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The impact of nagana*

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ABSTRACT

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The disease in cattle, called nagana in Zululand, was linked with trypanosomal parasitaemia and tsetse flies. Nagana occurs in livestock throughout the tsetse belts of Africa. Wild animals are tolerant of trypanosomal infections.

Nagana affects individual animals, herds and socio-economic development. In susceptible animals nagana may be acute, but chronic infections are more common. The host-parasite interaction produces extensive pathology and severe anaemia. Clinically affected animals lose condition and become weak and unproductive. Nagana is often fatal and, at herd level, its impact is wide ranging. All aspects of production are depressed: fertility is impaired; milk yields, growth and work output are reduced; and the mortality rate may reduce herd size.

Africa has to feed its rapidly growing human population, and animal products are a vital dietary component. However, in most tsetse areas, there is not enough meat and milk. Furthermore, animal draft power is often not available, which limits cultivation and local transport. These factors lower household incomes and retard socio-economic development.

Sustainable rural development requires that nagana be controlled. This in turn needs considerable resources, whichever control strategy is adopted.

INTRODUCTION

The impact of nagana on the health of domestic animals was recognized long before David Bruce started investigating the disease in Zululand 100 years ago. We now know that tsetse flies are a unique feature of the ecology of much of sub-Saharan Africa. The 23 species of tsetse (genus *Glossina*) infest a range of habitats that includes savannas, forests and riverine land. Tsetse are parasitic and feed only on the blood of vertebrate animals, but their true significance is that they are the cyclical vectors of salivarian trypanosomes which are pathogens of domestic animals.

The trypanosomes that tsetse transmit, are well-adapted parasites of many species of Africa's wild mammals: tsetse, trypanosomes and vertebrate hosts have evolved together over millennia. Under natural conditions they exist in a balanced relationship. Humans first started keeping domestic animals in tsetse-infested areas only relatively recently; humpless taurine cattle of West Africa were introduced from 4 500 BC, whilst humped Zebu cattle were brought to Africa some 3 000 years later and did not reach southern Africa until around 700 AD (Epstein 1971). Goats and sheep were introduced at about the same time. One consequence of this relatively recent

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introduction of domestic animals to the tsetse belts is that the host-parasite relationship between livestock and trypanosomes has not fully evolved. Nevertheless, the humpless cattle of West Africa do possess the trait of trypanotolerance: they survive levels of trypanosomal infection to which other breeds of cattle succumb (Murray, Morrison & Whitelaw 1982).

People living near tsetse-infested areas and those who farm in the presence of the fly, know well the signs of tsetse fly disease shown by their animals. The early European travellers did not long remain ignorant regarding the disease that affects livestock in tsetse belts where wild animals roam. Affected animals become lethargic, weak and often pitifully thin; they appear to be in low spirits or depressed, a condition referred to in the Zulu language as "nakane" (the "k" being pronounced as a soft "g"); the English pronounce it "nagana".

Sir David Bruce was a British physician who had specialized in bacteriology. Soon after his arrival in South Africa, in 1894, he was sent by the Governor of Natal to the north of Zululand to report on the outbreak of nagana in native-owned cattle (Bruce 1915). Bruce, accompanied by his wife, travelled by mule-wagon and ox-wagon: the journey from Pietermaritzburg to Ubombo, where nagana had broken out, took 39 d. Today it is a journey of a few hours. Bruce (1915) recorded that, as a bacteriologist, his first step in investigating the disease was to examine blood and organs bacteriologically. These results proved negative and so he resorted to examining the blood microscopically. This procedure, stated Bruce, "had become popular, thanks probably in great measure to Ehrlich, and it was the fashion to make elaborate examinations of red and white blood corpuscles" (Bruce 1915). The veranda of a small wattle-and-daub hut served as Bruce's laboratory and it was here that he discovered in stained blood smears "a curiously shaped object different from anything previously found in blood ...". Realizing that this might be a blood parasite which could be motile, Bruce then set about finding it in fresh preparations of blood. His efforts were rewarded and he returned to Natal to consult the literature. In India, Evans (1880) had discovered *Trypanosoma evansi* in the blood of horses and camels affected by a disease known locally as "surra", and Bruce realized that he had found a similar trypanosome in cases of nagana. This did not mean, however, that these parasites caused the disease and, in the following year, Bruce returned to Ubombo to continue his investigations. His studies, which lasted for less than four months (Bruce 1895), demonstrated his astute and methodical approach to unravelling the connection between trypanosomes and nagana as well as the link between tsetse flies and the disease.

