The CENTRAL AFRICAN JOURNAL OF MEDICINE

Vol. 3. No. 9. SEPTEMBER, 1957.

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PUBLISHED MONTHLY, ANNUAL SUBSCRIPTION £2 2s. 0d.
Registered at the General Post Office as a Newspaper.

The Central African
Journal of Medicine

Volume 3 SEPTEMBER, 1957 No. 9

Relapsing Fever in Africa

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The relapsing fevers, broadly classified into the louse-borne and tick-borne varieties, are characterised clinically by an initial pyrexia of 2-4 days' duration, followed at intervals of a few days by successive relapses, and caused by spirochaetes (*Borrelia*) which are present in the circulating blood in the acute stages of the illness.

Classification and nomenclature are not yet well-defined in the spirochaetes which are morphologically indistinguishable but biologically separable. The spirochaete is specifically referred to as *Borrelia recurrentis* (or *B. obermeiri*) in the louse-borne form. In the tick-borne form a variety of names has been given to the responsible spirochaetes, largely indicating the geographical region of occurrence or the worker who identified them, thus, *Borrelia duttoni* is the spirochaete of Central and Southern Africa, and *B. venezuelensis, B. aegyptica, B. berbera, B. kochii, B. novyi* are names of the spirochaetes found elsewhere.

Louse-borne relapsing fever is predominant in Eastern and Southern Europe and Asia as well as in North and West Africa and Egypt. Like louse-borne typhus fever, louse-borne relapsing fever not infrequently occurs in epidemic form, the infection being carried under suitable conditions from man to man by lice which infest the body and clothing. Lice become infected when feeding on relapsing fever sufferers. They do not immediately become infective, as the ingested spirochaetes disappear in 24 hours and only re-appear in the body-fluid 3-5 days later, rendering the louse infective for the rest of its life. Human infection is not transmitted by the bite of the louse, but occurs when its body-contents and excretions are rubbed into the skin during scratching.

Tick-borne relapsing fever carried by the *Ornithodorus* group of ticks is endemic in Central and Southern Africa. It also occurs in the Mediterranean countries of Europe as well as in the Middle East and in parts of North and West Africa. In endemic regions the disease may occur in outbreaks of a restricted nature.

The *Ornithodorus moubata* is a domestic tick found in the cracks and crevices of the walls and floors of native huts and dwellings. It is also present in rest-houses and camping sites on caravan and other travel routes. The ticks emerge at night from their hiding places and take their blood-feed from sleeping persons whom they infect with the spirochaete-containing coxal fluid and body excretions which issue from the tick during feeding and enter the bite wound. Ticks become infected from the blood of relapsing fever sufferers and remain infected indefinitely. The spirochaetes enter the ovaries of the tick and the eggs and larvae thus become infected, and in this way hereditary transmission is maintained. It is for this reason and the fact that ticks remain alive for many years, even though deprived of food, that infection may light up once more in a once-infected site which had been abandoned and later re-occupied.

B. duttoni is transmitted by the *Ornithodorus moubata* tick, although it has been recorded in lice and is able to infect *Ornithodorus savignyi* ticks. The East African spirochaetes *B. kochi* and *B. rossi* are probably of the same type. Other spirochaetes occurring in West and North Africa are probably related organisms, but under natural conditions may be carried by ticks other than *Ornithodorus moubata*.

Both louse-borne and tick-borne relapsing fever may occur in the same country as in the Far East, India, Greece, Italy, Spain and in parts of North and West Africa.

THE OCCURRENCE OF RELAPSING FEVER IN AFRICA

In 1851 Griesinger discovered and gave a detailed account of cases in Egypt at a time when the disease was commonly confused with typhoid and typhus fevers and the bilious remittent form of malaria. It is almost a century now since David Livingstone suggested that relapsing fever in Africa was transmitted by the bite of the tick. In 1884 sporadic cases and small outbreaks of the disease were reported from Egypt. In 1904 Cook described African tick fever and a spirillum found in the blood of patients. Ross and Milne in the same year saw spirochaetes in the blood of tick fever sufferers in Uganda. It was also then that Dutton demonstrated relapsing fever spirochaetes in monkeys transmitted by infected ticks. Dutton and Todd in 1905 independently found the spirochaetes in the blood of patients in the Belgian Congo and also indicated the mode of infection with *O. moubata*.

A number of severe and extensive louse-borne relapsing fever outbreaks have swept across Equatorial and North Africa in the 1920's and again in the early 1940's. These are referred to below.

The general distribution of the disease in Africa is shown in the maps (Figs. 1 and 2).

A BRIEF REVIEW OF RELAPSING FEVER IN THE VARIOUS COUNTRIES OF AFRICA

The following is a summary of the occurrence of relapsing fever in the countries of Africa which for convenience have been grouped into regions as follows:—

(1) *North Africa*: Morocco, Algeria, Tunisia, Libya and Egypt.
(2) *North West Africa*: French West and Equatorial Africa, Sierra Leone, the Ivory Coast, the Gold Coast, Nigeria and the Cameroons.
(3) *North East Africa*: The Sudan, Eritrea, Abyssinia and Somaliland.
(4) *Central and East Africa*: Belgian Congo, Uganda, Kenya and Tanganyika.
(5) *Southern Africa*: Angola, Northern Rhodesia, Nyasaland, Portuguese East Africa, Southern Rhodesia, South West Africa, Bechuanaland Protectorate, the Union of South Africa and the Swaziland and Basutoland Protectorates.

