The Effects of Trypanosomiasis on Rural Economy*

With Special Reference to the Sudan, Bechuanaland and West Africa

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Trypanosomiasis, both of humans and of livestock, is one of the most important factors restricting economic development in Africa today. The present paper outlines how this disease is limiting agricultural, veterinary and forestry development in the Sudan, Bechuanaland and West Africa.

The present tsetse-fly distribution is reviewed. Glossina palpalis and G. morsitans occur in the south Sudan and G. morsitans in the Ngamiland district of Bechuanaland; G. morsitans, G. palpalis and G. tachinoides are the most important species in West Africa.

These tsetse flies have altered the cattle distribution in all three regions and, in addition to causing widespread disease, have created local overstocking problems in the tsetse-free grazing areas, and have enforced nomadism on breeding herds and economic loss in slaughter cattle along the trade cattle routes in West Africa.

Human trypanosomiasis is not now such an urgent problem and public health measures have led to its control in all three areas.

Increased agricultural development, which can be a successful and economic method of reclaiming land from tsetse flies, must be intensified in all three areas.

Forest conservation policy comes into conflict with tsetse control measures only in West Africa.

Detailed tsetse-fly surveys and research, on which future plans can be firmly based, are now urgently required.

It is difficult for anyone concerned in the fight against trypanosomiasis to examine a map showing the distribution of tsetse flies throughout Africa without feeling dismayed by the magnitude and economic importance of the problem.5 One must also be humbled by the thought of how far short of unqualified success have been the majority of tsetse-fly eradication schemes. Prior to the advent of residual insecticides, the methods available—such as hand catching, trapping, the total or discriminate clearing of vegetation, and controlled game destruction—have been tedious and often uneconomic.

The problems presented by the presence of tsetse flies are not only those of disease; human and social issues are also closely involved.

Medical workers have been concerned for many years with human sleeping-sickness caused by Trypanosoma rhodesiense and T. gambiense, both trypanosomes being transmitted by several species of tsetse fly. Not only does this disease cause considerable human suffering, varying degrees of mortality, and serious loss of efficiency wherever it occurs, but whole units of population may require to be moved out of infected areas with the consequent disruption of all human activity.

The veterinarian is concerned with the disease in domestic animals caused by T. congolense, T. vivax, and to a lesser extent T. brucei, and transmitted by seven or more different tsetse-fly vectors. Where

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5 See, for instance, the maps in the article by J. Ford on page 653 of this issue.
one or more of these tsetse-fly species are prevalent, livestock is absent. Wherever tsetse-livestock contact is possible, in areas adjacent to tsetse-fly infestations, mortality, debility, and loss of production are an invariable consequence. A heavy expenditure of money and effort is necessary to provide the necessary drug-therapy to keep the disease in check.

Now that rinderpest and contagious bovine pleuropneumonia are largely under control, trypanosomiasis remains the greatest single impediment to the stock-raising industry in the Guinea Zone of West Africa.

The shortage or entire absence of cattle over large areas of Africa, with the consequent absence of draft animals and loss of manure to maintain soil fertility, has had a profound effect on agricultural development and productivity.

Forestry policy has also been stultified and hampered owing to the close relationship of vegetation to tsetse-fly distribution.

In the present paper, these various problems are reviewed by a study of the present position in three representative regions—the Republic of the Sudan, Bechuanaland Territory, and West Africa with particular reference to Northern Nigeria.

**TSETSE-FLY DISTRIBUTION IN THE THREE REGIONS**

**Sudan**

The present distribution of tsetse flies in the Sudan is shown in Fig. 1. At the extreme south, along the Nile-Congo watershed, involving the upper parts of the tributaries of the Nile, both *G. palpalis* and *G. morsitans* are prevalent and cattle are absent. Other tsetse-fly species are present in localized areas but are of less importance. The situation is complicated by the activities of tabanids acting as mechanical transmitters of animal trypanosomes in the grazing areas outside the tsetse-fly zone. A small pocket of *G. morsitans* in the Nubian mountains has now been eliminated.

The interrelation of the present tsetse-fly distribution and the prevalence of mechanical transmission in the southern grazing areas and the prevalence of *T. evansi* in camels has been well shown by Buxton (1955, Fig. 158).

**Bechuanaland**

The only tsetse-fly species known to exist in Bechuanaland is *G. morsitans*. Two contiguous areas are now infested, the Okavango river swamps in Ngamiland and the northern Chobe river delta. Both rivers draw their water from the heavy rainfall area of the Angola highlands.

The Okovango river enters the Protectorate in its north-east corner and meanders through a papyrus-covered "collar" for 60 miles (or nearly 100 km) before flooding into its 7000-square-mile (18 130-km²) triangular delta. The smaller Chobe swamp is identical in character and in the effect it has on the vegetation cover.

Both rivers influence the normal Kalahari scrub to make it more mesophytic in nature and produce a vegetation type which is ideally suitable as a habitat for *G. morsitans*. This infestation occurs in patches within the flooded area and within a band of heterogeneous vegetation varying in width from a few miles to as much as 30 miles (or nearly 50 km) around the perimeters of the deltas.

Fig. 2 and 3 show the areas infested in pre-rinderpest years and their shrinkage into three small foci by 1900. The subsequent rate of expansion has been remarkable, and it has been estimated that the flies recovered approximately 3000 square miles (7800 km²) between 1922 and 1942, and 6500 square miles (16 800 km²) in the next twenty years. The effects of this advance on cattle distribution and on the economy of the country, as will be noted later, have been very considerable.

**West Africa**

Tsetse-fly distribution in West Africa is, as everywhere, dependent on climate and vegetation, and some knowledge of the main ecological zones is necessary for an understanding of the problem.

The coastal forest zone, with its abundant tree cover and high humidity, is infested by *G. palpalis* and several species of forest tsetse fly. This, together with the paucity of grasslands and the high parasitic infestations of ticks and helminths, ensures that this zone will not be an important cattle-raising area in the near future.

North of the coastal zone, between the forest in the south and the desert in the north, from Senegal and Guinea in the west to Chad and Cameroons in the east, stretches a wide belt of savannah woodland. Within this belt, the vegetation has been classified into three main ecological zones (Fig. 4), the northern Sahel Zone, the middle Sudan Zone and the southern Guinea Zone (Keay, 1953).

The northern Sahel Zone has an average annual rainfall of below 10-20 inches (250-500 mm), and the vegetation consists of open thorn savannah with short sparse grass cover. The climate is too hot
and dry for tsetse flies and trypanosomiasis is absent, and the other parasitic diseases are of relatively minor importance. This zone, although an important livestock-breeding area, offers a relatively short grazing period of only a few months each year and cattle herds are therefore chiefly nomadic.

The two vegetation zones in which the economy of livestock are seriously affected by trypanosomiasis are the Sudan and Guinea savannah zones, the latter being of special importance.

