Improving the livelihood of resource-poor goat farmers in Southern Africa through strategic drug and nutritional interventions against gastro-intestinal nematode infections: 2002 to 2003 update

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Abstract

The Department for International Development (DFID) Animal Health Programme (AHP) is funding a project in South Africa that began in April 2002 and will run for three years. It is testing the hypothesis that, under the farm management and agro-ecological conditions found in the resource-poor areas of South Africa, the holistic approach of strategic anthelmintic treatment of gastro-intestinal nematode infections of goats and, or, additional supplementation of their diet with urea-molasses blocks will lead to sustainable and cost-effective improvements in health and the value of livestock products. The study will include on-station and on-farm trials, socio-economic investigations and the dissemination of current information on worm control during the course of the project, as well as the results of current research towards the end of the project.

Background

Parasitic gastro-enteritis is indisputably a cause of serious production losses to small ruminants in sub-Saharan Africa (Connor et al., 1990; Over et al., 1992), and indeed worldwide (Fabiyi, 1987). Within the resource-poor semi-arid summer rainfall areas of South Africa, information on the production constraints caused by parasitic gastroenteritis is relatively sparse, as the main emphasis was previously directed to the South African commercial sector. However, Haemonchus has been shown to be one of the most important helminth species in the small ruminants farmed in these resource-poor areas (Vatta et al., 2002).

The application of a strategic drug treatment for the control of parasitic gastroenteritis has been shown to improve production in small ruminants in sub-Saharan Africa (Connor et al., 1990; Over et al., 1992), as have improvements in the nutritional status of goats (Chartier et al., 2000).

Anthelmintic resistance is known to be widespread in the commercial sheep-farming sector of South Africa (Van Wyk et al., 1999). There is, therefore, a drive to slow down the rate of development of anthelmintic resistance and in addition to reduce the amount of chemicals in the production chain (Waller, 1993). Thus more recently, attention has been directed towards a holistic approach to parasite management involving sustainable integration of options which reduce the reliance on frequent chemotherapy (Coop and Kyriazakis, 1999). This includes examining the interaction between helminthosis, nutrition
and strategic drug intervention (Mahato et al., 2000). Although the individual effects of strategic anthelmintic treatment and nutritional supplementation on goat productivity in South Africa are to be established in the present project, the effect of the interaction between nutritional supplementation, drug treatment, gastrointestinal nematode infections and goat productivity will also be examined. This information is currently almost totally lacking and needs to be quantified.

Research hypotheses

The project will test the hypothesis that under the farm management and agro-ecological conditions found in the resource-poor areas of Southern Africa (sub-Saharan Africa), the holistic approach of strategic anthelmintic treatment of gastrointestinal nematode infections of goats and, or, additional supplementation of their diet with urea-molasses blocks will lead to sustainable and cost-effective improvements in health and the value of livestock products.

This general hypothesis gives rise to four specific hypotheses which will be addressed through on-station and on-farm experiments, and which will attempt to answer the following:

- **Hypothesis 1**: that a strategic treatment administered before the peak in faecal egg counts will lead to a lower peak (lower worm burden) and hence better production.

- **Hypothesis 2**: that supplementation with urea-molasses blocks will help maintain or increase body weight. Such supplementation increases microbial fermentation which leads to increased microbial protein post-ruminally. This increased protein is thus available for the processes of regeneration and repair in the damaged alimentary tract and for mounting an effective immune response. This in turn leads to less protein being diverted from body tissue and hence maintenance of body weight.

- **Hypothesis 3**: that the interaction between nutritional supplementation with urea-molasses blocks and strategic anthelmintic treatments for gastrointestinal parasitism will lead to measurable improvements in goat productivity. This will provide particularly novel information.

- **Hypothesis 4**: that the benefit to production of the combined improved feeding and drug treatment strategy will not be unduly affected by extrinsic management practices in a selected agro-ecological zone.

Experimental programme

**Experiment 1 (On-station)**

The purpose of this trial is to quantify, under the conditions at Onderstepoort Veterinary Institute (OVI), the effect of urea-molasses supplementation in ameliorating the negative effects of gastrointestinal nematode infection of goats, with or without the inclusion of strategic anthelmintic interventions. This will test hypotheses 1, 2 and 3 and will allow the most cost-effective management programme to be determined. This management programme will be selected for the on-farm trials.
Experiment 2 (On-farm)

This experiment will determine the effect of varying management practices on the production benefits of a combined feed supplementation and strategic anthelmintic treatment. This will investigate hypothesis 4.

Socio-economic analysis

In the first year of the project a socio-economic analysis will be carried out. Full use will be made of data gathered in earlier studies by various authors, as well as rapid rural appraisal methodologies, informal farm interviews and semi-structured questionnaires where appropriate. Data such as current income from livestock, livestock numbers, numbers of small-scale farmers, numbers of women involved in farming and current marketing practices will be collected. The data will be used to estimate the costs to South African resource-poor farmers of the supplementation methods, the cost of anthelmintic treatments and the availability of anthelmintics, and the value of the stock. This information can then be used as a baseline to determine whether or not the various management changes suggested are indeed cost-effective and acceptable. The project has engaged the services of an independent company (Strategy and Tactics, South Africa) to carry out the socio-economic work. This company is experienced in questionnaire design and techniques, including assessing the risks associated with both questioner and responder bias. The additional advantage of their involvement is that the socio-economic information gathered will not be biased by direct involvement of the project team, as they and the socio-economists will interact with the resource-poor farmers independently.

Goat-keeper extension packages

A goat-keeper interest group, that will include farmers participating in the on-farm trials, will be provided with information on 12 topics, including roundworms, coccidiosis, abortions, abscesses, footrot, heartwater, mastitis, orf, pneumonia, pulpy kidney, rectal prolapses and tetanus. Information will also be provided on basic procedures such as drenching and injections. The topics were determined through a participatory process and through observations made at veterinary clinics held by the State Veterinarian of Ixopo, KwaZulu-Natal, in the South Western Region of KwaZulu-Natal (B A Letty, unpublished work). The information is being compiled into an A3-size flipchart-type manual which will be laminated for easy reference while working with goats and made available to participating farmers in Zulu, the local language. The manual will be tested in the field during the second year of the project. Training in the FAMACHA© system will form part of contact sessions with the farmers. The FAMACHA© system is a method used to determine whether a sheep or goat requires treatment for haemonchosis by clinically evaluating an animal for anaemia (Malan et al., 2001; Vatta et al., 2001). This is done by comparing the colour of the conjunctival mucous membrane with a colour chart. The chart depicts five degrees of red, from white (anaemic) to red (non-anaemic or healthy). Animals are scored in one of the five categories and those animals in the anaemic categories are treated with an effective anthelmintic.

Following the outcome of the on-station and on-farm trials, and taking into consideration any other disease or management deficiencies noted on-farm, a modified animal health package will be produced and distributed to participating farmers, Provincial Departments of Agriculture, the Society for the Prevention of Cruelty to Animals, local NGOs, Nufarmer and African Entrepreneur (a local newspaper aimed at the developing farmer), the Community Outreach Programme of the Faculty of Veterinary Science, and through the activities of the Animal Health for Developing Farmers Programme at OVI.
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It is anticipated that such an approach will lead to the rapid dissemination of the project findings to the target beneficiaries (goat farmers in resource-poor areas of South Africa). The findings would equally be applicable to other areas of sub-Saharan Africa and the information will be disseminated to appropriate bodies.

Progress to date

On-station trial

Before the project could start it was necessary to locate a source of goats from a heartwater-free area, because the OVI experimental station is free of the blood parasite causing heartwater (*Ehrlichia ruminantium*), but is not free of the vector (which is the bont tick, *Amblyomma hebraeum*). Some modifications had to be made to the buildings and grazing areas at the OVI experimental station, to improve the fencing and night accommodation for the goats before they were moved to the farm. Milkweed (*Asclepias fruticosa*) was growing in the camp and had to be treated with a herbicide.

Interestingly, anthelmintic resistant worms were discovered in some of the purchased goats. Eighty-eight goats were bought for the on-station trial, one was slaughtered (because it was found to be lame with degenerative changes in the left stifle joint and the prognosis for recovery was very poor) and the remaining 87 were intensively dewormed, while being kept in concrete pens at OVI. We were unable to clear the infection from three of these goats. Suspected resistance was found to oxendazole, levamisole and ivermectin. Samples of the resistant worms have been collected and frozen in liquid nitrogen for possible future studies. The animals in which the infection was cleared were re-infected with a known anthelmintic-susceptible strain of *Haemonchus contortus*. These goats were then moved to the experimental farm.

The factors mentioned above combined to delay the planned start of the on-station trial by three months, from June 2002 to September 2002. Following a four-week pre-experimental period, which began on 27 August 2002, the goats were ranked for live weight on 25 September 2002 and randomly assigned to four groups. They are green (basal diet), blue (basal diet with “dry”-season supplementation), orange (basal diet with “wet”-season supplementation), and red (basal diet with “wet”- and “dry”- season supplementation). The four groups are housed separately at night and are fed their supplements, commercially produced urea-molasses blocks (Voermol Protein Blocks, Voermol Feeds, KwaZulu-Natal), in their night pens.

The nutritional interventions are taking place from the beginning of December 2002 to the end of February 2003 for those groups receiving the “wet”-season treatment and from the beginning of June 2003 to the end of August 2003 for those groups receiving the “dry”-season treatment. Animals are being monitored on a weekly basis for faecal egg count (FEC), haematocrit (packed cell volume), total serum proteins, serum albumin and urea. The goats are weighed and scored for body condition. They are also FAMACHA© scored and treated with ivermectin orally if the animals score 3, 4 or 5 (Vatta *et al.*, 2001) on an individual basis. The strategic anthelmintic intervention was administered on 28 January 2003, although the FECs were still low (Figure. 1). This is probably related to low rainfall during the previous months (Figure. 2), the size of the camp (150 ha.), and the presence of large amounts of browse in the camp. It is still too early to make any detailed deductions from the data.
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Field studies

The Sub-Wards of Nkwazela, Hlafuna and Njobokazi in the Maphephetha Ward in the Hlanganani District of KwaZulu-Natal, situated on the road between the towns of Bulwer and Donnybrook, have been identified as a study site for the fieldwork planned for 2003/2004 and a very successful initial meeting has been held. The aim is to continue with the provision of information to the villagers during the first 9 months of 2003 and to obtain the co-operation of a small number of farmers (probably four) to take part in the on-farm trial. Specific farmers will be identified in the second year of the study shortly.
before the start of the on-farm trial. The project team is being assisted by the extension services in KwaZulu-Natal Province.

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References


Roundworms in goats – getting the message across

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Abstract

Effective extension to resource-poor farmers is a two-way process: farmers inform researchers of areas in which they require information and assistance, and extension workers provide information to farmers that is currently available, while researchers provide a pool of new knowledge that farmers via extension workers can draw upon at a later stage. Extension messages need to be clear, simple and easily understood. This is demonstrated in the article by means of the example of the control of roundworms in goats. A three-prong approach to the management of roundworms is proposed. This consists of the use of worm remedies, improvements in nutrition and the use of the FAMACHA© system, a method of selectively treating anaemic animals with a worm remedy.

Background

A number of projects that have been funded at Onderstepoort over the past several years have had an extension component. These included:

• Food and Agriculture Organization (FAO) Technical Co-operation Project (TCP/SAF/8821)

• Survey of Internal Parasites of North-West Province, South Africa

• Animal Health for Developing Farmers’ Programme at Onderstepoort Veterinary Institute.

Our aim has been to provide information on diseases that affect the animals of resource-poor farmers in South Africa. This is to fulfil a large demand for information that has come from resource-poor farmers (Getchell et al., 2002; Krecek, 1999; Letsoalo et al., 2000; Masika et al., 1997a; Masika et al., 1997b; Minnaar and Krecek, 2001; Wells and Krecek, 2001). We wish to emphasize, however, that our main function is research, not extension, but that we have become involved in extension because resource-poor farmers have requested information to help them improve their knowledge, farming skills and productivity.

Objectives

This paper has two objectives:
1) To convey a simple message on roundworms in goats that can be offered to resource-poor farmers, if appropriate.

2) To explain briefly about our methods of extending the message to the farmers.

