Section of Tropical Diseases and Parasitology

President—P. H. MANSON-BAHR, D.S.O., M.D.

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Malaria in Nyasaland

By J. GORDON THOMSON, M.B., Ch.B.

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[The topography and climate of the country were then described.]

The Population of Nyasaland, with a Note on Vital Statistics.

When the 1901 census was taken, the total European population numbered only 314; by 1911 this had increased to 766 and at the last census (1931) the increase was still maintained, there being 1,975 persons, mostly engaged in Government employ, Christian missions, planting, commerce, and railways. At the time of the last census there were 1,591 Asiatics, mostly traders, while the native population totalled about 1,599,880. It is greatly to be regretted that, as was pointed out by Follit (1932), the potential value of these accurate census returns largely is stultified by the absence of birth and death records and that it is not possible to determine a general death-rate, a birth-rate, or an infantile mortality rate.

The population was divided, at the time, into three age-groups, viz. 0 to 5 years, 5 to 15 years, and adults. Follit considers it to be a fair deduction to make from the census returns that an enormous wastage of life occurs between the ages of 0 to 5 years, and that in every 100 infants born probably not more than 30 survive the first year of life, and not more than 10 in every hundred live to be 6 years of age. In the Annual Medical Report for last year, Dr. Williams (1934) gives a short note on vital statistics and quotes an experiment on registration which was started at Fort Manning in 1932. The system adopted is not official, but chiefs and village headmen are co-opted and native recording officers are employed. There is no compulsory registration and the margin of error must be considerable. Little or no attempt has been made to record the causes of death. The figures in this experiment at Fort Manning are as follows: birth-rate per 1,000 was 68·2 and death-rate per 1,000 was 25·8. The infantile death-rate per 1,000 births was 97·3 and the still-birth-rate per 1,000 live births was 89·3. The infantile mortality is very high, and when the mode of life of the natives is considered, this is not surprising. It is quite impossible to estimate to what extent the death-rate in infants is due to malaria or to the many other prevalent diseases. Malaria is so widespread that it must play a large part in the death-rate of young children. Bilharzia, ankylostomiasis, and

other intestinal worms are so common that about 80 to 90% of the children showed a degree of eosinophilia. At Cholo, Dr. Gopsill reported *S. hæmatobium* eggs in 82% of those examined, and at Kota-Kota 82·1 were infected with the same parasite. Yaws and venereal diseases are common.

The Medical and Sanitary Services.

The Medical Service consists of a Director of Medical and Sanitary Services, a Senior Health Officer, a medical entomologist, fourteen medical officers, a bacteriologist, a matron, and ten European nursing sisters. In addition there are two sanitary superintendents and a clerk and medical storekeeper. This small, but highly efficient European staff, are engaged in the colossal task of looking after the general health of the Europeans and of a huge native population of one million and a half, and in investigating and improving sanitary conditions. There are ten sub-assistant surgeons, all Asiatics. African natives are being gradually trained in medical work, and at present a staff, 534 strong, are employed as hospital attendants, dispensers, sanitary inspectors, and vaccinators, while some 240 more natives are employed as sanitary labourers.

The gradual extension of preventive medicine is in progress, but the task of controlling disease over this huge area occupied by primitive natives is limited by the economic state of the country, and is hampered by the ignorance and mode of life of the natives. The government medical service is ably assisted by medical practitioners associated with Christian Missions scattered throughout the territory. Recently three Women and Child Welfare clinics have been approved. An elementary knowledge of hygiene is being taught in native schools, and anti-mosquito work is in continual operation around the larger European populations.

The Seasonal Incidence of Malaria and Blackwater Fever in Nyasaland and their Correlation with Rainfall and Anopheline Density.

The months of June, July and August are practically rainless, and during this dry season vegetation lies dormant ; the rainy season usually begins in October and continues until the end of March. The rains fill the rivers, which overflow and form vast lakes and marshes, and recently the water level of Lake Nyasa has been steadily rising in a remarkable manner. This has resulted in the flooding of low-lying regions around the lake shores. Lamborn (1925) clearly demonstrated that *Anopheles funestus* persisted in large numbers throughout the entire year, but that *Anopheles gambiæ* is extremely rare during the dry months. The failure of Daniels (1900) to find *A. gambiæ* in the Shire Highlands and the Upper Shire Valley was due to his having visited these areas in the dry season, and for the same reason, Newstead and Davy (1911) were able to find only a single specimen of *A. gambiæ*.

Lamborn (1925) graphically demonstrated the marked increase of numbers of *A. gambiæ* during the rains (Chart I) and, from figures of cases of malaria collected by the late Dr. Milne Tough, it was evident that the incidence of clinical malaria rose steadily with the rainfall and the increase in prevalence of *A. gambiæ*. Cases of malaria appear in October and steadily rise in numbers during November, December, January, and February, and then tend to fall. During the dry season, May, June, July and August, the incidence of malaria is low. Shelley (1931), in an analysis of 67 cases of blackwater fever, showed that, while this disease may occur at any time of the year, nevertheless the highest incidence of cases occurred in May, June, and July, that is to say, immediately after the intensity of malaria had become manifest. The state of affairs in Nyasaland bears a remarkable resemblance to what was found in Southern Rhodesia by Thomson (1924), Leeson (1931), and Ross (1932), and confirms the fact that there is a definite co-relationship in both areas between rainfall, temperature, anopheline density, malaria, and blackwater fever. It will be noted (Table I) that, from the observations of Lamborn (1925) in

TABLES A.B+C SHOWING ACTUAL NUMBERS OF ANOPHELINES TAKEN IN EACH MONTH IN THREE DIFFERENT STATIONS IN NYASALAND. (AFTER LAMBORN 1925).

