Bull. Org. mond. Santé
Bull. World Hlth Org. } 1951, 4, 301-327

MALARIA IN NIGERIA

LEONARD J. BRUCE-CHWATT, M.D., D.T.M. & H., M.P.H.

Malaria Service, Medical Department, Lagos-Yaba, Nigeria

1. GENERAL SURVEY

1.1 Topography

Nigeria, divided for administrative purposes into three regions (northern, western, and eastern) forming a Protectorate, is situated on the northern shore of the Gulf of Guinea and bounded on the west, north, and east by the French territories of French West Africa, French Equatorial Africa, and part of the Cameroons under French Trusteeship. It is the largest British dependency in West Africa, with a total area of 372,674 square miles (964,853 km^2).

Along the entire coast of Nigeria is a belt 1-60 miles (1.6-97 km) wide of mangrove swamp forest. Farther inland is a zone 50-100 miles (80-160 km) wide of tropical rain forest. Beyond this zone the vegetation changes to dry forest and farther north to open woodland and to grass savannah interspersed with scrub. In the extreme north desert conditions prevail. Most of the south of the country is less than 1,000 feet (300 m) above sea level, while most of the north is between 1,000 and 2,000 feet (300-600 m) above sea level.

Nigeria possesses few mountains except along the eastern boundary, where the Cameroons mountain rises to 13,350 feet (4,070 m), and on the central Bauchi plateau, which rises to over 6,000 feet (1,800 m) above sea level.

The river Niger enters the territory from the north-west and after flowing nearly 500 miles (800 km) is joined by its principal tributary, the Benue, at Lokoja about 340 miles (550 km) from the sea. From here it flows due south into its delta, which extends for over 100 miles (160 km) along the coast and for about 140 miles (225 km) inland. The Niger has two almost independent floods—in the upper river from July to January and in the lower river in September-October. Second in importance to the river Niger (with its main tributary the Benue) is the river Cross. In southern Nigeria several rivers flow into the coastal creeks and lagoons. In northern Nigeria a few smaller rivers drain from the Bauchi highlands toward the Lake Chad basin.

1.2 Climate

The most important features of the climate of Nigeria are connected with the rainfall, the main source of which is the south-west wind, which comes from the Gulf of Guinea. The total annual rainfall varies from over 140 inches (3,556 mm) at Forcados to well under 25 inches (635 mm) at Maiduguri and diminishes steadily from the south to the north. (Debundscha, on the western slope of the Cameroons mountain, has an abnormally high annual rainfall of 375 inches (9,525 mm), the second highest on earth.) The eastern part of the coast of Nigeria has a higher and more constant rainfall than the western part. The double maximum curve of the annual rainfall is less pronounced in the east and very noticeable on the western part of the coast. In the north-east the annual rainfall shows pronounced local variations on account of the configuration of the Bauchi plateau, which is about 4,000 feet (1,220 m) high. The number of rainless months in southern Nigeria varies between nil and four. In the north the average number of rainless months is five or six, but in the far north of the country there are only four months during which any rain may be expected. The bulk of the rain falls between the months of May and September ; in the north the month of August constitutes the peak of the brief rainy season.

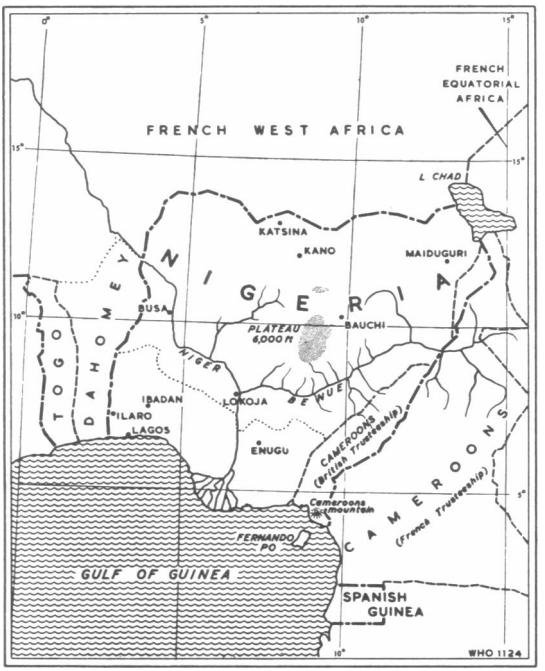
In the coastal belt the mean daily temperature throughout the year is within the 84°F-93°F (28.9°-33.9°C) range with little variation. Farther inland the range of variation of the daily temperature increases, particularly during the rainless season on account of the dry north-eastern " Harmattan " blowing from the Sahara. In the north during the early part of the dry season variations between a maximum temperature of 110°F (43.3°C) during the day and a minimum of 60°F (15.6°C) at night are not uncommon. In that part of the country the mean monthly temperature shows also pronounced seasonal variations, being lowest in December and January (73°F (22.8°C)), rising steadily throughout the first four months of the year to a mean of 88.5°F (31.4°C) in May, then decreasing to a mean of 78°F (25.6°C) in August, rising again to a lower peak of 80°F (26.7°C) in September, and decreasing once more towards the low mean in December. The high elevation of the Bauchi plateau and of the Cameroons highlands creates climatic conditions of a temperate category.

The humidity along the coast of Nigeria is on a high level, with little seasonal or daily variation, within a mean daily range of relative humidity of 75%-85% (5-10 millibars of saturation deficiency). Farther inland the periods of seasonal high humidity are shorter and the influence of the Harmattan becomes more pronounced, until in the far north the mean monthly range of relative humidity is from 63% to 74% during June to September (saturation deficiency, 10-20 millibars), decreasing steadily to

20% and less during the period December to February (saturation deficiency, 20-40 millibars), and then slowly rising to higher values.

The ecological zones of Nigeria as related to annual rainfall can be divided into : (1) the forest region, and (2) the savannah region. The first is subdivided into the rain forest and dry forest zones and covers roughly

FIG. 1. MAP OF NIGERIA



the southern third of the country. The much larger savannah region can be subdivided into the Guinea savannah, Sudan savannah, and the northernmost Sahel savannah.

1.3 Population

No general census has been undertaken throughout Nigeria since 1931, when the population was found to be 19,928,171, inclusive of natives of Nigeria, natives of foreign extraction, and non-natives. Estimates of varying degrees of accuracy are made from annual returns of taxpayers. These returns have only a limited value as guides to population trends, if only because women are not subject to direct taxation in large parts of the territory, so that their number, as well as that of children, can be only approximately estimated. None the less it can be stated that the native population of Nigeria is increasing, the estimated figure for the last pre-

war year being 20,588,840, and those for the years 1943, 1944, and 1945 being 21,329,328, 21,498,674, and 22,023,662 respectively. The estimated figure for 1948 was 24,388,470. The mean density of the population in the south is 97 per square mile (250 per km²). In the north the figure is 40 per square mile (100 per km²).

The predominant anthropological type in the population of Nigeria is that of the " Sudanese Negro ", to be found with greatest uniformity and purity in the heavily timbered country of the south-east where overland migration has always been difficult and unattractive. In the north and west Hamitic stock has mingled with the substratum, while in the south-east there is evidence of Bantu admixture.

The relative strength of the four main linguistic groups, as shown by the 1931 census, is : Hausa, 3,604,016 ; Ibo, 3,172,789 ; Yoruba, 3,166,154 ; and Fulani, 2,025,189.

In northern Nigeria it is customary to divide the population into Moslem tribes and non-Moslem or Animists (Pagans). The principal Moslem tribes, numbering about 8,000,000, are the Hausa, Fulani, Kanuri, and Nupe. The non-Moslem tribes are the Tiv, Gwari, Angas, and Burra. In the south the two largest groups are the Yoruba in the western portion and the Ibos in the eastern part. Both these tribes number about 7,000,000, while the smaller tribes—Ibibio, Bini, Ijaw, etc.—are next in size.

Nigeria is still very largely a country of peasant farmers. Although no accurate figures are available to show the numbers actually engaged in the various branches of agriculture, it can safely be stated that the great majority of both the male and female working population is so employed. This overwhelming predominance of agriculture as the source of livelihood should not, however, be allowed to obscure the full appreciation of the growth of wage-earning employment in government services—such as the railway, colliery, mines, public works, and postal and telegraph services —and in private firms.

