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Ecological Effect of Control of African Trypanosomiasis

A connection between the West African cattle industry and Sahelian drought is possible.

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African sleeping sickness of man and Nagana of cattle are both caused by trypanosomes transmitted by the tsetse fly. Governments, therefore, tend to regard these two patterns of disease as a single entity and to set up tsetse and trypanosomiasis control organizations that operate in both medical and veterinary fields. This has caused some serious misconceptions.

In this article, I discuss the difference between these two diseases, particularly in relation to the adverse effects that control measures can have on the ecology of the African continent. These adverse effects seem to be due, at least in part, to lack of appreciation of the fundamental difference between human and cattle trypanosomiasis. Measures which have been introduced as a combined attack on the two diseases have been relatively ineffective against sleeping sickness but have been so successful with cattle trypanosomiasis that the resultant increase in the cattle population may already be causing serious damage to the environment.

The control of cattle trypanosomiasis has caused a situation that is well recognized as an effect of disease control (*1*); that is, populations have been allowed to increase beyond the carrying capacity of their environment so that in this instance, unless there is a corresponding improvement in the practices of husbandry or of environmental control, serious damage may result. The increase in cattle populations can so easily be represented in economic and nutritional terms as improvement that the destruction of vegetation may be ignored. If my hypothesis, which relates the destruction of vegetation to climatic change, carries any scientific validity, there is now an urgent need for reassessing the priorities of trypanosomiasis control in Africa.

Vegetational Zones and the Distribution of Trypanosomiasis in West Africa

Trypanosomiasis occurs in the tsetse belt of Africa that is shown in Fig. 1 (*2*). This belt straddles the rain forests of Africa and extends to the dry areas of the Sahara in the north and the more diffuse southerly dry areas of Namibia, adjacent parts of South Africa, Botswana, and Angola. The following discussion specifically concerns the northwestern part of the tsetse belt and the southwestern part of the Sahara, but the principles apply generally to arid zones at the margin of the tsetse belt.

West Africa is divided into vegetational zones (Fig. 2) (*3*) that include the Sahara, which today has little vegetation and no permanent water, and the Sahel, or desert margin—an area of about 1.5 million square kilometers with rainfall of about 150 millimeters per year, occurring mainly in July and August—which has a cover of thorn and sparse grass. In this area *Trypanosoma evansi* is transmitted by tabanid flies. Possibly *T. brucei* and *T. vivax* are also transmitted in this way, but in the absence of tsetse, which cannot survive in this dry open country, only a small amount of transmission must occur. Consequently, from July to October the Sahel is an important place and time for nomadic cattle-breeding tribes such as Moors, Tuareg, and Fulani (known to Francophones as Peul).

Moors and Tuareg mainly seek grazing in the Sahara and Sahel zones, but many of the Fulani, when the grass will no longer support their cattle, move them south into the Sudan zone. This zone is also dry except during the period from June to October, although the annual rainfall is some 20 percent higher than in the Sahel. Both grass and woodland in this zone have been greatly modified by grazing and by grass fires, but these do not affect the Fadama, damp valleys which contain "fringing forest" that harbors tsetse. These valleys have been associated with some of the worst outbreaks of sleeping sickness, but they have the best arable land and grazing in the area. However, tsetse, mainly *Glossina tachinoides*, do not leave the thicket of the fringing forest and herdsmen are aware that it is dangerous for cattle.

The Sudan zone merges with the Guinea zone which has a relatively high rainfall and permanent woodland that is penetrated widely by *G. morsitans* except during the driest part of the year, from January to March. Thus, unprotected cattle receive heavy challenge from *T. vivax* and *T. congolense* and are severely affected. The woodland, dominated by *Uapaca* and *Isoberlinia* and resembling the miombo (*Brachestegia* and *Isoberlinia*) of East Africa, is interspersed with areas of grassland that are particularly important because of their rapid regrowth after burning, even during the dry season. This regrowth provides grazing for cattle when it is unobtainable elsewhere. Sleeping sickness also occurs in this zone, and is associated with *G. tachinoides* and *G. palpalis* in the fringing forest. *Glossina morsitans* does not, in this region, directly affect man.

The Guinea zone is bordered on the south by the Littoral High Forest zone. Although there is much grazing in this zone, there are also many tsetse, which make it impenetrable by nomadic cattle from the north unless special control measures are instituted. Sleeping sickness, generally speaking, does not occur in this zone.

