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R. M. GORDON



EAST AFRICA HIGH COMMISSION

LIVERPOOL
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Annual Report

of the

**EAST AFRICAN INSTITUTE OF
MALARIA AND VECTOR-BORNE
DISEASES**

July 1955—June 1956

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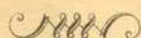
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**EAST AFRICAN INSTITUTE OF
MALARIA AND VECTOR-BORNE
DISEASES**



ANNUAL REPORT



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JANUARY 194~~5~~—JUNE 1955

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A comparison of examinations of adjacent and essentially similar areas in 1946 and 1951 is shown below.

TABLE IV
Human Indices—British Somaliland

	Exam.	Spleen Rate	Parasite Rate	Parasite Infestation
1946 ..	74	60	20	140
	57	18	4	—
1951 ..	108	21	37	250
	87	34	51	580

During the latter part of the year, a start was made in assisting the execution of drainage projects, not only by advice in planning but also in the more practical form of survey of levels of the ground to be drained.

EXPERIMENTS IN CONTROL

Residual Insecticides

Brief reference only is made to an essay in control by residual insecticides on an estate at Arusha Chini near Moshi as, although initiated and still supervised by the Director, it is mainly a Tanganyika project. This experiment has shown that, although *A. gambiae*, the sole vector in the area concerned, is greatly reduced in numbers by a three-monthly treatment of 1 gramme/sq. metre with B.H.C. dispersible powder (P.520 and Supona B), there is a rapid recovery in house infestation, to a level almost equal to that found in the untreated camps, before the end of each three-monthly period. Moreover the parasitaemia in man, although rather lower in the treated camps, is not significantly so. During 1952 the dosage will be increased to 2 grammes/sq. metre, again at three-monthly intervals.

AIRSPRAYING WITH D.D.T.

In collaboration with the Colonial Insecticide Research Unit and the Tanganyika Malaria Unit, an essay in spraying D.D.T. solution by aircraft was undertaken at Dar es Salaam in April-May. Several factors militated against the success of this trial; one was the exceptionally heavy and frequent rain that occurred during this year's long rains at Dar es Salaam; another was an injury to the pilot of the aircraft, resulting in interruption of the continuity of the applications; and a third was an unheralded alteration of the long established municipal catching stations that interfered with the assessment of the results. Additional catching stations were selected prior to the commencement of the spraying and, until results from these have been accumulated over a full cycle of the year, it will not be possible to make a final assessment of the results.

In the meanwhile some provisional conclusions may be suggested. No absolute anopheline control was achieved, and no apparent reduction in anopheline density in the catching stations was found. On the other hand during the period of spraying the catches in uncontrolled areas became three or four times greater, while the catches in the sprayed areas rose only slightly. There was in fact a strong suggestion that the normal seasonal rise in anophelism had been checked, in the area sprayed. In some of the catching stations this may in part have been attributable to an increased efficiency on the part of the normal ground control; in others where there was no ground control it could be attributable only to the airspray. The former explanation is an unlikely one, as the seasonal failure of ground control methods, so usual in a tropical African town as difficult for control as Dar es Salaam, was more than usually apparent during the months of April and May in the municipal area as a whole.

Several queries remain; among them doubt as to the effect of the undue interval between sprayings, the adequacy of the D.D.T. dosage and the suitability of the particular type of spray used. An unfortunate limitation on further investigation of such questions is the high cost of their undertaking, since they can only be answered by similar practical applications. But the experiment has led to the re-examination of the whole basis of larvicidal action by such insecticides as D.D.T. in oily solutions, and this examination, which is all to the good, is now proceeding.

The following table gives an indication of the course of anopheline infestation during the course of the spraying.

