MALARIA CONTROL IN THE NORTHERN TRANSVAAL

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The object of this paper is to present a short review of the present position in the Northern Transvaal as regards malaria control over an area of over 60,000 square miles with a population of about a million and a half with a relatively thin rural distribution.

As far back as 1930 a beginning was made to control malaria in the Northern Transvaal, when the late Dr. Siegfried Annecke started work from his headquarters at Tzaneen. With the materials then available a significant measure of success was attained by 1943. The anti-malaria organization was expanded after the war and it reached its present strength by 1947. Since then it has not failed in its purpose even during seasons most favourable for the epidemic spread of malaria. It is considered that well over 80% of the population at risk 10 years ago are now protected and free of risk from malaria.[1] A stage has now been reached where the disease may be considered as eradicated over large parts of the Northern Transvaal and hypo-endemic in the remaining areas, where the vector density had been greatly reduced by anti-mosquito measures and the parasite pool in man had consequently died out. The contact between vector and parasite, however, is subject to considerable fluctuations caused mainly by climatic variations. Control measures must therefore continually be adapted to these fluctuations.

Other factors, like the cost of malaria control, the possible development of resistance by the vector to the residual insecticides, or the development of resistance in the parasite against the 4- and 8-amino quinoline anti-malarial drugs like daraprim, make it necessary that methods of malaria control should be continually reviewed and adapted to changing circumstances. In his annual report for 1955 the Director General of the World Health Organization[2] draws attention to the danger that threatens tropical and sub-tropical countries if the malaria parasite or the vector develop the resistance that have been observed in certain areas such as Northern Nigeria and the Middle East. In the introduction of his report Dr. Candau[2] states that 'in the field of communicable diseases the main development in 1955 was the new approach to the malaria programme by the VIII World Health Assembly, who decided that, as the capacity of anopheline vectors to acquire resistance to insecticides can now be considered as an established fact, the only rational plan was to aim at the eradication of the disease in the shortest possible time wherever this is technically feasible'.

The further fact that the boundaries of the Northern Transvaal are common with those of 4 other territories where malaria occurs, has now become one of the most important factors to be taken into account in planning our future methods of malaria control. This factor has also been stressed by the WHO at its various recent Regional Malaria Conferences,[3] and elsewhere.[4] It is therefore necessary to show here how the malaria control measures which are being applied in the Northern Transvaal are designed to comply with the requirements of the VIII World Health Assembly, namely to eradicate malaria in the shortest possible time wherever this is technically feasible.

Malaria Incidence and Case Distribution

The number of cases of malaria that occur in an area is the most important indicator of the size of the malaria

problem and of the measures that should be taken to control it. In Table I are given the cases reported to the Union Health Department since 1950. The years 1950-52 were exceptionally

TABLE I. CASES OF MALARIA NOTIFIED IN THE NORTHERN TRANSVAAL 1950-57

Year ended 30 June	*No. of Cases*	*Year ended 30 June*	*No. of Cases*
1950 ..	51	1954 ..	104
1951 ..	41	1955 ..	251
1952 ..	19	1956 ..	131
1953 ..	700	1957 ..	92*

* 45 Europeans and 47 Natives.

dry and were followed by a number of years of heavy rains during the summer season. The table includes all cases reported by medical practitioners and hospitals in the Northern Transvaal region, but excludes a large number of cases which occurred in the Witwatersrand gold mines. These mines recruit a large proportion of their Native labour from

TABLE II. DISTRIBUTION OF MALARIA CASES IN NORTHERN TRANSVAAL, YEAR 1955-57

Area	*Districts*	*No. of Cases 1955-56*		*No. of Cases 1956-57*
West ..	Rustenburg	1	9	6
	Waterberg	8		
Central ..	Potgietersrus	2	5	1
	Pietersburg	3		
North ..	Soutpansberg ..	49	62	38
	Letaba	13		
East ..	Pilgrims Rest ..	28		
	Nelspruit	12	52	47
	Barberton	12		

areas outside the Union, and during 1956-57 97 cases of malaria were reported by them. Amongst the malaria cases included in Table I 8 were imported by Natives who came from outside the Transvaal to work on rural farms, and 20 were imported European cases. Most of the cases in Europeans are due to carelessness when staying or moving

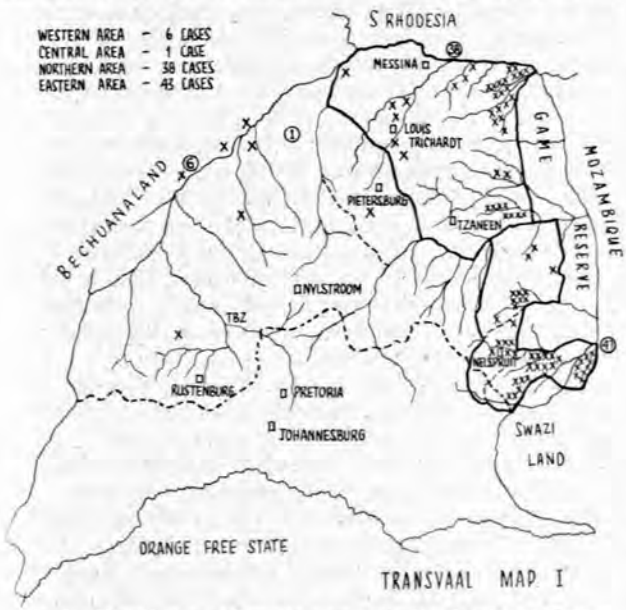

Fig. 1. Distribution of malaria cases in the Northern Transvaal, year ended 30 June 1957.

in the recognized dangerously malarious areas. In Table II is shown how the cases reported during the year 1956-57 are distributed in the Transvaal in comparison with the cases reported in the previous year. The details are further arranged to indicate more clearly the extent of the problem which remains to be solved. To illustrate the position further the details of Table II are shown on Map I (Fig. 1).