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The Difference Between Human and Bovine Trypanosomiasis

The natural histories of the two diseases are fundamentally different. Three species of trypanosomes are involved: *T. brucei, T. vivax*, and *T. congolense*. Other species can, for practical purposes, be regarded as subspecies or strains of these three (*4*). Man has a factor in his blood that enables him to resist infection with all of these species except for a limited number of strains of *T. brucei* (*5*); this factor is absent from the blood of bovines, which are susceptible to all three species. Tsetse flies are also resistant to *T. brucei* and rarely carry an infection rate of this species of more than 2 percent and, as few of these strains are infective to man, the chances of his acquiring infection from a random tsetse bite are remote. However, tsetse populations are very frequently nonrandom. Some species of tsetse (*Glossina palpalis* and *G. tachinoides*) are normally found concentrated in the fringing forest along watercourses, and are frequently isolated in small forest groves where flies are limited in their flight and cannot range widely (*6*). *Glossina morsitans*, which can range widely during the wet season, also becomes concentrated in fringing forest and is thus limited in its flight range during the dry season. Only the forest species of the *fusca* group range widely at all times, and this group has not hitherto been implicated in the transmission of sleeping sickness. It is this limitation of flight range when a small number of individual flies can feed regularly on a small number of individual infected hosts, either human or animal, that causes dangerous infection rates to be built up in a few localized foci (*7*). These foci occur at particular sites—river crossings, watering places where women come to wash clothes, hunters' and fishermen's camps beside or within the fringing forest, and, most dangerous of all, houses in the bush—which are all places where small populations of flies become concentrated and feed repeatedly on man.

West and East African forms of sleeping sickness have traditionally been considered as different diseases. Various factors, such as the more rapid reproduction in laboratory animals of sleeping sickness trypanosomes from East Africa, and the different species of tsetse that are found in the two areas, have led to the erroneous conclusion that there is a fundamental difference between eastern and western forms of the disease and of its epidemiology (*8*). Differences certainly exist; but the two important similarities, namely focal infection in populations of tsetse and the existence of reservoir hosts in addition to man himself (*9*), are now recognized on both sides of the continent.

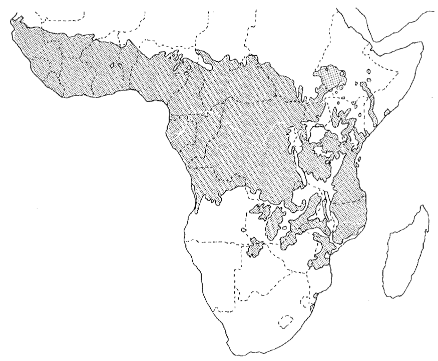


Fig. 1. Africa south of the Sahara. Stippled areas are infested with tsetse fly, *Glossina* species. [Adapted from Ford (*2*)]

The epizootiology of cattle trypanosomiasis is entirely different. *Trypanosoma congolense* and *T. vivax* will readily infect tsetse, the latter at rates which can reach 90 percent. Consequently, cattle can be infected by any tsetse wherever they meet, whether the tsetse are concentrated or ranging widely. Thus, unless beasts are given prophylactic drugs, their condition deteriorates in direct proportion to the degree of exposure to tsetse.

Sleeping Sickness Control

The first large-scale attempts to control sleeping sickness were carried out in Uganda before 1910. These measures consisted of moving the population from the affected area to places where there were no tsetse; no other measures were feasible at that time. The area remains largely depopulated and the most recent study ascribes this continuing lack of population to the original evacuation (*10*). Similarly, low populations occur now in Tabora and Mpanda districts (formerly Western Region), Tanzania, where the villages were regrouped in the 1930's—a situation which may also be ascribed to earlier removal of the population (*11*). However, this argument cannot be applied to the main sleeping sickness areas of Zambia, that is, Kasempa district and the northern part of the Luangwa valley, since no enforced movements of population have occurred during this century. African villages, like any other closed communities, contain individuals who leave to found their own community in isolation. Normally these new communities thrive and multiply; but, where sleeping sickness trypanosomes are enzootic and are being freely transmitted by tsetse, small communities die off unless they are protected. The most effective methods of protecting communities were worked out in Tanzania, described by Wilcocks (*11*) as follows: Villages were grouped into large units and the houses were placed in the center of the agricultural area with the bush at a distance beyond the flight range of *G. morsitans*. Methods of identifying cases of sleeping sickness were also instituted so that those whose occupations tended to take them into the fringing forest (fishermen and honey hunters) could be treated if they became infected and not become a danger to the rest of the community by infecting tsetses in the immediate neighborhood.

Since colonial times a constant struggle has continued in Tanzania and Zambia (*12*) (where it has been recorded), and probably throughout Africa, between individuals who wished to develop in their own way and the authorities who tried to establish large villages with schools, clinics, shops, and water systems. The most determined attempts at regrouping are being made in Tanzania with collectives (the ujamaa villages), and it is likely that this system—designed for other purposes—may have an important place in the control of sleeping sickness.

In this concept of control by regrouping of villages, mass extermination of tsetse plays no part. The spraying of local concentrations of tsetse with insecticides may be of importance, for example, in sacred groves which cannot be cut down; however, bush clearing is seldom of value beyond such areas as can be maintained for agricultural use and, since fringing forest is most dangerous where it occurs near villages, the introduction of fish-farming schemes, which change this particular habitat, is likely to constitute an important form of sleeping sickness control.

