Insecticide-treated cattle for tsetse control: the power and the problems

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Abstract. Trypanosomiasis control increasingly involves financial input from livestock owners and their active participation. If control is carried out on smaller scales than in the past, methods such as aerial and ground spraying and sterile insect techniques will have reduced application. There will be increased reliance on trypanocidal drugs, and bait methods of tsetse control – where flies are attracted to point sources and killed. If drug resistance develops, cheap and simple bait methods offer the only means of disease control that might be applied, and paid for, by stockowners themselves. The methods have been effective in some circumstances, but not in others, and it is important to understand the reasons for the successes and the failures. Analysis is presented of the results of two Tanzanian tsetse control campaigns involving the use of insecticide-treated cattle. Between 1991 and 1996, following the introduction of widespread dipping in the Kagera Region, trypanosomiasis declined from >19 000 cases to <2400 and deaths from >1000 to 29. On four ranches in the region, tsetse have been almost eliminated and trypanosomiasis prophylaxis is no longer used. Similarly aggressive use of pyrethroids on Mkwaja Ranch in Tanga Region has not had such dramatic effects. Tsetse and trypanosomiasis are still common, despite high levels of prophylaxis and the deployment of =200 odour-baited targets. The difference in the results is attributed to a combination of the much smaller area covered by treated animals at Mkwaja, a greater susceptibility to re-invasion and a more suitable habitat for the flies. A better understanding of the dynamics of the use of insecticide-treated cattle is needed before we can predict confidently the outcome of particular control operations.

Key words. Glossina, cattle, pyrethroids, trypanosomiasis, tsetse, Tanzania.

Introduction

Current trends in the control of tsetse (Glossina spp.), strongly influenced by donors, envisage a reduced role for central government. Ownership of livestock is seen as a commercial enterprise and the costs of controlling diseases such as trypanosomiasis should therefore be borne by the stockowner. Thus, the Republic of Zambia (1996) plan for tsetse control and rural development quotes the Zambian Agricultural Sector Investment Programme document as stating that: ‘Private sector and community participation in activities such as target deployment, maintenance, etc. will form the basis for all field level interventions. Drugs used to control the disease will be obtained through the private sector at full cost to the livestock holder.’

This type of policy, typical of those being imposed on African countries as part of larger economic structural adjustment programmes, has implications for the entire approach to tsetse and trypanosomiasis control because of the resulting change of scale. Methods such as aerial and ground spraying and the sterile insect technique (SIT), which may be appropriate over large areas, are inappropriate when applied locally. If, for example, stockowners living in a tsetse area spray 100 ha with DDT they may well kill many tsetse, but re-invasion will be such that disease levels in their cattle will be unaffected. In short, they will simply be wasting time and money.

Policy makers may have understood this point but there is an implication in their proposals that there are alternative methods of tsetse control which can be used successfully on a small
scale. The wording of the Zambian proposal suggests that drug treatment of the disease and/or bait methods (see below) of tsetse control are what the donors have in mind. Indeed, if ground and aerial spraying and SIT cannot be used, it is hard to see what other options exist for disease control. It is therefore important to assess just how well these alternative methods have worked in the past and are likely to work if they are applied by small-scale stockowners.

A detailed discussion of the pros and cons of a complete reliance on the use of drugs is beyond the scope of the present paper but it is noted that: (i) it is quite possible to keep cattle alive on such drugs, even in areas of high trypanosomiasis challenge; (ii) given the progressive decline in the efficacy of tsetse control programmes in most tsetse infested areas in Africa, stockowners rely increasingly on drugs – almost all of which they pay for themselves; (iii) trypanocidal drugs have no direct effect on tsetse. In the event of the development of drug resistance, the trypanosomiasis problem will therefore return. In that event, and given the exigencies referred to above, bait methods appear to be almost the only remaining options for disease control.

Tsetse control currently relies heavily on two bait systems where flies are attracted to, and treated at, point sources. The first is traps and targets, which are composed of fabric sheets treated with insecticide which kills tsetse on contact. The second is insecticide-treated livestock. Both systems have the advantage of causing little direct damage to the environment (Vale, 1993) and of being very effective if applied properly in the appropriate circumstances.

The low reproductive rate of tsetse makes it possible to use evenly spaced odour-baited targets at densities of $\sim 4$ km$^{-2}$ to provide good control, and sometimes eradication, of tsetse populations within 2 years (Vale et al., 1988; Dransfield et al., 1990; Willemsse, 1991). Insecticide-treated cattle have been used, with different degrees of success, to control tsetse and trypanosomiasis. Such operations have been carried out in Zambia (Chizyuka & Liguru, 1986), Zimbabwe (Thomson et al., 1991), Tanzania (Fox et al., 1991, 1993), Kenya (Stevenson et al., 1991), Burkina Faso (Bauer et al., 1992, 1995, 1999) and Ethiopia (Leak et al., 1995).

