RNRRS PROJECT COMPLETION SUMMARY SHEET

Date Sheet Completed: March 2006

Title of Project: Integrated vector management: controlling malaria and trypanosomiasis with insecticide-treated cattle.

R Number: **R8214**

Programme Manager (Institution): Professor Ian Maudlin, CTVM, The University of Edinburgh

Sub-Contractor (if relevant): Natural Resources Institute, UK

RNRRS Programme: Animal Health Programme

RNRRS Production System: Semi-arid

RNRRS Programme Purpose: Strategies to improve sustainably the health and productivity of livestock maintained by poor livestock keepers validated, promoted and disseminated.

Commodity Base: Livestock - cattle

Beneficiaries: Livestock keepers in tsetse- and malaria-affected areas of east and southern Africa

Target Institutions:

Ethiopia: FARM-Africa, Addis Ababa; Konso Development Agency (KDA)

Tanzania: Farming in Tsetse-controlled Areas (FITCA), Tanga; Ministry of Water and Livestock Development, Dar es Salaam; National Institute for Medical Research, Muheza; Kilimanjaro Christian Medical Centre (KCMC), Moshi

Zimbabwe: Department of Veterinary Services

Geographic Focus: Ethiopia, Tanzania, Zimbabwe

	PLANNED	ACTUAL
START DATE	October 2002	October 2002
FINISH DATE	March 2006	March 2006
TOTAL COST	£359,797	£359,706

Project Completion Summary

Project Purpose

The purpose of this project was to develop cost-effective, appropriate and sustainable strategies to control diseases of livestock maintained by poor livestock keepers in semi-arid production systems.

In Africa, there are 250–450 million cases of malaria per year, and the annual economic losses associated with this are estimated to be ~ $US 2 billion. Some 10 million km^2 of the malaria-affected regions of sub-Saharan Africa are also infested with tsetse flies which transmit trypanosomiasis, a complex of diseases affecting the health and productivity of humans and livestock, which has been estimated to cost Africa $US 4.5 billion a year.

The use of insecticide-treated cattle to control tsetse is an increasingly important means of controlling trypanosomiasis, especially for poorer livestock owners. In the more arid, tsetse-affected regions of east and southern Africa, the main vector of malaria is *Anopheles arabiensis*, which obtains a significant proportion of its bloodmeals from cattle. Theoretical evidence suggests that in areas where malaria is transmitted by this vector, the insecticidal treatment of cattle could reduce malaria incidence.

Outputs

This project aimed to:–

1. Quantify relationships between density and distribution of cattle and people and the transmission of malaria.
2. Derive recommendations on the suitability of insecticide-treated cattle to control mosquitoes and tsetse in the project area in particular and tsetse-infested areas of Africa in general.
3. Analyse the impact of aerial spraying operations on tsetse populations in Botswana.

The role of livestock in the transmission and control of malaria

This project assessed the likely impact of insecticide-treated cattle on malaria transmission in Konso, southern Ethiopia. In this region, *An. arabiensis* is the main vector of malaria, levels of livestock ownership are high (>70%) and there is an established use of insecticide-treated cattle to control trypanosomiasis.

Between March 2003 and February 2004, a weekly sampling routine was conducted in six villages to measure (i) indoor- and outdoor-biting rates on humans, (ii) biting rates on cattle, (iii) sporozoite infection rates in the *An. arabiensis* population and (iv) the proportion of blood meals from humans and cattle. The results for *An. arabiensis* showed a highly marked seasonal fluctuation in the biting rate ranging from ~1000 bites/person/night to <<1 bite/person/night, the circumsporozoite infection rate was ~1% and between 58–91% of blood meals were from cattle. Incorporating these data into a simple epidemiological model of malaria suggested that if the cattle of Konso were treated with an insecticide formulation that was effective against *An. arabiensis*, the prevalence of malaria would be reduced by ~80%.