Malaria Mortality

With the introduction of more efficient anti-malarial drugs during and since World War II, the mortality from malaria is negligible. In Table III is given the mortality figures

TABLE III. MALARIA MORTALITY, NORTHERN TRANSVAAL, 1949-53

Year ended 30 June	*Whites*			*Non-Whites*			*Total*
	Male	*Female*	*Total*	*Male*	*Female*	*Total*	
1949 ..	4	2	6	21	7	28	34
1950 ..	5	3	8	7	2	9	17
1951 ..	6	4	10	11	1	12	22
1952 ..	4	1	5	8	3	11	16
1953 ..	3	5	8	41	27	68	76

compiled by the Bureau of Census and Statistics for 1949-53. The increase in the mortality figures for 1953 is partly the result of the enforcement of registration of deaths amongst Natives. An increase would also be the natural result of the higher case incidence in 1953 (Table I).

Spleen Rates

Another indication of the incidence of malaria is the spleen rate but this index is now considered to be approximately accurate only if the same observer examines the spleens. One medical officer could not inspect the spleens of a representative number of children in each part of the Northern Transvaal and spleen rates have been abandoned in favour of random sampling by taking a number of blood smears much larger than the number of spleens that could be examined.

Parasite Rates

Blood smears are now taken regularly by experienced technical assistants and health inspectors and from Table IV a clear indication can be obtained of where the highest

TABLE IV. PARASITE RATE: RANDOM SAMPLING BY THICK BLOOD SMEARS, NORTHERN TRANSVAAL

Area	*District*	*Year ended 30 June 1956*		*Year ended 30 June 1957*	
		No. taken	*No. positive*	*No. taken*	*No. positive*
West	Waterberg	385	1	1,821	—
Central	Potgietersrust ..	130	1	414	1
	Pietersburg ..	—	—	254	—
	Groblersdal ..	—	—	139	—
North	Soutpansberg ..	275	15	961	182 (18·9%)
	Tzaneen	454	—	2,038	89 (4·3%)
East	Lydenburg	321	1	200	—
	Pilgrims Rest ..	—	—	717	—
	Nelspruit	1,031	4	479	8 (1·7%)
	Barberton	70	3	604	13 (2·2%)
	Komatipoort ..	666	25	1,348	45 (3·3%)
Total	12	3,332	50	8,975	337 (3·6%)

parasite incidence occurs and where any danger remains. A thick smear is taken of each case and is stained in the laboratory at Tzaneen by Giemsa's method.

To obtain an indication to what extent malaria transmission still occurs in the eastern areas the number of positive blood smears were classified in Table V according to the

age and sex. It will be seen that there is a higher rate in males of school age but not in older males. After school age the males leave home to work in the mines or the larger towns, whereas the females remain exposed to malaria at home and therefore show a higher incidence throughout the higher age groups. Transmission is most intense in the Soutpansberg even in the lowest age groups. Further to clarify the distribution of the malaria parasite, Map II (Fig. 2) has been prepared to indicate more clearly than figures where the danger remains and where anti-malaria measures must be intensified.

TABLE V. RANDOM BLOOD SURVEY: MALARIA CARRIERS, NORTHERN TRANSVAAL, 1956-57

Age	0–12 months		13–24 months		2–4 years		5–9 years	
Sex	M	F	M	F	M	F	M	F
No. positive	3	—	11	4	20	23	64	45
No. tested	56	68	262	257	409	442	719	665
Percentage positive	5·4	0	4·2	1·6	4·9	5·2	8·9	6·8

Age	10–14 years		15–19 years		20–29 years		30–39 years	
Sex	M	F	M	F	M	F	M	F
No. positive	54	34	10	13	4	11	6	13
No. tested	605	614	329	217	152	280	187	312
Percentage positive	8·9	5·5	3·0	6·0	2·6	3·9	3·2	4·2

Age	40–49 years		50–59 years		60–69 years		70+ years		Total
Sex	M	F	M	F	M	F	M	F	
No. positive	1	6	3	7	2	2	—	1	337
No. tested	165	224	78	82	49	50	8	11	6,241
Percentage positive	0·6	2·7	3·9	8·5	4·1	4	0	9·1	5·4%

Fig. 2. Parasite distribution according to random blood survey, Northern Transvaal, year ended 30 June 1957.

Parasite Resistance

There is no indication of parasite resistance to any of the various amino-quinoline drugs; they have not been used intensively in a mass chemotherapy campaign. The reports of resistance concern mainly daraprim and so far trials have been limited to the use of chloroquine diphosphate (Avlochlor) on small groups. The difficulty is to trace in the Native areas, those cases who had received the drugs. Of 51 cases who had positive blood smears, only 28 could be traced after 2 months, and of these only 2 had positive blood slides. The attempt to administer the drug in those areas in the north-east part of Soutpansberg on the Limpopo River will be continued where the parasite rate is highest (see below). The cases are difficult to trace at certain seasons when they cross the Limpopo into foreign territory.