Effective extension

In effective extension, there is a two-way flow of information:

• From the livestock owner on what he or she knows about management and treatment of diseases

• From the researcher, veterinarian, and extension officer by providing information on topics of relevance to the farmer

Some questions that need to be asked are:

1. What information and assistance do resource-poor farmers require?

2. What information and assistance can the researchers currently provide?

3. What research still needs to be done?

This should lead to:

1. The provision of available information.

2. New research.

The example of roundworms in goats

Resource-poor farmers complain that their goats “don’t multiply” and that worms (locally known as “izikelemu” or “dibokwana”) are a major cause of death. It would appear that the milk tapeworm is more commonly implicated, although roundworms are also mentioned. Symptoms, such as bottle jaw, occur that are indicative of worm infection.

Our approach includes the use of a slide set, large pictures of parasites, simple display units of preserved parasites, posters, a video, a CD, a booklet, and a “goatkeepers’ extension package” on animal diseases (the latter is still in development.)

The focus of this discussion is on a poster which we have developed (Figure 1). The current poster has been considerably simplified from a previous draft and it will be translated into a local language, Zulu, and tested with the farmers for a period of a year before a final copy is made and printed.

The aim of the poster is to answer the questions:

1. What is the problem?

2. What causes the problem?
3. What signs do you see?

4. What is the treatment and prevention?

To answer the question of what the problem is: roundworms are parasites of grazing animals such as cattle, goats and sheep. Roundworms are more dangerous than tapeworms, even though tapeworms appear to be more commonly seen by farmers.

To explain the cause of the problem: goats get roundworms when they ingest the immature worms on the grass. These immature worms grow into adult worms in the animal. The worms feed on the proteins and, or, blood of their host. Young animals are most badly affected.

The signs of roundworm infection may be any one or more of the following:

- Bottle jaw
- Paleness of the mucous membranes (anaemia)
- Diarrhoea
- Animals in poor body condition
- Worms seen in dead animals with signs of paleness of the carcase, fluid-filled intestines or bleeding.

To treat and prevent roundworm infection, we propose a three-fold approach that includes the use of worm remedies, improved nutrition and the use of the FAMACHA© system, where appropriate.

**Worm remedies**

Worm remedies are still the cornerstone of worm control, but there are problems with worm remedy resistance. The search for alternatives to worm remedies is an active area of research.

**Improved nutrition**

Animals in good condition, that are well-fed, are less affected by worms than animals that are fed poorly. Our message here is, “Give your animals supplementary feed, which should include a protein supplement, during times of food scarcity”. This advice is because a protein supplement has been shown to improve the animals’ ability to withstand the effects of, and build up immunity against, worm infection (Coop and Kyriazakis, 1999).

**The FAMACHA© system**

A novel technique for the assessment and subsequent treatment of *Haemonchus* spp. (wireworm, barber’s pole worm) has been developed in South Africa in response to the emergence of severe worm remedy (anthelmintic) resistance (Malan *et al.*, 2001). The technique is referred to as the FAMACHA© system (named after its originator, Dr Francois “FAffa” Malan CHArt). It is a method of selective treatment which may lead to a large reduction in the use of anthelmintics. It is currently being tested in other countries of Africa, North and South America, and Asia.
The system is based on the fact that *Haemonchus*, a parasite of the abomasum (milk stomach) of sheep, goats and cattle is a voracious bloodsucker, which causes anaemia in severely affected animals. This may be seen by examining the mucous membranes of the eyes. Capitalizing on this fact, a colour chart depicting five shades of red corresponding to degrees of well-being, from healthy (“red”) to severely anaemic (“white”) was developed for use in sheep. The chart is compared with the colour of the mucous membranes of the eye, allowing the sheep to be classified into one of the five colour categories. A decision is then made on treatment. The method was subsequently tested in goats (Vatta *et al.*, 2001; 2002).

Goats (and sheep) are examined in sunlight and the colour of the mucous membrane of the lower eyelid is noted. The eye should be opened for a short time only. The colour of the mucous membrane is then compared with the chart and the goat is scored from 1 to 5. Goats are treated with an effective anthelmintic if they fall into categories 3 to 5. If in doubt, the goat is scored at a paler category. Treated goats are marked or their treatments recorded.

There are a number of precautions that should be borne in mind when the FAMACHA® system is used. Firstly, only properly trained persons should use the FAMACHA® method. The card is an aid in the control of *Haemonchus* spp. only. Standard worm control measures need to be maintained, for example animals must be on a good plane of nutrition. The system should only be used by farmers where back-up assistance is available from a veterinarian or scientist.

Use of the FAMACHA® system leads to a reduction in the use of worm remedies for treatment when compared with conventional drenching practices. This will have economic gains for the farmer. The method should also slow down the development of anthelmintic resistance. This is important because new worm remedies are not yet on the market. The FAMACHA® system may be used to identify animals that repeatedly require treatment, to enable them to be culled from the flock. This leads to better livestock management.

**Conclusion**

We have proposed a three-prong approach to roundworm control in goats, namely the use of worm remedies, the supplementation of animals with protein and the selective treatment of animals using the FAMACHA® system. This three-prong approach is based on current scientific knowledge, which we have attempted to simplify to be understood and adopted by the resource-poor farmer. When new methods of worm control become available, through further research or from practices used by farmers which prove to reduce helminth levels, these will be added to the recommendations to farmers.

**References**


WHAT ARE ROUNDWORMS?
• Roundworms are parasites of grazing animals such as cattle, goats and sheep.

WHAT CAUSES ANIMALS TO GET ROUNDWORMS?
• Goats, sheep and cattle get roundworms when they ingest the immature worms, on the grass. These immature worms grow into adult worms in the animal. Young animals are most badly affected.

WHAT SIGNS DO YOU SEE?

1. BOTTLE JAW
   • You may see bottle jaw which is a soft, cold swelling under the chin of the animal.
   • The inside of the eyelids could be pale.
   • Diarrhoea may occur. Diarrhoea may also have other causes (such as coccidial parasites or toxic plants).
   • During winter or the dry season, particularly, animals may be in poor condition.

2. BLOODY FLUID
   • If you open the carcass of an animal, there may be bleeding or worms on the stomach or intestinal lining.

3. WORM REMEDIES
   • If you see these signs treat with a worm remedy.

4. LICK
   • Keep your animals in good condition. Give them hay and a lick - they will be less likely to become ill from worms.

5. USING THE FAMACHA® CARD
   The FAMACHA® system can be used to determine which animals require treatment - instead of treating the whole flock.

6. MILK TAPEWORM
   • Another type of worm, the milk tapeworm, commonly occurs in sheep and goats and appears as white segments on the droppings of the animal. The milk tapeworm should not be mistaken for the more dangerous roundworms.

For further information contact your animal health technician, veterinarian or other appropriate persons
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South Africa: Questions and answers

**Why use urea/molasses blocks?**
Urea/molasses blocks are used because they have been used before, are cheap and are easily available because of the sugar industry.

**Is there a guaranteed response to feeding the blocks?**
If soluble energy is missing from the diet, as would be the likely situation with crop residue-based feeds, molasses will help guarantee a response to urea, thus improving the energy and microbial protein derived from the diet.

**Is tethering of goats common?**
Tethering is established in South Africa, it is a system of grazing that requires comparatively little labour and protects growing crops from damage.

**You mentioned a training manual. Is it available?**
The manual is still being developed. It will be produced in the local language. It has not been tested on farmers yet, but has been based on comments they have made regarding identification of problems. The commercial sector has shown some interest in the manual.
The potential of controlling gastrointestinal parasitic infections in tropical small ruminants using plants high in tannins or extracts from them

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Abstract

A series of previous studies with quebracho tannin (QT) had shown that the tannin was effective at reducing the worm burden of temperate sheep infected with \textit{Haemonchus} and \textit{Trichostrongylus}. The potential of using tanniniferous browse plants available in the tropics as a means to reduce or control nematode infections of small ruminants was, therefore, investigated. Leaves of different browse trees and shrubs were assayed for condensed tannin (CT) concentration using a colorimetric method. Five species with the highest levels were sampled monthly and analysed in order to map their seasonal variation in CT. The level of CT in the leaves ranged between 58 – 283g kg\textsuperscript{-1} DM. Purified quebracho tannin was used as the standard. Seasonal changes in CT levels were affected by the stage of leaf maturity with peak levels occurring after the end of main rain season in June. Anthelmintic activity of crude extracts from leaves of two of the plants shown to have a high tannin content (\textit{Acacia polyacantha} and \textit{Tamarindus indica}) and that of commercial tannin preparation from wattle tree (WT) was then tested \textit{in vitro} against freshly isolated goat nematodes. Time of death of the parasites was recorded. Survival of the nematodes was significantly (\(P<0.001\)) reduced by both leaf extracts and by the WT.

\textit{Acacia} sp. leaves were then feed to goats to investigate their effect on faecal egg output and worm burdens of animals with a mixed nematode infection. Twenty-four bucks were infected with a single dose of nematode larvae and faecal egg counts (FEC) were monitored regularly. On day 38 post-infection (p.i.), half of the goats were offered a supplement of dried acacia leaves at 130g per animal for 20 days while the remaining half (control) received a grass supplement with comparable nutritional value but without condensed tannins. All goats were humanely slaughtered at the end of the trial for worm burden estimation. Mean FEC of the acacia-fed group was 27 per cent lower with a slight reduction (13 per cent) in the population of the large intestine worm, \textit{Oesophagostomum columbianum}, compared to the control group. In a second trial, 36 bucks were infected as before and then randomized on the basis of their FEC into three equal groups 30 days after infection. For three consecutive days one group received 1.2g WT/kg body weight, one 2.4g WT/kg and the third group received a placebo drench. All goats were humanely slaughtered on day 42 p.i. Neither FEC nor worm burdens were significantly reduced by the drench administration. This is in contrast to studies with quebracho tannin and temperate sheep conducted earlier.

Studies are also required using sheep reared in the tropics to determine whether the apparent species differences are real rather than due to adaptation of the animals to tannins prior to the experimental study.

It is not possible yet to come to a definitive conclusion on the value of tannins in controlling parasitic infections in tropical small ruminants.
Introduction

Gastrointestinal (GI) parasites are responsible for significant production losses in livestock worldwide (Gill and LeJambre, 1996) particularly under tropical and subtropical climates (Waller, 1997). Marginal levels of nutrition and a climate that favours survival of the parasites in most of the year explains why GI infections are more devastating in these regions (Waller, 1997). Control of GI nematode infections has traditionally been done using anthelmintics (chemotherapy) with best results being obtained when this approach is integrated with proper grazing management and resistant animals. However, in the last 2-3 decades there has been over-dependency and even misuse of the chemotherapeutic approach with consequent evolution of anthelmintic resistance (Ngomuo et al., 1990; Prichard, 1994). This is especially true among major nematode species of small ruminants. Apart from anthelmintic resistance, poor availability and affordability of anthelmintics to resource-poor farmers in developing countries have compounded the problem (Hammond et al., 1997). Moreover, there is a growing concern over drug residues in the food chain and the environment. Search for novel anthelmintics that are both more sustainable and environmentally friendly is undoubtedly a sensible approach to the control of parasitic infections. One such alternative could be harnessing of the available ethnoveterinary knowledge (Hammond et al., 1997), i.e., the use of medicinal plants with anthelmintic activity. Plant anthelmintics have been known and used in many parts of the world for a long time but little research has been done to validate their use, especially in veterinary medicine. Forages rich in condensed tannins (CT) have been found to improve general performance of parasitised sheep through reduced worm burdens (Niezen et al., 1993; 1998). Furthermore, our recent studies have shown that dietary inclusion of CT in quebracho extract dramatically reduced egg output and worm burdens of sheep infected with *T. colubriformis* (Butter et al., 2000). This has been confirmed by other workers (eg. Athanasiadou et al., 2000). As reported to the Morogoro workshop (Max et al., 2002), an oral drench of QT is effective at reducing both faecal egg counts and worm burdens in sheep infected with *H. contortus*. Some effect was also noted on *T. colubriformis* infection. *In vitro* studies had also shown that the wattle tannin extract available in Tanzania also had antihelmintic properties.

The main objective of the current phase of project (R7424) was to determine whether locally available tanniniferous browse materials or readily available extracts from them could be used to control or reduce the impact of nematode infections in small ruminants under the conditions found in the tropics.

Materials and Methods

Location

The studies were conducted in Morogoro region, which experiences an equatorial type of climate with a bimodal rainfall pattern; a main wet season, usually from March – May and minor wet season from November to January. Browse trees and shrubs constitute the largest proportion of small ruminant feed especially during the long dry season because they are drought tolerant and readily available.

