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Modelling the Use of Insecticide-Treated Cattle to Control Tsetse and *Trypanosoma brucei rhodesiense* in a Multi-host Population

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T. b. rhodesiense is the acute form of African human trypanosomiasis or sleeping sickness which is common in East and Southern Africa. Trypanosomiasis is caused by the parasite *Trypanosoma brucei* and transmitted by tsetse flies (genus *Glossina* spp). Trypanosomes are multi-host parasites capable of infecting a wide range of domestic and wildlife species, which constitute a reservoir for human infections. In domesticated animals clinical cases have been detected in cattle, water buffalo, sheep, goats, camels, horses, donkeys, alpacas, llamas, pigs, dogs, cats and other species. In wild animals clinical cases have been detected in bushbuck, duiker, giraffe, impala, lion, warthog, waterbuck, zebra and other species. In most parts of Africa, cattle are the main species affected, tsetse preferring to feed on them rather than on smaller domesticated animals such as goats and pigs.

The control of Trypanosomiasis is based on case finding and treatment, coupled with tsetse control. Treatment of livestock in sub-Saharan Africa with trypanocidal drugs has been hindered by drug resistance and proves to be too expensive for many farmers. Treatment of human sleeping sickness is also expensive, normally ranging from US$150 to US$800 per patient, depending on the stage of the infection. Tsetse control methods include aerial and ground spraying, sterile insect technique, and bait technology, including the use of insecticide-treated cattle (ITC). Bait technology methods cause little damage to the environment and are very effective if applied properly in appropriate circumstances (1,2). There has been an increasing emphasis in sub-Saharan Africa on getting farmers to control tsetse and animal trypanosomiasis themselves, instead of relying on governments or donor organisations. The only feasible techniques that can be taken up by farmers as self-help schemes are bait methods, and the most cost-effective of these is the use of ITC in tsetse infested areas where cattle provide a substantial proportion of tsetse blood-meals.

Tsetse Feeding Preference and ITC

Since its inception, the ITC approach has been refined through the demonstration that it is not necessary to treat every animal in a herd since tsetse feed preferentially on larger animals in a herd. Tsetse find it hard feeding on young cattle due to their higher defensive movements. Moreover, field observations show that tsetse feed preferentially on the legs and belly of these larger, generally older, cattle. By restricting the application of insecticides to these locations, and to the ears where ticks accumulate, the amount of insecticides required for tsetse and trypanosomiasis can be reduced, and simultaneously provide tick control. This restricted application approach thereby provides financial benefits to the farmers, can cater both tsetse and tick control at the same time so farmers do not need to worry about the latter, and helps to allay concerns about the environmental impact of insecticide use (1,3-5).

The impact of ITC on the transmission of trypanosomiasis

We considered two techniques of application of insecticides on cattle: whole-body (WB), where insecticides are applied on the entire animals body and restricted application (RAP), where insecticides are applied on the legs, belly and ears of the animal.

To compare the two techniques, we used a mathematical model that allow tsetse to feed on a population of *n* different host species. Cattle are assumed to be treated with insecticides at a constant rate with either the WB or RAP technique. For numerical results, the model was reduced to 3 host species, that is, cattle, humans and wildlife.

Numerical results show that in areas where tsetse vectors predominantly feed on cattle, keeping 21% or 27% of the cattle population on insecticides per day using WB or RAP approaches, respectively, can potentially reduce the basic reproduction number to less than one and therefore, lead to the control of *T. b. rhodesiense.* The duration of insecticide efficacy was taken to be 4 weeks, which is the same as the waning of the insecticidal effect. For both treatment strategies, the proportion of animals needing to be treated with insecticide per day decreases with the increase in the efficacy of insecticides.

Effect of ITC on the tsetse population

For both WB and RAP strategies, there are significant decreases in the tsetse population. The results reflect a situation where birth is the predominant source of tsetse replacements. The only way the tsetse population can be kept constant in the presence of ITC is if the increased mortality is balanced by an increase in birth and/or immigration. If immigration alone is the predominant source of tsetse replacements, then older flies which are above the average age of being able to transmit trapanosome infections are entering the population. Generally, where ITC is used, either against closed populations of tsetse or on a sufficiently large scale that the vast majority of the area is uninfected by immigration of tsetse flies across the boundary, the expectation is that the fly population will decrease (6).

Whole-Body versus Restricted Application

In areas where cattle provide the majority of feeds for tsetse both the WB and RAP strategies of insecticidal treatment can be used for the effective control of tsetse and of human trypanosomiasis. As expected, the absolute impact per animal treated was greater when the WB approach was used. But what is encouraging is that the RAP approach, which uses about 20% of the insecticide required for the WB treatment, is only about 21% less effective per animal treated.

The RAP approach also has a number of other livestock health and productivity benefits. For example, most farmers in Africa have indigenous breeds of cattle, which are resistant to several tick-borne diseases. The resistance depends on young cattle being bitten by infected ticks. With the RAP approach, tsetse and human trypanosomiasis control can be achieved without needing to treat young cattle: these young animals will thus still be bitten by ticks, allowing them to build up immunity to tick-borne diseases.

Widespread use of pyrethroids can adversely impact invertebrate dung fauna, which play an important role in maintaining soil fertility. This adverse effect can be mitigated by using the RAP instead of the WB approach, as indicated above. Finally, studies have shown that most cattle-feeding Diptera (flies that have a single pair of wings) land on the animals' legs. This means that the use of RAP on cattle may be an appropriate method for controlling other vector-borne diseases of livestock and humans (4).

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