Research into the susceptibility of the parasite to the various amino-quinoline drugs, into variation in form of the parasite and its relapse pattern, was not attempted because of the relative rarity of the disease and the absence of adequate facilities to do this type of research. Apart from the finding of the parasite in cases of suspected malaria for the purpose of diagnosis, routine enquiry was made in order to determine the source and locality of infection. It is realized that problems in respect of the parasite await solution but it does not appear that the lack of a solution will materially retard the final attainment of the object of malaria eradication.

Chemotherapy

Several hospitals in the Soutpansberg and Pilgrims Rest districts reported in 1956 that they preferred camoquin (amodiaquine) in the treatment of cases of malaria because this had proved effective and no cases came back for treatment of a relapse. Over a period of 18 months up to June 1956, 50 cases were treated at Masana Hospital for falciparum malaria, 46 receiving camoquin with excellent results. Of the other cases one died of cerebral malaria and one developed haemaglobinurea after treatment with mepacrine. Over a period of 2½ years the Elim Hospital reports only 24 cases, of which 23 suffered from *P. falciparum* and one from *P. malariae*; 12 cases were treated with camoquin, 7 with aralen (chloroquine) and 1 with atebrin and plasmoquin. The treatment of the other was not recorded but no deaths were noted.

Those district medical officers who replied to enquiries in 1956 stated that they rarely see cases who suffer from malaria. Whenever a case is suspected of suffering from malaria they resort to treatment with camoquin or chloroquine, usually without taking blood smears beforehand and with very satisfactory results. They stated that it was very easy to treat and cure the case at once and that they hesitate to delay cure in order to take blood smears for examination. They appear to be in danger of losing their clinical skill at diagnosing malaria because they rely on a therapeutic test of their suspicions. It was also remarked that paludrine does not give the dramatic results usually obtained by administration of camoquin or chloroquine, while daraprim does not appear to be often used.

There has been no observation showing that the local faciparum strain of the parasite has developed any resistance to the drugs used in treatment or in prophylaxis. Many tourists and officials who proceed to malarious areas use these 4-amino-quinolines prophylactically. However, one medical practitioner observed a party visiting Northern Rhodesia, of which one section used paludrine as a prophylactic and the other section chloroquine. After their return those who used paludrine developed malaria soon after stopping the prophylactic use of the drug, but none of those who used chloroquine developed malaria. The risk of

exposure to malaria infection appeared to be the same for both sections of the party. This medical practitioner has extensive experience in the treatment of malaria and is perturbed at the large number of non-immune persons who settle in the Soutpansberg district without taking any precautions against malaria infection.

Vector Incidence

Little investigation could be made in the last few years into the bionomics of the vector *A. gambiae* owing to loss of professional and technical staff. The position has now been rectified, and the work of testing resistance in malaria vectors and the effects of residual insecticides is in hand. The field staff, however, has continued to survey their areas regularly and carry on control work. For the check spraying of huts 4,173 gallons of pyagra in kerosene was used in the year 1956-57. Table VI indicates the results of their activities since 1951 in the search for vectors and their destruction. It will be noticed that in the abnormally wet years 1952-53 and 1954-55 the vector incidence was high; this resulted in the higher incidence of malaria shown in Table II. In order

TABLE VI. HABITATIONS TREATED AND VECTORS FOUND ON CHECK SPRAYING: NORTHERN TRANSVAAL, 1956-57

Year ending 30 June	Total habitations sprayed	Huts checked	Vectors found	Vector/hut ratio
1951 ..	356,819	168,812	1,572	1 : 107
1952 ..	320,785	175,063	1,133	1 : 139
1953 ..	414,787	145,219	5,806	1 : 25
1954 ..	287,566	149,911	716	1 : 208
1955 ..	352,863	170,763	3,512	1 : 48·6
1956 ..	288,730	170,762	902	1 : 189
1957 ..	300,774	183,275	3,280	1 : 55·8

to reduce the vector incidence a large number of habitations are sprayed as shown in Table VI. From this table it may be concluded that in favourable conditions such as occurred in 1952-53 and 1954-55 the vector does propagate itself rapidly and can be restrained only by the vigorous exertions of the anti-malarial organization. Further to illustrate the exact distribution of the vector, Map III (Fig. 3) and Map IV (Fig. 4) have been prepared for the year 1956-57 The maps indicate the presence of the vector in given areas but the absolute prevalence is not indicated. The vectors may have been found concentrated in a small number of huts or in limited areas. A comparison of Map III with Map IV shows how the larvae and adults were found along the Limpopo and other rivers and tributaries. It is the intention that this annual sequence of events should be limited by intensive larviciding measures every year, which will so decrease vector density as to ensure the eventual eradication of the malaria parasite in this area.

Fig. 3. Incidence of vector larvae, Northern Transvaal, year ended 30 June 1957.

Fig. 4. Distribution of adult *A. gambiae*, Northern Transvaal, year ended 30 June 1957.

