THE IMPLICATIONS OF TSETSE FLIES ON THE HISTORY, ECOLOGY AND ECONOMY OF AFRICA

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Generalities

The maintenance of an animal population in a given environment depends upon the equilibrium between the energy required by the former and that which can be supplied by the latter. This principle also applied to human populations of the past when primitive bands of hunter-gatherers had to live from the natural products of the land, until the age of the first agriculturalists and pastoralists. Since his liberation from the daily chores as a hunter-gatherer, man has made a number of step-wise technical advances but each of them has added, in one way or another, to the precariousness of his position within his own environment.

Food production was responsible for permanent settlements, the increase of the human population and at the origin of the first cities. Such concentration, however, allowed for the increased circulation of infectious diseases, some of them perhaps new to the human race and the more lethal because unknown and uncontrolled. Diseases such as smallpox, plague, cholera, leprosy kept human populations at par with food production and territorial space. In tropical Africa, human populations were thinned out by such diseases as paludism and trypanosomiasis.

The next important step to upset the balance between humans and the environment was the "industrial revolution", which led from coal and steam, oil and combustion engine, to uranium and nuclear power. Medical and health sciences have kept up with technical knowledge so that epidemics of communicable and other diseases, which normally would have wiped out vast numbers from high density areas, have been largely averted allowing free rein to the population increase. With the resulting dwindeling water supplies, whether from miss-use or pollution, the poisonous atmosphere over large cities from exhaust gasses, and the impending food shortages we have now approached a very serious crisis.

The moment has come for knowledge and action, first to save what can be saved of our natural environment and resources, secondly to study the problems and by better planning avert the disastrous consequences which in the past often followed the unilateral application of "progress". Birth control seems at the moment a possible way of at least slow down the process of self-smothering. This, together with the conservation or well-planned exploitation of natural resources, might stabilize a situation which in certain parts of the world comes dangerously close to the collapse of the ecosystem for normal human occupation, and the preservation of an environment suitable for the maintenance of a physical and mental healthy human population.

The African environment

In tropical Africa the abuse of the environment is not so much by industrialization than well of the miss-use of agriculturaly potential land and the overgrazing of grassland by domestic stock. Generally speaking, most of the African continent consists of ancient plateaus which have been eroded and leveled, covered with very ancient soils which are worn with age (Gourou, 1966).

The equilibrium of a climax biotope occurs under natural conditions through the methodical use of the available energy cycling through the climax components. The destruction of one or more of the components may rupture the cycle, perhaps irreversibly, and cause the complete collapse of the system, or reduce it to a secondary, low-grade community (Lambrecht, 1966).

In the stage of hunter-gatherers or shifting-cultivation by sparsely distributed inhabitants, Africa presented a picture of balanced climax biotepes. The introduction around 5,000 B.C. of cattle and the later rapid increase of the human and cattle populations, especially after the introduction of modern medicine and hygiene and subsequent introduction of cash-crops, have changed the picture to a point where many areas have reached the stage of complete degradation. In addition to land miss-use, the destruction of wild animal biotopes and hunting has been responsible for drastic changes in faunal composition and numbers. The shooting out in certain areas of predatory animals, such as lion and leopard, has been followed by a rapid increase of certain ungulates resulting in overgrazing and general deterioration of pastures. The increase of the elephant population in Tsavo Park in Kenya is such that vast areas of woodland savannah have been devastated, denying certain other animal species their normal vegetation cover and means of survival.

The tsetse fly

The best part of tropical Africa lies within tsetse fly belts. Some 24 species of tsetse (genus GLOSSINA) are known. Both male and female flies feed on vertebrate blood. If the blood is derived from a Trypanosoma-infected animal, the protozoan flagellate becomes established in the fly which then remains infective to each subsequent animals on which it feeds. Two trypanosome species are infective to man, causing sleeping sickness, while other trypanosome species affect domestic animals and produce a disease, called "nagana". African game animals harbour both human and cattle trypanosomes but are themselves tolerant to the parasites circulating in their bloodstream. This immunity has been acquired from many years of contact with tsetse and trypanosomes, and from natural selection of those that were resistant. Man and cattle, however, are of relative recent evolution and introduction, and immunity mechanisms have not had the opportunity to develop, nor natural selection the chance to operate. Man and cattle are forced to live outside the fly belts or die.

