

## FINAL TECHNICAL REPORT

### THE INTERACTION BETWEEN NUTRITION AND GENETIC RESISTANCE TO TRYPANOSOMOSIS IN TRYPANOTOLERANT CATTLE

JANUARY 1993 - MARCH 1996

Partially funded by Livestock Production Programme (R5184)  
Mainly funded by European Union

#### Collaborating Institutions

NRI Natural Resources Institute, UK  
UGVS University of Glasgow Veterinary School, UK  
ITC International Trypanotolerance Centre, The Gambia  
CIRDES Centre International de Recherche et Developpement sur l'Eleavage en zone  
Subhumide, Burkina Faso  
CIRAD- Centre de Cooperation, Internationale en Recherche Agronomique pour le -  
EMVT Developpement: Departement d'Eleavage et de Medecine  
Veterinaire, France

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**YEAR 1 TRIAL: (ITC)**

Romney D L, N'Jie A, Clifford D, Holmes P H, Richard D and Gill M (1996) The influence of plane of nutrition on the resistance of trypanotolerant cattle to infection with *Trypanosoma congolense*

**YEAR 1 TRIAL: (University of Glasgow)**

Wassink G.J., Fishwick G., Parkins J.J., Gill M., Romney D.L., Richard D. and Holmes P.H (1996). The patho-physiology of *Trypanosoma congolense* in Scottish Blackface sheep. Influence of type of roughage on digestive function. Submitted to Animal Science

**YEAR 2 TRIAL: (ITC)**

Akinbamijo O.O., Bennison J.J., Jaitner J. and Holmes P.H. (1996) Haematological assessment of N'Dama and Gobra Zebu bulls during *Trypanosoma congolense* infection: I The anaemia and erythrocytic responses

Akinbamijo O.O., Bennison J.J., Romney D.L., Wassink G.J., Jaitner J. and Clifford D.J. (1996) An evaluation of feed intake, digestive physiology and live weight changes of N'Dama and Zebu bulls during *Trypanosoma congolense* infection

**YEAR 3 TRIAL: (ITC)**

Bennison (1996) Effects of nutrition pre-partum and post-partum on subsequent health and productivity of N'Dama cows infected with *Trypanosoma congolense*.

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<b>CIRDES</b>	<b>Centre International de Recherche et Developpement sur l'Elevage en zone Subhumide, Burkina Faso</b>
<b>CP</b>	<b>Crude Protein</b>
<b>DGXII</b>	<b>Directorate General XII</b>
<b>DM</b>	<b>Dry Matter</b>
<b>EU</b>	<b>European Union</b>
<b>ITC</b>	<b>International Trypanotolerance Centre</b>
<b>LPP</b>	<b>Livestock Production Programme</b>
<b>MEM</b>	<b>Metabolisable Energy requirements for maintenance</b>
<b>N</b>	<b>Nitrogen</b>
<b>NRI</b>	<b>Natural Resources Institute</b>
<b>OM</b>	<b>Organic Matter</b>
<b>PCV</b>	<b>Packed Cell Volume</b>
<b>UGVS</b>	<b>University of Glasgow Veterinary School</b>

## EXECUTIVE SUMMARY

1. Funds from the ODA Livestock Production Programme (LPP) funds were used to provide additional support to a research project principally funded by the EU. The parent project was collaborative, involving 5 institutes: University of Glasgow Veterinary School, UK (UGVS); International Trypanotolerance Centre, The Gambia (ITC); Centre de Recherches sur les Trypanosomoses Animaux, Burkina Faso (CIRDES), Centre de Cooperation Internationale en Recherche Agronomique pour le Developpement, France (CIRAD) and the Natural Resources Institute (NRI), with NRI being responsible for project co-ordination. The purpose of the project was to increase understanding of the interaction between nutrition and genetic resistance to trypanosomosis in trypanotolerant cattle. In the longer term the aim was to generate information which can be used to develop strategic feeding systems for animals in areas of tseste challenge. The three main technical objectives were as follows;

- i) To quantify the interaction between nutrition and genetic resistance to trypanosomosis in West African cattle.
- ii) To determine whether differences in digestive function and efficiency contribute to trypanotolerance in livestock.
- iii) To determine the effects of nutrition on the pathogenesis of ruminants infected with trypanosomosis.