TABLE A. CATCHES MADE THREE TIMES A WEEK IN NATIVE HOSPITAL. FORT JOHNSTON. HOSPITAL SITUATED ABOUT 30 YARDS FROM THE SHIRE RIVER.

	JAN:	FEB:	MAR:	APR:	MAY	JUN:	JUL:	AUG:	SEP:	OCT:	NOV:	DEC:
A. gambiae. (FEMALE)	254	480	45	10	19	8	8	25	24	12	7	33
A. funestus. (FEMALE)	849	808	181	97	258	472	770	1094	1374	596	608	951

TABLE B. CATCHES IN NATIVE GAOL, ABOUT 130 YARDS FROM SHIRE RIVER.

	JAN:	FEB:	MAR:	APR:	MAY	JUN:	JUL:	AUG:	SEP:	OCT:	NOV:	DEC:
A. gambiae. (FEMALE)	68	274	462	130	113	187	72	23	7	10	5	2
A. funestus. (FEMALE)	1500	1921	571	309	365	761	744	785	818	2007	1664	1057

TABLE C. CATCHES IN A NATIVE HUT AT A DISTANCE OF TWO MILES FROM THE SHIRE RIVER.

	JAN:	FEB:	MAR:	APR:	MAY	JUN:	JUL:	AUG:	SEP:	OCT:	NOV:	DEC:
A. gambiae. (FEMALE)	57	147	172	26	98	23	11	3	—	—	3	15
A. funestus. (FEMALE)	240	482	164	13	230	462	256	13	48	134	336	215

TABLE D. CATCHES IN SOUTHERN RHODESIA. (AFTER LEESON 1931). THESE INCLUDED CATCHES OUTSIDE, IN BLACKWATER HOUSES, NATIVE HUTS, OUTHOUSES, STABLES AND EUROPEAN HOUSES. SHAMVA.

	JAN:	FEB:	MAR:	APR:	MAY	JUN:	JUL:	AUG:	SEP:	OCT:	NOV:	DEC:
A. gambiae. (FEMALE)	55	111	209	84	2	—	—	—	—	—	2	11
A. funestus. (FEMALE)	111	282	332	110	58	158	15	26	1	8	6	—

TABLE I.

Nyasaland, and those of Leeson (1931) in Southern Rhodesia, *A. funestus* persists throughout the year but increases in density during the wet season. *A. gambiæ*, on the other hand, almost entirely disappears during the dry months of the year. As *A. funestus* has been proved to be an active transmitter of malaria, this mosquito must be wholly responsible for any infections which occur during the dry season. It is extremely difficult to decide to what extent fresh infections of malaria are contracted during the dry season.