The important general population trend which began during the war years has been a steady drift to Lagos, Ibadan, and to other towns, particularly in the western provinces. This was accentuated by heavy demands for labour for military works, but the main reason is undoubtedly the attraction of higher wages and increased social amenities in the towns with which, owing to improved communications, the peasant is now becoming increasingly familiar.

1.4 Vital Statistics

While the registration of vital statistics is compulsory in certain townships in the Protectorate and is also undertaken with varying success by a number of native administrations in both the northern and western provinces, a fair standard of accuracy has been attained so far only in Lagos where

registration has been in operation since 1867. The available Lagos figures indicate that during the past quarter of a century the crude death-rate has decreased from 25.2 per 1,000 per year to 18.6 per 1,000 per year (1948). The crude birth-rate was 29.8 in 1925 and 51.0 in 1948. Infant mortality fell during that period from 238.2 to 105.5 per 1,000 live births.

Apart from deaths in the hospitals, certification of death is compulsory only in Lagos. The percentage of deaths due to unspecified or unknown causes occurring in government hospitals was 0.015 in 1947 and 0.011 in 1948.

The registry of births and deaths at Katsina in northern Nigeria was started in 1945 under the aegis of the medical services. This scheme though not compulsory is supported by the authority of the Emir, and its results are too valuable to be omitted since it refers to a population of about 80,000 and is the most reliable registry of vital statistics in the north. The crude birth-rate for Katsina town was 37.2 per 1,000 in 1945 and 40.5 per 1,000 in 1946. The respective rates for the Katsina Emirate were 33.9 in 1945 and 40.5 in 1946. Crude death-rates for Katsina town were 24.9 and 27.4 per 1,000 in 1945 and 1946 respectively. For the Katsina Emirate comparable figures were 22.3 and 16.9 per 1,000.

Infant mortality, investigated in 1928 by McCulloch,[8] gave the appalling figure of 412 per 1,000 live births per annum. A later figure, quoted for 1946 by Bruce-Chwatt (unpublished report), was 173 per 1,000 live births.

1.5 Nosology

Human diseases

Only the most important of the communicable human diseases known to exist in Nigeria are outlined in this brief account.

Bilharziasis is an important cause of morbidity. Surveys carried out in the north revealed the presence of eggs of *Schistosoma haematobium* in over 30% of urine specimens and *S. mansoni* in 15% of stool specimens. The highest prevalence is found in adolescents, among whom as many as 50% have been found infected with *S. haematobium*. Reported cases of bilharziasis do not reflect the true incidence since many cases show mild clinical symptoms or are temporarily asymptomatic.

Brucellosis has been reported sporadically from the Northern Provinces where the infection is enzootic among goats.

Cerebrospinal meningitis appears nearly every year as a more or less widespread and strictly dry-season epidemic in several northern areas. A particularly severe epidemic was reported in 1948 with about 40,000 cases and a case fatality-rate of 20%.

Diphtheria in its clinical forms is relatively rare but subclinical infections in urban areas are common, judging from the results of Schick-test surveys.

Dysentery, both amoebic and bacillary, is common and accounts for at least 1% of all hospital admissions. The actual incidence is certainly much higher since many cases are unclassified. The ratio of bacillary to amoebic dysentery is approximately 1 : 5. In cases of the former, *Shigella flexneri* is most commonly reported.

Filariasis. Loa loa is very common in the east, particularly in the Cameroons, but occurs also in some areas of the western provinces. During sporadic surveys microfilariae of loa loa have been found in about 5% of children and 25% of adults. The same geographical distribution applies to *Acanthocheilonema perstans* which is believed to be asymptomatic. *Onchocerca volvulus* is common in the north-east and the Cameroons and may be associated with blindness.

Helminthic infections are extremely common affecting probably about 80% of the population. Ankylostomiasis is found in approximately 30% of examined specimens. *Ascaris lumbricoides*, *Trichuris trichiura*, and *Hymenolepis nana* are present in about 10%-20% of single examinations. *Paragonimus westermani* is not exceptional. *Taenia saginata* was present in about 10% of specimens during a survey carried out in the north. Cysticercosis seems to be uncommon. *Dracunculus medinensis* (guinea worm) is particularly common in the north and north-east and may result in a prevalence of 160 per 1,000 in some areas. Smaller foci of the disease are also found in the west.

Hepatitis of viral origin is reported sporadically though an extensive outbreak occurred recently in the river Cross area.

Leishmaniasis (cutaneous) is not uncommon in the extreme north of the country.

Leprosy constitutes a major problem. There are about 400,000 lepers in Nigeria, of whom one-quarter are thought to be infective. The highest incidence of leprosy is signalled from the eastern provinces, but smaller foci are distributed over the central and northern areas. The incidence varies from between 0.5 to over 10 per 1,000 of the population. Surveys, treatment, segregation, and research on leprosy are directed by the new Leprosy Service of the Medical Department.

Neurotropic virus infections constitute a new group of diseases of the central nervous system, the importance of which is constantly growing. The annual number of cases of poliomyelitis averages 30. Among the others, Bwamba fever is the first virus infection previously recorded in East Africa to be found also in West Africa.

Pneumonia and other acute respiratory infections are one of the major causes of death, particularly in the lower age-groups.

Rabies in dogs and other animals is enzootic and several human cases are reported every year.

Relapsing fever (predominantly louse-borne) occurred during recent years in the form of considerable outbreaks amounting to about 4,000 cases.

Smallpox occurs sporadically in many areas. Extensive outbreaks occurred recently in the Northern Provinces, where the peak annual incidence was 7,600 reported cases.

Skin diseases account for at least one-fifth of all hospital attendances, with tropical ulcers constituting about half of the total number of skin diseases. Staphylococcal, streptococcal, and fungal infections are very common. The same applies to scabies. Myiasis and infestation by the jigger flea (*Tunga penetrans*) are often reported. In the past the latter assumed serious proportions in mining areas of the Bauchi plateau.

Tetanus causes a considerable number of neonatal deaths but is relatively uncommon in adults.

Trypanosomiasis. A series of surveys carried out in 1930 revealed a mean prevalence of 5%-25% of the population in endemic areas, though in some of them the figure was as high as 50%. Large-scale surveys carried out during the past few years on about 2,000,000 people have shown that as a result of mass treatment and vector control the prevalence of the disease was approximately 1.5 per 1,000. Surveys, and the control of human trypanosomiasis, are directed by the Sleeping Sickness Service of the Medical Department.

Tuberculosis amounted in 1948 to about 3 per 1,000 of all hospital attendances and seems to be on the increase particularly in urban areas of the south. About 1,500 pulmonary cases and 750 non-pulmonary cases are reported annually, but the true incidence is not known. The clinical course is often rapid and severe.

Typhoid and paratyphoid are sporadically recorded from many parts of the country though their overall incidence is low.

Typhus (louse-borne) was first reported in 1945 on the Bauchi plateau where about 400 cases were diagnosed. Smaller outbreaks occurred during recent years in the north.

Venereal diseases. Syphilis, gonorrhoea, and chancroid are common throughout the country, and in some hospitals comprise nearly half of all attendances. Syphilis is more common in the north while gonorrhoea is prevalent in the south-east. The two latter diseases constitute 3.9% of all hospital admissions (1947) but this does not reveal their real incidence, which in some parts of Nigeria was found to be 125 per 1,000 adult males. A large-scale treatment scheme was planned on the basis of 500 infections per 1,000 population per year. Of some 50,000 cases reported annually about half are due to gonorrhoea and one-third to syphilis. There is evidence of a mutually exclusive distribution of syphilis and yaws, the former being prevalent in the north and the latter in the south of the country.

Yaws is prevalent in the eastern provinces of Nigeria and in the Cameroons but uncommon in the north and west of the country. The number of cases reported annually averages 30,000 and constitutes about 2.5%

of all hospital admissions. The prevalence is greater in rural areas where it may average 100 per 1,000 of the population and is seen predominantly in the lower age-groups.

