Prospects for controlling trypanosomosis

G.A. VALE

Southern African Centre for Epidemiological Modelling and Analysis
University of Stellenbosch, Stellenbosch

ABSTRACT

VALE, G.A. 2009. Prospects for controlling trypanosomosis. *Onderstepoort Journal of Veterinary Research*, 76:41–45

The best technical package for the future comprises trypanocidal drugs for temporary relief and the use of insecticide-treated cattle, artificial baits and aerial spraying to attack the vector, to so give more lasting security. Whether this can speed the previously slow progress will depend on overcoming past hindrances to tsetse control: sporadic support, disputes over its desirability, difficulties of sustaining international operations, and poor planning in some instances. The Pan-African Tsetse and Trypanosomiasis Campaign intends to speed the progress but will fail unless it improves its image by breaking its association with the sterile insect technique and quickly executing some cheap and effective operations in large areas. Even then, there could be severe brakes due to Africa's political and financial instability. Overall, the pace of control is likely to increase, but perhaps only a little.

INTRODUCTION

A century ago, when Onderstepoort Veterinary Institute began, Bruce (1895) had already shown that tsetse transmit the trypanosomes that cause the usually fatal diseases of nagana in livestock and sleeping sickness in humans. His work, in Zululand, raised the prospect of overcoming these diseases that severely limit African heath, agriculture and transport. Since then we have found several trypanocidal drugs but their use alone is problematic (Barrett, Coombs & Mottramm 2004): there is widespread resistance to the veterinary prophylactics, for humans there is no prophylactic and the curatives are dangerously toxic. These difficulties and the apparent impossibility of developing a vaccine and the logistical problems of restocking with the few trypanotolerant breeds of cattle, mean that trypanosomosis is best tackled by controlling tsetse, with drugs as temporary expedients. Much has been done to implement various methods of tsetse control, but the flies continue to occupy $\pm$ 10 million km^2 (Rogers & Robinson 2004), much as in Bruce's time.

The present essay addresses the prospects for better progress by discussing the available techniques, the scale and organization of their implementation, and ways of improving these matters.

TECHNIQUES

The widespread application of residual insecticide is now unacceptable. Host destruction and bush clearing are also outmoded as deliberate tactics, but will continue *de facto* due to wider and denser settlement (Jordan 1986). The main options, and their pros and cons, are as follows:

Sequential aerial spraying

This technique involves 4–5 applications of non-residual insecticide, sprayed in the cool season to foster descent of droplets (Allsopp & Hursey 2004). Excellent results are possible, especially with the newly improved methods of aircraft guidance, and large areas can be tackled quickly (Kgori, Modo & Torr 2006), but the aircraft must fly low at night, precluding application in mountainous terrain. Moreover, the technique gives no protection against invasion, and establishment costs are substantial, so that operations in less than about 1 000 km^2 are uneconomic.

Baits

Stationary artificial baits (Vale & Torr 2004) consist of either traps or pyrethroid-coated screens, i.e. targets. Traps are costlier than targets and less efficient, but since they retain the flies they are useful for surveys. With the savannah species of tsetse the performance of traps and targets is enhanced many times by adding the odour attractants identified from cattle, but the riverine species respond poorly to odours. Pyrethroid can also be applied to cattle, whose wanderings enhance fly-bait contact. The cost-effectiveness of cattle treatment is improved by restricting application of insecticide to where most tsetse feed, i.e. the legs and belly of larger animals (Torr, Maudlin & Vale 2007). Baits can form barriers to invasion (Hargrove 2003) but cattle are useable only where they occur, and targets can be stolen.

Sterile insect technique (SIT)

This technique releases sterile males to swamp wild males and so reduce breeding (Feldmann 2004). However, SIT demands the costly and lengthy establishment of large and complex rearing facilities, and requires insecticidal campaigns to suppress the wild tsetse population prior to sterile male release. Moreover, control by reducing the breeding of the long-lived tsetse is inherently much slower than killing the pest (Vale & Torr 2005).

FIELD COSTS

Tables of costs should be viewed cautiously since they can misleadingly compare techniques used for distinctive purposes under different conditions, and with various costing procedures. Standardizing on the basic field costs of government-run clearance of an isolated population of savannah tsetse, the costs are 761 US$/km^2 for SIT, $380 for aerial spraying, $283 for artificial baits, $56 for whole body spraying of 8 cattle per km^2 and $12 if application is restricted to the legs and belly (Shaw, Torr, Waiswa & Robinson 2006). The high costs of SIT are greater if the suppression expenses are added, and would rise further if mixed infestations were tackled, requiring the release of sterile males of each species present.