With support from DFID's Knowledge and Research (Health and Disability) programme, the Halley Stewart Trust and the University of Greenwich, studies were also made of the behaviour and mortality of *An. arabiensis* exposed to deltamethrin-treated cattle. The results showed that a standard pour-on formulation, usually applied at monthly intervals to control tsetse-borne trypanosomiasis, was only effective for ~1 week against *An. Arabiensis.* Studies of the behaviour of *An. arabiensis* attracted to groups of cattle showed that most mosquitoes fed on the legs of older cattle, suggesting greater efficacy could be achieved by applying insecticides selectively to the legs of older cattle. This finding is consistent with recent findings from other AHP-supported projects (R7539, R7987 and R8318) showing that an identical treatment regime would also provide more cost-effective control of trypanosomiasis.

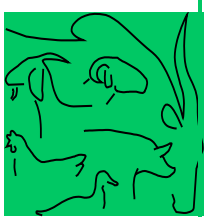
A crucial determinant of the impact of insecticide-treated cattle on *An. arabiensis* is the importance of cattle in the vector's diet. To assess the inherent 'preference' of *An. arabiensis* for either cattle or human hosts, wild *An. arabiensis* in Ethiopia, Tanzania and Zimbabwe were presented with a choice of entering a trap baited with either human- or cattle-odour. In Tanzania, >80% of *An. arabiensis* entered the cattle-baited trap whereas in Ethiopia and Zimbabwe, >80% of *An. arabiensis* entered the human-baited one. However, even when populations showed an inherent bias for humans, as was the case in Konso, the proportion of bloodmeals taken from cattle was still relatively high (58–91%). Further experiments indicated that this paradox is because the sleeping patterns of humans makes them less available than cattle; humans in Konso, for instance, sleep indoors or on raised platforms which provides some protection from being bitten. These data suggest that both local biological factors, such as the inherent host preferences of a mosquito population, as well as sociological characteristics such as the design of huts, use of bednets, and cattle management practices will have a profound effect on the proportion of *An. arabiensis* biting cattle and hence malaria transmission and the likely impact of insecticide-treated cattle.

Field assistants setting up an insecticide bio-assay, Zimbabwe
Photo: Steve Torr

The use of insecticide-treated cattle to control malaria and trypanosomiasis
The above results indicate that the insecticide regimes currently used to control tsetse- and tick-borne diseases will not have a significant impact on malaria-transmitting mosquitoes. Nonetheless, the results do suggest that the use of insecticide-treated cattle could contribute significantly to the reduction of malaria transmission in areas where *An. arabiensis* is the main vector, such as the Greater Horn region and the savannah regions of east and southern Africa. To achieve this impact however, a formulation of insecticide that is effective against tsetse, ticks and mosquitoes must be identified.

The control of trypanosomiasis in Botswana
In 2001, the government of Botswana initiated an operation to eliminate *Glossina morsitans centralis* from the Okavango Delta. Initially, the northern half of the Delta (7180 km^2) was aerial sprayed with five cycles of deltamethrin (0.26–0.3 g/ha) and the southern half (8720 km^2) was sprayed the following year. These operations were supported by the deployment of 12,000 deltamethrin-treated targets to prevent tsetse invading from the southern block into the northern one between the spraying operations. This project analysed the results of surveys undertaken during and after the control operation.

Prior to spraying, the mean catches of tsetse from man fly, rounds were 44.6 tsetse/round/day in the northern block and 101 in the southern. Surveys (~820 daily fly rounds and ~2050 trap days undertaken between September 2002 and November 2005) undertaken after the operation, however, did not catch a single fly. Simulations of tsetse populations suggest that while



spraying operations can reduce tsetse populations to levels that are practically impossible to detect by standard survey techniques, such populations will recover to densities at which there is a very high probability (>0.999) that the surveys would have caught at least one fly. Since none was caught, it is argued that tsetse have been eliminated from the Delta. The particular success of this operation in comparison to the 18 aerial spraying operations previously conducted in the Delta is attributed to the application of an adequate dose of insecticide and the effective use of targets to prevent invasion of tsetse.

Contribution of Outputs to Project Goal

The project has made three major contributions to the project Goal.

