

A considerable portion of the kill obtained particularly in the early stages is apparently due to drifting particles of insecticide.[3] Mosquitos suspended in cages in the centre of treated huts were killed by such air-borne particles.

To sum up, there is nothing in these results to alter the conclusions of Macdonald and Davidson that DDT can control malaria in many natural conditions. In mud walled huts 2 g per square metre at six-monthly intervals will control African malaria vectors under many conditions. DDT is cheap, safe and readily available but cannot be relied on for control under conditions of high malarial stress.

BHC

Davidson repeated Muirhead-Thompson's experiment with BHC and obtained very similar results. With 0.2 g gamma BHC per square metre in a hut with walls plastered with non-active red soil and gravel and a thatched roof the kill was well maintained for three months but fell drastically in the fourth month. With non-absorbent walls such as those made of banana leaves Burnett found that the effect was practically the same but that on a wall plastered with very absorbent mud only the action was far more prolonged. That the persistence was due to the wall which rapidly absorbed the BHC and then slowly released it as a vapour was shown by contact tests with mosquitos. An experiment by Burnett to determine the effect of treating the walls only was ruined by invasions of ants which removed the dead mosquitos before they could be counted.

A heavy deposit of gamma BHC in urea-formaldehyde resin (2.5 g gamma BHC per square metre) gave nearly 100% kill for about 18 months but the preparation is expensive and requires a paint sprayer and special gas-mask for its application so that there seems little future for it in African houses.

To summarize, on non- or semi-absorbent surfaces BHC at 0.2 g gamma isomer per square metre is highly effective for 2-3 months and then becomes rapidly quite useless. If the hut contains absorbent surfaces the falling off is delayed possibly until the seventh month or later and may remain above 50% for ten months. BHC may be expected to be highly effective where mosquito densities show an abrupt and short-lived peak and where malarial transmission is seasonally high. The timing of the applications may however be critical.

Dieldrin

Davidson was able to make only one trial with dieldrin, in a hut with mud and gravel walls. At that time it was not possible for us to estimate the deposit chemically and Davidson assumed, on the basis of previous experience with suspensions of DDT and BHC, that he achieved about 0.5 g per square metre. The mortalities obtained were very high for over a year and appreciable for 21 months. Burnett repeated this experiment at an expected 0.4 g per square metre and got results fully as good for a year, after which the trial was discontinued. Since, however, it has become possible to estimate dieldrin in our laboratory, Burnett has been unable to get similar results with known dosages of 0.4-0.5 g per square metre. Burnett has tried out this insecticide in various combinations of dosage and substrate and the results show some interaction between the two factors but the interpretation is complicated by seasonal variations in kill. The general conclusions are that dosages of 0.3 g per square metre will not meet stringent conditions for more than four months. Dosages of about 0.4 g per square metre on mud and sand plaster or on a plain plaster of not very absorbent mud will give a high kill for a maximum of nine months. Dosages of 0.7-0.8 g on plain mud were effective for about a year and on a mud and sand plaster gave high kills for 29 months!

It would seem therefore that the dosages in the early experiments were actually nearer 0.7 than 0.4 or 0.5 g per square metre.

DDT and BHC

At one time it appeared that a mixture of BHC and DDT would combine the virtues of both, and several combinations were tried. It was found that results were

satisfactory at or above 2 g DDT and 1 g technical BHC per square metre but that at dosages below this the DDT merely irritated the mosquitos which left before the BHC could kill them.

Dosage and spraying cycle

In the control of adult mosquitos by the residual treatment of African huts it is by no means certain that it is useful to have a treatment which lasts 18 months or more. If the rate of hut rebuilding or replastering is high - and it may be 25% per annum - it is obviously desirable to respray at fairly short intervals to avoid serious gaps. The procedure adopted in practice will depend on the relation between insecticide and application costs and on the staff available which will determine how often the spraying can be done. If there is, elsewhere, the seasonal effect found at Taveta, it may be possible to time the applications so that the second rainy season arrives before the deposit is too attenuated to respond, but this would be a risky method. On the other hand there will definitely be a reinforcing effect by later applications if the first insecticide has not been lost to the hut but merely absorbed in its surface. Saturation of the outer layer of the plaster will slow up absorption of the second dose.

This effect is therefore to be expected on mud walls treated with dieldrin or DDT. It will not happen where insecticide is lost mechanically from a non-absorbent surface or by volatilization from an absorbent one, as is the case with BHC.

