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

EXPERIENCES IN THE CONTROL OF MALARIA CARRIED BY
A. MINIMUS IN BURMA

by

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(Item 1.2 of the Provisional Agenda)

The experiences related in this paper are those of a WHO Malaria Control Demonstration Project which operated in the Northern Shan States of Burma for two and a half years from October 1951 to March 1954. The area of operations and observations which covered a total of some 2,500 square miles, was one composed of hills and valleys covered with forest and jungle. There were a number of large rivers and numerous smaller streams. The area under cultivation formed only a very small proportion of the total. The elevation above sea level ranged from 1,200 to 5,000 feet, the town of Lashio, the headquarters of the project, being at just under 3,000 feet.

Meteorological records for Lashio for the years 1896 to 1940 showed that the highest monthly mean daily maximum temperature was 86.8°F, and the lowest monthly mean daily minimum was 46.2°F. The average annual rainfall was 61.86", 80 per cent. of which usually fell between mid-May and mid-October. Observations carried out by the Project from December 1951 gave readings close to these averages except in the case of rainfall. April was the hottest month in both 1952 and 1953, monthly mean maximum temperatures being 89.6°F and 91°F respectively. The coldest month in both years was January when the monthly mean minimum temperatures were 46.0°F and 45.3°F respectively, the lowest temperature recorded each year being 41°F and 35°F respectively.

Rainfall recorded for the year April 1952 to March 1953 was 54.93" which is considerably less than the normal average. There was no rain at all from mid-November 1952 until after the end of March 1953. From April 1953 to March 1954 the total was 55.48" which is still below the average but the distribution was more normal.

During the first year, control operations covered 800 square miles and included the towns of Lashio, Hsenwi, Hsipaw, and Namtu-Panghai, and 379 villages. Of the total population of 55,267, 24,892 lived in the towns and 30,385 in the villages, thus the density of population in the rural area was 38 per square mile. In the second year, the towns of Kyaukme and Mong-yai and an additional 467 villages were also covered bringing the total population protected up to 109,665 of which the total rural population was 76,986, giving an overall rural density of 30.4 per square mile.

The vast majority of the population in the rural areas are Shans, but there are also some villages of Palaungs, Kachins, Shan-Chinese, and Indians (Gurkhas). In the towns large numbers of Chinese, Indians and Burmans are found.

Collection and identification of anophelines revealed the presence of 24 different species in the area, recorded here in the order of their frequency of occurrence:

<u>A. minimus</u>	<u>A. hyrcanus</u>	<u>A. majidi</u>
<u>A. varuna</u>	<u>A. vagus</u>	<u>A. gigas</u>
<u>A. fluviatilis</u>	<u>A. philippinensis</u>	<u>A. leucosphyrus</u>
<u>A. aconitus</u>	<u>A. pallidus</u>	<u>A. stephensi</u>
<u>A. culicifacies</u>	<u>A. barbirostris</u>	<u>A. tessellatus</u>
<u>A. jeyporiensis</u>	<u>A. subpictus</u>	<u>A. lindesayi</u>
<u>A. maculatus</u>	<u>A. splendidus</u>	<u>A. aitkeni</u>
<u>A. annularis</u>	<u>A. kochi</u>	<u>A. insulaeflorum</u>

Of these, the last eight species mentioned were only encountered on one or two occasions.

Dissections of 20,702 anophelines were carried out up to the end of 1952. This number included 9.799 A. minimus of which 32 were found with sporozoite-

infected salivary glands, giving an overall infectivity rate of 0.326 per cent. for this species. No other species was found infected.

For the first few months adult and larval collections were made at random, but from March 1952 fixed catching stations were arranged in 30 villages selected in different parts of both the demonstration and check areas, though random collections were continued in addition. For all adult collections individual records of the resting place of each anopheline captured were made as follows:

- i. House or cowshed;
- ii. If from house, whether from bedroom or other room;
- iii. Height of floor of house above ground level;
- iv. Height above floor at which mosquito found;
- v. Whether resting on sprayable or unsprayable surface.

In the rural areas the vast majority of houses are constructed entirely of bamboo with grass-thatch roofs. The houses are normally raised anything from three to eight feet above ground level on bamboo poles. The floors are made of large bamboos split and flattened, and the walls and partitions are made of similar material woven into mats. In some cases the bamboo poles, flooring and matting may be replaced by timber.

