HELPING SMALLSTOCK KEEPERS ENHANCE THEIR LIVELIHOODS: IMPROVING MANAGEMENT OF SMALLHOLDER OWNED SHEEP AND GOATS BY UTILISING LOCAL RESOURCES

Proceedings of the second DFID Livestock Production Programme Link Project (R7798) workshop for smallstock keepers

Sokoine University of Agriculture, Morogoro, Tanzania, 8-10 January 2002

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EDITORS NOTE

This document summarises the events, action points and conclusions of a United Kingdom Department for International Development's Livestock Production Programme funded workshop on 'Helping smallstock keepers enhance their livelihoods: improving management of smallholder owned sheep and goats by utilising local resources', held at the University of Sokoine, Morogoro, Tanzania between 7th and 10th January 2002. In editing the contributions made by the speakers and participants some omissions and misrepresentations of the facts may have been inadvertently made. For these the editors apologise.

Tim Smith, Sarah Godfrey, Peter Buttery and Emyr Owen

ACRONYMS

ADF	Acid detergent fibre
ADIN	Acid detergent insoluble nitrogen
AHP	Animal Health programme
ASARECA	Association for Strengthening of Agricultural Research in East and Central Africa
CD	Compact disk
CP	Crude protein
CSM	Cottonseed meal
DFID	Department for International Development
DGDP	Dairy Goat Development Project
EE	Ether extract
ENRECA	Enhancing Research Capability
EPG	Eggs per gram
FAO	Food and Agricultural Organization
FPR	Farmer participatory research
FINNIDA	Finnish Development Agency
GLM	General linear models
GP	Goat Project
Hh	Households
HPI	Heifer Project International
IAEA	International Atomic Energy Agency
ILRI	International Livestock Research Institute
LPP	Livestock Production Programme
KKKT	Kanisa la Kienjili la Kilutheri
MAC	Ministry of Agriculture and Cooperatives (Tanzania)
Mc2	Small scale mechanized mixed farming
MPT	Multi-purpose trees
NDF	Neutral detergent fibre

NDIF	Neutral detergent insoluble fibre
NR	Natural region
ODA	Overseas Development Administration
OM	Organic matter
OMD	Organic matter digestibility
Pe1	Perennial mixed home garden farming
PEG	Polyethylene glcol
PRA	Participatory rural appraisal
PTD	Participatory technical development
PDMI	Predicted dry matter intake
QT	Querbacho tannin
RPCLK	Resource poor crop livestock keepers
RDP	Rumen degradable protein
SEA	Small East African (goat)
SEGODEN	South eastern Zone goat development network
SOWEGODEN	South western Zone goat development network
STIR	Short term intake rate
TAGONET	Tanzania Goat Network
TPFOL	Total phenolics
TWAWOSE	'Let Us Go Together'
TWB	Total worm burden
UMG	Urea molasses granules
WT	Wattle extract
YbPL	Ytterbium precipitable phenolics

INTRODUCTION

In large parts of the tropics small ruminants, especially goats, are an essential component of maintaining the livelihood of the urban and peri-urban populations. This has been recognised by the United Kingdom Department for International Development's Livestock Production Programme, managed by NR International who have commissioned projects in several different target countries. In order to ensure that there is exchange of expertise between these projects and, therefore, an increase in their combined impact, a meeting of the participants of three projects, from Tanzania, Zimbabwe and India, was held in Udiapur, India in September 2000. This meeting clearly achieved its objectives and a follow-up meeting was recommended, but this time increasing the participation to include projects supported by other agencies. A workshop was, therefore, held at the University of Sokoine, Morogoro, Tanzania in January 2002. This volume presents the proceedings of that meeting, where the findings of the individual projects were presented. The workshop formed the focus for the creation of a network of workers all with the common aim of increasing the impact of projects designed to improve the livelihood of under-resourced livestock farmers.

The success of the meeting owes a lot to Professors Abiliza Kimambo and Louis Mtenga of the University of Sokoine, who acted as hosts for the meeting and undertook so much of the local organization.

This publication is an output from a research project funded by the United Kingdom Department for International Development (DFID) for the benefit of developing countries. The views expressed are not necessarily those of DFID. R7798, Livestock Production Research Programme.

Peter Buttery

Photograph of participants at the workshop

INTRODUCTION TO THE LPP LINK PROJECT R7798

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I am grateful for this opportunity to address this second meeting of the LPP link project on sheep and goats. I would like to cover three issues during this short address: first, to emphasise what the planning committee hope to achieve from the meeting; second, to try and place into context the work which we will be discussing and reviewing over the next 2 days; and third, to present some views of future thinking of DFID (UK Department for International Development) about the direction of livestock research.

Purpose of the meeting

In planning the meeting, we decided to widen the net and invite representatives from research projects funded by other organizations which are addressing similar problems to those of the LPP (Livestock Production Programme) sheep and goat cluster projects. In particular, those who are conducting research on low-cost management of sheep and goats with resource-poor farmers in developing countries. Thus we are pleased to welcome scientists from South Africa, Zimbabwe, Tanzania, Kenya, Ethiopia, India and the UK. Apart from DFID's Livestock Production Programme, their attendance has been supported by DFID's Animal Health Programme (AHP), FARM Africa and Sokoine University.

One of the main purposes of this meeting is to forge closer alliances between research institutions with current interests in improving the management of sheep and goats of poor livestock keepers. We trust that by the end of the meeting, not only will there have been a sharing of such information and ideas but new collaborative initiatives will have been set-up. The other purpose of the meeting is to critically assess the progress of the LPP funded projects and thereby ensure scientific rigour and developmental relevance of the outputs. The edited proceedings of the meeting will be published and made available widely as hard copies, on a CD-ROM and put on the LPP website at <http://www.lpp.uk.com>

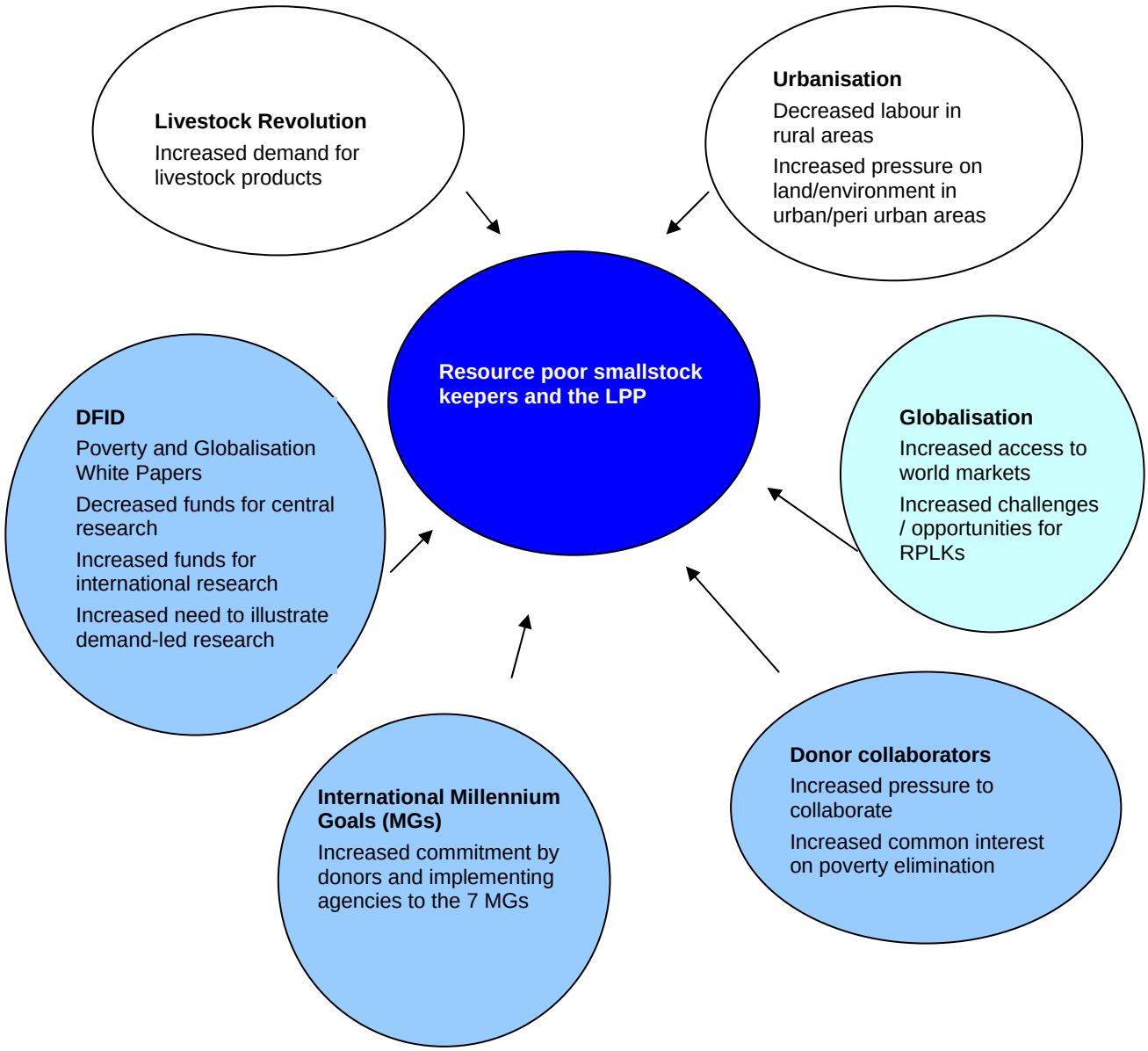
Livestock research and development in context