TABLE V
Average Anopheline Vector House Catches

Week ending	Sprayed areas	Extra-limital areas	Difference of means	
10-2-51	14.2	5.6	None Significant	
17-2-51	8.0	4.7		
24-2-51	9.9	4.0		
3-3-51	17.4	7.8		
10-3-51	12.1	13.7		
17-3-51	12.5	6.7		
24-3-51	8.4	12.5		
31-3-51	6.9	17.1		
7-4-51	5.1	26.5		Exceeds 5% level
14-4-51	4.8	26.8		do.
21-4-51	7.6	24.7	do.	
28-4-51	11.7	45.7	Exceeds 1% level	
5-5-51	14.4	42.3	Exceeds 5% level	
12-5-51	17.6	47.9	do.	
19-5-51	12.0	36.6	do.	
26-5-51	9.5	50.4	Exceeds 1% level	
2-6-51	12.4	42.6	Exceeds 5% level	

The cost of this spraying varied to some extent with the dosages used. At one quart/acre, insecticide cost Sh. 1/07 per acre. The flying in either case cost Sh. 3/13 per acre. The total cost per acre was therefore either Sh. 4/20 or Sh. 5/27 depending on whether one or two quarts were applied per acre. Owing to the retention of an aircraft and pilot wholly for this work, the flying cost nearly £40 an hour or £95 a square mile, and the total at the higher dosage £175 a square mile, in round figures, per treatment.

These costs can only with difficulty be compared with those of spraying on the ground. Whereas the wet areas would cost a minimum of Sh. 22 an acre with a plain mineral oil mixture, with a D.D.T. larvicide they would cost about Sh. 3. On the other hand, when working on the ground, dry areas can be avoided as they cannot be from the air, and the average cost in the area under consideration might perhaps be put at two-thirds of the above figures: bearing in mind that an incomplete coverage will be the rule.

GENERAL

Relationships with the several territorial medical departments have remained satisfactory, and an increasingly close co-operation has been attained in a number of directions. In the case of the East Africa Medical Survey and Filariasis Research Unit, and of the Colonial Insecticide Research, whose interests have so much in common with those of this Unit, co-ordination of activities has been effected by means of discussions and reciprocal visits, and no wasteful overlapping is allowed to occur.

Relationships within the Unit have been equally happy; all the wives of European members of the Unit have assisted either in the secretarial or in the technical aspects of the work. In this connexion mention may be made of the progress that has been made in the building up of a library, with the assistance of Mrs. A. M. Gillies. Several intelligent African recruits have, during the year, begun to play a useful part in the activities of the Unit.

D. BAGSTER WILSON,
Director, East African Malaria Unit.

VII. CHEMISTRY

Since the arrival of Dr. T. E. Fletcher in September 1954, he has been occupied in equipping his laboratory : a process that has been delayed by inordinate shipping delays, and some essential chemicals have not even yet arrived. The main elements of his programme will concern the assessment of the inter-relation between available insecticide and biological effect, in residual spraying, and in particular the study of the development of insect resistance and its mechanism in anopheles.

Dr. Press has been assisting on the human side of the Pare Scheme, by doing haemoglobin estimations, and some five hundred cholesterinase estimations. He has also worked out a colorimetric method, whose value still remains to be confirmed, for the estimation of Dieldrin. This method consists in the transformation of Dieldrin to Aldrin, bromination of the double bond, and estimation of the excess of bromine remaining.

There has been close collaboration between the chemists at Amani and at the Colonial Insecticide Research at Arusha.

IX. ENGINEERING AND OTHER ADVICE

The Malaria Engineer was fully occupied up to the date of his leaving on resignation. During the period covered by this report he investigated and reported on drainage projects at Arua, Gulu, Lira and Tororo in Uganda. He made a similar contribution at Eldoret, and his advice was sought from Mombasa. In Tanganyika he prepared substantial plans for Mtwara, Lindi, Kilosa, Dar es Salaam and Korogwe.

In other directions, the advice or assistance of the Institute has been given in a variety of ways. These have included the rather difficult problem of control in the eroded valleys of Songea township, and the development of Korogwe and Mtwara. Liaison and support have been given in the investigation of the important new problems arising from dam building programmes, both in Kenya and Tanganyika.

