Onderstepoort Journal of Veterinary Research, 61:385–390 (1994)

Epidemiology and control of trypanosomosis*

V. CHADENGA

Tsetse and Trypanosomiasis Control Branch, P.O. CY 52, Causeway, Zimbabwe

ABSTRACT

CHADENGA, V. 1994. Epidemiology and control of trypanosomosis. *Onderstepoort Journal of Veterinary Research*, 61:385–390

Tsetse-transmitted trypanosomosis remains a major constraint to the development of agriculture, particularly to that of livestock production in sub-Saharan Africa.

It is estimated that 10 million km^2 of Africa are tsetse infested, exposing some 50 million people and 60 million cattle to the risk of trypanosomosis. The epidemiology of the disease is complex and is greatly influenced by management and farming practices.

The different control strategies are reviewed and their comparative advantages assessed.

It is concluded that eradication of tsetse flies, while desirable, is rarely achieved. It is perhaps more realistic to aim for disease suppression, with vector-control campaigns linked to sustainable land-use programmes. Nevertheless, progressive tsetse eradication remains the long-term goal.

INTRODUCTION

Trypanosomosis constitutes a major constraint to livestock production in sub-Saharan Africa and has a considerable influence on the pattern of land utilization. Spread mainly by the bite of a trypanosome-infected tsetse fly, the disease is debilitating and commonly fatal. Sir David Bruce's experiments showed that the fly readily acts as a carrier of the disease from affected to healthy animals (Lorne 1986). He also correctly associated the presence of game with the disease in domestic animals. These important discoveries identified major epidemiological determinants and facilitated the formulation of control strategies against the disease.

* Presented at the 23rd Annual Congress of the Parasitological Society of southern Africa as part of the David Bruce centenary celebration

Accepted for publication 9 September 1994—Editor

Tsetse flies occur in some 37 countries and across 10 million km^2 of tropical Africa. In some 7 million km^2 of this tsetse belt, the raising of livestock is limited or precluded by the presence of trypanosomosis (Allsopp & Barrett 1988). In addition, over 35 million people are exposed to the risk of sleeping sickness. A disheartening aspect of the trypanosomosis problem is that, despite considerable scientific and technological advances as well as costly control measures, the eradication of the disease remains elusive, continuing to take its toll in many African countries to the detriment of the continent's fledgling economies.

Trypanosomosis seriously constrains development by:

- direct economic and social losses in terms of mortalities and morbidities arising as a result of exposure of humans and livestock populations to the disease;

- indirect economic and social losses arising in rural communities and reducing productivity, ultimately to affect the national economy.

Current annual costs of the disease, including production losses and control costs, are estimated to be more than US$500 million. The human population in sub-Saharan Africa is increasing at a rate of more than 3 % per year, while meat and milk production grow at only 1,4 % and 2,3 %, respectively. In order to satisfy the current demand for meat, an overall annual growth of an estimated 4 % would be required (De Haan & Bekure 1991). Trypanosomosis militates against the realization of this objective.

EPIDEMIOLOGY AND DISTRIBUTION OF TSETSE SPECIES

The epidemiology of trypanosomosis in the common flybelt of Malawi, Mozambique, Zambia and Zimbabwe is a dynamic problem and has recently been outlined (Connor 1993). It depends on the complex interaction of five main factors, viz. climate, tsetse flies, their host animals, the trypanosomes that they transmit and livestock-management practices. The effect of each of these factors on the occurrence of trypanosomosis is not easy to determine. Although the impact of the catastrophic drought in 1992 on the incidence of disease was not assessed, local climatic and seasonal changes are known to alter management practices, the condition of livestock and tsetse flies and trypanosome transmission rates. In some areas, the incidence of trypanosomosis is greater during the rainy season than during the dry season; in other areas the converse is true. Whilst the severity of the disease depends to a great degree on the species and virulence of the trypanosome and the health and immunity of the host, tsetse challenge is possibly of greater importance. To a large extent this is determined by the way that people manage their livestock. Management practices alter the challenge to which livestock are subjected, and in this sense, management is central to the epidemiology of animal trypanosomosis. Just as poor management can inadvertently exacerbate the severity of trypanosomosis, so too, good management can mitigate its effects.