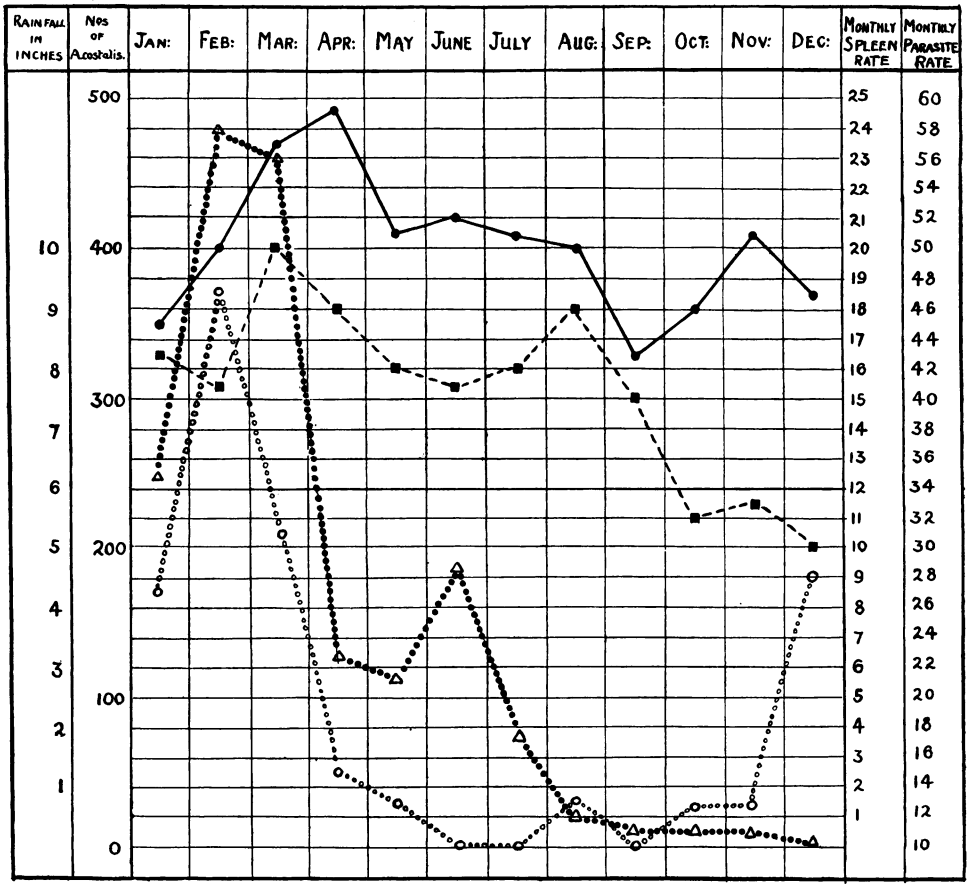

Chart I.

An examination of the incidence of malaria in native children in Nyasaland clearly shows that malaria persists throughout the whole year (Table II), but that the peak of highest incidence is associated with the increased density of anophelines accompanying the annual rains (Chart I). Observations would seem to show that the anopheline density of the wet, hot season of the year is due to an increase in numbers and biological activity of both *A. gambiæ* and *A. funestus*, and that during that time both species are actively engaged in biting man. Thomson (1924) in Southern Rhodesia drew attention to the fact that malaria and blackwater fever were definitely associated with the appearance of *A. gambiæ* in the European houses,

but Leeson (1931) in the same area has demonstrated that *A. funestus* also increases steadily in numbers during the wet season. As an explanation of the fact that the endemicity of malaria is low during the dry season, although there is an efficient carrier available (*A. funestus*), it may have to be assumed that either *A. funestus* is not infected or that its biting activities are not so marked. At the present moment this question is not solved but it seems reasonable to suppose that, during the dry season, the adults of *A. funestus* resting in houses are not actively engaged in ovipositing, and consequently are not so urgently in need of blood. If *A. funestus*, although abundant, is really quiescent and *A. gambiæ* is almost absent, this would explain the scarcity of fresh acute cases during this period of the year. With our present knowledge no estimate can be formed of the extent to which malaria during the wet season may be due to *A. gambiæ* or *A. funestus*.

In a personal communication, Sir Malcolm Watson has shown that at a mine in N. Rhodesia, although almost complete control of *A. gambiæ* has been established, the malarial incidence has been maintained owing to the persistence of *A. funestus*, but at a lower level. This seems to be a distinct proof that both these anophelines play a part in the production of epidemic malaria during the wet season. However, in the Heath Clark lectures, Hackett (1934) raises this problem above the simple one it would at first appear to be. Evidently any anopheline species is capable of producing, under certain biological or ecological conditions, different races which, owing to their feeding habits, differ in their importance as malaria transmitters. Leeson (1930) has drawn attention to the variations in the wing ornamentation of *A. funestus* of Southern Rhodesia, and has emphasized the fact that further study of this anopheline is necessary to determine whether certain biological races occur, which differ from one another to such an extent that one race may transmit human malaria and others be of little importance.

Examination of the Peripheral Blood of Native Children under 10 years of age to determine the Parasite Rate and the Species of Parasites found.

In order to determine the parasite rate and the percentages of the various species found, an examination of the blood was carried out in native children under the age of 10 years, and only thin films were used throughout. (1) Several groups of children from different areas were examined on one occasion only. This might be termed "random sampling" and obviously furnished data for only one particular period of the year. (2) In order to get more accurate details, Dr. Lamborn and the author collaborated in a survey in which 103 children were examined once a month during the year 1931, for the presence of splenic enlargement and parasites. This group of children were living continuously throughout the year in the same village under hyperendemic conditions. A comparison between these two methods of examination shows the importance of the latter method in estimating the true state of malarial infection in any area, and the results would be even more accurate if it were possible to examine a group more frequently, say, once a week.

By the first method three groups of children from birth to 10 years of age were examined on one occasion only, and the results were as follows:—

(*a*) In a village twelve miles from Fort Johnston, at a height of just over 3,000 feet above sea-level, 103 children, all under 10 years of age, were examined during March and April 1934. In thin films the parasite rate was 50%. Of these positives, 85% were *Plasmodium falciparum* and 15% were *P. malariæ*. No infections with *P. vivax* were detected. Crescents were present in 7·5% of the positive films and quartan gametocytes in 7·5%.

(*b*) In a group of children from the Zomba area at an elevation of about 4,000 feet, in the month of April the parasite rate was 57%, and again of these positives 91·8% were *P. falciparum* and 8·2% were *P. malariæ*. Again no infections

with *P. vivax* were detected. Crescents were present in just over 5% and quartan gametocytes were also about 5%.

(*c*) A third group of children, 233 in number, were collected from various villages on the Angoniland plateau at a height of 4,000 feet or over, from villages at the lake level, from Kota-Kota, and Cholo. These were examined during the dry season and the parasite rate was only 43%. *P. falciparum* formed 83% of the infections. *P. malariæ* was found in 16% and *P. ovale* in 1%.