(1) *North Africa*

Relapsing fever is a common disease in North Africa and was first recognised in 1886. It is generally of the louse-borne type and its epidemic occurrence was originally noted in 1910. An extensive louse-borne epidemic occurred in 1912-1915. Thereafter, since 1925 serious outbreaks were not reported until the great epidemic of 1942-1946, in which there were more than a million victims and at least 50,000 deaths. It commenced in the semi-desert Fezzan district of Libya in the latter part of 1942 and swept through Tunisia (1943-1944), Algeria (1944) and Morocco (1944) in the west, and Egypt (1944) in the east. French West Africa was subsequently affected by Sengalese soldiers evacuated to Dakar from Morocco in July, 1945.

Tick-borne relapsing fever is endemic in some parts of North Africa, but remains localised.

Morocco.—The great North African louse-borne epidemic affected Morocco severely in 1945 and 1946, and this was the first large-scale outbreak it had experienced. In 1945 there were more than 20,000 cases with a 2 to 9 per cent. case-mortality rate.

Cases of tick-borne relapsing fever have been reported from time to time. In Southern Morocco *B. duttoni* has been recovered from the *Ornithodorus erraticus* collected mainly in the burrows of rodents. Two varieties of this tick have been described: a large variety widely distributed in the eastern humid regions and infected with *B. hispanica*, and a small non-infected variety in the desert regions of Southern Morocco.

Algeria.—Louse-borne relapsing fever is predominant in Algeria. Outbreaks of the disease have been reported in 1910, 1922 and 1938. The great North African louse-borne epidemic affected Algeria in 1943-1945 and infected more than 400,000 persons. Since then the disease has not been reported.

Tick-borne relapsing fever does occur in various regions of the country. The *B. hispanica* was found in the brains of 1 per cent. of sewer rats in the town of Algiers, but this reservoir was probably of little significance in view of the rarity of local clinical cases. The *O. erraticus*, although prevalent, is not naturally infected.

Tunisia.—Relapsing fever was first recognised in 1903 in the south-west part of the country and further cases were periodically reported. No further cases occurred from 1923 until the great North African louse-borne outbreak originated there in the latter part of 1943. In 18 months there were more than 30,000 cases with a 12 to 20 per cent. case-mortality rate.

Tick-borne relapsing fever sometimes occurs, due it is believed to *B. hispanica* carried by the widely distributed *O. erraticus* which normally inhabits the burrows of small rodents.

Libya.—Louse-borne relapsing fever has been universal in Libya in the Beduoin Arabs, especially in the winter. A serious outbreak originated in the Fezzan district in 1905 and spread to Algeria. It was in the Fezzan region too that the great North African louse-borne epidemic commenced in October, 1943, and swept across to the neighbouring countries as already described.

Tick-borne relapsing fever frequently occurs, believed to be due to *B. hispanica* carried by *O. marocanus* or *O. erraticus*, with the reservoir probably in the desert or gondi rat (*Ctenodactylis gondi*).

Egypt.—Louse-borne relapsing fever was first recorded in 1884, and a few hundred cases of the disease were reported each year from 1905 onwards until 1916, when a serious epidemic occurred lasting about four years and infecting some 40,000 persons. Hardly any cases occurred from 1926 onward until the great North African louse-borne epidemic swept through Egypt in 1944 and 1945, causing nearly 110,000 cases with more than 2,000 deaths.

There is a relatively small incidence of tick-borne relapsing fever. The *O. moubata* has not been in-

criminated or its presence reported, but *O. erraticus* from which spirochaetes have been recovered is widespread in the desert, cultivated areas and in urban communities, where it lives in nests, burrows, dens and shelters. The hedgehog is thought to be the important reservoir host.

(2) *North West Africa*

An extensive and deadly louse-borne epidemic lasting until 1929 swept across Equatorial Africa between the latitudes 10-15° N., spreading across British and French West Africa. It was first reported in 1921 from Senegal and the French Niger. It affected millions of people and caused some 100,000 deaths.

The great louse-borne 1942-1946 epidemic of North Africa spread into French West Africa and was devastating in its effects. Since 1948 louse-borne cases have been reported, mainly from the Dakar region.

There are only small foci of tick-borne relapsing fever in West Africa. The infection was reported in 1931 and again in 1933 in Dakar, where it was found that the spirochaetes in human relapsing fever were identical with those found in local shrew mice. In the absence of *O. moubata*, the *O. erraticus* was regarded as the likely vector. The most important reservoir hosts were thought to be *Cricetomys gambianus* and the *Rattus rattus alexandrinus*, and in 1950 spirochaetes were found in 2.8 per cent. of local wild mice (*Mus musculus*).

Gold Coast.—A louse-borne outbreak of relapsing fever occurred in Accra in 1923 ascribed to soldiers returning from the war in Kenya Colony, where the West African forces suffered severely. The spread was probably also transmitted from the neighbouring French territory during the extensive epidemic which affected Senegal and the French Niger in 1921. Cases have occurred for a few years from 1929 onwards, but relapsing fever infection has not been reported in recent years.

There is no record of the occurrence of the *O. moubata* tick.

Nigeria.—In the northern region of the country outbreaks of relapsing fever in the recent past have been of the louse-borne type. In 1925 there were 1,276 cases in the whole of Nigeria, possibly introduced by soldiers returning from foreign service in World War I. An epidemic of relapsing fever, probably spread from French West Africa, commenced in July, 1947, and continued for more than two years, resulting in 5,000 cases and 200 deaths. The disease has only rarely been reported since then.

Sporadic cases only of relapsing fever occur elsewhere in Nigeria. No cases have been recorded in the last 10 years from the eastern and western regions.