Control of Sleeping Sickness in Cattle Areas

The concept of sleeping sickness control in Nigeria has differed from that developed in Tanzania, but in many ways it has been equally successful in controlling the disease. Identification of cases and subsequent treatment have again been important, as, to a large extent, has the regrouping of villages (for example, in the famous Anchau settlement scheme) (*13*). Mass tsetse control has also been used, with large-scale clearance of woodland and spraying campaigns that have most recently been carried out from the air. These techniques are now being widely used throughout West Africa (*14*).

The techniques used for controlling sleeping sickness in West Africa differ from those developed in East Africa, and it is generally assumed that these differences reflect a different nature and epidemiology of the disease. However, as I asserted above, there is no very sound basis for this assumption. Different techniques have been adopted because wherever sleeping sickness occurs in the Sudan and Guinea zones migratory cattle are also likely to contract trypanosomiasis. The involvement of cattle, which are of such great economic importance to the countries of West Africa, ensures that greater resources are put at the disposal of tsetse and trypanosomiasis control organizations, thus enabling them to contemplate the more radical methods of exterminating tsetse from the affected area. Nevertheless, extermination of tsetse is, for reasons stated above, of greater benefit in the control of cattle trypanosomiasis than of sleeping sickness. Therefore, if large-scale tsetse extermination were withdrawn as the normal control measure for sleeping sickness in West Africa, sleeping sickness control could still be carried out at least as effectively as at present. Limited clearing, which does not exceed the agricultural needs of the people, gives an effective control of sleeping sickness, while the fulfillment of their immediate need for dams, fishing facilities, and services to support their agriculture are likely to give more permanent protection from sleeping sickness than extensive clearing and spraying programs against tsetse that cannot be maintained by the people themselves (*15*).

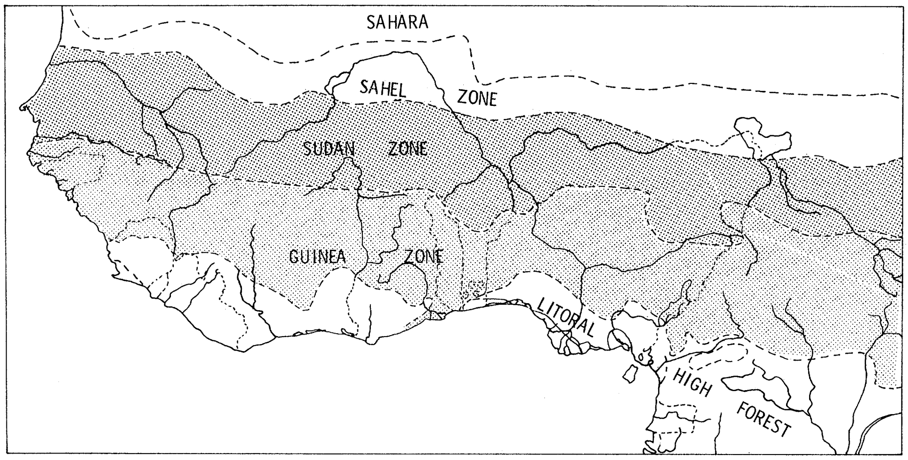


Fig. 2. Vegetational zones of West Africa. [Adapted from Keay (*3*)]

Control of Cattle Trypanosomiasis

Unlike sleeping sickness trypanosomes, which infect only a few tsetse concentrated at particular foci, all tsetse, wherever they may be, are liable to harbor trypanosomes that are infective for cattle. Whereas man can be bitten without ill effect by large numbers of tsetse, in cattle each tsetse bite materially decreases yields as well as the chance of surviving drought, malnutrition, and other infective diseases that would normally be tolerated.

Cattle must be protected either by chemoprophylaxis or by the more effective method of keeping them away from tsetse. After the great rinderpest epizootic of 1895, which greatly reduced the population of African game animals and thereby cleared tsetse from many areas, the belief that man might achieve similar eradication was widely held. Expensive programs of bush clearing, exclusion of game animals by fencing, and their extermination by shooting and, later, of aerial spraying have had little overall effect, and, despite the direct ecological damage that these techniques may have caused, the advance of tsetse has not generally been checked. Although these campaigns have not achieved the purpose for which they were designed, considerable progress has been made in West Africa in support of the movements of nomadic cattle. The importance of this progress is apparent when compared to the much greater success which has been achieved in elimination of rinderpest and bovine pleuropneumonia, the other important epizootic diseases of West Africa. Apart from trypanosomiasis there is now virtually no means of restraint from the progressive overgrazing of the arid marginal areas of tropical Africa.