Yellow fever is endemic throughout the country, but many cases are unrecognized on account of their mild and often subclinical course in the indigenous population. During the period 1934-44 about 30 cases were reported every year, mainly among non-immune immigrants. The present rarity of this disease in the non-African population is due solely to compulsory inoculation. Protection-test surveys revealed that in southern Nigeria immune antibodies are present in about 80% of the indigenous population under 15 years of age. Urban, *Aëdes aegypti*-transmitted epidemics are rare and due to series of particularly favourable epidemiological factors. Sylvan yellow-fever, the actual vector of which has not yet been discovered in West Africa, is prevalent in the south and localized in the north along the watercourses with their fringing forests.

In addition to communicable diseases, problems associated with nutrition deserve a very important place in any health survey. *Malnutrition and deficiency diseases* are very common particularly in the north where shortages of food due to droughts are frequent. Large numbers of children suffer and die from kwashiorkor[a] or malignant malnutrition, most probably caused by protein inadequacy. Protein—vitamin A and vitamin B complex —deficiencies (particularly ariboflavinosis) are common. Hemeralopia is frequently seen in the north. Beriberi and pellagra vary from year to year but about 1,500 cases are reported annually. Scurvy and rickets are rare. Endemic goitre is seen on the Bauchi plateau and in the Cameroons.

Of the diseases causing high hospital mortality the following should be mentioned in decreasing order of absolute numbers of annual deaths (1948) :

Pneumonia, bronchopneumonia, and bronchitis
Infectious diseases (mainly cerebrospinal meningitis, relapsing fever)
Tuberculosis (all forms)
Violent and accidental deaths
Diseases of the heart and circulatory system
Dysentery and enteritis
Malaria
Hernia and intestinal obstruction
Diseases of the liver and biliary passages
Diseases of blood-forming organs
Diseases of pregnancy and puerperium
Smallpox

[a] An article on kwashiorkor in Africa, by J. F. Brock and M. Autret, will appear in a forthcoming number of the *Bulletin of the World Health Organization*. — ED.

Animal diseases

Animal trypanosomiasis is the major veterinary problem of the country and takes a heavy toll of cattle. The trypanosomes involved are *Trypanosoma congolense, T. vivax, and T. brucei* in decreasing order of priority. The problem of control of the disease is difficult on account of the nomadic habits of cattle-owners. During the seasonal movements over long distances the herds maintain their old infections through mechanical transmission by Tabanidae or Stomoxys or they disseminate their infection through tsetse flies encountered en route.

Rinderpest and contagious pleuropneumonia are next in importance, followed by haemorrhagic septicaemia, blackquarter, contagious abortion, foot-and-mouth disease, heartwater, piroplasmosis, and rabies.

2. MALARIA

2.1 Morbidity and Mortality due to Malaria

In West Africa the morbidity and mortality attributed to malaria should always be assessed separately for the transient, small, non-indigenous population (highly susceptible to the infection though more or less successfully protected by mechanical methods and antimalarial drugs) on the one hand, and for the very large, immune or semi-immune indigenous communities on the other.[4] The recent tendency to make hospital and health returns in which these two dissimilar groups are pooled may be politically expedient but is scientifically unsound and is to be deplored.

Approximate morbidity and mortality figures for the non-African population of Nigeria, which numbered about 6,000 in 1944 and 10,900 in 1948, are given in table I.

TABLE I. MALARIA MORBIDITY- AND MORTALITY-RATES AMONG NON-AFRICANS IN NIGERIA, 1944-8

	1944	1945	1946	1947	1948
Morbidity-rate per 1,000 population (malaria)	298	305	212	266	206
Mortality-rate per 1,000 population (malaria and blackwater fever)	1.28	0.97	0.93	1.08	0.55

Data referring to the morbidity and mortality caused by malaria in the indigenous African population are incomplete and not reliable. Adequate records submitted to the Medical Department refer only to government and native administration hospitals. The attendance figures for the native administration dispensaries which are submitted to the Medical Department are not shown in the annual returns of diseases and deaths.

It is true that the morbidity statistics based on dispensary figures might be misleading, since the diagnosis made by the dispenser is of limited value. On the other hand, the dispensaries are far more numerous than the hospitals (526 against 75), more evenly distributed, more accessible, and their total attendance figures average one-and-a-half times the total number of in-patients and outpatients in all the government and native administration hospitals. Thus the hospital data represent not a cross-section of the population seeking medical aid but refer to a highly selected sample.

Actually, as concerns the diagnosis of malaria in West Africa even the hospital figures, based on medical evidence, are of limited value. There is

TABLE II. MALARIA MORBIDITY AMONG AFRICAN PATIENTS IN HOSPITALS IN NIGERIA, 1944-8

	1944	1945	1946	1947	1948	Total 1944-8
Inpatients	97,048	106,083	116,429	118,774	133,838	572,172
Outpatients . . .	947,341	866,449	1,002,244	1,051,345	1,214,712	5,082,091
Inpatients and outpatients . .	1,044,389	972,532	1,118,673	1,170,119	1,348,550	5,654,263
Malaria cases :						
inpatients . . .	6,049	7,913	9,028	8,036	9,267	40,293
outpatients . .	78,352	76,248	90,705	100,090	113,998	459,393
inpatients and outpatients .	84,401	84,161	99,733	108,126	123,265	499,686
Percentage of malaria cases :						
inpatients . . .	6.23	7.46	7.75	6.77	6.92	7.04
outpatients . .	8.27	8.80	9.05	9.52	9.38	9.04
inpatients and outpatients .	8.08	8.65	8.92	9.24	9.14	8.84

little doubt that the diagnosis of malaria in the immune or semi-immune African is subject as often as not to individual interpretation of clinical symptoms by the medical officer, in the majority of cases without the critical support of the blood examination. To complicate the issue, a positive blood-slide from an indigenous inhabitant of West Africa is not necessarily a criterion of the diagnosis. Subclinical parasitaemia may be found in the majority of African children and in from 10% to 20% of African adults, without any obvious symptoms of the disease. Thus the morbidity—and perhaps even the mortality—data culled from the annual medical and sanitary reports in West Africa [10] must not be treated as irrefutable and absolutely reliable.

TABLE III. MALARIA MORTALITY AMONG AFRICAN PATIENTS IN HOSPITALS IN NIGERIA, 1944-8

	1944	1945	1946	1947	1948	Total 1944-8
Total deaths . .	4,575	4,501	4,373	4,596	5,689	23,734
Deaths from malaria	132	122	157	157	240	808
Percentage of deaths due to malaria	2.89	2.71	3.59	3.42	4.22	3.40
Malaria case fatality-rate (per 1,000 cases) . .	1.56	1.45	1.57	1.45	1.95	1.62

Tables II and III show malaria morbidity and mortality data with regard to the African population attending or admitted to any of the 75 government and native administration hospitals in Nigeria during the period 1944-8.

Data with regard to blackwater fever, given in table IV, are shown separately for the non-African and for African patients. While the diagnosis of blackwater fever in non-Africans is usually reliable, it is felt that a certain number of cases of " blackwater fever " diagnosed in Africans are not related to malaria but are of a different origin (sickle-cell anaemia, toxic haemolytic anaemia, haematuria, etc.).

2.2 Distribution of Malaria

Much information on the prevalence of malaria in Lagos was obtained in 1930-1 by Barber & Olinger.[1] During the period 1934-47 series of malaria surveys were carried out by J. Y. Brown (unpublished reports to the Director of Medical Services, Nigeria). Supplementary surveys of the country were carried out during the war by the military authorities and particularly by No. 7 Malaria Field Laboratory, Royal Army Medical Corps (unpublished reports to the Deputy Director of Medical Services, West Africa). The total number of all these surveys is nearly 60, of which over 40 refer to different stations. Not all of them are comparable, since many were restricted to one or two malariometrical or entomological data, and most of them are of a brief reconnaissance type. More complete and recent malaria survey data are available for Lagos, Katsina, and Enugu.

TABLE IV. BLACKWATER FEVER CASES IN HOSPITALS IN NIGERIA, 1944-8

	1944	1945	1946	1947	1948	Total 1944-8
Non-Africans . .	10	9	5	7	2	33
Africans	16	17	14	35	20	102

Note : The case fatality-rate in non-Africans was 33%, in Africans 13%.