Tannin sources

Wattle (mimosa) extract (WT), a commercial preparation of tannin from the barks of the tropical tree, *Acacia mearnsii* was supplied by The Wattle Tannin Company, Tanzania. Wattle tannin is used in the leather industry. Drench solutions were prepared by dissolving 1 part of WT in 2 parts of lukewarm water (w/v). Solutions of varying concentrations were
used in *in vitro* studies to determine the potency of WT against cultured parasites. Freshly prepared crude aqueous extracts from dried leaves of tropical browse trees, *Acacia polyacantha* and *Tamarindus indica*, were also used as another source of CT for the *in vitro* assays.

**Test parasites**

Three important caprine nematodes, *Haemonchus contortus*, *Trichostrongylus vitrinus* and *Oesophagostomum columbianum* were isolated and maintained as a mixed infection through passage in goats held at the Sokoine University of Agriculture. Faeces from the passage goats were cultured to obtain infective stage larvae (L3). The L3 were suspended in distilled water and kept at 4 – 8 °C in plastic tubes until used (maximum of 2 weeks).

**Animals, housing and feed**

Small East African (SEA) entire bucks aged between 12 and 14 months were purchased from small-scale goat keepers in Morogoro, Tanzania and housed in individual, raised-floor, wooden pens. The goats were offered a daily allowance of urea- and molasses-treated rice straw and supplemented with 150g maize bran-based concentrate. Once in the experimental house, the animals received a single oral dose of broad-spectrum anthelmintic to clear any gastrointestinal nematode infestations and sprayed with acaricide to rid them of ectoparasites. Due to the endemic nature of coccidiosis in the area of experimentation, a coccidiostat was given regularly as prophylaxis. Body weights were monitored weekly to the end of the trial.

**Determination of the concentration and seasonal variation of condensed tannin content of selected browse plants**

Browse plants including trees and shrubs from Morogoro were used in the study. Pilot sampling was conducted in January, April and June 2000 to represent the end of the dry season and the onset of the rain season and cool season respectively. These samples were analyzed to shortlist the selected browse plants to five species with the highest tannin content. Briefly, about 1 kg of twigs, 10 - 15 cm from the branch tip were harvested from different branches of a mature tree or a shrub. The leaves and leaflets were separated from the twigs and dried in an oven at 55 °C to a constant weight. The dried leaves were ground to pass through a 1-mm screen and then stored in clean airtight glass jars at room temperature pending laboratory analysis. Concentration of CT in the plant samples was assessed using the acid-butanol method (HCl-butanol-iron) as described by Terrill et al., (1992). Since quebracho tannin was used as a standard, the final concentrations are expressed as quebracho tannin equivalents. It should be noted that due to the complexity of tannin molecules accurate determination of CT is difficult and the acid-butanol method was chosen because its relative simplicity makes it possible to rapidly handle a large number of samples.

**In vitro** anthelmintic activity of browse plant extracts and WT on goat nematodes

(a) **Worm recovery**

A goat parasitised with both abomasal and large intestinal nematodes (*H. contortus* and *Oe. columbianum* respectively) was humanely slaughtered each time the survival assay was undertaken. On slaughter, the entire gastrointestinal tract was removed and ligatures were applied to separate the abomasum and the large intestine. Contents of each compartment were processed separately to recover the live worms. The recovered worms were placed on a Petri dish containing lukewarm phosphate buffered saline (PBS). The entire procedure
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was carried out quickly to ensure that worms were not excessively exhausted prior to incubation.

(b) Preparation of culture media and survival assay

Dried leaves of \textit{A. polyacantha} and \textit{T. indica} were ground to pass through 1-mm mesh. Five grammes of the leaf powder were placed in a 50-ml plastic tube; PBS was added to give a 10 per cent w/v extract solution and left to soak for 90 minutes with regular shaking. The mixture was passed through a coffee strainer to make clear culture media for each plant species. Equal amounts of acacia and tamarind leaf powders were thoroughly mixed and then soaked as before to make a 10 per cent solution of mixed culture medium. Preparation of culture media containing wattle extract was carried out using lukewarm PBS to give 0, 2, 4, 8 and 12 per cent w/v concentrations. To about 20 ml of the culture medium in a Petri dish, known number of male and female worms (approximately 10 - 15 each) were placed, covered and incubated at 38 - 39°C for a period of 10 hours. Survival rates were recorded over different time intervals. Motility and viability of the parasites was assessed by gently prodding the worms using a pointed probe or forceps. The response was recorded as either live or dead. Worms were considered dead when a minimum reaction to touch was observed.

Determination of the effect of tanniniferous browse on FEC and worm burdens of goats with mixed nematode infection

(a) Collection and preparation of supplemental leaves

\textit{A. polyacantha} leaves were collected in June 2002, approximately a month after the end of main wet season. Leafy twigs, 10 to 15 cm from the tip were removed from main branches and sun-dried within 24 hours. The dry twigs were stamped using sticks and then passed through wire gauze to separate the leaflets from stalks and petioles. The dry leaflets were kept in a cool dry place until needed. To balance for the nutritive value discrepancy between browse-fed and the control group \textit{Panicum trichocladum} (donkey grass) leaves were used. \textit{Panicum} sp. was selected because it contains no condensed tannins and has a crude protein value comparable to that of \textit{A. polyacantha}, it is palatable and was readily available during the trial. The dry \textit{Panicum} sp. leaves were ground to pass through 2-mm screen and kept as before. Samples from the two species were taken for estimation of CT and crude protein content.

(b) Experimental design

After two weeks of acclimatization to the experimental environment, 24 bucks live-weight 15.8 ± 2.4 kg were infected using a single oral dose of the mixed nematode infective stage larvae at a rate of 2000 larvae per 20 kg body weight. Faecal egg outputs were monitored regularly and on day 38 post infection the goats were randomly allocated into two equal groups (n = 12). Animals in one group, the browse-supplemented, received their daily concentrate allowance of 150g/animal/day in which 100g of dry \textit{A. polyacantha} leaves were added. Animals in the control group were supplemented with 100 g/animal/day of dry ground grass leaves (\textit{P. trichocladum}). The browse and control supplements were increased to 130g per day on day 44 post-infection as the goats became more used to eating the leaves. Any refusals were collected and weighed early in the morning before the daily allowance was offered. On day 59, all animals were humanely sacrificed and the abomasas, small and large intestines removed for worm burden assessment as described by Dawson \textit{et al.} (1999).
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Investigating the effect of WT drench on FEC and worm burden of goats with experimental mixed nematode infection

The effect of WT drench on FEC and worm burdens of tropical goats was investigated in a very similar experimental design. Thirty-six goats weighing 13.5 ± 2.2 kg were infected as before. Faecal egg counts were monitored regularly from day 16 post-infection to the end of the trial. On day 29 post-infection, the goats were blocked according to faecal egg numbers and randomized into three groups (n = 12). Two groups (LWT and HWT) received low and high doses of WT (1.2 and 2.4 g kg⁻¹ body weight), respectively, whereas the third group (control) received a placebo drench (tap water). The goats were drenched for three consecutive days from day 30 to day 32 and allowed to rest for 9 days before they were slaughtered for worm burden estimation on day 42.

Statistical analysis

The effect of tannin concentration on the survival time of the worms was analysed by survival analysis for censored data using a statistical package, Genstat 6, Lawes Agricultural Trust, UK. A linear model was used to predict estimated mean survival times with their upper and lower confidence limits. Faecal egg output data were subjected to ANOVA as repeated measurements with treatment structures and individual animals as blocks. The impact of treatment on faecal egg output was measured using faecal egg counts taken a day after the first dose of treatment to the day of slaughter inclusive. Worm burden data were subjected to one-way ANOVA with individual animals as block structures. Differences were assumed significant at $P<0.05$.

Results and Discussion

Concentration and seasonal variation of foliar CT in selected browse plants

Figure 1 shows concentration and seasonal variation of CT in five browse species, which were selected for their high levels. *Acacia polyacantha* had the highest overall mean CT concentration (282.5 g/kg⁻¹ DM) whereas the lowest value (58.2 g/kg⁻¹ DM) was measured in neem tree (*Azadirachta indica*) samples. The average levels of extractable CT reported here were very comparable to those usually found in tropical herbaceous legumes (Sotoby et al., 1997; Getachew et al., 2000). Variation in CT levels in the plants followed a regular pattern with the lowest concentrations being recorded in samples collected in November to February; the values increased gradually to a peak in the month of July before declining gradually toward November. Stage of leaf maturity was pointed out as an important factor determining the seasonal changes in CT concentration. The two leguminous tree species, *Acacia polyacantha* and *Tamarindus indica* (Tamarind) are widespread, not only in Morogoro region but country-wide and throughout tropical Africa with several varieties (Mbuya et al., 1994). The trees are well adapted to a range of soil types and they are leafy especially towards the end of the main wet season. The remaining three species relatively less abundant but yet widely distributed in the country especially in rural communities where they are used for medicinal (*Azadirachta indica*) and horticultural (*Psidium guajava* (guava) and *Persea americana* (avocado)) purposes (Mbuya et al., 1994).
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![Figure 1](image)

**Figure 1** Seasonal change in foliar concentration of condensed tannins in selected browse trees. The values represent a mean of quadruplicate analysis of a pooled sample for the particular month.

It is accepted that the assay used may not have given an absolute value for the tannin content of the various leaves but rather an indication of the seasonal variation.

**In vitro** activity of crude leaf extracts and WT against goat nematodes

Reports about the use of parasitic stages of target nematodes to study anthelmintic activity of plant extracts *in vitro* are rare due to difficulties in obtaining and maintaining the parasites outside their hosts (Witty, 1999). The current findings indicate that *H. contortus* and *Oe. columbianum* adults can be recovered live and maintained in a simple culture medium for up to 16 hours. The survival of the parasites in culture media containing the crude leaf extracts and WT was significantly ($P<0.001$) reduced (Figures 2 and 3). The results suggest a direct anthelmintic activity of WT and crude extracts from acacia and tamarind. Similar results have been reported using QT against rat nematodes (Butter *et al.*, 2001) and purified tannins from four forages against ovine nematodes (Molan *et al.*, 2000). The possible increase in survival time when the parasites were incubated in culture media containing WT concentrations above 2 per cent might have been due to the astringency of extract which deterred the worms from ingesting the surrounding medium. Although the mechanisms involved in the toxicity of CT to nematodes are not known, recent studies studying the effect of ellagitannin preparations against the tree-living nematode, *Caenorhabditis elegans*, have shown fatal disruption of internal organs including the gonads, uterine wall and the intestines (Mori *et al.*, 2000).
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Figure 2 Survival of *H. contortus* in culture media containing 10 per cent (w/v) aqueous crude extracts from various browse plant leaves. (□) Males; (■) females; (Aca) acacia; (Tam) tamarind; (A+T) mixture of acacia and tamarind. Values are mean of triplicate assays.

Figure 3 Survival of *H. contortus* (□) and *Oe. columbianum* (■) adults in culture media containing varying concentrations of wattle extract; (NT = not tested). The values are mean of quadruplicate assays; the error bars indicate 95 per cent upper and lower confidence limits.

Effect of a tanniniferous browse supplement on mixed nematode infection in tropical goats

With time, the goats accepted the browse supplement; a few refusals (involving concentrate-browse mixture) were observed in the browse-supplemented group during the
first week of treatment introduction. Egg counts were first observed in faeces of most goats on day 21 after infection. Although supplementation of goats with dried *A. polyacantha* leaves for 20 days did not significantly (**P** > 0.05) reduce FEC, the supplemented group had an average of 27 per cent fewer eggs than the control group from day 46 to the day of slaughter (Figure 4). Comparison of egg counts between the two groups on the day of slaughter alone showed a reduction of 33 per cent in the browse supplemented group. Similarly, no significant reductions in total worm burdens of the treated group but a slight reduction (13 per cent) in worm burden of the large intestine dweller, *Oesophagostomum* sp. (means: control vs. supplemented, 273 and 238 worms respectively; pooled SED: 32) was observed (Figure 5). Significant drops in both FEC and worm burdens following consumption of tannin-rich browse have been observed in a similar study (Kabasa *et al*., 2000) but unlike the current trial, the goats were allowed free access to various browse plants for up to 6 months. In the current study, the control group tended to void wetter faeces than the browse-fed group (treatment x time interaction, **P** = 0.041).

![Figure 4: Effect of *Acacia polyacantha* leaf supplement on faecal egg outputs (eggs per gram (EPG) dry faeces) of goats with mixed nematode infection. Each goat in the supplemented group (●) received acacia leaves at 130g/day from day 44 to the end of trial. The control group (○) was offered a similar amount of grass supplement. (SED = 1355, df = 22).](image-url)
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![Bar graph showing mean number of worms](image)

**Figure 5** Effect of *Acacia polyacantha* leaf supplement on total worm burdens of goats with mixed nematode infection. Supplemented (■), non-supplemented control (□).