In the past, the migration routes of people and cattle in Africa was very much influenced by the presence or absence of tsetse (Lambrecht, 1964). It can be assumed that early human populations avoided areas of high tsetse density if only from annoyance. Even more affected by the presence of tsetse were the early pastoralists when they suffered heavy losses in their livestock whenever it was kept in contact with fly or travelled through a fly belt. The migration southwards from the Nile Valley followed routes along the high ridge country on both sides of the Central Rift Valley. Some of the first migrants might have been metal users so that the route they followed has played an important part in the diffusion of culture and subsequent occupation. These migration patterns became important in later economic development, the fly-free migration corridors became connecting links between trading posts and other permanent settlements. Other fly-free areas resulted from clearings made by agricultural tribes, established mainly along forest fringes because of fertile soil and adequate water supply. Their fields provided a buffer strip between fly habitats of the forest and those of the savannah. Such areas were exploited by the pastoralists not only as migration routes, but also often as permanent pastures for their cattle. The occupation of the same area by tribes of very dissimilar background led to a sort of feudal relationship in which the pastoralists imposed their social structure upon the agriculturalists. Such a system was in use for some 500 years in Rwanda and Burundi, until recent political events, following independence from the Belgian administration, ended the pastoral Batutsi overlordship in bloody uprisings of the Bahutu.

The presence of tsetse, especially the savannah flies, curtailed the full occupation of vast areas otherwise suitable for cattle and agriculture and no doubt has been the main reason for the preservation of original biotopes and their related fauna. The protection also operated during and after the arrival of the first western explorers and settlers, being depended, as they were, upon oxen and horses for drawing their supply-wagons. Many expeditions had to turn back after they had set out from coastal and other fly-free areas. Anderson (1857) tells of one party of Englishmen with many horses, accompanied by natives and their cattle, journeying to the north of Lake N'gami and how they had to turn back after they had lost most of their horses, one man suffered the loss of thirty-six, and also sustaining heavy losses in cattle, all victims of the tsetse flies which infested the areas through which they had to travel.

It was only after motorized transport became available, dispensing with draught animals, that the full impact of western technology and occupation on the interior of the African continent began to be felt. Penetration and permanent settlements also increased after the establishment of medical services and better knowledge of the causative agents of tropical diseases and vectors. The disease agents and vectors of cattle

trypanosomiasis and the two trypanosomes causing human sleeping sickness were discovered and described between 1895 and 1912.

The seriousness of sleeping sickness is realized from the great epidemic that raged north of Lake Victoria between the years 1902-05 when the disease carried away 200,000 out of a population of 300,000.

The first attempts to control the disease through the control of the glossina vector were made in the early 1920's, with the basic studies of the ecological requirements of the fly. Methods for control were, for many years to come, a matter of trials and errors. The hold on the African continent of the tsetse fly was little understood. Error in judgement occurred which had grave consequences. During the early 1900's the administrator of the Semliki River territory induced a population living on the slopes of Mount Ruvenzori to move down to the valley where easy water and better soils were available. This seemed a logic and apparent wise decision. Unfortunately, the banks of the river were the haunts of the riverine tsetse, Glossina palpalis. Some years later most of the villagers were either dead, had fled or were hospitalized. Sleeping sickness spread from the valley north and east to the shores of Lake Edward and Lake George, where the Uganda Government was forced to evacuate many thousands of people and their cattle from areas they had inhabited for the preceding 300 to 400 years. The abandonment of the grassland resulted in the development of thicket vegetation. This allowed G. pallidipes to advance from foci high up the slopes, and occupy the valleys. The advance proceded steadily and was only halted about 100 miles east from its starting point.

The development of Acacia savannah, after the abandonment of grassland, seems to be a general rule at least in East Africa. Should this occur adjacent to established fly belts chances are that the fly will advance into the newly created habitats as soon as a certain density of trees is reached, especially as the absence of human occupation will make the woodland more attractive to game and thus provide the fly with the required hosts on which to feed. An example of this occured in the Karagwe region of the Bukoba District in the north-western corner of Tanzania where, during the latter part of last century, where pastoralists' cattle occupied excellent grazing lands in open grassland savannah. Tribal wars disturbed the peace and cultural structure, resulting in the abandonment of the grazing lands by the pastoralists. Soon the grassland reverted to Acacia and other pyrophitic tree species savannah, and was later invaded by G. morsitans. The fly continued to advance and by 1950 had reduced the 300 mile gap between the northern and eastern belts to about 50 miles.

The abandonment of pasture land is often caused by the degradation of the grassland by overstocking, the tendency among tropical pastoralists being to keep more cattle than the land can support, for herdmen take more pride in the number of animals they own than they care about the returns and quality.

The Bugesera region in Rwanda offer another example of how the development of Acacia woodland, after the people had left this time because of a bad outbreak of rinderpest in their herds, permitted G.morsitans to invade from across adjacent Tanzania. The Bugesera was later reoccupied, but close contact with G.morsitans which had by now spread in large areas and was followed by vast numbers of game, resulted in heavy losses in cattle and the outbreak of human sleeping sickness.