Summarizing the available information it can be stated that the whole of Nigeria is malarious. Hyperendemic malaria extends from the coast to the 10-inch (254-mm) dry season (November-April) isohyet. Malaria of varying degrees of endemicity extends through the rest of the country. While in the hyperendemic southern area there are islands of low endemicity (Ijebu Ode), in the northern part of the country there are numerous hyperendemic foci (Katsina). One would expect to find, at least in the Sahel savannah zone, with its small annual rainfall and the consecutively very short transmission period, a typical picture of epidemic malaria with its clinical consequences. Actually, there is no evidence of such a condition, and in investigated rural and urban communities in the far north of Nigeria a picture of highly endemic or hyperendemic malaria is common. The reason for this is not quite clear at present, and it seems that the problem of indigenous malaria in the north of Nigeria deserves a thorough and long-term investigation. The distribution of malaria on the Bauchi plateau and in the Cameroons highlands has not yet been investigated, but in at least one area in the Cameroons highlands (Bamenda) there is evidence of endemic malaria.

In the southern hyperendemic belt spleen-rates in the 1-10 age-group are rarely below 60% and usually vary between 65% and 80% with relatively little seasonal variation. In the north, the mean spleen-rates are between 50% and 60%, with an increase up to 70% and more towards the end of the rainy season. The average enlarged spleen varies usually between 1.2 and 1.8 (Hackett's classification) but rises to 2.5 towards the end of the transmission period. Large and very large spleens (Hackett's sizes 4 and 5) are uncommon.[b]

Parasite-rates vary considerably according to the area investigated, to the time of the year, and to the age-group involved. Approximate average figures are as follows :

In infants the crude parasite-rate (all species) is usually between 15% and 50%, although this figure depends considerably on the composition of the less-than-1-year group : the higher the mean age of this particular group the higher the parasite-rate. In the north the crude parasite-rates of infants less than 6 months of age seem to be consistently higher than the corresponding rates in the south. In the 1-10 age-group the mean crude parasite-rates vary between 65% and 90%. The highest rates are consistently found in the 3-4 and 5-7 age-groups, so that once again the mean parasite-rate of the 1-10 age-group depends to a great extent on its composition. The influence of the transmission season on the crude parasite-rate of this group is more pronounced in the north than in the south of Nigeria.

[b] It must be pointed out that in West Africa the spleen-rates taken during separate surveys are strictly comparable only if the composition of the 1-10 age-groups of African children is very similar. Usually the 3-4 and 5-7 age-groups show considerably higher spleen-rates than the 8-10 age-group, not only because in the latter group the enlarged spleen retracts following the increase of the acquired immunity but also because of the early muscular development of the abdominal wall, which often makes the correct palpation of the spleen more difficult.

The adolescent group (11-15 years) has a mean parasite-rate varying between 20% and 50%. In adults the parasite-rate was found to be usually between 11% and 28%.

The specific parasite-rates are as follows. The overall rate of *Plasmodium falciparum* corresponds rather closely to the crude parasite-rate, since about 96% of all infections are due to this species. *P. malariae*, either alone or associated with *P. falciparum*, occurs in 5%-20% of all examinations. Highest rates of *P. malariae* seem to occur in the 3-7 age-group. As a rule *P. malariae* is more common in southern than in northern Nigeria. *P. vivax* is uncommon and rarely seen more frequently than in 0.5% of examinations. *P. ovale* was recorded sporadically from several areas in Nigeria. Recently a focus of *P. ovale* was found in a suburb of Lagos with a specific parasite-rate of 3% in about 300 schoolchildren.

The overall density of the plasmodial infection measured by the estimation of the Parasite Density Index (PDI) (Bruce-Chwatt [3]) varies in relation to the mean age of the sample of the examined population and to epidemiological conditions of the area at the time of the survey. In southern Nigeria the PDI for *P. falciparum* averages 1.5-2.0 in infants, rises to 2.5-4.0 in the 1-4 age-group, occasionally remains at this peak figure in the 5-7 age-group, but usually decreases steadily to about 1.0 in adolescents and to 0.5 and below in adults.

Gametocytes of *P. falciparum* are seen in approximately 10% of examined infants, (this rate varies considerably in relation to the age composition of the infant group), 20% of young children (1-4 age-group), and 12% of older children. In adolescents the gametocyte-rate is usually below 5%; it decreases to between 0.5% and 1% in adults. The gametocyte density is usually low—around 80-150 per mm^3.

Falciparum gametocyte carriers with over 200 sexual parasites per mm^3 are an exception. The highest gametocyte density of 960 per mm^3 was observed only once, as was the next highest of 520 mm^3.

This low average *P. falciparum* gametocyte density explains the disparity of results produced by various investigators with regard to the gametocyte-rate in West Africa.

2.3 Malaria in Infancy

Malaria in African infants was investigated during the period 1947-9 through studies of 616 infants attending two infant-welfare clinics administered by the Health Department of Lagos Town Council. Thus the investigation was carried out on a selected sample of the population. None the less it is applicable to a large portion of the urban and peri-urban child population.

Consolidated results of 3,657 blood examinations of all 616 infants, from 1 week to 18 months of age, treated as a random sample are shown in table V. For comparative purposes this table contains also some similar data reported by other workers in West Africa.[1, 2, 5, 12]

During the first four months of life the proportion of infants infected with malaria is usually below 10%. During the second half of the first year this proportion rises steadily and by the end of the first year at least two-thirds of all the infants are infected. Finally, during the second year of life most of the children show the presence of malaria parasites in the blood, even on a single examination.

TABLE V. COMPARISON OF PARASITE-RATES FOUND IN AFRICAN INFANTS IN LAGOS, NIGERIA, AND FREETOWN, SIERRA LEONE, 1925-49

Age in months	Lagos and environs			Lagos	Freetown		
	Study, 1947-9			Barber & Olinger, 1931 [1]	Blacklock & Gordon, 1925 [2]	Davey & Gordon, 1933 [5]	Turner & Walton, 1946 [13]
	Number of examinations	Number of infections	%	%	%	%	%
1 or less	964	8	0.83	25.0	4.9		13.0
2	350	14	4.0		7.3	4.8	14.6
3	362	20	5.5	22.4			30.0
4	392	36	9.2	29.7	17.3		40.0
5	326	58	17.8			41.2	39.0
6	230	52	22.6				55.0
7	220	72	32.7				
8	184	58	31.5	57.6		58.8	
9	206	64	31.1		27.6		55.0
10	134	69	51.5				
11	72	32	44.4			70.6	
12	46	32	69.6	90.0			
13	50	28	56.0				
14	44	36	81.8				
15	30	28	93.3				
16	18	15		93.6	41.8	83.7	
17	15	14	87.2				
18	14	12					
Total	3,657	648					

Specific identification of parasites involved was as follows : *P. falciparum* was found in 98% of all infections, *P. malariae* in 2.8%, and *P. ovale* and *P. vivax* in 2.1%. There were 5 mixed infections with *P. falciparum* and *P. ovale* or *P. malariae*. Gametocytes of *P. falciparum* were found in 3.2% of all examinations and in 28.3% of all infections.

The density of the plasmodial infection for *P. falciparum*, which was determined by counting the number of parasites per mm^3 and calculating the PDI, is shown in table VI.

Table VI shows that the average intensity of the infection acquired by African infants starts at a low level and rapidly increases during the first 18 months in a way similar to the parasite-rate.

TABLE VI. PARASITE DENSITY INDEX IN 616 AFRICAN INFANTS ACCORDING TO AGE, LAGOS, 1947-9

Month of life .	1st	2nd	3rd	4th	5th	6th	7th-9th	10th-12th	13th-18th
Parasite density index	0.01	0.07	0.08	0.23	0.38	0.59	1.3	1.89	2.42

2.4 Malaria as a Cause of Death in Childhood

There are many unanswered questions with regard to the importance of malaria as a cause of the reproductive wastage of the African population inhabiting hyperendemic malarious areas. The reasons for this unsatisfactory state of knowledge are obvious. In large areas where there are no elementary biostatistical data pertaining to birth or death, how can a reliable and numerically important figure for the causation of death be expected ?

Smith,[11] in his report on the child mortality in Lagos based on 500 postmortems of children up to 5 years of age, found that malaria was a cause of death in 10.8% of 293 infants and 14.5% of children from 1 to 3 years of age. Whitbourne [13] estimated that malaria is responsible for 8%-10% of the total infant mortality in Lagos.