An active part has been taken in the long awaited Nandi residual spraying campaign in Kenya, which is complementary to the Pare experiment, the one being in an epidemic highland area and the other in a lowland hyperendemic one. The Director has paid several visits to this project, and the necessary examination of some thousands of blood films is being carried out at Amani.

X. UNITED NATIONS ORGANISATIONS ASSISTANCE

This assistance has taken various forms. On the one hand four staff members have been working at Amani since the end of 1954 : Dr. Holstein, some of whose work is referred to above, but who has also been endeavouring to decipher the chromosome patterns in the salivary glands of larvae of *A. gambiae* : Dr. Press, who has been filling a variety of gaps in the chemical field, in spite of inadequate equipment, and has also worked at Arusha with the Colonial Insecticide Research Unit ; Mr. Taylor-Allan who has assisted in a variety of ways in fostering the teaching aspect of the Institute's activities, both in the preparation of teaching material and by actual teaching ; and Mr. Showman, who is rapidly acquiring the necessary techniques both in the laboratory and especially in the field.

On the more material side, the United Nations Children's Fund has contributed vehicles, spraying equipment and insecticides for the Pare Malaria Scheme, and some substantial items of equipment to the Institute for teaching and research, especially in connection with the evaluation of the residual spraying in Upare.

VI.—CHEMICAL AND INSECTICIDE WORK

DIELDRIN ESTIMATION AND OTHER WORK

T. E. Fletcher

Two of the problems which are at present waiting investigations are first the differentiation between the residual, vapour and particulate action of dieldrin, sprayed as a wettable powder on a mud wall, and second the possibility of the development of resistance to this insecticide in *A. gambiae*.

Both these problems require a rapid and accurate method of dieldrin estimation at the microgram level. The phenyl azide colorimetric method is considered too laborious, and work is in progress on a new method of analysis. This depends on reducing dieldrin to aldrin and attempting to react it with a reagent absorbing heavily in the ultra-violet to form a product having appreciable U.V. absorption.

Considerable time has been spent in training African staff and on a range of smaller projects in support of other workers at the Institute. These include a considerable number of calcium determinations of water from breeding sites of *Phyopsis globosa*, the calibration of microloops, and general advice on various aspects of insecticides particularly the newer phosphorus compounds.

CHEMICAL ANALYSES AND DIELDRIN ESTIMATION

J. M. Press

(World Health Organization)

The following analyses were carried out in connection with the physical assessments which are made of samples of the population in the Pare-Taveta area:

Cholinesterase	in whole blood	944 determinations;
Haemoglobin		70 determinations;
Proteins (albumin and globulin)		52 determinations.

The following analyses of daraprim were carried out in connection with experiments conducted by Dr. Clyde, Malariologist to the Government of Tanganyika, on the prophylactic action of this drug:—

Daraprim	in serum	41 determinations;
Daraprim	in the milk of lactating women	21 determinations.

A new method was developed for the analysis of dieldrin. By this method dieldrin is transformed into aldrin after removal of the epoxy group by using the reduction acid mixture of 48 per cent hydrobromic acid plus acetic anhydride and zinc, and the estimation of the insecticide is made by colorimetric determination of the excess of the bromine after bromination of the reactive double bond with the dye "Fast Green FCF".

The accuracy of the method is 20 to 40 microgrammes. It has not yet been tried for estimations required by field workers.

THE VAPOUR TOXICITY OF DIELDRIN

A. S. Msangi

Experiments have been started to assess the vapour toxicity (as opposed to the particulate toxicity) of dieldrin. The preliminary stages of these experiments strongly suggest that, although the particulate action is obviously the more important, the vapour action is quite considerable, and must be taken into account when trying to assess the toxicity of dieldrin residues in houses which have been sprayed with the insecticide. *Anopheles gambiae* laboratory-bred females were exposed to the vapour of 50 per cent water dispersible powder of dieldrin (the form used in residual sprays in the Pare-Taveta Malaria Scheme) for 24 hours. A large proportion died during the 24 hours' exposure period and all the rest died during the subsequent 48 hours. Mortality in the controls was very considerably less.