The Sudan Zone of vegetation lies immediately to the south and, together with the Sahel Zone, forms the most important livestock area in West Africa. The average annual rainfall is usually less than 25 inches (600 mm), with six to seven consecutive months almost entirely free of rain. During the dry season, the average relative humidity in the early afternoons, for about five months in the year, is below 10%, with zero readings common during the height of the harmattan.
Most of the area has been inhabited for centuries, and, as a result, the vegetation has been profoundly modified by cultivation, by the cutting of trees for firewood and for buildings, by the annual grass fires, and by livestock grazing in large herds.

The upland woodland may be open or dense, but throughout the zone the grass is short and sparse and after grass fires fresh shoots do not spring up until just before the rains. Grazing, therefore, is limited to the rainy months of June to October and nomadism is again a feature of the livestock economy.

Tsetse flies find it difficult to survive in this zone, and the only penetration northwards from the Guinea Zone is by *G. morsitans* and *G. tachinoides* along the larger rivers and flood plains. Along the flat river valleys, fringing forest zones occur along the river banks and forest "islands" spread outwards on the seasonally swampy ground in a breadth of two to seven miles (3-11 km). Such islands are composed of tall evergreen trees such as *Diospyros mespiliformis*, surrounded by a dense thicket of climbers and shrubs, of which the most important are *Acacia ataxacantha* and *Combretum micranthum*. The ecology has some similarity to that already described in the flood plains in Ngamiland in the semi-arid country of Bechuanaland.

Tsetse flies may range outwards from these foci into the upland Sudan savannah during the rainy season, but rapidly retreat during the dry season, when atmospheric humidity drops and temperatures rise. Tsetse-fly distribution, even of *G. morsitans*, is therefore of a linear type, rather than the broad tsetse-fly belts one is accustomed to in African savannah.

The Guinea Zone is the most southern savannah zone, the northern limits merging gradually into the Sudan Zone, while the southern limits change relatively abruptly into the coastal high forest zone. Rainfall may be as high as 60 inches (1.5 m), and only four to five months in any year are continuously without rain. Relative humidity during the dry season may be as low as 14% in the early after-
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FIG. 3
EXPANSION OF GLOSSINA FLY-BELT IN NGAMILAND AND CHOBÉ
noon, but does not remain for many days at that low limit.

The vegetation is characterized by the *Isobertinia-Uapaca* woodland and an abundant tall grass cover dominated by *Andropogon* spp. and *Hyparrhenia* spp. It finds a parallel in the *miombo* (*Isobertinia—Brachystegia* woodlands) of East and Central Africa.

In the mixed Guinea savannah, where human disturbance has been relatively recent, most of the bush is secondary, with a wide variety of smaller trees and shrubs which do not give any continuous shade. Islands of shade, however, remain, formed by clumps of more mature trees, especially *Isobertinia* spp., *Uapaca* spp., and *Parenari* spp. The grass in this woodland is burned early in mid-December and fires may be fierce but there may be little burning in the "islands" of taller bush.

A characteristic, however, of this savannah is the rapid regrowth of green grass after the fires, providing grazing for the large herds of cattle during the late dry season.

Associated with this woodland, and important for the tsetse fly, are the ecotones or narrow belts of mixed *Isobertinia* woodland associated with rocky outcrops and drainage lines, and the open grassy *fadama* along certain rivers.

There is a further stage where vegetation has been largely destroyed and open farmland dominates, some of it under continuous cultivation for many years; here only the more valuable trees such as *Parkia oliveri*, *Vitex doniana* and *Afzelia africana* remain.

By contrast with the Sudan Zone, the climate and vegetation in the Guinea Zone are ideally suited for several species of tsetse fly. Where vegetation has been undisturbed or not radically altered, most of the rivers are infested with *G. tachinoides* and *G. palpalis*. The *Isobertinia* woodlands, if left undisturbed, are completely infested with *G. morsitans*, and throughout much of the mixed Guinea savannah of secondary bushland large *morsitans* belts occur.

In forest islands in the southern areas, local foci of *G. longipalpis* are also found.

The only areas in the Guinea Zone where tsetse flies are naturally absent are the high tablelands such as the Futa Jallon mountains in Guinea, the Jos plateau in Northern Nigeria, and the mountain ranges and plateaux of the Cameroons.

Apart from these geological limitations, tsetse-fly distribution elsewhere in the Guinea Zone, from Gambia in the west to the Cameroons in the east,
is governed by human activity. Around towns and villages, along highways, and on the fertile agricultural plains, where human population is dense and natural savannah has been largely destroyed by established farms, tsetse flies are absent and trypanosomiasis can be controlled by drug therapy.

In areas where population is sparse and human interference at a minimum and where vegetation and game animals, including wild pig, are largely undisturbed, tsetse flies thrive and roam at will. The pattern, therefore, is a mosaic, tsetse-fly belts alternating with settlements, both varying in size according to local conditions such as land fertility, availability of water, and density of population.

THE EFFECT OF TRYPSANOMIASIS ON LIVESTOCK PRODUCTION

The economic importance of trypanosomiasis to Africa as a whole can be given a gross statistical evaluation if it is related to the present distribution and numbers of cattle in comparison with the land surface which should be available for livestock production.

The present total cattle population in Africa is estimated at 114,000,000 head. The area infested with tsetse flies and devoid of cattle is approximately 4,000,000 square miles (or nearly 10,400,000 km²) of land, most of it of average fertility.

If the carrying capacity of this infested area is estimated at 32 cattle per square mile (8 per km²), this land, if cleared of tsetse flies, could provide for a potential cattle population of 125,000,000 head, or 11,000,000 more than the present total population.

The effect this increased meat supply would have on the human diet, which is notoriously low in protein, is of paramount importance. If 30 g per day or 11 kg per annum are taken as a reasonably optimum average meat consumption level in Africa—a low estimate compared with 40-90 kg per annum in Europe—more than half the countries in Africa fall below this level.

In the coastal territories of West Africa meat consumption is generally below 8 kg per annum, while in Liberia and Sierra Leone it is only 1-2 kg. Meat consumption levels in the Sudan and Bechuanaland are equally low.

In Bechuanaland, where up to 80% of the total value of exports are from the sale of cattle and cattle produce, 38,500 people, or 11% of the population, and 114,600 cattle, or 9% of the cattle population, are in the Ngami areas at present threatened by tsetse fly.

In West Africa 570,000 head of slaughter cattle are trekked each year from the Sahel and Sudan Zones to the large meat-consuming towns on the coastal belt. The present losses from trypanosomiasis are estimated at £1,000,000 per annum. If trypanosomiasis could be controlled or eradicated, this same number of cattle could be bred further south in the Guinea Zone of vegetation in areas now infested with tsetse fly. A further 500,000 head approximately of cattle would then be available for slaughter, the condition of the cattle before slaughter would be improved and the increased income to farmers would be approximately £10,000,000.

From the meat-consumption figures there is obviously an urgent present demand for increased meat supplies. With the ever-continuing urbanization and increased national income which accompany modern progress, the demand for meat is rapidly increasing.

With this general situation in mind, the present effects of trypanosomiasis in each of the three territories can now be studied in detail.

Sudan

Animal trypanosomiasis is of tremendous importance to the Sudan; not only does it affect the distribution of cattle, but it has also strongly affected the distribution and even the habits of the main tribes (Lewis, 1949).