Since then, there has been immense scientific interest in nagana, sleeping sickness, the causal trypanosomes and their vectors. The volume of scientific literature on the whole subject is now huge and there are numerous reviews. Since Laveran & Mesnil (1904) reviewed trypanosomes and trypanosomosis and Wenyon (1926) published two volumes on protozoology, great technological strides have been made which have provided a clearer understanding of the nature of trypanosomes and of the pathophysiology of the diseases they cause. The more recent works of Mulligan & Potts (1970), Ford (1971), Hoare (1972), Jordan (1986) and Stephen (1986) provide comprehensive reviews of trypanosomes and the African trypanosomosis.

The world has changed greatly during this century: mankind has developed mechanization, telecommunication, biotechnology, information technology and nuclear power. Nevertheless, the lives of millions of people in Africa have been little altered by these major achievements. For example, more than 90 million cases of malaria are reported annually in tropical Africa (World Health Organization [WHO] 1990) and, although only about 20 000 cases of human trypanosomosis are recorded each year, some 50 million people still live in tsetse-infested areas under the threat of sleeping sickness (WHO 1986). Furthermore, and of great economic significance, nagana still has an enormous impact on animal health and production. It exerts its effects on individual animals, herds and socio-economic development.

INFECTION AND DISEASE

The epidemiology of nagana is determined by five main factors, viz. climate, tsetse, host, trypanosome and management (Connor 1994). However, in the individual animal it is the host-parasite interaction that determines the outcome of infection. Three species of trypanosome cause nagana, viz. *Trypanosoma brucei*, *T. congolense* and *T. vivax*; within each species there are numerous variants or "strains". A fourth species of tsetse-transmitted trypanosome, *Trypanosoma simiae*, causes acute and usually fatal disease in pigs. Not all host species are equally susceptible to infection with each species of trypanosome: *T. vivax* is a serious pathogen in cattle to which pigs are refractory. Conversely, *T. simiae* is a serious pathogen of pigs that does not affect cattle.

The remarkable survival mechanism of the salivarian trypanosomes (reviewed briefly by Connor 1994) has thwarted attempts to devise a vaccine for controlling nagana. After an infective tsetse has fed on a susceptible host, trypanosomes multiply at the site of inoculation in the dermis before invading the bloodstream through the draining lymphatics. Infection is then characterized by intermittent fever and intermittent presence of trypanosomes in the blood. In the early stages of infection parasites are numerous, but as the infection progresses their number decreases

and the interval between parasitaemic peaks increases. In chronic infections (which are very common) parasitaemias are usually low grade and there are long aparasitaemic intervals. Trypanosomes owe their prolonged survival to the phenomenon of antigenic variation.

Bloodstream trypanosomes are tightly clad in a thick, protective glycoprotein coat; its antigenic nature provokes a humoral immune response after a few days. Usually in a population of trypanosomes, one antigenic type predominates and the host's antibodies bind to the surface coat causing most trypanosomes to lyse. However, some trypanosomes, which have a surface coat of a different antigen type, are not affected by the antibody against the dominant antigenic coat; they survive and form a new parasitaemic wave. This population is then removed by another specific antibody, but some trypanosomes always survive because their glycoprotein coat is different from that of the main population and, initially, does not provoke a marked immune response.

Although the pathogenesis of nagana is still not fully understood, it is related largely to these events. The lysis of large numbers of trypanosomes in successive parasitaemic waves produces dead and dying trypanosomes which are removed by cells of the mononuclear phagocytic series. The damaged trypanosomes release many biologically active substances such as haemolysins and enzymes. However, the pathogenesis of nagana varies with the species of trypanosome and with the host species. Pathology is variable and, although gross changes are seldom evident, microscopic lesions are extensive. In many animals a marked anaemia develops. The effect of the disease on an animal depends upon many factors, including the duration of infection and the degree of damage to organs. The organs most commonly affected are the haematopoietic system, lymphoid tissue, heart, reproductive organs, pituitary gland and the thyroid gland.

Some animals, such as the trypanotolerant breeds of cattle, and wild animals such as the buffalo, control the level of parasitaemia and are consequently less severely affected than animals that have higher levels of parasitaemia (Murray *et al*. 1982).

The impaired function of affected organs and tissues produces the signs of nagana in the individual animal. Typically, these are loss of condition, wasting, weakness and lethargy. Nagana also exerts its effects at herd level. These include: lower fertility rates (due to poor spermatogenesis, loss of libido, anoestrus, and abortion); increased mortality in suckling animals (resulting from low birth mass and weak, sickly neonates); reduced milk production; poor growth rate; and stunted growth. Because nagana is immunosuppressive, affected animals often succumb to secondary infections and die from causes other than the underlying trypanosomosis. Under heavy tsetse challenge, the death rate exceeds the birth rate and herd size declines so that, in many tsetse-infested areas, it is not possible to keep domestic animals without using trypanocidal drugs or applying tsetse control measures.