	All Forms of Parasites. Including Asexual Forms and Gametocytes.							Gametocytes only					
	M.T.	M.T. + Q.	Q.	M.T + B.T.	BT	M.T. Q. B.T.	Total	M.T.	Q	B.T.	M.T. + B.T.	Total.	Pig: Leuc:
Jan:	32	5	3				40	3	8			11	
Feb:	33	6	5				44		7			7	
Mar:	43	4	6				53	2	6			8	1
Apr:	51	1	2	2			56	4	1	1		6	
May:	42		5	1	2		50	6	3	2	1	12	3
Jun:	44	2	4				50	5	1			6	3
Jul:	37	2	5	1	3		48	8	4	2		14	
Aug:	42	2	1	1	1		47	7	1	1	1	10	1
Sep:	35	3	2				40	2	4			6	
Oct:	38	2	4				44	6	4			10	
Nov:	44	5	1	1			51	1	5	1		7	
Dec:	35	5	2				42	1	3			4	
	476	37	40	6	6		565	45	47	7	2	101	8

Findings in 103 children. Month by Month.

Table II.

The result of this random sampling of about 400 native children by using thin films only, thus gave a parasite rate varying from 43% to 60%, a variation due possibly to the time of the making of the survey. *P. falciparum* varied from 92% to 83% and quartan varied from 8% to 15%. No cases of *P. vivax* were detected but three cases of *P. ovale* were found. Two of these occurred at Cholo and one in a village in the Angoniland plateau.

The second method of making the survey was to examine a group of 103 children each month throughout the year, and the findings are interesting when compared

with those given above. This group was examined by Lamborn and the writer in 1931, and the investigation was carried out in the same village situated twelve miles from Fort Johnston, as was the first of the preceding investigations. Table II on previous page shows the actual parasite findings in the group each month. The monthly spleen rate has already been published by Lamborn (1932). It is now possible to correlate the parasite rates and the spleen rates (Charts I, II, III, and IV).

Ninety-nine out of the 103 children were positive at one time or another throughout the year, and four children remained consistently negative. The parasite

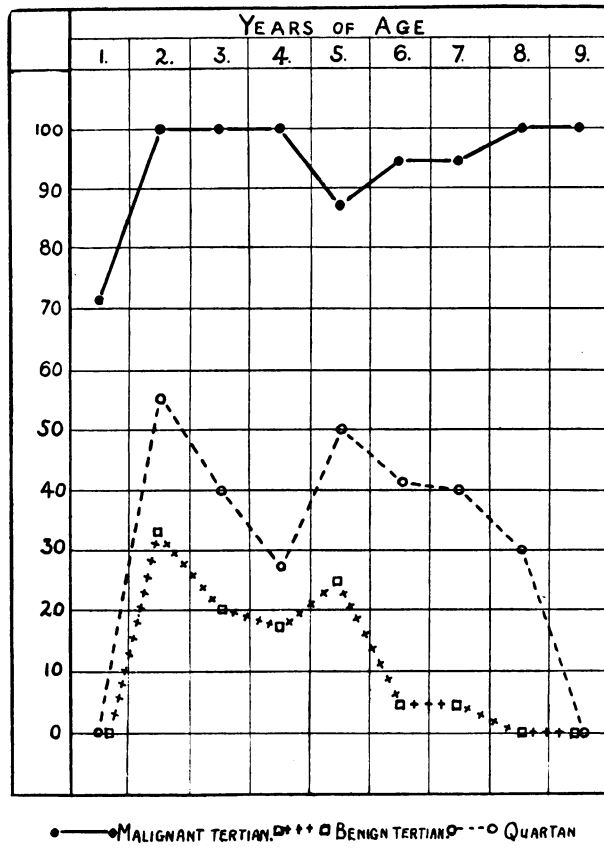

CHART II.—Percentage of children infected, according to age.

rate was therefore 96%. *P. falciparum* was found in 96 different children, *P. malariæ* occurred in 35 and *P. vivax* in eight. Of the positive children, therefore, 97% showed at examination *P. falciparum*, 35% *P. malariæ* and approximately 8% harboured *P. vivax*. Of these infections gametocytes were present in the children on 101 occasions. Crescents of *P. falciparum* occurred 47 times and gametocytes of quartan were found also 47 times, whereas gametocytes of *P. vivax* were only found on nine occasions.

A more detailed examination of this group shows that the parasite rate and spleen rate rise definitely during the months of March and April, that is, during the time

when anophelines are most active (Chart I), and when there is definite correlation with the rainfall and *A. gambiæ* density, as shown by Lamborn (1932).

If the infections be grouped according to age, it is seen that *P. vivax* drops as age advances, and shows the most rapid fall. This is followed by a drop in quartan infections, but *P. falciparum* seems to persist till 9 years of age at least without showing any fall in the numbers infected (Chart II). Gametocytes are most numerous in the blood of children about 2 to 3 years of age, and as age advances gametocyte carriers become less numerous. Here again the gametocytes of *P. vivax* show the most rapid drop as age advances and are followed by those of *P. malariæ* and *P. falciparum* (Chart III).