The Hypothetical Relationship Between Climatic Change and Overgrazing

It is easy for visitors to the arid marginal areas of tropical Africa to observe that increased cattle production often results in severe overgrazing. In such areas as the Kalahari or northern Namibia it appears obvious that local overstocking causes soil erosion which may in places be irreversible. Since these areas are unstable ecologically, an increase in stock can easily destroy vegetation to the point where it cannot rapidly recover. These changes are not, however, easily documented, and when destruction of vegetation occurs it is usually accepted as inevitable and ascribed to changes in the African climate and advancing desiccation, rather than to overstocking. In the past it was thought that the Sahara was advancing southward, and this was then interpreted (erroneously) as being due to uncontrollable climatic change. It is now generally agreed that the changes were due largely to mismanagement (*16*). Recently the connection between overgrazing and increasing desiccation has been further examined. In southern Tunisia near Nefta, an area which was fenced 60 years ago for military purposes has acquired an 85 percent coverage of vegetation as compared with the surrounding area, which is 5 percent covered. Since the same rainfall (80 mm per year) occurs in the two areas, the only possible difference between them is that the former area has not been subjected to grazing (*17*). A similar state of affairs has occurred in the Sinai-Negev, where a fence was erected 5 years ago along the Egypt-Israel armistice line of 1948–49. The line of this fence is shown clearly by satellite photography to be a clear-cut demarcation between an area of low reflectivity to the north and the high reflectivity to the south. North of the fence there is an almost uninterrupted growth of vegetation, whereas to the south, vegetation has been removed by the Bedouin grazing their goats, sheep, and camels; by light plowing; and by the removal of shrubs for domestic purposes (*17a, 18*).

These examples of the effect of grazing and uncontrolled land use in desert areas illustrate how an effective change in the reflectivity of the earth's surface can be brought about. It is now realized that surface reflectivity is one of the most important factors in determining patterns of rainfall. Accordingly, two theoretical studies have been made of reflectivity and rainfall patterns in the Sahara by integrating the general circulation model of climate developed at the Goddard Institute for Space Studies (*19*). The first study was made by using the actual climatic conditions on 18 June 1973 as the initial condition. Integration was carried out at low albedo (albedo is a measure of the reflectivity of the earth) of 14 percent, corresponding to the hypothetical state in which the whole Sahara is covered with vegetation, and at high albedo of 35 percent, representing the existing reflectivity of the fully exposed desert soil. The model was used to give a resolution of between 4° latitude and 5° longitude, equivalent in area to the whole Sahara and equivalent in time to the 7 weeks from 18 June to the end of July (July, August, and September are the main rainy months in the Sahara). In comparing the hypothetical low albedo integration against those of existing conditions of high albedo, the model predicted a difference in rainfall in the Sahara representing an increase of about 42 percent, with a 6 percent increase in rainfall in the whole zone of latitude. Most of the rainfall that occurs in the Sahara takes place in the Sahel, and in this region the rainfall predicted from the high albedo integration corresponded closely with the observed rainfall in September 1973.

The second study was made of conditions that occurred in an area corresponding to the Sahel alone, for a shorter period (from 21 to 28 June 1973) and the same differences in albedo. The results showed a decrease in Sahelian rainfall of as much as 75 percent at the higher albedo. The result of this study shows clearly, if one accepts the validity of the general circulation model of climate and the methods of solution used, how important the integrity of the vegetational cover of the Sahel must be in maintaining the climate of this part of Africa; but it also emphasizes, by showing a feedback relation between rainfall and vegetation, how very fragile the ecology of the Sahel must be even when intrusive factors, such as overgrazing, are not involved.

Although there is good archeological evidence that at one time the Sahara had vegetational cover that may have been removed by grazing (*20*), there is little practical meaning in the assumption of the low albedo integration of the existence of vegetational cover for the whole Sahara; moreover, the Sahel is the only part of the Sahara with a relatively constant rainfall and, therefore, with significant vegetational cover.

Because of the conclusion that the Sahel region is ecologically and climatically unstable, it seems important to examine the pressures that are now being placed on it. It is particularly urgent to analyze the extent of these pressures because of their probable relation to La Sècheresse, the severe drought which recently occurred and affected not only the Sahel but the whole region to the south of the Sahara.

Factors Which Might Affect the Balance of Climate and Vegetation

The periods of high and low mean rainfall as recorded at a number of stations in the Sahel and Sudan zones are shown in Fig. 3. It is interesting to speculate whether the pattern has been influenced by any known factors.

One of the names used by Tuareg to refer to 1912, the first year of an earlier drought cycle, is the year of the locust; this draws attention to the possibility that elimination of vegetation by locusts could predispose to drought. However, the data available (*21*) do not support this hypothesis. In fact, it appears that periods of drought tend to precede rather than follow outbreaks of locust swarming (Fig. 3), and it is not clear what significance should be ascribed to this pattern.

Fire, which is of such importance in the ecology of the Sudan and Guinea zones, has less effect in the Sahel because of the sparseness of vegetation and is unlikely to play more than a subsidiary role in the exposure of desert soils.