2. The immediate objectives of the NRI contribution (partly funded by LPP) were as follows;

- To contract, supervise and co-ordinate four other partners to undertake a research programme of seven individual but related projects
- To train staff in techniques used to study ruminant digestive physiology
- To participate in establishment and conduct of experimental work at ITC, The Gambia
- To analyse samples of feed and faeces used/produced in the experiments at ITC and UGVS
- To assist in the dissemination of results from the experimental work

3. The four partners were successfully contracted at the beginning of 1993. During the course of the project, three co-ordination meetings were organised as well as a final workshop, in which all experiments carried out under the project were discussed. Two scientists who had recently been involved in similar studies were invited to make additional presentations. Other researchers in the field, from Nigeria and Senegal were also invited to attend and participate in discussions in order to improve the review and dissemination of findings.

4. Staff in the Gambia were trained in digestive physiology techniques and by the end of the project a team of animal scientists and technicians were skilled in experimental techniques to estimate digestibility and rate of passage. NRI staff played a major role in trials in the Gambia and had a small input into experimental work in Burkina Faso. Samples of faeces from ITC and UGVS were analysed for chromium content in the NRI laboratories to enable rate of passage to be estimated.

5. The work covered in the project answered a number of questions and helped clarify the relationships between nutrition and resistance to infection with trypanosomosis. Improved nutrition resulted in a less extreme expression of disease symptoms and in some cases appeared to assist tolerant animals to self-cure. Tolerant animals appeared not to become as pyrexia as those susceptible to the disease. Reduced pyrexia appeared to be reflected by a smaller increase in maintenance requirements in infected tolerant, compared to susceptible, animals. Pyrexia and the concomitant increase in maintenance requirements are considered to be largely responsible for the decrease in productivity of infected animals.

## BACKGROUND

1. It has become clearly established that certain breeds of West African cattle, most notably the N'Dama and Baoule, are genetically resistant to trypanosomosis (Murray et al. 1982). Such breeds have enormous potential as a sustainable resource for enhancing cattle production in trypanosome-endemic areas of sub-Saharan Africa. However, it would appear that the stability and expression of this genetically-based trait is influenced by a number of factors, of which nutritional status of the host can be considered to be the most important (Murray 1987). However, studies to examine the influence of nutrition on trypanotolerance have been limited.
2. Early evidence arose from observations that the severity of the disease is often most marked at times of the year when cattle are under nutritional stress. More recently, studies carried out in the Gambia have shown that the severity of infection in grazing cattle under natural challenge can be reduced by supplementing with small amounts of concentrate feed (Agyemang *et al.* 1990; Little *et al.* 1991). There are also preliminary indications that previous nutrition, as measured by body condition, may influence resistance to infection (Little *et al.* 1990).
3. Some more detailed work has been carried out in small ruminants. Katunguka-Rwakinshaya (1993) carried out a study of the role of protein intake on the pathogenesis of infections with *Trypanosoma congolense*. In this study, infected sheep with higher protein intakes (HP) were able to maintain growth rates and had a greatly enhanced erythropoietic response. In contrast, infected sheep on low protein intakes (LP) lost weight relative to controls and recovery following treatment with a trypanocidal drug was slower compared to HP animals. Workers in the Netherlands (Zwart et al. 1991; Versteegen et al. 1991) showed that both heat production and nitrogen excretion were increased in West African dwarf goats infected with *T. vivax*, leading to higher energy and protein requirements which could not be met from the lower feed intakes also observed.
4. Prior to the present, project detailed work in cattle had been limited and the objectives of the project were focused on the clarification of a number of issues concerning the interactions between nutrition and genetic resistance to trypanosomosis.