Recent influential publications, such as the 1996 OECD document on 'International Development Goals', the 1997 World Bank Report 'Rural Development from Vision to Action', the 1999 IFPRI/FAO/ILRI paper on 'Livestock to 2020 - the Next Food Revolution' and the 2001 IFPRI paper 'Livestock to 2020: The Revolution Continues' foresee a major increase in demand for livestock products and emphasise the importance of achieving productivity increases through research. Some donors of international livestock research believe that producing food to feed the burgeoning population of the developing world is best achieved by providing research support to successful farmers in favoured regions. However, unless the resource-poor who farm in more challenging conditions are also a focus of attention by the research community, rural and urban poverty will persist. To this end, the CG system intends to follow a two-pronged approach for future support to research: in favoured environments, to ensure food security and prevent future poverty; and in the marginal and difficult areas, tackling the more complex problems of poverty, with the emphasis on survival and escape from poverty scenarios. For its part, DFID's Livestock Production Programme will focus its whole attention for the next 3 years on addressing the needs of resource-poor livestock farmers.

Vision and strategy of DFID's Livestock Production Programme

Several recent global influences impact on the livelihoods of poor livestock farmers, such as sheep and goat keepers, see Figure 1

Figure 1 Global influences on poor livestock keepers and on the commissioning of research by LPP



These include: continued and rapid urbanization due to the attraction and opportunities afforded by towns and cities; pressure to vacate good agricultural rural and peri-urban land as a consequence of population growth increasing pressure for housing etc; the fore-mentioned increase in demand for livestock products. Associated with these phenomena is the decision by governments to promote globalization in the belief that this will promote '*...the interdependence and interconnectedness of the modern world as a means for new wealth creation and as an opportunity for lifting millions of the world's poorest people out of poverty*'(World Bank, 2000). Whereas the jury is out on the likelihood of the latter happening, there is little doubt that if the process of globalization is not properly managed, there is likely to be further marginalization and impoverishment of poor farmers. Factors which influence the nature of livestock research include a greater willingness by donors to collaborate in achieving the seven Millennium Development Goals by 2015 (see Table 1); and DFID's livestock research themes will need to conform to the guidance given within the two White Papers (on Development and on Globalisation and Poverty) which emphasises the importance of achieving sustainable rural livelihoods.

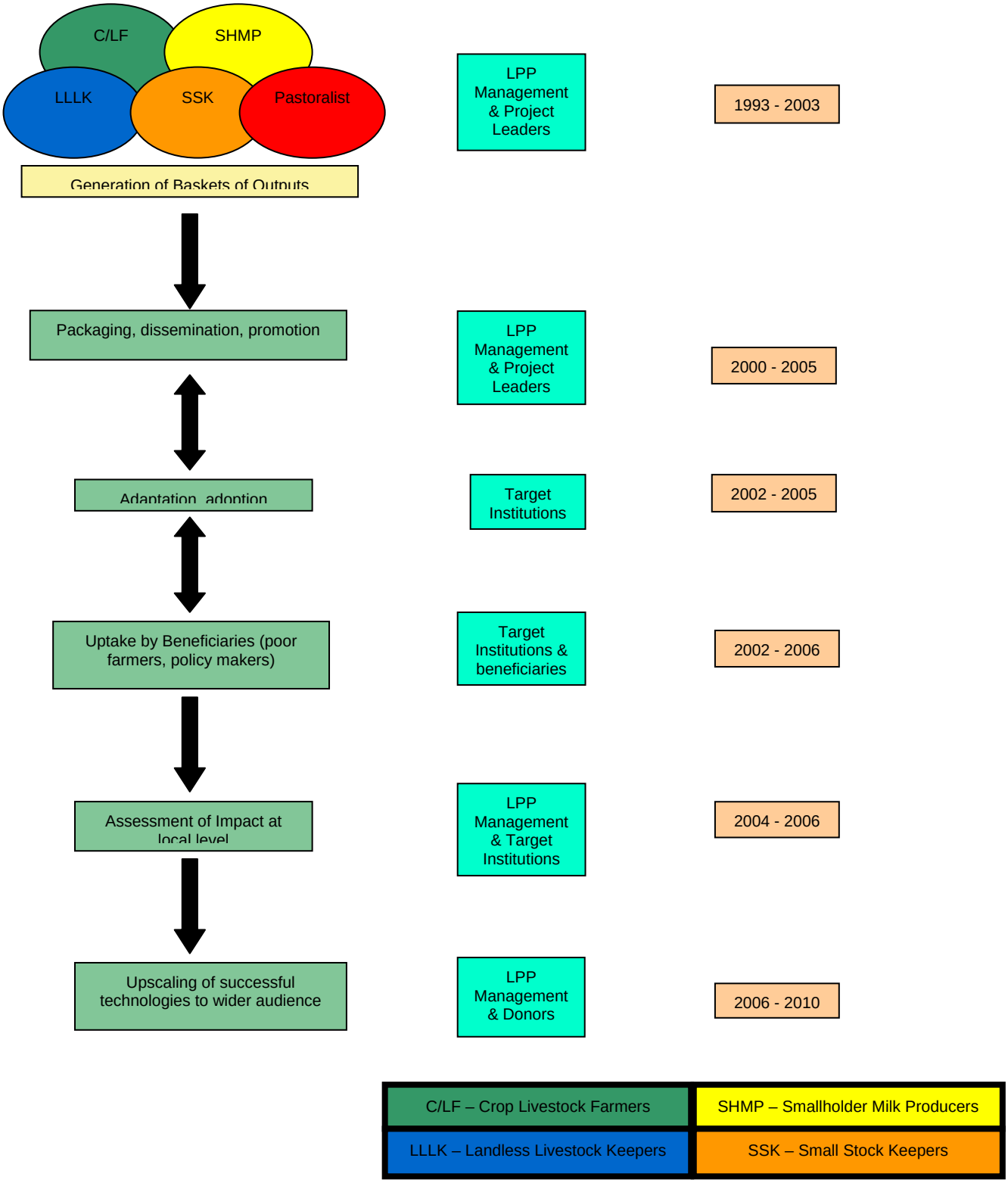
Table 1 The Millennium Goals

Millennium Goals
Eradicate extreme poverty and hunger
Achieve universal primary education
Promote gender equality and empower women
Reduce child mortality
Improve maternal health
Ensure environmental sustainability
Develop a global partnership for development

In view of the foregoing, the LPP, with the support of its independent Programme Advisory Committee recently modified its strategy and activities. Firstly, it will focus increased attention on promoting the technical and policy interventions developed by the Programme and on assessing their influence on the livelihoods of five different groups of resource-poor livestock keepers (RPLKs) and those dependent on them see Figure 2. Up until now, the LPP has commissioned research on the efficiency with which livestock commodities are produced within specific production systems. Secondly, the LPP will identify and improve the in-country institutional arrangements for ventriloquising the demand for information and interventions between specific beneficiary groups and the research community. Some of the other strategic changes include:

- More research on factors which influence the uptake of interventions/policies by target institutions and their adoption by end-users
- 'Research' on procedures to enable researchers and others with knowledge to identify appropriate target institutions ie those whose advice the end-users trust
- Greater inter-disciplinary and cross-sectoral involvement in projects; and for management to promote the possibility of greater inter-donor and inter-programme funding
- Include socio-economists, agricultural economists, anthropologists and dissemination specialists in research teams to complement the base knowledge of natural resource scientists
- Commission policy and technical interventionist research which deal with marginalised RPLKs, particularly the landless and pastoralist groups

Figure 2. Processes on the pathway from generation of knowledge to its impact on the livelihoods of poor communities – institutional responsibilities and time frame.