From the point of view of policy makers, the major advantages of bait methods are that they are relatively cheap (Barrett, 1994) and simple to apply. They could therefore, in principle, be carried out and paid for by stockowners themselves. Just as highly localized ground or aerial spraying is a waste of time (Hargrove, 1998), however, it is equally senseless for farmers in the middle of an extensive tsetse belt to deploy insecticide-treated targets around their houses, or to apply insecticide to small numbers of cattle.

Words such as ‘small-scale’, ‘localised’, ‘small numbers’ and ‘extensive’ have been used above in a deliberately vague fashion because there has been little consideration of the effects of scale on the efficacy of various tsetse control methods in general, and on bait methods in particular. Nor do we know how local climate and vegetation affects the outcome of localized tsetse control operations. We do not therefore know the circumstances under which it is worth a livestock owner attempting to control trypanosomiasis using bait methods or, alternatively, where this is a waste of time, effort and money.

The present paper looks at the outcome of two tsetse control campaigns in Tanzania involving the use of insecticide-treated cattle. The very different outcomes of the two campaigns suggest that the above concerns are of practical importance.

Results

Karagwe District (Kagera Region, north-west Tanzania)

Situation in 1992. The assumed tsetse situation in the Bukoba and Karagwe Districts in 1992 is shown in Fig. 1 (Kagera Regional Office, 1992). Between 1988 and 1993 more than 16,000 cattle were infected annually with trypanosomiasis and 460–990 cattle died of the disease annually (25–50% of the total deaths due to all tick-borne diseases). There were 24 new cases of human sleeping sickness reported in the Kagera Region between 1983 and 1992. This serious situation prevailed despite the huge amounts of money spent in the past on bush-clearing, game destruction and ground and aerial spraying of insecticides. These efforts had generally not been successful due to re-invasion of areas that had not been settled following the application of tsetse control measures.

Situation after 1992. Following trials involving the use of pyrethroids on livestock in Zimbabwe (Thomson, 1987; Thomson & Wilson, 1992a, b), on Mkwaja Ranch in the Tanga Region (Fox et al., 1993) and elsewhere (Thomson et al., 1991), the Karaga Livestock Development Programme (KALIDEP) began trials of their own in the Kagera Region in 1991. By 1997 the number of cases, of animal trypanosomiasis had declined from 19300 to 2383 (Fig. 2) and deaths from 730 to 29. The number of deaths had reached a peak of over 2000 in 1986. These figures represent numbers of animals showing clinical symptoms of trypanosomiasis rather than microscopic or biochemical diagnoses. Moreover, some cases of trypanosomiasis will have been undiagnosed or unreported, and the under-reporting may have differed from year to year. Nonetheless, there has obviously been a major decline in true levels of trypanosomiasis in the past decade, and there have been no reported cases of sleeping sickness in the Bukoba or Karagwe Districts since 1992.

These changes in trypanosomiasis are strongly correlated with the introduction of pyrethroids as a means of controlling tsetse and other biting flies. The biggest user in the Kagera region is the National Ranching Company (NARCO), who first used Decatix® (0.00375% deltamethrin) for cattle treatment on Kitengule Ranch in 1991/92. At the same time the Ranch management decided to stop using Samorin® for routine prophylaxis of cattle against trypanosomiasis. Not surprisingly, because the animals had no protection against infection, there was an increase over the next 2 years in the number of cattle requiring trypanocidal treatment drugs – Berenil®, Ethidium® or Novimid® (Fig. 3) – but the requirement even for these drugs has decreased consistently since 1994.

There was actually a decrease on Kitengule Ranch in the requirement for these drugs in 1990/91, before pyrethroids had
Fig. 1. Probable distribution of tsetse in Bukoba and Karagwe Districts, Kagera Region, Western Tanzania. The four NARCO State Ranches are Missenyi, Kitengule, Kikulwa and Kagoma. Prior to 1992, tsetse were abundant in all areas indicated as low density.
Fig. 2. Trypanosomiasis prevalence and spending on trypanocidal drugs and pyrethrroids in Kagera Region, Western Tanzania.

Fig. 3. The consumption of trypanocidal drugs and pyrethrroids on Kitengule ranch, Karagwe District, Western Tanzania.

been introduced, but when the cattle were still on Samorin® (Fig. 3). This may be related to the fact that KALIDEP had started using pyrethrroids in the neighbourhood of the ranch during that year. Possibly, also, owners of indigenous cattle may have been ahead of both KALIDEP and the ranch owners in their appreciation of the importance of pyrethrroids like Decatix®. There is evidence that some stockowners started importing the chemical from Uganda as early as 1988 (Okali et al., 1997).