## PROJECT PURPOSE

5. The project addressed indicative output 1 “Interactions between farmers and herders at the interface between the pastoral system and the crop-livestock system identified and management strategies for livestock production developed and promoted” of purpose 1 “Performance of livestock (including draught animals) in semi-arid crop/livestock and livestock production systems improved” under the Semi-Arid production system

## RESEARCH ACTIVITIES

6. LPP funds represented a small contribution to a relatively large collaborative project. It is not possible to separate out work funded specifically by the programme. However, programme funds were principally used to fund NRI staff time. NRI's responsibilities included the contracting, supervision and co-ordination of four other partners to undertake a research programme of seven individual but related experiments. Other inputs funded by the LPP included training, participation in experimental work and laboratory analysis.

7. The four partners were successfully contracted at the beginning of 1993. During the course of the project, three co-ordination meetings were organised as well as a final workshop, in which all experiments carried out under the project were discussed. Two scientists who had recently been involved in similar studies were invited to make additional presentations. Other researchers in the field, from Nigeria and Senegal were also invited to attend and participate in discussions in order to improve the review and dissemination of findings.

8. Staff in the Gambia were trained in digestive physiology techniques and by the end of the project a team of animal scientists and technicians were skilled in experimental techniques to estimate digestibility and rate of passage. NRI staff played a major role in trials in the Gambia and had a small input into experimental work in Burkina Faso. Samples of faeces from ITC and UGVS were analysed for chromium content in the NRI laboratories to enable rate of passage to be estimated.

9. The three main technical objectives were as follows;

- i) To quantify the interaction between nutrition and genetic resistance to trypanosomosis in West African cattle.
- ii) To determine whether differences in digestive function and efficiency contribute to trypanotolerance in livestock.
- iii) To determine the effects of nutrition on the pathogenesis of ruminants infected with trypanosomosis.

The main findings of the project as a whole are summarised below.

10. The first objective of the project was to quantify the interaction between nutrition and genetic resistance to trypanosomosis in West African cattle. In two experiments, trypanosensitive Zebu animals were compared with trypanotolerant N'Dama or Baoule cattle. Effects of the disease on PCV, parasitaemia and mean corpuscular volume were more severe in the susceptible animals as expected.

11. Pyrexia associated with trypanosomosis in goats has been shown to raise metabolisable energy requirements for maintenance (ME<sub>m</sub>) (Verstegen *et al.* 1991). Pyrexia was clearly observed in Zebu cattle in trials carried out in Burkina Faso and appeared to be greater than observed in Baoule cattle. Rectal temperatures in infected N'Dama heifers in the first year trial at ITC tended to be higher than for control

animals but differences were rarely significant. This evidence suggests that the increase in MEm observed in Zebu animals in the Gambia may have been caused by pyrexia. In the first year trial in Glasgow, using sheep considered to demonstrate trypanotolerance, rectal temperatures were not significantly higher for infected groups and no differences in liveweight gain were observed in response to infection in pair fed animals. This would appear to support the hypothesis that the observation of decreased feed conversion efficiency in response to infection is primarily due to pyrexia increasing MEm requirements. Furthermore, in the second year trial at ITC, in which Zebu and N'Dama cattle were compared, it was observed that infected Zebus lost weight, while their pair fed, un-infected partners continued to grow. Meanwhile, although liveweight gain of N'Dama cattle also decreased significantly in response to infection, the difference was proportionally smaller compared to the Zebu animals. These observations may reflect increased ME requirements for maintenance (MEm) in susceptible animals.

12. The project was also designed to determine whether differences in digestive function and efficiency contributed to trypanotolerance in livestock. Decreased digestibilities of OM and CP were observed in the first sheep trial while at the same time mean retention time increased, apparently due to a decreased rate of rumen outflow. Decreased rate of passage would be expected to increase rather than decrease digestibility, therefore there may be a concomitant change in efficiency of digestion, although insufficient measurements were made to determine where this may occur. There were no differences in DM digestibility in either N'Dama or Zebu cattle in the Gambia (CP digestibility was not measured). Only transit time appeared to be significantly lower in infected Zebu animals. In Burkina Faso, there were no differences observed in DM digestibility for either Baoule or Zebu animals. Meanwhile, there were indications that CP digestibility decreased in Zebu animals following infection, although the evidence was not conclusive.