Sierra Leone, Cameroons, Ivory Coast.—Relapsing fever has not been reported from Sierra Leone or the Cameroons in recent years, and only isolated cases of the disease have occurred in the Ivory Coast since 1937.

(3) *North East Africa*

Sudan.—Relapsing fever has never become endemic in the Sudan, although devastating louse-borne epidemics have occurred.

From 1908 onwards to 1924 Egyptian soldiers appear to have introduced relapsing fever into the Northern Sudan.

A great outbreak of louse-borne relapsing fever occurred in 1926-1927 in the westerly province of Darfur, probably brought in by immigrant labourers from French West Africa *via* the French Sudan, when more than 10,000 deaths occurred in six months in one district alone. Thereafter isolated smaller louse-borne outbreaks continued to occur up to 1931, especially in the provinces of the Blue Nile and Khartoum. After the disease had apparently died down some two years earlier, louse-borne relapsing fever re-appeared in epidemic form in 1936, initiated, it was believed, by immigrants from Abyssinia and Eritrea.

In 1940 a simultaneous outbreak of relapsing fever, yellow fever and infective hepatitis occurred in the indigenous inhabitants of the northern parts of the Nuba mountains. The Sudan also suffered in the great louse-borne epidemic of 1943 which swept eastwards across Africa from French West Africa.

The establishment of the tick-borne type there is not likely, because the local *O. savignyi* have not been found infected and the *O. moubata* is limited to the south.

Eritrea.—A fatal epidemic of relapsing fever was reported in 1929, probably introduced by travellers from Abyssinia. Ticks were not found. By 1936 the disease had become endemic in many towns and villages and a louse-borne epidemic occurred in that year with a case mortality rate of 13.2 per cent. in a population of about 10,000 persons.

During the period 1939-1942 both typhus and relapsing fever, both louse-borne, were endemic in Asmara. In the last 10 years, however, the incidence of the disease has been on the decline.

Abyssinia.—Relapsing fever was first reported in 1908, probably tick-borne, as a specimen of *Ornithodorus moubata* tick sent from Harar to a laboratory in Paris infected a monkey. In 1928 cases of relapsing fever were occurring and *Ornithodorus moubata* and *O. savignyi* ticks were reported prevalent. It was shown later, however, that *O. moubata* was quite rare, whereas *O. savignyi* ticks were present in large numbers and probably of importance. It was concluded, however, that the louse was the responsible vector in the highlands where ticks were not found. A louse-borne outbreak of the disease was reported in Addis Ababa in 1937. Numerous cases have been reported since 1942, probably all louse-borne.

Somaliland.—In this semi-desert country tick-borne relapsing fever with its high incidence has been a problem for many years, although the mortality rate remains low. It was first reported in 1915 and was very rife a year later in the Hargeisa district, where *O. moubata* was found. An epidemic occurred in 1920 in Burao which has remained an important focus of the disease. Relapsing fever is a disease of the towns; houses as well as coffee shops and other places of public resort being infested with ticks. Whole native towns have in the past been burned down in the effort to stay the disease, but without much success. Both the *O. moubata* and the *O. savignyi* are found, but the weight of evidence is against the latter as a normal vector. It is essentially a camel tick in this country living under trees where these animals are tethered.

An outbreak of supposedly louse-borne relapsing fever occurred in 1942, but later the very prevalent *O. moubata* was incriminated. In 1951 an outbreak occurred in the army camps where the floors of the huts were heavily infested with ticks.

In 1936 there were 902 and in 1946 625 cases of relapsing fever. From the latter year systematic control measures were initiated in the permanent settlements, and the incidence rate has rapidly gone down to 265 cases in 1950 and nil from 1953 onwards.

(4) *Central and East Africa*

Belgian Congo.—More than 50 years ago Dutton and Todd described the association of ticks and relapsing fever in the Belgian Congo. They suggested that ticks had arrived into the country by two routes—the first with the Arabs who never penetrated far into the west—from the East Coast into the Eastern Congo; and second, from Portuguese territory in the south with traders travelling into the Cataract region.

The *Ornithodorus moubata* is very common, but of uneven distribution in the eastern part of the Belgian Congo, occurring especially on the banks of the great African Lakes. It is very prevalent in pig styes and also in the burrows of warthogs in the Albert National Park, although rather uncommonly in Native huts. Only a certain proportion of the ticks, however, have been found naturally infected, and relapsing fever cases are not common. In the three years 1954-1956 some 200 cases have been reported with 10 deaths.

It is said that two or three cases of louse-borne relapsing fever occur each year.

Uganda.—Tick-borne relapsing fever is very common, although with a low mortality rate, in Uganda and has been a scourge for a long time, threatening caravan and other travel routes. The *Ornithodorus moubata* as well as *O. erraticus* is found in many parts of the country.

Kenya.—Tick-borne relapsing fever was first recognised in 1907. In the period 1937-1947 more than 3,000 cases with 82 deaths were recorded. The *Ornithodorus moubata* is very widely distributed along the east coast, where relapsing fever is endemic in the native population, 400 to 700 cases with tick-borne relapsing fever occurring each year in the focal areas. In the last three years, however, 200 cases with 10 deaths have been reported.

The *Ornithodorus moubata* has been found in burrows of porcupines in Central Kenya. The *Ornithodorus savigniyi* is present in large numbers under trees in certain parts of the country, but their importance as vectors is doubtful. The *O. graingeri* is abundantly present in the Kenya coast in burrows occupied by porcupines, which are probably their host.

