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The Secretary of the Expert Committee on Malaria
has the honour to communicate hereunder a report on

FIELD EXPERIMENTS WITH DDT EMULSION AND WETTABLE DDT, WITH SPECIAL
REFERENCE TO MALARIA INCIDENCE IN SWAZILAND DURING THE
TRANSMISSION SEASON 1949/50

by

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A. INTRODUCTION

1. In these experiments wide-scale spraying operations were carried out with DDT preparations. Huts received a single spray-treatment at the commencement of the season, our aim being to ascertain the effect on the malaria incidence of a rural population.
2. Before commencing our discussion on the methods used, it will be necessary briefly to repeat the character of malaria transmission in Swaziland, as set out in my previous papers on this subject ("Report on Malaria Survey in Swaziland" published 1946, and "Field Trials with Wettable DDT, Gammexan and DDT Emulsion" published 1949).
3. Generally speaking, the length and severity of malaria transmission in Swaziland depends on the topography of the district concerned. In middle veld areas, with an altitude of between 1,000 and 2,000 feet, the season is short, usually from February to April; transmission is of an epidemiological nature, with great variation from year to year. In bush veld areas, with an altitude of between 400 and 1,000 feet, endemic and hyperendemic conditions prevail; the transmission lasts approximately six months, usually from December to May.
4. In our experiments of the transmission season 1948/49, with DDT and Gammexan, hut-spraying was carried out in three relatively small areas, each approximately twenty square miles. Malaria incidence in these areas was noted, as compared with that in untreated control areas. The results, however, were not conclusive (see report published 1949), and it was decided that spraying operations during the following transmission season should be done on a far more extensive scale.
5. The areas chosen for the season 1949/50 consisted firstly of bush veld areas ranging from the Mpopu river in the north, to the Usutu river in the south; secondly of middle-veld areas ranging from Ezulwini to Bremersdorp, and from Mhlanga to the Usutu. Huts received one spray-treatment at the commencement of the season, one or other of the DDT preparations being used (the nature of which will be discussed under the heading "Methods Used"). A population of approximately 35,000 Africans was covered. The number of huts sprayed totalled nearly 23,000; besides sleeping huts, this total included those used for cooking purposes, etc. In this way we excluded the possibility of mosquitoes, lurking in extra huts, escaping the contact with DDT.
6. The bush veld areas south of the Usutu, and areas in the extreme north of the territory (Lomati Valley and Horo), were left untouched. The malaria incidence here was noted, and served as a control in comparison with that in sprayed areas.
7. It is felt that, by the experimentation in a large area, and thus on an increased population, a more reliable picture of comparative incidence of malaria transmission is gained, the factor of migration thus becoming more or less negligible.

B. METHODS USED

8. In our experiments we used mainly two DDT preparations, manufactured in the Union of S. Africa by Klipfontein organic products. Firstly an emulsion, M25, with a DDT content of 27%; secondly a 50% wettable DDT powder.

9. The emulsion was broken down in a proportion 1 part to 8 parts water; the wettable powder was used 1 pound to 1 gallon water. The approximate DDT concentrations thus obtained for use were then 3 1/2% used and 5% respectively. Huts were sprayed in such a way as to thoroughly wet the surfaces of inside walls and ceilings, without causing the solution to run down the walls.

10. Two kinds of pump were used. Firstly a plunger type "Champion" spray-pump of American manufacture; this gave very satisfactory results, especially with the wettable powder, since this pump in its constant agitation of the fluid, caused very little clogging. Secondly a double-action "Eclipse" pump, locally made, which was used mainly for the emulsion. Both pumps had a capacity of three gallons.

11. A total of 9,900 gallons of insecticide was used for the spraying of 25,000 huts, working out at approximately half a gallon per hut. The expenditure on insecticides, without labour, amounted to £1,145 or 11 1/2 d per hut.

12. The areas to be sprayed were subdivided into eighteen sub-districts, and spraying was started as soon as breeding of A.gambiae was reported.

13. After completion of spraying operations, a weekly check (spray-out with Pyagra) for A.gambiae hut infestation was done throughout the season, due care being taken that a large enough number of huts was tested in all sub-districts. The actual number of huts checked each month was in the neighbourhood of 1,000, approximately 5% of the total number of huts sprayed.