In the Bahr el Ghazal and Equatoria Provinces, the disease is so severe that cattle are almost completely absent in the areas occupied by G. morsitans. Trypanosomiasis sets such a limit to the raising of stock as to give rise to serious protein deficiency in the diet of many of the people (Tothill, 1948).

It is on the fringe of these fly-belts that animal trypanosomiasis chiefly flourishes, largely in the herds of cattle driven from the fly-free open grass plains into the fly-infested savannah woodland for dry-season grazing. Infected cattle (also game, which are important reservoirs) carry trypanosomiasis back with them into the wet-season grazing areas, where tabanids are so numerous as to set up widespread epizootics, transmission being entirely mechanical. These outbreaks reach such severity that, in 1946-47, one-and-a-half million cattle were affected in an area of over 100,000 square miles (260,000 km²). Most herds were infected, many losing more than half their beasts. At one time the death-rate exceeded 10,000 cattle in a month. Tsetse flies were completely absent.
Bechuanaland

Bechuanaland is vast and sparsely populated and the country generally is covered with arid and semi-arid vegetation. The only exception is in the Okovango and Chobe river swamps in the north-east, where the vegetation ranges from grassland, through scrub, to savannah woodland, with small patches of fringing forest lining many of the swamp channels. In a land short of water, there has always been adequate water in these rivers and swamps to support large herds. It has therefore been an important cattle area, and the present extension of tsetse flies, as already described, is a matter of some concern.

Since the spread of fly outwards from the fly pockets of 1900 to the present limits was gradual, little anxiety at first was caused as long as the people were able to retreat and still find water and grazing for their stock. The seriousness of the situation was realized only when the cattle of those people who could not move away started to die.

The spread of G. morsitans across the Chobe flats has led to the almost complete annihilation of the cattle population. In the Okovango, the advance of fly westwards was the most significant economically, although the advance eastwards that took the Naragha valley and threatened Maun, the capital, also radically affected the economy.

Failure has attended most of the recent attempts to develop underground water supplies in areas outside the tsetse-fly belt where good grazing is still available. Trypanosomiasis has therefore entirely changed the pattern of an even distribution around the swamps. Some 52% of the cattle are now concentrated around Lake Ngami, 20% are in the northwest on the Okovango river, 11% are on the Botletle river east of Maun, and the rest are in small groups to the south and west.

The total cattle population rose from 112,400 head in 1942 to 123,000 in 1954 and fell to 114,700 in 1961. Many factors contributed to the drop in the last seven years, and trypanosomiasis was undoubtedly one.

The annual offtake from this population may be 10% and the gross value realized was £180,000 per annum.

The four main tribes of Ngamiland are the Batawana, Bayei, Mampukushu and Damara. The Batawana and Damara own most of the cattle, the latter being the true cattle-breeders who feed on milk, meat, blood, and butter, all of which they get from their livestock. Both tribes readily sell their cattle for their needs and to enrich themselves.

Following the fly advance the Damara suffered least as they braved the rigours of the desert and took their cattle away from the danger.

The Batawana were slow to move and when they did so they were only just ahead of the advancing fly, so they lost much.

The Bayei inhabit the perimeter of the swamp and the islands, while the Mampukushu occupy the upper reaches of the Okovango. Both tribes fish and hunt; they own and sell fewer cattle because many of the swamp cattle are stunted and seldom reach the required weight of 850 pounds (385 kg) necessary before they can be sold for export. Also, cattle traders are reluctant to purchase beasts from the fly-belt or from areas from which cattle must be trekked through a fly-belt for export.

The tribes occupying the Chobe area are the Masubia, whose customs were similar to the Bayei's, and a band of exiled Batawana who settled there with their cattle in 1910. They prospered on the fertile Chobe flats and both carried on a vigorous trade in cattle and maize. But now they are very poor. The cattle population of 12,000 in 1939 dropped to 9,700 in 1942 and dwindled to a paltry 800 in 1961. With the proclamation of the game reserve between the Chobe flats and Rhodesia, the export trade in cattle was lost and there has been little incentive to reclaim the old grazing grounds. The Batawana suffered most, not only because they lost their riches but also because they were deprived of their traditional pattern of life. For animal proteins they now rely on hunting. The Masubia reverted to fishing.

More important than the decline in numbers is the permanent damage done to the "lake" and Botletle pastures of Ngamiland due to overstocking. The grass can support the cattle only when there is above-average rainfall. A slight drought leaves the lakes a dustbowl and browsing alone sustains the beasts. There is a resultant great increase in the calf mortality rate. Swamp pastures are little affected by the lack of rain and the condition of the cattle remains uniformly good despite the presence of liver fluke. Some slight relief may result if cattle are moved to the few successful boreholes put down south-east of the lake. The water potential in the western desert is as yet unknown, but the limiting factor may be the poisonous plant Dichapetalum cymosum, the exact limits of which are also unknown.
West Africa

The effects of trypanosomiasis in West Africa, as has already been pointed out, vary according to the zone of vegetation, increasing in importance from the dry north to the heavier rainfall areas in the south. In the Sahel Zone, trypanosomiasis is absent. In the Sudan Zone, tsetse-fly distribution is restricted to watercourses and seasonally inundated swampland, but even with this limited distribution the populations of *G. tachinoides* and *G. morsitans* have had considerable effects on human activity. Epidemics of human sleeping-sickness have occurred along these rivers within the last fifty years, decimating populations, as witnessed by the number of completely deserted villages along many of the rivers. Decrease in farming and human activity has then led to more ideal local conditions for tsetse flies and to a consolidation of their positions.

Livestock are affected during the rainy months of July to October by the spread of *G. morsitans* laterally from these linear foci into the adjacent upland grazing grounds, dispersal being often for a distance of 10-15 miles (or nearly 15-25 km). Severe epidemics of trypanosomiasis occur with a high mortality rate.

More important still is the fact that, because of these local infestations of *G. morsitans* and *G. tachinoides*, cattle herds are deprived of essential dry-season water supplies and grazing grounds. Lack of control, therefore, of these tsetse-fly foci aggravates the livestock position in the Sudan Zone and increases the necessity for annual nomadic movements southwards.

The importance of trypanosomiasis in the Guinea zone of vegetation cannot be over-estimated. The tsetse fly occupation of large areas in this zone has prevented a settled system of animal husbandry and completely dominated cattle distribution and animal production in the whole of West Africa.

It has produced directly the two dominant characteristics which distinguish cattle husbandry in West Africa today—the prevailing nomadic way of life of the cattle-owning tribes; and the potentially lucrative and well-organized slaughter-cattle trade which has developed along traditional lines between the northern cattle-producing Sahel and Sudan zones and the larger towns in the coastal zone.

Nomadism. The major cattle-producing areas are in the Sudan Zone; the territories of Chad, Niger, Mali, Northern Senegal and Northern Nigeria, all having large livestock populations varying from 4 000 000 to 8 000 000 head in each territory, with many more millions of sheep and goats.