An outbreak of louse-borne relapsing fever occurred in 1945 and 1946 and involved the hinterland of Mombasa and the Kenya coast. It may have originated in the great 1942-1946 louse-borne epidemic of North Africa, but was probably introduced into the territory early in 1945, when a number of Arab dhows arrived in Mombasa with infected cases on board. Nearly 2,000 cases occurred with a 40 per cent. mortality rate in untreated cases. Control measures with D.D.T., however, rapidly terminated the epidemic.

Tanganyika.—Tick-borne relapsing fever, already known by 1920, is now endemic in the territory. Both the tick and the disease occur throughout Tanganyika, and some of the up-country stations, especially on old caravan routes, are heavily infested, while the coastal stations are comparatively free. Native huts frequently swarm with ticks and a considerable proportion have been found infected. There is evidence that the *Ornithodorus moubata* is associated with the large burrowing animals such as warthogs and porcupines, but they are not infected with spirochaetes. Ticks appear to be spread by migrant labourers making their way north. Some 6,000 cases were reported in 1934-1938, 4,000 cases with 25 deaths in 1945-1954, and 3,517 cases and 19 deaths in 1955.

During 1947-1948 a large-scale scheme for the eradication of *Ornithodorus moubata* by the use of Gammexane was successfully carried out in Morogoro township and district.

(5) *Southern Africa*

Angola.—Relapsing fever caused by *Ornithodorus moubata* occurs in all parts of the country in Native workers, especially in the south and near the sea. The mortality rate, however, is not high.

Northern Rhodesia.—In 1915 the *Ornithodorus moubata* was recovered from warthog burrows in the Luangwa valley and elsewhere. At present the disease is found in many parts of the territory, and in 1924, when it was diagnosed, all compounds in Livingstone were reported tick-infested, although relapsing fever itself was not common. Numerous cases of the disease occurred in Fort Jameson in 1948. There were 132 cases in 1950-1951 and 88 cases with only one death in 1954-1955.

Nyasaland.—The *Ornithodorus moubata* type of relapsing fever has been reported from 1912 in many parts of the territory. Four deaths were reported among 835 cases of relapsing fever in the period 1934-1937.

Southern Rhodesia.—Relapsing fever undoubtedly existed in the territory by 1919. A heavy infestation of pig styes by *Ornithodorus moubata* was reported in 1931 in the Rusape district. These ticks are very generally distributed and relapsing fever is fairly well established in most parts of the country. The disease, however, does not constitute a major problem, but is sporadic in most parts. A small outbreak occurred in 1946 in the Chipinga district, on the borders of Portuguese East Africa, but was soon brought under control.

South West Africa.—About 15 years ago the spirochaete of relapsing fever was found in blood smears made from mine Natives in Tsumeb, mostly in recruits from the Okavanga territory and Angola, who had already most likely been infected before arrival in the country. Although *Ornithodorus moubata* is abundant in the territory, relatively little clinical relapsing fever is reported.

In Ovamboland, *Ornithodorus moubata* is found in a number of places, particularly in the floors of Native compound huts and in kraals. At Odangua, where blood smears have been systematically studied, it was found that 7 per cent. of 1,787 blood smears were positive for relapsing fever spirochaetes in 1952-1955. Insecticidal control measures are being carried out. It is thought that louse-borne relapsing fever also occurs in Ovamboland, as the heavily-skirted Ovambo women are louse-infested and babies often become relapsing fever victims.

Bechuanaland.—*Ornithodorus moubata* ticks occur in various parts of the country, and Zumpt and the author have confirmed relapsing fever infection in ticks from Kanye. In the six years ending 1955 there were 117 cases of relapsing fever recorded, nearly half of these being from Ramontsa in 1955. But the disease incidence is probably greater than the records show.

Portuguese East Africa.—Relapsing fever is one of the most important diseases of African labourers in certain parts of Portuguese East Africa. The disease is tick-borne and the *Ornithodorus moubata*, known there at least since Livingstone's time, is reported from all parts of the country. This tick has been obtained in various localities from the burrows of warthogs,

which appear to be the primary host. In the six years up to 1955 there has been an average of some 3,000 cases per annum with 13 deaths.

Union of South Africa.—In 1912 Park-Ross made reference to cases of relapsing fever in the coastal regions of Zululand. There does not appear to be a record of the occurrence of *Ornithodorus moubata* ticks south of the Orange River by 1930, but in the next few years the tick was reported from many parts of the Union. The first major outbreak of tick-borne relapsing fever occurred in 1937 in the north-eastern part of the Cape Province. Subsequently, during World War II, outbreaks of this disease were reported in the Graaff Reinet and Kimberley districts of the Cape Province. Investigations in the Northern, Eastern and Western Transvaal revealed the presence of *Ornithodorus moubata* ticks in these regions and the sporadic occurrence of relapsing fever.

On the Witwatersrand gold mines in Johannesburg a proportion of the Native labourers has since 1934 been derived from relapsing fever endemic areas of Africa, including Northern Rhodesia, Nyasaland and