A particularly impressive change in the tsetse population was seen in a refugee camp (Burigi TCRS) in 1993–94 following the regular dipping of 6000 head of cattle in the area with deltamethrin. The tsetse population declined exponentially over a 12-month period (Fig. 4a). Trypanosomiasis levels declined more slowly for the first 6 months then crashed to zero and remained there for the remainder of the study period (Fig. 4b). The owners and their cattle have since returned to Rwanda and the area has been re-invaded by tsetse.

The reduction in trypanosomiasis in Kagera has occurred despite a fall in expenditure on trypanocides from US$257 000 to US$5 000 (52 to 9 million Tshs; Kalidep, 1996; p. 117).
Fig. 5. Mkwaja Ranch, Tanga Region, Eastern Tanzania.

Fig. 6. The estimated distribution of cattle herds on Mkwaja Ranch, Tanzania in 1991. The solid line in the interior of the figure shows the boundary of the ranch. Each cell denotes 1 km² and the number in that cell is the estimated percentage probability that a herd of cattle (average herd size = 150) will graze in that area on any particular day. The blank cells at the bottom right of the figure denote the coastline of the Indian Ocean at the south-east extremity of the ranch.

Spending on pyrethroids has increased from zero to US$116,000 (67 million Tshs at the 1996 official exchange rate) over the same period (Fig. 2). There has thus been a substantial saving in terms of foreign exchange. Pyrethroids are, moreover, used also as acaricides, which would continue to be used even if trypanosomiasis disappeared completely. Only part of the pyrethroid cost should thus be attributed to the trypanosomiasis problem, which is now so small that some ranches have started to use cheaper acaricides that do not kill tsetse. Finally, no allowance has been made for the improvements in cattle productivity and condition resulting from the removal of trypanosomiasis (cf Fox et al., 1993) and the cessation of Samorin treatment.

Although detailed tsetse surveys have not been carried out in the Kagera Region, it seems that Glossina morsitans centralis Machado and G. pallidipes Austen have been eradicated over a large proportion of Bukoba and Karagwe (Fig. 1). On the ranches, certainly, tsetse numbers are now so low that they do not pose a threat to herds of animals routinely treated with pyrethroids. On Kitengule, for example, no Samorin has been used since 1992 but only 10 animals were treated for trypanosomiasis in 1996–97, compared with >10,000 in 1988–90. Similar changes have occurred on the other ranches and interviews with stockowners in areas near the ranches likewise indicate a sharp decline in trypanosomiasis challenge. In almost every case, owners have been using Decatix for extended periods since 1990.
**Discussion**

**Experience from other pour-on trials**

The two Tanzanian operations provide an interesting but disturbing contrast. Given only the results from the Kagera Region, one might conclude that insecticide-treated cattle provide a panacea for low-cost tsetse eradication. The results from Mkwaja warn that the matter is not entirely clear-cut. Baylis & Stevenson (1998) cite other examples of pour-on control operations that have encountered difficulties. They themselves found that, relative to a control area, the application of 50,000 doses of Spot On™ (1% deltamethrin) to cattle at Dakabuku, Galana Ranch, Kenya, produced little effect on the apparent densities of two species of tsetse. The reduction in trypanosomiasis was, however, more marked and they cited similar results from the work of Leak et al. (1995) in Ethiopia. An attempt to use treated cattle as a barrier to tsetse re-invasion from Mozambique into north-eastern Zimbabwe was also unsuccessful. Warnes et al. (1999) treated 5400 cattle at two-weekly intervals in an area of 428 km², but the area was nonetheless rapidly invaded and there was a serious deterioration in the disease situation.

It is important to understand precisely why fly populations were poorly controlled in some areas, but more successfully elsewhere, such as in Zimbabwe (Thomson et al., 1991) and in several campaigns in Burkina Faso (Bauer et al., 1992, 1995, 1999). Although we are not in the position to answer this question unequivocally in each of the cases cited, a comparison of the two Tanzanian studies provides some pointers to what may be important factors.

**Possible reasons for the differences in pyrethroid efficacy in Kagera and Tanga Regions**

The use of pyrethroids in Kagera has probably been particularly successful because there has been prolonged and regular dipping on the ranches, which cover a large proportion (>2000 km²) of one arm of the local tsetse belt. There has also been widespread, although less methodical, use of pyrethroids in areas adjacent to the ranch. Finally, the area is protected from re-infection from the west by the Karagwe Escarpment and from the east by heavy settlements that are tsetse-free. Re-infection can thus come only from two directions, which makes it easier to keep the region secure once the local tsetse population has been removed.