As the dry season advances, the grass species in this zone rapidly become woody and unnutritious and disappear, while water supplies are insufficient or absent. Transhumance or nomadism becomes essential, and millions of cattle move southwards into the Guinea Zone each year in search of grazing.

This annual southern migration of cattle commences in Northern Nigeria in November and movements are leisurely at first, the cattle grazing on farmland where the harvest is complete and crop residues are available and manuring the fields in return for this supplementary feeding. But as the movement of herds continues southwards, contact with the larger tsetse-fly belts, especially with the *G. morsitans* belts, is soon established and movement becomes more hurried in order to reach the safer grazing areas beyond, close to the larger rivers of Niger and Benue.

Relatively heavy trypanosome infections of herds occur both in traversing the *G. morsitans* belts, and from *G. tachinoides* and *G. palpalis* at riverine watering points.

The presence of *G. morsitans* also severely restricts the availability of grazing grounds for nomadic herds and makes settled livestock husbandry in the Guinea Zone almost impossible.

Some idea of the seriousness of the position is given by the records of cattle treated for trypanosomiasis in Northern Nigeria during the past nine years, which were as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of cattle treated</th>
</tr>
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<tbody>
<tr>
<td>1952</td>
<td>95 100</td>
</tr>
<tr>
<td>1953</td>
<td>183 000</td>
</tr>
<tr>
<td>1954</td>
<td>216 000</td>
</tr>
<tr>
<td>1955</td>
<td>406 400</td>
</tr>
<tr>
<td>1956</td>
<td>578 600</td>
</tr>
<tr>
<td>1957</td>
<td>771 400</td>
</tr>
<tr>
<td>1958</td>
<td>735 600</td>
</tr>
<tr>
<td>1959</td>
<td>571 300</td>
</tr>
<tr>
<td>1960</td>
<td>424 500</td>
</tr>
</tbody>
</table>

At 1/- per dose, the cost to cattle owners of approximately 4 000 000 doses over the nine years was £ 200 000; but the cost to the Government of Northern Nigeria in staff, transport and maintenance of almost 350 treatment camps was approximately £ 1 000 000. Unless active steps are taken to eradicate tsetse flies the cost will continue annually.

At the end of the dry season, there is little temptation for the nomadic herds to linger in the Guinea Zone.
Zone. As the rains commence, the savannah tsetse flies become more widely dispersed, and men and beasts are anxious to complete the journey back to their ancestral homes in the Sudan Zone. Movement of herds is therefore hurried and restricted to well-defined, traditional, migration routes.

These routes, through *Isoberlinia* woodland infected with tsetse fly, become foci of local concentrations of *G. morsitans*, attracted by the availability of food. Infection of herds with trypanosomiasis may again be heavy. Also, cattle movements along these routes favour the spread of tsetse flies into suitable woodland beyond. This has been an important factor recently in the spread of *G. morsitans* in Northern Nigeria (Wilson, 1958).

**Trade cattle routes.** Tens of thousands of trade cattle pass through the Guinea Zone at all seasons of the year on their way from the producing areas in the Sahel-Sudan Zone in Chad, Niger, Mali and Upper Volta to the meat-consuming towns in the south, especially on the coast. These towns, being in the tsetse-fly-infested forest zone, depend entirely on this source for their meat supplies.

The amount and direction of this trade are shown in Fig. 5 and are obviously of considerable economic importance. The numbers amount to 570,000 head approximately and the commercial value, if in good condition at time and point of delivery, would be as high as £22,800,000.

Movement of these trade cattle is usually on foot along traditional routes built up gradually over the years by independent traders. The main trade cattle routes in West Africa are shown in Fig. 6. All pass through the Guinea Zone, with varying degrees of trypanosomiasis infections, into the heavily infested forest zone.

The time taken by herds from the main markets at Fort Lamy, Zinder, Niamey, Mopti and Bamako to the consuming centres of Lagos, Kumasi, Accra and Abidjan may be up to three months and during this time losses from deaths and in weight and in quality may be substantial. These losses are predominantly due to trypanosomiasis.

In one experimental study on the stock routes from Mopti to Accra deaths ranged from 5% to 15% according to the type of trypanosomiasis treatment administered, while survivors incurred live-weight losses of 15%–30%. Losses due to trypanosomiasis on these trade routes must exceed £1 million per annum.

**HUMAN TRYPANOSOMIASIS**

**Sudan**

A full description of sleeping-sickness in the Sudan has been given by Bloss (1960) and by Morris...
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FIG. 6
MAIN STOCK ROUTES IN WEST AFRICA


The only form of the disease present is that due to *T. gambiense* and this has been confined to a comparatively narrow belt of the country along the southern border of Equatoria Province, adjacent to Uganda, the Congo, and the Central African Republic.

The vector is *G. palpalis*, which has a considerably wider distribution than that of *T. gambiense*. The seven outbreaks, as can be seen from Fig. 1, have occurred close to the northern limit of the vector, and this has had two apparently contradictory effects. The epidemics were of considerable violence since conditions adverse to the tsetse fly are frequently favourable to the rapid transmission of *T. gambiense* (Morris, 1951, 1962b); yet they were amenable to a high degree of control, amounting in effect to complete eradication, for the very reason that *G. palpalis* was living within a narrow margin of its threshold of existence.

Of the seven outbreaks shown, six have been eradicated by treatment while the seventh is being dealt with successfully. The human sleeping-sickness problem, therefore, for the moment has been largely solved but *G. palpalis* remains. The continued presence of the vector together with the fact that active foci of *T. gambiense* still occur just over the border in Uganda and Congo make the reintroduction of this infection a real possibility. An equally dangerous possibility is the introduction of *T. rhodesiense* from an uncontrolled epidemic in central Uganda which is spreading eastwards into Kenya.

The first outstanding lesson is in fact the ease with which *T. gambiense* can be introduced and reintroduced into this territory. This is due to the tribal movement across the border, often among peoples whose tribal area has been divided by the political frontiers. There is also long-distance movement by traders and travellers along active trade routes. Labour routes are also important owing to the large number of migrant labourers who seek work outside the country. One of the most important labour routes, from the trypanosomiasis point of view, is that following the Nile to the Buganda and Busoga districts of Uganda. This route carries 25 000-30 000 labourers annually and has been responsible for outbreaks of sleeping-sickness since 1910.

Political changes have also played a part. The administrative changes in 1954-55 which led to the
revolt in Southern Sudan caused the breakdown of the well-established sleeping-sickness inspection and control. The Yambio outbreak then arose with alarming suddenness and in contrast to a previous slow increase, reaching 871 cases in 1957. This and other sudden outbreaks are now being controlled with exemplary thoroughness.

**Bechuanaland**

An outline of the history of the discovery of sleeping-sickness in Bechuanaland has been given by Machichan (1940), and Lewis ¹ pointed out that the infective trypanosome was identified by Gear & de Meillon (1939) as *T. rhodesiense*. Ormerod (1960) correlates the dense cell inclusions seen in the trypanosomes collected in Ngamiland with the chronic form of the disease.

