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The Secretary of the Expert Committee on Malaria has the honour to communicate hereunder the following note:

AN EXPERIMENT IN RURAL MALARIA CONTROL IN MALAYA

by

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I. INTRODUCTION

For many years before World War II, Malayan workers relied chiefly on antilarval measures for the successful control of malaria. These measures were a practical application of the principle of "species sanitation"; identify the vector species, eliminate its (or their) breeding places over a sufficiently large area, and malaria within that area should disappear. Malayan vectors happen to be unusually amenable to control by antilarval measures, and money was provided to carry out permanent as well as temporary drainage work, so that malaria did, in fact, virtually disappear from all the larger towns and was much reduced on many rubber estates. On some estates, however, antilarval measures were not so successful, and in Malay "kampong" areas they remained impracticable.

A Malay kampong is not a village; it is instead an extreme example of ribbon development, an irregular line of separate houses, each in its own little compound, which may straggle for miles along the banks of a river or beside a foot track. In such areas the usual antilarval measures would be prohibitively expensive and difficult. Efforts were, therefore, directed to the possibility of devising some cheap and practicable naturalistic means of eliminating vector breeding places, but these efforts were interrupted by the outbreak of war.

The only other control method then available, drug prophylaxis with mepacrine (Atebrin), was coming into favour on rubber estates especially where antilarval measures had had but limited success; this method, however, did not seem suitable for use in scattered rural populations with little medical supervision.

To Malaya, therefore, as to many other countries, the post-war advent of the residual insecticides brought the first reasonable prospect of attempting malaria control in rural areas. But before attempting control, much basic information had to be obtained. It had long been known that few Malayan anophelines rest in houses during the day; do they rest indoors long enough at night, either before or after their blood meal, for a sufficiently large proportion of them to be killed by residual insecticides? If so, what dose of insecticide would be needed? What should be the interval between sprayings? Answers had to be found to these and other important questions before house-spraying could be undertaken as a public-health measure.

Plans were prepared for experimental trials of insecticides in window-trap huts, and for an experiment in malaria control in a rural area. These experiments were supported by research grants from the Colonial Development and Welfare funds of the United Kingdom Government, and were carried out by the staff of the Divisions of Malaria Research and Entomology of the Institute for Medical Research, Federation of Malaya. Preliminary investigations started in 1948, and the experiments ended late in 1952. This report is a brief account of the observations made by many people during these four years.

II. THE WINDOW-TRAP HUT EXPERIMENTS

The huts were a modification of the type used by Muirhead Thomson in West Africa; details of their construction and use will be found in the papers published by Wharton (see References). Observation of the mosquitos found alive in the morning in the window-traps showed that the insecticides continued to cause an appreciable mortality for 24 or 48 hours after contact; an arbitrary level of 50 per cent. mortality after 24 hours was adopted as a lower limit of effectiveness. By this standard, DDT at 100 mg per square foot (1.1 g per square metre) and BHC (Gammexane) at 10 mg gamma isomer per square foot (0.11 g per square metre) remained effective for about three months.

With higher doses - DDT 200 mg per square foot (2.2 g per square metre) and BHC 40 mg gamma isomer per square foot (0.44 g per square metre) - the insecticides remained effective against Anopheles maculatus for 22-24 weeks, i.e. not far short of six months. A.maculatus was the principal and probably the only vector in the experimental rural areas, and the higher doses were adopted for use there, with intervals of six months between sprayings.

Work with trap huts in other areas soon revealed that Malayan anophelines have a wide range of susceptibility to DDT and BHC. A.maculatus is the most susceptible; A.sundaicus and A.barbirostris, important vectors in the coastal plains, are only moderately susceptible and deposits of DDT and BHC remain effective less than half as long against these two as against A.maculatus; DDT is even less effective against A.letifer than it is against sundaicus and barbirostris; whereas A.umbrosus is about as susceptible as maculatus.

Preliminary trials of Dieldrin in experimental huts indicate that it will last longer against all mosquitos than DDT or BHC, but that the order of susceptibility of the various species remains the same as to DDT or BHC.

Other studies made in association with the trap hut work revealed that A.maculatus is much more catholic in its feeding habits than had previously been suspected. Although relatively anthropophilic by comparison with most other Malayan anophelines, greater numbers of maculatus are attracted to cattle than to man. This new light on the feeding habits of A.maculatus, considered in conjunction with its known preference for outdoor resting places, suggested that house spraying would be unlikely to have much effect on the total population of this species, despite its relative susceptibility to the action of the insecticides. Goats and buffaloes are sufficiently numerous in most kampongs to provide a readily available alternative to human blood; and they are seldom housed in sheds or other buildings which could be sprayed in addition to the human habitations. The effect of spraying on the numbers of other less susceptible species would be still more problematical.