About 90 per cent. of A. minimus were found in houses as opposed to cowsheds. In this connexion it should be pointed out that very few cowsheds as such exist in the area. Cattle may be kept in the open space beneath houses or in other opensided sheds, neither of which provide very suitable resting places.

Of the specimens of A. minimus which enter houses 90 per cent. on an average were found to rest on the lower three feet of the walls, and some 70 per cent. were found in bedrooms as opposed to other rooms, and at least 70 per cent. were found resting on permanent sprayable structures such as walls, as opposed to movable, unsprayable objects such as clothes, ropes, tools, etc.

Studies on nocturnal movements of A. minimus showed that the species tends to enter houses at all times of the night, with some seasonal variations. The fact that 75 per cent. of the specimens found entering houses during the first half of the night were either unfed or freshly fed indicated that they enter the houses for the purpose of feeding.

Searches in a large variety of possible outdoor resting places produced only very few specimens of A. minimus.

These investigations indicated that A. minimus was the only species of importance as a vector in the area, that the species was closely associated with man, that it rested predominantly in houses and on permanent sprayable structures in houses, chiefly at heights below three feet from the floor, and that it would therefore be readily amenable to control by means of normal indoor residual spraying methods and possibly by some form of selective spraying.

Based on the results of these entomological observations, it was decided that although in the main part of the demonstration area all houses should be sprayed with DDT at the dose of $2g/m^2$, some experimental work on selective spraying was also indicated. During the first year of operation, therefore, a fairly well-populated area to the north east of the main area was divided into four zones where the following four types of treatment were applied:

- i. Walls of all living rooms up to a height of six feet only;
- ii. Walls of bedrooms only up to a height of six feet only;
- iii. Walls of all living rooms up to a height of three feet only;
- iv. Walls of bedrooms only up to a height of three feet only.

All the spraying was done with DDT at a dose of $2g/m^2$. The population of each zone was about 1,500.

As further variants, one group of villages with a total population of 2,200 was sprayed at a dose of $1g/m^2$, and a second group with a total population of 1,800 was sprayed at a dose of $4g/m^2$.

In no case were cowsheds sprayed.

The results of the first year's spraying operations were quite satisfactory from the entomological point of view, good results being obtained with all the different spraying techniques. In the case of the area sprayed at $2g/m^2$, the A. minimus density in houses was maintained at a very low level for 12 months, the reduction as compared with the check area averaging 95 per cent. In the area sprayed with DDT at $4g/m^2$, no specimen of A. minimus was found in any houses or cowshed in the area for 14 months with the exception of two specimens found in a cowshed 10 months after spraying. In the area sprayed

at the dose of $1g/m^2$ a good degree of control was also obtained for some eight months, but by that time fair numbers were beginning to appear in cowsheds. In the selectively sprayed areas results as judged from adult collections were all satisfactory and there was little to choose between three of the four techniques used. The technique which gave definitely inferior results was that in which the spraying was confined to bedrooms only up to a height of three feet only.

A group of villages with a population of 1,800 which was sprayed at the normal dose of $2g/m^2$ in 1952 was left unsprayed during the 1953 campaign so that observations might be carried out on how long such a dosage would remain effective. It was found that good entomological control was maintained for 14 months, the original spraying being carried out in April 1952 and the first marked rise in vector densities being noted in the middle of June 1953. The area was resprayed in July 1953.

The group of villages (population 1,800) which was sprayed at the dose of $4g/m^2$ at the beginning of June 1952 was left unsprayed in the 1953 campaign. No anophelines were found during routine daytime collections in houses in this area from the date of spraying in 1952 up to the time of respraying in February 1954. A. minimus was also virtually absent from cowsheds (which were not sprayed) up to July 1953, after which time the species was to be found but only in scanty numbers.

Turning to the results of the first year's operations as judged by malarionetric measurements further evidence of satisfactory control can be found. A pre-operational survey was made in December 1951/January 1952 and the first post-operational survey was carried out one year later. The period of the year chosen for these surveys corresponded to the end of the peak of transmission. In the Table which follows spleen rates (S.R.), average enlarged spleen size (A.E.S.), and parasite rates (P.R.) for the two to nine years age group, and infant parasite rates (I.P.R.) are given, the figures in parenthesis being the number of subjects examined in each case.