V.—SECOND YEAR RESULTS OF RESIDUAL SPRAYING: ANOPHELINE FINDINGS

A. Smith

1. HOUSE CATCHES OF ADULTS

The level of anopheline infestation in treated houses in the Taveta Pare area remains very low, following the residual spraying first carried out in July—November 1955. Houses were again sprayed in two further cycles, during February—June 1956, and October—February 1957. In Table 3 certain periods before and after spraying are contrasted. As *A. funestus* has now disappeared from the area, figures for *gambiae* only are shown, and the reduction in numbers of this species is of the order of 95—97 per cent. A summary of the catches in untreated experimental huts is given in Table 17 on page 18, and this reveals the persistence of a considerable *gambiae* population ready to enter houses. This is confirmed by casual catches, in houses untreated either because they are new or have been missed, that have been as high as 71 per house during the year.

TABLE 3.—SPRAY CATCHES OF *A. GAMBIAE* BEFORE AND AFTER DIELDRIN APPLICATIONS

	Before Treatment			After Treatment		
	1955		1955	1956		1957
	Mar.-May	June-Aug.	Mar.-May	June-Aug.	Mar.-May	
Taveta	14	6	0.2	0.06	0.4	
S. Pare Roadside	36	5	3	0.1	1.4	
S. Pare Swamp	63	38	18	1.1	2.9	

2. ANOPHELINE INFECTIVITY

No *Anopheles funestus* of the type form has been caught. A few hundred specimens of uncertain taxonomic status, but of the *funestus* group, that have been dissected, have all shown uninfected salivary glands.

In the case of *A. gambiae*, collected chiefly from houses but also out of doors, 6,570 were dissected during the year, and 2 infected glands found. In each case, these infected specimens came from a very isolated village that had been missed or inadequately treated. Infectivity before treatment was 0.2 to 0.3 per cent.

3. HOST CHOICE: PRECIPITIN TESTS

Before residual spraying started, the position was that *gambiae* in houses had fed on man to the extent of 68 per cent around Taveta, and 35 to 88 per cent in the lower and upper parts of South Pare respectively. In and around the open cattle pens on the other hand, no more than 3 per cent had fed on man, and a very similar percentage was found in those caught on the outside of houses. Another 3 or 4 per cent have fed on other animals, but the great majority of the balance were, in all the above situations, cattle fed.

Tests carried out during the past year have given the results shown in Table 4, which shows that there has been no appreciable variation in the choice of host since spraying began. In this table "boxes" refers to simple box shelters placed in the neighbourhood of cattle pens and elsewhere. The suggestion of an increase in man-fed *gambiae* from boxes in S. Pare arises from the siting of a rather greater proportion of them nearer to human dwellings.

Some 290 *A. pharoensis* and 40 *coustani* were also tested; one of the former, and two of the latter, had fed on man.

4. ANOPHELES FEEDING AND RESTING OUTDOORS

There are no typical *funestus* coming to bite man outdoors. There are a few other members of the *funestus* group that do so however: all were identified, where this was possible, as *rivulorum*. So far as *A. gambiae* is concerned, in the two-hour period 19.00—21.00 hours, catches off paired observers' legs have ranged between 0 (five months) and 5.8 (months of January to March) per man/night. These figures are not significantly different from those for the previous year. A similar number of *coustani*, and a few *pharoensis*, are also caught on these occasions.

The collection of mosquitoes resting outdoors, by means of box shelters, and also from natural vegetation, has continued. But the numbers of *A. gambiae* caught on vegetation is insignificant and, as shown in Table 5, remains very low in boxes.