The epidemiology of nagana is almost entirely restricted to the areas infested by tsetse flies. Tsetse infest three main types of habitat, viz. riverine, forest and savanna.

The forest tsetse are confined largely to humid zones of West and Central Africa while the savanna species' distributions are associated with the sub-humid areas. The distribution of riverine species coincides with that of the forest group, but also extends into the sub-humid zone in West Africa.

Humid and sub-humid Central Africa

The major part of this zone is either sub-humid or humid and has potential for annual perennial crop production. With the exception of limited highland areas, the rest of the zone is tsetse infested with virtually the entire cattle population of 9 million exposed to tsetse [Food and Agricultural Organization of the United Nations (FAO) 1991].

Sub-humid highland zone of East Africa

These highlands have a higher density of both human and livestock populations, with the population of draught animals constituting some 75 % of the total for Africa (FAO 1991). The combined pressures of human and livestock populations have resulted in an over-exploitation of available land and under-utilization of tsetse-infested, but otherwise fertile, lowland areas. Of the estimated population of 49 million cattle in the zone, 28 % are at constant risk to trypanosomosis (FAO 1991).

Sub-humid and semi-arid southern Africa

Countries in this zone are faced with a similar problem; the threat of tsetse advances, following the virtual elimination of wildlife species during the rinderpest panzootic at the turn of the century, when major recessions occurred in the overall fly distribution. The recovery of game animal populations and the introduction of cattle, following tsetse reduction, resulted in the recuperation and spread of tsetse populations. It is estimated that 3,5 million head of cattle out of a population of 20 million are exposed to trypanosomosis challenge. The relatively low proportion of cattle at risk in this zone can be attributed to the effectiveness of ongoing vector-control programmes.

MANAGEMENT TECHNIQUES FOR TSETSE AND TRYPANOSOMOSIS CONTROL

Parasite control

The direct control of trypanosomosis is well documented and has changed relatively little over the past 40 years. Curative and prophylactic drug use is likely to remain the most widely used method of disease control for the foreseeable future. However, the limited choice of available drugs and their abuse by farmers, has led to the development of drug-resistant trypanosomes, a development of major concern. In most East and West African countries, drugs have been the basis of their trypanosomosis control. On the other hand, in much of the humid and sub-humid zones of Central and West Africa, there has been the exploitation of N'Dama and West African shorthorn trypanotolerant breeds. While trypanotolerant cattle remain an important option, the breeds have not found general acceptance throughout Africa.

Furthermore, it has to be stressed that the N'Dama cattle are merely tolerant to the disease, but succumb to it when under high challenge or physiological stress.

While drugs have been effective in alleviating trypanosomosis, management of the disease can be effectively implemented only when the vector, the tsetse fly, is eliminated or suppressed to a low level.

Tsetse-control methods

Past strategies to control trypanosomosis placed emphasis on the eradication of the tsetse vector. Eradication was the more attractive option in that it implied a "once and for all" solution to the problem.

However, this has in reality rarely been the case, owing to the fact that control organizations usually lack the ability to consolidate and protect against reinvasion. Zimbabwe offers a good example of what can happen in the absence of consolidatory programmes.

Owing to the practical difficulties associated with achieving vector eradication, the emphasis is now on vector suppression. In view of the harsh economic climate prevailing in Africa today, most current tsetse-control programmes are funded by outside agencies. For this reason, control methods have sometimes been selected on the grounds of acceptability to the donor rather than on the grounds of effectiveness and practical application (Dransfield & Brightwell 1991).

Tsetse-control methods are well established and documented (Chadenga 1991; Alsop 1993).