In an attempt to collect more data, it was decided to extract from the past records of the Pathology Department of Lagos General Hospital all the information pertaining to postmortems performed on African children from the age of one week to 15 years, to classify them, and to consolidate the information gathered in this way. The records cover the period 1933-48.

To determine if malaria was the actual or most probable cause of death the records were critically reviewed. Only the following pathological pictures were retained as criteria of death caused by malaria :

(1) Acute cerebral malaria : pigmentation of the grey matter, congestion and oedema, blockage of cerebral capillaries by malaria parasites or swollen endothelium.

(2) Acute general infection with an enlarged and intensely congested, slate-coloured, parasite-containing spleen, and/or pigmentation and enlargement of the liver with fatty changes, and/or diffuse pigmentation and lymphoid macrophage response of the lungs, and/or presence of schizonts in the blood from the heart.

Malarial cachexia was hardly ever seen on the postmortem table and very rarely mentioned in records. Smith [11] makes a special point of mentioning that the feature of the malaria group was the well-preserved and nourished appearance of the children.

Tables VII and VIII present the consolidated information gathered from the records of the General Hospital in Lagos.

TABLE VII. MALARIA AS A CAUSE OF DEATH, AS REVEALED BY 3,085 POSTMORTEMS ON AFRICAN INFANTS AND CHILDREN, ACCORDING TO AGE, LAGOS, 1933-48

	Age in years						Total	
	Less than 1	1 - 2	3 - 4	5 - 7	8 - 10	11 - 15	Number	%
Total number of postmortems	755	753	562	421	250	344	3,085	100
Malaria :								
cerebral	38	57	34	12	3	4	148	4.8
other	28	44	40	19	6 *	2	139	4.5
total	66	101	74	31	9	6	287	9.3
Proportion of malaria in postmortems (%) . .	8.7	13.4	13.2	7.4	3.6	1.7	9.3	

* One death from blackwater fever has been excluded.

Note : Respiratory diseases, including tuberculosis, were the most common (70%) cause of death in all these groups ; diseases of the alimentary tract, meningitis, malaria, anaemia, and malnutrition were the next most important causes of death.

In the Lagos General Hospital (which caters for an important portion of the urban African population) 40% of all postmortems during the period 1933-48 were carried out on subjects below 15 years of age. Of these, as shown in tables VII and VIII, nearly half were on infants and children between one and two years of age. Malaria as a cause of death seemed to play the most prominent and equally important part in the age-groups 1-2 and 3-4 years, where it amounted to over 13% of all causes of death. In African infants the average percentage of malaria diagnosed as a cause of death was 9%. In all age-groups, but particularly in the 1-2 years' group, there was a considerable increase of the postmortem diagnosis of malaria during the first half of the war years. It is not possible to decide whether this was due to a particularly severe form of the disease or to other, perhaps extraneous, factors.

It should be emphasized that the figures quoted above do not apply to the death-rate by specific causes of the entire infant and child population of Lagos. The mean ratio of postmortems to the total number of infant and children's deaths registered in Lagos varies considerably. The hospital

TABLE VIII. MALARIA AS A CAUSE OF DEATH, AS REVEALED BY 3,085 POSTMORTEMS ON AFRICAN INFANTS AND CHILDREN, ACCORDING TO AGE AND CALENDAR YEARS, LAGOS, 1933-48

Year	Age in years														
	Less than 1			1 — 2			3 — 4			5 — 7			8 — 15		
	Post-mortems	Malaria	%	Post-mortems	Malaria	%	Post-mortems	Malaria	%	Post-mortems	Malaria	%	Post-mortems	Malaria	%
1933	8	1	12.5	9	0	0	10	1	10.0	15	1	6.7	17	0	0
1934	23	0	0	17	0	0	15	1	6.7	21	0	0	20	0	0
1935	18	1	5.6	17	2	11.8	24	6	25.0	11	0	0	22	1	4.5
1936	22	1	4.5	17	4	23.5	24	2	8.3	17	3	17.6	15	0	0
1937	26	0	0	18	2	11.1	15	1	6.7	12	0	0	16	1	6.2
1938	12	1	8 3	18	2	11.1	22	3	13.6	12	0	0	18	0	0
1939	27	1	3.7	21	1	4.8	35	5	14.3	28	3	10.7	33	2	6.1
1940	48	6	12.5	46	18	39.1	31	5	16.1	26	2	7.7	50	2	4.0
1941	70	12	17.1	101	27	26.7	41	6	14.6	41	5	12.2	37	2	5.4
1942	141	15	10.6	98	8	8.2	50	4	8.0	40	2	5.0	60	0	0
1943	110	8	7.3	110	9	8.2	60	4	6.7	44	2	4.5	52	1	1.9
1944	59	5	8.5	75	10	13.3	60	10	16.7	41	3	7.3	67	0	0
1945	51	2	3.9	80	6	7.5	47	4	8.5	37	1	2.7	70	0	0
1946	59	7	11.9	42	3	7.1	45	9	20.0	25	1	4.0	45	2	4.4
1947	41	5	12.2	45	5	11.1	62	11	17.7	39	8	20.5	49	3	6.1
1948	40	1	2.5	39	4	10.3	21	2	9.5	12	0	0	23	1	4.3
Total	755	66	8.7	753	101	13.4	562	74	13.2	421	31	7.4	594	15	2.5

Note : The X^2 test of this series of observations gave a P value less than 0.001, showing that the series of values observed in the five columns arranged by age-groups differ between themselves to a far greater degree than might be expected to occur by chance.

cases represent a highly selected sample and are not sufficiently large nor are they representative of the cross-section of the community. Interpretation of these tables is therefore subject to the usual difficulties encountered when dealing with proportional rates.

2.5 Transmission of Malaria

In the coastal belt the transmission period of the malaria infection is practically perennial. Throughout the forest region, with its more than 60 inches (1,524 mm) annual rainfall, this transmission period may be interrupted or considerably slowed down during the peak of the dry season, but it is never shorter than eight to nine months in the year. In the central

dry forest zone the transmission period is shorter and averages six to seven months in the year. In the Sudan and Sahel savannah regions the natural transmission period is usually less than five months in the year. It must be emphasized that the transmission season depends not only on the total annual rainfall but also on its distribution in time, viz., the number of rainy days. Local factors may be more important than meteorological conditions ; as, for instance, in some northern towns where the numerous borrow-pits, which hold water throughout the year, contribute to the artificial, perennial transmission and create hyperendemic foci within an endemic area.

Of the total of some 28 anopheline species found in Nigeria, eight have been found infected with oocysts or sporozoites of malaria. They are (in order of importance) *Anopheles gambiae* group (including *A. gambiae* var. *melas)*, *A. funestus*, *A. hargreavesi*, *A. pharoensis*, *A. nili*, *A. moucheti* var. *nigeriensis*, *A. hancocki*, and *A. rufipes*. Of all these, two only—*A. gambiae* group and *A. funestus*—are widely distributed and of permanent importance as malaria vectors. The others are secondary vectors either because of their localized distribution or on account of their low density and short, seasonal breeding peak. Of the secondary vectors, *A. hargreavesi* followed by *A. nili* are the most likely to be efficient vectors in Nigeria. There is little doubt that the six secondary species play little part in the epidemiology of malaria compared with the enormous total amount of infection carried by *A. funestus* and the *A. gambiae* group.

Comparison of the epidemiological importance of the two main species reveals the following facts applicable to West Africa in general and to Nigeria in particular :

A. gambiae gambiae (but not *A. gambiae* var. *melas* which is strictly coastal) has a country-wide distribution due to its relatively indiscriminate breeding-habits in many kinds of water, completely or partially exposed to sunlight, and situated more or less close to human habitations in rural as well as urban areas. On the other hand, the distribution of *A. funestus* is patchy, because of its preference for breeding in clean water, more or less shaded by vegetation.

The seasonal prevalence of the two vectors varies considerably in relation to general meteorological and local ecological factors. Nevertheless, it is possible to describe summarily the general trend of the breeding activity of the two species.