If overgrazing is liable to cause a decrease in rainfall it might be hypothesized that a decrease in grazing (due to a decline in the cattle population) could cause increased rainfall. In this connection it can be seen (Fig. 3) that outbreaks of rinderpest in the Sahel have not necessarily been followed by periods of increased rainfall. However, this lack of a negative response does not necessarily invalidate the hypothesis that there is a positive relation between overgrazing and decreased rainfall, for the following reasons: (i) Outbreaks of rinderpest, although extensive, remained localized in certain areas (*22*); for example, the panzootic of 1918–19 was largely confined to Chad where 70 percent of the cattle died. (ii) Although overgrazing (that is, the eating of vegetation down to and including its roots) decreases the vegetational cover, underutilization would not normally be expected to have the reverse effect. In fact, the stimulus of growth is likely to be greater, within certain limits, with more rather than less grazing. One would not, however, expect these factors to apply to the situation where, as is now the case, recovery from previous overgrazing is occurring; regrowth under these circumstances would be enhanced by underutilization. At the times when rinderpest and pleuropneumonia were prevalent in the Sahel, commercial pressure for grazing had not yet developed. It is therefore unlikely that substantial overgrazing would have occurred or that consequent increase in rainfall, due to regeneration of vegetation, would have followed these outbreaks of epizootic disease.

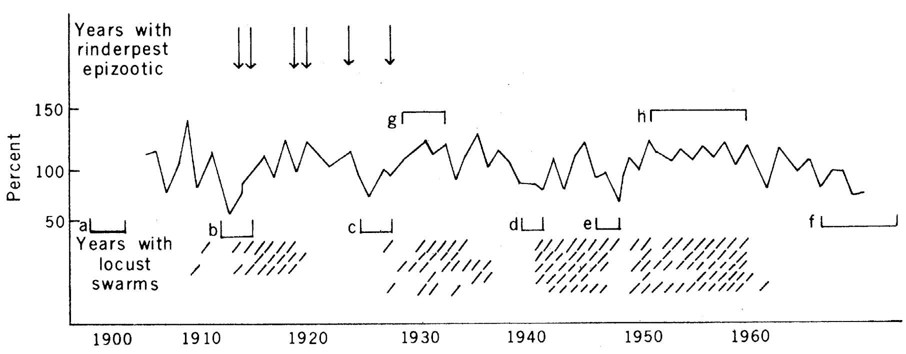


Fig. 3. Variation in rainfall; 100 percent = 29-year average based on records from Kano, Sokoto, Maiduguri, Naimey, Zinder, Ségou, Maradi, and Njamina (*32*). Periods of more than 2 years with below-average rainfall are labeled by letters a to f. Names of periods are as follows: (a) Sale of children; (b) Chest famine (year of locust); (c) Stroke your mat (that is, nothing else to do); (d) Forget your wife (*17a*); (f) La Sècheresse. (g, h) Periods of more than 2 years with above-average rainfall. Arrows represent years with rinderpest epizootic (*22*). Each diagonal line represents a year with locust swarms and each line of diagonals represents a Sahelian country (*21*).

Different species of animals are likely to cause different types of destruction of vegetation. Camels and goats browse on trees and bushes from which their owners frequently cut branches. Cattle and sheep, also capable of browsing, eat predominantly grass. Sheep, especially, eat very close to the roots in a manner that can be particularly damaging.

Agriculture, particularly the cultivation of millet with its short growing season, has recently been extended in the Sahel beyond the traditional areas of the Niger valley, where long-established custom dictates the successive use of the land by arable farmers and nomadic herdsmen (*17a, 23*). This extension is partly due to the introduction of cash crops, cotton, and groundnuts into the more fertile areas. The planting of millet in what would otherwise be grassland can leave the ground with little vegetative cover for much of the year and, since the millet crop competes with grazing animals for the moister areas, the animals tend to be excluded during the growing season and are put to graze more arid terrain. The increase in Sahelian agriculture has also been encouraged by a particularly long period (Fig. 3) in which rainfall has been above average. Each of these factors contributes to desiccation, and each increases with the increasing human prosperity that has come to the Sahel as a result of the thriving West African meat trade.