Early attempts to control tsetse flies were based on uncompromising and emotionally charged strategies like game elimination and clearance of vegetation. The basis of this strategy was the rinderpest panzootic of 1895, which devastated domestic livestock and cloven-hoofed game populations, and was followed by the disappearance of tsetse throughout the Limpopo and Zambezi basins, demonstrating that elimination of hosts would be effective in eliminating tsetse. On the other hand, bush clearing was used extensively in East Africa with satisfactory results. However, these strategies became politically and environmentally untenable, since they destroyed valuable natural resources.

Following the discovery of DDT in the 1940s, it was widely believed that tsetse flies could be eradicated. The following are the established methods for tsetse control:

- Ground spraying
- Aerial spraying
- Odour-baited traps and targets
- Applications of insecticides to cattle by dipping or pour-on formulations
- Sterile-insect techniques

Of these methods, ground spraying has probably cleared more areas of tsetse infestation than any other technique, and aerial spraying has the proven capability of reducing tsetse densities over huge areas more rapidly than by any other method.

Ground spraying

Selective applications by ground-based teams of residual insecticides such as DDT and dieldrin to tsetse resting sites has been the backbone of most of the large-scale tsetse-control efforts from the 1950s into the late 1980s (Lovemore 1986). Ground spraying was successfully used to control large tsetse infestations in Nigeria, East and southern Africa (Kenya, Uganda, Zambia and Zimbabwe).

However, in recent years, use of ground spraying has declined and the technique has lost favour among tsetse-control institutions, for the following reasons:

- Environmental concerns over the extensive use of DDT and dieldrin. This is in spite of the fact that selective application of the insecticide is used and that studies show that side effects on non-target organisms are minimal and transient.
- The technique is labour intensive and requires strict operational supervision.
- Treated areas are easily reinvaded, necessitating costly retreatment programmes.
- Appearance on the scene of environmentally friendly, cheaper and simpler control methods.

However, ground spraying remains a valuable option for use in localized elimination of tsetse populations from rugged terrain or from small, recalcitrant pockets of infestation (Allsopp & Barrett 1988).

Aerial spraying

Aerial spraying is, technically, the most demanding strategy for tsetse control. It involves the use of fixed-wing aircraft applying low dosage, non-residual insecticide sequentially, delivered as a fine aerosol. The technique is ideal for eradication of tsetse over large areas of suitably flat terrain and of rapid vector suppression in acute problem situations such as sleeping-sickness outbreaks. When an aerial spraying campaign is carried out, the aim is to kill all adult tsetse during the first cycle. Subsequent cycles are designed to kill emerging flies before they can larviposit. The technique was extensively used over the past 25 years in Nigeria, Zimbabwe and South Africa; with less success against the forest species of West Africa.

The following are the major advantages of aerial spraying.

- Large areas can be treated rapidly, thereby benefitting from economies of scale.
- It is not labour intensive.
- As the insecticide applied is in aerosol form and is non-residual, there is no significant environmental contamination.

Although aerial spraying has produced excellent control in many countries, the strategy has its disadvantages:

- Since the insecticide used is not persistent, areas cleared of tsetse are subject to reinvasion immediately after the operation is completed.
- The technique is relatively expensive and has serious limitations when used in rugged terrain.
- Aerial spraying is highly technical and inflexible, requiring strict timing, especially with regard to repeat sprays which are meant to cover the period of pupal development.
- Droplets are easily dispersed by wind which can and does change direction during an operation, a situation which can result in a pocket which is left untreated, a development which can jeopardize the entire operation.

Aerial spraying is normally conducted at night when temperature inversion usually occurs, indicating air stability. It is worth noting, however, that the terminal velocity of a micron droplet is 0,012 $m.s^{-1}$ and that an upward trend or air movement greater than this, could prevent sedimentation.

Odour-baited and insecticide-treated targets

Environmental concerns and the inability of spraying measures to provide year-round protection against reinvasion, necessitated the search for alternative strategies. Artificial attraction devices, i.e. targets and traps, proved an acceptable cost technology amenable to community participation. Baits are either cattle, dipped in a formulation of insecticide, or surrogate cattle/targets consisting of a panel of black cloth or black cloth flanked by panels of blue cloth and baited with attractants: Acetone, 1-octen-3-ol, 4 methyl phenol and 3-n-propyl phenol. The cloth is treated with insecticide.