TABLE 4.—HOST CHOICE OF ANOPHELES AFTER RESIDUAL SPRAYING

	Number of tests	Per cent positive	
		Man	Ox.
<i>Taveta:</i>			
<i>gambiae</i> houses	132	71	27
<i>South Pare:</i>			
Main Road <i>gambiae</i> houses	340	82	11
Intermediate <i>gambiae</i> houses	370	53	37
Valley <i>gambiae</i> houses	1,403	37	52
<i>Taveta, Mata:</i>			
<i>gambiae</i> boxes	47	0	96
<i>gambiae</i> salt bush	10	0	100
" <i>funestus</i> " boxes	349	0.3	93
" <i>funestus</i> " salt bush	4	0	100
<i>South Pare:</i>			
<i>gambiae</i> bushes	37	0	97
<i>gambiae</i> boxes	176	19	56
<i>gambiae</i> house eaves	362	9	85

TABLE 5.—OUTDOOR CATCHES

Month	Number per 20 boxes/days	
	<i>A. gambiae</i>	<i>A. "funestus"</i>
<i>Taveta Forest:</i>		
... 20 Boxes		
June	0	1
July	0	6
August	0	6
September	0	3.3
October	0	10.7
November	0	15
December	0	7
January	2	3.3
February	0.7	0
March	0	0
April	0	0
May	0	0
<i>Mata:</i>		
... 5 Boxes		
June	—	—
July	0	14.7
August	1	8
September	0	34.7

or the old ones dry up; and they were also found to vary inversely with the rate of infectivity in the anopheline population. The method was also used to show that the time at which females come in to bite during the night was independent of their age-group.

But this method of separation of the very young by the need for two blood meals soon proved to have the disadvantages that a number of older females was included, and that in other areas it was not necessarily applicable. A further means of distinguishing nulliparous females was however observed, namely the presence of a mating plug for a short period after fertilization. This was most easily observed in *gambiae*, but was present in other anopheline species also. At the same time the methods used by other workers for the determination of age, by measurement of the ampullary part of the oviducts, and the recognition of qualitative changes in these or other parts of the ovaries, were fully tried out on the East African vectors, and found to be inapplicable when used alone. In the upshot, combinations of these various methods, developed either at Amani or elsewhere, have given reliable means of distinguishing the youngest age-groups, and have, for example, enabled a clear difference between the survival of *gambiae* in coastal areas and inland to be demonstrated. The latest developments in combinations of these techniques of age-grouping are referred to in the current section of this report.

The foregoing work has had a high relevance to the various essays in the arrest of malaria transmission that have been going on in various parts of Africa, and in particular to the Pare-Taveta Scheme, with which it has in fact been closely interlocked. The relevance of means of assessment of out-door populations, of changes in the survival rate, and of changes in the densities of *Anopheles* will become apparent later in this review.

THE EFFECT OF INSECTICIDE SPRAYING OF HOUSES ON MALARIA TRANSMISSION

The area that was subject to this experiment is shown in the map. After a period of preliminary assessment, which was, as is ever the case, found to be inadequate in length, but none the less greater than in any similar scheme, the first spraying was carried out in some 15,000 houses. This protected not only those living in these houses, but also the people who were normally resident in the mountains above, but often visited below.