III. THE EXPERIMENT IN RURAL MALARIA CONTROL

Areas and Methods

Four separate yet essentially similar valleys in the hilly rice-growing areas of Negri Sembilan State were selected. The DDT area had a population

of 1,370; the BHC area a population of 475; and a third area with a population of 1,300 was used for a trial of suppressive proguanil; the fourth area with a population of 875 was left as a comparison. All were kampong areas, with relatively stable Malay populations engaged in a peasant farmer type of agriculture. The chief subsistence crop was rice, but sales of rubber, coconuts and a variety of fruit served to provide an additional cash income.

Observations on mosquitos were a combination of regular larval surveys, and adult trapping at night, the latter either with the human-bait mosquito-net trap or by bare-leg catching. Catches were sent daily to the Institute laboratory for identification and dissection. Fourteen species of anophelines were recorded, but A.maculatus was considered to be certainly the principal malaria vector, probably the only one. No other recognized vector species was recorded in significant numbers; out of a total of 9,350 anophelines dissected, just over 1,000 were A.maculatus and these provided the only two gut infections, and the one gland infection found during four years' observations.

The buildings to be sprayed were usually houses raised three or four feet from the ground with wooden or split bamboo floor and wall, and a palm thatch roof. Ceilings were few. There were no cattlesheds; apart from houses the only buildings sprayed regularly were the mosques, which were frequently occupied up till about 9 p.m. (Darkness falls at about 7 p.m. all the year round.)

The insecticides used were wettable powders of DDT and BHC, applied with a stirrup pump in doses of 200 mg DDT or 40 mg gamma isomer BHC per square foot (2.2 g or 0.44 g per square metre) at intervals of six months. Insecticide deposits were checked by means of test papers hung on the walls before spraying and examined afterwards to find the amount of insecticide deposited.

In these scattered kampong areas, house-spraying is slow work, and costs were approximately $2/- per head per year. ($1/- Malayan = 2/6d. sterling = about 35 cents US.)

A house-to-house census of each area was made, after which anyone could be identified and located. Dispensaries staffed by Malay Hospital Assistants

were built in each valley, and records were kept of the movements of individuals into or out of the areas. In the proguanil area, bottles containing the correct number of tablets were delivered weekly to each household, but there was no supervision of the actual taking of the weekly dose of one 0.1 g tablet per person, except in the local schools where the teachers gave the doses to the schoolchildren.

Observations on malaria were of three types: (i) Spleen and parasite surveys of the population were made every six months, and two of these had been completed before control work started. (ii) Blood films were collected regularly every two weeks from all infants born after 1 January 1949 and remaining in the valleys. Infants did not receive suppressive proguanil, and attacks were treated with chloroquine as they occurred. (iii) When a patient with fever came for treatment, the dispensary Hospital Assistant collected and examined blood films before giving any medicine, and these films were subsequently checked by a Malaria Research Officer.

In these three ways, it is thought that a close check on malaria incidence was obtained.

Observations began late in the year 1948, and almost a year was spent in preliminary investigations before control work started; the observations then continued for three years of control.

Results

A. Effect of spraying on the mosquito population

The only undoubted effect of the insecticides on the mosquito population that could be detected was upon the numbers found in houses. In unsprayed houses, small numbers of anophelines (but not the vector A.maculatus) and culicines could be found resting by day. In DDT-sprayed houses, virtually none could be found apart from a few dead on the floor. In BHC-sprayed houses, however, resting anophelines reappeared within a few weeks after spraying; but if kept many died inside 24 hours, and this delayed killing effect persisted up to about 20 weeks after spraying. Presumably the insecticides had similar effects upon A.maculatus entering sprayed houses, but there was no direct evidence of this.

There was no indication of any change in the overall mosquito population as a result of house-spraying. Some figures from bare-leg catching in the open suggested that the numbers of adult A.maculatus may have been slightly reduced in the sprayed areas, but there was nothing to show that any other species was affected.

Comment. Perhaps the most important conclusion from the entomological observations is that after three years thorough house-spraying with comparatively high doses of DDT or BHC, there was not the slightest sign that A.maculatus would ever be eradicated by this means. One may perhaps emphasize again that this species appears to be the Malayan vector most susceptible to the action of these insecticides.

B. Effects of control on malaria incidence

The effects of control on malaria incidence, as assessed by the three methods described above, may be summarized briefly in a series of tables.