Simple, unbaited traps and insecticide-impregnated targets have been used since the late 1960s in West Africa, to control riverine species of tsetse, but were not as effective against savanna species. Work conducted in Zimbabwe by Vale & Hargrove (1986) demonstrated that tsetse flies *Glossina morsitans* Westwood and *Glossina pallidipes* Austen can be controlled by attracting them to visual targets that are baited with odour attractants and coated with insecticide. As a result, odour-baited traps are now the method of choice for surveying some species of tsetse, and odour-baited targets are now widely used in tsetse-control operations throughout Africa.

Bait technology has several advantages over established methods of tsetse control:

- The technology is simple and cheap compared with several annual repetitions associated with ground or aerial spraying.
- When baits are used, mistakes can be rectified without jeopardizing the entire operation.
- The technique has scope for community participation, making it more sustainable and cost effective.
- Targets can be used in barrier situations, work all year round and can be deployed in all types of terrain.
- They are highly specific to tsetse, and given that insecticide application is confined to man-made artifacts, there is no perceptible contamination of the environment.
- Variations can be introduced to the technique to make it more cost effective. Cost analysis suggests that it is possible to improve cost effectiveness, e.g. by increasing the amount of insecticide applied to the target and by reducing the number of retreatment schedules, thereby creating a tradeoff between insecticide costs and vehicle costs.

With a density as low as 4/km^2, targets have given excellent levels of control, and where the placement and density are optimal, eradication was realized. The odour-baited, insecticide-impregnated targets currently form the major basis of control in the Regional Tsetse and Trypanosomosis Control Programme (RTTCP) in southern Africa.

As far as cost is concerned, targets are the cheapest alternative if control on a recurrent basis is the chosen strategy.

While odour-baited traps and -targets have produced excellent results against savanna flies, their effect on riverine and forest species is a subject of continuing research.

However, while bait technology offers exciting prospects for the future, there remains the need to address problems of fire/animal damage, human interference/theft of target materials, as well as different fly species, environments and social milieux.

Application of insecticides to cattle (cattle-dipping/pour-on)

The technique is not new, and can be considered a further progression of the target method.

It was reasoned that cattle would be more attractive than artificial targets. In controlled experiments it was shown that, following a single treatment with deltamethrin as a wash or pour-on, almost 100% of alighting tsetse were killed within 2 weeks. For 8 weeks, 60% of alighting tsetse were immobilized or "knocked down". It is known that 95% of knocked-down flies are predated upon and fail to survive in the natural environment.

There are 60 million head of cattle at risk in tsetse-infested areas (FAO 1991) and the majority are surviving with the aid of trypanocidal and prophylactic drugs. However, the major problem is that the few trypanocidal drugs available have been in use for a long time and resistance to them is increasing rapidly. For this reason, chemotherapy alone is unlikely to succeed, and a permanent solution to the problem lies in vector control/eradication.

The traditional methods are proving costly, complex and environmentally unacceptable. Application of insecticides to cattle offers a simpler low-cost technology easily understood by rural people and sustainable by them in the absence of experts. Another major advantage of applying insecticide to cattle is that the technique is flexible and easily integrated with targets.

However, for the technique to succeed, the following are necessary:

- Domestic livestock must be present in the area in sufficient numbers.
- Cattle must represent the overwhelming proportion of the host complex of the tsetse area.
- Most of the cattle must be presented for treatment on a regular basis.

Sterile-insect technique

The technique involves release of sterilized males which mate with wild virgin females. In view of the fact that females mate only once, the technique effectively induces sterility in those females that mate with sterilized males. Sterile-insect technique was successfully used in some parts of West Africa and, more recently, in Tanzania.

However, though the technique is theoretically attractive, it is unlikely to find wide application, especially in control situations. Its advantages of species-specificity and non-contaminating nature, are outweighed by the high cost and considerable sterile-insect production and release logistics.