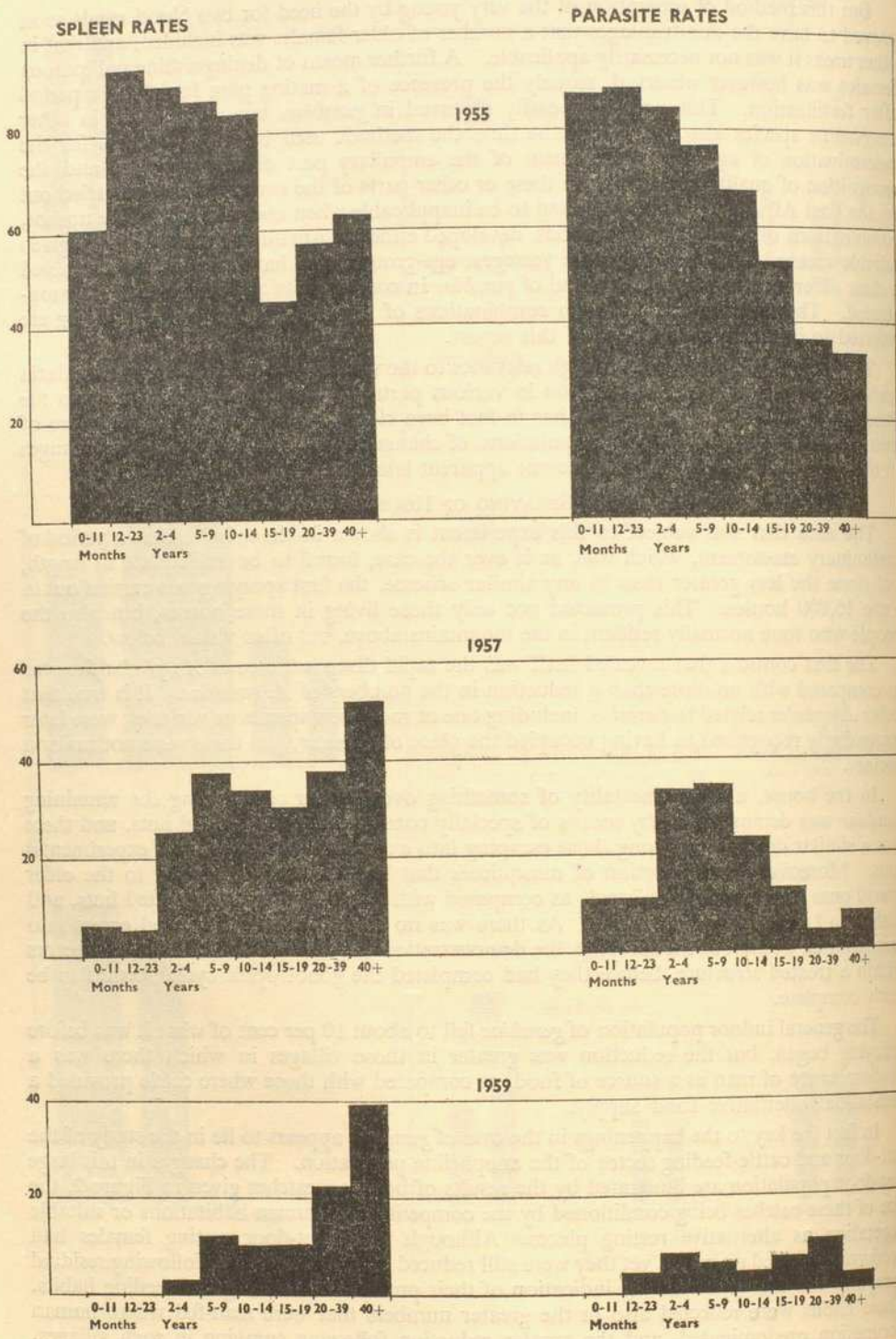
The first contrast that revealed itself was the rapid disappearance of *Anopheles funestus* as compared with no more than a reduction in the numbers of *A. gambiae*. It is true that other *Anopheles* related to *funestus*, including one or more new species or varieties, were later increasingly recognised as having occupied the place of *funestus*; but these were not malaria vectors.

In the house, a direct mortality of something over 40 per cent among the remaining *gambiae* was demonstrated by means of specially constructed experimental huts, and there was a similar death rate among those escaping into exit traps applied to these experimental huts. Moreover the proportion of mosquitoes that had fed the same night to the older gravid ones rose to a ratio of 7 to 1, as compared with 5 to 1 in similar untreated huts, and with 2 to 1 before spraying began. As there was no evidence of an increased egress into exit traps as a result of the spraying, the demonstration of death of most of the adult vectors within a treated structure, before they had completed the gonotrophic cycle, seemed to be fairly complete.