Sheep and goats, their importance to livelihoods and researchable issues

A recent DFID commissioned mapping study by ILRI indicates clearly that sheep and goats are key livestock species for poor households under most production systems, see Figure 3 at the end of this paper. Sheep, goats and cattle are found in the same areas in most of Africa but their distribution differs significantly in much of the rest of the world. In Africa, most are associated with pastoral systems in or near the Sahel, Sudan, Somalia and in parts of northern Africa; they are also found in Zimbabwe and South Africa. Sheep and goats are much more widespread across central Asia than cattle although they are equally numerous in most Southern Asian countries. In Latin America, they are common in Peru, Chile, western Argentina and Uruguay; and they are less widespread than cattle in Central America. Consideration of the map showing the density of poor livestock keepers by farming systems (see figure 4 at the end of this paper) with that of sheep and goat distribution (Figure3) shows that there is a great deal of convergence illustrating the key importance of these two species to the livelihoods of the poor. They are kept for a number of reasons including: an easily liquidated resource that can be used for saving/raising cash; for home or village consumption of meat and milk; for manure production, maintenance of soil fertility and seed recycling; goats for their ability to survive on browse material during the dry-season; for social status, to pay bride dowries, gifts at other important social occasions; provide keepers with networking mechanisms. Local goats have further advantages, in that they need few facilities that have to be maintained, they are cheap to buy and have a more rapid reproductive rate than the larger herbivores; this allows them to make a quicker return on invested capital. In addition they adapt to a wide variety of climatic conditions and survive on browse material not normally consumed by other stock.

The problems faced by sheep and goat keepers mainly revolve around: nutritional constraints caused by seasonal challenges (growth rates of sheep and goats can be more than doubled by sufficient quantity and quality of feed); the interaction between nutrition and disease accounts for the majority of the causes of low productivity in sheep and goats. Parasitism of the gastrointestinal tract appears to be the most important disease condition globally because of its high economic impact at the poor farmer level in all production systems; ectoparasites also result in significant production losses as do neonatal mortality, reproductive wastage and inappropriate genotype (see Perry *et al.,* 2002). It is comforting to know that the research being discussed at this meeting addresses many of the above primary issues.

Future perspectives of DFID livestock research

As alluded to above, future funding for livestock research will depend on our ability to illustrate its value in improving the livelihoods of the poor. This I believe is more dependent on the time frame and research process than on researchable topics. By process I mean the manner in which research is conducted and the responsibility we all have in promoting research knowledge so that it is made available in an appropriate format to poor farmers. Increasingly sceptical research donors need to be assured that research is cost-effective, that the research product (technical intervention or policy guideline) is something which is required by the poor, that its adoption is guaranteed to work, that it is easy and cheap to use and that it will result in an improvement in quality of life. The likelihood of achieving the foregoing will increase if the research process involves all stakeholders at all stages of the research process from project design to assessment of impact and upscaling to a wider audience It is unfortunate that the majority of research effort is still concentrated in devising and testing an intervention in a laboratory or 'on-farm' and once the research paper is written, effort levels by the researcher wane considerably as it is perceived, understandably perhaps, that his/her expertise does not lie in down-the-line activities, including dissemination, extension leaflets, promotion, training, adaptation, adoption, impact assessment, up-scaling. However, if such research products are not taken up by the target institutions which deal with extension (NGOs, Ministry Extension Services etc) then all the research effort is for nought and future funding is further jeopardized. And as for insufficient time, we envisage that the true indicator of the success of the research programme in 2005 will be uptake of research products (interventions, policies and guidance) by target institutions such as Civil Society groups. Thus,

while at this meeting, we are likely to focus attention on the quality of the generated research outputs, at the next meeting (to be held in Kenya in February 2003) we will focus attention on packaging, dissemination and promotion of knowledge and I expect that a large proportion of the audience will represent Civil Society organizations, commercial companies, Ministry staff etc. This will challenge researchers involved in the link project to compose suitable extension material (text, teaching material, video, theatre, radio (discussion and 'soap' broadcasts), school curriculum material etc) so as to convince the audience of the relevance of the research product to poverty alleviation and the ease with which it could be promoted to poor farmers. I look forward to hearing your presentations over these next few days and in Kenya in 2003.

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Map 5.
Sheep and Goat Density

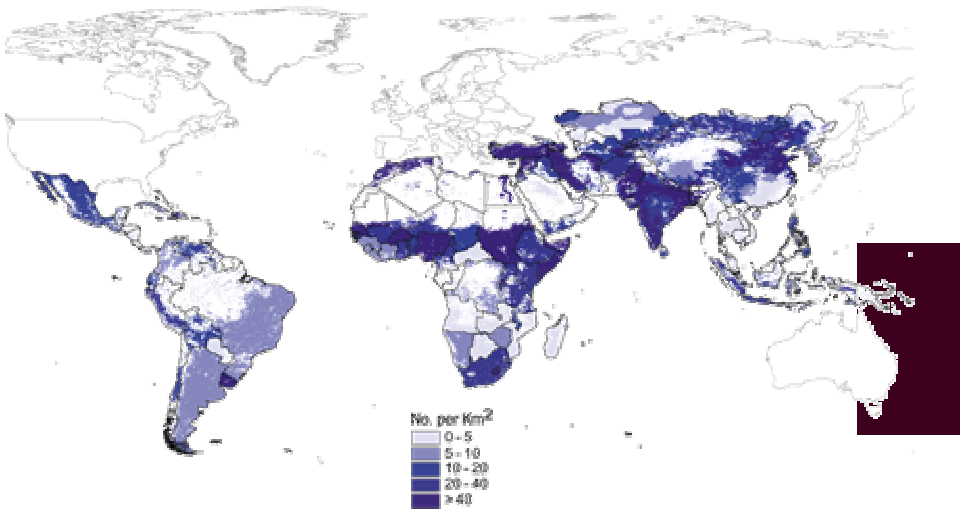

Figure 3 Sheep and goat density (Thornton *et al.*, 2002)

Map 9.
Density of *Poor Livestock Keepers* by Farming System

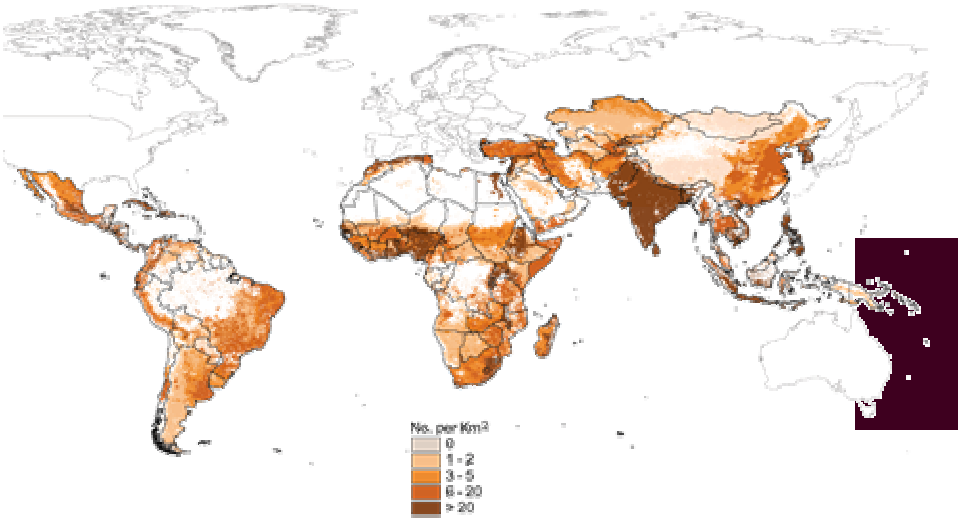

Figure 4 Density of poor livestock keepers by farming system (Thornton *et al.*, 2002)

GOAT PRODUCTION IN TANZANIA: AN OVERVIEW

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Abstract

The role of goats, their outputs in terms of milk, meat, skins and manure and their production systems operational at smallholder level are discussed. Goat numbers and their distribution in Tanzania are presented. Performance indices with respect to feeding, reproductive wastage, breeding and economics are discussed. Common breeds and types of goats and constraints to goat production in Tanzania are listed. Goat development projects in Tanzania are presented and possible opportunities for improvement are suggested.

Introduction

In Tanzania, as in many African countries, goats are kept for meat, milk, skins and manure. Socially, goats have a number of roles to play:

- They are used to pay bride price (dowry)
- In ceremonies, parties and festive celebrations, goat meat is served because of its tenderness and good taste, preferred to that of cattle
- Goats can be offered as a present to a relative, visitor, or friend, or for thanking somebody in appreciation for his/her good deeds.
- In some tribes goats are slaughtered during certain traditional rituals or reconciliations following disputes
- In case of economic crisis at the household level, goats can easily be sold because they are affordable to many people
- Goat meat is used for roasting in most drinking places in Tanzania (and other parts of East Africa)

Sometimes it is difficult at farmer level to distinguish between the roles and advantages of keeping goats. The question of why people keep goats and not other ruminants is important. The following are seen as major advantages of keeping goats:

- They are cheap to buy and require few facilities for upkeep and maintenance
- Goats have a faster reproductive rate than cattle and because of their shorter generation interval it is possible to make a quicker return on invested capital. The rate of genetic improvement is also potentially greater.
- They are able to adapt to a wide variety of climatic conditions due to their ability to feed on drought resistant trees and shrubs. They use water and low quality feed resources more efficiently than other ruminants. Due to their feeding behaviour, goats offer less competition to other ruminant species

- Because of their small size, they are easily handled, moved and cared for by women and children
- Their manure is richer in N than sheep or cattle manure and being in pellet form retains nutrients much better, and releases nutrients more slowly thus ensuring better soil fertility (Okeyo, 1998)
- Most goat development projects target the most needy groups of the population

Population and distribution

According to the Ministry of Agriculture and Cooperatives (MAC) (2001) there are about 11.643 million goats in Tanzania compared to 15.042 million cattle and 3.489 million sheep. They are distributed in all zones of the country with the highest and least concentrations found in the Western and South Lowlands respectively (Table 1). About 83% of all the goats are concentrated in four zones namely Western, Lake Northern, and Central. There was an increase of 42.I% and 80.7% from 1978 to 1984 and from 1984 to 1998 respectively. With the exception of the Northern zone, all zones have shown steady increases in number of goats.

