FINAL TECHNICAL REPORT:

A low-cost haemoglobinometer as a decision support tool for bovine disease diagnosis in sub-Saharan Africa

R7597

Executive Summary

The developmental problem addressed in this project is the low productivity of livestock, particularly cattle, in high potential and peri-urban areas of tropical countries, which results from high levels of endemic diseases (trypanosomiasis, tick-borne diseases, helminthoses, and malnutrition). Control of these diseases has until recently been the remit of state veterinary services, which have now all but disappeared for resource-poor farmers with the global trend towards privatisation. With this contraction of veterinary services, increasing responsibility falls on the farmer, animal health assistants and other extension workers, groups that are ill equipped for the task of diagnosis of the common, important cattle diseases. Appropriate drug use and other disease control strategies depends on correct diagnosis and a working understanding of the suitability of therapeutic options. Existing techniques for diagnosis of these diseases are too costly and unavailable to the groups making treatment decisions in the modern scenario.

The specific research activities of the project were validation of rapid, reliable and cheap diagnostic tests for bovine disease control, and associated user-friendly, field level decision support tools. These were a low cost, pen-side method of measuring *haemoglobin* (a measure of *anaemia*) and a supplementary low-cost, low-technology decision support tool. Several candidate systems for measuring haemoglobin were identified and evaluated under laboratory and field conditions. These ranged from simple colour charts for use with filter paper strips to hand-held colorimetric haemoglobinometers. When testing in cross-sectional and longitudinal field studies of cattle under local conditions in smallholder mixed crop-livestock production systems in East Africa a hand-held haemoglobinometer was found to be a simple and effective means of determining haemoglobin levels. These same studies were used to provide data on the prevalence, incidence and impact of a number of common endemic bovine diseases including trypanosomiasis, theileriosis, anaplasmosis, babesiosis, cowdriosis, haemonchosis, schistosomiasis, and fasciolosis. Finally, a Delphi survey of expert opinion of animal health-field veterinarians and veterinary scientists, was conducted to obtain quantitative information of key clinical signs for endemic bovine diseases. The results of the Delphi survey were incorporated into a low-technology decision support card suitable for use by farmers and livestock keepers themselves, community animal heath workers, animal health and veterinary assistants, other extension workers and qualified veterinarians. Initial studies on the effectiveness of the decision support card to discriminate among the various diseases were highly promising, but further validation is required. The decision support card concept may also be extended to include a wider range of diseases and target species.

The project outputs are expected to contribute towards DFIDs development goals through provision of sustainable and affordable strategies for control of endemic animal diseases, which represent a major constraint to sustainable rural livelihoods and agricultural development.

Background

The developmental problem addressed in this project is the low productivity of livestock, particularly cattle, in high potential and peri-urban areas of tropical countries, which results from high levels of endemic diseases (trypanosomiasis, tick-borne diseases, helminthiases, and malnutrition). A recent DFID commissioned report "Tsetse and Trypanosomiasis Research and Development from 1980 - An economic analysis.", by Budd (1999) showed for African bovine trypanosomiasis that the ratio between Research Costs and Potential Total Net Benefit was likely to be between 1:75 and 1:175. This disease alone is estimated to cost livestock producers and consumers US$1340 million annually, without including indirect livestock benefits such as manure and traction (Kristjanson *et al.*, 1999). In tsetse infested areas of Africa (including about 46 million cattle), trypanosomiasis reduces the offtake of meat and milk by at least 50% (Swallow, 1999). For tick-borne diseases, from which 80% of the worlds 1288 million are at risk, global costs have been estimated between US$ 13.9 and 18.7 billion (de Castro, 1999). In Africa specifically, annual US$ costs of trypanosomiasis, theileriosis and heartwater (SADC Region alone), have been estimated at 700 million (Kristjanson *et al.*, 1999), 168 million (Mukhebi, A.W. *et al.*, 1992) and 37-47 million (Minjauw *et al.*, 2000) respectively. TickCost (1999), a combined ILRI/ACIAR research project has estimated that in Kenya, actual losses attributable to East Coast fever amount to $US 95 million, while heartwater and babesiosis/anaplasmosis are responsible for losses of $US 13.3 and 6.9 million respectively. The greater part of this loss is borne by small scale and mixed farmers.