Vector Blood Meals

In order to determine the nature of the meals taken by the vector mosquito, the blood in the gut of 294 wild-caught specimens were pressed out on filter paper, marked and sent to the Lister Institute at Elstree, London, for serological identification.[5] From the results in Table VII it will be seen that only 4 specimens had definitely fed on man and these mosquitos all came from the areas where the parasite rate was high. This method of determining the extent of contact between the vector and man is relatively inexpensive and less exacting and time-consuming than dissection for finding the sporozoite rate. The mammals which were tested for besides man were the sheep, goat, horse, pig, dog, cat, while 'bovids' included ox, sheep, goat and giraffe. Notwithstanding that 24 of the 293 tests did not differentiate further than 'mammal' and that a small percentage may have been human blood, the method of testing is fairly accurate. It determines 258 blood meals out of 282, or 91·1%, and is to that extent of assistance as an indicator of the activity of the malaria vector, which can be taken as predominantly zoophilic, presumably because the human population is almost entirely protected by residual spraying indoors. This aspect of malaria is discussed in an interesting way by Davidson[6] and Lacan.[7]

TABLE VII. SEROLOGICAL IDENTIFICATION OF MOSQUITO BLOOD MEALS: NORTHERN TRANSVAAL, 1956

Type of Mosquito	Origin of Blood in Mosquito Meals							
	Man	*Ox*	*Horse*	*Pig*	*Bovid*	*Mammal*	*Negative*	*Total*
A. gambiae	4	194	3	2	47	22	11	283
A. cinereus	—	2	—	—	1	—	—	3
A. demeilloni	—	2	—	—	—	—	—	2
A. longipalpus	—	—	—	—	1	—	—	1
A. listeri	—	—	—	—	—	1	—	1
A. pretoriënsis	—	1	—	—	—	1	—	2
A. rufipes	—	1	—	—	—	—	—	—
Total	4	200	3	2	49	24	11	293

A. funestus has apparently been eradicated in this area, so that *A. gambiae* is the only vector of importance.

Organization of Anti-malaria Staff

For the purpose of malaria control, the Northern Transvaal is being divided into 39 areas of approximately 1,000 square miles each under the supervision of trained European field assistants with 15-25 trained Native labourers. The field assistant has a ¾-ton motor truck with which to move about in his area, to check on the work of the labourers, to do mosquito and larval surveys and to convey supplies of

Fig. 5. Areas under control of malaria field assistants, Northern Transvaal, 1957.

DDT and BHC to the points where it is needed by the labourers. The distribution of field assistants is shown in Map V (Fig. 5); each has a camp in his area from which he operates, where insecticides are stored and to which the bulk stores are brought from time to time as required. Each labourer is provided with sufficient insecticide for his area together with an Eclipse can and sprayer to spray with BHC wettable powder the huts and other outbuildings and structures where vectors find a hiding place. For antilarval work DDT-Emulsion M.25 and Malariol are used. The amounts of all insecticides used are shown in Table VIII. The number of huts sprayed with insecticide, the number of huts checked by pyrethrum sprays for the presence of adult *A. gambiae* and other anophelines, as well as the number of vectors found, is shown in Table VI.

TABLE VIII. MATERIALS USED IN VECTOR CONTROL: NORTHERN TRANSVAAL, 1951-57

Year ending 30 June	*DDT-emulsion (gallons)*	*DDT 5% (gallons)*	*BHC-40% wettable powder (lb.)*	*Malarial (44-gal. drums)*
1951 ..	2,238	11,924	111,608	8,602
1952 ..	1,802	3,964	127,808	4,595
1953 ..	3,222	15,389	118,404	3,164
1954 ..	3,009	10,363	141,434	469
1955 ..	4,147	15,263	168,649	201
1956 ..	3,436	6,395	125,652	238
1957 ..	3,911	5,584	129,121	474

In view of the reduced incidence of the vector, the parasite, and cases of malaria, the number of field assistants and the labour force was being reduced proportionately in 1957.

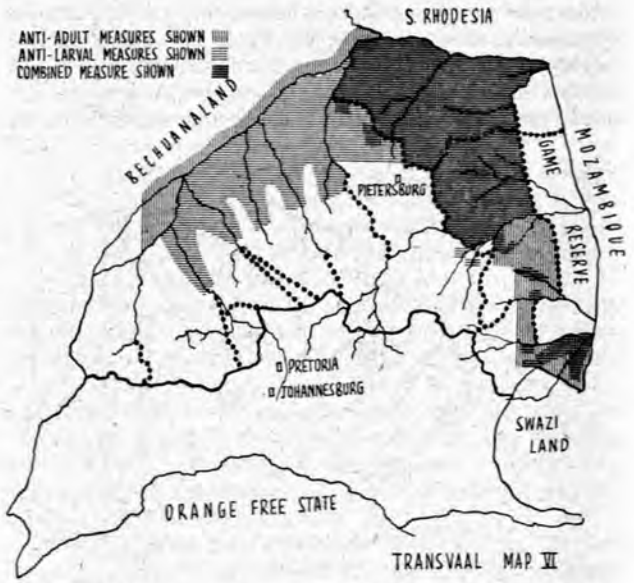

Fig. 6. Malaria vector control work in the Northern Transvaal, 1957.

From Map VI (Fig. 6) it will be seen that in the western and central areas of the Northern Transvaal the anti-larval work is limited to the large rivers where the vector breeds in winter, while residual spraying has been discontinued over the same areas to a large extent. In the northern and eastern areas

residual spraying still continues between once and twice every year.