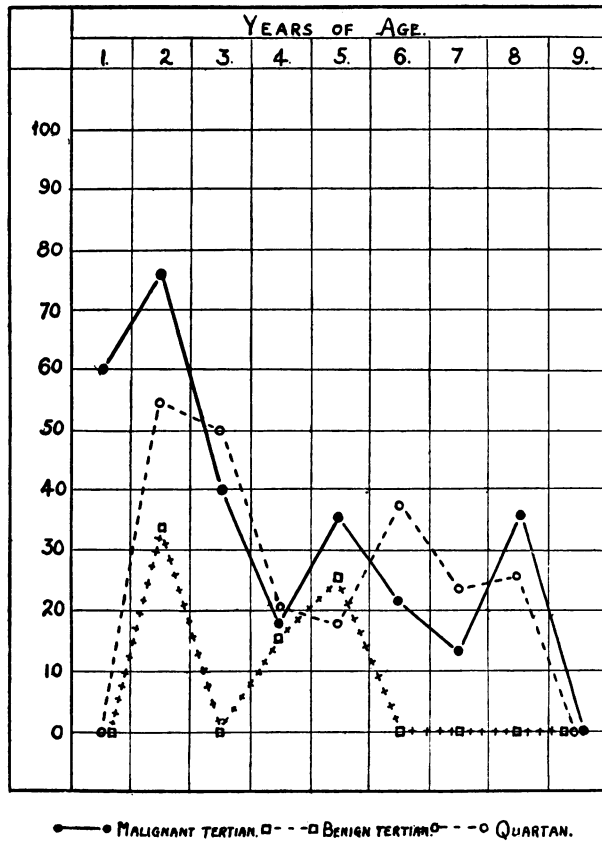

CHART III.—Percentage of gametocytes in infected children, according to age.

This development of tolerance has been observed by Ciuca, Ballif and Chelarescu-Vieru (1934), who found, under experimental conditions, that immunity is also produced against quartan malaria by repeated infections, but that the process is of slower development than the immunity towards benign tertian, and that immunization against *P. falciparum* takes longer than against either benign tertian or quartan malaria.

It seems, therefore, that immunity is most rapidly established against *P. vivax*, followed by a more gradual development of immunity against quartan, and that *P. falciparum* is by far the most persistent parasite as age advances. The

examination of the cases above also showed that native children living under identical conditions in a hyperendemic zone show very varied degrees of resistance to infection. The four children in whose blood parasites were not found were either not infected or, as is more probable, had an infection so low that it was never detected. Knowles (1934) has demonstrated the interesting fact that latent malaria in monkeys may be stimulated into activity by extirpation of the spleen. Other children showed moderate susceptibility to infection, and again a further group were highly susceptible. This may be compared with the observations made on non-immunes during experimental infections with *P. vivax*.

Yorke and Macfie (1924), Yorke (1925 and 1926), Rudolf (1926), James (1926), James and Shute (1926), and James (1931), have all noted that a considerable percentage of individuals are refractory to induced malaria. James (1926 and 1931) has emphasized this varied resistance of individuals who have never before suffered from malaria. It has been proved that experimental acquired immunity can be developed in man. The work of Yorke and Macfie (1924), Nicol and Steel (1925), James (1926 and 1931), and Rudolf (1926), has shown that, if one strain of

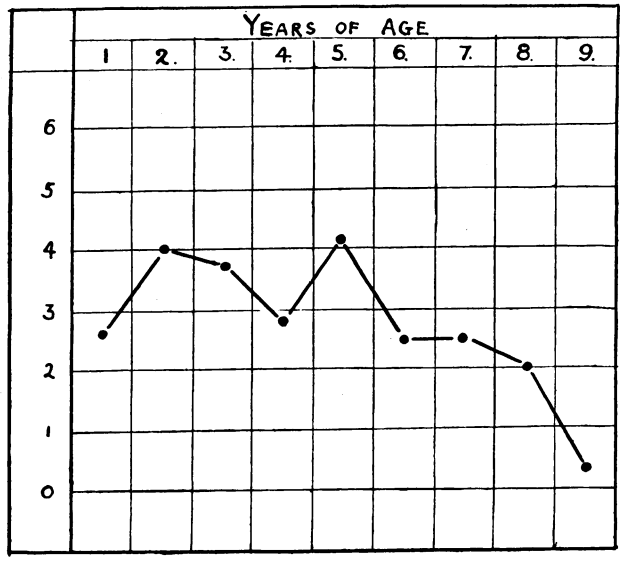

CHART IV.—Average number of enlarged spleens in 103 children, according to age.

P. vivax was used, an immunity to this strain developed. Patients immune to one strain may be successfully inoculated with another strain.

According to the findings of gametocytes in the native children, it appears that the chances of mosquitoes being infected with *P. falciparum* and *P. malariæ* were equal, and thus one would expect that the percentages of parasite findings of *P. falciparum* and *P. malariæ* would be identical in Nyasaland. It is quite possible that all the children are actually inoculated with both parasites but that the quartan infection is held in check by the presence of *P. falciparum*. The gradual development of resistance to infection is also graphically seen in the drop in the spleen rate as age advances (Chart IV).