The curve of the seasonal density of *A. gambiae gambiae* corresponds with the rainfall curve with a time lag of a few weeks. In Nigeria the breeding activity rises sharply, almost explosively two to four weeks after the onset of the rainy season, shows a short high peak in June-July-August, and then falls away more or less rapidly to almost nil in January-March. The breeding activity of *A. gambiae* var. *melas* is related less to the rainfall

curve and more to the tides, particularly where the range of tidal movements is considerable. It could reasonably be expected that throughout northern Nigeria, with its prolonged dry season, breeding of *A. gambiae gambiae* would be restricted to a few months in the year. Actually in some localities the situation may be surprisingly different, and even during the peak of the dry season considerable anopheline breeding may exist in quasi-perennial borrow-pits and hundreds of small, private wells. This is particularly true with regard to the famous borrow-pits in northern towns and villages. They serve as quarries, water-sources, sewage-disposal sites, bathing-places, communal laundries, cattle dips, etc., and incidentally as semi-permanent anopheline breeding areas with daily outputs varying from a few hundred to well over 100,000 anopheles per day. The fascinating problem of the hibernation of *A. gambiae gambiae* in northern Nigeria has still to be investigated.

The minimum density of *A. funestus* is just before the onset of the rains. Later the curve rises more slowly and steadily well into the wet season in July and then decreases somewhat during the slight rains. Heavy downpours do not always increase the breeding activity of *A. funestus* but on the contrary may decrease it by swelling the watercourses and washing away or stranding the eggs and larvae. With the lessening of the rainfall the density of *A. funestus* rises again and then falls to its minimum in March. It can be said that while *A. gambiae gambiae* is the wet season vector, *A. funestus* becomes the chief vector during the first half of the dry season.

A. gambiae gambiae is virtually omnipresent and plays an important part as a vector of malaria in both rural and urban areas. *A. funestus* is more common in either rural communities or small urban areas, though in northern towns it may often share with *A. gambiae gambiae* the same overgrown borrow-pits and breed among the vegetation on the shady side, under an earth bank, while its sun-loving neighbour chooses the sunny, shallow, edge on the opposite side.

Most of the infectivity-rates of both vectors investigated in Nigeria are based on the dissection of salivary glands for sporozoites. The mean overall sporozoite-rate of the *A. gambiae* group in Nigeria, irrespective of seasons or localities, is 5.89% ; the comparable figure for *A. funestus* is 4.96%. However the month-by-month trend of the infectivity-rate may vary in Nigeria within a range of 0%-20.0% for *A. gambiae* and 0%-15.0% for *A. funestus*. During the dry season the apparent [c] sporozoite-rate of *A. gambiae gambiae* is very low ; it increases rapidly soon after the beginning of the rainy season and reaches its peak when the rains decrease. With the decreasing rainfall the infectivity-rate of *A. gambiae* declines, at first slowly then more rapidly, to almost nil at the peak of the dry season.

[c] The reference to the apparent sporozoite-rate is due to the fact that during the dry season the numbers of captured adult female anopheles are usually very low and in many instances the low infectivity figures are due to small numbers of dissected mosquitos. Dry season sporozoite-rates statistically comparable with sporozoite-rates as found soon after the peak of the breeding activity are very difficult to obtain in the field.

The above does not necessarily apply to *A. gambiae* var. *melas*, the breeding activity of which depends little on the rainfall. There is evidence of the *A. gambiae* var. *melas* sporozoite-rate being rather lower than that of *A. gambiae gambiae*. The respective trend with regard to *A. funestus* differs as far as the infectivity is concerned since its high level extends well into the dry season.

The highest infectivity figure of 20.0% recorded in Nigeria for the *A. gambiae* group was found in 1942 in Ibadan. The next highest figure is 14.0% recorded from Gusau in the north (1948). The highest infectivity figure for *A. funestus* was found in 1941 in Tiko—15.0%. These very high infectivity figures often accompany high anopheles densities. The number of infective mosquito-bites received by each person exposed to such epidemiological conditions as existed in September 1948 in Gusau in northern Nigeria may amount to 640 per year—a somewhat theoretical but none the less fantastic figure.

2.6 Antimalaria Measures and Programmes

The general methods of mosquito control in Nigeria are limited to the domestic control of *Aëdes aegypti*, by inspection and enforcing the dry pot day routine. Anti-anopheline measures are : filling in borrow-pits and depressions, controlled tipping, small-scale drainage, and larviciding by gas-oil or malariol. Imagocidal measures are carried out more or less occasionally by spraying groups of houses with DDT in kerosene or DDT wettable powder. Lately the use of the less expensive benzene hexachloride (BHC) in wettable powder form or in kerosene dilutions has become more frequent. All these antimalaria measures are on a rather small scale, not very regular, with little adequate supervision, and are usually carried out as part-time work of the local public-health organizations.

No country-wide antimalaria programmes are being carried out or planned, but plans and estimates are ready for series of area-wide mosquito-control schemes, particularly in the north.

The Lagos Mosquito Control Scheme by swamp drainage began in 1942 as a limited military project. It was later extended, and eventually completed by the end of 1947 at a total cost of approximately £120,000. It was put on a maintenance basis in January 1948, and handed over to the Lagos Town Council's Public Health Department on 1 April 1948. This scheme, which extends over an area of nearly 4,200 acres (1,700 ha) of coastal swamps, was executed with a view to controlling the breeding activity of *A. gambiae* var. *melas*, at first near the Royal Air Force Airport at Apapa and later in the Lagos urban area proper. The breeding foci of *A. gambiae* var. *melas* were formerly irregularly distributed over a wide area of tidal swamps covered with a dense tangle of mangroves and coarse swamp grass—conditions that precluded the effective application of larvicides.

This drainage scheme, designed and executed by Gilroy,[6] consists of : (*a*) a sea-wall or bund which encloses the low-lying swamp and prevents the tidal waters from flooding it ; and (*b*) a system of channels and contour drains which lead the impounded water to (*c*) a controlled outlet in the form of hand-operated sluice-gates. The sluice-gates open at low tide and permit the outflow of water from the system of drains into the creek. At the rising tide the gates are closed and prevent the inflow of water when the water level outside the bund is higher. The success of this scheme is obvious with regard to the control of *A. gambiae* var. *melas* in its main breeding areas.

The urban district of Lagos covers an area of 24 squares miles (62 km²), of which about 7½ squares miles (19.5 km²) were tidal swamps breeding enormous numbers of mosquitos. Since 1947, of this vast mosquito breeding area there remain 1½ square miles (4 km²) which are slowly being reclaimed by sand pumping or controlled tipping and are treated with larvicides under the supervision of the Medical Officer of Health, Lagos. The Medical Officer of Health, Lagos, also administers measures for the control of the freshwater breeding *A. gambiae gambiae* in the township itself. The latter is divided into 35 zones, each of which has a permanent larvicidal team which deals with the respective zone in six days at the rate of one sector per day. Gas-oil, alone or with the addition of 1% DDT, is in routine use.

Of the specific antimalaria programmes carried out at present two merit mention. The first is the Ilaro Experimental Anopheles Eradication Scheme and the second is the malaria-control programme of the Cameroons Development Corporation.

The aim of the Ilaro scheme is twofold : (*a*) to investigate the practical possibility of an " island " eradication of the anopheline vectors by intensive residual spraying of all dwellings within a determined medium-sized (7 square miles (18 km²) area situated in a hyperendemic part of West Africa ; (*b*) to assess the influence of a prolonged removal of the vectors of local malaria on the collective picture of malaria and the general health of an untreated African community.

The Ilaro scheme, conceived by the Malaria Service, began in February 1949 when Ilaro, a medium-sized Yoruba town in south-western Nigeria, was tentatively chosen for an experimental " island " anopheles eradication. Ilaro has some 12,000 inhabitants and 2,300 houses and is a typical mixed urban and rural community, situated within a geographical zone that corresponds to hyperendemic malarial conditions in Nigeria.