CHOICE OF TECHNIQUES

Given that insecticidal methods are relatively cheap and simple, and that their efficacy is proven by their clearance of huge areas (e.g. Torr, Hargrove & Vale 2005; Kgori *et al*. 2006), it is best to employ only those techniques. They should be used according to the following rules:

- If the operational area is not isolated, make it so by an invasion barrier of baits. Then, to eliminate the isolated population, put insecticide on cattle if these are present. If not, then:
  - If the area is fairly flat and greater than about 1 000–2 000 km^2, use aerial spraying, especially if there is a risk of target theft.
  - If not, use targets.
- If a campaign employs a mosaic of control methods to suit varying terrain and land use, run the techniques to produce a synchronized effect, so that tsetse movement does not allow some flies to avoid treatment by any method. Natural and artificial baits are the most compatible since they can be applied at any season to work at similar speeds. Combining baits with aerial spraying may require the partial overlapping of treated areas.
- Have targets ready to deploy promptly in any residual pocket left after aerial spraying, before the pocket expands.

PLANNING

Whatever techniques are used, their timing, location and intensity must be planned with a ‘feel’ for the population dynamics of tsetse. Problems resulting from the absence of such a feel are exemplified by the aerial spraying of the 25 000 km^2 of the Okavango Delta, Botswana, in 18 years from 1973–1991 (Hargrove 2003). Annual campaigns were piecemeal, with inadequate attention to the routes and rates of reinvasion. Hence, there was a poor effect until the better planning in 2001/02, with targets placed for an effective invasion barrier (Kgori *et al*. 2006). To strengthen the prospects for good planning elsewhere, we might encourage the use of user-friendly models of tsetse populations (www.tsetse.org). For example, one such model has compared the cost-effectiveness of SIT and insecticidal methods (Vale & Torr 2005), drawn lessons from the results of the recent spraying and target campaigns in Botswana (Kgori *et al*. 2006) and helped to predict the costs of all control methods (Shaw *et al*. 2006).

IMPLEMENTATION

Tsetse control has been implemented on a range of scales, by a variety of agencies, but it consists of just two basic set-ups. *Firstly*, there are large campaigns run by governments, often with donor funds, to clear many thousands of square kilometers. *Secondly*, the development of cheap and relatively simple bait techniques has allowed smaller self-help schemes (Dransfield & Brightwell 2004). The relative merits of each set-up depend first on the appropriate scale of operations.

SCALE

For any single technique applied in one area, the fixed overheads mean that the costs per unit area decline as the operation becomes larger. However, when operational areas are small, they usually cover settlements where insecticide-treated cattle are appropriate for control. Expansion from such areas will embrace unsettled places where the more costly aerial spraying or targets are needed. Then there are the establishment costs for more than just one technique. Moreover, ground access must be developed and maintained for any technique in unsettled places—for the associated surveys and monitoring if not necessarily for the control measures themselves. Hence, the average costs per unit area tend to increase with the scale of control. Conversely, the more the operations embrace unsettled areas, or places where livestock farming is inherently unproductive, the less the average benefit per unit area. The upshot is that the sustainable use of the cheaper control methods is beneficial in highly productive settlements (Shaw 2004). Operations nearby can be justified to counter invasion, but wider control is uneconomical—and downright damaging when it encourages unregulated settlement where wildlife enterprises are the appropriate land users (Cumming & Lynam 1997).

Against these arguments for limited control, larger campaigns have the benefit of clearing more of the invasion sources, thereby offering a more permanent solution. Indeed, the technical ideal is the clearance of whole fly-belts, removing forever the invasion threat. Hence, lively debate arises about the required scale of control (DFID 2003). For now a compromise is needed: the only large unsettled areas that should be tackled are those that will not be damaged by land use change and which can be conveniently held against invasion, as exemplified by the recent work in Botswana (Kgori *et al*. 2006). Elsewhere, less ambitious schemes would be appropriate. The balance within this compromise will be determined by the support given to the distinctive types of implementing agency involved.