Residual Spraying

DDT has been used for 10 years since 1947 as well as BHC later on, and so far no firm evidence of the development of resistance by the vector has been found. Now that it is realized[8, 9] that *A. gambiae* is a wild mosquito that only enters human habitations for its own convenience or owing to climatic conditions or pressure of mosquito population, a search in places other than human habitations has shown that practically as many vectors can at times be found outside as indoors. *A. gambiae* is not an obligatory domestic mosquito, but in the Northern Transvaal owing to its low density the search for it must be extensive and is usually only carried out by energetic and enthusiastic workers.

No systematic observations have been made on vector resistance by the Busvine test[10] but the work is in hand. Where the vector density is as low as in Northern Transvaal it is often impossible to find enough specimens to carry out a resistance test on wild-caught *A. gambiae*. Specimens from various areas are bred to ascertain whether any degree of resistance is present and whether it varies between different places in Northern Transvaal.

Vector Importation

A relatively minor danger is the importation of vectors in air and surface craft. Cases are known where vectors suddenly appeared nearly a hundred miles from the nearest known vector breeding places. This could only be explained by the fact that gravid vectors could be transported in motor vehicles which stay overnight near these breeding places, usually near the Limpopo River. Certain outbreaks of malaria in non-malarious areas might probably also be due to importation of infected vectors from malarious areas. If such importation of vectors becomes a menace to vector-free malarious areas steps may have to be taken to prevent its occurrence.

Anti-larval Measures

When it became evident that little further progress was being made in eradication through residual spraying, larviciding had been resorted to in areas which serve as the winter breeding places or vector nurseries, like the Limpopo River and its tributaries, Crocodile River and Olifants River. However extensively house-spraying and other anti-adult measures are carried out there will always be adults that escape and continue breeding in suitable places.

Larviciding by hand application with spraying apparatus is still the best method, because it enables the labourer to search out every pool and breeding place. Our present knowledge is based on many years of observation of the winter breeding places or nurseries of the vector along the large rivers and should enable us now to reduce the vector considerably by larvicidal measures.

Anti-larval measures must be taken during late winter and early summer, when the rivers are at their lowest and when pool formation in the river beds is limited, because later in the year floods assist by wiping out suitable breeding pools. To be effective these measures require to be coordinated on both sides of any river to avoid omitting important breeding places and so giving the vector a foothold to start breeding. This aspect is very important on rivers which form interterritorial boundaries, like the Limpopo, or where they cross boundaries, like the Olifants, Sabie, Crocodile and Komati Rivers.

Concern is often expressed at the continued simultaneous use of chemically related insecticides against both adults and larvae in the same areas, because the danger of development of resistance in the vector is greatest under such circumstances (Malaria Conference for the Western Pacific and South East Asia). Efforts are therefore being made in the Northern Transvaal to eradicate malaria as soos as possible, mainly by the destruction of the adults.

The need for larvicidal measures in addition to the imagocidal measures has been questioned mainly because it was believed that such a procedure, besides being expensive, induced resistance to the residual insecticides more quickly. This argument falls away now that Davidson has shown that resistance depends on a genetic factor. Experience in the Northern Transvaal has shown that winter conditions limit adult *A. gambiae* activity to defined stretches of the Limpopo, Olifants, Komati and other rivers. The water in these rivers is at its lowest during the day time just after July and August, depending on the amount and distribution of the rains during the previous summer. By carrying out fairly intensive anti-larval control in these larva-breeding stretches of rivers, the adults were limited to those river areas right into the summer season, which made much imagocidal work unnecessary.

Adults could always be controlled by resumption of residual spraying where they created a threat of malaria. Furthermore, large tracts of countryside are so thinly populated that imagocidal work is as expensive as larvicidal work. This argument of expense would not be valid if the residual insecticides could retain their activity over a period of 6-9 months. In that case it will have to be considered whether mass chemoprophylaxis in the remaining danger areas of the eastern part of the Northern Transvaal, together with residual spraying of all habitations and outhouses at the beginning of the summer, should not be adopted as the cheapest method of eradicating malaria. Until the prolonged action of the insecticides is proved and can be relied upon and until complete interterritorial cooperation in malaria is obtained, larval control is considered a necessary method of control in Northern Transvaal.

Places on the rivers inaccessible on foot could be reached by flat-bottomed boats. This aspect of anti-malaria work will require careful consideration to ensure complete control of vector breeding. The boats cannot reach all breeding places and there will be many difficulties if they have to be carried from one river stretch to another. Their usefulness therefore will be limited.

The application of insecticides by spraying from aircraft has been used successfully in the Union to eradicate tsetse flies and for other purposes. This method might be used to spray larvicides in otherwise inaccessible stretches of rivers, but it is expensive at 4s. 6d. per mile with a swathe of 30 yards. An aircraft certainly covers the mile more rapidly than a labourer with his spray apparatus, but it cannot reach every pool where breeding occurs, especially under trees and high rocks or when wind and weather are unfavourable. In bad weather aircraft may not be able to work at all for weeks at a time. Suitable landing-places also are not freely available.[11] The only drawback with Native labour is their fear of snakes, crocodiles, hippopotami and buffalo, near the larger rivers. In such conditions labourers can be

used in groups, but against these occupational risks they require protection and compensation.

With four-wheel propelled transport it is considered possible to reach most places along the banks of rivers where *A. gambiae* usually breeds, and with Natives to spray the breeding places it is concluded that it is less expensive and more reliable to ulitize hand-spraying methods than aircraft spraying.