The general indoor population of *gambiae* fell to about 10 per cent of what it was before spraying began, but the reduction was greater in those villages in which there was a predominance of man as a source of food, as compared with those where cattle provided a substantial alternative food supply.

In fact the key to the happenings in the case of *gambiae* appears to lie in the study of the out-door and cattle-feeding sector of the anopheline population. The changes in this large out-door population are illustrated by the results of box-trap catches given in Figure 2, the size of these catches being conditioned by the competition of human habitations or suitable vegetation as alternative resting places. Although these out-door resting females had predominantly fed on cattle, yet they were still reduced by over 90 per cent following residual spraying, and this is in itself an indication of their promiscuous resting and feeding habits. These habits were reflected also in the greater numbers that were man-fed where human occupation predominated, and the greater reduction following spraying in such villages.

FIGURE 4 ENDEMIC INDICES TAVETA FOREST



Following further the results of tests for the origin of blood meals, it was found that *funestus* was always 80 to 90 per cent man-fed, and the same was true of *gambiae* in the villages where there were few or no cattle. On the other hand in the villages with many cattle, the percentages fed on man and cattle were approximately equal among females caught in houses; and 90 per cent or more of those caught outside were cattle fed. Although there was no apparent change in the man-biting habit of *gambiae* as a result of the treatment of houses, it is to be noted that there was some indication of an appreciable amount of feeding on people sleeping out-of-doors during the hotter weather.

During the preliminary assessment, it was shown that the calculated human inoculation rate of 25 to 50 times a year was maintained by weight of anopheline numbers, as anopheline infectivity was comparatively low. After spraying, only three infected *gambiae* were found, in exceptional circumstances on the periphery.

Assessment of anopheline survival by the determination of relative numbers in the youngest age-group as compared with the remainder of the population gave a calculated increase in the daily mortality rate in the *gambiae* population as a whole from about 14 to about 23 per cent, leaving too high a survival rate for the interruption of transmission to be likely to occur.

Although the endemicity of malaria varied according to rainfall and local topography, the changes resulting from the insecticidal treatment did not differ correspondingly: they depended far more directly on the mosquito-host relationships. The magnitude of the reduction in human parasite levels is illustrated by Figure 4, referring to an area in which man was the main host of the vectors. Parasite rates fell slowly at first, and then more rapidly, from the hyperendemic levels of 90 to 30 per cent (according to age) down to less than 10 per cent. The change in spleen rates was, for evident reasons, less striking, especially among adults; although there was a considerable reduction in average spleen size at all ages. It is perhaps especially worthy of notice that the gametocyte rate, and therefore presumably human infectivity, did not fall to the same degree as the parasite rates. This finding is not shown in the figure, but was present in all areas.

The evaluation of the factors responsible for the parasitaemia remaining at the end of four years' treatment is not easy. One clear conclusion, established by the repeated examination of infants, to whom special attention was given, and questioning with regard to their movements, is that, of the 2 to 5 per cent of infections found, half must have been acquired locally, some part of the remainder being putatively attributable to journeys outside the treated zone. The third possibility is that of recrudescence parasitaemia. The much higher residual parasite rate in the older children is unlikely to be due to any greater frequency of infection acquired outside the area, nor is there an evident probability of their being more liable to reinfection than infants, yet the alternative presupposes a very long persistence of *Plasmodium falciparum*, the species that was a little more predominant at the end than at the beginning of the experiment. As parasite rates were still falling at the end of the period under review, this question remains open, as does that of whether infants or children provide the more sensitive index of new infections.

These human results in general indicated that, from the point of view of human morbidity, transmission was reduced to an unimportant level but not arrested. They supported the mosquito results, in that transmission was more nearly arrested in the villages where cattle were least available to provide an alternative source of food for the anopheline vectors, even though a good deal of infectivity persisted in man.