First, the results indicate that while the insecticide formulations currently used to treat cattle to control tsetse and ticks will not have a significant impact on malaria transmission, if cattle were treated with a formulation effective against tsetse and *An. arabiensis,* then insecticide-treated cattle could make a significant contribution to the control of malaria in the areas where *An. arabiensis* is the main vector.

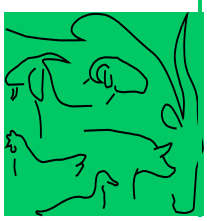
Second, the project has developed a rational framework for assessing the likely impact of insecticide-treated cattle on malaria vectors. This includes not only field-based techniques for quantifying the impact of insecticide-treated cattle on mosquito populations but also a theoretical basis for predicting the likely contribution of insecticide-treated cattle to the control of malaria.

Third, the analysis of control operations in Botswana provides a timely reminder that insecticide-based techniques can eliminate tsetse over large areas. This has important policy implications for the Pan-African Tsetse and Trypanosomiasis Eradication Campaign (PATTEC) which is promoting area-wide operations to eliminate tsetse. The Botswana operation demonstrates that aerial spraying can eliminate tsetse over a large area very rapidly but securing these gains against re-invasion is dependent on the use of either natural barriers and/or insecticidal baits. Currently, the governments of Botswana, Namibia, Angola and Zambia are initiating a programme to eliminate the *Glossina morsitans centralis* infestation common to these countries. The lessons learned from the Botswana operation will contribute to the design of the regional programme.

Publications

Habtewold, T., Prior, A., Torr, S.J. and Gibson, G. (2004). Could insecticide-treated cattle reduce Afrotropical malaria transmission? Effects of deltamethrin-treated Zebu on *Anopheles arabiensis* behaviour and survival in Ethiopia. *Medical and Veterinary Entomology* **18**, 408–417.

Liu Qunhua, Kang Xin, Chao Changzhi, Feng Shengzheng, Li Yan , He Rongzhi, Zhang Zhihua, Gibson, G. and Kang Wenmin (2004). New irrigation methods sustain malaria control in Sichuan Province, China, *Acta Tropica*, **89**, 241–247.



Prior, A. and Torr, S.J. (2002). Host selection by *Anopheles arabiensis* and *An. quadriannulatus* feeding on cattle in Zimbabwe. *Medical and Veterinary Entomology* **16**, 207–213.

Internal Reports

Coleman, P.G. (2005). Modelling the effects of insecticide treatment of livestock on the transmission of malaria in Ethiopia. (presentation for the national meeting of the Royal Entomological Society; University of Sussex, 12–15 September 2005).

Costantini, C., Vale, G., Santolamazza, F., della Torre, A. and Torr, S. (2005). Intrinsic host odor preferences of *Anopheles arabiensis* and *An. quadriannulatus* from a remote game area of Zimbabwe. (presentation for American Society for Tropical Hygiene and Medicine; Washington DC, USA; December 2005)

Gibson, G. (2002). Controlling malaria and trypanosomiasis. *Disability and Healthcare Technology. Newsletter of the KaR Programme on Disability and Healthcare Technology*. **2**, 7.

Gibson, G. (2004) Identifying 'natural environments' from an insect's point of view. Can we be sure we are asking them the right behavioural questions with our bioassays? Presentation at a symposium on “Chemical Ecology of Mosquitoes: Sensory Capacity, Resource Utilization, and Manipulation for Vector Control” (ACME 2, 53rd Annual Meeting of the American Society of Tropical Medicine and Hygiene, 7–11 November 2004, Miami, Florida USA).

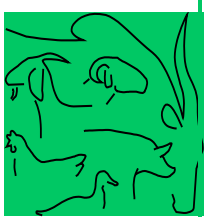
Habtewold, T. and Tirados, I. (2004). Interaction between *Anopheles*, Cattle and Humans: Effects of cattle management practices on the behaviour of *Anopheles arabiensis* in Ethiopia. Presentation (by Habtewold) at a workshop convened by the Royal Entomological Society (Medical and Veterinary Entomology Special Interest Group/North Region Meeting, University of Durham, 17 November 2004).