**Effect of WT drench on FEC and worm burdens in tropical goats**

Following its encouraging *in vitro* activity against goat nematodes and the results of studies with QT drenches of sheep, WT was administered as a drench to investigate its impact on faecal egg output and worm burdens of tropical goats with mixed nematode infection. Surprisingly, neither FEC nor worm burdens were reduced \((P>0.05)\) after three consecutive days of drenching with WT. Unlike drenching temperate sheep with QT, WT induced only slight physiological changes to the goat’s GI tract probably due to their adaptation to high tannin feeds. It was, therefore, possible that the *in vivo* anthelmintic activity of commercial preparations is a result of physiological changes in the gut (mucus hyper-secretion and increased faecal water content). These changes could promote dislodgment and expulsion of worms. The present study appears to be the first to report the effects of a commercially available WT extract on parasitised tropical goats. However, the heterogeneous nature of tannins as a group implies that results of one study using a particular type or source of tannin could not be used to generalise their potential as future anthelmintics. The fact that drenching nematode-infected goats with wattle extract, which contains a large proportion of CT, produced poorer results than supplementing them with tanniferous browse is interesting. McNabb *et al.*, (1998) has stated that the chemical structure of CT may be more important than their concentration. It should, however, be noted that the WT was very effective *in vitro*. In addition it should be accepted that the potency of the extracts (from browse leaves and those produced primarily for the leather industry) may not be directly due to their tannin content per se but due to other bioactive components in these preparations.

**Conclusion**

The work undertaken so far has demonstrated significant *in vitro* anthelmintic activity of commercial tannin preparations (quebracho and wattle extracts) and crude extracts of tanniniferous plants (*A. polyacantha* and *T. indica*) against mice and goat intestinal nematodes. Furthermore, administration of QT as drench to the temperate sheep with
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mono-specific and mixed nematode infections was found to drastically reduce FEC and worm burdens of *H. contortus* but had less effect on *T. colubriformis*. However, administration of WT drench to tropical goats with a mixed infection did not significantly reduce FEC or worm burdens of any of the nematodes including *H. contortus*. It is suggested that, since the drench was also associated with gut physiological changes in the temperate sheep, but not as marked in the tropical goats, then the *in vivo* anthelmintic activity of the commercial tannin extracts was a result at least in part of gut changes. The reduction in both FEC and worm burden of *Oe. columbianum* following acacia supplementation in goats was an indication that an interaction between specific type of CT, other attributes of the plant and the complex host gut environment might be involved.

While several but not all of our studies have indicated the use of dietary tannins to reduce intestinal parasites in small ruminants, at present it is not yet possible to develop a protocol to exploit these observations in the field. Parasitic nematodes remain as a major problem in small ruminants kept by resource poor farmers in the tropics.

References


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**Dissemination strategy for control of gastro-intestinal parasitic infections in small ruminants using plants rich in tannins**

<table>
<thead>
<tr>
<th>Audience</th>
<th>Objectives</th>
<th>Message</th>
<th>Channel</th>
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<tbody>
<tr>
<td>Farmers</td>
<td>Help farmers to be more aware of the loss of productivity and income that can result from even moderate parasitic infections. Suggest sustainable ways of reducing worm burdens in their goats and sheep. Suggest simple methods of determining when level of infection indicates the use of commercial anthelmintics e.g. the examination of eye colour.</td>
<td>Locally available plants that are rich in condensed tannins can be fed to small ruminants to control worms in a cheap way. There is still a need for the use of drugs in cases of severe infection.</td>
<td>Leaflets, posters, radios, TV, farm visits and demonstrations</td>
</tr>
<tr>
<td>Extension workers</td>
<td>As for farmers plus more technical information such as the limitations of the approach, the need for alternative control methods, the importance of protecting the effective plant species from overexploitation, etc</td>
<td>The limitations of the method e.g., the fact that response to tannins can vary widely as a result of changing levels and types of tannins in plants. There is still a need for the use of drugs in cases of severe infection.</td>
<td>As above together with training</td>
</tr>
<tr>
<td>NGOs</td>
<td>As for the farmers and extension workers with emphasis on the impact of improved animal productivity on livelihoods. The need to integrate other practices such as improved feeding, proper use of existing drugs to reduce infections i.e., a holistic approach</td>
<td>That the nematode infections poses a real problem which requires concerted efforts from animal scientists, extension workers, policy makers and funding agencies.</td>
<td>Bulletin, technical notes, meetings etc.</td>
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It is essential that further ‘on-farm trials’ are conducted to determine if feeding of browse plants with high tannin content are beneficial in reducing intestinal parasitic burden under practical conditions. These trials should be conducted practicing the principles of participatory research.
Tanzania: Questions and answers

Would the different feeds available in temperate and tropical environments have affected the results?

It is possible that the nature of feed in the tropics affected the results. Many tropical browse plants, which make a significant component of small ruminant feed, contain substantial amounts of condensed tannins. Thus tropical subjects can be referred to as 'tannin-adapted' whereas their temperate counterparts are 'tannin-naive'. This was clearly evident in our findings because administration of tannin preparation as drench to temperate sheep was associated with significant gut physiological changes that were less marked in the tropical goats following similar treatment. These changes were believed to have helped to facilitate expulsion of the parasites from the gastrointestinal tract. Absence of these changes in the tannin-adapted tropical goats reduced the effects of tannins. It has to be remembered that tannins also appear to have direct effects upon the parasites.

Are there differences in response between sheep and goats?

It should be noted that when the tannin extracts were tested in vitro they were equally toxic to nematodes of both tropical and temperate origin. It is however known that there are differences in the response of sheep and goats to anthelmintics. One of our future plans is to try to find out whether the same principle will apply to a natural product such as tannins or not. For example to compare the effects of a tannin drench on nematode infected tropical sheep compared to tropical goats.

Why was the lower concentration of tannin more effective than the higher levels?

The presentation showed that worm survival in culture media containing the lower concentration of 2 per cent (quebracho or wattle tannin) were more effective than the stronger concentrations of 4, 8 and 12 per cent. Tannins are usually described as having unpalatable (or astringent) taste, it is therefore possible that when incubated in a medium containing 2 per cent tannin the worms were more likely to eat/ingest the medium, rather than the stronger tasting concentrations of 4, 8 and 12 per cent. A similar behaviour has been observed when nematodes were incubated in increasing concentrations of anthelmintics, levamisole and pyrantel. This increase in the rate of survival when the concentration of drug is increased has been noted by others and is often referred to as 'recovery phenomenon'. Perhaps we should look more carefully at the effects of lower doses in vivo.

Why, when you reduce the egg count, can the animal have more worms?

For the faecal egg count test, it is generally assumed that faecal egg counts (FEC) correlates well with worm burdens and it is therefore accepted that FEC is an indicator of worm population in the gut. However, this does not hold true always because of a phenomenon called hypobiosis (or 'arrested development'). Hypobiosis is a survival strategy whereby nematodes in the host's gut sense unfavourable external environment and burrow into gut mucosa (stopping further development) until the conditions are favourable. In this case there will be more worms in the host's gut than the FEC will indicate. It is also important to know the type of parasite in question since some worm species (e.g. *Haemonchus*) are known to be prolific egg layers while others (e.g., *Trichostrongylus*) are less so.
Alleviating seasonal nutrient fluctuations in semi-arid areas of Zimbabwe: potential for tree fruits as protein supplements for goats

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Abstract

This paper presents the studies undertaken to evaluate the potential of locally available tree fruits as supplements for goats in the dry season in semi-arid areas of Zimbabwe. Initially the evaluation process was carried out in laboratories. This process entailed chemical characterization with emphasis on protein and phenolic content, these being the two main constituents that affect the value of fruits as protein supplements. Chemical composition and in vitro fermentation of fruits and separated fruit fractions from Acacia nilotica, A. erubescens, A. erioloba, Piliostigma thonningii and Dichrostachys cinerea tree species were determined. The presence of phenolics reduced fermentation in vitro and interfered with the determination of in vitro organic matter degradability, due to their solubility in the fermentation medium. The nutritional effects of tannins were investigated using an in vitro tannin bioassay where fruit substrates were incubated with and without tannin-binding polyethylene glycol (PEG). Treatment with PEG increased the fermentation of tree fruits suggesting that tannins limit their fermentation.

Wood ash solution, a locally available alkali, inactivated tannins in D. cinerea and A. nilotica fruits, resulting in improved fermentation in vitro. The effect of alkali and PEG treatments on nitrogen balance of goats was evaluated using D. cinerea fruits as protein supplements. Goats were offered a basal diet of standing grass hay. Fruit supplements were compared to a commercial protein supplement (CPS). Treatment with PEG caused excessive protein degradation in the rumen resulting in nitrogen loss through the urine. Goats offered untreated fruits had the same nitrogen retention as those offered CPS. Dichrostachys cinerea fruits used in this study did not require tannin inactivation treatment. A feeding trial in which does were offered fruit supplements showed that supplemented does had higher conception rates, weaning weights and fewer kid mortalities.

Introduction

Zimbabwe’s smallholder agricultural sector, based in the communal lands, holds about 97 per cent of the estimated 4.7 million goats (CSO, 1997) in the country. Most of these animals are in the dry and less productive agro-ecological zones (Kusina and Kusina, 1999). With the exception of drought tolerant sorghum and pearl millet, crop production in these semi-arid areas is risky due to the low and unpredictable annual rainfall of less than 600mm. The result of recurrent droughts and poor rainfall is that high quality animal feed is always in short supply resulting in the drought tolerant goat and donkey playing a prominent role in the livelihood of the smallholder farmers in semi-arid areas. Despite the potentially high rate of reproduction, the productivity of the goat in Zimbabwe is low (Kusina and Kusina, 1999). This is attributed to dry season malnutrition, high rates of kid mortality and incidence of disease, as well as poor marketing structures (Kindness et al.,
Kids that are born during the rainy season (from December to April), when feed quantity and quality is high, show good health and survivability. This suggests a link between nutritional status of the doe and reduced kid mortality, which in turn affects goat productivity. The number of does kidding in October and November is low (Kindness et al., 1999) suggesting poor conception rates due to feed shortages in June and July (dry season).

The *Acacia* thornveld is the main feed resource for goats in the semi-arid areas of Zimbabwe. Goats browse on green leaves for most of the rainy season while in the dry season fallen fruits from the same trees are consumed. In most cases goats and other animals, are given free access to the fruits, hence the fruit supply does not last through the dry season, and under-utilization often occurs, especially in the early dry season when the goats have a wider choice of feed. Fruits from these trees could be used as a protein source for animals feeding on low quality roughage later in the long dry season. Many *acacias* produce potentially nutritious fruits with up to 20 per cent crude protein. While supplementation with fruits has the potential to improve goat productivity little is known about the nutritive value of the fruits. Anti-nutritional factors are known to be a significant component of most browse tree species (Aganga and Mosase, 2001). Caution should be exercised especially on the quantities that are fed to an animal, the frequency of feeding and the form in which the fruits are fed. Feeding large quantities of fruits frequently may result in animals developing haemorrhagic lesions in the gastro-intestinal tract, resulting in the death of the animal (Terblance et al., 1967).

The objectives of the study were to improve the productivity of smallholder owned goats through dry season feeding interventions based on locally available tree fruits. Several studies were undertaken to assess the potential of tree fruits to reduce the fluctuations in nutrient supply experienced during the dry season in semi-arid areas of Zimbabwe.

**Material and methods**

**Chemical characterization**

Mature and ripe fruit samples were harvested by hand in June 1999 from *Acacia nilotica*, *A. erubescens*, *A. erioloba*, *Piliostigma thoningii*, *Dichrostachys cinerea* and *A. sieberiana* trees growing in the thornveld in Mbembeswana communal areas, about 100 km south west of Matopos Research Station, Bulawayo, Zimbabwe. Annual rainfall in this area averages 400mm. The fruits were bulked by species and stored in brown paper bags until required for use.

Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined by refluxing 1 g samples in neutral and acid detergent solutions, respectively, according to the method of Goering and Van Soest (1970). Acid detergent insoluble nitrogen (ADIN) was determined by nitrogen analysis on ADF, dried at 40°C for 48 hours, using the Dumas total combustion method with a Carlo Erba Elemental Analyser 2100.

Samples used for the analyses of N and phenolics were further ground to pass through a 1mm sieve. Total N was determined on 50mg sample using the Dumas method as for ADIN.