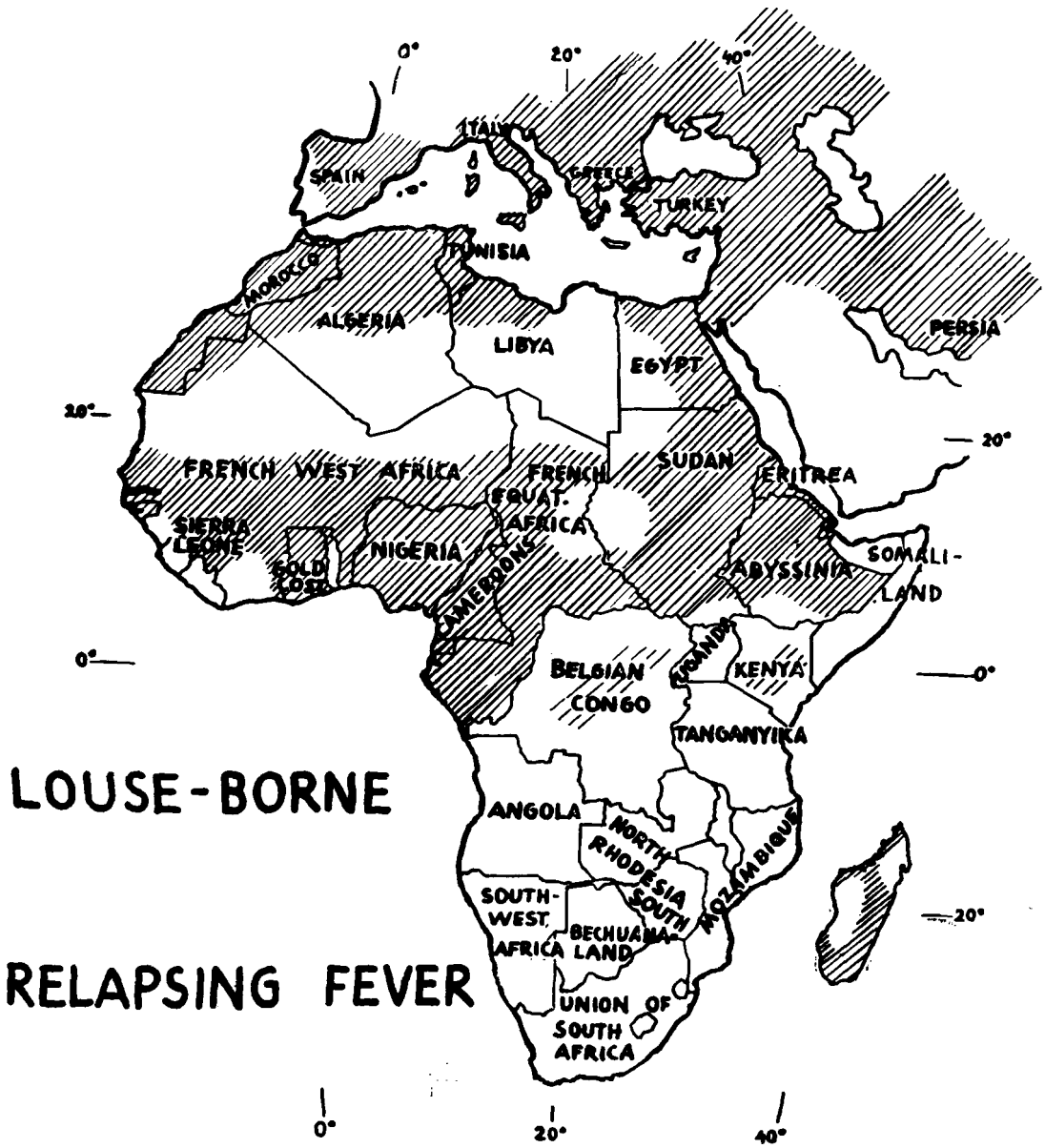

Fig. 1—General distribution of louse-borne relapsing fever in Africa.
(Precise geographical definition is not intended.)

Portuguese East Africa. It is not surprising, therefore, that clinical relapsing fever is diagnosed not infrequently in these "tropical" Natives admitted to the mine hospitals.

Swaziland.—Although *Ornithodorus moubata* ticks are well known in the territory, the occurrence of relapsing fever is uncommon. The disease was reported in 1928 and first diagnosed microscopically ten years later. In the last three decades only 11 cases have been reported from Swaziland, but so far only from the highlands.

Basutoland.—Neither *Ornithodorus moubata* ticks nor relapsing fever cases have been reported.

THE TICK VECTOR IN AFRICA

There is little doubt that the *Ornithodorus moubata* is the important vector of tick-borne relapsing fever in Central and Southern Africa.

The *Ornithodorus savignyi* has in the past not infrequently also been incriminated in certain areas, but the weight of evidence is against its being a normal vector. In Kenya it is found abundantly under trees on the ground, but its rôle is not clear. In Somaliland and in the Sudan the *O. savignyi* is essentially a camel tick and lives in soils and loose sand where stock have halted or under trees where mules are tethered. The *Ornithodorus erraticus* is present in the burrows of small rodents, but has not been found naturally infected.

The tick vector of relapsing fever is well known to the Native populations in the endemic areas of Africa. The European refers to the "tampan" tick, but amongst the Native peoples the tick is known by a variety of names according to the district and the local tribes. For example, the Nyasaland Natives know the tick as *Kufu*. Some of the tribal names applied to the tick in Northern Rhodesia are *Nkhufi, Nkuswi, Tambani* and *Inkoko;* in Tanganyika, *Itungu, Ithou, Vari* and *Ngage;* in the Belgian Congo, *Bifundikala, Bimpusi* and *Mouyata;* and in South West Africa, *Oshilumati* and *Enghopio.* A common name in the east is *Kimputu.* A Swahili name is *Papasi,* and in the Northern Transvaal the Bapedi tribe call the tick *Twakga,* and in the Bochem district it is known as *Makadoela,* while in Portuguese East Africa it is referred to as *Xirrota.*

The mode of spread of the tick vector is not quite clear. It is well known, however, that Natives travelling from endemic to non-endemic areas carry ticks along with them so that they may be periodically bitten and thus not lose their immunity. Ticks may also be transported in blankets rolled up by travelling Natives after a night spent in a tick-infested hut or camping site. Ordman has shown that in the Cape Province ticks have been carried to new sites in bricks and other building materials taken from broken-down tick-infested dwellings for use in rebuilding elsewhere. It is said that in parts of Tanganyika the increase in the numbers of bicycles acquired by the Native population has led to the spread of infestation and a rise in the incidence of the disease.