Control of these diseases has until recently been the remit of state veterinary services, which have now all but disappeared for resource-poor farmers with the global trend towards privatisation. With this contraction of veterinary services, increasing responsibility falls on the farmer, animal health assistants and other extension workers, groups that are ill equipped for the task of diagnosis of the common, important cattle diseases. Effective diagnosis of endemic diseases is required for rational treatment and control, but this is impeded by the unavailability of suitably trained professional staff and of field-level diagnostic tests, as well as a general lack of knowledge about cattle diseases among livestock owners. Appropriate drug use and other disease control strategies depends on correct diagnosis and a working understanding of the suitability of therapeutic options. Existing techniques for diagnosis of these diseases are too costly and unavailable to the groups making treatment decisions in the modern scenario.

In the absence of effective diagnosis, preventive measures and treatments are either not applied or applied inappropriately. This may compound the economic losses already associated with the diseases concerned. For instance, indiscriminate use of trypanocides is undesirable because it is uneconomical to treat uninfected animals, and misuse and overuse of trypanocides may be associated with the development of drug resistance (ICPTV, 1999), poor productivity (Mdachi, 1999) and occasionally with toxicity (Eisler *et al.*, 1997). Hence the consequences of inadequate diagnosis and consequent misguided therapeutic decisions include disease-induced losses in productivity (calves, milk, meat, draught performance, manure) and increased mortality of cattle owned by poor people, therapy-induced losses in productivity,

therapy-induced loss of efficacy of trypanocides and anthelmintics, and losses due to unnecessary expenditure on inappropriate medications.

Although the project will concentrate on Uganda, and Kenya, the outputs will be applicable throughout the tropics and in all developing countries where cattle are important to livelihoods of poor people, since it is essentially a globally applicable technology. The decision support tools and extension material will be based on generic principles, so they too should have global applicability, with minor modification as necessary for various regions.

Project Purpose

The Programme Output addressed by the project is **Cost-effective and appropriate strategies developed to sustainably control diseases of livestock that affect the livelihoods of the poor**.

The specific research objectives are validation of rapid, reliable and cheap diagnostic tests for bovine disease control, and associated user-friendly, field level decision support tools. These will be a low cost method of measuring *haemoglobin* (measure of *anaemia*) and a supplementary low-cost, low-technology decision support tool similar to a slide-rule.

Research Activities

2000-2001

1. The project was initiated with **stakeholder meetings** conducted in Africa involving the UK-based and African project partners to fine-tune the project objectives of development of a hand-held haemoglobinometer and associated decision-support tool as an aid to the diagnosis and treatment of the major endemic disease constraints to cattle of poor people in East Africa, and to plan the work for the year.
2. Several candidate **systems for measuring haemoglobin** were **identified and evaluated under laboratory and field conditions**. These ranged from simple colour charts for use with filter paper strips to hand-held colorimetric haemoglobinometers. In the laboratory, these systems were tested for precision and accuracy, and sources of error were pinpointed. The most promising system was a haemoglobinometer with a simple, combined pipetting device, pre-filled reaction chamber and measuring cuvette.
3. With a view to compiling an **evidence-base for the diagnosis and treatment of endemic bovine diseases in East Africa**, a Ugandan scientist based in Glasgow conducted a critical review of the literature and initiated a Delphi survey of expert opinion both in Uganda and internationally.
4. **Cross-sectional field studies** of 450, mainly small East-African zebu, cattle were conducted in 9 villages in 4 districts of south-east Uganda. These involved comprehensive veterinary examination for key clinical signs of disease, together with detailed parasitological and microbiological examination for causal organisms of disease. Haemoglobin levels were measured using two candidate haemoglobinometers. Cattle were categorised as diseased, in which case at least one clinical sign was present, or clinically normal. Normal cattle were used to provide references ranges for haemoglobin, while associations between causal organisms of disease and

clinical signs and haemoglobin were investigated and added to the evidence base.

