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User-friendly models of the costs and efficacy of tsetse control: application to sterilizing and insecticidal techniques

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Abstract. An interactive programme, incorporating a deterministic model of tsetse (Diptera: Glossinidae) populations, was developed to predict the cost and effect of different control techniques applied singly or together. Its value was exemplified by using it to compare: (i) the sterile insect technique (SIT), involving weekly releases optimized at three sterile males for each wild male, and (ii) insecticide-treated cattle (ITC) at 3.5/km^2. The isolated pre-treatment population of adults was 2500 males and 5000 females/km^2; if the population was reduced by 90%, its growth potential was 8.4 times per year. However, the population expired naturally when it was reduced to 0.1 wild males/km^2, due to difficulties in finding mates, so that control measures then stopped. This took 187 days with ITC and 609 days with SIT. If ITC was used for 87 days to suppress the population by 99%, subsequent control by SIT alone took 406 days; the female population increased by 48% following the withdrawal of ITC and remained above the immediate post-suppression level for 155 days; the vectorial capacity initially increased seven times and remained above the immediate post-suppression level for 300 days. Combining SIT and ITC after suppression was a little faster than ITC alone, provided the population had not been suppressed by more than 99.7%. Even when SIT was applied under favourable conditions, the most optimistic cost estimate was 20–40 times greater than for ITC. Modelling non-isolated unsuppressed populations showed that tsetse invaded ~8 km into the ITC area compared to ~18 km for SIT. There was no material improvement by using a 3-km barrier of ITC to protect the SIT area. In general, tsetse control by increasing deaths is more appropriate than reducing births, and SIT is particularly inappropriate. User-friendly models can assist the understanding and planning of tsetse control. The model, freely available via http://www.tsetse.org, allows further exploration of control strategies with user-specified assumptions.

Key words. *Glossina*, insecticide-treated cattle, mathematical model, population dynamics, sterile insect technique, tsetse, tsetse control, Africa.

Introduction

Strategies for controlling several insects of medical and veterinary importance are based on mathematical models. The Ross–Macdonald model (Ross, 1911; Macdonald, 1957) and its elaborations (e.g. Anderson & May, 1991; Smith & Ellis McKenzie, 2004) rationalized strategies to control malaria for more than 50 years. More recently, population models of *Aedes aegypti* L. (Focks *et al*., 1993a, b; Maguire *et al*., 1999) and *Lucilia sericata* Meigen (Fenton *et al*., 1999; Wall *et al*., 2000) have helped to design strategies for controlling dengue and sheep strike. Paradoxically, however, the control of tsetse-borne trypanosomiasis has not been generally guided by models, even

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