14. During the non-transmission season a parasitological survey was done on five-hundred infants and children up to the age of twelve years. These parasite rates represent the static load of parasites carried over by a child from one season to another. The infections, which are usually of low parasitic density (see Malaria Survey Report 1946), can naturally not be ascribed to the following transmission season. For the evaluation of parasitic rates in children during the transmission season, it is essential to have this information on the "carry over" load of parasite positive cases.

15. During the transmission season, that is February to the end of June, bloods (thick drops) were taken by our field staff from all age groups, chiefly infants and children, and examined at the laboratory. It was regarded as essential that the sampling of bloods was done not only from different parts of the sprayed areas, but also that the numbers examined each month were sufficiently large. Not less than 500 bloods were examined monthly, which gives a total of well over 3,000 during the transmission season. The type of parasite, as well as the degree of parasitic infestation was recorded, the latter being expressed + to ++++ according to the severity of infestation. The same procedure was adopted in the case of the untreated control areas.

C. RESULTS

16. Since breeding of A.gambiae depends largely on climatic conditions, especially rainfall, these must be taken into consideration. The average rainfall is represented in Table I.

Table I. AVERAGE RAINFALL IN SWAZILAND
TRANSMISSION SEASONS 1948/49 and 1949/50

| | 1948/49 | 1949/50 |
|----------------|---------|---------|
| November | 4.0 | 6.5 |
| December | 3.6 | 6.0 |
| January | 4.8 | 3.3 |
| February | 6.7 | 4.5 |
| March | 3.5 | 0.9 |
| April | 2.3 | 1.3 |
| May | 2.2 | 0.4 |
| June | 1.5 | 0.0 |

17. As will be seen from the above table, except for early Spring rains (November/December), the rainfall during the transmission season 1949/50 was unusually low, and from March onwards, negligible.

18. Malaria vector breeding was naturally influenced by these semi-drought conditions. Except for hyperendemic areas situated alongside perennial bush-veld rivers, the average mosquito density was extremely low, and transmission of malaria accordingly mild.

19. Average mosquito densities in sprayed and unsprayed control areas are represented in Table II. Since spraying operations were not completed before then, results were recorded only as from March.

Table II. AVERAGE MOSQUITO DENSITIES
TRANSMISSION SEASON 1949/50

| | <u>Sprayed</u> <u>Emulsion</u> <u>DDT</u> | <u>Sprayed</u> <u>Wetttable</u> <u>DDT</u> | <u>Unsprayed</u> <u>Control</u> |
|-----------|---|--|------------------------------------|
| March ... | 0.02 | 0.01 | 1.20 |
| April ... | 0.02 | 0.04 | 1.90 |
| May ... | 0.00 | 0.00 | 0.20 |
| June ... | 0.00 | 0.00 | 0.00 |

20. With regard to the results shown in the above table, it has to be noted that while the density figures for sprayed areas were taken from endemic areas only, those of the unsprayed control areas came from endemic, hyperendemic and also epidemic areas (middle veld). These middle veld areas would naturally have a lower mosquito density, and their inclusion would tend to reduce the average total figure. Nevertheless an average mosquito density not exceeding 2 per hut, must be regarded as exceptionally low for an average malaria season in Swaziland.

21. It is worth mentioning that even in our hyperendemic sprayed areas, the average mosquito density per hut never exceeded insignificant figures. Despite these extremely low catches (inside the huts), malaria transmission was quite considerable, a point which will be discussed in detail at a later stage.

Malaria Incidence

22. As stated in the introduction of this paper, our object in these experiments was to achieve a comparison between the malaria incidence in populations of sprayed and non-sprayed areas.

23. Parasite rates, in age groups for the various areas, are represented in Table III, thus; Column (i) non-transmission season; Column (ii) total sprayed areas; Column (iii) total sprayed areas with the exception of hyperendemic areas; Column (iv) sprayed hyperendemic areas; Column (v) unsprayed control areas.