5. A concept-form low-technology decision-support system was designed and a strategy for further formulated with information technology partner at the University of Strathclyde.

2001-2002

6. A **longitudinal study of cattle** belonging to mixed-crop livestock smallholder farmers was conducted in villages in 2 districts of south-east Uganda with the following objectives:
   (i) Obtain key indicators for the differential diagnosis of anaemia-causing parasitic infections in local breeds of cattle in the mixed crop-livestock production system in South East Uganda, especially trypanosomiasis, anaplasmosis and fasciolosis.
   (ii) Determine the incidence of common endemic diseases in local breeds of cattle in this production system.
   (iii) Determine the importance of tick-borne disease as a cause of morbidity and mortality in local breeds of cattle in this production system, particularly during the first 2 years of life.
   (iv) Determine the importance of the three species of tsetse-transmitted trypanosomes pathogenic for cattle as a cause of morbidity and mortality in this production system.
   (v) In collaboration with AHP project R7596, extract trypanosome DNA from the blood of trypanosome-infected cattle for use in molecular epidemiological studies into the importance of the domestic animal reservoir for rhodesiense sleeping sickness and the potential for its control using chemotherapy of cattle.

7. In July 2001, four villages in the Tororo district of Uganda were identified as the initial step of the longitudinal study. The villages were chosen at random but all had similarities in geographical location. Each village showed a willingness to participate in the project. In September 2001, the second set of four villages was identified in Busia district. These villages were also chosen at random and all had similarities in geographical location. A suitable bi-lingual person was identified in each village to become the project contact. The role of this village "facilitator" was the initial collection of census material, cattle numbers, herd size and owner names. These facilitators also arrange the presentation of cattle for monthly sampling, and for the monthly herd health visits. In each village 80 cattle were chosen at random and eartagged. The cattle were from three age groups, and evenly matched by sex. The aim was to include in the study as many of the cattle owning farmers as possible. The four villages in each group, i.e. Tororo and Busia were randomly assigned to one of four treatment groups: control, mass isometamidium chloride treatment of all trypanosome susceptible livestock, oxytetracycline treatment only tagged cattle, mass isometamidium chloride and oxytetracycline treatment as before. In the Tororo villages, monthly sampling commenced in August 2001 and in Busia, October 2001. Clinical examination and sampling of the identified cattle in all eight of the chosen villages continued until November 2002. Overall a marked increase in interest by the villagers was noted as the health of their animals improved, specifically in improved body condition of the animals, and a marked decrease in animal mortality.

8. In addition to these activities
   (i) workshops were held at LIRI Uganda in July 2001 and February 2002 to review project progress with representatives all stakeholder groups, and plan ongoing and future research and dissemination activities,
   (ii) the results of the first round of the Delphi survey were analysed fully, and the second round mailing has been conducted and
   (iii) in collaboration with the University of Strathclyde, investigations were conducted into the development of low-cost, low-technology approaches to the delivery of decision support systems.

2002-2003

9. A **Delphi survey**, involving experts on animal health-field veterinarians and veterinary scientists, was successfully conducted. Quantitative information of key clinical signs for endemic bovine diseases (trypanosomosis, East Coast fever, anaplasmosis, babesiosis, cowdriosis, fasciolosis, PGE and schistosomosis) was collected.

10. A **low technology decision support tool has been developed** using quantitative information obtained from the Delphi survey and field studies. Initial validation studies have shown promising results, and these will be completed in due course. The longitudinal study conducted in Southeast Uganda was used to assess the importance of endemic bovine diseases in terms of their morbidity and to compile the frequency of clinical signs associated with the diseases for further development and refinement of the decision support tool.