NAGANA AND SOCIO-ECONOMIC DEVELOPMENT

The effects of nagana on animal health and production have serious economic implications. Impaired fertility results in lower offtake: there are fewer animals for slaughter and sale. As a consequence of the lower birth rate fewer animals lactate; even those that are in milk produce less. Family income and human nutrition suffer as a result of these effects. Nagana causes severe anaemia and so animals used for cultivating fields and for pulling carts are too weak to work properly, if they can work at all. In tsetse areas, where control measures are either not in place or are not effective, agricultural production is lower than in tsetse-free areas; this is largely because of the impact of nagana on animal traction. With fewer working animals, less land is cultivated, less manure is spread on the fields—because this depends on the availability of animal-drawn carts to move it from night pens to the fields—and crop yields are lower. The cumulative effect of lower milk production, reduced work output, lower crop yields and impaired local transportation, is that household incomes in tsetse areas are usually lower than those in tsetse-free areas. Consequently, rural development in affected areas is impeded.

These direct losses are difficult to quantify, but are only a part of the true cost of the disease. The cost of controlling nagana also has to be taken into account. There are three main control strategies, viz. using trypanocidal drugs to remove the parasite, controlling the vector to reduce transmission of trypanosomes and using trypanotolerant livestock. The antigenic complexity of trypanosomes has so far thwarted attempts to develop a vaccine and so this option, which has been successful in controlling many major diseases, is not available in the case of nagana.

The costs of the different strategies vary with the different economic circumstances and local epidemiology, and the choice of which one to use is not simple. In southern Africa, the use of trypanotolerant livestock is not currently possible: their numbers are low and they are to be found mainly in parts of West Africa where, because of their small size, they are not always popular with farmers who aspire to owning the larger, improved breeds. A strategy of controlling nagana on a long-term basis by using trypanocidal drugs is not viable either. Trypanosomes have developed resistance to all drugs that have been marketed and, because of the high cost of developing

new drugs, no new trypanocides will become available in the next decade. Attacking the vector is therefore the preferred medium- to long-term strategy for controlling nagana (Chadenga 1994).

Nagana is a disease of increasing importance in many places. The rapidly growing human population in sub-Saharan Africa requires more land for farming, but most of the land that remains unused is either too arid, or is infested with tsetse. The result is that increasing numbers of people are settling in or near tsetse-infested habitats where they are confronted by nagana. The relief of this constraint has to be seen in the context of the needs of affected countries in which the dominant problems are poverty, population growth and environmental degradation. Appropriate means of controlling tsetse have to be devised so that they can be used on a sustainable basis. There is a growing opinion that the local communities should participate in the control of vector-borne diseases such as nagana. This approach has far-reaching practical implications; it would require new attitudes and orientation on the part of the technical and professional people who would still be needed to design and guide operations.

NAGANA IN THE FUTURE

One hundred years ago, nagana represented a major constraint on settlement and development in much of sub-Saharan Africa: transportation away from the line of rail relied almost exclusively on animal-drawn wagons. By the middle of this century, animal traction had given way to motorized transport and, on commercial farms, tractors took over most of the tasks of draft animals However, over the past 20 years there has been a growing realization that mechanization is not sustainable in most developing communities and that greater use must be made of animal power. Consequently, the control of nagana has a pivotal role in sustainable rural development and, if correctly applied, would offer the opportunity of orderly settlement. This view is opposed by vocal conservationists and environmental watchdogs who still adhere to the well-worn slogan that "the tsetse fly is the guardian of Africa". Large numbers of people have no choice but to settle in tsetse-infested lands and so there is an urgent need to steer a middle course: the threat of nagana has to be reduced, whilst at the same time renewable resources and the environment have to be safeguarded.

Over the past 100 years, many people have devoted their lives to controlling nagana, and hundreds of scientists have attempted to answer questions about trypanosomes, the diseases they cause and the flies that transmit them. In spite of significant growth in our knowledge of tsetse-transmitted trypanosomosis many questions remain, e.g.: By what mechanisms could drug resistance be overcome? How can control methods be used on a sustainable basis? Is vaccination possible? Can trypanotolerant traits be transferred? Parasitologists, together with other scientists, have an important role in answering these and other questions. Beneficiary communities will have to participate in the research to ensure that it is relevant to the problems they face in their daily lives and that results can be applied on a sustainable basis (Connor, Terblanche & Verwoerd 1994) to lessen the impact of nagana.

We have learned a lot about the intricacies of nagana since Bruce's discovery 100 years ago. We have now to learn how to apply our knowledge to relieve the constraint that nagana imposes on development in Africa.

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