Table III. TOTAL PARASITE RATES
NON-TRANSMISSION AND TRANSMISSION SEASONS 1949/50

| AGE GROUPS | (i) NON-TRANSMISSION SEASON | (ii) | (iii) TRANSMISSION SEASON | | (v) |
|------------|--------------------------------|---------------------|--|----------------------------|---------------------------|
| | | Total Sprayed Areas | Total Sprayed Areas with exception of Hyperendemic Areas | Hyperendemic Sprayed Areas | Non-Sprayed Control Areas |
| 0-1 | 4.8% | 12.3% | 5.1% | 28.5% | 20.2% |
| 1-12 | 20.2% | 26.5% | 19.5% | 36.0% | 57.0% |
| 13-18 | 7.7% | 8.6% | | | 33.0% |
| Adults | 5.7% | 11.0% | | | |

24. The above figures reveal some interesting facts. As is well known, in judging the severity of malaria transmission, the parasite rates amongst the infant group are the most significant, the majority of infants not having been exposed previously to malaria, and acquired immunity towards this disease being at its lowest.

25. From our table, Columns (i) and (ii), it may be observed that during the transmission season the parasite rate amongst the infant group rose from approximately 5% to just over 12%. If, however, one regards the position in endemic areas only (i.e. if one excludes hyperendemic areas), there was no increase from that observed during the non-transmission season (Columns (i) and (iii), 4.8% and 5.1% respectively). In the hyperendemic areas only (Column (iv)), the parasite rate rose to 28.5%. It is therefore evident that practically all fresh infections amongst infants occurred in hyperendemic areas. It is a point of interest that here the parasite rate was actually higher than that observed in the control areas, this being due to the fact that our control samples were taken from epidemic and endemic, besides hyperendemic areas.

26. With regard to the second age group (1-12 years), the position here was similar to, but not as marked as, that in the infant group. Parasite rate difference between total sprayed and control areas was, however, statistically marked, reaching almost double values in the unsprayed areas. Similar results were shown in the third age group (13-18 years).

27. Adult parasite rates in our control areas are not recorded here. With the varying degrees of immunity towards malaria in the adult, an accurate parasite-rate for this group is difficult to assess. As only a limited number of adults was examined, it was felt that this low figure was unreliable for parasite rate assessment.

28. In Graph I (see Annex) we show parasite rates, as recorded monthly during the season, in our total sprayed and control areas.

29. The graph illustrates firstly that the rates in our control areas were always well above those in sprayed areas, particularly noticeable in April, the month of peak transmission. Secondly, the parasite rates in sprayed areas were represented more or less by a straight line, that is, not appreciably exceeding those of non-transmission months.

30. Regarding the severity of parasitic infestation, the percentage of heavy infections (+ to +++) over the whole season was recorded in total sprayed and control areas; the figures were 37.9% and 59.2% respectively, further proof of heavier infestation in the control areas, and heavier transmission.

31. Distribution of the Plasmodium species is represented in Table IV. As will be seen, the results showed no great variation.