Table 1 Goat population in '000's and their zonal distribution (%) in Tanzania

Zone	Goat population		
	1978[1]	**1984[1]**	**1998[2]**
Lake	919 (16.60)	1,309 (20.31)	2,273 (19.53)
Northern	1,940 (35.05)	1,663 (25.80)	2,052 (17.62)
Eastern	387 (6.97)	427 (6.62)	640 (5.51)
Central	895 (16.17)	1,016 (15.77)	1,674 (14.38)
Western	948 (17.13)	1,349 (20.94)	3,384 (29.06)
Southern Highlands	375 (6.78)	582 (9.04)	1,349 (11.59)
South Lowlands	72 (1.30)	98 (1.52)	271 (2.33)
Total	5,536 (100.00)	6,444 (100.00)	11,643 (100.00)

[1]Mtenga *et al*., (1990)

[2]MAC (2001)

Table 2 provides information on the number of agricultural households and percentage of those households that keep goats. On average 37.8% of all agricultural households in Tanzania keep goats. Besides having low goat numbers, the South Lowlands and Eastern zones also have the lowest percentage of households keeping goats. On the other hand over 50% of the agricultural households in Western and Lake zones own goats.

Accurate meat production figures from goats are lacking but estimates were made by Mtenga *et al*. (1990) and MAC (2001) (Table 3). Meat production has been increasing with time in all zones. The increase in meat production from 1978 to 1984 (6 years) was 16.4% while that from 1984 to 1998 (14 years) was 80.1%.

Table 2 Distribution of goats according to households (MAC, 2001)

Zone	No of Agric Households ('000's)	Percent of households with goats
Lake	882	51.0
Eastern	439	10.0
Northern	726	45.0
Central	500	33.2
Western	727	54.6
South Lowlands	367	13.3
Southern Highlands	974	31.9
	Total 4,615	Average 34.1

It has been difficult to estimate milk production from goats in Tanzania mainly because the number of goats that are milked is not known nor is their lactation performance.

Table 3 Meat production from goats

Zones	Goats meat in metric tones[1]		
	1978[2]	1984[2]	1998[4]
Lake	2,665 (16.6)[3]	3,796 (21.3)	6,593 (19.5)
Northern	5,626 (35.0)	4,822 (25.8)	5,957 (17.6)
Eastern	1,119 (7.0)	1,237 (6.6)	1,836 (5.5)
Central	2,596 (16.2)	2,947 (15.8)	4,855 (14.4)
Western	2,749 (17.1)	3,912 (20.9)	9,814 (29.1)
Southern Highlands	1,088 (6.8)	1,689 (9.0)	3,913 (11.6)
South Lowlands	209 (1.3)	284 (1.5)	786 (2.3)
Total	16,052 (100)	18,687 (100)	33,754 (100)

[1]Estimated as number of stock multiplied by 0.0029 (assumed off-take of 26%, live weight taken to be 25 kg with a dressing percentage of 45%)

[2]Source: Mtenga *et al*., (1990)

[3]Figures in brackets show percentage of zonal meat output.

[4]MAC (2001)

Goat breeds and breeding

The predominant meat goat breed is the Small East African (SEA) goat. A small proportion of meat is also obtained from crosses between some exotic meat breeds and, or, dairy and indigenous breeds. Among the exotic meat breeds imported into Tanzania for cross-breeding purposes include Boer (from South Africa) and Kamorai (from Pakistan). Crosses of Boer x indigenous have been observed to have a better weight for age ratio body size and carcass weight and quality compared to indigenous goats. Cross-breds obtained of Kamorai x Indigenous were highly prolific, hardy against diseases, and had a good mothering ability. A synthetic breed termed, “Blended goats”, has been developed in Tanzania. Das and Sendalo (1991) estimated the average genetic constitution of the breed to be 55% Kamorai, 30% Boer

and 15% Indigenous. Tanzania has also imported Galla goats from Kenya but currently there are very few left in the country.

Serious research in dairy goats commenced in the early 1960s when exotic dairy goat breeds were imported into Tanzania. The breeds imported were Saanen, Anglonubian and Toggenburg (Das and Sendalo, 1991). Earlier research efforts concentrated on on-station evaluation of their performance. In 1983 Sokoine University of Agriculture (SUA) imported Norwegian dairy goats. Since then these goats together with their crosses with indigenous goats have been evaluated at SUA and Mgeta. The recent importation is of the Alpine breed into the Kagera region. Generally there is very little documented information on the performance of these goats at farmer level. There is a growing trend of cross-breeding exotic breeds to local goats to obtain cross-bred dairy goats.

Goat production systems

The main sources of feed for goats are natural grasses, trees and shrubs in the rangeland. Rangeland utilization is characterized by communal land ownership with less than 2% being enclosed and improved. In highly populated areas, the 'cut and carry' system is common. The systems of goat production in Tanzania can be conveniently categorized as:

- Pastoral
- Extensive agro-pastoralism
- Semi-intensive production system
- Intensive system which includes tethering and *in situ* 'cut and carry'.

These systems have been extensively reviewed by Njombe (1986). Pastoralism or nomadism is characteristic of arid and semi-arid areas of the country. Goats are extensively grazed, normally with sheep and cattle. Some pastoralists have no permanent homesteads, thus they will stay in a place as long as there is feed and water. In this system, normally large numbers of animals are kept for fear of total loss in the event of unexpected hazards. Consequently, overstocking of rangelands is a common phenomenon.

Extensive agro-pastoralism involves raising goats extensively while practicing some form of crop production. Permanent homesteads are formed and livestock are grazed and brought back to the homestead on a daily basis. During the dry, or drought, season some family members move with the animals to distant places in search of water and grass.

The semi-intensive system is meant for small herds of local (indigenous) or dairy goats which are fed both at home (through cut and carry) and outdoors by short-term grazing or tethering. Crop residues are used to feed the goats and manure is ferried back to the crop fields. Farmers engage in crop production for most of the time. Supplementation of goats with energy and protein rich feeds is normally practiced.

In the intensive system goats are kept indoors and fed through a cut and carry system. Often, natural forages are used but establishment of pastures is also common. Energy and protein feeds are also offered to the goats.

Performance and potential

Feeding

Experience has shown that in Tanzania growth rates of goats (and sheep) can be doubled or trebled by proper feeding (Mtenga, 1986). Indeed, the interaction between nutrition and

disease could account for more than 80% of the causes of low productivity of small stocks (Mtenga *et al*., 1990). Thus poor feeding results in:

- Poor growth rates (20 – 40 g/day *vs* 70-100 g/day)
- High mortality rate (25-50% *vs* 5-10%)
- Poor reproductive rates
- Long time to reach slaughter weight (4-5 years *vs* 1-2 years)
- Low carcass weight (less than 13.0 kg *vs* 18-20 kg)
- Poor meat quality (less than 5% fat *vs* 8- 11% fat)

The figures for potential productivity are from data obtained from feeding studies at SUA and show that feeding is a major limiting factor.

Reproductive wastage

There is tremendous reproductive wastage in goats although factors associated with this wastage are not clearly known. There are also no hard figures to quantify these losses but experience at SUA and elsewhere in Africa (Mtenga *et al*., 1990) show that:

- Age at first oestrus is more than 20 months (expected 8 – 12 months)
- Kidding percentage is low (30-50% versus 75-90%)
- Twinning rate is low (10-15% versus 70-11%)
- Long kidding interval (12-16 months versus 6-8 months)
- Low off-take rate (20-28% versus 70–80%)
- A modest improvement in these parameters can easily double the meat output from goats.

Genotype

Information on the performance of goats and the degree of variability between genotypes and strains in different agro-ecological zones of Tanzania is not documented. There is also limited knowledge on the genetic potential of local goats under reasonably acceptable levels of management.

Economic contribution

The economic importance of goats is not fully appreciated by government policy makers. Using the 1998 livestock census (MAC, 2001) goats contribute annually about US$37.5 million in meat and US$5.045 million in skins. There are no figures available for the value of the milk.