Currently no single method of insecticide control of tsetse flies has proved to be the method of choice in all circumstances. All the available techniques have their advantages and disadvantages, and often greater gains can be obtained by using a suite of control techniques than by relying on a single one. In any large-scale programme, one first has to decide whether eradication or control is the preferred approach, and then which is the most cost-effective method, given the local infrastructure. This can mean the overlapping of two or more techniques in the same area, one to achieve major suppression and a follow-up one to eradicate residual populations.

PROSPECTS FOR THE FUTURE

There is growing evidence that donor communities are becoming increasingly reluctant to support open-ended control programmes, particularly in situations where the degree of constraint caused by trypanosomosis is not quantified, and the need for intervention is completely justified. It is also clear that, for the foreseeable future, most African governments will not be in a position to provide adequate funding for tsetse- and trypanosomosis-control programmes. Given this state of affairs, tsetse-control organizations are urged to refrain from embarking on large-scale eradication campaigns.

Instead, priorities must be identified. Large campaigns can be replaced by smaller, more manageable programmes and integrated with rural development, with the objective of disease suppression to a level where livestock raising is not precluded.

CONCLUSION

Therefore, in view of the high rate of human population growth in sub-Saharan Africa and the reduced agricultural production, there is an ever increasing demand for food, which can be satisfied only by optimising agricultural production over greater areas of land.

Given the enormous direct and indirect losses associated with trypanosomosis, the choice facing African governments is either to live with the disease or to try and eliminate the disease vector—the tsetse fly.

The raising of trypanotolerant breeds and chemotherapy make the former option possible, but treated animals become reinfected. The alternative option, vector control, offers hope of a permanent solution, but this can be realized only through consistent funding and sustained control programmes.

The eradication of tsetse flies and the disease trypanosomosis remains intractable and elusive. However, the availability of low-cost technologies, prospects of community participation and regional cooperation give cause for optimism.

REFERENCES

ALLSOPP, R. & BARRETT, J.C. 1988. Perspectives on the insecticidal control of tsetse flies. *Proceedings of KETRI/KVA Workshop on Regional Development and Implementation of Tsetse Control Strategies in East Africa.*

ALSOP, N. 1993. Review of recent approaches to sustainable control and an analysis of the potential of modern techniques for large-scale use. *Proceedings of the Meeting of the Panel of Experts on Ecological Technical and Development Aspects of the Programme for the Control of African Animal Trypanosomiasis and Related Development*. Rome, Italy

CHADENGA, V. 1991. Analysis of efficacy, practicality and cost of various tsetse control techniques as used in Zimbabwe. Paper presented at the Meeting of the Panel of Experts on Ecological Technical and Development Aspects of the Programme for the Control of African Animal Trypanosomiasis and Related Development. Harare, Zimbabwe.

CONNOR, R.J. 1993. *Review of animal trypanosomiasis in the common fly belt*. Regional Tsetse and Trypanosomiasis Control Programme, Malawi, Mozambique, Zambia and Zimbabwe.

DE HAAN, C. & BEKURE, S. 1991. Animal health services in sub-Saharan Africa; initial experiences with new approaches. *World Bank Report, Washington.*

DRANSFIELD, R.D. & BRIGHTWELL, R. 1991. Control of tsetse and trypanosomiasis: Myth or reality. *Parasitology Today*, 7: 287–291.

FAO 1991. *Programme for the Control of African Animal Trypanosomiasis and Related Development. Second Meeting of the Inter-secretariat Coordinating Group*. Rome: Food and Agriculture Organization of the United Nations.

LORNE, E.S. 1986. *Trypanosomiasis, a veterinary perspective.* Pergamon Press.

LOVEMORE, D.F. 1986. Tsetse control by chemical means in Malawi, Mozambique, Zambia, Zimbabwe. *Proceedings of the EEC International Symposium, Ispra*: 27–41.

VALE, G.A. & HARGROVE, J.W. 1988. Odour-baited targets for the control of tsetse flies in Zimbabwe. *Bulletin of Entomological Research,* 78:31–49.