13. Feed intakes decreased in nearly all experiments and there were indications that animals selectively reduced intake of the more fibrous fraction of the diet where selection was possible. No changes in intake occurred in the second Glasgow trial, where DM intake was already restricted. Preliminary results from 1995 showed that decreased intakes occurred with *T. vivax* but not with *T. congolense* infection for sheep fed similar diets, suggesting that different strains of trypanosome have different effects.

14. It has been hypothesised that intakes decrease as a result of pyrexia. From this, it might be expected that decreases in intake would be more severe in susceptible Zebus where pyrexia was greatest. However, where sensitive and tolerant breeds were compared, falls in intake were similar, although in the Gambia, the N'Dama started to recover intakes earlier and more rapidly compared to the Zebu bulls in the recovery phase.

15. The final objective of the project was to determine the effect of nutrition on the pathogenesis of trypanosomosis in ruminants. Five of the experiments carried out under the DGXII project considered the influence of diet on the course of infection. Dietary effects on PCV were only observed in two experiments, where anaemia was less severe in those infected cattle and sheep with higher intakes of energy and protein.



This mainly reflected higher PCV levels pre-infection on the better diets and there were no significant interactions between diet and infection. No effect of diet was observed where nitrogen (N) but not energy intake varied, nor where only the fibre source differed.

16. Similar observations were made with respect to blood biochemical parameters, where albumin and cholesterol, which decreased in response to infection, were only affected by diet where both N and energy levels differed. As with PCV, the effect of diet and infection in these cases appeared to be additive rather than interactive and maximum PCV levels were observed where nutrient intakes were highest. The lack of effect where only N was altered may suggest that energy is the primary nutrient influencing these parameters. However, it should be noted that where N only was altered, the additional N was provided as urea to animals for which rumen degradable protein may not have been limiting. Hence the extra N may not have been utilised, and a different effect might have been observed if it had been provided in the form of rumen undegradable protein.

17. There were some indications that higher rectal temperatures occurred in non-infected animals on higher planes of nutrition, although the difference was only significant for sheep and not N'Dama heifers. There also appeared to be some interactive effect in response to infection, although responses did not appear to be consistent between species. In sheep, a greater pyrexia effect in response to infection was observed in animals on the lower plane of nutrition, whereas the reverse tendency occurred in cattle.

18. In general, nutrition did not appear to have an effect on degree of parasitaemia. In one trial with sheep there appeared to be a tendency towards higher levels of parasitaemia in animals on the higher plane of nutrition. In another trial with cattle, parasitaemia tended to decrease earlier in animals with higher nutrient intakes. However, in neither of these cases were differences significant.

## OUTPUTS

19. Outputs, as listed in the project framework, included contract documents, co-ordination meeting minutes, and reports of laboratory analyses. These documents are available on file.

20. NRI staff working on the project have also contributed to a number of scientific abstracts, research reports and articles. A list of publications is presented below.

21. A workshop was successfully held in the Gambia at the end of the project and the attendance of research scientists from other West African institutions not directly involved in the project allowed the results to be disseminated more widely to other researchers in the field.

22. A team of animal scientist and technicians skilled in the use of techniques to study ruminant digestive physiology are now based at ITC in the Gambia.

23. The main technical output of the project is increased knowledge of the interaction between nutrition and genetic resistance to trypanosomosis in West African cattle. The results showed that infected cattle were unable to maintain feed intakes and that this appeared to be the main factor responsible for reduced productivity in tolerant animals infected with trypanosomosis, rather than alteration in MEM requirements. There were also some indications that the animals mainly reduced their intake of poor quality feeds and that providing better quality feeds may allow animals to maintain their productivity under infection.

## PUBLICATIONS

24. The following is a list of all publications arising during the course of the project, including those already submitted as well as some currently in preparation and at first draft stage. Papers where the first author is D.L. Romney were prepared using NRI staff time funded by the LPP. The two papers where the first author is O.O. Akinbamijo include some LPP funded inputs, particularly sample and data analysis as well as intellectual contributions. The 1996 paper submitted by Wassink et al. to Animal Science includes rate of passage data from samples analysed by NRI staff funded by the programme.