Constraints

Production constraints in goat production systems in Tanzania are many and complex but could be conveniently classified into five groups: those related to water scarcity, feeds and feeding, animal health, genetic make up of the animals and those associated with socio-economic factors (Table 4). Of these, the most crucial constraints are those of feeding, health

and socio-economic factors. Alleviation of these constraints will result in substantially increased goat productivity in Tanzania.

Table 4 Constraint to goat production in Tanzania

Category	Arid	Semi-arid	Coastal area	Highlands
1. Water				
Water scarcity and variable rainfall	+++	++	+	+
2. Feeds/Feeding				
Forage availability	++++	+++	+	++
Quality of pastures, forages, crop residues	++++	++++	++	++
3. Animal Health				
Gastrointestinal helminths	++	+++	+++	+++
Respiratory infections	++	+++	+++	+++
Trypanosomiasis	+++	++++	++++	+
4. Genotype				
Low productivity	+	++	++	++++
No characterization	++	++	++	++
5. Socio-economic factors				
Lack of extension services	+++	+++	+++	+++
Poor transportation and marketing infrastructure	++++	++++	++	++
Weak institutions	+++	+++	+++	+++
Land tenure	++++	++++	++	++
Drug availability	++++	++++	++++	+++

++++ = Very important, +++ = Moderately important, ++ = Important, + Not important

Current goat development programmes

There are many goat development programmes with goats, but only two concerned with local goats and the remainder with dairy goats. Those programmes concerned with local goats are:

The Regional Integrated Project Support (RIPS) in Lindi and Mtwara regions

This is a meat goat extension programme which started in early 1980s, originally supported by the Overseas Development Administration (ODA) and later (1992 to the present time) supported by Finnish Development Agency (FINNIDA). A village goat credit scheme was established and run by goat loan committees. Farmers were given two female local goats and repayment was based on passing on the same number of female goats to the next loaner. The rate of payment by passing on goats to other farmers has been 100% between 13 and 20 months. Other farmers outside the programme have also adopted the system. The major problem facing the project is higher (28%) mortality rate (Smets *et al*., 1996).

Characterization of the local goats

There are many sub types of the Small East African goats, some of which are claimed to be more productive than others. Screening of three-sub types of goats (Newala, Kigoma and

Dodoma goats) is being carried out at SUA supported by Denmark sponsored Enhancing Research Capability (ENRECA) project. Data is being accumulated on :

Phenotypic characteristics

- Genetic distance
- Resistance against worms
- Response to different feeding and management strategies

Projects concerned with dairy goats are:

Mgeta dairy goat project

Initiated as an on-station research project at SUA in 1983, the project introduced dairy goats (Norwegian breed of different blood levels from cross-breeding with local goats) in Mgeta in 1988. On-farm and farmers' participatory research has been emphasized in the project. The first 10 farmers were given goats at subsidized prices on the condition that each built a good goat house and established pasture and multi-purpose tree (MPT) gardens. Other farmers joining the project had to meet all the costs. The project funding was ended in 1992 but it has continued to expand since then. The main features that favour goat keeping at Mgeta include the local mountainous conditions and farming practices in the area that create a special niche for these animals. The absence of dairy cattle and cattle milk is another contributing factor. The Department of Animal Science at SUA has facilitated the establishment of a farmer organization, 'Let Us Go Together' (TWAWOSE), which handles problems associated with domestic livestock including pigs, chicken and sheep. The major problem facing goat keepers is inbreeding due to lack of replacement bucks.

HPI Dairy Goat Projects

Heifer Project International (HPI) has been the largest supporter of dairy goat projects in Tanzania. These projects, spread over 17 regions, providing goats to local NGOs, most of them being church organizations. These organizations are responsible for selection of target farmers and for overseeing implementation of the project. HPI has played a central role in:

- Providing "goat loan in kind" or "heifer in trust" schemes, where a farmer receiving one pregnant goat must return the first, third and fifth female kids, to be given to other farmers. After that, the farmer becomes a non-project farmer.
- Giving technical advice by supporting the government extension agents.

Babati Dairy Goat Project

Sponsored by Farm Africa (UK), dairy goats are components of agricultural projects being carried out in Babati, Arusha region. As with HPI, Farm Africa also follows a "loan in kind" policy but in this case, each farmer is given a pregnant female goat but the adult female moves from one farmer to another, until it reaches the fourth farmer and the cycle ends. A major success is the establishment of breeding stock for other farmers in Tanzania and establishment of farmers' organizations.

Other projects

There are other mushrooming dairy goat development projects and include the Association for Strengthening of Agriculture Research in Eastern and Central Africa (ASARECA) (Morogoro), World Vision (Arusha), Livestock Production Research Centre (Dodoma, Kondoa), Mvumi Training Center (Dodoma), Uyole Agricultural Centre (Mbeya), Anglican Diocese (Morogoro) Kagera Livestock Development Project (Kagera), Catholic diocese (Mara), St Constantine (Arusha), Kanisa la Kienjili la Kilutheri (KKKT)- Karagwe diocese

(Kagera) and a Special Programme on Food Production (Morogoro and other regions) (See Njombe, 1999).

Dairy goat distribution policies in projects

There are two main types of distribution policy:

The loan in kind distribution policy

Advantages:

- Facilitates scaling up and even poor resource farmers are reached
- Ensures spirit of responsibility and cooperation
- Ensures proper use of credit funds

Disadvantages:

Encourages dependence

Repayment could be low in some projects as close follow up procedures are necessary

Distribution on sale terms

Advantages:

- Encourages independence
- Less demand on follow up

Disadvantages:

Resource poor farmers not likely to be reached unless subsidized

Problems facing dairy goat projects

1. Inbreeding

This is a major problem in all the projects.

Possible solutions include:

- Establishment of workable buck cycles
- Determining the degree of acceptable coefficient of inbreeding under smallholder conditions.
- Studying and applying the traditional methods used in controlling inbreeding.
- Possibility of using artificial insemination to reduce costly importation of bucks.

2. Disposal of excess male animals

There is need to establish an information flow mechanism and hence encourage exchange of bucks between localities.

3. Monitoring of goat performance

There is a need to encourage formation of farmer-based breed associations. This may need the support of government in the initial stages of formation of these associations.

4. Extension services

These are not sustainable due to various reasons. In the long run, community based extension services are the only sustainable solution.

5. Resource use

The complementary, supplementary or competitive role of dairy goats with other resources in the complex agricultural systems in Tanzania is yet to be determined.

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PARTICIPATORY RESEARCH AND EXTENSION IN TANZANIA: EXPERIENCES FROM MGETA AND GAIRO

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Abstract

Since the 1980s there has been a lot of intensive research and developmental activities towards improving performance of goats in Tanzania through crossbreeding with dairy goats. In 1988 the Department of Animal Science and Production (DASP), Sokoine University of Agriculture (SUA) introduced dairy goats in Mgeta with the purpose of developing dairy goat husbandry systems suitable for small scale farmers and improving farmers' living standards. Through farmers' involvement (using a few contact farmers to extend the innovation to the rest of the farmers) the project spread rapidly. Recently, the achievements observed in Mgeta were extended to a contrasting environment (semi-arid vs highland sub-temperate), at Gairo. Preliminary observations indicate that with limited resources, concentrating on a few carefully chosen farmers who can in turn spread the technology and encourage other farmers to adopt the intended innovations is a successful dissemination pathway. The paper addresses the challenges of forming farmers' groups, farmer-to-farmer exchanges and their effectiveness in technology adoption.

Introduction

In 1982, a project entitled "improved feeding of dairy cattle in the tropics" was started at the Department of Animal Science and Production (DASP), Sokoine University of Agriculture (SUA) with the aim of developing feeding and management packages for dairy cattle. In 1983 the project added a dairy goat component, whereby some 63 dairy goat kids were imported from Norway for subsequent cross-breeding with local goats. The anticipation was that Norwegian x Tanzanian crosses would be better suited to producing milk, while withstanding the stresses inherent in tropical livestock production systems, compared to pure-bred Norwegian goats. The objective was to provide milk where cattle were not kept.

By 1987 it was clear that both the pure and cross-bred goats were not demonstrating the anticipated performance at SUA and it was decided to extend the dairy goat technology to Mgeta. Mgeta's climate (at an altitude of 1550 – 1750 m above sea level (a.s.l.), with temperatures between 16 – 20 °C and an average annual rainfall of 1400 mm) sharply contrasts with that of SUA (altitude of 600 m a.s.l., and annual rainfall of 800 mm). It was, therefore, considered suitable to try transferring the technology to Mgeta where on-farm research would be carried out with the following set of objectives:

- Establish dairy goat performance under smallholders' conditions
- Develop a dairy husbandry system suitable for small scale farmers in highland areas
- Improve smallholders' living standards through better nutrition and income

Before the goats were physically transferred to the area, a survey was conducted, where a total of 20 farmers were visited, interviewed and assessed for interest and potential for dairy goat keeping. Only five farmers were selected from three project villages (Nyandira, Mwalazi and Tchenzema), trained in various management aspects of keeping dairy goats, including

feeding and management, animal health, animal breeding, record keeping and milk processing techniques. In May 1988, after they had constructed suitable goat houses, each received two pregnant half-bred does (Norwegian-Tanzanian crosses). The selected farmers were also given the opportunity to visit SUA before they received the goats, so that they could see and participate practically in similar activities at DASP. It was also considered that this visit would increase their interest and boost their determination to embark on the enterprise.