Habtewold, T. (2003). Zooprophylaxis in Ethiopia: an experimental approach in Ethiopia. Presentation at a workshop convened by the Medical and Veterinary Special Interest Group at the Royal Entomological Society, London, UK (April 2003).

Habtewold, T. (2003). Effect of deltamethrin insecticide applied to cattle on *Anopheles* in Ethiopia. Presentation at the annual meeting of the Royal Entomological Society, University of Reading, UK (July 2003).

Habtewold, T. (2005) Interactions between *Anopheles*, Cattle and Humans: Exploration of the Effects of Various Cattle Management Practices on the Behaviour and Control of *Anopheles arabiensis* in Ethiopia. PhD thesis, University of Greenwich.

Kgori, P. (2005). Elimination of tsetse from the Okavango Delta of Botswana. (National meeting of the Royal Entomological Society (presentation for



the national meeting of the Royal Entomological Society; University of Sussex, September 2005).

Kgori, P.M., Modo, S., Phillemon-Motsu, T.K. and Torr, S.J. (2005). Aerial spraying and odour-baited targets used to eliminate tsetse from the Okavango Delta of Botswana. (Internal report)

Tirados, I and Torr, S.J. (2004). Workshop to present findings to Ethiopian stakeholders. Awassa, March 2004.

Tirados, I. (2003). Workshop to present interim findings to Ethiopian stakeholders. Addis Ababa, November 2003.

Tirados, I., Costantini, C., Gibson, G. and Torr, S.J. (2005). The blood-feeding and resting behaviours of the malaria vector *Anopheles arabiensis* in southern Ethiopia. (Internal report)

Torr, S.J., Gibson, G. and Schofield, S. (2003). Controlling vector-borne diseases: Where is the Achille's Heel? Paper presented at Conference on Ecosystem Approaches to Human Health. IDRC, Montreal, Canada (May 2003).

Other Dissemination of Results

In Ethiopia, FARM Africa conducted annual workshops to present the findings of the project to representatives from the Ministries of Health and Agriculture, WHO and relevant NGOs. Participants at these workshops developed recommendations on the future direction of research and the promotion of methods to control malaria and trypanosomiasis to livestock keepers and local NGOs. In the final year, members of development associations were trained in dissemination techniques and, subsequently, community meetings and theatrical performances were conducted in Konso and Derashe districts. These activities were supported by radio programmes, the distribution of cards to guide group discussions, CDs on community-based methods of controlling trypanosomiasis, posters on the control of malaria and trypanosomiasis and T-shirts.

Follow-up indicated / planned

The findings of this project suggest that in the Greater Horn region and savannah areas of east and southern Africa, treating cattle with an insecticide effective against *An. arabiensis* would have a significant impact on malaria. To develop this approach further, research is required to identify an insecticide formulation that is effective against ticks, tsetse and malarial mosquitoes. Following on from this, large-scale field trials to assess the impact of insecticide-treated cattle on mosquito populations and malaria transmission should be initiated. Such trials should be undertaken in areas where *An. arabiensis* is the main vector of malaria and where cattle are a major source of bloodmeals. Such areas include the Konso district of southern Ethiopia, the Lower Moshi region of Tanzania and the Zambezi valley of Zimbabwe.

The research undertaken by this project, and others, has shown that the 'preference' of *An. arabiensis* for human or cattle hosts is highly variable. The variability appears to be due to a combination of genetic and environmental factors. Understanding the basis of this variability will enable a more rational improvement and development of methods for controlling malaria, including the use of bednets, insecticide-treated cattle and, possibly, traps. The project has demonstrated that many of the techniques that contributed to the successful development of baits to control tsetse could be readily applied to the study of mosquito behaviour. It is strongly recommended therefore that the use of these research methods is promoted within the wider mosquito research community.

The analysis of the Botswana tsetse control operation made extensive use of '*Tsetse Muse*', a decision support tool that enables users to estimate the impact and financial cost of various interventions against tsetse. The system could assist greatly in the design of large-scale operations to control tsetse being developed as part of the wider PATTEC initiative and it is therefore important that the programme is promoted and further developed in collaboration with users.

Name and signature of author of this report

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