Phenolics were estimated after extraction of 40mg sample three times with 10ml 70 per cent aqueous acetone for a total of 15 minutes. Soluble condensed tannins (SCT) were estimated using the butanol-HCl reagent (95:5 v/v) (Porter et al., 1986). Aqueous acetone extract (0.5ml) was pipetted into a glass screw cap test-tube and 5ml butanol-HCl reagent
Addition of the test-tube was closed and then placed on a heating block at 100°C for 1 hour. Absorbance was measured after the test tubes had cooled to room temperature. The measurements were reported as absorbance units (au) at 550 nm. Determination of trivalent ytterbium precipitable phenolics was done on a 70 per cent aqueous acetone extract, which was obtained as described above for SCT and insoluble condensed tannins (ICT). Ytterbium precipitable phenolics were gravimetrically determined using the procedure described by Reed et al., (1985) Results were expressed in g kg⁻¹ DM.

Effect of tannins on in vitro fermentation

Microbial fermentation was assessed using the Reading Pressure Technique (RPT) (Mauricio et al., 1999). About 1g of sample, ground to pass through a 2mm sieve, was weighed into 125ml serum bottles. Using an automatic dispenser (Jencons, Hemel Hemstead, England), 90ml reduced buffer was added to each serum bottle. The buffer was divided in two and polyethylene glycol (PEG) dissolved in one set to give an application rate of 1g PEG per 1g DM of substrate, based on work done by Makkar et al. (1995) and Salawu et al. (1997). Serum bottles without samples (blanks) were also included for each of the six withdrawal periods (6, 12, 18, 24, 48 and 96 h post-incubation) to allow correction for gas produced from rumen liquor. After addition of the buffer, the flasks were sealed and stored at room temperature (20°C) before being transferred into the incubators, set at 39°C, 8 h before inoculation with rumen fluid.

Rumen fluid was obtained from a cow fed ad libitum on a diet comprised of grass and maize silage and concentrate (wheat, barley and soya bean meal). Rumen fluid was collected at 07.00 h, prior to feeding. Inoculation was complete within 60 minutes of fluid being prepared. Rate of gas production, in vitro dry matter degradability (iDMD), in vitro organic matter degradability (iOMD) and partition factors were determined.

Detannification: in sacco evaluation

Alkaline treatment was carried out by soaking fruits overnight in distilled water, in which NaOH pellets had been dissolved to give a 6 per cent (w/w with the fruit sample) NaOH treatment level. Sufficient water was added to wet the entire sample, producing a thick paste ensuring that no leaching of the sample occurred. Polyethylene glycol-4 600 (Aldrich Chemical Co. Inc, USA) was dissolved in distilled water and the solution mixed with D. cinerea fruits. A PEG application rate of 200mg g⁻¹ of sample was used. The mixture was left to react overnight. The treated samples were then spread onto polythene sheets and sun-dried for 24 h.

Three adult male Matebele goats fitted with ruminal cannulae and weighing about 25kg live weight were used in this study. These animals had been used in a previous experiment, where diets containing mixtures of fruits were compared. The goats were housed individually in crates under a roofed shed with a concrete floor. They were fed on 200g mixed fruits per animal per day and grass hay ad libitum. Water was available at all times. The animals had been on this diet for 85 days. Dry matter loss from the rumen and nitrogen degradability were determined using nylon bags (Lockertex, Cheshire, England), measuring 6cm * 12cm with a pore size of 40 µm. About 5 g of each sample were weighed in duplicate, for every treatment and each incubation time, into nylon bags, which were incubated in the rumen of the fistulated goats (internal diameter of the rumen cannulae was 40mm). The incubation was carried out in a 3*3 Latin square design trial. Each period was of 3 days duration and a 24h changeover period was allowed, to ensure that there was no residual effect of the previous treatment on the following treatment. All bags were inserted into the rumen at the same time (07.00 h) on the first day, before the morning
feeding, and were incubated for 4, 6, 12, 24, 36, 48 and 72 h. The bags were withdrawn at different times (sequential withdrawal). Upon removal from the rumen the bags were cleaned with tap water and immersed in ice water to stop microbial fermentation activity (Shannak et al., 2000). The bags were frozen until all the incubated bags were withdrawn at the end of the period. Together with the 0h bags, incubated bags were washed with cold water three times in cycles of ten minutes, in a twin-tub semi-automatic washing machine (Rotary tub, Goldfish, South Africa). Washed nylon bags were then dried in a forced-draught oven at 60°C for 48 hours and cooled in a desiccator, followed by weighing.

Loss in dry matter (DM) for each incubation period was calculated as follows:

\[
\text{DM Disappearance} = \frac{\{(OSBW - BW) \times DM1\} - \{(RSBW - BW) \times DM2\}}{(OSBW - BW) \times DM1}
\]

where:

- OSBW = Original sample weight + nylon bag (g)
- BW = Nylon bag weight (g)
- RSBW = Residual sample weight + nylon bag (g)
- DM1 = Dry matter of feed sample
- DM2 = Dry matter of residue sample

Loss in N was calculated on the basis of N incubated as follows:

\[
\text{N Disappearance} = \frac{(\%N1 \times OSW \times DM1) - (\%N2 \times RSW \times DM2)}{\%N1 \times OSW \times DM1}
\]

where:

- \(\%N1\) = Percent nitrogen in original feed sample
- OSW = Original sample weight (g)
- DM1 = Dry matter of feed sample
- \(\%N2\) = Percent nitrogen in residue sample
- RSW = Residual sample weight (g)
- DM2 = Dry matter of residue sample

Degradation data were fitted to the Ørskov and McDonald (1979) non-linear model using NEWAY Excel Version 5.0 package (Chen, 1997). The Ørskov and McDonald model reads:

\[
p = a + b(1 - e^{-ct})
\]

where:

- \(p\) = disappearance of DM and N
- \(a\) = washing loss or soluble fraction
- \(b\) = degradable part of the insoluble fraction
\[ e = \text{degradation rate of fraction } b \]

This gave estimates for the soluble and insoluble fractions as well as the rate of degradation. Effective degradability (ED) of N was calculated, after assuming a 5 per cent h\(^{-1}\) solid outflow rate, according to the following equation:

\[ ED = \frac{a + b \cdot c}{k + c} \]

where \( a \), \( b \) and \( c \) are the constants from the Ørskov and McDonald (1979) equation above and \( k \) is the outflow rate of the solid phase in the rumen.

The effect of treatments on chemical composition (DM, OM, NDF, ADF, N and NDIN) was obtained by subjecting the data to a one-way analysis of variance. The effect of treatments on the in sacco degradability was analysed using the general linear models procedures of SAS (SAS/STAT, 1996) for a Latin square.

**Detannification: in vivo evaluation**

Thirty castrated Matebele goats, aged 18 – 22 months and weighing on average 27.4kg, (s.d. = 2.5) were assigned to five diets, using a randomized complete block design after the animals had been blocked according to initial live-weight. Each of the five diets was randomly allocated to the five animals in the six weight-blocks. The goats were then penned individually in metabolism crates measuring 120cm long, 54cm wide, and 90cm high and raised 90cm above the floor. The crates were fitted with feeders and drinking bowls. All the goats were dewormed at the beginning of the adaptation period, by oral administration of 8ml of Systemex liquid, active ingredient, oxfendazole 2.265 per cent m/v (Cooper Zimbabwe, Pvt Ltd), using a 10ml syringe.

The five experimental diets consisted of mixed grass hay in combination with the following supplements:

- **Diet A** - 200 g day\(^{-1}\) of alkali treated *D. cinerea* fruits
- **Diet B** - 200 g day\(^{-1}\) of polyethylene glycol treated *D. cinerea* fruits
- **Diet C** - 200 g day\(^{-1}\) untreated *D. cinerea* fruits
- **Diet D** - 200 g day\(^{-1}\) CPS (National Foods Pvt Ltd, Bulawayo, Zimbabwe) (positive control)
- **Diet E** – 800 g grass hay fed alone (negative control)

All animals received a daily ration of 600 g of mixed grass hay except for those on Diet E. Fruits were treated with NaOH and PEG in bulk and sun-dried to ensure less variable supplements were offered to goats throughout the trial. The treatment involved soaking fruits overnight at the rate of 0.6kg in a litre of distilled water in which 36g of NaOH pellets had been dissolved to give a 6 per cent NaOH treatment level. Polyethylene glycol treatment was carried out by dissolving 120g polyethylene glycol-4 600 (Aldrich Chemical Co. Inc, USA) in a litre of distilled water and mixing the solution with 0.6kg of *D. cinerea* fruits to give a PEG application rate of 200mg g\(^{-1}\) feed. The mixture was left to react overnight and sun-dried to improve intake.
Feed supplements were offered at 0800 h everyday and the animals were allowed 2h to consume them. After 2h, supplement refusals were weighed and removed from the feeding troughs. All the animals were then offered half of the grass hay ration, 300g for animals receiving supplements and 400g for the animals on the negative control. The other half was offered at 1600 h. Refusals were weighed and collected before fresh feed was offered. Clean, fresh, drinking water was offered at 0800, 1400 and 1600 h everyday. Grass hay refusals were weighed in the morning before the feeding of supplements.

Goats were allowed to adapt to the different diets and metabolism crates for 21 days. During this period feed intake was closely monitored to ensure that the goats were eating approximately the same amount everyday.

The collection period lasted seven days. During this period a complete collection of faeces and urine from each experimental animal was made. Sub-samples of faeces were taken for dry matter determination everyday. The DM was determined by drying the faecal samples in an oven at 100°C for 12 h. About 10 per cent of the total faecal collection from each animal was bulked over the entire collection period and stored in a freezer at –4°C to await chemical analyses.

Urine was collected in plastic containers over 25ml of 10 per cent (v/v) sulphuric acid. The volume of the urine was then measured using a measuring cylinder and a 10 per cent aliquot was removed everyday, bulked over the collection period and stored at –4°C pending nitrogen analysis. Refusals from supplements and the basal diet were weighed separately each morning and dried at 60°C for 48 h to determine dry matter refused. Sub-samples of the feed offered were also taken and similarly dried to determine the amount of dry matter offered per day. The difference between dry matter offered and dry matter refused was used as the measure of dry matter intake. Feed, faeces and refusals were both analysed for OM, N, NDF, ADF, neutral detergent insoluble nitrogen (NDIN) and ADIN to estimate the intake and digestibility of these constituents.

The proportion of average daily feed intake not excreted in faeces was used as a measure of apparent dry matter digestibility:

1. DM apparently digested = DM intake (g day⁻¹) – Faecal DM (g day⁻¹)
2. Apparent DM digestibility = DM apparently digested / DM intake⁻¹ (g g⁻¹DM)
3. Digestibilities of organic matter, NDF, ADF, N, NDIN and ADIN were calculated as in 1 and 2 on a DM basis.

Nitrogen retention was calculated as the difference between total nitrogen intake and the losses through faeces and urine:

N retention (g day⁻¹) = Total N intake – (Faecal N + N in urine)

Intake and digestibility data for OM, N, NDF and NDIN as well as retention of N were statistically analysed using the general linear models procedures of SAS (SAS/STAT, 1996).
Results and Discussion

Table 1 shows the chemical composition of tree fruits from different tree species. Terblance et al., (1967) reported incidences of poisoning leading to deaths when goats consumed excess *A. nilotica* fruits in South Africa. Symptoms observed include abortions, dyspnoea, tachycardia, methyoglobinemia, ruminal atony and hyperglycaemia. Although the toxic principle was not identified at the time, the report indicates that caution should be exercised when feeding *A. nilotica* fruits to goats on a daily basis. Soluble condensed tannin content is much lower in *A. nilotica* fruit while *D. cinerea* and *P. thoningii* fruits have higher levels.