RESERVOIR HOSTS OF THE RELAPSING FEVER SPIROCHAETE

It has been thought for many years that the *Ornithodorus moubata* tick was dependant upon an animal reservoir for its infection, and much investigation has been carried out to confirm this point. When the longevity of the tick is considered as well as the transmission of relapsing fever infection to its offspring, the need for an animal reservoir host does not seem to be great. Their feeding upon particular animals in burrows may be just as incidental as their occurrence in the dwellings of Natives in endemic areas.

Heisch found large numbers of *O. erraticus* in the burrows of pigmy gerbils (*Dipodillus* sp.) in Kenya. He interestingly postulated the evolution of *B. duttoni* as originally a parasite of gerbils and other small animals with the *O. erraticus* or other "burrow-haunting" ticks as the vector. In turn, the burrow-infesting *O. moubata* became infected with the spirochaete maintained in porcupine and warthog reservoirs. This tick then became adapted to dwellings and other sites as man became involved and the human spirochaete cycle commenced.

In Dakar the important reservoirs of relapsing fever infection are considered to be *Cricetomys gambianus* and the *Rattus rattus alexandrinus.* Spirochaetes could be demonstrated in nearly 3 per cent. of the wild mice (*Mus musculus*) caught there. In Dakar as well as in Egypt the hedgehog has been regarded as the most common host of *O. erraticus,* which in Egypt is found in desert regions or in cultivated areas in the urban communities, and lives in nests, burrows and dens. Heisch is of opinion that *O. erraticus* may be infected with spirochaetes which, although closely related to *B. duttoni,* are only very mildly pathogenic to man.

The reservoir host in Libya was thought to be the desert or gondi rat (*Ctenodactylus gondi*). The *O. moubata* has been found in burrows inhabited by porcupines and hedgehogs in Central Kenya, the Sudan, Northern Rhodesia, Tanganyika and Portuguese East Africa. In the latter country this tick has also been found on the scaly ant-eater and Lichtenstein's hartebeest. The *O. graingeri* has also been found on

the Kenya coast south of Mombasa on the cave-inhabiting porcupines, which are thought to be the principal hosts of this tick, the infectivity of which, however, is not known.

In a town in Algeria, *B. hispanicum* was detected in the brains of about 1 per cent. of the sewer rats, but the rarity of local human cases indicated that this reservoir was of very little epidemiological importance. In Tanganyika the interesting studies by Geigy and Mooser revealed that wild rats, mice and fowls from tick-infested dwellings did not show spirochaetes on blood-smear examination. *Ornithodorus moubata* ticks were found in burrows occupied by warthogs. More than 1,000 "bush ticks" (*Ornithodorus moubata* type, but with some differences) were collected in these burrows, but not found infected with spirochaetes. Neither was such infection revealed after careful examination of 25 captured warthogs, nor in three warthogs and one porcupine inoculated with human pathogenic spirochaetes. The warthog could thus not be