Increase of Immunity with Increasing Age.

From the results of the parasite and spleen surveys given above, it is apparent that the development of tolerance, even under hyperendemic conditions, is a gradual process. As was pointed out by Christophers (1924) in India, acute infestations

with malaria accompanied by severe clinical symptoms occur in young infants between the ages of 0 and 2 years, and immune infestation accompanied by a lower parasite infection and slight clinical symptoms gradually develops up to the age of 10 years.

In Nyasaland the conditions are similar to those described by Christophers. During the height of the malarial season young native children up to the age of 2 years frequently have as many as three or four parasites to one red cell, and many develop convulsions which may lead to a fatal termination. According to Dr. Turner of the Livingstonia Mission at Loudon, North Nyasaland, such cases with this clinical picture and fatal termination are quite common. He states quite definitely that such cases occur during the height of the malarial season about the month of March. If the infection is detected before the onset of the serious clinical symptoms, the administration of quinine will save the child. Severe infections also occur in European children but at rather different ages, owing to the absence of any developed tolerance. Again the clinical picture is frequently one of convulsions. The gradual development of tolerance to the parasite and clinical symptoms is illustrated by the surveys detailed above, especially that carried out throughout the whole year. The children in this survey, although infected, showed little or no clinical manifestations, and all those old enough to walk were able to run about as if perfectly healthy, even when parasites were readily demonstrable. Of the four children who never showed parasites, two were only aged 9 months and 11 months respectively at the beginning of the survey. This varied resistance to infection of children below the age of 10 would seem to indicate that certain individuals have an inherited tolerance against infection, and possibly these to a large extent are the survivors who reach adult life.

The adult natives of Nyasaland, the majority of whom are infected, seldom suffer from clinical symptoms, although sometimes there is a failure of this relative tolerance. Probably the best example of such a breakdown is found during pregnancy. Thus, sixty native women were examined for the presence of blood parasites, and later, after the birth of the child, the blood from the maternal surface of the placenta was also subjected to examination. Smears from fourteen of the newly born children were taken with the object of detecting any cases of congenital infection. Despite the shock of childbirth most of the women remained absolutely immune to clinical malaria.

During the course of the pregnancies, only six of the sixty native women showed the presence of parasites in the peripheral blood when thin blood smears were examined. Four women had massive placental infections with all stages of *P. falciparum* up to and including mature schizonts, and only one showed rings of *P. falciparum* in the peripheral blood-stream before the birth of the child. Two women with parasites in the blood before the birth of the child showed only a few parasites in the placental smears. It would appear that this form of tolerance is not always absolute but is rather a matter of degree. One case was interesting, for although, so far as thin blood smears were concerned, the woman was free from parasites during pregnancy and examination of the placenta also gave a negative result, she, nevertheless, two days after the birth of the child, developed clinical malaria associated with the presence of asexual forms of *P. falciparum*. Many native women develop acute clinical malaria after childbirth.

Where European women are concerned, the danger of acute malaria with fatal coma or blackwater fever after childbirth must be considered even when, during pregnancy, there is no evidence of clinical malaria and blood-films remain consistently negative. This is so important that, as a routine, quinine should be administered before the birth of the child in order to avoid abortion and dangerous complications to the mother during the puerperium.

The blood-films from newly born infants were all negative. The question of the occurrence of congenital malaria is one of importance. There seems to be not much

doubt that congenital malaria, i.e. malaria contracted *in utero*, is a rarity and that despite the fact that Mackay (1933), Schwetz and Peel (1934), and Schwetz (1934) have reported positive cases. These positive babies had very few parasites, which is a very distinct contrast to the heavy maternal placental infections. On the other hand, Blacklock and Gordon (1925), Van den Branden (1927) and Lombart (1931) found no infections of newly born babies.

The Control of Infection by Phagocytosis : Phagocytosis in the Placenta.

It is a matter of the utmost difficulty to find any reason to account for the fact that there is no comparison between the intensity of the placental infections and the degree of parasitization of the corresponding peripheral blood. The phagocytic picture exhibited by these placental smears affords a remarkable demonstration of the active part played by the large mononuclear macrophages and the polymorphonuclear leucocytes as controlling factors, modifying the course of the infection. It has been shown (Thomson, 1933) that phagocytosis must play an important rôle as a bodily protection against the over-production of malarial parasites, though Yorke (1933) seems rather to hold the view that the reticulo-endothelial function may be that of a scavenger, clearing the blood-stream of *Plasmodia* previously damaged or rendered more easy prey to the phagocytes by hypothetical antibodies of some kind or another. Be that as it may, it is a most curious phenomenon how the placental polymorphonuclear leucocytes exhibit such a marked predilection for fully developed or nearly mature schizonts. The mechanism by which malarial parasites are destroyed has been discussed by Lowe (1934), who has reached the conclusion that it may take place by two methods: (1) by the lysis or phagocytosis of free merozoites, or (2) by the ingestion of infected red blood-corpuscles by the reticulo-endothelial system of cells. Both these processes operate from the beginning but, as time goes on, they are often augmented by a spontaneous disappearance of the parasites, with an accompanying respite from the fever.