Pastoralism in Africa is not always well spoken of. Gourou (1966) says: "... damage done by pastoralism is incalculable, whilst the economic advantages are insignificant. In fact, the savannahs that form the prevailing vegetation types in the Sudan, East Africa and Madagascar are mainly due to the need for making grazing grounds." He goes on: "In pastoral areas the annual burning of the grass has become a necessary and customary practice." "The damage done by this is immense and out of proportion to the benefit obtained from the pastoral facilities it procures."

Burning has always been, and still is, a matter of controversy. The arguments brought forward against or for depend on whether the subject is discussed by the conservatist, agronomist, veterinarian or botanist. In East Africa the authorities try to reach a compromise by recommending early fires to destroy the useless straw cover. Early burning, they say, causes less harm to trees. This, however, may lead to the re-establishment of dense tree cover, reducing the grassland and encouraging the formation tsetse fly habitats. Specialists think that bush country and woodland savannahs have increased at least during the present century, and probably before. They say that one of the reasons might be the shifting cultivation methods in which fields are abandoned each year, usually followed by the development of secondary growth, bush and woodland.

A recent example of the creation by man's activities of habitats suitable for fly is in the Alego District, a hilly country with relative high rainfall east of Lake Victoria. The area was heavily settled because of fertile lands, has a network of permanent rivers and a number of important towns close by. G.fuscipes and G.pallidipes existed along the lake's shores and in the adjacent bush and woodland and sleeping sickness occurred, mainly among the fishermen. Before 1960 no flies had been reported from the plateaus, however, but a sudden increase of sleeping sickness cases, this time among the inhabitants of the inland villages, indicated that local transmission did occur. An entomological survey revealed that G.fuscipes had invaded the plateau-land and bred in dense patches of neglected Euphorbia tirucalli and Lantana sp. (the latter brought in as an ornamental hedge-plant by white settlers earlier in the century) planted for paddocking groups of huts and fields, and sometimes water-holes. Under the circumstances, contact between man and fly became very intimate and resulted in intense sleeping

sickness transmission, amounting to some 70 cases per month by the end of 1964.

From the examples described above it is realized that the ecology of vast areas in Africa is constantly interferred with. Combined with fluctuating long-term climatic changes this results in alternating cycles of advances and retreats of man and tsetse flies.

Control of tsetse fly

The large-scale tsetse control measures so far applied fall into three categories: (1) vegetation clearing; (2) game control: (3) the application of insecticides.

The practicability of tsetse control by means of bush clearing was realized when early studies had shown that the flies were dependent upon microclimatic conditions within certain vegetation communities. It was obvious, of course, that none of the tsetse species could survive in a completely denuded area; no tsetse habitat was ever found in open grassland. But ruthless bush clearing is expensive and also the question arose of its effect on the soils thus exposed to weathering and erosion. This again was a subject of controversy. Some opinions were to the effect that erosion after bush clearing would wash away fertile top-soil; other that removal of tree-cover would promote grass-growth which would hold soil better especially in places of dense upper canopy where grass-cover was often poor and erosion did occur.

Cost and other considerations led to refinements in bush clearing methods. The basic idea of "selective, or discriminative clearing" was that only enough shade-trees should be felled to make of tsetse fly habitat unsuitable for the fly. Such methods met with various degrees of success. Failures were often due to the empirical application of a certain degree of clearing that had proven successful in a given area, with disregard to the fact that the ecological requirements are not always the same in all areas, even for the same tsetse species. Requirements depend not only on the vegetation, but includes local climate, length of dry and rainy seasons, altitude, and of the availability of vertebrate hosts on which the fly prefers to feed.

Regeneration is another problem and one which necessitates recurrent expenditure, unless the cleared area is an isolated block that has no contact with other fly belts.

An unexpected success was achieved at Abercorn, Rhodesia, where G.morsitans was eradicated from a large area after the thinning out of about 2% of the vegetation in drainage lines that intersected an area of wood and grassland. Obviously, the fly had had to rely on the denser riverine vegetation for its survival during the dry season.

The second method of tsetse control is through the elimination of

its food supply by the shooting out of game animals. This method has been successful in areas of Uganda, Rhodesia and Zululand, at relatively small cost. Game control has met with fierce opposition, and rightly so being brutal and distasteful. Furthermore it is difficult to organize and expenses might be very high, depending on game density, the terrain and necessity of close supervision. Its success will also depend, of course, on how well the treated area can be protected from reinvasion of game from the surrounding areas. In N'gamiland, Botswana, game control carried out between two game-fences in the protection of Maun, the capital, has been going on for more than 15 years and game is still present, especially the smaller species and nocturnal animals. Of course, the area is directly connected with the vast Okovango swamps in the north where game is plentiful and mostly undistrubed.