As the performance of goats continued to be encouraging at Mgeta the second batch of 10 pregnant does was sent to a second group of five farmers (who had also been trained in dairy goat keeping) in May 1990. Since then, three pure Norwegian bucks have been placed in the three project villages and are rotated annually. Other farmers, who were not directly incorporated into the project, acquired dairy goats, either through crossing their local does with Norwegian bucks from the project or by buying crosses from the project farmers. In 1994, 10 of the non-project farmers were incorporated into the project. Encouragingly, these farmers showed a lot of dairy goat keeping skills learnt from the project farmers. It was thus easy for the project staff to cope with the new farmers from the outset. As time went on, the farmers saw that it was important for them to form their own organization, which would involve other livestock keepers, in order to solve common problems. Such a move, together with networking is seen as important tools for sustainable livestock improvement (Muhikambele *et al*., 1998).

In September 1995, the first dairy goat show was staged in Mgeta. The show and the others that followed further stimulated more farmers around Mgeta to be interested in dairy goat keeping.

Farmer-to-farmer exchange of knowledge

Two forms of exchange were observed to be important in knowledge transmission of information in Mgeta, within the same locality and between different localities. Non-project farmers within the project area could gain awareness and acquire knowledge about dairy goat-keeping from the project farmers, through seeing, consulting and copying. It was established that farmers learn better from their peers than by receiving instructions directly from extension agents or researchers. The two parties speak the same language and in most cases share the same traditions and beliefs. "*If my neighbour has tried and succeeded, why not me*? *After all there is nothing different between us*!"

Farmers from different areas visited each other and learnt from each other's experiences. Project farmers from Mgeta and some farmers from Arumeru district, Arusha exchanged visits in 1988 and 1989. Mgeta farmers were also visited by farmers from Babati, Arusha. Apart from dairy goat knowledge, the exchange visits enabled the farmers to learn about other practices, agricultural and social, from their colleagues.

Farmers' organizations for involvement of farmers in research and Development

In response to the expansion and interest in goat-keeping, goat farmers in Mgeta initiated in 1994 'TWAWOSE' (LET US GO TOGETHER), a group organization (sharing responsibility in the provision of input services.

This was initially for dairy goat keepers but later incorporated all livestock keepers in the area. The organization was formed to serve a number of functions, including organizing seminars and ensuring an effective information flow. It was soon decided that every intervention by SUA researchers, project visitors and extension agents be coordinated through TWAWOSE, rather than through collaboration with individual farmers.

It has been observed that through the organization, the farmers have been able to collectively tackle problems relating to livestock production. They enjoy economies of scale in purchasing

veterinary drugs and concentrate feeds, they set prices acceptable to all, seek and communicate with markets for their livestock etc. Gairo dairy goat farmers, who have already started operating as a group, have noted the lessons from Mgeta's experience. It is believed that such groups act as strong tools, empowering people in decision making. Group approached research and development activities are more likely to succeed than when individual farmers are involved.

Networking as a way of increasing farmers' participation in research and Development

Realizing that there were various governmental and non-governmental organizations dealing with goat development without any form of collaboration, DASP organized a meeting of these organizations with an objective of forming a goat network. The network, known as TAGONET (Tanzania Goat Network) was launched in November 1993 with a number of objectives, the most important being:

- To serve as a forum for the exchange of information among goat stakeholders
- To identify constraints to goat development and suggest possible solutions to responsible organs
- To efficiently share resources (money, staff, technology, facilities and animals)
- To exchange animals (bucks) in order to avoid inbreeding
- To encourage training and communication at all levels of production so that all partners participate in research and development
- To establish a reporting format for goat projects and standardize recording at farm and institutional levels
- To encourage formation of goat breed associations

TAGONET holds meetings annually as well as informal meetings whenever there is an opportunity.

Based on the philosophy of TAGONET, it was decided to form a similar network for the whole of East Africa. In 1997 the first regional meeting was held in Embu, Kenya and EAGODEN (Eastern Africa Goat Development Network), including Ethiopia, Kenya, Tanzania and Uganda was formed. So far, three meetings of EAGODEN have been conducted, the second one being in Moshi, Tanzania (1998) and the third in Harrar, Ethiopia (1999). The fourth meeting was supposed to be held in Kampala, Uganda last year but was postponed (likely to be held in 2002). The foremost objective of EAGODEN is to share experiences among people interested in goat keeping, to develop coping strategies for use in various field situations.

After critically reviewing the functioning of TAGONET and EAGODEN, it was soon realized that most of the stakeholders of these networks were leaders of the institutions and non-governmental organizations (NGOs), leaving out the grass-root partners (farmers and extension workers at the field level) mainly due to the high costs involved in carrying out the network activities, especially attendance at meetings. TAGONET responded by introducing zonal networks, or branches, in order to reach far more of the targeted people. So far three functional zonal networks have been started:

1. Northern Eastern zone (NETAGONET)
2. South-Western zone (SOWEGODEN)
3. South-Eastern zone (SEGODEN)

The objectives of these networks are similar to those of TAGONET, but they cover a smaller area. It is believed that through smaller networks, it is easier to reach and involve many stakeholders. The youngest zonal network, SEGODEN, was launched in June 2001 but was able to organize a dairy goat show and competitions in August 2001 at a National Agricultural show in Morogoro. A second meeting was held in Mtwara (December 2001).

Up to now the zonal networks have only involved extension workers and research staff. Very few farmers have participated. The objective is to encourage formation of farmer-based networks with the aim of establishing farmers' organizations and develop breed associations. However, given the current economic situation, very few people can afford to meet the cost of attending network meetings. The networks currently depend on sponsorship, either local or from outside, rather than individual contributions. We hope that with time, and realization of the importance of networking, people will contribute in meeting some of the costs involved in networking. At present there is a problem of creating awareness among the community of the value of networks. The sustainability of networks will depend on associating them with breed associations and with clear economic and developmental advantages.

Goat shows

Since 1995 there have been a number of dairy goat shows (See Table 1) at which the public have opportunity to see animals of different breeds and farmers have competed for excellence prizes in dairy goat keeping, based on various criteria.

Table 1 Dairy goat shows conducted in Tanzania

Year	Place of the show	Major organizers
1995	Mgeta, Morogoro	DASP, SUA
1996	Babati, Arusha	Farm Africa
1997	Temi, Arusha	HPI
1998	-	-
1999	Mgeta, Morogoro	DASP, SUA
2000	-	-
2001	Tungi, Morogoro	SEGODEN/TAGONET

The most important lesson from these shows is that they have proved to be one of the quickest ways of disseminating information on stock improvement to all the players, including: policy makers; researchers; extension staff; and farmers. They also serve as a means of scaling up technologies so that as many people as possible are reached with minimal cost.

Participatory research

Methodologies in participatory research in livestock are not as well defined as those of crop production research. This is mainly due to the problems associated with controlling variables of animal experiments such as age, breeds, feeds and the great variability among farmers in management aspects.

Participatory research has been carried out in identifying and ranking constraints in feeding of dairy goats (Jähnig, 1996). One of the most interesting observations is that the farmers are able to identify and rank the various feeds available in their area, in close agreement with tables of nutritive value. In addition, farmers are aware of the various plants that have medicinal properties, although, at the present time, the active ingredients have not been identified. Another typical example of a study of participatory research in livestock is the DFID sponsored project reported by Massawe (1999). In this study, farmers identified problems, ranked possible solutions and carried out research on factors limiting the use of forages for livestock in the highlands. To-date, box baling, a technology researched and adopted by farmers, is spreading in its use.

In the year 2000, a project was initiated in Mgeta, Gairo and Bagamoyo involving farmers at all stages of research and development:

- Problem identification
- Ranking of solutions
- Developing researchable areas
- Carrying out research
- Monitoring and evaluation

In all these stages, extension workers were members of the team. The goat team at SUA strongly believes that participatory approaches in research and development involving farmers, researchers and extension personnel coupled with networking and livestock shows is the surest way to establish sustainable livestock development programmes.

