Tsetse control*

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Summary: Some twenty-three species of tsetse fly occupy over 10 million km\(^2\) in 37 African states resulting in a major constraint on livestock production and placing 35 million people at risk to sleeping sickness.

Despite the expenditure of large sums of money on tsetse and trypanosomiasis research and control projects over the last few years, very little has been achieved in combating the problem.

A brief description is given of the tsetse situation and the practices being adopted to exercise control, in the countries from which reports have been received.

The various techniques currently available for the control of the vector and the disease are listed, with comment being made on their application and efficiency. Chemotherapy of domestic stock is regarded as a temporary measure only and has the disadvantage that only very few trypanocidal drugs are available and poor administration results in the development of immunity by the parasite.

The phenomenon of trypanotolerance shown by wild herbivores and some breeds of West African cattle requires further investigation and holds some promise as a future solution. The use of bush clearing of tsetse habitat and the destruction of wild host animals are considered to have only limited application and are not suitable for large-scale tsetse control.

The sterile male release technique has several disadvantages when considered for tsetse control. The laboratory rearing of flies and dissemination of pupae sterilised by radioactivity is considered to be too uneconomic and technologically demanding for practical use. The alternative, involving the capture, chemosterilization and release of wild flies by automatic trapping devices would be a more practical alternative and may warrant further investigation.

Traps and screens for control and eradication are being used on an increasing scale, particularly in West Africa and the results are promising. The addition of attractive odours to the trapping devices increases their efficiency several-fold. The identification and isolation of tsetse attractive odours is being carried out in Zimbabwe and the United Kingdom and, if perfected, would greatly enhance the efficiency of this method.

Insecticidal control is the only proven method available for large-scale use at the present time. Various methods of application are given and, of these, selective residual ground spraying and the aerosol aerial technique are more fully assessed.

The necessity for more sensitive tsetse population surveying techniques is

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emphasised and, in this regard, odour baited traps and mobile electrocuting devices, if perfected, show the most potential.

KEY-WORDS: Africa - Cattle diseases - Chemoprophylaxis - Disease prevention - Glossina - Therapy - Trypanocidal drugs - Trypanosomiasis.

INTRODUCTION

The present tsetse distribution in Africa has changed very little over the past seventy years despite the expenditure of large sums of money on research, control and eradication. Some twenty-three species of tsetse fly still occupy over 10 million km$^2$ in 37 African states between the large deserts situated in the north and south of the Continent. The presence of tsetse is one of the major constraints on the agricultural development of the region and over 35 million people are currently at risk to the human disease, sleeping sickness.

In 1983 approximately 200 million US dollars were spent by aid agencies on supporting various tsetse control and research projects in Africa and similar amounts of expenditure have been incurred in previous years. One would expect that with these large inputs, tsetse control and eradication should now be well underway, but if one considers the OAU tsetse distribution maps, produced in 1972, it is evident that very little progress, if any, has been made in the last twelve years.

It has been estimated that the potential meat production of infested areas is about 5 billion US dollars per annum and that the improved agricultural practices that would result from tsetse clearance could increase this production by over 30 billion US dollars per year.

COUNTRY REPORTS

In order to emphasise the seriousness of the tsetse problem throughout the African Continent it would be useful to outline the current tsetse situation in those countries for which reports are available and to note the action, if any, being undertaken to alleviate the problem.

IVORY COAST

The entire territory is infested with tsetse, and animal trypanosomiasis presents a serious obstacle to the development of economic animal production. Tsetse control measures are being implemented but are still in their infancy. Surveys have been undertaken, mostly in the savannah regions and a tsetse distribution map produced. A control campaign undertaken in the northern region, in an area where G. morsitans is absent and only riverine species are found, has reduced the tsetse density by approximately 90% and the incidence of trypanosomiasis in animals has decreased from 25% to 4%. This campaign has been in operation for one year and incorporates the use of biconical traps impregnated with insecticide. It is planned to extend the area under treatment and to investigate the use of odour-baited targets as a method of improved control.
ZAIRE

The country is infested by eight species of tsetse with widespread distribution. No coordinated tsetse control programmes are being undertaken.