Blackwater Fever in Nyasaland.

The analysis of sixty-seven cases of blackwater fever made by Shelley (1931), and referred to above, dealt with cases occurring during the years 1921 to 1931 inclusive. Of these, fifty were in Europeans and the balance of seventeen cases was in Asiatics. An examination of records of the disease in this territory from 1911 to 1933 inclusive shows that during this period of twenty-three years 157 cases of blackwater fever have been reported, with a death-rate of 30%. Last year (1933) there were eight cases. It is thus regrettably obvious that malaria is still far too common and intense amongst Europeans. Conditions in Nyasaland appear to be very similar to those existing in Southern Rhodesia: there is insufficient protection from repeated infections with malaria. Blackwater fever really seems to depend more on the mode of life of the individual himself, as these cases all tend to occur in zones or houses well outside the areas controlled by organized European communities. Such persons neither protect themselves from the onslaught of mosquitoes nor take quinine as it should be taken. It seems clear, however, that improvement has gradually taken place as a result of better housing conditions and general hygienic measures, for in an appendix to the Annual Medical Report of the Protectorate Sir Harry Johnston (1895) wrote that:—

"The death-rate amongst Europeans rose from the former death-rate of 6·5% to 9·7%. The number of deaths registered was 28 out of an average European population of 275. Of these deaths 20 were due to various forms of malarial fever (including blackwater fever). . . . Out of 20 deaths from malarial fever 16 were cases of blackwater fever. Besides these 16 cases there were as many more where recovery took place."

It seems, therefore, that in the year 1895 there were about 32 cases of blackwater fever in a population of only 275 Europeans.

The Prevention of Malaria and Blackwater Fever.

The control of malaria by sanitary engineering, drainage, oiling of pools, screened houses, and every known method of breaking the contact between anophelines and man, can be applied around townships and villages inhabited by Europeans. Throughout such vast territories as Nyasaland and Rhodesia, where malaria is hyperendemic and the population is widely scattered, it is not infrequently necessary to advocate most strongly the use of prophylactic quinine to those careless persons who will not defend themselves against the onslaughts of anophelines. For many years past all medical men, who have had personal experience under hyperendemic conditions, have unanimously agreed that, where living conditions amongst Europeans in blackwater-fever areas was such as to render protection from malaria an impossibility, a dose of 5 gr. of quinine should be taken with absolute regularity, at least for the duration of the malarial season. Attention has been drawn (Thomson, 1924) to the dangers of intermittent quinine-taking and to the fact that, to be efficient as a malarial and blackwater-fever prophylactic, the quinine dosage must be regular.

During 1934, Monseigneur Guillemé published his experiences of blackwater fever in the *Nyasaland Times*, and these observations by a most distinguished scholar are of the greatest interest and historical value. When the White Fathers began to establish Central African Missions (1878) the use of quinine was not known as it is now, and accordingly the Fathers only took a dose when they felt that they had a malarial attack or that one was impending. This method proved to be disastrous, for blackwater fever supervened and caused the deaths of more than 200 of the Fathers, whose graves are now spread around the Great Lakes of Central Africa from Nyasa to Victoria Nyanza. Bishop Guillemé considers that nearly all were the victims of a faulty method of taking quinine. This condition of affairs lasted for about twenty-seven years and then, instead of taking quinine as a remedy for malaria, the drug was utilized as a preventive. Five grains of quinine were taken daily, beginning on the day of the departure from Marseilles, and if any felt ill, tired, sickly, or out of sorts, the dose was doubled for a few days. The success of this method has been marvellous. There are now more than 600 White Fathers serving under these malarious conditions, and for the past twenty-eight years, since the adoption of the regular 5 gr. of quinine a day rule, not one single case of blackwater fever has occurred. This serves to emphasize once again that quinine prophylaxis should be carried out properly or not at all.

Conclusions.

(1) The two chief vectors of malaria in Nyasaland are *Anopheles gambiæ* and *A. funestus*. *A. gambiæ* is very scarce during the dry season, but appears in increasing numbers with the onset of the wet season; *A. funestus* adults are plentiful throughout the entire year, but their density also increases during the wet season.

(2) Epidemic malaria occurs during the wet season. Although *A. funestus* may be found in large numbers in houses during the dry season, it is probable that this mosquito is not actively engaged in the transmission of malaria. According to Leeson there are several biological races of *A. funestus*; the rôle played by these strains in the transmission of malaria requires further investigation.

(3) "Random sampling" of blood-films from native children only provides information limited to the particular time when the survey was carried out. Using this method, three cases of *P. ovale* infection were detected.

(4) A continuous survey of 103 children examined once a month for one year showed that 99 were infected and that four remained consistently negative. The children showed great variations as regards their susceptibility to infection. Some were refractory, some were moderately susceptible, while others were highly susceptible. *P. falciparum* predominated and was present in 96 of this group. Thirty-five of the children had *P. malariæ* and nine had *P. vivax*.