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FROM THE FORESTS TO DRUG DISCOVERY: WHAT SHOULD BE THE APPROACH? A CASE STUDY

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Abstract

Disease-related ethno-biomedical surveys are used by some researchers for developing new drugs from plants. The relevance and suitability of this methodology in our setting has been explored. This methodology was used to identify plants for the treatment of non-insulin dependent diabetes mellitus (NIDDM) among the Wazigua of Handeni, Tanga region. We collected 68 plant specimen, representing 31 families, 54 genera and 61 species. Literature showed that 26 % of the plants are being used elsewhere to treat NIDDM related symptoms such as impotence, as aphrodisiacs and for hypocholesterolemic activity. Based on literature, 26 plant species were tested for effect on blood glucose. Only two (7.5 %) out of the 27 plants tested improved glucose tolerance and did not have a hypoglycemic effect. Also surprisingly four of the plants (15 %) worsened glucose tolerance. Having spent so much on these plants it was decided to subject them to other tests. Interestingly out of 14 plants which were tested for cytotoxic activity, 10 showed positive results. Six of the plants showed antibacterial and 6 showed antifungal activity. Based on these initial results it is suggested that, the disease-related ethno-biomedical drug prospecting may not be the most efficient methodology for evaluating our vast plant genetic resources. Plants need subjecting to a range of bioassays to understand their full potential. This approach requires a collaborative network to overcome the scarcity of resources

Key words: Drug prospecting, Disease-related, Ethnobiomedical, plant derived, appropriate approach, diabetes, antibacterial, antifungal, cytotoxic activity.

Introduction

Tanzania has a wide diversity of plants comprising of over 10,000 species, among which 1122 are endemic (Brenan, 1978, Polhill, 1968). About 10 % of these plants are used traditionally as medicines (Mahunnah, 1991). Since about one-third of all the world pharmaceuticals are derived from plants (Eisner, 1994), it should be expected that this large number of plant species could provide prophylactics and cure for a number of both human and veterinary diseases. The problem is how to optimally exploit this vast genetic resource.

The local communities and traditional healers are of great importance in this endeavour. However, considering that some of the cures claimed by traditional healers may be mere placebos for the specific conditions, a cost-effective approach is needed that will justify the money spent on research.

One of the popular approaches is the use of disease-related ethnobiomedical surveys. This is an interdisciplinary approach which involves the collaboration of western-trained doctors, ethnobotanists and indigenous healers and the collaboration of indigenous people (King and Tempesta, 1994; Cox, 1994; Cox and Balick, 1994; King and Carlson, 1995). The establishment of such a team permits the physician to interact with the native healers in evaluation of the clinical diagnosis, while at the same time the ethnobotanist can identify the

plants being used as medicines (King and Carlson, 1995). The information collected can, therefore, be compared with information from literature to help to make a list of priority plants for both phytochemical and pharmacological studies. This approach was adopted to search for plants for the management of NIDDM. Based on literature the plants were prioritized for biological testing. The outcome of the study and results of additional tests unrelated to the initial objectives are reported. Based on the results from these studies a suggestion is being made of an effective approach in the exploitation of the Tanzanian plant resources.

Locality of Study

The study was conducted in Handeni district, Tanga Region (northeastern Tanzania) between October, 1995 and October 1996. The study involved interviewing traditional healers and testing their knowledge on the management of NIDDM.

Knowledge of diabetes

Traditional healers were given prior information about the visit and on the appointed date they all assembled at designated sites (primary schools or local government offices). The symptoms of diabetes mellitus namely polyuria, polydipsia, excessive thirst, sweating and general body weakness were described to the healers. The healers who recognized or had attended patients with these symptoms were enrolled for a detailed interview. The selected healers were interviewed alone and were required to mention the plants they used for treatment. An expanded list of symptoms common in diabetes was mentioned to them and they were required to indicate the plants they used to treat each of the symptoms. Such symptoms included general body weakness, pain or fatigue, headache or back pain, lack of strength/vitality, numbness, cramp in feet and legs or hands and arms, fainting spells or dizziness, chest pain or heart disease. Also included were impotence, thirst, diarrhoea at night, excessive sweating, chronic infected skin sores and ulcers, gangrene in toes or feet; fungal infection (Candida infection of vagina, feet, hands, nails), chronic foot sores that do not heal, round, brown slightly raised, painless lesions on sheens or back of hand and passage of urine that attracts insects. Similarly, case presentations, with and without photographs, were made to the healers and they were required to identify the conditions described or shown in photograph and mention the treatment used for each condition. If any three of the list of symptoms in the expanded diabetes diagnostic criteria were treated by the same plant or if a plant was mentioned three or more times for the treatment of the same symptom, this plant was recorded as potentially useful in diabetes management.

Detailed information including ethnobotanical, ethnomedical and economical uses for the selected candidate plants was recorded. Specimen of each of the selected plants were collected, dried and taken back to the Institute of Traditional Medicine for identification, literature search and screening for hypoglycaemic activity. The vouchers (vouchers no MJ 10 - MJ 75, ACM 16 and TMRU 3156) are available in the Herbarium of the Institute.

Selection and prioritization of plants for testing

Based on the available literature plants used by traditional healers to treat diabetes or as aphrodisiac in other countries were given priority. Similarly plants for which there was scant information in the literature were also ranked as priority plants for testing for hypoglycaemic activity. A total of 27 plants were earmarked for laboratory testing.

Preparation of plant extracts

Seed powder, aqueous and 20 % aqueous ethanol extracts were used. The plant material was dissolved in distilled water or suspended in 1 % carboxymethlycellulose (CMC), as appropriate, before administration to animals.

Oral Glucose Tolerance Test (OGTT)

Male and female healthy albino rabbits weighing 1.2 - 2.2 kg were used. The rabbits were starved for 20 hr after which they were divided into three random groups each containing 12 rabbits. Blood was collected, pre-dose, from each rabbit for the determination of fasting blood glucose. The rabbits in Group 1(Control), were given orally 2 ml/kg body weight distilled water or 1 % CMC. Those in Group 2 were given an oral dose of 0.2 g/kg body weight of the plant extracts in distilled water or as a suspension in 1 % CMC. Rabbits in Group 3 were given 0.1 g/kg body weight chlorpropamide in distilled water (Naik, *et al*., 1991). Rabbits in the three groups were given an oral glucose load of 1 g/kg body weight (Perfumi, *et al*., 1991), 30 min after dosing with either solvent or the extract. Blood was collected from rabbits in both groups at 0.5, 1, 2, 3 and 4 h, after the oral glucose load, for the measurement of blood glucose. Blood was collected from the marginal ear vein (Akhtar, *et al*., 1981). Blood glucose was measured using a YSI glucose analyser model 23 AM (Yellow Springs Instruments Co. Inc, Yellow Springs, Ohio 45387, USA).

Effect on fasting blood glucose (FBG)

Three pre-starved groups of rabbits were dosed with 2 ml/kg body weight distilled water or 1 % CMC in water, 0.2 g/kg body weight plant extracts and 0.1 g/kg body weight chlorpropamide (10), respectively. Blood samples were collected pre-dose(0 h) and at 1, 2, 3, 4 and 6 h, after dosing with plant extract or solvent, for the measurement of blood glucose.

Data analysis

The data for OGTT and FBG were analysed using one way analysis of variance for repeated measurements. The Neuman-Keuls range test was used to determine differences at each point, considered significant at $P< 0.05$.

Testing for antibacterial activity.

The hole-plate method, developed in this laboratory was used (Malele *et al*., 1998). Three standard bacteria i.e *Staphylococcus aureus* (NCTC 6571), *Escherichia coli* (NCTC 10418) and *Pseudomonas aeruginosa* (NCTC 0031) were used with Chloramphenicol (30 µg/well) as positive control. Sterilized Mueller Hinton agar was used for the study and extracts were tested at a concentration of 10 mg/ml (10 µl of extract was put into each hole). Zones of inhibition were then measured in mm.

Testing for antifungal activity

Candida albicans (strain HG 392) obtained from the Department of Clinical Microbiology and Immunology was used in the hole-plate assay method already established in this laboratory (Malele *et al*., 1998). The extracts were tested at a concentration of 10 mg/ml (10 µl/hole) while 200 µg/ml (2 µg/hole) ketoconazole was used as a positive standard. The plates were incubated at 30^{o}C for 24 hrs. After incubation the inhibition zones were measured in millimetres (mm).

The brine shrimp lethality test

Brine shrimp (Artemia salina) eggs were hatched and the resulting napulii were incubated with the plant extracts. Ten napulii were incubated in duplicate vials with 8, 24, 40, 80, 120 and 240 ug/ml of the extracts. Incubation was continued for 24 h after which the number of surving napulii was determined. A graph of percentage mortality against log (conc) was plotted and the LD_{50} read directly from the graph.