Chemoprophylaxis

In the relatively small and well-defined areas where a moderate parasite rate is found it was decided to institute trials with chemoprophylaxis to reduce the parasite rate and the possibility of malaria transmission. Trials were commenced in the winter (July 1957) in order to observe the parasite rate throughout the following malaria season. The prophylactic is not given more frequently than at 4-6 weeks' intervals, because often in the summer season it is not possible to reach these areas more frequently owing to floods and the bad state of the approach roads.

The area chosen for the trial was at the northern end of the game reserve in the triangle between the Limpopo and the Levubu Rivers known as the Pafuri Game Protection Area. (See Tables IV and V and Map 2.). There are some 322 families in an area of over 62 square miles and each house was visited and chloroquine diphosphate (Avlochlor) and pyrimethamine (daraprim) was administered. The dosage of chloroquine base was 600 mg. or 4 tablets per adult of 13 years and over, 300 mg. or 2 tablets for children between 3 and 12 years, and 150 mg. or 1 tablet for children under 3 years. The tablets were administered from 30 July 1957 after thick blood smears had been taken, and the second series of blood smears were taken from 9 September 1957 and the second dose of drug administered. From Table IX it will be seen that the reduction in parasite incidence effected by chloroquine was from 29·6% to 5·3% and by daraprim from 24·1% to 2·4%, and from Table X that of those who were not treated at all 35·1% were found infected.

TABLE IX. MASS ANTI-MALARIA CHEMOPROPHYLACTIC TRIAL WITH (1) CHLOROQUINE DIPHOSPHATE AND (2) PYREMETHAMINE (DARAPRIM): NORTHERN TRANSVAAL, 1957

Age-group	Before Treatment + M	+ F	— M	— F	Number Examined	Number Positive
0—11 months	—	—	—	—	—	—
12—23 months	1	—	2	—	3	1
2—4 years	1	—	7	6	14	1
5—9 years	15	5	12	11	43	20
10—14 years	21	6	24	15	66	27
15—19 years	1	2	5	5	13	3
20—39 years	—	3	5	13	21	3
40—59 years	—	—	5	13	18	—
60+	—	—	2	6	8	—
Total	39	16	62	69	186	55 (29·6%)

Age-group	After Treatment with Chloroquine + M	+ F	— M	— F	Number Examined	Number Positive
0—11 months	—	—	—	—	—	—
12—23 months	—	—	—	—	—	—
2—4 years	1	—	6	4	11	1
5—9 years	—	—	26	10	36	—
10—14 years	6	—	34	18	58	6
15—19 years	—	1	5	5	11	1
20—39 years	—	—	4	10	14	—
40—59 years	—	—	5	7	12	—
60+	—	—	2	6	8	—
Total	7	1	82	60	150*	8 (5·3%)

Age-group	Before Treatment + M	+ F	— M	— F	Number Examined	Number Positive
0—11 months	—	—	—	—	—	—
12—23 months	—	—	1	1	2	—
2—4 years	3	—	4	2	9	3
5—9 years	3	3	2	1	9	6
10—14 years	1	1	—	1	3	2
15—19 years	—	—	—	2	2	—
20—39 years	1	1	3	12	17	2
40—59 years	—	—	2	4	6	—
60+	—	—	2	4	6	—
Total	8	5	14	27	54	13 (24·1%)

Age-group	After Treatment with Daraprim + M	+ F	— M	— F	Number Examined	Number Positive
0—11 months	—	—	—	—	—	—
12—23 months	—	—	1	1	2	—
2—4 years	—	—	5	2	7	—
5—9 years	1	—	4	3	8	1
10—14 years	—	—	—	2	2	—
15—19 years	—	—	—	1	1	—
20—39 years	—	—	—	12	12	—
40—59 years	—	—	2	3	5	—
60+	—	—	2	3	5	—
Total	1	—	14	27	42†	1 (2·4%)

* After treatment with choroquine diphosphate.
† After treatment with pyrimethamine (daraprim).

TABLE X. MASS ANTI-MALARIA CHEMOPROPHYLACTIC TRIAL CONTROL: NORTHERN TRANSVAAL, 1957

Age-group	Without Treatment + M	+ F	— M	— F	Number Examined	Number Positive
0–11 months	—	—	—	—	—	—
12–23 months	—	3	1	1	5	3
2– 4 years	4	5	3	2	14	9
5– 9 years	3	7	3	3	16	10
10–14 years	—	1	—	2	3	1
15-19 years	—	1	1	2	4	1
20–39 years	—	3	1	11	15	3
40–59 years	—	—	2	11	13	—
60+	—	—	3	4	7	—
Total	7	20	14	36	77	27 (35·1%)

It is proposed to repeat this prophylactic treatment, mainly with chloroquine because daraprim is suspected of creating a drug resistance in the malaria parasite and as so many tourists use daraprim as a prophylactic it is probably wise to limit mass chemoprophylaxis to drugs that are not suspected of generating parasite resistance. It may also possibly be more poisonous because it is tasteless, whereas chloroquine, being very bitter, is unlikely to be taken freely in poisonous doses.

It is interesting to note from Table IX that males predominated amongst the infected in the mass chemoprophylactic trial and from Table X that females predominated amongst those who omitted to obtain treatment at the first trial. No satisfactory explanation for this population distribution is yet available. *P. falciparum* was the only parasite encountered in this series.