Table IV. DISTRIBUTION OF PLASMODIUM SPECIES

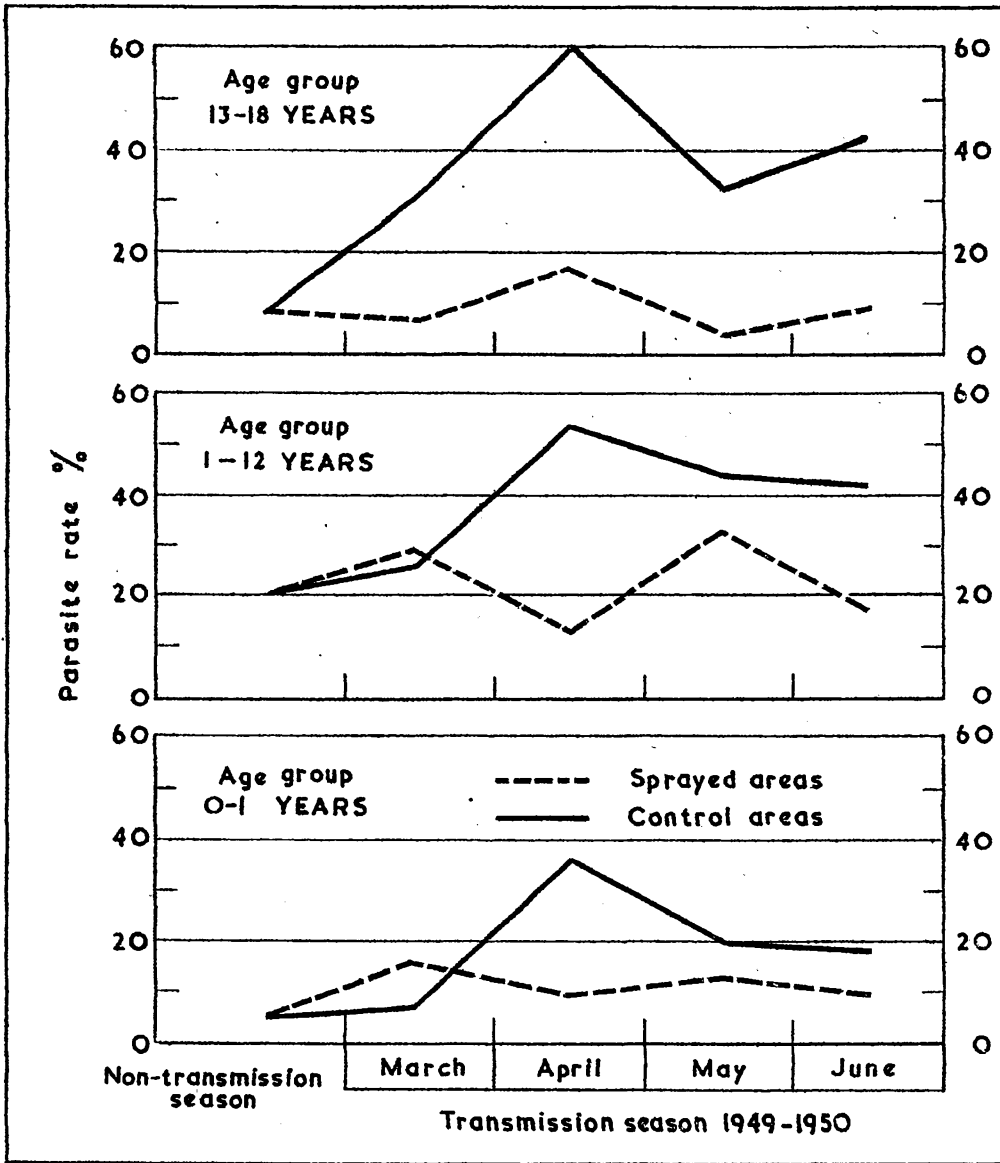
| | <u>Sprayed</u> <u>Areas</u> | <u>Control</u> <u>Areas</u> |
|-----------------------------|--------------------------------|--------------------------------|
| P.falciparum | 82.9% | 84.1% |
| P.vivax | 15.5% | 12.4% |
| Mixed (P.falc. & P.vivax).. | 1.6% | 3.5% |

32. While the figures for P.falciparum and P.vivax are almost identical in sprayed and control areas, those for mixed infections were somewhat higher in control areas. This may be explained by the fact that, owing to the larger number of infected mosquitoes present in untreated areas, a subject would be exposed to a greater number of infective bites per time unit; the chances of double infection then, would be greater than in a sprayed area.

33. As was to be expected, the crescent carrier percentage (i.e. where crescents were found in the peripheral blood) was identical in the two areas. Figures, expressed as a percentage of total P.falciparum positive cases, were as follows:

Sprayed Areas: 27.1% crescents
Control Areas: 25.5% crescents

GRAPH I



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D. CONCLUSIONS.

34. From the results of these experiments, certain conclusions can be drawn as regards the effectiveness of an anti-adult campaign conducted by the spraying of hut interiors with DDT. Firstly, there can be little doubt that a DDT treatment, either as emulsion or wettable powder, will reduce mosquito numbers to a considerable extent, and for a duration of at least three months.