A danger exist that after the shooting of game the fly will still be able to survive in small foci when it can feed on domestic animals and man. This, in turn, might result in increased trypanosome transmission in these alternative hosts.

The third kind of tsetse control is the one of the application of insecticides. Broadly speaking, this can be done in two ways: (1) by "contact" insecticides from the air; (2) by "residual" insecticides on the ground.

The first method is expensive and presents many technical problems. Its main advantage is the speed by which large areas can be treated. It has been successfully applied in Zululand and during experimental trials by the Tropical Pestitides Research Institute in Tanzania. If cost and certain technical problems can be reduced, aerial spray could become a method of choice in many instances.

Ground spraying has now been applied in many areas of Africa and against several tsetse species, mostly with complete success. A great advantage over aerial spraying is that on the ground the insecticide can be applied in restricted areas of the real habitats and even there with a varying degree of selectivity, when the exact resting sites of the flies are known, or their dry season refuges. A good example of selective spraying as a result of precise knowledge of fly behaviour was against G.fuscipes in Kenya. The application of insecticide was restricted to the edge vegetation facing the riverbanks after it had been observed that the fly used the inside edge during its movements along and across the watercourse. This very selective spraying was completely successful in eradicating the fly from a vast river system.

The effect of insecticide spraying on wildlife has been the object of studies and publications. "Silent Spring" typifies the outcry of the American naturalist. In regard to the application of insecticides in the control of tsetse flies, the noxious effect upon wildlife is not as serious as one might believe. In tsetse control by ground application the insecticide is sprayed only on the holes and lower branches of

trees, not on the foliage. As such, bird life is very little affected. In addition the insecticide is only applied in a relatively small part of the total area to be liberated and on a very small proportion of the vegetation. The application being only on the bark of trees eliminates the risks of the chemical being ingested by browsing and grazing animals.

A new method of possible tsetse fly control is that of biological control by the "sterile male Technique", experimentally successful in the laboratory. The difficulty of its application in the field is a matter of the breeding and release of sufficient numbers of sterile males in the natural habitats.

Another biological control possibility is that of hybridization. This was proven feasable in laboratory experiments when two related species, G.swynnertoni and G.morsitans were mated and produced non-fertile hybrids. Attempts were made to duplicate the experiment in nature by the introduction of G.morsitans males in G.swynnerton habitats, and visa versa. Results proved disappointing under the circumstances of the experiment.

Game versus domestic stock

Under the conditions of the African environment wild animals are far superior to domestic stock; they are less susceptible to diseases (including trypanosomiasis), make use of almost all African grass species, need smaller ranges, have far lesser water-requirements, have a faster rate of reproduction and a faster gain in lifeweight and maturity. Because of these overwhelming advantages it seems indicated to explore the possibilities of utilizing this vast source of animal proteins. The possibilities fall under two headings: (1) the culling of animals from natural or "ranched" wild animals; (2) the breeding and selection of certain wild species.

I have dealt with this subject in some detail in a previous paper (Lambrecht, 1966). I concluded from analyses of publications by Dasmann and other authors, that on comparable land and other things being equal, the harvest of meat from wild animals should be several times greater than that from domestic livestock under the conditions found in most of Africa. Added to the direct economic gain of game-ranching are all the advantages of long-term conservation principles, e.g. the maintenance of natural vegetation cover and the preservation of faunas adapted to their natural environment.

The domestication of selected wild animal species, to which game-farming could eventually lead, opens up another wide field of practical application. Larger animals, such as the eland, would obviously be the first choice; domesticated eland are already herded in certain parts of the Transvaal and the Rhodesias.

Conclusion

Tsetse flies have acted for a long time as a buffer against man's encroachment of African biotopes. With the increase of the indigenous population and modern means of tsetse control, the tsetse fly's role as the guardian of natural environments is coming to its close. But time has come to consider the consequences to the environment of vast tsetse eradication measures. The first pertinent question should be: "do we really need the liberated land and is it suitable for human settlement?".

Vast areas occupied by savannah flies are marginal lands where soil is poor, often looked upon as waste lands. It would be unwise to spend large amounts of money to eradicate the fly from those areas should it be proven that they cannot support a permanent human occupation. Such marginal areas are nàt "lost" if they can be exploited wisely. They could be organized as national parks or faunal and floral reserves. We owe at least that much to future generations. Certain areas could serve as local sources of animal proteins through judicious methods of culling. National parks could become a permanent source of income from the tourist trade and perhaps provide a better return, money-wise, than when converted in farming and grazing lands on poor soil.

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