ETHIOPIA

Five tsetse species infest some 98 000 km$^2$, or 8% of the country. Surveys are being conducted to delimit the infestation. Land resettlement and the consequent destruction of tsetse habitat has resulted in the reclamation of some areas.

MOZAMBIQUE

Despite widespread tsetse infestation, no tsetse control programmes are being implemented. Cattle throughout the country are maintained by the use of drugs and some 350 000 head are treated annually.

MALAWI

The extent of tsetse infestation is unknown but is believed to be in the region of 8% of the total area. No tsetse control operations are undertaken.

ZAMBIA

Much of the country is infested by *G. morsitans* and *G. pallidipes* and this infestation is reported to be increasing. The locally based tsetse control unit is unable to function due to lack of finance and therefore only small-scale emergency holding operations have been undertaken in the last few years.

ZIMBABWE

The current infestation covers some 55 000 km$^2$ although approximately one half of the country constitutes ecologically suitable tsetse habitat. Since 1981, the local tsetse control organisation has treated some 10 000 km$^2$ of infestation annually and has, during the last four years, eradicated the species *G. morsitans* and *G. pallidipes* from approximately 20 000 km$^2$. The main method of eradication is the selective application by ground spraying of a 4% DDT aqueous suspension to tsetse resting and breeding sites, augmented by the fixed wing aerial spraying technique using endosulfan e.c. applied as an aerosol.

Although no other country reports are to hand at the time of writing, it is known that ongoing tsetse control operations are being conducted in both Botswana and Somalia and are considered worthy of mention.

BOTSWANA

The area of tsetse infestation, by *G. morsitans* only, is confined to the Okavango delta and associated drainages northwards towards Caprivi and Angola. Large-scale control operations using the fixed wing aerial spraying technique have been undertaken annually over the last ten years. This has resulted in good control of the tsetse population and promises to achieve eradication over the next few years. In 1984 some 9 000 km$^2$ were treated over a three-month period.
AN ASSESSMENT OF CONTROL TECHNIQUES

Although it is appreciated that operations to control tsetse flies and the associated disease trypanosomiasis may be currently undertaken in other African states, from which reports are not available, the country reports summarised above show that very little is being done to combat a problem of immense proportions. It is therefore considered worthwhile to assess the various techniques currently available for the control of the vector and the disease and to comment upon their use and efficiency. As the main topic of the report concerns the control of tsetse, only brief mention is made of methods aimed at the control of the disease.

Control by drugs

The use of drugs for both curative and prophylactic purposes in the control of trypanosomiasis, in both domestic stock and human populations, is practised on a large-scale throughout the continent where man has chosen to co-exist with the tsetse fly. In most affected states this is the major method used to ensure utilisation of infested areas for the rearing of domestic stock. There are several major disadvantages attached to total reliance on drug treatment and it can only be regarded as a temporary measure of disease control.

There are only a few drugs available for the treatment of trypanosomiasis and all are susceptible to the development of immunity by the parasite. Although in recent years attempts have been made to improve the efficiency of the curative and prophylactic drug isometamidium there is, at the present time, no promise of new and improved compounds being developed. The administration and use of those available therefore depends on two critical factors. The first is that an efficient diagnostic system be available for the detection of the disease and the second that good control of the domestic stock can be maintained so that prophylactic treatment can be ensured on a regular basis in order to avoid the development of immunity. In most countries these requirements are impossible to achieve. A third factor to be considered in the use of drugs is that very often regular stocks are not guaranteed, due to the shortage of foreign exchange for importation, and this presents another very serious complication.