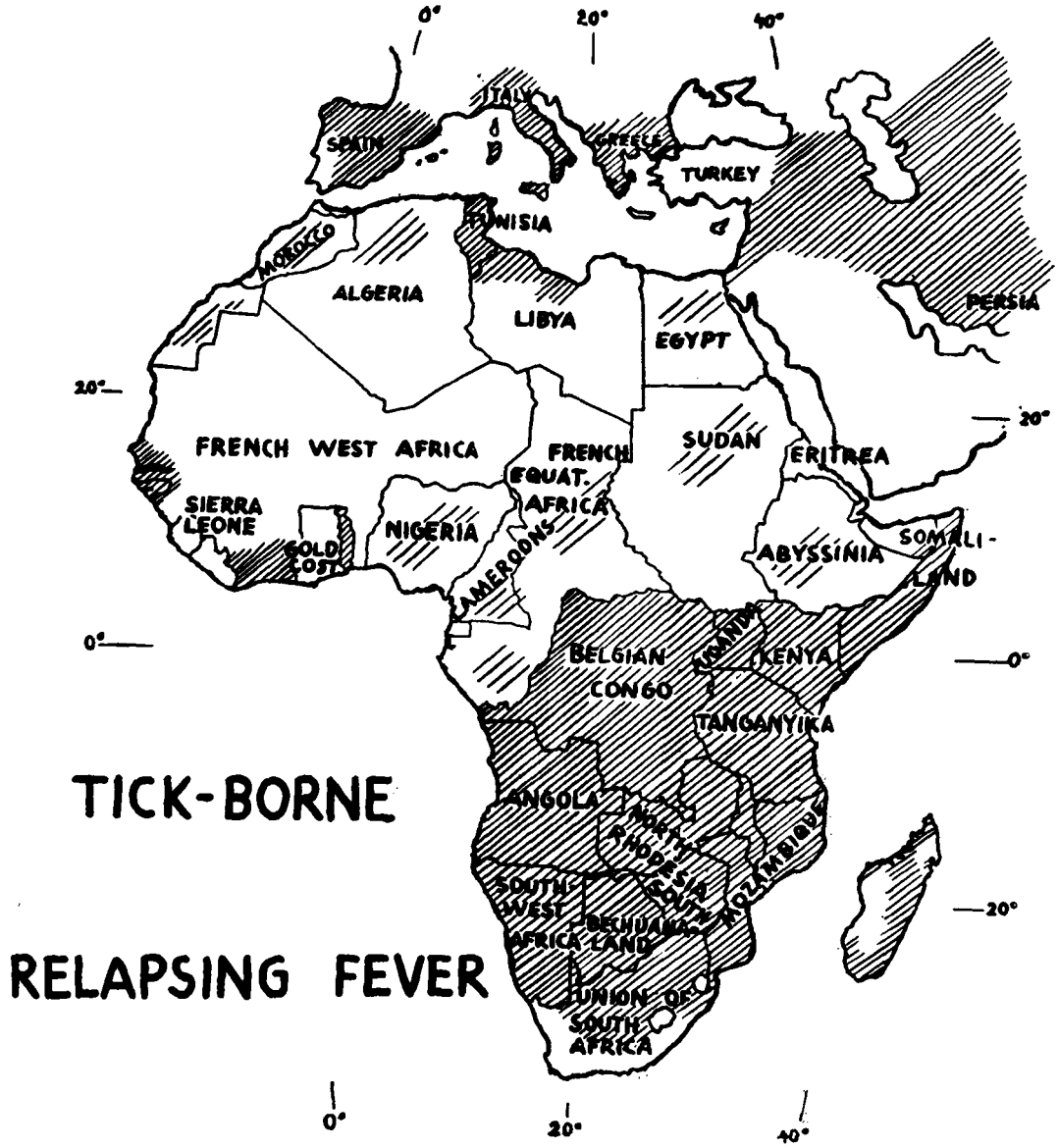

Fig. 2.—General distribution of tick-borne relapsing fever in Africa. (Precise geographical definition is not intended.)

regarded as a possible reservoir of relapsing fever in that district, nor could "bush ticks" be vectors of *B. duttoni*.

SIGNS AND SYMPTOMS

After an incubation period of two to ten days relapsing fever manifests itself with severe frontal headache and backache, with generalised pains and aches in the body and limbs and often with pain in the splenic region. The temperature rapidly rises to 102-104° F. Epistaxis is a feature in some outbreaks. Shivering, conjunctival congestion and vomiting may be present. The fever lasts from one to three days, followed by an apyrexial period lasting three to seven days, followed by a relapse similar to the initial attack. Such relapses are usually repeated three or four times, but may occur up to seven or eight times. In the relapses the pyrexial period may become shorter and the symptoms less severe if immunity develops in the patient. In each bout of pyrexia, especially initially, the temperature may drop by crisis, leaving the victim exhausted and often in a state of collapse. As the illness proceeds, the spleen may become enlarged to a moderate degree, with enlargement of the liver and jaundice. In addition to epistaxis, other haemorrhages may occur and haemorrhage from the bowel may simulate a specific dysentery. Ocular symptoms include iritis, iridocyclitis, retinitis and choroiditis. The uveal tract in Natives is probably more vulnerable as resistance is lowered by accompanying infections. Additional symptoms may include phlebitis, parotitis and polyarteritis. Symptoms relating to the central nervous system are not infrequently seen. More commonly, however, these symptoms are transient, but they may become permanent and include peripheral nerve paralysis, ptosis, aphasia, facial paralysis and hemiplegia. In some cases poliomyelitis-like symptoms have been reported. Symptoms relating to the respiratory system may occur and bronchopneumonia and lobar pneumonia may be the cause of death.

PATHOLOGY

There is hardly any specific pathological feature of relapsing fever found on post-mortem examination. The liver, kidney and heart muscle show cloudy swelling and generally the spleen is large and soft with fibrinous exudate. Multiple splenic infarcts were present in 2.5 per cent. of cases in an epidemic in Egypt. Lobar consolidation is often seen. The spirochaetes can be demonstrated in sections of liver and spleen.

DIAGNOSIS

The diagnosis of relapsing fever infection should be made clinically in endemic areas on the characteristic symptoms of severe headache, backache and neckache with a sudden high temperature lasting one to three days, followed by relapses of a similar nature thereafter. Spirochaetes can readily be seen on dark-ground illumination study of a drop of blood or on microscopic examination of suitably-stained thick blood smears made at the rise or height of the pyrexia. The need for blood smears, which would naturally be investigated in malarious regions, could be overlooked in dry areas and the diagnosis accordingly missed. Serum agglutination tests will of course identify enteric infections as well as the rickettsioses. It should be remembered, however, that in louse-borne relapsing fever agglutination of the Kingsbury strain of *B. proteus* can occur to a titre of 1: 800.

If a diagnosis of relapsing fever is to be confirmed in the apyrexial period the patient's serum is submitted to a complement fixation test, the antigen employed by the laboratory being a suspension of spirochaetes. Alternatively the patient's blood on intraperitoneal inoculation into a mouse will cause the appearance of the spirochaetes in the animal's circulation from the third day onwards, disappearing and re-appearing every few days thereafter in a "relapsing" manner.

In endemic areas the occurrence of iritis, iridocyclitis or other eye conditions in numbers of local Natives should raise the suspicion of a possible relapsing fever infection.

TREATMENT

The older method of treatment involved the use of arsenical preparations which were in general satisfactory, particularly if given at the rise of the temperature. In louse-borne relapsing fever in Nigeria one injection of 0.6-0.9 gms. Novarsenobillon or occasionally two or more injections sufficed. Intramuscular Acetylarsan was similarly effective. In Portuguese East Africa Neoarsphenamin given intravenously in 0.3-0.6 grm. doses on two successive days were effective. Cases of a very severe type, however, have been reported there with a comparatively high resistance to arsenic compounds.