In the more heavily infected river valleys evacuation of the population has been used as a method of control by Machichan. At present, by dint of energetic blood-slide surveys in zones of high infection, infected persons have been discovered and treated and the disease incidence kept at a reasonably low level. The abandonment of the much-feared tryparsamide drug in favour of melarsoprol BP (Mel B) has made the task easier.

The incidence of the disease over the past 21 years has varied from a high total of 318 cases in 1942 to an average of two cases per year during the period 1953-55. The steady rise since 1957 to a total of 112 cases in 1960 is partly attributable to increased medical activity and to an increase in the man-fly contact caused by fly advances.

The position of the disease in Ngamiland is not alarming but the potential for epidemics is present in some areas. Lewis (op. cit.) explained that the over-all density around the swamp, where most people are concentrated, is between 18.5 and 23.3 persons per square mile (6.7-9.0 per km²), while the density calculated to be the most favourable for the epidemic spread of this disease is 5-25 per square mile (1.9-9.6 per km²).

**West Africa**

The importance of sleeping-sickness in West Africa varies from territory to territory. An excellent review of the present situation is given by Vaucel et al. The use of chemoprophylaxis (Pentamidine) combined in many areas with riverine tsetse-fly clearings has had success and has reduced the general significance of the human disease in contrast to the urgency of the veterinary problems. The continued presence of the tsetse vectors, however, over vast areas means that the potential for epidemics remains if the present control measures are relaxed.

**THE EFFECT OF TRYPANOSOMIASIS ON AGRICULTURE**

Land is the basic resource of a developing country and although a nation’s land is fixed, its productivity can usually be improved. Some of the usual methods to achieve this improvement are bush clearing, provision of water supplies, and use of cattle as draft animals and for the provision of manure.

These methods, to be successful, must lead to an integrated settled system of farming, an ideal which is impossible if trypanosomiasis is present. Tsetse flies and the diseases they cause engender instability in both human and livestock populations.

**Sudan**

The close link between agriculture and human trypanosomiasis is well illustrated by events in the Sudan. The start of the Yambio outbreak in 1946 coincided with this town becoming the centre of the new Zande Development Scheme, in which a formerly scattered population was settled at a fairly high density in country intersected by numerous *G. palpalis*-infested streams. No control of this fly was attempted as it was considered impracticable. The resulting situation, of a heavy population in intimate contact with the vector, provided ideal conditions under which the epidemic then arose. The Yambio incident is but one among a number of instances elsewhere in Africa in which agricultural developments, without regard to the risks arising from increased contact with *Glossina*, have provoked epidemics of *T. gambiense* (Morris, 1960).

Conversely, agricultural development, properly handled, can be the most successful and economic method of reclaiming land from tsetse fly. The first step must be an attack upon the vector species to the point of their elimination. When *G. palpalis* is the vector, as in the Sudan, the terrain it occupies is usually the most fertile and well watered. Consequently the land gained from the fly can be fully developed, for agriculture, livestock, and often fishery. A dual purpose is thus served: justifying the expense of tsetse-fly eradication, and stabilizing the control. A stable form of control obviates the need for maintenance, which often in the long run

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² See the article on page 545 of this issue.
proves even more costly than the initial reclamation. Since tsetse-fly eradication removes at once the danger of animal as well as of human trypanosomiasis, a follow-up with full agricultural development, including mixed farming, is possible, and the eventual benefits to the economy as well as to the health of the country are immense.

Bechuanaland

The advance of the tsetse fly has driven the Batawana out of the fertile, well-watered valleys they previously occupied, while the Bayei, who preferred to remain at the rivers, have lost most of their ploughing oxen.

Although hand-hoeing is the original cultivation method practised by the indigenous Bayei, the cattle-owning Batawana built up a mixed farming tradition around the ox-drawn, mouldboard, single-furrow plough, and introduced it to the Bayei, who were eager students. The method of ploughing is primitive in the extreme, but it did enable farmers to meet their own requirements and still leave a surplus for sale. The animal manure and urine helped to maintain soil fertility. Despite the loss of some areas and the reversion to hand-hoeing in others, it is still possible for Ngamiland to produce a surplus of maize in good years. There is no incentive to increase this surplus because the price demanded by the producers is too high to offset costly transport and an export trade cannot be established. If the price could be lowered to permit export, then the economic value of mixed farming land would be eight times that of ranching land. One beast (ranching) needs 40 acres (16 ha) and gives £16 gross return. Forty acres (mixed farming) planted with mealies gives 120 bags valued at £120 (20 shillings a bag).

The needs of Ngamiland have been neglected for years owing to lack of staff but the interests of the communities affected by trypanosomiasis cannot be for ever ignored. An agricultural survey is now in progress to determine the needs and possibilities of resettlement in relation to trypanosomiasis control, and a small experimental farm is to be established.

The opportunities of using resettlement, however, as an attacking control method against trypanosomiasis are limited because the lack of population pressure, the abundance of land and the general low soil fertility do not create conditions suitable for dense settlement. Though this is generally true, there are localized areas where the density is very high, as in the Shorobe swamps where a small area, three square miles (7 km²) in extent, supports 137 persons per square mile (53 per km²). What is urgently needed is a detailed village-to-village population map with the fly line superimposed on it. The position will then be clearer.

Density figures in areas where concentrations of settlements have acted as a deterrent to advances would be invaluable for the future, as trypanosomiasis control plans might be able to incorporate controlled redistribution of population. The insistence of the Agricultural Department on stock being introduced early in any scheme and the dangers of sleeping-sickness will require the tsetse-fly density to be reduced to a safe level before people and their stock can be allowed in. Each element of trypanosomiasis control would play its proper role in a combined attack and this is as it should be. Tsetse-fly control will reduce the density, drugs will keep stock and people free from disease, and resettlement will consolidate and eventually justify expenditure with increased productivity.

West Africa

One of the most urgent problems in West Africa today is the establishment of mixed farming in the Guinea Zone of vegetation, with animal production playing an important role.

Farmers in West Africa recognize the necessity of farmyard manure for the maintenance of soil fertility but to date all schemes of mixed farming in areas of low population density have failed owing to the losses from trypanosomiasis.

If agricultural productivity is to keep pace with increasing populations and if national income is to improve, control of trypanosomiasis in this zone is a first essential.

Considerable advances in tsetse-fly control have been possible in the Sudan Zone by ground-spraying of vegetation with residual insecticides. One whole belt has been eliminated and others are being dealt with successfully.

Progress in the Guinea Zone is more difficult owing to the widespread dispersal of G. morsitans in the Isoberlinia woodlands and the use of different resting-sites by this tsetse species. The use of consolidated human settlements is expensive and limited in application owing to the lack of population pressure and the reluctance of villagers to leave their ancestral habitats. But in spite of these difficulties the opportunities for successful control schemes are improving.
TRYPANOSOMIASIS AND FORESTRY POLICY

The necessity to establish and maintain adequate forest reserves in every territory requires no justification. African farmers are, of course, interested in the destruction of woodland in order to establish farms; cattle owners are anxious to keep woodland open to encourage grass development and improve grazing and so annual grass burning of savannah is practised. Both operations are inimical to the tsetse fly and should therefore be encouraged as much as possible. But if woodland is destroyed without control, other very serious climatic and domestic problems arise. Governments, therefore, for many years have practised a policy of forest reservation.