Romney D L, N'Jie A, Clifford D, Holmes P H, Richard D and Gill M (1996) The influence of plane of nutrition on the resistance of trypanotolerant cattle to infection with *Trypanosoma congolense*. Submitted to Journal of Agricultural Science Feb 1996

Wassink G.J., Fishwick G., Parkins J.J., Gill M., Romney D.L., Richard D. and Holmes P.H. (1996). The patho-physiology of *Trypanosoma congolense* in Scottish Blackface sheep. Influence of type of roughage on digestive function. Submitted to Animal Science

Romney, D. L., Bennison, J.J., N'Jie A. and Holmes, P. (1994) The effect of timing of dietary supplementation on blood parameters of Gambian N'Dama cattle infected with trypanosomiasis. *Proc. Soc. Nutr. Physiol.* 3: 327

Romney D L, N'Jie A., Holmes P. and Gill M. (1994). The effect of plane of nutrition on the response by trypanotolerant cattle to infection with trypanosomiasis. *Animal Production* 58: 464A

Romney D L, N'Jie A, Clifford D, Holmes P and Gill M (1994) Use of groundnut hay and groundnut cake as supplements to N'Dama heifers exposed to trypanosomiasis. Presented at: *Second Biennial Conference of the African Feed Resources Network (AFRNET) 6-10 December 1993, Harare, Zimbabwe* (in press).

### Scientific papers at first draft stage

Akinbamijo O.O., Bennison J.J., Jaitner J. and Holmes P.H. Haematological assessment of N'Dama and Gobra Zebu bulls during *Trypanosoma congolense* infection: I The anaemia and erythrocytic responses.

Akinbamijo O.O., Bennison J.J., Romney D.L., Wassink G.J., Jaitner J. and Clifford D.J. An evaluation of feed intake, digestive physiology and live weight changes of N'Dama and Zebu bulls during *Trypanosoma congolense* infection

## Scientific papers in preparation

Wassink G. and Holmes P: Effect of urea supplementation and plasma cholesterol levels on *T. congolense* infection in Scottish Blackface sheep.

Wassink G. and Holmes P: Plasma nitric oxide levels in *T. congolense* infected Scottish Blackface sheep fed a normal or a urea-supplemented diet.

Wassink G. and Holmes P: The effect of dietary arginine restriction on parasitaemia levels in mice infected with *Trypanosoma congolense*

Kanwe A, Grimaud P and Richard D: Effet de l'infection a *Trypanosoma congolense* sur la physiologie digestive des taurins (Baoules) resistant et des Zebus sensibles.

Kanwe A, Grimaud P and Richard D: Effet de la note d'etat corporel sur l'infection a *Trypanosoma congolense*

## CONTRIBUTION OF OUTPUTS

25. The information gained, together with the results from other strategic projects can be used to design appropriate feeding and management strategies for cattle in tsetse infested areas. The results have indicated that for the trypanotolerant animals used in the trials, manipulation of diets and the provision of better quality feeds does potentially allow the maintenance of productivity, in terms of weight gain, despite infection. However, this approach to management may be inappropriate and economically infeasible in some circumstances, compared to therapeutic control.

26. In order to design and implement new strategies to control disease, and to identify where strategic supplementation could play a role, it would be important to use the information gained together with an understanding of the priorities of farmers and factors influencing their decisions. In many cases survival of the animal may be of much greater importance than maximising production. Ultimately, decision support systems in areas of endemic trypanosomiasis, integrating and optimising the use of genetic, therapeutic and nutritional resources could be developed. These issues are dealt with in a parallel ODA funded project also at ITC (B0025: Development of strategic supplementary feeding regimes for N'Dama cattle under trypanosomiasis challenge).

27. The documentation and training outputs contributed to production of the technical outputs. The presence of trained staff at ITC will assist in continued research efforts in this area.

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