A preliminary malaria survey carried out between March 1949 and March 1950 revealed that malaria in Ilaro is on the lower level of hyperendemicity with a pronounced subclinical endemic wave that starts shortly after the beginning of the rainy season and lasts for at least four months. *P. falciparum* with the concomitant *P. malariae* is the main parasite species. *A. gambiae gambiae* and *A. funestus* are the main vectors, with

A. funestus persisting throughout the year, while *A. gambiae* has a pronounced seasonal importance during the rains.

The residual spraying of Ilaro began in March 1950. The insecticide used for it is the BHC wettable powder P.520 containing 6.5% gamma isomer. The dosage is 10 mg gamma isomer per square foot (109 mg per m^2). The routine spraying equipment consists of Eclipse " Super Triumph " bucket sprayers (stirrup-pump pattern) with a 20-foot (6.1-m) hose, 2-foot (0.61-m) lance with trigger release, and nozzle of 3/64 inch (0.12 cm) aperture giving a flat fan-shaped jet. Modifications of this equipment are being tested. There are 4 spraying squads each composed of 1 recorder and 4 sprayers.

The spraying of the 2,300 houses containing over 11,000 rooms is being repeated every three months. All dwellings within a 3 miles' (4.8 km) radius round Ilaro are also treated. The results of the residual spraying are being assessed by means of entomological (anopheline density, larval density, infectivity-rate) and malariometrical (spleen-rates, parasite-rates, parasite densities, morbidity, etc.) data.

The second well-defined malaria-control programme carried out at present is the Mosquito Control Scheme of Tiko and Bota areas organized by the Cameroons Development Corporation. These two main centres of activity of the Corporation are within a widespread breeding area with *A. gambiae gambiae*, *A. gambiae* var. *melas*, *A. funestus*, *A. hargreavesi*, and *A. nili* as vectors. Both larvicidal work and imagocidal spraying are carried out within a mile from the inhabited area. For residual spraying the BHC dispersible powder P.520 and the liquid concentrate LG.240 are used. The frequency of residual spraying is four times a year.

2.6.1 *Organization of antimalaria services*

Activities connected with malaria control are directed by the Director of Medical Services through the Deputy Director of Health Services, the three regional Deputy Directors of Medical Services, and Assistant Directors of Medical Services (Health). Eight medical officers of health, 40 sanitary superintendents, and a cadre of sanitary inspectors are directly responsible for the malaria-control work within their areas. As a rule the malaria-control work forms a part of the general hygiene and environmental sanitation routine.

In Lagos only there exists a separate antimalaria section of the Public Health Department of the Town Council directed by the Medical Officer of Health and the Assistant Medical Officer of Health.

The work of the Malaria Service, established in Nigeria in 1948 under the Colonial Development and Welfare Act as an ancillary service of the Medical Department, began in February 1949. Its objectives are as follows :

The Malaria Service acts in an advisory capacity to the Director of Medical Services. It carries out field surveys, research on chemotherapy,

epidemiology, and entomology of malaria, and organizes pilot control schemes. It trains the junior personnel of the Medical Department in field entomology and the technique of malaria control. It co-operates with educational bodies, such as the University College, Ibadan, in teaching and training in malariology. It interchanges results and methods with other branches of the Medical Department and with other British or foreign West African dependencies. It will also co-ordinate the antimalaria work throughout the country.

A ten-year scheme for the Malaria Service was drawn up in 1948 under the Colonial Development and Welfare Act. The financial provision for the first two years of this project was approved, and future expenditure is to be determined at the end of this preliminary period in the light of experience gained.

2.6.2 *Legislation on malaria*

The most important legal document pertaining to the problem of mosquito-borne diseases is the " Ordinance to provide for the Destruction of Mosquitoes " No. 31 of 26 April 1945.

This Ordinance defines (1) the powers for appointing sanitary authorities for particular areas, and (2) the powers of the appointed sanitary authorities in taking preventive measures, performing works and recovering costs, imposing penalties for default, and general regulations with regard to antimalaria schemes.

2.6.3 *Prophylaxis and treatment of malaria*

There is no standardized schedule of treatment of acute malaria but a survey carried out in 1949 [4] revealed that for the immediate treatment of very severe attacks of malaria intravenous or intramuscular quinine in doses varying between 5 and 20 grains (0.32 g and 1.29 g) (fractional) in the first 24 hours is favoured by most of the medical officers in Nigeria. Intramuscular mepacrine in doses of 0.3 g - 0.9 g during the first 24-48 hours is the next best choice.

For the treatment of malarial attacks of average severity the most popular combined therapeutic regimens are the following :

(1) Quinine — given as a single intramuscular injection of 5 grains (0.32 g) or orally 30 grains (1.94 g) a day for 2-3 days followed by 0.2 g - 0.6 g mepacrine a day for 4-6 days.

(2) Quinine — dosage as above, followed by proguanil 0.3 g - 0.6 g a day for 7-10 days.

(3) Mepacrine — 0.6 g - 0.9 g on the first day, 0.3 g - 0.6 g on the second day, followed by proguanil 0.3 g - 0.6 g daily for 4-10 days.

Prophylactic (=suppressive) antimalarial drugs are taken by practically every non-African resident in Nigeria and many educated Africans have

adopted a more or less regular schedule of antimalarial drugs for their children and occasionally for themselves.

Prophylactic proguanil is used by 65% of the non-African population at the daily dose of 0.1 g. Quinine taken at a daily dose of 5 grains (0.32 g) is used by 23% of non-Africans, while mepacrine (0.4 g - 0.7 g a week) is used by 10% of non-Africans. Chloroquine is still new in West Africa

TABLE IX. ESTIMATE OF YEARLY CONSUMPTION OF ANTIMALARIAL DRUGS IN NIGERIA

Source	Quinine (all formulations)		Mepacrine (all formulations)		Proguanil (tablets)	
	lb = kg		lb = kg		lb = kg	
Delivery by the Medical Department Stores . .	5,792	2,627	2,315	1,050	1,102	500
Sales through private firms .	661	300	2,601	1,180	772	350
Total	6,453	2,927	4,916	2,230	1,874	850

and used as a regular suppressive only by a very small fraction of the non-indigenous population.

A recent experimental evaluation of the therapeutic activity of the three synthetic antimalarial drugs, carried out on a fair-sized sample of African children, has revealed that chloroquine seems to be the most active schizontocidal drug followed closely by mepacrine.

Treatment is free for the African population while prophylaxis and treatment are free for all government officials.

Approximate amounts of antimalarial drugs consumed in Nigeria per annum (1949) can be estimated from table IX.

ACKNOWLEDGEMENTS

My thanks are due to the Director of Medical Services, Nigeria, for permission to publish this paper.

I am indebted to Dr. David Cannon, Assistant Director, Laboratory Services, Medical Department, Nigeria, for permission to use the postmortem records of the General Hospital in Lagos.

SUMMARY

In the first part of the article, the author describes briefly the topography and climate of the country. Details are also given of the population by numbers, anthropological type, tribal and linguistic division, and occupation, and such vital statistics as are available for the region are summarized. A brief account of the principal communicable diseases—human and animal—prevalent in Nigeria follows.

Data on malaria in Nigeria are discussed in the second part under five main heads : malaria morbidity and mortality ; distribution of the disease ; malaria in infancy ; malaria transmission ; and antimalaria measures.

Malaria morbidity and mortality data are presented separately for the small non-African population, on the one hand, and the very large indigenous population on the other. The total number of malaria cases among the indigenous population has increased from 84,401 in 1944 to 123,265 in 1948, while the case fatality-rate per 1,000 cases has increased from 1.56 to 1.95 over the same period. These figures cannot, however, be considered absolutely reliable, as annual returns are based solely on attendance figures at the 75 government and native administration hospitals, exclusive of attendance figures at the 526 native administration dispensaries, and, even in the hospitals, malaria diagnosis is often based purely upon an individual interpretation of clinical symptoms without confirmation by laboratory examination.

Surveys over the last 20 years have revealed that the whole of Nigeria is malarious, while several regions are hyperendemic. Available data on the mean spleen-rates, parasite-rates, specific parasite-rates (about 96% of all infections are

RÉSUMÉ

Dans la première partie de l'article, l'auteur décrit brièvement la topographie et le climat du pays. Il donne également des indications sur le chiffre de la population, le type anthropologique, la division en tribus, les langues parlées, les occupations des habitants, ainsi qu'une analyse succincte des statistiques démographiques actuellement disponibles. Suit un bref exposé sur les principales maladies, transmissibles à l'homme et aux animaux, qui sévissent dans la Nigeria.