Outputs

1. A number of existing haemoglobinometers and other low-technology haemoglobinometers were evaluated for suitability for use in cattle in village conditions in smallholder mixed-crop livestock systems in south-east Uganda. One instrument in particular, the HemoCue™ (HemoCue AB, Sweden) was found to be highly suited for this purpose and used extensively in longitudinal field studies. The only drawback with this instrument was the relatively high unit cost of the disposable cuvette. Because of this a new instrument was designed in conjunction with a commercial company, Elcomatic Ltd. of Neilston, Renfrewshire and prototypes were constructed and tested. The initial prototypes were promising but further development would be required to make them fully suitable for use in cattle in Africa.

2. A low-technology decision support tool was developed and implemented based on the results of the cross-sectional and longitudinal studies of cattle in smallholder mixed-crop livestock systems in south-east Uganda, and on the Delphi survey of expert opinion of the importance of individual clinical signs in the diagnosis of endemic diseases in these cattle. A simple diagnostic decision support tool was developed based on quantitative information on the diagnostic value of clinical signs of eight bovine diseases: trypanosomosis, theileriosis, anaplasmosis, babesiosis, cowdriosis, parasitic gastroenteritis, schistosomosis and fasciolosis, obtained from a panel of animal health experts through a Delphi survey as described by Linstone and Turoff (1975). A total of 64 veterinary scientists and 64 field veterinarians were initially sent questionnaires. After two rounds of the Delphi survey, responses were received from 46 participants who included 32 veterinary scientists and 14 field veterinarians. Data received from experts, consisting

of scores of clinical signs of the targeted diseases is shown in Table 1. This data was incorporated into a colour-coded chart - the decision support card (DSC). The chart was designed based on a combination of the pattern-matching and colour-banding techniques (Cockcroft, 1999; Middleton, 2001). The chart shown in the figure below utilizes scores ranging from 0 to 4, in which 0, 1, 2, 3 and 4 represent values (colours), 0 (black), >0% (grey), >9% (yellow), >14% (orange) and >21% red), respectively. The colour band and the score reflect the weight of a sign state in the event that a disease is present. The basis of this chart is comparison of clinical signs observed with disease profiles. A list of differential diagnoses is constructed ranked in the order in which the disease profiles match the clinical signs observed. To make differential diagnosis, scores of the various sign states of each disease are added up and overall scores of the possible differentials are ranked. The disease with the highest total is considered the leading differential diagnosis. A tie for the top rank is considered to signify a case of concurrent disease involving more than one disease. In the present study, a simple diagnostic decision support tool was developed based on quantitative information on the diagnostic value of clinical signs of eight bovine diseases. In an initial evaluation by 15 pairs of experts in comparison to the DSC using cases of known aetiological and clinical diagnosis, the DSC detected 15 out of 16 (93.8%) cases, while the 'experts' detected 12 out of 16 (75%) cases. Whereas the DSC misdiagnosed only one case of fasciolosis that presented with anaemia, diarrhoea and weight loss for parasitic gastroenteritis, the experts misdiagnosed four cases: two cases of fasciolosis and two cases of schistosomosis for parasitic gastroenteritis and trypanosomosis. Distinction of parasitic gastroenteritis from fasciolosis and schistosomosis, and trypanosomosis from schistosomosis and fasciolosis is difficult since these diseases present with similar signs. The DSC was better than the experts at distinguishing parasitic gastroenteritis from schistosomosis and schistosomosis and fasciolosis from trypanosomosis, when enough information on clinical signs (at least 3) is provided. However, the DSC still needs refinements to allow it to distinguish parasitic gastroenteritis from fasciolosis, especially when cases of fasciolosis present with diarrhoea in addition to anaemia and weight loss. Weight loss is an important clinical sign of chronic gastrointestinal nematode infections in older cattle, while anaemia, oedema, diarrhoea and anorexia are associated with severe cases of parasitic gastroenteritis observed in younger cattle, with diarrhoea being the main clinical sign (Eysker and Ploeger, 2000; Ganaba *et al*., 2002). Weight loss and anaemia are also associated with mild or chronic fasciolosis in cattle (Urquhart *et al*., 1996). Presence of anaemia and diarrhoea has been assigned higher diagnostic scores for parasitic gastroenteritis than for fasciolosis, while presence of weight loss and submandibular oedema have been assigned higher diagnostic scores for fasciolosis than for parasitic gastroenteritis in the DSC. This leads to misdiagnosis of cases of fasciolosis that present with anaemia, diarrhoea and weight loss, but without submandibular oedema. However, such cases are unusual. Veterinarians could deal with such situations by applying broadspectrum anthelmintics that clear both gastrointestinal nematodes and flukes. Despite the impressive performance of the DSC for the majority of diseases, including anaplasmosis, babesiosis, cowdriosis, East Coast fever and trypanosomosis, one needs sufficient information on clinical signs in order to use this tool. This tool is not useful for cases that present with only one sign. In case of concurrent