By contrast, the area grazed by treated cattle at Mkwaja is <100 km² (Figs 5 and 6). In areas adjacent to the ranch there is no organized dipping, and pyrethroids are less widely used, so that the ranch is subject to re-invasion from all sides except from the sea to the east. Re-invasion was similarly cited by Leak et al. (1995) as a possible reason for failure to eradicate tsetse, and hence trypanosomiasis, from an area of >200 km² in the Ghibe valley of Ethiopia. The area treated by Baylis & Stevenson (1998) was smaller yet than Mkwaja and it is therefore scarcely surprising that there was at best a modest effect on the tsetse population.

![Fig. 7. The trypanosomiasis situation on Mkwaja Ranch, Pangani, Tanga Region, Eastern Tanzania. (a) Herd size, (b) trap catches of tsetse flies (mostly G. pallidipes) from odour-baited Ng out traps, (c) consumption of trypanocidal drugs.](image-url)
The bigger reductions in tsetse number in the pour-on operations of Bauer et al. (1992, 1995) may be due in part to the larger areas involved (500–1000 and 1400 km², respectively). Bauer et al. (1999) did effect >90% decreases in apparent tsetse densities in an area of only 400 km² but, in addition to treating up to c. 7000 cattle with insecticide, they also deployed 1500 insecticide-treated targets in the area. We do not know, therefore, the relative importance of the targets and the treated cattle in the resulting reductions in fly populations and disease levels.

The study area used by Warnes et al. (1999) was approximately the same size as that of Bauer et al. (1999), but tsetse control using treated cattle alone was considerably less successful in the former situation. Odour-baited targets at a density of 4–5 targets/km² did, however, provide an effective barrier prior to the treated-cattle trial, and targets were used to retrieve the situation after that trial had ended.

Differences in tsetse control efficacy between different programmes may not be entirely due to levels of re-invasion. Indeed it is difficult to assess the importance of this factor because none of the works cited produced quantitative information regarding the levels of tsetse in areas surrounding the treatment sites. In the Zimbabwe barrier trial, Warnes et al. (1999) point out that, although the mean density of treated cattle was at the level recommended for such an operation (Bauer et al., 1992), the patchy cattle distribution reduced their efficacy.

In the case of Mkwaja, maps of vegetation and cattle distribution (Figs 5 and 6) show that, even on the ranch, there are extensive thickets that are not penetrated by the treated cattle but that harbour populations of warthog, bushpig and other favoured tsetse hosts. The Tanga climate, hotter and wetter than in the area of the NARCO ranches in Karagwe, is also probably more favourable for tsetse. The higher temperatures ensure optimal birth rates, and the high humidity should ensure low death rates.

Practical conclusion regarding the Tanzanian campaigns

Pyrethroids have been applied regularly, for 9 years, to between 8000 and 13 000 animals on Mkwaja Ranch and the trypanosomiasis problem is so severe that frequent treatments with Samorin and Berenil are still required (Fig. 7c). There is therefore every reason to suppose that the use of pyrethroids on a smaller scale in ecologically similar parts of Tanga Region would be even less successful. It would therefore be unwise for small-scale livestock keepers in that area to spend money on pyrethroids if their sole intention is to reduce trypanosomiasis levels in their cattle. There is thus an urgent need for research into the question of what livestock keepers in the region can do, on their own account, to combat the trypanosomiasis problem.

The way forward

Analysis of the studies cited above, and of the present results from Tanzania, suggests several factors which could affect the outcome of tsetse control campaigns involving the use of treated cattle: (i) scale effects and, particularly, rates of re-invasion; (ii) the topology of the treated area and, particularly, of the untreated tsetse habitat in and around it; (iii) the ecological suitability of the treated (and surrounding) area for tsetse. The ratio of game to livestock and, hence, the proportion of bloodmeals taken from livestock should affect success, but this ratio was unknown in the present instance.

When the technique is used by small-scale cattle owners other factors will also become important: (i) herd structure and size; (ii) cattle management practices and, hence, tsetse-cattle contact. Practices vary enormously between pastoralists, ranchers, and keepers of zero-graze animals. (iii) Ability and willingness of stockowners to buy and use insecticides.

Studies currently being undertaken in Zimbabwe and Tanzania aim to quantify the effects of as many as possible of the above variables. These data are being used to develop predictive models to describe the relationship between cattle distribution, tsetse–cattle contact and tsetse population dynamics. In particular, the models investigate the effects of scale on rates of tsetse control and of re-invasion. Computer modelling already carried out supports the conclusion that the use of treated cattle in areas of about the size of Mkwaja Ranch may be expected to face problems due to re-invasion (Vale et al., 1999). The continuation of experimental and theoretical studies of this type is of obvious importance if we are to understand fully the limits of the power of insecticide-treated cattle as agents for trypanosomiasis control.

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