The West African Meat Trade

There are a number of breeds of cattle in West Africa. They are as follows: the Azavaq, small drought-resistant cattle bred by the Tuareg in the northern Sahel; the Zebus, which are large, drought-resistant, but very susceptible to trypanosomiasis, and, although bred mainly for milking, are efficient producers of meat; and the longhorn N'dama, which are smaller and more resistant to trypanosomiasis, and originated in the Futa Jallon plateau of Guinea. There are also a number of breeds of dwarf West African shorthorn (including Lagune, Baoulé, Simba, and Muturu) which originated from the high forest region from Ivory Coast to Cameroon and are also resistant to trypanosomiasis. These resistant cattle are of little commercial value when raised under bush conditions but under managed conditions, whether they are purebred or crossed with European breeds, can give useful yields of milk and meat (*24*). There is hope that ranches of these animals in the high forest zone may produce commercial yields without the ecological damage associated with dryland grazing as discussed above; whether this is possible is a question open to long-term assessment. Nevertheless, under present circumstances, the Zebu dominates the meat production market and it is largely from its herds that the meat requirements of the coastal towns and their supporting population are met. Towns such as Accra, Lomé, Abidjan, and Lagos have increased their populations and standards of living progressively since World War II, and the standard of living inland has also risen. N'dama and dwarf shorthorn cattle raised locally supply only a small proportion of this need; thus, it is now largely met by production of Zebu cattle in the north. The extent of this production in terms of annual sales of cattle and their approximate destinations in 1957–59 is shown in Fig. 4. The pattern remains the same, although the trade has doubled in the past decade. Most of these cattle are trekked from the north over distances of 500 to 2000 km. Deaths and loss of condition are considerable, probably about 25 percent. It is only the fittest beasts that arrive; many are slaughtered on the route and many have contracted trypanosomiasis by the time they arrive but are slaughtered before they have had time to lose much weight.

An increasing number of cattle are transported by lorry (*25*), and a few carcasses are transported by air. Abattoirs with cold storage equipment are now installed at centers such as Bobo-Dioulasso and Ougadougou (*26*), an indication of the growing commercialization of the West African meat trade.

The recent increases in cattle holdings of savannah and mixed states since 1961 are shown in Fig. 5. This is almost certainly an underestimate since it is based mainly on returns for taxation, which the Fulani are adept at avoiding (*27*). In the savannah states the cattle produced and sold are always in excess of those slaughtered locally, while the reverse is true of coastal states that receive the cattle trekked south from the Sahel. Cattle production may give a better indication of the true figures, although accurate count is lost due to slaughterings in up-country villages. Nevertheless, the figures show that production for export from the savannah states has doubled in the decade since 1961 and, although there are no reliable figures, it is likely that a similar rate of increase has continued for some time, perhaps since the beginning of the century.

Table 1. Comparative productivity of Fulani and British cattle (per hundred head) (*28*).

Item	Fulani	British
Breeding cows and heifers	30	46.1
Average birth rate	40	84.0
Calf mortality	15	17.7
Calves reared*	85	82.3
Herd mortality	5	4.3
Output †	5	27.8

*Annually. † Yearly surplus per hundred.

Cattle Production by Nomadic and Seminomadic Tribes

In the full nomadic state both the Tuareg and the Fulani (Bororo) ways of life dictate that they should increase their cattle and not dispose of them if there are other means of obtaining the necessities of life. The Bororo concept of rearing stock is radically different from that of Europeans (*28*) (Table 1), not only in the small proportion of the stock that they dispose of, but also in their tendency to retain older rather than younger animals. This is not due solely to the desire to accumulate traditional wealth and status but is a deliberate policy of insurance: money is to them of limited value, and in the desert it is easily stolen or lost. In the Sahel, mature Zebu cattle—which can most effectively survive drought, starvation, epizootic disease, and long-distance travel—are the most stable form of investment capital, capital which, moreover, provides a dividend of milk. But so great is the value of their cattle to others that a special class of middlemen (the Dillalai) having close relations with the Bororo has evolved to facilitate the sale of cattle from their otherwise reluctant owners.

There is, however, a wide difference between the nomadic Bororo and the settled clans of the Fulani (*17a, 29*), such as the Fula of Guinea, who have abandoned the values of nomadism and will readily sell their livestock for modern luxuries. This variation also occurs in other pastoral tribes that own cattle and grow millet at the edge of the Sahara. The implication of both the nomadic and seminomadic ways of life for the ecology of West Africa is that a given level of activity in the cattle trade indicates a much greater level of stockholding by the owners than would be expected by European standards (Table 1).

Moors and Tuareg, generally speaking, do not migrate south of the Sahel, and as a result the stock that they carry cannot greatly increase. However, the Fulani, whether nomadic or seminomadic, tend to