Penicillin has largely replaced arsenic in the therapy of relapsing fever. Already some ten years ago in Egypt it was found that 1,000,000 units of penicillin in 25,000-unit doses given intramuscularly every three hours cured all cases with no relapses. In Nigeria 600,000 units of penicillin given intramuscularly daily for three

days effectively controlled the infection. Other very satisfactory therapeutic regimens have included the use of 50,000 units of penicillin hourly, with the disappearance of spirochaetes in 24 hours, or 40,000 units three-hourly to 2,400,000 units.

Other workers have, however, not found penicillin entirely effective. Penicillin-resistant cases have been reported from Uganda, and Yeo on the Witwatersrand found a 75 per cent. relapse rate in patients receiving 200,000 to 2,000,000 units.

IMMUNITY

There is little doubt that tick relapsing fever infection carries with it an immunity in convalescence and thereafter. This is well shown in endemic areas where infected persons manifest mild symptoms and where the death rate is very low. If a new population from non-endemic regions, however, enters such an area to seek employment or as troops in times of war, they may be severely affected. This was well shown in a tick-borne outbreak that occurred in the northern part of the Cape Province in South Africa in a community of mining Natives from non-endemic areas. Some 1,800 cases of relapsing fever occurred, with a case mortality rate of 9 per cent. On the other hand, in the Northern and Eastern Transvaal and generally in the endemic areas of Central Africa the disease runs a mild to moderate course.

Many of the Natives have acquired by experience an understanding of the immunity conferred by repeated mild infections and the loss of such immunity after a long absence from an endemic region. The Banyruanda people, for example, coming into Uganda, carry their own ticks with them to maintain their acquired immunity from bites from these ticks; the Angoni in Nyasaland and the Natives of Matala's tribe in the Bochem district of the Transvaal, as well as the Natives of Somaliland, are also known to maintain their immunity to relapsing fever in this way.

CONTROL.

The control of louse-borne relapsing fever is, like epidemic typhus fever, a matter of improved hygienic and social conditions leading to the elimination of lice from the clothing and bodies of the affected population. In modern practice the application of D.D.T. to infested persons and their contacts will readily prevent the spread of the disease.

Tick-borne relapsing fever involves the avoidance of contact with ticks and their elimination from their usual harbourages. For Europeans in endemic areas who usually live in well-built houses, and so in general are not victims, this means the avoidance of resting or sleeping in huts, dwellings or camping sites frequented by Natives on caravan or other travel routes.

Before the advent of the newer insecticidal agents the elimination of the ticks from their indoor hiding places posed a difficult problem. It was a question of whether to "build out" the ticks and so prevent their finding accommodation in the cracks and crevices of walls and floors, or whether to burn down the existing structures and re-build compounds or houses in tick-proof manner, preferably with reinforced concrete. The latter approach may be required for Native huts of reeds, twigs and mud. Re-building is a costly process, but is undoubtedly the most satisfactory approach where large numbers of Natives live close together for employment in local industries. In the Northern Transvaal a re-building programme was very effectively carried out and proved worthwhile in view of the permanency of results. "Building out" the tick was carried out in the outbreak in the Northern Cape Province already described, and effectively put an end to the progress of the disease. All cracks and crevices in the compound rooms of the Natives were treated with a blow-lamp to destroy the ticks there present, and cement poured in to seal these openings. All the joins of wall with floor, windows and doors were smooth-cemented. The results were entirely satisfactory, as ticks were completely eliminated.

The modern approach, however, to tick control is through the agency of the newer insecticidal drugs. Gammexane, the drug of choice, is a benzene hexachloride compound and exists in five isomers, of which only the gamma-isomer is highly insecticidal. This material permits of an efficient, cheap and easily-operated procedure and readily applicable to all forms of African housing. It has been used in various parts of Africa and invariably with success. In Northern Rhodesia it has been used in a powder consisting of 5 per cent. gammexane and 95 per cent. sawdust. This mixture was sprinkled at the base of all internal walls of the houses in a four-inch wide band and a thick carrying-band across the doorways. The mixture was allowed to remain on for three weeks so that the nymphal stages were destroyed on hatching from the eggs. Of 1,500 houses so treated, only 4 per cent. required a second treatment. The cases of relapsing fever were reduced from 306 in 1947 to seven in 1952. In gammexane applications

it is advisable to deal with all huts or houses in a village simultaneously to prevent the re-infestation of those not treated. In Morogoro in the latter part of 1947 the houses were treated with a powder made of 2.5 per cent. gammexane in very light kaolin powder in the proportion of 1:4. After four to five months the tick population was reduced to negligible numbers. It was concluded that an initial full-scale application of this material, followed by regular treatments with half the dose every six months, would keep down ticks almost entirely and in this way reduce relapsing fever in the population. In Kenya the control of *Ornithodorus* was carried out with 0.5 per cent. gammexane. One application reduced the number of ticks in Native huts significantly for three months, and these remained free for a further seven to eight months after a second application. In the Northern Transvaal gammexane in a concentration of 300 to 600 milligrams of gamma-isomer per square foot was applied to the inner walls of Native huts with very satisfactory results.

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Acknowledgments

The latest information in regard to relapsing fever was sought from the countries of Africa by letter and questionnaire. Gratitude is expressed to the various *Directors of Medical Services* for their kind co-operation. Tribute is paid to the usefulness of the *Tropical Diseases Bulletin* in facilitating reference to work on relapsing fever.