La seconde partie est consacrée à l'étude des données relatives au paludisme dans la Nigeria, lesquelles sont classées sous cinq rubriques principales : morbidité et mortalité par paludisme ; répartition de la maladie ; paludisme chez les enfants ; transmission du paludisme ; lutte antipaludique.

Les chiffres de morbidité et de mortalité par paludisme sont présentés séparément, d'une part pour la population non africaine, qui est peu nombreuse, et d'autre part pour la population africaine qui, au contraire, est très importante. Le nombre total des cas de paludisme dans la population africaine s'est élevé de 84.401, en 1944, à 123.265, en 1948, le taux de létalité passant de 1,56 à 1,95 pour 1.000 au cours de la même période. Ces chiffres appellent cependant certaines réserves, car les statistiques annuelles sont basées exclusivement sur les cas traités dans les 75 hôpitaux relevant des services gouvernementaux et de l'administration indigène, et ne tiennent pas compte des malades qui ont reçu des soins dans les 526 dispensaires administrés par les autorités indigènes. D'ailleurs, même dans les hôpitaux, il arrive fréquemment que le diagnostic soit fondé uniquement sur l'examen clinique, sans être confirmé par des épreuves de laboratoire.

Les enquêtes entreprises au cours des vingt dernières années ont révélé que l'ensemble de la Nigeria est impaludé, l'infection étant hyperendémique dans plusieurs régions. L'auteur énumère les données disponibles sur l'indice splénique

due to *Plasmodium falciparum*), and gametocyte-rates are cited by the author.

Investigations on malaria in infancy were carried out in Lagos from 1947 to 1949. The results obtained, combined with similar data from earlier workers in Lagos and in Freetown, Sierra Leone, may be taken as representative of urban conditions throughout Nigeria. Malaria parasites are to be found in the blood of most infants of two years of age, with *P. falciparum* as the causal agent of 98% of the infections. Postmortems performed between 1933 and 1948 at the General Hospital at Lagos on African children from one week to 15 years of age revealed that 9% of the deaths had been caused by malaria. These figures, although representative of only a cross-section of one community, are significant.

The malaria transmission period in Nigeria varies from less than 5 months a year in the Sudan and Sahel savannah regions to almost 12 months of the year in the coastal belt. While eight species of anopheline vectors have been found, *Anopheles funestus* and the *A. gambiae* group are the most important. *A. gambiae gambiae*, which breeds relatively indiscriminately, is found throughout Nigeria, while *A. funestus* is found only near clean, more or less shaded, water. The seasonal prevalence of the two vectors varies considerably ; nevertheless, it may be said that while *A. gambiae gambiae* is the wet season vector, *A. funestus* becomes the chief vector during the first half of the dry season.

No country-wide antimalaria programmes are in operation in Nigeria at present. However, a ten-year malaria-control scheme was inaugurated in 1948 when a special Malaria Service for Nigeria was established under the direction of the Director of the Medical Services. Meanmoyen, l'indice parasitaire, les indices d'infections spécifiques (environ 96% de toutes les affections sont dues à *Plasmodium falciparum*) et le taux des gamétocytes.

Des observations sur le paludisme chez les tout jeunes enfants ont été faites à Lagos de 1947 à 1949. Les résultats obtenus, complétés par les données analogues rassemblées par des auteurs qui avaient procédé à des enquêtes antérieures à Lagos et à Freetown (Sierra-Leone), peuvent être considérés comme caractéristiques des conditions qui règnent dans l'ensemble des agglomérations de la Nigeria. Des parasites du paludisme se rencontrent dans le sang de la plupart des enfants de deux ans, *P. falciparum* étant l'agent de 98% des infections. Les autopsies effectuées de 1933 à 1948 au General Hospital, à Lagos, sur des enfants indigènes âgés d'une semaine à quinze ans, ont révélé que 9% des décès avaient été causés par le paludisme. Bien qu'ils ne portent que sur un groupe particulier dans une seule collectivité, ces chiffres sont significatifs.

La période de transmission du paludisme varie selon les régions : inférieure à cinq mois par an au Soudan et dans la région de savanes du Sahel, elle couvre presque toute l'année dans la zone côtière. Des huit espèces d'anophèles vecteurs qui ont été observées, *Anopheles funestus* et le groupe de *A. gambiae* sont les plus importants. *A. gambiae gambiae*, qui se reproduit pratiquement dans tous les milieux, sévit sur l'ensemble de la Nigeria ; en revanche, l'on n'observe *A. funestus* que dans le voisinage des eaux limpides, plus ou moins ombragées. La prédominance saisonnière de l'un et de l'autre de ces deux vecteurs est très variable ; toutefois, on peut dire que *A. gambiae gambiae* est le vecteur de la saison des pluies, tandis que *A. funestus* devient le vecteur principal pendant la première moitié de la saison sèche.

Il n'existe actuellement, dans la Nigeria, aucune campagne antipaludique entreprise dans l'ensemble du pays. Cependant, un programme décennal de lutte antipaludique a été amorcé en 1948, lors de la création d'un Service antipaludique spécial, placé sous la direction du Directeur des Services

while, mosquito-control schemes have been introduced in some regions. In the period 1942-7, 6 square miles (15.5 km^2) of tidal swamps breeding huge numbers of mosquitos were reclaimed in the urban district of Lagos through the Lagos Mosquito Control Scheme. A pilot project—the Ilaro Experimental Anopheles Eradication Scheme—for anopheles eradication was instituted in the town of Ilaro in 1950 by the Malaria Service. The Cameroons Development Corporation has organized a Mosquito Control Scheme in the Tiko and Bota areas.

As regards treatment and prophylaxis, while there is no standardized treatment schedule for malaria in Nigeria, quinine, mepacrine, and proguanil are in general use, and antimalarial drugs are taken regularly by many educated Africans, as well as by nearly all non-African residents.

médicaux. D'autre part, des plans de lutte contre les moustiques ont été mis en œuvre dans certaines régions. De 1942 à 1947, en application du plan appelé « Lagos Mosquito Control Scheme », il a été procédé, dans la zone urbaine de Lagos, à l'asséchement de 15,5 km^2 (6 milles carrés) de marais à flot, qui constituaient un terrain exceptionnellement favorable pour la reproduction des moustiques. En 1950, le Service antipaludique a organisé, dans la ville d'Ilaro, un programme-pilote dénommé « Ilaro Experimental Anopheles Eradication Scheme ». La Cameroons Development Corporation a institué un plan de lutte contre les moustiques dans les régions de Tiko et de Bota.

En ce qui concerne le traitement et la prophylaxie du paludisme, il n'existe pas de pratique uniforme dans la Nigeria, mais l'emploi de la quinine, de la mépacrine et du proguanil est très répandu. En outre, de nombreux indigènes instruits, ainsi que la quasi-totalité des résidents non africains, font un usage régulier de médicaments antipaludiques.

BIBLIOGRAPHY

1. Barber, M. A. & Olinger, M. T. (1931) *Ann. trop. Med. Parasit.* **25,** 461
2. Blacklock, D. B. & Gordon, R. M. (1925) *Ann. trop. Med. Parasit.* **19,** 327
3. Bruce-Chwatt, L. J. (1951) *Trans. R. Soc. trop. Med. Hyg.* **44,** 563
4. Bruce-Chwatt, L. J. & Bruce-Chwatt, J. M. (1950) *Brit. med. J.* **2,** 7
5. Davey, T. H. & Gordon, R. M. (1933) *Ann. trop. Med. Parasit.* **27,** 27
6. Gilroy, A. B. (1948) *Malaria control by coastal swamp drainage in West Africa,* London
7. Great Britain, Colonial Office (1949) *Colonial annual reports, Nigeria, 1948,* London
8. McCulloch, W. E. (1929-30) *W. Afr. med. J.* **3,** 1
9. Macdonald, G. (1950) *Trop. Dis. Bull.* **47,** 915
10. Nigeria, *Annual reports on the medical services for the years 1944, 1945, 1946, 1947, 1948, and 1949,* Lagos
11. Smith, E. C. (1943) *Trans. R. Soc. trop. Med. Hyg.* **36,** 287
12. Turner, J. G. S. & Walton, G. A. (1946) *Report on malaria in Freetown and district,* Freetown, Sierra Leone
13. Whitbourne, D. (1930) *W. Afr. med. J.* **4,** 3, 39