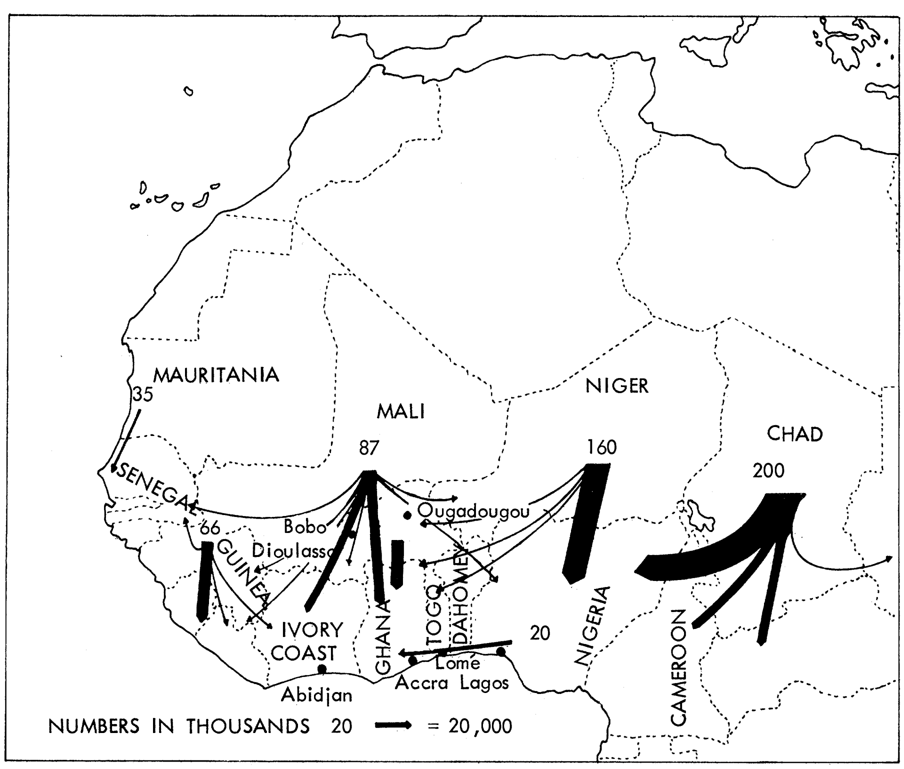
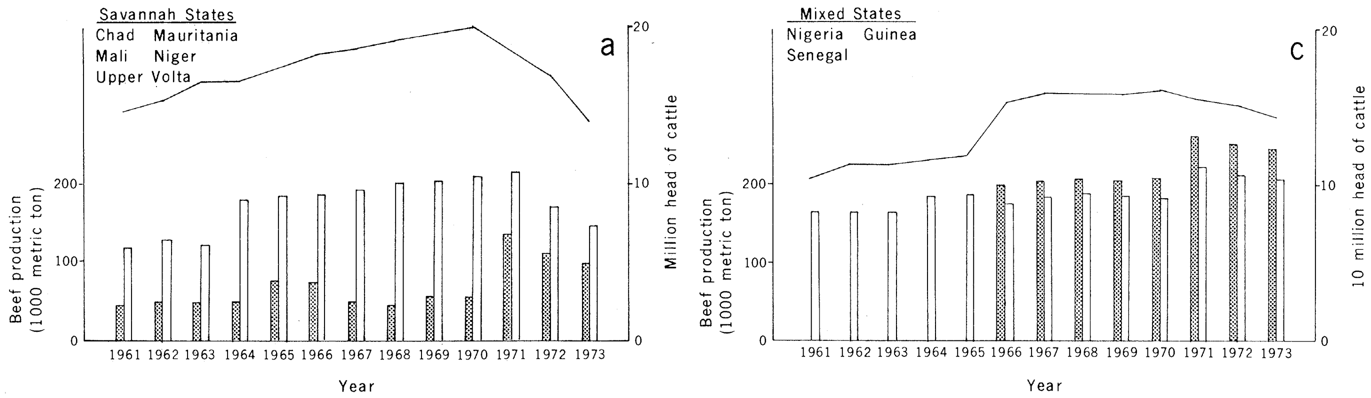


Fig. 4. Map of West Africa showing the numbers of trekked cattle and their approximate destinations in 1957–59. [Adapted from Mittendorf and Wilson (*27*)]



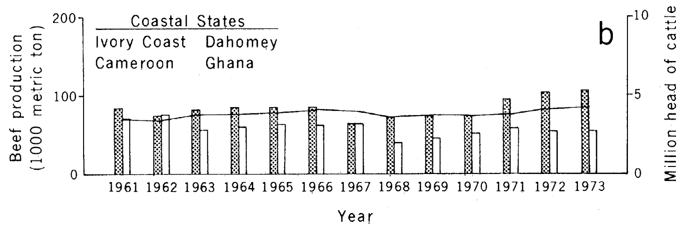


Fig. 5. Graphs representing cattle population. Curves show beef production; stippled bars show slaughterings within the country; open bars show total production, including export. (a) Savannah states. Some interesting points are as follows: (i) the excess of exports over local slaughterings; (ii) the increase in local slaughterings in 1971; and (iii) the increase in production (and stocking) from 1961 to 1970. (Mauritania is counted as a savannah rather than as a mixed state because of the low coastal population). (b) Coastal states. The number of slaughterings (of cattle imported from savannah states) exceeds local production; this excess is likely to be an underestimate because of unrecorded slaughterings of trekked cattle in the villages. (c) Mixed states. The figures are mainly from Nigeria which, besides its large production, also imports cattle, thus accounting for the excess of slaughterings over local production. [Data from *FAO Annual of Agricultural Production*]

take their cattle on seasonal transhumance either to the inland delta of the Niger or southward into the Sudan and Guinea zones. As with cattle owners in Tanzania, the greater the presence of drought the more they tend to penetrate woodland infested with tsetse, and it is at this point that they suffer their greatest losses from disease (*2*). Nevertheless, their success in balancing the consequences of their cattle dying of starvation or dying of trypanosomiasis has made the Fulani the predominant graziers and is responsible for the large population of Zebu cattle in West Africa.