For several years research at the International Laboratory for Research on Animal Diseases (ILRAD) has been directed at the production of a vaccine suitable for mass immunisation against trypanosomiasis. Due to the antigenic variation which the parasite is capable of producing, this work has not achieved its objective and the development of a vaccine does not seem likely in the near future.
Trypanotolerant livestock

Several species of wild African herbivores are known to tolerate trypanosomiasis infections without showing clinical symptoms and with no apparent detriment to their health. It is also known that certain indigenous breeds of cattle, particularly those in West Africa, may also tolerate the disease and in some cases recovery from the disease without the aid of chemotherapy has been noted. The potential therefore exists to replace susceptible herds with those that are trypanotolerant and this possibility is currently being investigated by several West African countries, in collaboration with such international agencies as the FAO and ILRAD.

In order to be an economically viable proposition these investigations must show that the smaller bodied trypanotolerant breeds, such as the N'Dama, are a productive alternative to more exotic types and the extent to which they can tolerate the disease must be elucidated. Evaluations to date indicate that infected animals are less productive than healthy ones and succumb to the disease if subjected to nutritional or physical stress conditions. There are also indications that even trypanotolerant cattle show clinical symptoms if maintained in areas of high trypanosomiasis challenge. Further investigations into the mechanism of trypanotolerance and its practical application to livestock production are required and should be encouraged.

Control by bush clearing

Early studies into the behaviour and ecology of tsetse flies indicated that the various species showed specific preferences for certain types of habitat related to the vegetation available. This indicated the possibility of achieving eradication by the destruction of this natural vegetation and its replacement by planned land resettlement. This method, aimed at both control and eradication, was used more extensively in the early years but has since been abandoned mainly for two reasons: first, the implementation of planned land resettlement and soil conservation was very seldom practised thus leading to poor utilisation and consequent soil erosion. Second, in many cases, where selective destruction of the habitat was carried out rather than sheer clearing, the tsetse demonstrated the ability to adapt to the new conditions. The method has also proved to be expensive to implement, requiring the use of heavy mechanical equipment. Nevertheless it is still considered to be of use in reducing man/fly or cattle/fly contact in specific areas such as at water points and around small agricultural settlements. As human populations in African countries increase, the demand for land results in the destruction of tsetse habitat as an incidental achievement and in this way large areas have been cleared of fly in Nigeria and more recently in Ethiopia. With the high rates of population increase being experienced and the consequent accelerated demand for land it may not be impractical to assume that, with the passage of time, tsetse may be eradicated from large areas of Africa without the implementation of deliberate control measures.

Game destruction

Tsetse flies are haematophagous insects and depend on a regular blood meal for all their nutritional requirements and to provide energy for the development of their young during the transitional phase from larva to adult. Should insufficient host animals be available to ensure an adequate and regular food supply then the tsetse population would experience conditions of stress resulting in a population decline and subsequent control. This fact is the basis used for the destruction of wild animal species which have been identified as preferred tsetse hosts. The method was used extensi-
vely in the past, particularly in Uganda and Zimbabwe, with reasonable control being achieved but there are several limitations.

When denied a preferred host species, tsetse are able to adapt to feeding off other animals thus increasing the number of species that have to be destroyed. Obviously this is a method that could not be implemented in the many African game parks and nature reserves nor could it be applied to areas where settlement with domestic stock occurs. There are very few records of eradication having been achieved by game destruction although satisfactory control of fly populations and the prevention of their re-invasion into reclaimed areas has been reported. This method has very limited practical application in modern times except in those areas where game and cattle free hunting barriers can be maintained between tsetse belts and settled areas.

Control by sterilisation

The fact that all species of tsetse normally only mate once during their life, the sperm being stored in the spermathaecae of the female, gives rise to the possibility that sterilisation of the males could result in a population decrease and eventual eradication. Several investigations and field trials into the practical feasibility of utilising this technique have been conducted in recent years. Normally the policy has been the rearing of large tsetse populations in the laboratory followed by sterilisation of the pupae obtained, usually by the use of radioactivity, and the dissemination of these into the field where the sterile males produced compete with wild flies for the fertilisation of females. The rearing of large numbers of flies under laboratory conditions, in order to obtain sufficient numbers of pupae and the dissemination of the pupae so obtained over large areas have remained insurmountable problems. Of the species of tsetse that exist only a few have been laboratory bred in large numbers. In addition the advanced technology and expertise required to successfully rear large colonies is not always available in many African countries. The recurring costs of pupae production is high (currently approximately 0.25 US dollars each) and, in order to successfully compete with wild males, the numbers of sterilised pupae released must also be of a magnitude several times greater than the natural population. Despite large investments, objectives have not been achieved. It has been recorded that sterilised tsetse retain the capacity to transmit trypanosomiasis and that their longevity is not affected. The introduction of large numbers into an area could therefore result in a short-term increase in the incidence of the disease.