Table 1 Nitrogen (N), acid detergent insoluble nitrogen (ADIN), neutral detergent fibre (NDF), ytterbium precipitable phenolics (YbPh) (g/kg DM) and soluble condensed tannins (SCT) (au) content of tree fruits

<table>
<thead>
<tr>
<th>Species</th>
<th>N</th>
<th>ADIN</th>
<th>NDF</th>
<th>YbPh</th>
<th>SCT</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Dichrostachys cinerea</em></td>
<td>19.9</td>
<td>5.7</td>
<td>441</td>
<td>485</td>
<td>3.4</td>
</tr>
<tr>
<td><em>Acacia erioloba</em></td>
<td>21.3</td>
<td>3.9</td>
<td>415</td>
<td>206</td>
<td>0.7</td>
</tr>
<tr>
<td><em>A. erubescens</em></td>
<td>27.1</td>
<td>6.7</td>
<td>543</td>
<td>175</td>
<td>0.5</td>
</tr>
<tr>
<td><em>A. nilotica</em></td>
<td>14.7</td>
<td>7.8</td>
<td>236</td>
<td>758</td>
<td>1.2</td>
</tr>
<tr>
<td><em>Piliostigma thoningii</em></td>
<td>13.5</td>
<td>4.2</td>
<td>493</td>
<td>299</td>
<td>4.1</td>
</tr>
</tbody>
</table>

1YbPh – ytterbium precipitable phenolics

2SCT – soluble condensed tannins

As shown in Table 2, PEG inclusion increased cumulative gas production in all tree fruits except *A. erubescens*. The highest response was obtained with *D. cinerea* fruits indicating that the tannins in the fruits from this species may reduce the availability of nitrogen to the rumen microbes. Although a 100 per cent increase in cumulative gas production was obtained with *A. nilotica* fruits, it is important to note that the majority of phenolics in this species are not condensed tannins (Table 1). The effect of PEG inclusion on OM degradability was underestimated due to the presence of PEG-tannin complexes in the residue (undegradable material) after filtration. In addition, the procedure of determining *in vitro* degradability means that phenolics that are solubilised in the fermentation medium are erroneously quantified as degradable material since these are lost during filtration.
Having established that tannins may reduce the utilisation of some tree fruits (Table 2), an experiment was carried out to evaluate the effect of detannifying *D. cinerea* fruits on nitrogen availability both *in sacco* and *in vivo*. Table 3 shows DM and N disappearance in the rumen of goats. Treatment with PEG caused excessive N loss in the rumen while alkali treated and untreated fruits caused moderate losses of N in the rumen. It is, therefore, likely that PEG treatment of *D. cinerea* fruits will cause a reduction in N retention in animals compared to alkali treatment.

### Table 2 Responses to Polyethylene glycol (PEG) inclusion (+/-) of cumulative gas production (ml/g OM) and organic matter (OM) degradability (g/g OM) at 48 h post-inoculation

<table>
<thead>
<tr>
<th>Species</th>
<th>Cumulative gas production</th>
<th>Organic matter degradability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td><em>Dichrostachys cinerea</em></td>
<td>48</td>
<td>156</td>
</tr>
<tr>
<td><em>Acacia erioloba</em></td>
<td>130</td>
<td>164</td>
</tr>
<tr>
<td><em>A. erubescens</em></td>
<td>102</td>
<td>115</td>
</tr>
<tr>
<td><em>A. nilotica</em></td>
<td>78.8</td>
<td>150</td>
</tr>
<tr>
<td><em>Piliostigma thoningii</em></td>
<td>143</td>
<td>193</td>
</tr>
</tbody>
</table>

### Table 3 *In sacco* disappearance of dry matter and nitrogen from treated and untreated *Dichrostachys cinerea* fruits incubated in the rumen of Matebele goats

<table>
<thead>
<tr>
<th>Parameter ‡</th>
<th>Untreated</th>
<th>NaOH treated</th>
<th>PEG treated</th>
<th>s.e. mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>26.4&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.3&lt;sup&gt;b&lt;/sup&gt;</td>
<td>42.8&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.71</td>
</tr>
<tr>
<td>b</td>
<td>48.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>36.4&lt;sup&gt;b&lt;/sup&gt;</td>
<td>32.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>2.22</td>
</tr>
<tr>
<td>c (% h&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>3.26&lt;sup&gt;a&lt;/sup&gt;</td>
<td>3.92&lt;sup&gt;a&lt;/sup&gt;</td>
<td>5.78&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.549</td>
</tr>
<tr>
<td>PD&lt;sup&gt;2&lt;/sup&gt; (a + b)</td>
<td>74.7</td>
<td>65.7</td>
<td>75.6</td>
<td>-</td>
</tr>
<tr>
<td>ED&lt;sup&gt;3&lt;/sup&gt;</td>
<td>44.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>43.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>59.7&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.19</td>
</tr>
<tr>
<td>a</td>
<td>47.5&lt;sup&gt;a&lt;/sup&gt;</td>
<td>52.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>61.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.72</td>
</tr>
<tr>
<td>b</td>
<td>43.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.9&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.74</td>
</tr>
<tr>
<td>c (% h&lt;sup&gt;-1&lt;/sup&gt;)</td>
<td>3.59&lt;sup&gt;a&lt;/sup&gt;</td>
<td>6.76&lt;sup&gt;b&lt;/sup&gt;</td>
<td>11.63&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.463</td>
</tr>
<tr>
<td>PD (a + b)</td>
<td>90.6</td>
<td>81.8</td>
<td>89.7</td>
<td>-</td>
</tr>
<tr>
<td>ED</td>
<td>64.7&lt;sup&gt;a&lt;/sup&gt;</td>
<td>68.8&lt;sup&gt;b&lt;/sup&gt;</td>
<td>81.0&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.49</td>
</tr>
</tbody>
</table>

<sup>1</sup>In a row, means with the different superscripts differ significantly (P < 0.05)

<sup>‡</sup>Units: For Dry matter a, b, PD and ED are measured as per cent of DM, for Nitrogen a, b, PD and ED are measured as per cent of N incubated.

<sup>2</sup>PD = Potential degradability
ED = Effective degradability estimated as: $ED = a + \frac{b \cdot c}{k + c}$, $k$ (outflow rate of solids) assumed to be 5 per cent h$^{-1}$

Table 4 shows the results when detannification treatments were compared in a metabolism trial. Goats offered untreated fruits had significantly ($P < 0.0001$) higher N retention values when compared to those offered treated fruits. There were significant ($P < 0.05$) differences among treated fruits, with alkali treated fruits causing higher N retention values than PEG treated fruits (2.70 vs. 0.96 g N day$^{-1}$ respectively). All supplements increased the goats’ intake of grass hay by at least 50 per cent over the unsupplemented animals. This confirms that provision of N to rumen microbes improves the utilization of fibrous poor quality feedstuffs. An increase in grass hay intake was observed when calves were supplemented with *Acacia tortilis* fruits (Coppock, 1993). Tanner *et al.*, (1990) reported similar findings when sheep fed on maize stover were supplemented with *A. tortilis* fruits.

**Table 4 Metabolism trial: *in vivo* evaluation of detannification treatment of *D. cinerea* fruits**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Untreated</th>
<th>NaOH$^2$</th>
<th>PEG$^3$</th>
<th>Goat Meal</th>
<th>Unsupplemented</th>
</tr>
</thead>
<tbody>
<tr>
<td>OM intake (g)</td>
<td>610$^{bc1}$</td>
<td>598$^b$</td>
<td>640$^c$</td>
<td>622$^{bc}$</td>
<td>297$^a$</td>
</tr>
<tr>
<td>Urine N (g)</td>
<td>0.67$^a$</td>
<td>0.46$^a$</td>
<td>1.68$^b$</td>
<td>0.48$^a$</td>
<td>2.09$^c$</td>
</tr>
<tr>
<td>OM dig</td>
<td>0.54$^b$</td>
<td>0.50$^a$</td>
<td>0.56$^b$</td>
<td>0.58$^b$</td>
<td>0.58$^b$</td>
</tr>
<tr>
<td>NDF dig</td>
<td>0.46$^b$</td>
<td>0.51$^b$</td>
<td>0.55$^c$</td>
<td>0.51$^b$</td>
<td>0.59$^d$</td>
</tr>
<tr>
<td>N balance (g)</td>
<td>3.7$^c$</td>
<td>2.7$^b$</td>
<td>0.96$^a$</td>
<td>4.1$^c$</td>
<td>-3.4$^d$</td>
</tr>
</tbody>
</table>

$^1$In a row, means with the different superscripts differ significantly ($P < 0.05$)

$^2$NaOH = sodium hydroxide treated *D. cinerea* fruits

$^3$PEG = polyethylene glycol treated *D. cinerea* fruits

The unsupplemented animals in this experiment represent the plane of nutrition for smallholder owned goats during the dry season. Negative N balance and low feed intake suggest that the animals gradually lose weight during the dry season and thus are prone to malnutrition and disease. By offering *D. cinerea* fruits as a protein supplement, farmers may be able to maintain their goats through the dry season. In absolute terms, the production improvements, as a result of the N retention, observed in this study are modest but it is important to emphasise that maintenance of animals through the dry season is the most appropriate production objective in the communal farming system. It appears that tannins in *D. cinerea* fruits used in this experiment are beneficial to the animal and hence did not require inactivation. This raises questions about the suitability of *in vitro* tannin bioassays as predictors of *in vivo* tannin effect. There is need to include, as part of *in vitro* tannin bioassays, measures of the effect of tannins on protein degradability. This might be investigated by fermenting tanniniferous forages with and without PEG in a nitrogen deficient medium. This ensures that the nitrogen deficient rumen environment when goats
are consuming low quality fibrous diets in the dry season is adequately simulated. The improvement in fermentation with PEG treatment can then be attributed to the increased availability of nitrogen in the fermentation medium.

Conclusions

This study revealed that tree fruits harvested from Mbembeswana communal lands contain enough protein to improve the utilization of poor quality feeds during the long dry seasons experienced in this area. However, the presence of phenolics reduced protein degradability in sacco. Up to 70 and 50 per cent of the dry matter of A. nilotica and D. cinerea fruits, respectively, were made up of phenolics, which negatively affected in vitro fermentation of the fruits. Evaluation of feedstuffs rich in phenolics has concentrated on the colorimetric and gravimetric assays, which unfortunately say little about the potential biological activity of the phenolics.

Alkaline treatments had limited efficiency (up to 30 per cent) on fruit tannins compared to PEG. This could be because tannins in ripe and mature fruits exist in bound form and their reactive sites are not accessible to the alkali. Polyethylene glycol was more efficient because its mechanism of action is mediated through its high affinity for tannins allowing it to bind tannins, which are already bound to other constituents.

Results from the nitrogen balance trial showed that alkaline treatment, unlike PEG, did not cause excessive protein degradation in the rumen.

References


Supplementation of on-farm goats using feed resources available in south-west Zimbabwe


1Matopos Research Station, Private Bag K5137, Bulawayo, Zimbabwe
2School of Agriculture, Policy and Development, The University of Reading, Earley Gate, PO Box 237, Reading, RG6 6AR, United Kingdom

Introduction

Goats in the communal areas of Zimbabwe are primarily dependent on natural range for their forage requirement. During the dry season, when the quantity and nutritional quality of grazing in natural pastures is low, browse species form a major portion of food for goats. In these areas goat productivity is severely affected by high kid mortality and low growth rates. Most of the goats in the drier regions kid in the dry season. In the smallholder sector farmers can lose more than 50 per cent of goat kids born in a year.

In the present study communal goat flocks were evaluated in terms of animal performance when supplemented with browse pods.

Area

The study was conducted in eight sites located in Matobo, Matabeleland South Province, at 21° S and 28°3′ E longitude, in the south-west of Zimbabwe. The district is in natural region IV, on a scale of 1 (high potential) to V (arid).

The vegetation is mainly Colophospermum mopane and Acacia species and other thorny bush species; and some perennial grasses provide ground cover. Rainfall is between 450mm-650mm and the altitude is above 900m. Drought cycles are common in this area. Soils are shallow, coarse clay and sand over reddish brown sandy clay from granite.

Animals

A total of 254 female goats were monitored during the dry season, August to October 2001. Only pregnant and lactating goats were monitored.

Farmers

A total of 66 farmers, resident at the eight sites, hosted the on-farm trials. Farmers fed the goats their own choice of pod supplement, mainly determined by availability. A few farmers did not supplement their goat and their flocks were regarded as control groups.

Measurements

Monthly weights were collected for both adults and their progeny.

Results

The results are presented in Figure 1 as an example of an extension message for farmers.
Does being monitored had twins. Kid mortalities were very low. Kid birth weights appeared high, probably because weighing was dependant on Matopos Research Station, who visited each site on a monthly visit. There was a weight difference between supplemented and unsupplemented does. In two of the areas does lost weight.

Farmers who fed their animals with pods (whole or ground with a pestle and mortar) expressed satisfaction in the condition of their animals. Further work is needed to quantify milk yield in both supplemented and unsupplemented does. Most households value the contribution of milk produced in excess of the requirements of the kids. Dry season supplementation has the potential to increase this.

**Figure 1 Extension message**

**Dry season supplementation is necessary**

Supplementation of goats in the dry season supports high growth rates

Browse trees produce fruits and leaves which are rich in protein

Fruits can be collected and stored for later use

**Benefits**

Increased kid survival

Increased milk production

Increased meat production

Cheap feed resource for farmers in the rural areas

Easy to process

More value to natural resources

During the wet season goats feed on browse leaves and grass
1. A farmer picking browse pods during the dry season

2. Goats feeding on fallen browse pods

Goats kidding in the dry season when there is no feed: doe and kids in poor condition
Pods collected can be stored in a granary/drum/plastic bag.