Agencies

Progress towards fly-belt clearance requires international coordination and donor help. The possibilities were explored as one aim of the Regional Tsetse and Trypanosomosis Control Programme (RTTCP) for Malawi, Mozambique, Zambia and Zimbabwe, started in 1986 with EC support. The technical option to clear the 380 000 km^2 of the fly-belt common to all four countries was proved, but it was confirmed as neither practicable nor worth it in the foreseeable future. Hence, the RTTCP wound down in the late 1990s (RTTCP 1999). Another chance for international co-operation originated in the technical success of SIT on Unguja Island (Vreysen, Saleh, Ali, Abdulla, Zhu, Juma, Dyck, Masangi, Mkonyi & Feldmann 2000) and the publicity given to it by the International Atomic Energy Agency (IAEA). Subsequently, the SIT Forum was created with IAEA encouragement, and lobbied successfully for the establishment of the Pan-African Tsetse and Trypanosomosis Eradication Campaign (PATTEC) in 2000, supported by the African Union and aimed at rapid continental clearance. A SIT laboratory is already built in Ethiopia and more are discussed (Enserink 2007). However, many of the traditional donors for tsetse control believe that the aims of PATTEC are not achievable, and that even large national operations should not be supported (DFID 2003).

Even if marked progress towards continental clearance were made by PATTEC, or via an accumulation of separate government campaigns, it would take many decades to achieve. Hence, we must learn now to cope better with tsetse locally, in ways sustainable with little or no external funding. Much of the focus is therefore on the cheapest and simplest options, i.e. baits, implemented by ranches and local communities (Dransfield & Brightwell 2004). The restricted application of insecticide to cattle is the most promising bait method, not simply because it is much cheaper but also because cattle usually occur in the very districts where trypanosomosis is an immediate problem.

However, self-help is hindered by beliefs, from precedent, that tsetse control is a government responsibility. Specialist help is required with planning, monitoring and procurement. Moreover, where invasion is a problem there is a limit to how small an area can be tackled effectively. This explains why in Tanzania the National Ranching Company could use insecticide-treated cattle successfully in 2500 km^2 of the Kagera Region, whereas the technique was less successful on Mkwaja Ranch that was a tenth of the size, with cattle in only part of the area (Hargrove 2003). Therefore, to minimize any invasion problem, the area treated by one local community should adjoin those of other communities, governments or PATTEC.

COST REDUCTION

With any implementing agency, and at any scale, the prospects for support depend largely on reducing the costs—not just the field costs quoted above, but also the overheads. Shaw *et al*. (2006) estimated the overheads to be 213–240 US$/km^2 for a full complement of administration, surveys, monitoring, ecological impact assessments and socio-economic studies. However, while the administrative and survey costs are unavoidable for sound planning and management, the other cost components are usually deemed necessary only with schemes run largely through governments and donor funding. Hence, opportunities for cost reduction occur not only via the coordination of public and private attacks on adjacent infestations but also by partnerships in which the private sector implements control in its particular area and governments offer there the minimum of specialist help with planning, surveys and public health matters. Such a system is now established in Uganda (Kabasa 2007). This involves the restricted application of insecticide to 37000 head of cattle in five districts covering a total of 10 000 km^2. It is particularly exciting since treatment expenses have been reduced to just two US cents per animal per month, even when private vets are paid to assist, so that field costs are around $1 per km^2 per year.

However, in areas where invasion pressure is more serious, it would be necessary to employ baits as invasion barriers, the basic costs of which in government-run schemes are around 120 US$/km^2 protected per year if artificial baits are used, or about $22 if insecticide-treated cattle are employed (Shaw et al. 2006). While treated cattle are by far the cheaper, they are at permanent risk of trypanosomosis near the invasion front—tsetse alighting on treated cattle usually feed before dying and so can transmit disease. Thus, targets are technically better as barriers. How, then, could target costs be lowered towards those for cattle treatment? The performance of odours to use with targets for savannah tsetse might be doubled by identifying the complete range of attractants in cattle odour (Torr, Mangwiro & Hall 2006). We need to re-check the apparently poor response of riverine tsetse to odours—it being expected a priori that odours would be important in habitats where visibility is poor. Moreover, it was recently shown that for riverine tsetse in Kenya the normal target size, i.e. 1 m^2, can be reduced to 1/16 with only a halving of effectiveness (Jenny Lindh, personal communication). This raises the possibility of deploying handkerchief-sized baits that are cheap, disposable and bio-degradable.

Therefore, in overview, while we cannot guarantee continental clearance of tsetse in the next 100 years, we now have the prospects of effective compromise and cooperation, of being freer of trypanosomosis where immediately needed, and of improving the technologies and implementation arrangements that can help most.

ACKNOWLEDGEMENTS

The author thanks Dr Alexandra Shaw and Proff. D. Cumming, J. Hargrove, I. Maudlin and S. Torr for comments on the draft.

REFERENCES

ALLSOPP, R. & HURSEY, B.H. 2004. Insecticidal control of tsetse, in *The Trypanosomiases*, edited by I. Maudlin, P.H. Holmes & M.A. Miles. Wallingford: CABI.