The malarial status of the protected communities after spraying did not greatly differ from that in similar projects in Africa, although malaria transmission was perhaps cut down to a rather lower level than in most. Where it did differ was in the measure of the assessment, and therefore in the understanding of the events leading up to this result. Whereas the dosage of insecticide and the spacing of spraying were not inadequate, but caused an overnight mortality of 40 per cent among the *gambiae* remaining in the house or leaving it, the effect on the survival rate of the population as a whole was only to halve it. It seems therefore that the alternatives of food and shelter available to *gambiae* were what

provided it with the opportunities for survival. To what extent this conclusion is generally applicable must depend on the uniformity or variability in the genetic composition of this species. There remains the paradox that the more fully *gambiae* depends on man in an area, and the more actively therefore it transmits malaria, the more effective residual insecticides are likely to prove against it.

Other projects of residual spraying in East Africa, in which this Institute has taken an interest and an active part in various ways, namely those in the Nandi District of Kenya and in Zanzibar, have given general support to these conclusions. In the first place they have emphasised the necessity, in the present state of knowledge, of adequate preliminary assessment of all spraying projects: a conclusion now at length being accepted elsewhere. Secondly, in Zanzibar and Pemba the dependence of the effectiveness of spraying on the man-mosquito relationship, especially with regard to feeding, is so far in accord with the Pare-Taveta results.

APPLICATIONS OF INSECTICIDES

Some contribution has been made by Institute staff to the important watch for the development of insect resistance to insecticides. In fact susceptibility to dieldrin—the insecticide used in the Pare-Taveta Scheme—did not change, although various methods of assessment were employed on a considerable scale. On the other hand domestic culicine mosquitoes and other household pests such as bedbugs, fleas, and lice showed either a natural resistance, or an increasing resistance with the years.

A detailed analysis of costs, has shown that the average cost per house, over the last three spraying cycles, was Shs. 3.95, or Sh. 1.15 per head of the population directly protected, plus about 2 per cent additional for overall supervision and accounting.

The opportunity was also taken to measure the degree of exposure among the spraymen to the somewhat toxic insecticide. Examination of absorbent pads worn by the spraymen indicated that the daily skin exposure was of the order of 100 mg. a day. This did not give rise to any symptoms except in one dubious case, in contrast to other schemes in which longer hours were worked, and perhaps less adequate precautions taken. More recent work on excretion of dieldrin is referred to in the current section of this report.

In spite of the present emphasis, in the anti-malarial use of insecticides, on the attack against adult mosquitoes, larvicides still play a very important part in the prevention of malaria in East Africa, and various forms of application have received attention. Assistance was given in the assessment of trials of a granular formulation of dieldrin, first applied by hand and then, after this had proved successful, from aircraft. The very great advantage of this type of preparation in dealing with breeding places that are overlain by vegetation was abundantly proved. Attempts to find or develop a machine for application from the ground are continuing.

A further enquiry into larvicidal formulations concerned the need for the addition of a spreading agent to larvicidal oils containing a chlorinated hydrocarbon such as DDT. It was found that the assumption of the necessity for this additive, to increase the rapidity and effectiveness of spread on the water surface, was in fact unfounded. Reference is made in this year's record to a comparison between DDT and BHC as an active principle in this type of larvicidal oil.

In general the objective of avoiding those problems that could be studied elsewhere has been adhered to. The establishment of a semi-field testing technique at Amani has enabled trials of larvicides to be undertaken with a precision, and a relevance to African field conditions, that does not appear to be available elsewhere.

It is in this field that dependence upon and collaboration with the Colonial Pesticides Research Unit has naturally been closest.

THE CHEMICAL CONTRIBUTION

It should have become apparent in the course of the preceding pages how often the completeness of various investigations has depended on the assistance of the chemical section of the Institute. This has applied to the work on larvicides, and of course to the biochemical estimations in connection with the Pare-Taveta Scheme. The assistance of a