If the control of tsetse by sterilisation is to be pursued, then, in view of recent advances made in the identification of tsetse attractive odours and the development of more efficient trapping systems, consideration should be given to the capture, chemo-sterilisation and release of the natural population.

Biological control

Several natural predators of tsetse flies have been recorded, notably the Bombylid fly Exhylanthrax spp., Syntomosphyrum and Muttilla glossinae, all of which parasitise the pupal stage. In some cases, rates of parasitisation are relatively high but a biological balance between the species is maintained. Several investigations into tsetse parasitisation have been undertaken but, to date, a predator with potential for control has not been identified.

Control by traps and screens

The development of trapping devices attractive to tsetse flies extends back to the nineteen twenties. In the early years traps were mainly used for population surveys
but more recently, with improved design and the addition of odours attractive to tsetse, the catching efficiency of these devices has been so improved that they may now be considered for use in control eradication campaigns.

Intensive research and field trial work in Zimbabwe over recent years have resulted in the production of an odour-baited trap with the potential to effect control of *G. morsitans* and *G. pallidipes*. Similarly, the biconical trap of Laveissière and Challier developed for use against West-African tsetse has resulted in good control of several species, as borne out by the results recently obtained in the Ivory Coast.

The efficacy of traps can be greatly increased if they are treated with insecticide and thus able to remove not only the flies that enter but also those that alight, even momentarily, on the outer surface. Trapping efficiency depends on many factors such as trap design, colour, selection of placement sites, density and the presence of odours. The requirements for optimum catching efficiency may vary from species to species. Even within a species, traps have been shown to have a bias for a particular segment of the population. It has been suggested that in order to achieve effective control, approximately 2.5% of the female tsetse population must be removed on a daily basis.

The utilisation of traps on a large-scale in future control programmes is a very real possibility although further work needs to be done on determining the best trap design for the various species and on identification of more efficient tsetse attractive odours. Current use of the biconal trap, without odours, in West Africa, to reduce the frequency of man/fly contact in order to combat sleeping sickness in the tropical forest areas has achieved reasonable results.

Where the objective is solely control or eradication it may be possible to replace the more expensive and sophisticated traps with a cheap and much simpler insecticide impregnated screen or target.

The development of a screen suitable for use against *G. morsitans* and *G. pallidipes* is currently being undertaken in Zimbabwe and its use has been assessed in a small-scale trial on an isolated island in Lake Kariba where eradication was achieved after one year. A larger field trial is now underway covering some 600 km$^2$ of dense tsetse infestation in the Zambezi Valley. The screens are set on a swivel base to allow rotational movement and incorporate a section of transparent fine gauze at each side of the visible black central section. This ensures that inquisitive tsetse, which have no intention of alighting, fly into the netting and receive a lethal dose of insecticide. All screens are provided with acetone and octanol as odour attractants. Placed at a density of three per square kilometre the original populations of both species have been reduced by over 95% in five months. This assessment has been made in the extreme tip of the area where the influence from re-invasion is minimal. Although eradication has not yet been achieved the indications are that screens will, at the very least, provide good control and may be a useful tool in the protection of claimed areas against re-invasion. The advantages of their use are that they are inexpensive, easy to maintain, can be distributed at minimal cost and do not cause environmental contamination.

There is, therefore, an urgent need to pursue the improvement of screen designs, identify attractive odours and to evaluate the method for use against all economically important tsetse species.