Farmer processing pods: pounding (pestle and mortar)
A farmer feeding goats in a pen/kraal Ration: one handful of pods per adult goat

Goat not fed (lost all her kids)  Goat fed with pods (her kids survived)

Browse trees

isinga  umkhaya
uguwe  ugagu
umtshatshatsha  ihabahaba
iwohlo

143
Zimbabwe: Questions and answers

Is supplementation provided at the best time, e.g. at the time of breeding?

Bucks are available throughout the year but the trial may generate change, especially when farmers want to sell finished kids around Christmas. The issue of whether it would be better to advise farmers to change their management strategy so that kidding takes place during the rainy season or when there is enough forage to reduce high mortalities was raised earlier. However, generally there is no controlled breeding in the rural areas. Bucks run with females throughout the year. With time, controlled breeding will be discussed with farmers and thereby strategies will be set. This could reduce kid mortality and farmers could supplement young animals for sale.

Were pods fed at the same stage of maturity in each year?

It is difficult to control the stage of maturity across years as pods are collected at ‘pod fall’, There are large differences between trees of the same species within relatively small plots. Pods, of each species, are bulked for each trial to reduce variation in the supplements fed.

Was treatment with NaOH making the carbohydrate fraction more digestible as well as inactivating the tannins?

This is an important question, how to apportion the possible effects of treatment. The issue of whether the effects of treatment with alkali (wood ash) was due to improved digestibility of the pods or solely through reducing the tannin content was considered. Alkali treated material was incubated with PEG and the increase in digestibility was compared to that of the untreated material also incubated with PEG. The effect of PEG on treated material was expected to be less than its effect on untreated material.

Have you ranked the acceptability of the different pod species?

We have intake and refusal data from feeding and metabolism trials.

Two comments were made from the floor:

1) It can be useful to have a cafeteria system in ranking the browse supplement to assist in selecting pod species for study in long-term feeding trials to supplement information from the laboratory. We have data available in our laboratory (Professor S.A. Abdulrazak)

2) This is an example where the STIR (Short Term Intake Rate) technique could be used (Professor E. Owen).
General Discussions

The discussions following the presentations often resulted in the discussion of general issues, as well as the more project-specific ones that have been included at the end of each country chapter.

Worm burdens: three approaches to the problem

Three approaches to the problem of worm burdens were presented at the workshop:

a) Increasing energy
b) Increasing protein
c) Use of tannins

The first two approaches are limited by the environment the farmers are working in.

Are the approaches of increasing energy or protein causing different responses in the animal? For example, does increased energy supply increase immunity?

- No, an increase in protein would have more effect on an increase in immunity.
- Maize and barley contain energy and protein, both necessary for the formation of microbial protein. An increase in energy to the diet results in an increase in digestibility.

When you feed a ruminant it is difficult to separate protein and energy supply. When you get a gut infestation that causes leakage of bodily fluids, therefore, the increase in protein and energy can just be replacing lost nutrients. The gut is one of the most important organs for protein metabolism.

How can you suggest increasing protein and energy supply when these aren’t always available to farmers? Will farmers accept this approach?

Maybe alternative sources of proteins could be used, i.e. ones that don’t compete with human diets. One example would be *Mucuna pruriens* used by farmers in Karnataka, India (Project R6953).

It is difficult to tell people to give feed supplements to their smallstock as they are very expensive. But, if you can demonstrate their benefits it might be easier to convince people to invest in them.

Farmers need to know the best time to provide supplements to their smallstock. The critical time is often at the start of the rainy season.

Is enough known about the use of tanniniferous plants as anthelmintics? For example, how long do the animals need to be supplemented with them?

First, we need to demonstrate that tanniniferous plants work in practice. Wattle tannin was used here because of its availability from the local leather industry. There is a massive database of plants with biological control available from the USA at a very low cost to non-profit making organizations.

The plants used by Project R6953, in India, are found to have an effect as anthelmintics. It was agreed that LPP would supply funding to enable the University of Nottingham to
analyse the plants used in Dr Joshi’s project. It was suggested that the programme should be working with entomologists to look at the nature of the tanniniferous plants used.

**Urea molasses blocks**

*The use of urea molasses blocks was heavily promoted a few years ago by FAO, but what has happened? Are they being used by farmers?*

These have been used in India, molasses granules are also used. In Tanzania the blocks weren’t used because people preferred to use the molasses for making spirits.

When interventions are suggested to farmers, they should be given a full explanation of the reasons for this. Often farmers are told to do something but not given all the information, the treatment does not work and the farmers lose trust in the information-provider. In some instances, this may have happened with the block technology.

One of the advantages of urea molasses blocks was that all animals had an opportunity to lick the block; with a supplement added to communally available feed weaker animals were less likely to receive a fair share.

Where farmers feed their animals with conserved residues they get better results from their animals. Some farmers are using poultry litter as a feed supplement for smallstock. However this increases the risk of disease transmission and can also be expensive.

**Contribution of research to development by 2005**

Donor expectations are felt by researchers to be unrealistic. Providing livelihood improvements by 2015 may well be achievable but the process of moving demand-led interventions from the researcher to the farmer requires a minimum of 10 years. The process requires many steps: dissemination / promotion / uptake by service providers / adaptation by farmers / adoption by farmers / impact on livelihoods / up-scaling.

It was felt that inter-agency activities at research and development level (CGIAR, NARS and international NGOs) should share more of the effort and resources, so that more effective delivery of research findings could be ensured. Farmers must be involved in this process. Interdisciplinary problems or approaches should be given top priority.

**Basket of options**

An approach that the link project should consider is to consolidate their outputs into a basket of options. The concept is that farmers (and service providers) are more likely to adopt knowledge if they were presented with a choice of interventions to choose from. This is a hypothesis which needs to be tested. However, it must be an improvement on the golden bullet approach often promoted by researchers where a single intervention or ‘fix’ is expected to resolve all a farmers’ problems.

In South Africa, there are a number of studies showing that farmers need basic information on simple concepts. An example is the importance of nematodes as pathogens in goats, indicators of when they are present in the animal, the signs of disease and how to treat animals to remove the worm burden. This information can be put in a ‘basket’ of options that farmers can use/adopt/gain from.
Maybe there is a need to re-visit the analysis of project outputs so that they are all analysed from a process perspective with a particular emphasis on examining how the research process has helped to embed target/goal farmers within a problem-solving partnership.

A Participatory Rural Appraisal from project R7351 in Zimbabwe has indicated that pods are traded but which pods and how much has not been known. The project has tried to answer this. There is information for a ‘basket’.

From a Zimbabwean perspective, farmers visit the stations (Matopos Research Station and others) from time to time. The Station staff advise them on management issues for successful goat production. For example, general management, disease control (tick borne), proper shelter for goats, appropriate feed resources (pods and commercial feed) for pen finishing, supplementation during the dry season. This information is appropriate for inclusion in a basket.

There is a need to look at the farmers’ needs from a holistic approach and certainly the sociological aspects have to be considered. Farmers need to be involved more in the research process.

The issue of involving farmers in technology development has been addressed by KARI since 1993, where farmers have been participating in diagnosis, prioritization of constraints and interventions, research and to some extent dissemination. What was lacking was the up-scaling of these technologies from the few participants to the wider community and moving to other areas with a similar environment. This is now being addressed by the Agricultural Technology and Information Response Initiative (ATIRI) where farmer groups are demanding the technology, are helped to get it and are given a ‘backstop’, through access to the researchers. What is lacking is an integrated, or holistic, approach to the farmers’ needs. The farmer is a soil manager, livestock manager, economist, marketer and the vet operating for his survival within a constraining sociological environment.

We need to go beyond the basket to ‘how to be successful’. The ‘how to’ may mean ‘what partners to work with to transfer the basket,’ so you pre-empt other obstacles that might arise after the basket begins to be used. For example, a partner to deal with marketing of the increased output may be needed. These are some of the strategies that the Africa Agricultural Technology Fund (AATF) is encouraging other scientists and players to follow, for example forming partnerships with the private sector to promote uptake of research outputs. We need to break down the isolation of groups.
Recap of the meeting

C.J. Garforth

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Scientific presentations

On Tuesday we heard teams of scientists who over the last few years have been grappling with the variability of farming systems outside the laboratory and research station. I felt that the research teams presented a lot of learning they had gone through about how to do rigorous research in variable environments, e.g. those with seasonal or annual variation etc. I also heard a lot of frustration in conversations over having to squeeze scientific research into timeframes set by donors. I also heard caution, both in the presentations and later, at the end of the day, in the general discussions, about being asked to articulate specific messages on a number of grounds:

- Ethical concerns – are we sure we won’t be running the risk of harm to animals? Do we know enough?
- Broader concerns about the research, i.e. is more research needed to refine the information to be promoted?

Perhaps because the emphasis on Tuesday was on science, I heard very little about the potential impact on livelihoods. There was some talk of economic analysis but as we are aware, the assumptions lying behind the economic analysis may not be matched by people’s realities in the field. A simple example is using the value of an increased production of milk as an economic benefit when people aren’t selling milk. Does that match with the way the goat keeper would estimate value to the household?

Very little data was reported regarding on-farm data to report who we are working with in relation to resource-poor poverty. Is this because we don’t know who we are working with?

At the end of Tuesday the feeling I was left with was that we need the same kind of rigour applied to science to be applied to reaching conclusions about the livelihoods and poverty effects of our findings. That perhaps is one of the challenges the programme faces over the coming years.

Field visit

The workshop visited members of the Meru Goat Breeders Association and learnt how different groups were benefiting from involvement in the scheme; both by obtaining access to goats and also to learning how to work in partnership with one another. Like many other people I was impressed with the set-up of the Meru goat project. Some questions have been raised about the question of economics at the household level. From the questions raised, there is no doubt the members of the groups feel their efforts are more than worth it for the benefits derived. Maybe it is more in terms of the social capital they gain and the human capital, e.g. knowledge gained, not just in relation to breeding and goat management but in relation to the wider farming system. The people involved think it is worthwhile. How do they articulate the costs and benefits?
Equally impressive was the whole institutional set up of the Meru Goat Breeders’ Association (MGBA), a very bottom-up institution from local groups up to the breeders association itself. It is a strong civil society organisation that has already achieved power in local affairs and has given people a voice.

Also impressive was the very effective collaboration between the service providers, vets, research, non-government organisations (NGOs, e.g. FARM-Africa and others), and government extension officers all working together. It was suggested that leadership and the personalities of individual people who initiated the programme have been an important factor in that. I think it also reflects the project set-up that provides incentives for all those organisations to play a part. One of the incentives is the creation of an environment that allows the organisations to do their jobs correctly. We should learn from this.

**Extension messages and dissemination workshop**

I think we were all disappointed we didn’t have more service providers here despite all the work of the workshop organisers. That is disappointing on three fronts:

1. We know we need service providers and we know we want to work with them. We are a small number of researchers, we have very limited time and budgets for dissemination and promotion and we need to use these resources strategically. We need these intermediate groups to deliver our messages.

2. We wanted to engage in dialogue with them. There are questions we want to ask. For example, how much information do service providers want before they will accept our messages? We want to know how we can serve their needs more effectively.

3. Maybe, although this may be reading too much into a single event, it gives us a hint towards service providers’ attitudes towards research. Maybe they didn’t think the Workshop would be particularly relevant to them. This implies we have to convince the service providers that they can benefit from dialogue with us.

The term service provider is controversial and some people have expressed unease with it. For some it implies organisations that are contracted by a public body to carry out a service, e.g. street-sweeping. If we are stuck with the label we must articulate what we mean. Dan Kisauzi made the point that there is a danger in using the label because it lumps together some very disparate organisations. It is a convenient label but we need to be clear what we mean by it.

**Message presentations**

It was interesting that after all the caution expressed earlier the teams were prepared to come up with very specific messages that they felt could be promoted to farmers and others. Some were based on existing knowledge, with the provision that research would refine the results. Other people said this is what we think we would be willing to promote, but more work is required. Some of the caution expressed earlier had disappeared. There were both technical messages and process messages.
**Working groups in the afternoon**

In a very short space of time all the groups came up with useful dissemination and promotion frameworks within which strategic decisions could be made about communicating to different audiences. There was very little time to do this. One possible further step would have been to prioritise the constraints to uptake identified by different audiences; e.g. if credit is a major limiting factor, how does this affect uptake?