Sudan

In the Sudan, the fact that the main sleeping-sickness outbreaks are along the Congo-Nile watershed (Fig. 1) brings forestry interests under consideration, one of the most important functions of a forest being protection of the soil and prevention of run-off on such catchment areas.

For this reason, control measures such as chemoprophylaxis or the removal of tsetse fly by spraying with insecticides or trapping (Morris, 1962a) may be preferable to the well-proven method of fly control by bush-clearing.

On the other hand, the advantages to be gained by the agricultural development of land cleared of fly-belt are so great that this form of reclamation still has a high claim for consideration. Selective clearing allows all the valuable trees to be preserved and, by replacing riverside bush with grass cover, improves the soil-binding properties (Morris, 1946).

Bechuanaland

In the Bechuanaland fly area, the only forest is a belt of Baikiaea plurijuga ("mokusi"), 3000 square miles (7800 km²) in area, which covers a large portion of the Chobe district. This forest is separated from the tsetse-fly habitat on the flats by a ridge and tsetse flies have not become established in this vegetation community. Plans to exploit the timber possibilities of this forest will therefore be unhampered by the threat of sleeping-sickness.

West Africa

In West Africa, forest reservations have always been of secondary importance to agriculture in the Sudan and Guinea zones and it is the usual policy, when establishing forests, to exclude existing farmlands. Forest reserves are therefore usually marked out in unoccupied land, and the policy in the savannah zones is to leave such reserves untouched for many years until the natural woodland develops. An active management policy is rare.

In the dry Sudan Zone, this policy has little effect on the general trypanosomiasis problem, since tsetse flies are absent from the dry woodland, and can be controlled in the restricted riverine areas.

In the Guinea Zone, the opposite is true, as the forest reserves too often coincide with tsetse-fly-infested woodland. Within these reserves, grass fires are controlled, tree and shrub regeneration is encouraged, grass cover decreases, shade increases, and game animals find a sanctuary. Conditions may therefore become ideal for tsetse-fly breeding and concentrations develop.

These concentrations favour dispersal of tsetse flies outwards into adjacent farmlands; a retreat of the flies in response to growing population pressure may be halted; and a situation may arise when flies are enabled to move forward from one reserve to another and so advances are encouraged (Wilson, 1958). Farming and cattle husbandry near forest reserves are especially vulnerable.

The present forest policy therefore in the Guinea Zone must be revised in light of present knowledge of tsetse-fly distribution. Forest reserves must be limited in extent so as not to exceed 25 square miles (65 km²) in area, in order to assist tsetse-fly control. Within fly-belts, they should never be demarcated on the periphery of the belt near farmland, but always be at least three miles (5 km) within the known fly limits. Outside tsetse-fly areas, no reserves should be considered nearer than 10 miles (16 km) to known fly-belts lest they become "stepping-stones" for future tsetse-fly advances. For the same reason, no forest reserves should be closer than 10 miles to each other and farmland should be closely established between reserves. Wherever possible, reserves should not impinge on railways and roads as traffic would aid fly dispersal.

These important principles should be recognized and practised throughout West Africa as an integral part of trypanosomiasis control.

FUTURE POLICY

In view of the crippling effect trypanosomiasis is having on the economy of each of the three regions under review, the importance of future control measures is obvious.
Sudan

The problem of animal trypanosomiasis in the Sudan is one for which no immediate remedy can be suggested, yet its great importance to the health of the people (through diet) and to the prosperity of the country make it a matter of considerable urgency. Research is needed, and it must be of a practical nature, such as a study of the complete cattle → G. morsitans → cattle → Tabanus cycle through all its complexities. It is possible, for example, that if the G. morsitans cyclical-transmission stage could be cut out, the Tabanus mechanical-transmission cycle might not, alone, be sufficient to maintain the virulence of T. congolense. Further studies of the Tabanidae must be undertaken, and trapping is going to prove valuable in this respect (Thorsteinson; ¹ Morris, 1963). The physical immensity of the tabanid problem is such that results may, perhaps, be more quickly obtained through attack on the better understood G. morsitans cycle or through modifications in the grazing, herding and migrating habits of the cattle effected through the people themselves. Drug therapy and prophylaxis should be considered, but again the immense size of the problem and the nomadic habits of cattle owners present great difficulties in application. In the G. morsitans and G. palpalis areas some pilot schemes could be started at once. It is quite certain that development schemes, carefully planned on adequate local knowledge, could increase the cattle potential in the meat-hungry areas of Bahr el Ghazal and Equatoria, thereby bringing them both a richer diet and a more efficient and productive agriculture.

By contrast, when it comes to the human disease Sudan has set an example which might well be emulated by other territories. Indeed it is of vital importance that T. gambiense should be eliminated from the adjoining countries of Congo and Uganda to prevent any repetition of reinfection, as has occurred in the past. The case of Congo is difficult, and must presumably be dealt with through the international organizations. On the other hand, Uganda has been well capable of dealing with this problem in the past. The present outbreak in West Nile district represents a spread of infection in a locality which may be termed an epidemic-prone area, where a high population is living in intimate contact with innumerable G. palpalis-infested streams (Morris, 1962b). The threat to Uganda is along the route followed by migrant labourers returning to their homes in Equatoria Province.

The same labour route raises the second threat, that of the introduction of T. rhodesiense from the uncontrolled epidemic in the Busoga district of Uganda, where much of the Sudanese labour finds its work. In Equatoria Province, where many of the labourers have their homes, G. morsitans (the vector of T. rhodesiense) is widespread.

The implications are obvious. The Busoga T. rhodesiense epidemic should be tackled seriously. A previous incipient outbreak was checked by the successful eradication of G. morsitans from that particular area (Morris, 1960).

Regarding T. gambiense, the West Nile outbreak could be brought under complete control within a year or two by an energetically pursued campaign of chemoprophylaxis.

Bechuanaland

The picture in recent years in Ngamiland has been one of retreat before actual or threatened G. morsitans advances while plans for control have been hampered by lack of staff and shortage of funds.

Present achievements in control. Macaulay (1942) gives details of the operation of trypanosomiasis treatment centres from their inception in 1937 to 1941. A total of 3045 cattle were treated and discharged as cured while there were 348 deaths. Treatment was with tartar emetic. The centres were operated until 1951 but later details are not available. Their closure was due to lack of funds and lack of support by the Africans, who became disturbed at the effect on their cattle of inefficient injecting techniques.

Apart from this work, which was fairly successful in the early days, little was done. It was impossible to put surveys, investigations and control by drug therapy on an organized basis owing primarily to a necessary preoccupation with the control of outbreaks of foot-and-mouth disease since 1957.