**Chemical control**

To date the use of insecticides for the control and eradication of tsetse is the only
proven method available for large-scale use. There are several methods of application and insecticides may be used in either residual or aerosol form.

The selective application of residual insecticides to tsetse habitat using motorised and pneumatic knapsack sprayers has been in extensive use since the early sixties, the insecticides of choice being mainly the chlorinated hydrocarbons, DDT and dieldrin. The method was successful in eradicating large areas of tsetse infestation in Nigeria, Uganda, Kenya and Zimbabwe. It has also been used on a smaller scale in other countries, such as the Cameroons, to augment other methods and to contain re-invasion. Although successfully proven, particularly against the savannah species of tsetse, its use has now declined for possibly two main reasons. It is logistically very demanding, requiring experienced professional staff for the planning of operations and dedicated field staff to ensure efficient execution of the campaign.

There is also a danger of insecticide contamination of the environment and an increase in public concern regarding the use of the most suitable insecticide, DDT. Large-scale campaigns of approximately 8,000 km$^2$ are still undertaken annually in Zimbabwe where the use of the ground spraying technique has resulted in the eradication of tsetse from large tracts of the country. The method is relatively economical; Zimbabwe 1984 costs were 110 US dollars/km$^2$, and, due to a greater understanding of tsetse behaviour, DDT application rates have been reduced to approximately 200 g a.i./ha with no loss in efficiency.

The use of helicopters in applying residual doses of insecticide has been carried out, mainly in West Africa. The method may have some application in the control of savannah tsetse particularly in those areas where long dry hot seasons are experienced and suitable tsetse habitat becomes restricted, usually to water courses. The results from work carried out in the Ivory Coast, the Cameroons and Burkina indicate that more critical studies on tsetse behaviour and movement during the dry season are required in order to identify the areas requiring treatment. Further studies on the behaviour and residual effect of insecticide droplets is also required to ensure sufficient coverage within the target area. The method has the added disadvantage of being relatively expensive with uncontrolled pollution of watercourses.

The non-residual application of insecticide from fixed wing aircraft was first used successfully in Zululand, South Africa, in the nineteen forties. Since then the technique has been considerably improved and has today become the main method of chemical control. The technique is currently suitable for use against savannah tsetse only, as the fine aerosol of insecticide droplets is unable to penetrate dense forest vegetation. Because of the small droplets required for successful operations, v.m.d. of 30 microns or less, treatment can only be carried out during inversion conditions which normally only prevail during the night and for short periods in the evening and morning. In order to further ensure the penetration of the insecticide into the target areas, aircraft are required to fly as close to tree top height as possible. Due to these requirements, areas suitable for treatment have remained restricted but in Botswana, where ideal conditions exist during the winter months, large-scale operations have been undertaken annually over the last ten years and have resulted in a dramatic reduction of the tsetse population with every likelihood of eradication being achieved over the whole 20,000 km$^2$ of infestation in the Okavango delta within the next few years. Similar successful results have been recorded in northern Nigeria, Zambia, the Ivory Coast and Zimbabwe. In Zimbabwe, in 1982, 2,400 km$^2$ of tsetse infestation were treated by this technique, integrated with 4,000 km$^2$ of ground spraying to prevent
re-invasion, with the result that 2 100 km$^2$ were successfully eradicated of $G. morsitans$ and $G. pallidipes$.

Field studies carried out in Zimbabwe from 1982 to 1984 have indicated that fixed wing aerial spraying may successfully be undertaken over fairly undulating and broken terrain providing the swathe widths between the aircraft’s flightpath are kept in the region of 200 m apart. There are also indications that with modification of the insecticide dosage rate and/or a change in formulation it may be possible to achieve eradication from a flying height of up to 150 m above ground level. This area of research is being actively pursued as it would ensure the successful treatment of even more rugged terrain which is currently treated by ground spraying. Due to the lack of suitable alternatives, aerial spraying has become the method of preference for most African countries. It is relatively inexpensive (Zimbabwe 1984 costs were 254 US dollars/km$^2$), results in minimal pollution of the environment and does not require the extensive planning and logistical support of ground spraying.