Area	Pre-operational survey				1st post-operational survey			
	S.R.	A.E.S.	P.R.	I.P.R.	S.R.	A.E.S.	P.R.	I.P.R.
2g/m ² whole houses	90.0%	2.54 (668)	26.5% (635)	35.2% (125)	66.6%	2.03 (613)	3.7% (624)	0 (127)
Check area (unsprayed)	90.0%	2.48 (307)	25.6% (300)	41.2% (17)	82.5%	3.64 (405)	43.4% (302)	46.0% (72)
1g/m ² whole house	92.4%	2.67 (104)	30.0% (106)	18.0% (17)	62.0%	2.06 (118)	14.6% (117)	6.0% (33)
2g/m ² up to 3' bed-rooms only	94.5%	2.25 (73)	17.9% (73)	9.1% (11)	70.0%	1.97 (56)	3.6% (56)	6.6% (15)
2g/m ² up to 3' in all living rooms	91.0%	2.27 (155)	33.6% (155)	22.3% (9)	66.0%	2.03 (147)	8.14% (147)	6.3% (16)
2g/m ² up to 6' in bed-rooms only	88.0%	1.88 (73)	33.8% (77)	40.0% (5)	64.8%	1.72 (71)	4.2% (72)	12.5% (8)
2g/m ² up to 6' in all living rooms (+)	52.8%	1.63 (199)	13.5% (194)	20.5% (44)	26.1%	1.53 (180)	1.78% (169)	8.3% (24)
4g/m ² whole houses	100.0%	2.66 (65)	44.7% (65)	50.0% (14)	69.0%	2.63 (71)	24.0% (71)	0 (9)

All the above figures refer to rural areas except that marked (+) which was an urban area and which accounts for the lower initial rate.

From these figures it can be seen that in the area in which whole houses were sprayed at the dose of 2g/m² there was a reduction in spleen rate from 90 per cent. to 66.6 per cent., and an average enlarged spleen size from 2.54 to 2.03. Reductions in the areas treated with experimental dosages were of a similar order. Both parasite and infant parasite rates in sprayed areas also show reductions, though in some cases, particularly in infant parasite rates, the number of subjects examined was too small to give statistically significant results. However, monthly infant parasite surveys were carried out each month from July to December 1952 and these gave the following aggregate results over that period:

Area	Number examined	Number positive	Percentage positive
2g/m ² whole houses	519	1	0.19%
Check area (unsprayed)	187	44	23.5%
1g/m ² whole houses	57	2	3.5%
2g/m ² up to 3' in bedrooms only	35	3	8.5%
2g/m ² up to 3' in all living rooms	68	2	3.0%
2g/m ² up to 6' in bedrooms only	51	0	0
2g/m ² up to 6' in all living rooms	77	0	0

These figures confirm that one annual spraying of whole houses at a dose of 2g/m² gives virtually complete control of transmission, and also show that selective spraying of houses up to a height of six feet from the floor also appears to give good control.

The plans for the second year's operations were formulated after careful study of the malariometric and entomological data available at the end of 1952. It was thus decided that the encouraging results obtained in the area where spraying had been restricted to a height of six feet from the floor warranted a larger scale trial of this method. The 1952 selective spraying rural area together with a part of the extension area with a total of 131 villages and a population of 10,901 was therefore treated at a dose of 2g/m² sprayed on all walls of houses up to a height of six feet only. In four towns - Lashio, Hsipaw, Hsenwi and Kyaukme - spraying took place at a dose of 1g/m² in February/March 1953, and again in August/September 1953. This was done in the hope of obtaining better control of nuisance mosquitos which prevail during and after the rains, and which are particularly troublesome in urban areas where they tend to minimize public appreciation of the malaria control campaign. The remainder of the original demonstration area and of the new extension area was sprayed with DDT at 2g/m² on walls and roofs of all houses with the exception of the observation areas which were left unsprayed as mentioned in an earlier paragraph, being a group of villages sprayed at 2g/m² in 1952 which was resprayed in July 1953, and the group of villages sprayed at 4g/m² in 1952 which was left unsprayed for the whole of 1953.

The total population covered in the second year, including these observation areas, was 109,665.

Control of A. minimus in all sprayed areas was well maintained throughout 1953 as indicated by routine and random entomological observations and from this point of view there was little to choose between the different methods of spraying employed.