BARRETT, M.P., COOMBS, G.H. & MOTTRAMM, J.C. 2004. Future prospects for chemotherapy of trypanosomiasis, in *The Trypanosomiases*, edited by I. Maudlin, P.H. Holmes & M.A. Miles. Wallingford: CABI.

BRUCE, D. 1895. *Preliminary report on the tsetse fly disease or nagana in Zululand*. Durban: Bennet & Davis.

CUMMING, D.H.M & LYNAM, T.J.P. 1997. Land use changes, wildlife conservation and utilization, and the sustainability of agro-ecosystems in the Zambezi Valley. *Final technical report,* Vol. 1. Harare: WWF.

DRANSFIELD, R.D. & BRIGHTWELL, R. 2004. Community participation in tsetse control: the principles, potential and practice, in *The Trypanosomiases*, edited by I. Maudlin, P.H. Holmes & M.A. Miles. Wallingford: CABI.

DFID 2003. Tsetse control: the next 100 years. *DFID Animal Health Programme.* Centre for Tropical Veterinary Medicine, University of Edinburgh, UK.

EINSERINK, M. 2007. Welcome to Ethiopia's fly factory. *Science*, 317:310–313.

FELDMANN, U. 2004. The sterile insect technique as a component of area-wide integrated pest management of tsetse, in *The Trypanosomiases*, edited by I. Maudlin, P.H. Holmes & M.A. Miles. Wallingford: CABI.

HARGROVE, J.W. 2003. Tsetse eradication: sufficiency, necessity, and desirability. *Research report, DFID Animal Health Programme.* Centre for Tropical Veterinary Medicine, University of Edinburgh, UK.

JORDAN, A.M. 1986. *Trypanosomiasis control and African rural development*. London: Longman.

KABASA, J.D. 2007. Public-private partnership works to stamp out sleeping sickness in Uganda. *Trends in Parasitology*, 23: 191–192.

KGORI, P.M., MODO, S. & TORR, S.J. 2006. The use of aerial spraying to eliminate tsetse from the Okavango Delta of Botswana. *Acta Tropica*, 99:184–199.

ROGERS, D.J. & ROBINSON, T.P. 2004. Tsetse distribution, in *The Trypanosomiases*, edited by I. Maudlin, P.H. Holmes & M.A. Miles. Wallingford: CABI.

SHAW, A.P.M. 2004. Economics of African Trypanosomiasis, in *The Trypanosomiases*, edited by I. Maudlin, P.H. Holmes & M.A. Miles. Wallingford: CABI.

SHAW, A.P.M., TORR, S.J., WAISWA, C. & ROBINSON, T. 2006. Comparable costings of alternatives for dealing with tsetse: estimates for Uganda, in *ICOPA,* XI:589–592.

RTTCP 1999. *Annual report for 1999*. Harare: RTTCP.

TORR, S.J., HARGROVE, J.W. & VALE, G.A. 2005. Towards a rational policy for dealing with tsetse. *Trends in Parasitology*, 21:537–541.

TORR, S.J., MANGWIRO, T.N.C. & HALL, D.R. 2006. The effects of host physiology on the attraction of tsetse (Diptera: Glossinidae) and *Stomoxys* (Diptera: Muscidae) to cattle. *Bulletin of Entomological Research*, 96:71–84.

TORR, S.J., MAUDLIN, I. & VALE, G.A. 2007. Less is more: restricted application of insecticide to cattle to improve the cost and efficacy of tsetse control. *Medical and Veterinary Entomology*, 21:53–64.

VALE, G.A. & TORR, S.J. 2004. Development of bait technology to control tsetse, in *The Trypanosomiases*, edited by I. Maudlin, P.H. Holmes & M.A. Miles. Wallingford: CABI.

VALE, G.A. & TORR, S.J. 2005. User-friendly models of the costs and efficacy of tsetse control: application to sterilizing and insecticidal techniques. *Medical and Veterinary Entomology,* 19:293–305.

VREYSEN, M.J.B., SALEH, K.M., ALI, M.Y., ABDULLA, A.M., ZHU, Z.R., JUMA, K.G., DYCK, V.A., MASANGI, A.R., MKONYI, P.M. & FELDMANN, U. 2000. The use of the sterile insect technique (SIT) for the eradication of the tsetse fly *Glossina austeni* (Diptera: Glossinidae) on the Island of Unguja (Zanzibar). *Journal of Economic Entomology*, 93: 123–135.