(5) Gametocytes were found on 101 occasions. Crescents of *P. falciparum* were present forty-seven times and gametocytes of *P. malariæ* occurred also on forty-seven occasions. Gametocytes of *P. vivax* were found on only nine occasions.

(6) Tolerance was most rapidly developed against *P. vivax*, and this was followed later by tolerance against quartan infections. *P. falciparum* persisted longer as age advanced, and would seem to be the most prevalent infection in adults.

(7) Resistance to *P. falciparum* in adults is frequently broken down, as was seen after childbirth in native and European women. An examination of the blood of the mother before the birth of the child may give no information regarding the presence of malaria, as is well demonstrated by examination of the maternal surface of the placenta. Abortions and stillbirths due to *P. falciparum* infections of the placenta are common, and acute clinical malaria in the mother may show rapid onset after the birth of the child.

(8) Phagocytosis of fully developed schizonts by polymorphonuclear leucocytes is an important method of controlling *P. falciparum*, as is well seen in placental smears. Parasites are also engulfed by the large mononuclear macrophages; these cells also swallow pigment and infected red blood-corpuscles. Infection of the unborn child is possibly rare.

(9) Blackwater fever occurs amongst Europeans and Asiatics. The use of quinine as a prophylactic against this condition is recommended. Unless this drug is used correctly it is dangerous and of no value as a prophylactic. Routine treatment of all pregnant cases before the birth of the child is necessary where malaria is suspected, even when the peripheral blood of the mother is negative.

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Discussion.—Sir RICKARD CHRISTOPHERS said that Professor Stephens and himself must have been the first malariologists to visit Nyasaland. With regard to vital statistics in the case of backward countries, he thought the most important objective to strive for was accurate registration of births and deaths. Diagnosis of cause of death could not be expected to be of much value. Scientific study of the total death curve, interpreted through dispensary and hospital returns and other available information, was helpful. As to the relation of the numbers of anophelines to malaria prevalence, he did not think that in this case there were sufficient data to support any theory. The facts required working out in relation to length of life, state of the ovaries, precipitin reaction, and modern methods of investigation. He was glad that Professor Thomson had stressed the fact that figures giving the parasite rate always implied some arbitrary standard of amount of blood examined in arriving at the results. The fact that certain children in Professor Thomson's series remained negative throughout the whole year in which they were under observation, seemed to point to these as actual negatives rather than as merely apparent negatives due to insufficient examination; and this would almost necessitate the view that they were natural immunes. As to prevention, great importance should be attached to blackwater fever, and it did not appear that, as yet, the great value of suitably screened houses, constructed in the first place with this object in view, had been fully appreciated in countries where blackwater fever prevailed.

Colonel S. P. JAMES congratulated Professor Thomson on the results of his application of "the new method of malaria survey" by which, instead of studying malaria among native races as a mass problem on results obtained by random sampling, one made a continuous clinical and parasitological study of selected individuals. He noted that one of Professor Thomson's findings by this method was that several of the 103 children whom he examined month by month had apparently escaped the disease entirely throughout their lives, and seemed to possess a natural resistance or immunity to infection. Adults with the same kind of resistance were sometimes found among patients for whom a course of malariatherapy had been prescribed, and great difficulty was experienced in giving them the required course of malaria fever. A patient sent to Horton for a course of malariatherapy in February 1934 was a good example. He was a West Indian negro who had passed most of his life in Europe and, so far as could be ascertained, had never suffered from malaria. As it was considered very desirable to give him the benefit of a complete malaria course, he was inoculated on different occasions between February 8 and July 5 with *P. vivax*, *P. falciparum*, *P. ovale*, *P. malariæ* and *P. knowlesii*. Some of the inoculations with *P. vivax* and *P. falciparum* were by the bites of infected mosquitoes as well as with blood. Among all these parasites the only one which caused an attack of fever was *P. ovale*, and this attack was mild and ended in recovery without treatment on the sixth day. Following the series of three inoculations with *P. malariæ*, which were given on different occasions towards the end of June, a few quartan parasites had appeared in the blood between August 3 and 7 and the temperature on one day rose to 101° F., but that was the only result. None of the other species caused any clinical or parasitic manifestation. Four separate attempts to infect the patient with *P. knowlesii* had all been without result. This seemed to indicate that the patient possessed a natural resistance to malaria in general, for *P. knowlesii* is a species against which he could have had no opportunity of acquiring immunity by natural infection.

Sir MALCOLM WATSON said that the study of the Anopheles would be the foundation of the sanitary work which would make Africa healthy, and at the same time provide it with food. Work done in any one country was almost certain to throw light on the problems of other countries.

There was no proof that malaria was a social disease like tuberculosis, any more than syphilis and yellow fever were social diseases. The highest-class American and the best-housed and best-fed officials were those who suffered most from yellow fever. The same was seen in other countries. On the Congo mines the natives were well fed, well housed, and well looked after, nevertheless, as Dr. Van Nitsen had pointed out, malaria accounted for 50% of the sickness there. On the Roan Antelope Copper Mines, where mosquitoes were controlled, malaria among the African labourers was not of any economic importance. The assertion that malaria was a social disease merely obscured the problem.