There are notable exceptions to the forced veterinary inactivity. In 1959, 1500 head remained on the Nokaneng flats. Fly density was light and a scheme was started to investigate the possibilities of keeping the cattle under chemotherapeutic protection so that the grain production of the area would not suffer further through lack of draught oxen. Protection from trypanosomiasis was guaranteed. Influx was uncontrolled and, as protection meant free treatment,

¹ Paper presented at the 11th International Congress of Entomology, Vienna, August 1960 (to be published).
in no time the numbers of cattle doubled. Because funds were limited, original regimes involving mass prophylaxis with quinapyramine were abandoned in favour of curative treatment on request. So far the scheme is successful and little treatment has been necessary. A similar scheme involving the Shorobe cattle is also operating successfully. For little expense 3500-7000 cattle are maintained in two highly productive mixed farming areas.

Because of these difficulties trypanosomiasis work has largely devolved on anti-tsetse-fly measures. As in other parts of Africa the objects are to stabilize the fly-front and reclaim for development as required (Aspinall et al., 1960; Whiteside, 1958). Advances on Maun, the administrative and tribal headquarters, were held up by game control. Consolidation with discriminative clearing and ring-barking took the form of a “defence-in-depth” protective arc around the township. Clearings along the Taoghe between Nokaneng and Tsau in 1943 failed to hold the encroachment westwards. Expansions of the belt occurred northwards towards Gomare and southwards past Tsau towards Makakun. A discriminatively cleared barrier across Tsau helped to reduce movements in that area and a protective barrier at Makakun has not yet been threatened. A similar barrier was put across Gomare and this was backed by a deep, ring-barked zone. This seems to have stopped movement northwards. But a westerly encroachment from the swamps north of Gomare took place, slowly at first, until it reached a very suitable habitat, when it turned rapidly north to Sepopoa and south towards Gomare. On the eastern flank a very powerful thrust developed north of Shorobe which threatened to engulf settlements along the Maun-Shorobe road. While this was being dealt with by discriminative clearing a density build-up became evident in the swamp islands of Santandadibe just beyond the protective arc around Maun.

Small but obvious improvements in the animal trypanosomiasis position resulted from these tsetse-fly control efforts. In 1950 stock were completely absent from the Maun area, and today there are 3500 head. Some of these are traders’ cattle held for four months pending the export season. They receive a certain amount of treatment, while the African herds are largely unprotected and untreated. Macaulay was worried about the cattle from Toteng to Sehitwa because of the advance down the Naragha. There are now over 3000 more in this area. Confidence in tsetse-fly control measures resulted in the reintroduction of 3000 head into the Makakun area in 1960.

Having destroyed the Chobe cattle on the flats, the tsetse flies continued past Kachikau to Kavimba and started to filter down the narrow flood plain of the river. Timely bush clearing between Ngoma and Kavimba inhibited this advance. The habitat from Kachikau to Kavimba was ring-barked and catches at the “de-flying” stations together with those on fly-rounds reflected a marked improvement. Ploughing oxen are now kept between Ngoma and Kachikau.

**Plans for tsetse-fly and trypanosomiasis control as part of the future development of the cattle industry.** A realistic assessment of the trypanosomiasis problem will be impossible without kraal-to-kraal knowledge of the distribution of cattle in all areas where the tsetse fly is likely to transmit the disease, and in areas which are affected by seasonal movement of cattle in and out of fly-infested zones because of the danger of mechanical transmission. This knowledge should be accurately plotted on a map showing the fly-line. The next need is for detailed and repeated trypanosomiasis surveys round the perimeter of the fly-belt where cattle are in permanent or seasonal contact with tsetse flies. Blood smears should be examined from as many cattle as possible within 20 miles (about 30 km) of the fly-line. The information so obtained would provide an early indication of changes in the tsetse-fly position. An advance could be predicted long before flies are caught. An improvement in the trypanosomiasis incidence rate will be a valuable yardstick against which to measure the success of anti-tsetse-fly measures.

A start will be made in the Shorobe and Makakun-Setateng areas. Field laboratories will be built and these will be served by a mobile laboratory. There is provision for the purchase of 400 cattle for use in trypanosome challenge investigations in selected areas and for experiments in chemotherapy. The trypanosome challenge studies will open with controlled experiments using test herds in the Naragha valley, in the lower reaches of which the tsetse-fly density is very light.

The limits of tsetse-fly infestation in most areas are now plotted and shown on the maps accompanying this paper. Intensive sampling will be continued in the Ikwaga-Shakawe area to determine the potential for further advances, and to study the results of defence measures taken. Similar studies will continue south of Tsau and from Toteng to
The limits in the Seronga section have yet to be demarcated accurately.

Taking Ngamiland as a whole, blood-meal sampling reveals the preference of *G. morsitans* for ruminants (41.9%) and suids (35.5%). The single animal most favoured is the warthog (26.6%) followed by kuda (12.3%). Man provided 5.1%. Perhaps the most interesting is ostrich, which gave 4.7%. For the purpose of understanding the game/fly/trypansomosome complex in relation to vegetation and the domestic host a closer examination of the food preference is necessary in the various areas. Ashcroft, Burtt & Fairbairn (1959) indicated the probable importance of antelope as reservoirs of sleeping-sickness, and suggested that wild pigs may be important for trypanosomes pathogenic to cattle. Nash discussed the possible existence of restricted localities where the incidence of trypanosomiasis is high; ideal conditions are the suitability of vegetation for tsetse-fly infestation and the local dependence of the fly on a few animals of a species well capable of constituting a trypansomosome reservoir. The following tabulation compares the blood-meal figures (as percentages) in three areas for suids and ruminants with special reference to warthog and kudu:

<table>
<thead>
<tr>
<th>Area</th>
<th>West</th>
<th>Maun</th>
<th>Ngabe (north-east of Shorobe)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suids (Wart hog)</td>
<td>9.5%</td>
<td>37.7%</td>
<td>43.4%</td>
</tr>
<tr>
<td>(Warthog)</td>
<td>(9.5%)</td>
<td>(27.5%)</td>
<td>(41.3%)</td>
</tr>
<tr>
<td>Ruminants</td>
<td>50.1%</td>
<td>44.0%</td>
<td>41.3%</td>
</tr>
<tr>
<td>(Kudu)</td>
<td>(26.2%)</td>
<td>(7.7%)</td>
<td>(22.7%)</td>
</tr>
</tbody>
</table>

The preference for antelope suggests a high incidence of sleeping-sickness in the west, where, in fact, the disease is prevalent. The Maun area might be more important in relation to animal trypanosomiasis. Twenty-one bait cattle were kept in a part of the Naragha valley since April 1961 and 37 infections resulted despite the low apparent density (0.275).\(^1\) Infections were cleared with Berenil. Both diseases could be common in the Shorobe area. Cases of human trypanosomiasis do occur and blood-slide surveys in cattle reveal a fairly high nagana incidence.

Discriminative clearing and discriminative ring-barking are the methods of control locally favoured for consolidation. A joint project with WHO is planned to test the use of insecticides to eliminate fly and to halt movement. If the results are satisfactory then spraying will be a fast weapon to employ in combination with the more permanent methods. Resettlement might also be valuable as part of a combined attack, but this awaits land-use surveys.