Conclusion

I do not suggest that trypanosomiasis control is the sole cause of drought in the Sahel zone. Serious droughts, in 1900–03 and 1911–14, occurred before the era of trypanosomiasis control. In addition, the more recent drought of 1930–31 occurred before the widespread use of insecticidal sprays for controlling tsetse. There does seem to have been a difference in that these earlier droughts were more localized whereas the recent drought involved the whole region. Many factors seem to have contributed. They are as follows: (i) other forms of disease control, both in nomadic cattle and their herdsmen, have helped to cause an increase in population; (ii) increased herding and agriculture have caused the removal of trees and the lowering of the water table; and, most ironically, (iii) the provision of wells has tended to localize overgrazing. All of these factors have added to the desiccation, but the increase in cattle production has probably been the main feature. Cattle in this region constitute affluence, and affluence encourages a rise in human population. More people not only raise more cattle but also increase holdings of sheep and goats and increase the demand for millet and cash crops, thus completing the vicious circle. The only remaining restraint apart from starvation has been trypanosomiasis.

The control of sleeping sickness and cattle trypanosomiasis are likely to have similar effects in that they tend to cause increase in the populations that these diseases now limit. However, there is a great difference in the degree to which control has been exercised in these two diseases. In sleeping sickness, control has not been pursued with any great enthusiasm, the methods used have not always been popular and in the past have frequently involved compulsion, the people affected often live in remote areas and exercise little political or economic pressure on central governments or impact on world philanthropy, and only the threat of widespread epidemics (remote at present) continues to assure some academic interest in human trypanosomiasis. Nevertheless, as has been indicated above, its continuing effect in limiting populations may have been seriously underestimated. The control of cattle trypanosomiasis, on the other hand, has been pursued enthusiastically because of the economic and political importance of meat production. Unfortunately, local concentrations of cattle have built up beyond the carrying capacity of grazing areas, and the Sahel and Sudan zones of West Africa are the most obvious examples of this. These areas are so large that denuding them of vegetation may well influence the climate of the whole of this part of the continent.

The implications of this situation are obvious. Unless the pressure of grazing on the fragile savannah regions south of the Sahara is eased, greater droughts will occur at more frequent intervals. For a time, pressure has been eased by the death of so many animals and men, but there is every reason to suppose that the cattle population will be able to recover rapidly since many were herded south into the Guinea zone.

Since the beginning of the drought, increased efforts in tsetse control have been made in Senegal, Chad, Cameroon, and Nigeria. The effect of these campaigns—in fact, their objective—has been to allow migrating cattle to increase their range of penetration of woodland that is now denied to them because of tsetse. There is every reason to suppose that further extension of plans for tsetse control, possibly to the point of eradication in this region, are being considered.

It can be argued that vast areas in what is now the tsetse belt are not arid, and if the fly were eliminated they could accommodate the cattle that now must graze the Sahel. Although superficially attractive, this strategy is not without danger. It is characteristic of the tropical region of Africa (although not of similar latitudes in South America) that isotherms and isohyets run closely parallel and show the steepest gradient from humid to arid conditions in the world (*30*). The steepness of this gradient appears to indicate that the climate of this region is not immutable and could be changed radically by a change in land use. Because of insatiable demand for meat, removal of the tsetse barrier in advance of development of adequate techniques for land conservation might well cause climatic change (*31*); it is difficult to believe that the Sahel would not continue to be overexploited.

It is also difficult to propose the curtailment of plans when such curtailment would frustrate important short-term improvement in the cattle industry or, in more emotive terms, act as a lifesaving measure for the cattle graziers; but the long-term effects of reviving the cattle industry to its previous scale should not be ignored. A complicating factor is the widely held view that eradication of tsetse as required by the cattle industry would also control sleeping sickness. While it is true that sleeping sickness could not exist without tsetse flies, widespread eradication is—as I have stated above—unlikely to be the best method of control. The existence of sleeping sickness in an area in which control of cattle trypanosomiasis is planned cannot, therefore, be used as a valid argument for the use of large-scale bush clearing or aerial spraying which may well act to the detriment of settled communities.

The object of my discussion is to ask for delay and deep consideration of the possible ecological effects of trypanosomiasis control before the measures that are now in operation are intensified; such measures, introduced hastily, could have a profound ecological effect on the continent. Although the relation between overgrazing and climatic change cannot be regarded as proved, it reflects so much that accords with common experience that its importance cannot be ignored. There is urgent need for an international organization to assess the complicated factors that influence the ecology of Africa; without the coordination of such a body, decisions will continue to be taken that seem beneficial in one field of activity but can cause disaster in another.

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