We have to prioritise because we can’t do everything. We should focus on those things that will have impact.

Within the matrixes drawn up, it was very clear that many of the strategies identified need to be interactive based on face-to-face communication. A lot of the activities are not one-off but are ongoing and iterative, based on dialogue and discussion, trying to win people over to a point of view. So when we look at specific media applications, such as videos and posters, it must be remembered that the main role of the media is to support ongoing discussion, by providing essential inputs into that process. When we talk about deriving messages from research we are not suggesting that a message is synonymous with a single leaflet, which may simply be part of the process in understanding an idea.

**Draft leaflets**

I would like to re-emphasise that this was an *exercise*. The leaflet is a useful vehicle for realising the challenges for translating simple messages for farmers. One of the ways in which the groups tried to make the link was by highlighting the financial benefits of a particular practice.
Reflections on the leaflets

D. Campbell
*Mediae Trust, Nairobi, Kenya*

**Introduction**

I was really impressed with the leaflets. I was impressed that the groups arrived at simple messages quickly as it can be hard for scientists to use the 5-word concept\(^1\). Two of the messages can be used to emphasise some general points:

**Nepal**

The project from Nepal used very simple messages and had a clear image, the handful of maize. More work is required on this message to decide who it should be aimed at (children or adults).

In a leaflet produced by the Mediae Trust looking at malaria prevention, the actions were listed along the top, and the why underneath. The Nepal leaflet needs to provide back-up in the leaflet.

**South Africa**

The group had listed everyone as an audience but needs to be aware of their limited budget. One thing you could do is mix and match; for example the principle audience may be farmers, but the leaflet could also be of use to front-line extension officers as they have a similar level of understanding. I would always target one audience then look to see if it is acceptable to others, rather than trying to make something that will appeal to all.

**Next steps for production of promotion materials**

Look at your budget. Look again at the strategy of your dissemination and decide who the main audience will be. If you decide on a leaflet, I would suggest the next step would be to speak to the people involved in developing your print material, including the designer and printer. Using your notes, get them to lay out your designs on the computer. Work out what you want, and get 10-20 printouts in colour for pre-testing. Speak to farmers, give them the leaflets and ask them study them for later discussions. Then, taking account of the farmers’ comments, print a larger run (e.g. 1,000 copies) for wider field testing. Feedback on the first trial of the malaria leaflet resulted in the picture of the bed being changed because people said that no-one slept on a bed like the one depicted. The greater the quantity of leaflets printed, the lower the cost per leaflet. You need to over estimate the number of leaflets you need. In Meru we printed enough for the farmers known to us, plus an additional 50 per cent. My point is that you are not far away from getting your leaflets underway. You need to get the cost from the printer so you can see if it will fit into your strategy cost-wise. You will need to balance your books. Radio may be another option so you should look into the costs of that.

In general, I was very impressed with the leaflets. I think the next step is pre-testing.

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\(^1\) Mediae Trust advise that words of more than 5 letters should not be used in promotional materials
Comments on the meeting and dissemination presentations

Where do we think we are going with dissemination? Where do you think you should be putting your project efforts? What are the priorities?

On a project basis the LPP would like to think projects consider this to be a milestone for the coming year. The LPP would like to see a prioritised list of dissemination products coming out of each project’s work. A lot of people believe research is not delivering and it is partly a marketing issue. You need to make donors aware that there is a product there. Make sure you send your promotion messages to the donors as well as the other stakeholders.

- Participants said they had found the dissemination workshop very useful and interesting. Those at the end of their projects thought it would have been very useful to have had such a workshop at the start of their projects.
- It was suggested that dissemination guidelines should be produced for future projects.

Monitoring uptake and impact of promotion message – how do you go about this?

Before message transmission

In many countries, including India, Kenya, South Africa, Uganda and Zimbabwe, information is available. A good source of information is often the commercial providers of inputs, who need to know which socio-economic group they are communicating with at all times, and to have reliable measures of impact. Where applicable, there is basic data which can help projects decide which radio station to use, although they probably already have a feeling about this. Statistics can be obtained from a commercial organisation such as advertising agencies. Your printer or designer may also have access to relevant data.

After message transmission

Some monitoring of uptake and impact of promotion messages can be done by finding out how many people watched or listened to a transmission. It is expensive to do statistically viable monitoring regarding change of knowledge: Mediae Trust has done this in Kenya but as it is very difficult and expensive they are going to stop. Knowledge and attitude is slightly easier to measure. For project teams, the best bet is to go back to your target audience and see if they heard the radio programme; this could be done by working with small focus groups where you hand out leaflets and test people’s understanding of the message before and after receipt of the leaflet or listening to the radio programme etc.

The option of commissioning an independent group to find out attitude change is expensive; a recent nationwide analysis cost the Mediae Trust £22,000. It would be cheaper to use existing statistics plus 4 or 5 focus groups.
Service providers / promotion partners

A lot of service providers / promotion partners had been invited to the workshop but unfortunately most were unable to attend. Although participants at the workshop were pleased to see representatives from Heifer Project International, Meru Goat Breeders’ Association, BAIF, FARM-Africa, Nkoola Institutional Development Associates and Medie Trust, concern was felt about the service providers who did not attend. The research teams realised that although their role included carrying out the research and testing the efficacy of a dissemination product with a local target audience, promotion of the research findings could be passed to a much wider audience by the service providers.

The following were suggested as reasons why service providers may not have attended the workshop:

- They are too busy to attend
- They feel the research findings are not relevant to their work
- They feel the research teams are not including them sufficiently, and are concerned the research teams are trying to carry out their role
- Their organisations may not have enough people to attend the different workshops whilst ensuring that day-to-day work is carried out
- Lack of remuneration for attendance
- Lack of desire to interact with scientists
- This is the first meeting on this topic at Embu. If it was repeated annually attendance would increase with time.
- Organisers have targeted the wrong people, including those who aren’t aware of the project so have no interest in attending the meeting.

Possible solutions

- Maybe research teams should work more closely with the service providers, particularly in designing the final dissemination products (i.e. those aimed at the livestock keepers)
- Be more sensitive to service providers. For example, do not send a team of researchers, equipped with food and per diem payments etc., to an area where the extension worker is not provided with anything
- We also need to make it clear what people could get out of the meeting
- The interest to attend will depend on peoples’ motivation. The title of ‘international workshop’ is good to target people at the national level, because they can then delegate to their local office.

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2 During the meeting use of the term ‘service providers’ was discussed. Several of those perceived to be ‘service providers’ disliked the term as they felt it was misleading, e.g. it represented people hired for one specific service, or referred to organisations contracted by the government. The term ‘promotion partners’ was preferred by some people. To make easier reading these proceedings will use either term interchangeably. It should be recognised that service providers / promotion partners are not homogeneous; they will have different agendas and different roles to play in promoting research messages.
More emphasis needed on dissemination?

Most research projects underestimate the proportion of their budget which should be used for dissemination. There are some exceptions, notably the pharmaceutical companies who spend a much larger proportion of their budget on marketing. The research departments of the pharmaceutical companies are also often a lot more targeted than other research teams. However, with limited funds, a huge push on dissemination is usually well beyond the mandate of a single project.

So, where should this effort come from?

The research managers need to work together with the appropriate service providers to refine the research messages and to pass them on to the livestock keepers. It is unlikely that the service providers are going to be excited by a single fix so there needs to be a steady stream of fixes. The service providers also differ in their interests and, therefore, will concentrate on different aspects of the research findings.

If research managers are to take a more targeted approach, maybe project findings that are ready to be scaled up should be identified. We need to analyse more carefully who we should be working with. You do have to pick your service provider as somebody who has initiative and enthusiasm because that is very important for the sustainability of the work.

Heterogeneous nature of service providers

If we want to work with and through service providers and promotion partners we need to understand what motivates them. For an NGO working with small farmers, they may be interested in working with the projects represented here today because they see that the tools we have may add to their existing basket of knowledge, so that may not require financial inputs. The same could apply with extension. The private sector is a very varied mix, including companies with general interests and those with a particular service to offer, e.g. a design company. Input suppliers in the business of selling might be interested in taking up a particular technology because it may lead to increased sales. A drug company may want to combine a veterinarian and nutritional message. Others may want to improve their image with the general public. In identifying the most appropriate service providers, we need to understand what makes them tick and, therefore, which messages are appropriate to their operation.

Perhaps research teams need a negotiator to try to promote the basket of research outputs to the service provider. You need to go to the national level because local level people may not have sufficient authority. Promotion of particular research findings then becomes part of national policy.

What messages should be sent to those who didn’t attend the workshop?

The workshop discussed this issue and agreed that succinct summaries of the extension messages of the projects should be sent to service providers who were unable to attend the workshop, as well as service providers in those other countries represented at the workshop. The service providers would be given relevant contact details so that they could order copies of the proceedings of the Workshop if they required them.
The future of the link project

Summary

The following actions were agreed during the workshop:

- Each of the 6 projects would produce a leaflet for distributing to the service providers. Mediae Trust agreed to provide the structure guidelines: headings, approximate layout and word count.

- Mediae Trust kindly offered their service free of charge in providing guidelines on producing these summaries, and designing them. The guidelines will be sent to the LPP to distribute to the project teams.

- Projects to send text and photos to David Campbell, Mediae Trust, by the end of March 2003.

- We need to try to get the service providers on board so needs to be aimed at them. We need to have an introductory page.

- The LPP will pay for the printing of the summaries.

It should not be a problem that all the messages in the book are not appropriate to everyone. The booklet could include suggestions as to its use, for example certain companies might want to use this tool in a certain way. So the booklet would be a marketing ploy to facilitators in the different countries. This could be an opportunity to produce the term promotion partners.

Feedback on the workshop

- Got to know what other people are doing and the links between the projects eg Zimbabwe and Tanzania working with the same plants in different ways and these findings could be combined. The projects have worked together and will do so more.

- Very happy to have been involved in the link from the start of my project as it has made me much more aware of dissemination issues.

- We have a lot of intellectual benefit from the link meetings but we have limited resources. Is this the best way of spending link money or are there alternative ways in which the money could be spent to promote linkages?

- The field visits are very useful.

- These workshops are quite useful in learning what people are doing. The time is a constraint ie would be better to have a longer workshop.

- The original link project had 3 meetings scheduled and this was the 3rd one. The difference in presentation from the 1st meeting to this one is remarkable so that is an achievement. Yesterday was a real success, we all learnt a lot. Maybe the next thing is to cement the link. Maybe we should facilitate people working in different areas for eg a couple of weeks to get more exposure. Then we could have a final workshop in eg 2004.
The future of the link project

- If we had another workshop it would need a theme. The success of this workshop was its theme.
- What about looking at other smallstock groups eg poultry keepers?
- Maybe to continue cementing relationships there would be sense in exchange visits. There would need to be clear objectives.
- The International Goat Conference takes place in October 2004 in South Africa so maybe the link workshop could tie onto that. We could have the proceedings of this workshop available at that conference.

Where do we go next? How can we continue collaboration?

There are very clear links between the projects in South Africa, Zimbabwe and Tanzania. Representatives of the project in Tanzania thought they would benefit from the veterinary knowledge of the project in South Africa.

If exchange visits were to take place, their main objective would be lesson learning eg if a technology has worked in one area but not in another you could learn from the area where it worked ie you could learn whether mistakes were in your planning etc.

It was agreed that Peter Buttery would continue with the leadership of the Link Project, and would devise a mechanism whereby each project participating in the link project would be able to prioritise the technical exchange visits they would like to make. Peter Buttery would manage the budget and would authorise visits. Clear objectives should be set for the visits, and the visitors should impart knowledge to the hosts as well as learning from them.

Maybe the final workshop could be around the theme of testing the dissemination and providing LPP with some data on the impact of the dissemination and lessons learnt. It would be good to have methodology on measuring impact.

Mediae Trust could act as a central point of information by email to provide support to projects.

Action points:

- Peter Buttery to put together a format for people to use to apply to
- Project teams to discuss and send proposal to Peter Buttery.
- New funding period starts 1st April so LPP would need to know budgets before then.
### Participant details

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This publication summarises the events, action points and conclusions of the United Kingdom Department for International Development’s (DFID) Livestock Production Programme (LPP) funded working on ‘The contribution of small ruminants in alleviating poverty: communicating messages from research’ held at the Izaak Walton Inn, Embu, Kenya between 4th and 7th February 2003.

The meeting consisted of presentations of findings from DFID LPP projects based in India, Kenya, Nepal, Tanzania and Zimbabwe and a DFID Animal Health Programme project based in South Africa.

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