Unfortunately most effort in the immediate future must be expended on stabilizing the fly-front. To hold the line and keep the status quo will not be enough and plans for a counter-attack have been formulated to reclaim valuable ranching and mixed farming country to reduce the stocking rate in over-grazed regions and to put the economy of the cattle industry on a sounder footing. Areas earmarked for treatment are south of Tsau, the Nokaneng-Gomare-Taoghe flood plain, the Naragha valley and the sandveld between the central and western swamp drainage systems. Between 20 000 and 30 000 cattle could be moved from crisis areas.

**West Africa**

Recent advances in the use of residual insecticides for the ground spraying of vegetation used by tsetse flies as resting-sites have made complete control of trypanosomiasis a reality in the Sudan Zone. In this area it has already been noted that during the dry season tsetse flies are restricted to linear belts along watercourses and their resting-sites are on the bases of tree trunks within forest clumps. The areas requiring spraying are relatively small. Eradication of trypanosomiasis from both human and livestock populations is now only a matter of staff, finance and organization (Maclellan & Kirkby, 1958; Davies & Blasdale, 1960; Kirkby and Blasdale, 1960).

In the Guinea Zone, tsetse flies, especially *G. morsitans*, have a more dispersed distribution even at the height of the dry season and resting-sites differ from those frequented in the Sudan Zone. Control by spraying of vegetation is not so easy or economical and should where possible be combined with bush clearing and human settlement. This zone presents the greater problem for the future.

**CONCLUSIONS**

The problems presented by trypanosomiasis affect almost every aspect of human activity. Emphasis has been given in this paper to the general effect of this disease on rural economy. The restrictions placed at present on this economy are exemplified by the fact that, if tsetse flies could be controlled, the cattle population in Africa could be increased by 125 000 000 head, or more than

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\(^1\) Apparent density is defined as the number of flies per 10 000 yards.
Les problèmes soulevés par la trypanosomiase africaine ne sont pas seulement d’ordre médical, mais aussi d’ordre économique et social. Dans cet article les auteurs passent en revue ces problèmes dans trois régions typiques: le Soudan, le Bechuanaland, l’Afrique occidentale. L’accent est mis sur les entraves apportées par la trypanosomiase au développement de la vie agricole, des animaux et des forêts.

La répartition annuelle des mouches tsé-tsé est rappelée. Dans l’extrême Sud du Soudan, l’on rencontre à la fois Glossina palpalis et G. morsitans tandis qu’au Bechuanaland G. morsitans infeste les marécages situés près des rivières du Ngamiland, province septentrionale. En Afrique occidentale G. tachinoides et G. morsitans infestent des parties assez restreintes de la zone soudanaise de végétation; ces deux espèces sont, ainsi que G. palpalis, largement représentées dans toute la zone guinéenne.

Les entraves apportées par la trypanosomiase au développement du cheptel africain dans son ensemble sont évidentes; si l’on pouvait détruire complètement la tsé-tsé, le bétail pourrait augmenter de 125 millions de têtes et ainsi atteindre plus du double de son chiffre actuel.

Au Soudan, la répartition du bétail dans la province d’Equatoria est très sérieusement perturbée par la tsé-tsé.

Au Ngamiland, la tsé-tsé s’est emparée des paturages les plus importants du Bechuanaland et toutes les tribus pastorales en ont souffert. Les tribus Batawana ont beaucoup perdu par suite de leur lenteur à évacuer ces régions; non seulement elles se sont appauvries, mais leur mode de vie traditionnel s’en est trouvé altéré. Des pertes analogues ont été éprouvées par des tribus occupant la région de Chobé et, au nord-est du Bechuanaland. La diminution du nombre des animaux est d’ailleurs moins grave que le dommage permanent causé aux paturages sains par l’entassement du bétail.

En Afrique occidentale, la prédilection des mouches tsé-tsé pour les paturages de la zone guinéenne de végétation a eu pour conséquence le nomadisme actuel des tribus pastorales et a entraîné la séparation entre les zones septentrionales productrices de bétail et les villes méridionales où la viande est consommée.

La migration annuelle des troupeaux vers la zone méridionale guinéenne entraîne une infestation trypanosomiase sévère et des millions d’animaux doivent être traités chaque année. Les routes traditionnelles du bétail traversent les zones guinéennes et forestières infestées par la tsé-tsé et les pertes infligées au bétail destiné à l’abattage dépassent un million de livres sterling par an.

Au contraire, les problèmes de trypanosomiase humaine présentent dans ces trois régions des aspects plus réconfortants.

Dans le sud du Soudan, Trypanosoma gambiense ne se manifeste que peu ou pas, mais le vecteur G. palpalis subsiste et, avec lui, le danger de voir la maladie réintroduite à partir des pays voisins.

Au Bechuanaland, la maladie du sommeil humaine ne présente pas non plus de caractère alarmant, mais la possibilité d’épidémies dans certaines régions demeure.

**Résumé**

Les effets sur l’agriculture sont principalement le résultat de l’échec à établir un système d’agriculture mixte dans toute la région où la trypanosomiase rend la production agricole coûteuse. 

La foresterie et le contrôle des mouches tsé-tsé ont souvent été exploités par les paysans dans l’est. La destruction de certaines régions de tsetse et des arbres précieux pour le développement économique et le développement des arbres dans les zones côtières sur lesquelles se concentrent les pertes financières chaque année de plus de £ 1 000 000 annuellement.

Le contrôle des mouches tsé-tsé est de plus en plus important dans trois régions mais le potentiel pour les épidémies graves reste une menace.
En Afrique occidentale, la maladie du sommeil a considérablement reculé grâce à la chimio prophylaxie individuelle (pentamidine) combinée à la lutte contre la mouche tsé-tsé le long des routes.

L'expansion agricole peut, convenablement dirigée, constituer la méthode la plus efficace et la plus économique de récupération du terrain occupé par les tsé-tsés et l'on s'adresse à cette technique dans le Sud du Soudan.

Au Bechouanaland, les possibilités d’utiliser les regroupements humains dans la lutte contre la trypanosomiase sont restreintes du fait de l’absence de pression démographique; le sol peu fertile ne convient pas à l’installation d’une population dense. Mais les enquêtes agricoles progressent et de nouvelles ressources en hommes et en argent seront bientôt à la disposition de ces régions.

En Afrique occidentale, la lutte contre la mouche tsé-tsé n’a guère progressé dans la zone guinéenne; cette lenteur freine le développement agricole (élevage et récoltes).

Dans chaque pays africain, il est nécessaire de préserver des zones forestières. Ceci ne présente aucune difficulté particulière au Soudan et au Bechouanaland. Dans la zone guinéenne de l’Afrique occidentale, les forêts peuvent au contraire favoriser la pullulation des mouches tsé-tsé et leur émigration vers les régions voisines.

En ce qui concerne l’avenir, il convient au Soudan d’étudier minutieusement le cycle bétail—G. morsitans—bétail—taon. Au Bechouanaland, il importe d’effectuer des enquêtes dans les villages mêmes pour être en mesure de dresser un programme de lutte. En Afrique occidentale, l’essentiel est d’intensifier la lutte contre la tsé-tsé dans la zone guinéenne.

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