Table 1

Spleen rates and parasite rates of children aged 12 years and under

Area	Average of 2 surveys before control started			Last survey after 3 years of control		
	Number examined	Spleen rate %	Parasite rate %	Number examined	Spleen rate %	Parasite rate %
DDT	435	64	37	529	19	6
BHC	163	60	30	183	21	6
Proguanil	351	56	29	529	13	2
Comparison	305	54	26	354	32	10

Table 2

Primary malaria infections in infants during 3 years of control

Area	Number of infants being examined once every 2 weeks	Infants contracting primary malaria during 3 years of control	
		Number	Percentage
DDT	199	16	8
BHC	70	7	10
Proguanil	204	14	7
Comparison	124	32	26

Table 3

Fever and malaria in outpatients attending kampong dispensaries during 3 years of control

Area	Population	Fever and malaria rates per 1,000 population per annum in dispensary patients during 3 years of control	
		Fever	Malaria
DDT	1,370	74	10
BHC	475	46	10
Proguanil	1,300	200	19
Comparison	875	173	50

Comment. By each method of assessment, the comparison area had a consistently higher incidence of malaria than had any of the protested areas throughout the three-year control period. But the fall in spleen and parasite rates in the comparison area shown in Table 1 makes one wonder how much of the fall in rates in the other areas can be attributed to the control work, and how much was due to "natural" fluctuation. Part at least of the fall in rates is thought to have been due to the fact that a Hospital Assistant was living in the kampongs so that prompt treatment for attacks of malaria was readily

available. In a comparable kampong some miles away which had no resident Hospital Assistant, spleen and parasite rates in 1948 were 79 per cent. and 18 per cent. in 130 children examined; in 1952 the rates were 74 per cent. and 35 per cent. in 95 children examined. Neither these figures nor the malaria admission figures to local hospitals suggest that there has been a natural recession in malaria in this part of the country.

Another reason for the fall in rates in the comparison area is revealed when survey results are analysed by parasite species. At the first survey, all areas showed a high proportion of quartan malaria, which had decreased considerably at the second survey, several months before control work began. It was at first thought that this was a seasonal variation, but the proportion of quartan malaria continued to decrease in all areas including the comparison area, and is now extremely low. Vivax malaria seems to be uncommon in these areas, and the effect of control work on falciparum parasite rates is brought out in Table 4.

Table 4

Comparison of total parasite rates (from Table 1) and falciparum parasite rates before and after control in children 12 years and under

Area	Total parasite rate %		Falciparum parasite rate %	
	Average of 2 surveys before control	Last survey after 3 years control	Average of 2 surveys before control	Last survey after 3 years control
DDT	37	6	16	2
BHC	30	6	16	2
Proguanil	29	2	14	1
Comparison	26	10	11	7

The proportionate decrease in the falciparum parasite rate is much less marked in the comparison area than in the others, and the beneficial effect of residual spraying becomes more noticeable than it was when only total rates were considered.

Proguanil was found to have a more rapid effect on spleen and parasite rates than had the insecticides, as was to be expected if the drug was being taken at all regularly; and after three years the end results with proguanil were still slightly better. But the regular distribution of any drug to a scattered rural population is difficult to organize, and one cannot hope to supervise the actual taking of the drug except for brief periods during an emergency. For this reason house-spraying with an insecticide was preferred for general use in kampong areas, and DDT appeared to be slightly better than BHC.

C. Effects of control on vital statistics and general health

The degree of malaria reduction achieved in the three protected areas had no perceptible effect on vital statistics in general, to judge from the figures in Table 5 below.

Table 5

Vital statistics of the experimental areas during three years of control

Area	Population	Birth rate per 1,000 per annum	Death rate per 1,000 per annum	Infantile mortality rate per 1,000 registered births per annum
DDT	1,370	59	17	141
BHC	475	55	15	64
Proguanil	1,300	59	17	90
Comparison	875	56	18	74
State of Negri Sembilan	122,722	52	16	121
All Malaysians				

Comment. In view of the small numbers involved these differences in rates are trifling, although the DDT area did exhibit a higher infantile mortality rate for two of the three years. Malaria in these kampongs undoubtedly causes illness but does not appear to be an important cause of death even among infants;

gastro-enteritis seemed a much more frequent cause of infant deaths, especially during the main fruit season.

In rural areas of this type, where malaria is endemic rather than epidemic and many other causes of illhealth exist, it is scarcely possible to assess any improvement in general health due to a reduction in malaria prevalence alone, and there was nothing to indicate that an improvement had occurred. Nevertheless, it seemed a poor advertisement for control work when the schoolboys in the comparison area, where malaria had undoubtedly been more prevalent, succeeded in winning the annual football competition against all other Malay schools in Negri Sembilan for two successive years during the course of our investigations.