disease, the second place diagnosis needs to be considered as well. Field trials using a prescribed protocol need to be undertaken before the DSC can be released for evaluation by a larger number of independent potential end-users before dissemination for routine use.

Prototype Decision Support System for Endemic Diseases of Zebu Cattle in SE Uganda

	Anaplasm.	Babesiosis	Cowdriosis	Fasciolosis	PGE	Schistosm.	Theileriosis	Trypanosm.
Anaemia or Pallour	4	2		2	3	4	1	4
Anorexia or Depression	2	2	4				3	
Ataxia or Abnormal behavior			4					
Constipation	4							
Diarrhoea				1	3	1		
Dysentery						2	1	
Dyspnoea or Coughing							3	
Haemoglobinuria		4						
Icterus	1	2						
Lymph node enlargement							4	2
Pyrexia	3	4	4				4	1
Staring coat				2	2	1		3
Stunted growth or pot belly				2	3	2		
Submandibular/ventral oedema				3	2			
Weakness	1	2	3	3	1	3		2
Weight loss	1			3	2	3		4

Instructions for use

Identify the rows of the table showing the clinical signs present in the animal. Add up the numbers in the 'disease' columns for these rows only. Compare the totals for each column. The heading of the column with the highest total is the most likely diagnosis. Note that an animal may be suffering from more than one disease, which will complicate diagnosis. The system is intended to assist individuals with veterinary clinical training, and all other available information should be taken into consideration.

(This decision support system is a prototype for research purposes only. The authors accept no responsibility for the consequences of its use in clinical situations.)

3. Considerable progress has been made towards the development of extension messages on diagnosis and treatment of cattle diseases. The card format of the simple decision support system described in 2 above renders it effectively as an extension message in its own right, which is readily reproducible. In addition, comprehensive digital video footage has been obtained with a view to compiling a CD detailing the procedures required for diagnosis of bovine endemic diseases in the south-east Uganda production system.

4. Information on prevalence, diagnosis and haematology of endemic cattle diseases in Kenya and Uganda has been collated and compiled in a database and is currently still being analysed. Some of these data have already been disseminated in a number of scientific publications and presentations at scientific conferences and project workshops (see publications list). It was not possible to fully complete the analysis and dissemination of these data during the time frame of the project, because of the sheer quantity of data obtained. However, analyses are ongoing and the results will be disseminated as they become available.

5. One particular aspect of Output 3 (above) is the investigation of diagnostic differentiation and interaction between bovine anaplasmosis and trypanosomosis. This is being addressed as part of the ongoing analysis of data from the field studies, but is also being considered in the wider context of integrated control of tsetse and tick-borne diseases, on which a related detailed report has been submitted to DFID (Torr *et al*, 2002).