Further investigations and field trials are required to determine the limits of the technique, to understand more fully the behaviour of droplets within the target area and to effect economy, possibly by reducing flying hours or insecticide application rates. The provision of accurate and sophisticated navigational equipment in the aircraft would further ensure success and perhaps give added safety to the pilots performing low-level night flying.

In concluding this section, mention must be made of the current methods available for the detection of tsetse, for it is from the results of surveys that control operations are planned and their success assessed.

Until recent years, surveys were carried out using baits that were reasonably attractive mainly to the tsetse fly’s sense of sight which is somewhat limited. Some examples are the various traps designed for this purpose, such as the biconical trap used in West Africa and the mobile bait-ox which are generally used for the savannah species. Invariably all these methods tended to show a bias to attracting more of one sex or a certain age of the population. Recent studies of $G. morsitans$ and $G. pallidipes$ behaviour have shown that a much larger number of tsetse are attracted to baits than are actually caught and this has resulted in the design of the more sophisticated odour-baited traps mentioned earlier and in the construction of both mobile and stationary electrocuting devices which allow for the capture of that proportion of the tsetse population which would not normally alight on the visible surface. It is of extreme importance that more sensitive survey equipment be produced for all species in order that control campaigns may be better planned and implemented, and their success accurately evaluated.

**FUTURE PROSPECTS**

Control methods exist which would ensure the eradication of the savannah species of tsetse from Africa providing progressive large-scale operations were possible across international barriers. Many areas have been closed in the past only to be lost again due to the inability of the control agencies to continue operations to natural fly limits. Very often international funding agencies have invested in assisting Governments on small-scale schemes to alleviate crisis situations. In most cases the solution is only temporary due to failure of these agencies to recognise the need for long-term commitments.
Although the development of efficient odour-baited traps and screens may be seen as an exciting prospect for the future, it is envisaged that for effective control and eradication, campaign planners will have to look more to integration of all methods available if optimum results are to be achieved.

LUCHA CONTRA LAS GLOSINAS. — B.S. Hursey.

Resumen: Unas veinte especies de moscas tsé-tsé ocupan un territorio de más de 10 millones de km$^2$ repartidos en 37 estados africanos entorpeciendo la cría de ganado y haciendo correr a 35 millones de seres humanos el riesgo de contraer la enfermedad del sueño.

A pesar de las grandes sumas de dinero gastadas en el transcurso de estos últimos años en proyectos de investigación sobre las moscas tsé-tsé y las tripanosomiasis y los programas de lucha contra estas enfermedades y su vector, poco se ha realizado para combatir este problema.

Éste informe hace una breve descripción de la situación de la infestación por las moscas tsé-tsé y de las técnicas adoptadas para luchar contra estos insectos en los países que nos han enviado su informe.

Se facilita una lista de las distintas técnicas disponibles actualmente para luchar contra las tripanosomiasis y su vector junto con algunos comentarios sobre la aplicación de estas técnicas y su eficacia. Los tratamientos quimioterápicos del ganado que están considerados como medidas temporarias, presentan un inconveniente debido a que existen pocos medicamentos tripanocidas y que su administración a dosis insuficiente conduce al desarrollo de una quimioresistencia en los tripanosomas.

La lucha insecticida contra las moscas tsé-tsé es el único método demostrado, susceptible de ser utilizado en gran escala en la actualidad. Se describen en este informe distintos métodos de aplicación. Entre estos métodos, los preferidos son, o bien la pulverización selectiva por vía terrestre de insecticidas con efecto remanente, o bien el esparcimiento aéreo de insecticidas bajo la forma de aerosoles con efecto no remanente.

Se hace hincapié sobre la necesidad de poner en práctica técnicas de control de las poblaciones de moscas tsé-tsé más sensibles, y a este respecto, las caza-moscas odoríferos y los aparatos móviles de electrocución, en la medida en que serán perfeccionados, ofrecen las más grandes posibilidades.


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