Cost of Malaria Control

It is estimated that the expenditure on malaria control during the 1955-56 season was £145,000 in order to protect an estimated population of over 1,450,000. A more accurate method of accounting has since been adopted. Investigation

are in hand into the quality of the insecticide, the various formulations, dosages and methods of application

Endemiology

According to the definition of the Expert Malaria Committee of the WHO, malaria in the Northern Transvaal can now be described as hypo-endemic because the spleen rate in children under 9 years of age is under 10%. From the parasite rate (Table II) it would appear that the incidence is greatest along the eastern and north-eastern borders of our territory. Between Komatipoort and Pafuri the Game Reserve forms a buffer zone where little spread of the disease can occur because of its limited human population. It is on the other hand a nature reserve where vector control measures are not normally carried out except against vector larvae near the large tourist camps and against adult vectors immediately before the winter tourist season starts. It might therefore form a focus of vector propagation which must be watched carefully.

The annual occurrence of malaria in the northern and eastern boundary areas shows that the potential endemicity there is high and unless continuous surveillance is practised malaria may spread to become epidemic there, as well as in the western areas where vectors can propagate rapidly, as experience has shown in the past.

Of the factors that play a dominant role in endemicity the human carrier, the parasite and the vector have been discussed briefly. Human carriers exist in the Northern Transvaal and immigrant Natives may also import the parasite which infects the local vectors. A non-immune population is building up in the Northern Transvaal through immigration from other parts of the Union because of the economic opportunities in the Northern Transvaal afforded for example, by fruit, vegetable and cattle farming, the mining and timber industry, and canning and other secondary industries. The environment is suitable for the rapid propagation of the vector and the climate is so warm that the human element is much inclined to neglect personal precautionary measures. The general public accept it as a fact that malaria has been eradicated and acts accordingly. They also rely on drugs like camoquin (amodiaquine), and chloroquine (aralen, resochin) to cure malaria immediately. Others take these drugs as a preventive because they find it less troublesome and less expensive than to use bed nets, screen houses and take other such active measures. The chief reliance must therefore, from the public-health point of view, be placed on vector control and parasite eradication.

DISCUSSION

The various problems that require solution must now be discussed.

Statistics. It is necessary to ensure a more accurate recording of the number of cases of malaria and their thorough treatment and investigation in both Europeans and non-Europeans in malarious areas. At present there is a close liaison between hospitals, medical practitioners and the malaria staff in the Northern Transvaal so that most cases that apply for medical treatment are recorded. It is, however, felt that still greater accuracy is needed and for this purpose malaria was made a notifiable disease in 1956. There is now a statutory obligation on every medical practitioner, as well as tribal authorities as prescribed in sections 19 and 20 of the Public Health Act, to report every case of malaria, including cases of intermittent fever. There are at most a few hundred cases that would require notification. A prerequisite is the taking of blood smears from all suspected cases. The thorough treatment of all actual and suspected cases and a thorough investigation of the source of the infection is essential in order to eradicate the parasite.

Legislation. Existing legislation prohibits the creation of conditions which will facilitate the propagation of the vector mosquito. The application of this measure may initially be unpopular because it would require that farmers must ensure that irrigation water is so used that the water-table is not raised to an extent where puddle and pool formation occurs. It is necessary for farmers to cement-line all irrigation canals and channels to prevent seepage. If such a measure were enforced it would not only affect mosquito breeding but it would incidentally limit snail breeding and thus influence the incidence of bilharzia, as well as save large areas of land from becoming marshy and unsuitable for agricultural purposes. The enforcement of this measure is needed as urgently for the sake of agriculture and water supplies as of health. The increase in land values through closer settlement in itself already necessitates the control of irrigation water, in the eastern and northern areas of Northern Transvaal. The application of the existing regulations, enforced if necessary by prosecution, would soon induce farmers to adopt water conservation as a standard practice. It would save the malaria organization staff from dissipation of its time and energies on numerous over-irrigated farms and enable it to devote itself to vector control in the many natural water courses in the endemic areas.

Immigration of human parasite carriers into a territory where malaria is under control may result in the reintroduction of the disease and consequent spread to the indigenous population. Measures for the control of such carriers at international boundaries or for their treatment there with drugs for the eradication of gametocytes appears to be warranted. Concerted anti-malarial action by the governments concerned on both sides of the international boundary would offer the best means of preventing spread of the disease in this way.[13]

Importation of Vectors occurs relatively easily in two chief ways, viz. (1) by railway and especially motor transport, and (2) by aerial convection. Outbreaks of vector breeding and certain outbreaks of malaria could be explained only by assuming that infected females were transported to the particular locality by road motor or rail transport. It seems rather paradoxical that the few aircraft that enter the Union are sprayed to prevent the introduction of mosquitoes whereas the large volume of road traffic enters the Northern Transvaal from west, north and east without any attempt being made to prevent the importation of mosquitoes and other insect pests. If Brazil was subject to the importation of *A. gambiae* by aircraft then many areas in Africa must have been subject to similar transference of *A. gambiae* from one area to another by surface transport. Aerial convection may also play a part in so far as the prevailing winds may drive vectors from the eastern and north-eastern vector breeding areas on the Limpopo, Olifants and Crocodile rivers to the western areas and may account for the delay in the clearance of those areas of vectors. It is neces-

sary therefore to obtain close interterritorial cooperation where common boundaries exist.