35. The success of this method of control, will naturally depend upon whether or not the malaria vector is sufficiently reduced to fall below a certain critical level. This has recently been outlined by Bagster Wilson in his paper "On the Present and Future Malaria Control in East Africa", E.A. Journal vol.26, No.12, Dec.1949. In our case, the average number of mosquitoes found, by check-spraying hut interiors, was almost negligible, never exceeding 0.04 per month; this applied in both endemic and hyperendemic areas.

36. Despite this low mosquito infestation (as judged by catches of A.gambiae inside huts), malaria transmission in hyperendemic areas was remarkably high (28.5% in infant group of sprayed hyperendemic areas). It is difficult to explain this heavy transmission where hut infestation was so low. One wonders if mosquito catches from hut interiors really reveal the true picture of malaria vectors present in a certain district. Hocking, in 1947, put forward the suggestion that a certain amount of transmission takes place outside the huts, many mosquitoes never even entering the interiors. M. Thomson, in 1947, suggested that many vectors, having fed in the huts, left before receiving a lethal dose of DDT.

37. At this stage of our experiments, it is difficult to assess the value of the above theories in explanation of the low vector/heavy transmission condition. But one fact seems to us to be certain, namely that negative catches will not necessarily mean absence of malaria transmission in a certain area. It is of interest to note that A.gambiae was quite frequently found resting outside huts, especially under the eaves or in any other dark recess (tins, etc.). Whether the number of these mosquitoes was sufficiently great to be responsible for the observed high malaria transmission in hyperendemic areas, we cannot say.

38. Our results on malaria incidence in endemic and hyperendemic areas show a marked difference. The question arises as to whether repeated DDT treatment of huts, say every two to three months, in the hyperendemic areas, would be effective in further reducing malaria incidence. Bagster Wilson expresses the opinion that it seems unlikely that by anti-adult measures alone, anophelene numbers will be sufficiently reduced in the hyperendemic areas to render malaria transmission negligible. Provided additional funds can be made available to us, we intend to repeat DDT applications in our hyperendemic areas at least twice during the coming transmission season. It will then be possible to judge the effectiveness of an anti-adult campaign alone in the reduction of malaria transmission in these areas.

39. Another consideration has to be born in mind, namely whether hut spraying done in a certain area over several successive years, will contribute towards a higher effectiveness in the control of malaria in this area. We mention this point, since in certain bush veld areas treated over two successive years, we found a decidedly lower transmission than in areas treated for the first time only.

40. One must not forget that, owing to the aforementioned unfavourable breeding conditions, the past two transmission seasons (1948/49 and 1949/50) in Swaziland were exceptionally mild. It has still to be put to the test whether in a year of abundant and wide-spread mosquito breeding, an anti-adult campaign conducted by hut spraying with DDT will suffice as an effective control of malaria.

41. In conclusion, we would like to touch upon the subject of immunity status of a population in a hyperendemic area, with regard to the question of interference with that status. Whether an incomplete malaria control (of necessity this control will for the time being always be incomplete) in hyperendemic areas is a method which can be advocated with safety, is still a matter of speculation and guesswork. We are in agreement with P.C. Garnham ("Modern Concepts in Malaria Control", J.R.S.I. Sept. 1949, vol. 69, No. 5, pages 617-625) in his opinion that an incomplete control would bring about a reduction in the number of infective bites per individual, from some hundred to one or two per annum; it is quite conceivable that in so doing, one reduces the acquired immunity or premonition of that individual.

42. On the other hand, provided malaria control once started is continued yearly, one does not know that a certain reduction in degree of acquired immunity will have a deleterious effect on the health of a community in a hyperendemic area. We agree further with P.C. Garnham in that more investigation is required into the effect of purely anti-adult measures of malaria control in hyperendemic areas. It is our intention to carry out examinations on Africans (infant, child and adult groups) in these areas every transmission season. Note will be taken of the severity of parasitic infestation; also, on the appearance of pernicious forms of malaria, of the ability to suppress parasitaemia. That is, observation will be made as to whether or not these Africans of sprayed hyperendemic areas show symptoms of losing their immunity to such a degree that a malaria infection will impede their health as in a non-immune high veld community.

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