6. The impact of TBD and trypanosomosis on cattle in mixed crop-livestock production systems in south-east Uganda has been investigated in detail through longitudinal studies. Again, detailed analyses of data are ongoing and results will be reported as they become available.

7. The effect of isometamidium chloride (ISMM) block-treatment of cattle on human sleeping sickness transmission has been investigated in conjunction with Project R7596. Initial parasitological and molecular (PCR) analyses of trypanosome infections in cattle following these treatments have shown that the initial reductions in infection prevalence obtained using ISMM may be followed by counter-intuitive outcomes. Further analyses required to determine the infectivity of the trypanosome infections concerned for man are ongoing using SRA gene and other markers.
8. A computer-based decision support system (CDSS) training tool has been developed in conjunction with the University of Strathclyde, and described in an MSc thesis (Middleton, 2001). The decision support system is implemented using Excel (Microsoft Corporation) and is capable of running on a regular PC.
9. Improved levels of clinical diagnostic skills of veterinarians, animal health assistants (AHAs) and extension workers has been achieved in south east Uganda through the implementation activities of the project. In particular Veterinarians Dr Joseph Magona of the Livestock Health Research Institute (LIRI) and Dr Charles Waiswa of Makerere University have obtained extensive clinical experience of endemic bovine diseases in the field. A technical team from LIRI have also been trained to a high level of clinical proficiency.

Contribution of Outputs

The outputs of this project will contribute to DFIDs development goals through the provision of strategies specifically developed to sustainably control diseases of livestock that affect the livelihoods of the poor. Specifically, the haemoglobinometer and decision support card will improve farmers and animal health assistants' ability to diagnose the common endemic diseases of cattle and hence better target control strategies, particularly drug treatments.

This will require promotion of these technologies by appropriate agencies in East Africa such as the Livestock Health Research Institute (LIRI), Uganda, the Kenya Agricultural Research Institute (KARI), and the International Livestock Research Institute (ILRI), Nairobi, as well as other organisations working in agricultural and livestock development in the region. In the widest context these include a variety of players such as primary and secondary schools, agricultural and technical colleges and veterinary schools in East Africa, drug companies and pharmaceutical merchants, agricultural and veterinary extension services, non-governmental organisations (NGOs), e.g. dairy development groups, churches, women's' and self-help groups, and farmer field schools.

Prior to the widespread dissemination of the decision support card, a further phase of validation will be required to investigate and compare its effectiveness in the hands of a variety of possible end users. These potentially include farmers and livestock keepers themselves, community animal heath workers, animal health and veterinary assistants, other extension workers and qualified veterinarians. It is envisaged that this may be done in the context of a number of related projects following on form the present project, with funding from DFID, the EU and the Wellcome Trust.

In terms of the low-cost haemoglobinometer, there are two possible avenues to take this forward. Firstly, given the proof of concept established by the present project

that the haemoglobinometer is an appropriate and effective means of establishing the presence (or absence) and degree of anaemia in cattle in smallholder mixed crop-livestock production systems in East Africa, the company manufacturing the model tested (HemoCue AB, Angleholm, Sweden) could be engaged in negotiations to establish whether a lower unit cost per test could be obtained for use in African livestock. This might be obtained by production of an instrument and consumable cuvettes of slightly less exacting specification than currently produced, which are currently designed for exacting legislation on medical instrumentation for the USA and European markets, and are hence over-specified for livestock; or alternatively a more favourable pricing structure could be introduced for use in the developing country veterinary context. The other possible avenue would be to pursue the promising development of a prototype haemoglobinometer with Elcomatic Ltd., Neilston, Renfrewshire, UK. Both these avenues could be explored in the context of public-private partnership funding initiatives between DFID and the respective companies involved.

Annex / Appendix

(The following documents are available from the author of this report on request.)