CONTROL MEASURES

Control measures against the vector have been intensified by larviciding in the early spring in the areas along the Limpopo and its tributaries—the winter nurseries from where the vector is known to start spreading every year to other areas—when the water in the rivers is at its lowest and pools are dried up. This formidable task would be simplified by cooperative action on both sides of the rivers which form interterritorial boundaries. Where the overland approach to breeding places is difficult, spraying of larvicide from the air is unlikely to receive consideration because of the cost and the doubtful effectiveness of this procedure and because of the probable success of chemotherapeutic control.

Control measures by larviciding along the other large rivers in the eastern Transvaal, viz. the Komati, Crocodile and Olifants Rivers, would be slightly easier because they can be approached on both sides down to the border.

DDT emulsion is the larvicide of choice and so far there is no indication that resistance to DDT is a real danger.

Agricultural Practices

Agricultural practices play an important role in malaria control. Now that fertile areas have been cleared of the malaria danger new agricultral undertakings are started in a favourable semi-tropical climate. Owing to the abundance of water, irrigation schemes are begun without adequate planning and capital. Rivers and streams are dammed up and because the irrigation canals are not lined with cement, numerous seepage pools occur. Furthermore, planting of paddy rice is practiced in certain areas in a manner that favours the breeding of *A. gambiae* as well as other anophelines. Not only does this problem require that the existing malaria regulations should be strictly adhered to but all canals and furrows ought to be cement lined as well as strict control kept over water supplies. This anti-malaria measure would incidentally help to combat the snail and bilharzia problems. Farmers growing rice as food for themselves should be adequately instructed in the making of paddy fields. Rice, can, however, not be produced in the Northern Transvaal in competition with other areas in Africa and Asia. The growing of rice for gain could be stopped by the free importation of rice from elsewhere and the competition would discourage local production. On the other hand rice production in the Union could be protected by high import-tariffs and conditions for the growing of paddy rice prescribed which would eliminate the risks of mosquito and snail breeding. The higher price of rice would enable the farmer to comply with such requirements. A proposal has also been made that rice should be declared a luxury article and its importation totally prohibited. If that were done the local demand would cause the price for rice to rise to a level where the farmer could produce it economically as well as comply with the prescribed methods for rice production without at the same time causing malaria or bilharzia. The present production methods threaten to bring back malaria where it has been eliminated. It is, however, doubtful whether the limited area of soil suitable for agriculture in the Union should be utilized for such a soil-exhausting crop as rice. Whatever official action is to be taken it is clear that the matter will have to be brought to the notice of the individual rice grower.[14]

Land settlement is a problem because non-immune people are being transferred to malaria-endemic areas with the result that they succumb to malarial attacks much more readily than old residents. The problem is aggravated by the fact that, for a considerable period after arrival in the endemic areas, the new settlers are financially unable to provide themselves with suitable housing accommodation and protection against the vector mosquitoes. The solution to this problem may be to ensure (1) that the settler is provided with funds or facilities to build a house as soon as he arrives, (2) that he is allowed to arrive only at the end of the malaria season, (3) that he observes personal precautions, and (4) that he is provided with suppressive drugs regularly during the first few malaria seasons after his arrival.

International Cooperation

It is clear from past experience in the Northern Transvaal as well as in other countries that international cooperation is an essential requirement if the ideal of malaria eradication is to be attained.

If the evidence that malaria in the Northern Transvaal is under adequate control is accepted, then the next step is to proceed to malaria eradication; and if the experience of other member countries of the WHO is a reliable guide to the methods to be adopted then interterritorial cooperation is essential and the control measures of the various territories must be coordinated. Field staffs should meet frequently and information and views on all aspects of malaria incidence and methods of control be freely exchanged. Interterritorial conferences should also be held regularly to review the past and plan for the future, at which the experience of the WHO should be available.

CONCLUSION

Tables and maps are presented which provide reliable malariometric indices from which it can be concluded that malaria has been reduced to an almost negligible figure as compared both with its former epidemic occurrence and with the incidence of other communicable diseases in the Northern Transvaal.

If malaria is to be eradicated in the Northern Transvaal certain foci along the Limpopo and its tributaries as well as along the Olifants, Sabie, Crocodile and Komati Rivers must be eliminated or limited by more intensive residual spraying and by late winter and early summer larvicidal measures. Mass chemoprophylactic measures will be of great assistance in reducing malaria transmission in those areas where the parasite rate is still relatively high.

If the urgency of the need for malaria eradication on account of the threat of vector and parasite resistance, as indicated by the WHO is admitted, interterritorial cooperation and integration of anti-malaria programmes should be put into operation immediately.

SUMMARY

1. Measures to reduce the incidence of malaria in the Northern Transvaal have been in operation since 1930.

2. Since 1946 more intensive control was effected by using DDT and later BHC while the malaria control staff was also expanded. It is considered that well over 80% of the popu-

lation at risk 10 years ago are now free of risk from malaria.

3. The distribution of malaria cases and of parasite carriers discovered by taking a large number of blood smears shows that slight transmission still occurs along the eastern border of the Transvaal, especially near the Limpopo and Komati rivers and chemoprophylaxis may lead to final eradication of the disease.

4. Vectors occur in the Limpopo River during winter and spreads up the tributaries. Residual spraying has, however, ceased over the north-western parts because of the absence of parasite incidence.

5. Only close cooperation with adjoining territories will make final eradication of malaria in the remaining malaria foci in Northern Transvaal feasible, in conjunction with mass chemotherapy where the parasite rate is found to be high.

6. Measures to achieve this ideal are in hand.

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