A final malarionetric survey was carried out in December 1953 and January 1954. The results compared with the two earlier surveys are summarized below for four different parts of the area as follows:

Area I - that in which whole houses were treated with DDT at a dose of $2g/m^2$ in both 1952 and 1953.

Area II - that left unsprayed in 1952 and in which houses were treated with DDT at a dose of $2g/m^2$ in 1953.

Area III - the rural area sprayed with various selective methods in 1952 and in which walls of houses up to six feet high only were treated with DDT at $2g/m^2$ in 1953.

Area IV - that in which whole houses were treated with DDT at a dose of $4g/m^2$ in 1952 and left untreated in 1953.

The figures in parenthesis indicate the number of subjects examined in each case.

Area	Survey 1951/52				Survey 1952/53				Survey 1953/54			
	S.R.	A.E.S.	P.R.	I.P.R.	S.R.	A.E.S.	P.R.	I.P.R.	S.R.	A.E.S.	P.R.	I.P.R.
I	90%	2.54	26.5%	35.2%	67%	2.03	3.7%	0	12%	2.2	5.8%	0
	(668)		(635)	(125)	(613)		(624)	(127)	(550)		(550)	(68)
II	90%	2.48	25.6%	41.2%	83%	3.64	43.4%	46%	50%	3.0	15.3%	9.2%
	(307)		(300)	(17)	(405)		(302)	(72)	(385)		(385)	(65)
III	91%	2.2	30.0%	20.0%	66%	1.9	7.0%	7.7%	2.6%	1.7	1.1%	0
	(301)		(305)	(25)	(274)		(275)	(39)	(231)		(182)	(33)
IV	100%	2.7	44.7%	50.0%	69%	2.63	24.0%	0	40.3%	2.7	12.9%	6.2%
	(65)		(65)	(14)	(71)		(71)	(9)	(62)		(62)	(16)

These figures indicate that the indoor residual spraying of whole houses with DDT at a dose of $2\text{g}/\text{m}^2$ once a year gives good control of malaria carried by A. minimus in the Northern Shan States, that when the spraying is confined to wall surfaces up to a height of six feet from the floor adequate control also appears to be obtained, and that the spraying of DDT at a dose of $4\text{g}/\text{m}^2$ on all interior surfaces of houses gives a reasonable degree of control for a period of two years.

It is not proposed to go into the details of the organization of the various spraying campaigns. Suffice it to say that DDT was used both in the form of 75 per cent. water dispersable powder and in the form of an emulsion concentrate, and that there seemed little to choose between these two formulations from the point of view of results, though from the point of view of operations in a rural area, the water dispersable powder is certainly the more convenient product to use. Spraying equipment used consisted of two types of Hudson pressure sprayers.

A brief word may be said about the cost of the operations and these are summarized as follows for the two years:

	Operations 1952	Operations 1953
Insecticides	Ks. 36,000 or 59.0%	Ks. 62,000 or 58.8%
Equipment	Ks. 3,000 or 4.9%	Ks. 3,588 or 3.4%
Transport	Ks. 2,500 or 4.1%	Ks. 5,680 or 5.4%
Supervision	Ks. 7,000 or 11.5%	Ks. 12,000 or 11.4%
Labour	Ks. 7,778 or 12.8%	Ks. 16,994 or 16.1%
General	Ks. 4,722 or 7.7%	Ks. 5,258 or 4.9%
Total	Ks. 61,000 = US\$12,815	Ks. 105,500 = US\$22,164
Population protected	- 55,267	93,179
Cost per capita	US\$0.232	US\$0.238

With regard to the per capita cost it should be noted that the population given above as protected in 1953 is a figure adjusted to take into account the fact that at the time of this calculation four towns in the area had only received one of the two sprayings of $1\text{g}/\text{m}^2$. The slight increase in per capita cost in

the second year was due to the fact that the extension area included was much less densely populated than the 1952 area, so that the time taken and the cost of transportation were both greater.

The work recorded here was carried out by a joint WHO - Government of the Union of Burma Malaria Control Demonstration Team and the credit for the results achieved therefore goes to all the international and national members of that Team. It should be noted that there are many special aspects of the Team's work which have not been mentioned in this paper as these will no doubt be dealt with fully in future papers to be produced by other members of the Team.