The Malay kampong dwellers themselves do not appear to regard malaria as a serious menace to health. Their interest in residual spraying was chiefly because of its striking effect on household insect pests in general, rather than because attacks of fever may have been less numerous.

There is similar difficulty in attempting to assess any social or economic benefit from malaria control; other factors are far more important. For example, the extent to which rice fields are cultivated depends primarily on the prevailing price of rubber. When this is high, rice fields tend to be neglected and rubber tapping, usually on a share system, is the favourite occupation; when the price of rubber is low, more attention is paid to rice cultivation.

Discussion

The size and scope of these experiments were determined by the staff available, and by the fact that detailed observations were considered essential in order to obtain accurate basic information. Had larger areas and larger populations been chosen, observations on mosquitos and on malaria could not have been carried out in the manner desired. The results here reported may, however, be criticized on the grounds that the areas were not large enough, and that the populations that have been termed "protected" were, in fact, only partially protected, and had opportunities for contracting infection within a short distance of their homes. Although in this respect the comparison area was no different from the protected areas, this criticism may well be valid;

a house-spraying campaign carried out over a larger area might be more effective in reducing malaria than these results would suggest, provided that the spraying was done with the same care and attention to detail as in these experiments.

But, however carefully spraying is carried out, the residual insecticides cannot be expected to give results in Malaya comparable with those reported from neighbouring countries such as Thailand, Ceylon and India. The reasons are clear. Ceylon, for example, has only one malaria vector, A.culicifacies, which is probably more anthropophilic than A.maculatus and commonly rests inside houses by day, thus tending to come into prolonged contact with a residual insecticide. Here in Malaya there are several vectors, varying in their blood preferences but only partially anthropophilic; alike in their reluctance to rest inside houses during the day; varying considerably in their susceptibility to residual insecticides. The residual-spraying campaign in Ceylon has covered virtually the whole malarious area in the island for the past few years, yet one finds in the 1953 report of the Superintendent, Antimalarial Campaigns, Ceylon, a warning that unsprayed buildings in the dry zone are capable of harbouring A.culicifacies, and that occupation of such buildings before spraying might lead to the occurrence of cases of malaria. It is then not so surprising that in our experimental areas the numbers of A.maculatus should appear to be almost unaffected by three years of careful house-spraying.

This experiment has at least served its purpose by indicating what part house-spraying with residual insecticides may play in malaria control measures in Malaya.

(i) House-spraying will not and cannot replace the well tried and highly successful antilarval measures for the protection of towns and villages.

(ii) Where quick action is required, drugs must be used, as spraying is too slow to take effect.

(iii) House-spraying with DDT, or one of the newer residual insecticides, will provide the only practicable and economically possible method of control for the endemic malaria of rural areas; the larger the area that can be sprayed the better the results should be. Where A.maculatus or A.umbrosus is the vector, spraying once in six months should be adequate;

where A.sundaicus, A.barbirostris, or A.letifer are the vectors, spraying at more frequent intervals may be needed. But whatever the vector, eradication of either mosquitos or malaria by house-spraying alone is not to be expected. This means that spraying programmes, once started, must be continued indefinitely.

IV. SUMMARY

Experiments in Malaya with window-trap huts indicated that DDT at 200 mg per square foot (2.2 g per square metre) and BHC (Gammexane) at 40 mg gamma isomer per square foot (0.44 g per square metre) continued to kill at least 50 per cent. of the A.maculatus adults entering the huts for approximately six months after a single application. Other Malayan malaria vectors showed a wide range of susceptibility to the insecticides, and A.maculatus proved to be the most susceptible, A.letifer being the least.

In a field trial lasting for three years, DDT and BHC were compared with suppressive proguanil in separate Malay kampong areas, a fourth area being left untreated. A.maculatus was the principal vector, probably the only one, in all four areas. The insecticides were applied as wettable powders in the above doses at intervals of six months. There was no appreciable effect on the overall mosquito population. Malaria was reduced but by no means eradicated by the house-spraying, the effect of which was slower than that of the suppressive proguanil; the main reduction compared with the untreated area was in the incidence of falciparum infections.

It is concluded that these results are compatible with what is known about the feeding preferences and resting habits of the principal Malayan vector, A.maculatus. House-spraying with residual insecticides will be the only practicable method of controlling endemic malaria in rural areas, but it cannot replace antilarval measures for town areas, nor suppressive drugs where a rapid effect is required.

V. REFERENCES

A final account of this work is in course of preparation and will be published later. Several papers on the entomological findings have already appeared, and are listed below for convenience of reference, together with a circular on malaria control prepared for the Malaria Advisory Board, Federation of Malaya.

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