Publications:

- Anon. (2001). Working with Farmers to Protect Africa's Cattle. *Leading Edge* (University of Glasgow), **8**, 10-11.
- Eisler, M.C., Brandt, J., Bauer, B., Clausen, P.-H., Delespaux, V., Holmes, P.H., Ilemobade, A., Machila, N., Mbwambo, H., McDermott, J., Mehlitz, D., Murilla, G., Ndung'u, J.M., Peregrine, A.S., Sidibé, I., Sinyangwe, L. and Geerts, S. (2001). Standardised tests in mice and cattle for the detection of drug resistance in tsetse-transmitted trypanosomes of African domestic cattle. *Veterinary Parasitology*, **97**, 171-183.
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- Picozzi, K., Tilley, A., Fèvre, E.M., Coleman, P.G., Magona, J.W., Odiit, M., Eisler, M.C. and Welburn, S.C. (2002). The diagnosis of trypanosome infections: applications of novel technology for reducing disease risk. *African Journal of Biotechnology*, **1** (2), 39-45.
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- Machila, N., Wanyangu, S.W., McDermott, J.J., Welburn, S.C., Maudlin I. and Eisler, M.C. (2003). Cattle owners perceptions of African Bovine trypanosomiasis and its control in Busia and Kwale Districts of Kenya. *Acta Tropica*, **86** (1), 25-34.
- Eisler, M.C., Torr, S.J., Machila, N., Coleman, P.G. and Morton, J.F. (2003). Integrated control of tick and tsetse: epidemiological, social and economic implications. *ICPTV Newsletter*, **6**, 8-9.
- Eisler, M.C., Torr, S.J., Coleman, P.G., Machila, N. and Morton, J.F. (2003). Integrated Control of Vector-Borne Diseases of Livestock – Pyrethroids: Panacea or Poison? *Trends in Parasitology*, **19** (8), 341-345.
- Eisler, M.C., Majiwa, P., Picozzi, K. and Dwinger, R.H. (2003). Diagnosis and Epidemiology of Animal Trypanosomiasis. In: *The Trypanosomiases*, Eds Maudlin, Holmes and Miles. In press.
- Holmes, P.H., Eisler, M.C. and Geerts, S. (2003). Current Chemotherapy of Animal Trypanosomiasis. In: *The Trypanosomiases*, Eds Maudlin, Holmes and Miles. In Press
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Internal Reports:

- Quarterly Report AHP Project R7597 April-Jun 2000
- Quarterly Report AHP Project R7597 Jul-Sep 2000
- Quarterly Report AHP Project R7597 Oct-Dec 2000
- Quarterly Report AHP Project R7597 Jan-Mar 2001
- Annual Report AHP Project R7597 2000-2001
- Quarterly Report AHP Project R7597 April-Jun 2001
- Quarterly Report AHP Project R7597 Jul-Sep 2001
- Quarterly Report AHP Project R7597 Oct-Dec 2001
- Quarterly Report AHP Project R7597 Jan-Mar 2002
- Annual Report AHP Project R7597 2001-2002
- Quarterly Report AHP Project R7597 April-Jun 2002
- Quarterly Report AHP Project R7597 Jul-Sep 2002
- Quarterly Report AHP Project R7597 Oct-Dec 2002
- Quarterly Report AHP Project R7597 Jan-Mar 2003
- Annual Report AHP Project R7597 2002-2003
- Torr, S.J., Eisler, M.C., Coleman, P.G., Morton, J.F. and Machila, N. (2002). Integrated Control of ticks and Tsetse. A Report for the DFID Advisory and Support Services Contract (Managed by NRInternational Ltd) Project ZV0151; NRI code V0160

Other Dissemination of Results.

Results from this project have been disseminated in a number of scientific fora, including:

- Tosas, O., McOdimba, F., Picozzi, K., Welburn, S.C. and Eisler, M.C. (2002). Epidemiology of *Theileria Parva* in Zebu Cattle from Busia and Tororo Districts in South East Uganda. Poster exhibited at the British Society for Parasitology Trypanosomiasis and Leishmaniasis Seminar 2002. 8th-11th September 2002, Edinburgh, Scotland
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