Experiments carried out by Burnett with dieldrin and BHC confirmed these expectations.

A mud plastered hut treated previously with dieldrin at 0.4 g per square metre was resprayed at 0.3 g and the kill remained above 90% for nine months. The non-absorbent banana leaf surface originally treated at 0.4 g per square metre, when retreated at 0.3 g gave a kill above 80% for three months only. A mud walled BHC treated house when re-treated at the same dosage showed no improvement over the performance when first treated.

Experiments by Burnett and Woodcock[1] have shown that there is a great variation in the proportion of the insecticide expended which actually lands on the surface to be treated, depending on the type and size of jet, the pressure and the distance the jet is held from the wall or roof. In practice the proportion of insecticide which is actually left on the surfaces sprayed will usually vary between 50% and 75%. There is no need to emphasize how important this becomes when planning a residual campaign nor the necessity of assessing chemically the deposits actually obtained, especially in experimental work.

The assessment of deposits

Dr J. Robinson has done a considerable amount of work to determine the best size and distribution of sample papers for the most efficient estimation of the dosage applied in a house-spraying campaign. He has concluded that the best size of sample paper is about 10 x 50 cm and has found no evidence so far to suggest that the use of white sample papers gives a biased estimate.

Robinson has also used a useful method of studying the accumulated assessment data by means of control charts. It has been found generally in practice that the variation in deposit from house to house is much greater than the variation within a house, and continual checking is necessary to prevent this variation becoming too great.

Summary

Trials on residual insecticides have for the last five years been conducted at Taveta, Kenya, using trap huts.

DDT at about 2 g per square metre will kill 50-70% of mosquitos entering for at least six months after application whatever the surface of the walls. Treatment of only part of the interior surface gives lower kills. For some weeks after treatment mortality is increased by air-borne particles of insecticide. Thus DDT can control malaria in many natural conditions.

BHC at 0.2 g gamma isomer per square metre on non-absorbent or semi-absorbent surfaces (plaster containing much sand or gravel) is effective for three months and then rapidly becomes ineffective. On an absorbent surface it persists for up to ten months, giving mortalities of 100% to 90% for the first four months and 50-70% thereafter. This is due to rapid absorption and subsequent slow release by the wall surface and may be adversely affected by increased ventilation. BHC may be expected to be highly effective where there is a short season of high malarial transmission.

Dieldrin at 0.3-0.4 g per square metre, whatever the surface, needs renewing at six-month intervals as the decrease in its effectiveness, once it starts, is more rapid than DDT at 2 g. At 0.4-0.5 g per square metre dieldrin may be effective for nine months, especially on non-absorbent walls and at 0.7-0.8 g per square metre it is exceedingly persistent, for 29 months on a mud and sand plaster, for at least 11 months on plain mud and should be used at this dosage under conditions of persistently high rates of malarial transmission. Smoke has no deleterious effect on BHC but reduces the effectiveness of dieldrin.

There is a cumulative effect of successive treatments of dieldrin (and probably DDT) on absorbent walls but not on non-absorbent ones. BHC is lost by volatilization and no reinforcing effect occurs. Thus with dieldrin on mud-walled houses it is possible to economize in second and subsequent treatments by reducing the rate of application or extending the period between applications.

Knowledge of the actual deposit of insecticide on the relative surface is important; with the equipment usually used it is likely to equal only 50-75% of the amount expended.

The methods of sampling for chemical assessment of the deposits applied in a large-scale house-spraying campaign need careful attention.

REFERENCES

1. Burnett, G. F. & Woodcock, K. E. In press

2. Davidson, G. (1953) Bull. ent. Res. 44, 231-254

3. Davidson, G. & Burnett, G. F. (1952) Nature (Lond.), 170, 893

4. Hadaway, A. B. (1950) Bull. ent. Res. 41, 63-78

5. Hadaway, A. B. & Barlow, F. (1952) Bull. ent. Res. 41, 603-622

7. Macdonald, G. & Davidson, G. (1953) Bull. Wld Hlth Org. 9, 785-812

8. Muirhead-Thompson, R. C. Trans. roy. Soc. Trop. Med. Hyg. 43, 401-412

9. Robinson, J. Unpublished

10. Wilkinson, P. R. (1951) Bull. ent. Res. 42, 45-54