Results

Knowledge about diabetes

A total number of 169 traditional healers in Handeni were interviewed. Among these 53.2 % (90 healers) recognised and were treating one or more symptoms related to NIDDM. Among the plants mentioned 68 specimen were collected, representing 31 families, 54 genera and 61 species. Out of these, 17 are already reported in the literature for similar traditional uses and some have proven biological activity related to diabetes mellitus (Moshi *et al*., 2000) such as impotence, aphrodisiacs, treatment of sores, stimulants, hypocholesterolemic and antifungal activity

The effect on blood glucose

A total of 27 plants species out of the 61 collected satisfied the criteria for biological testing. Two plants, improved glucose tolerance but did not cause hypoglycaemia (Moshi *et al*., 1997; Moshi *et al*., 2000). Four plants, worsened glucose tolerance.

The brine shrimp lethality test

Out of the 14 plants tested 10 showed cytotoxic activity with LD_{50} values below 100 (μg/ml). Four plants gave LD_{50} values of 7.58, 11.50, 26.04 and 38.61 μg/ml, respectively, indicating that they may have compounds with anticancer activity.

Antibacterial and antifungal activity

Among the 16 plants which were tested, six showed positive antibacterial activity and another six showed antifungal activity against *Candida albicans*.

Discussion

Using an ethnobiomedical approach 61 plant species were identified, that may be useful for the management of some of the symptoms of NIDDM. Some of these plants are being used in other countries for similar conditions (Moshi *et al*., 2000), while a few have already been tested and confirmed to have biological activities that may help NIDDM patients (Moshi *et al*., 2000). There was a fairly good agreement between the reports collected from the traditional healers and the information that was obtained from literature. However, the plants which were eventually selected for biological testing did not fulfil the expectations. Only two out of the 27 plants which were tested improved oral glucose tolerance in rabbits (Moshi *et al*., 2000). At this stage almost US$15,000 of the available funds had been spent for a relatively small return.

Driven by the need to make the best use of the residual funds, it was decided to subject some of the remaining extracts to other biological tests. Therefore, the brine shrimp lethality test (a test used to predict anticancer activity), antibacterial and antifungal tests were carried out. It is interesting to note that out of the 14 plants that were tested on the brine shrimps 10 showed good activity ($LD_{50} < 100$ μg/ml). The LD_{50} values for four of the plants were quite low and may be promising candidates for the isolation of anticancer compounds. Work on these plants is ongoing. Similarly six plants showed antibacterial activity and six showed antifungal activity against *Candida albicans*. Remaining extracts of the plants are being used for other available bioassays, such as antiviral and anticonvulsant activity, a very satisfactory way of using the plants which were initially collected to test for ability to lower blood glucose.

It is concluded that much as the disease-related ethnobiomedical approach may lead to identification of active plants for certain diseases, it will be more beneficial to conduct a wide range of bioassays, to allow a maximum utilization of the collected plant material, thus increasing the chances for discovering new drugs.

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VALIDATION OF *ALBIZIA ANTHELMINTICA* AS AN ANTHELMINTIC AGAINST HELMINTHS IN CALVES

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Abstract

Traditional healers in both human and animal medicine use drug preparations of mainly plant origin for the treatment of many illnesses and injuries. The prohibitive costs of allopathic drugs have rendered popular the use of local recipes in the rural areas of developing countries (McCorkle *et al*., 1996). Scientific investigation of ethnoveterinary practices is aimed at providing guidelines on how best to use the available local remedies. On the other hand, scientific investigation can provide clues on how to improve the performance of local recipes. Field information from Simanjiro District (Minja and Allport 2001), based on participatory approaches had revealed that, worm infestation was a general problem adversely affecting the health of many animals, especially young stock. On this basis, it was agreed between the research personnel and the pastoralists that an experiment to validate one of the local anthelmintics was urgently needed. Out of a number of local anthelmintics, *Albizia anthelmintica* appeared most promising. The experiment *involved* a total of 45 calves aged from six months to one year with faecal eggs per gram (EPG) of 500 and above. The calves were split into three groups of 15 animals each, representing a control group (untreated), an experimental group (treated with *Albizia anthelmintica*) and the 'standard' group (treated with albendazole – synthetic anthelmintic). Based on the egg reduction in the groups, *A. anthelmintica* stem bark preparation compared very well with the synthetic anthelmintic (standard) used.

Introduction

The medicinal use of herbs represents an important aspect of the history of medicine as well as a contribution to the development of modern therapeutics (Farah 1991). This research work is aimed at improving the in-country capacity to develop and maintain its ethnoveterinary knowledge resource. Traditional healers in both human and animal medicine use drug preparations of mainly plant origin for the treatment of many illnesses and injuries. The prohibitive costs of allopathic drugs have rendered popular the use of local recipes in the rural areas of developing countries (McCorkle 1996). Scientific investigation of ethnoveterinary practice is thus of paramount importance in as much as it will elucidate questions on the efficacy of alternative therapies and their relationship to conventional treatment methods. In this project the Animal Diseases Research Institute collaborated with VETAID TZ, a registered international NGO in Tanzania, to elicit and document ethnoveterinary practices among the Maasai of Simanjiro in Northern Tanzania. There was also collaboration with the Veterinary Investigation Centre (VIC) Arusha and a community-based NGO of Simanjiro, Inyuat E Moipo.

Worm Infestation (*orkurto*)

Field information from Simanjiro District (Minja and Allport 2001), based on participatory approaches, had revealed that worm infestation, locally referred to as *orkurto*, affected the majority of the animals, especially young stock. It was, however, one of the diseases in Simanjiro District that farmers were confident to treat by traditional methods. The many local

remedies for this condition included *Osukurtuti* (*Cissus quadriangularis*), *Osukuroi* (*Aloe sp.*), tobacco residue (*Nicotiana tabacum*) and *Ormukutan* (*Albizia anthelmintica*).

Of these remedies, *Ormukutan* (*Albizia anthelmintica*) appeared to be most promising. About 500 grams of mature stem bark of *ormukutan* are boiled in 5l of water for forty-five minutes and, after cooling, each animal is drenched with 250-500mls of the resulting solution. The traditional healers reported that about 90% of the animals so treated recover without further problems. The traditional veterinary experts, however, cautioned against overdosing since, according to them, this could lead to severe toxicity with death al possible outcome. Maasai traditional healers interviewed in the course of implementing the current project speculated that this local anthelmintic probably possessed broadspectrum effects against different endoparasites, although ethnomedical information by Hedberg and Staugard (1989) suggested that *Albizia anthelmintica* could only be effective against tapeworm. Verdcourt and Trump (1969) have reported the presence in *A. anthelmintica* of a resin called musennin that, according to them, is as good as male fern in killing tapeworm. The same authors have also reported the presence of saponins in *A. anthelmintica,* but these were not associated with any anthelmintic activity. To undescore the importance of *A. anthelmintica,* it has been shown to be among the priority medicinal trees of Shinyanga Region of Tanzania (Derry *et al*., 1999) and Simanjiro District (Minja, 1999). *Albizia anthelmintica* is a small tree 9-35 feet tall, with a smooth bark (Watt and Breyer-Brandwijk, 1962).

Objectives

The two main objectives of this research work were:

1. To confirm scientifically the presence of anthelmintic activity in *Albizia anthelmintica,* as claimed by traditional healers.

2. To recommend *Albizia anthelmintica* as an alternative effective anthelmintic available as a local resource base.

Material and methods

Selection of sites and animals

Committed pastoralists from two bomas around Orkesumet accepted to provide 45 calves for the efficacy trials. These bomas had used neither local nor synthetic anthelmintics for more than six months. Boma 1 belonged to Mr Arpakwa while Boma 2 belonged to Mr Abel. In each of those bomas faecal samples were collected from calves, whose ages ranged from six months to one year, with faecal eggs per gram (epg) of 500 and above, representing a moderate to heavy degree of infection (Hansen and Perry, 1994).

Treatments and dosing

The 45 calves were split into three groups of 15 animals each, representing:

!. Control group (untreated)

2. Experimental group (treated with *albizia anthelmintica*)

3. Standard group (treated with albendazole –synthetic anthelmintic).

The *Albizia anthelmintica* bark was harvested from nearby bushes, dried for one day and boiled for about one hour, then left to cool overnight before drenching the animals. A well-known local traditional healer advised on the dosage procedure for the *albizia anthelmintica* decoction. To ensure the correct dose rate for the calves, with both the traditional and synthetic anthelmintic, a measuring tape was put round the body, just behind the front legs, to

measure the girth of the chest (cms). This allowed calf weight to be read from standard tables. Faecal samples were collected from all the animals at weekly intervals, except for the third week due to communication problems. The McMaster counting technique was used to determine the number of epg present. The results obtained are attached (see appendix).

Results and discussion

Judging by the reduction in faecal epg, the *Albizia anthelmintica* preparation compared very well with the synthetic anthelmintic (standard) used. The epg, after dosing with *A. anthelmintica* dropped from 1313 at day 0 (before drug exposure) to 71 at day 28, representing a drop of 94.6 %, while for the synthetic anthelmintic the epg dropped from 2473 at day 0 to 11 at day 28, a drop of 99.7 % (epg drop = 100 – (Group epg on a specific day post treatment / pretreatment group epg at day 0) X 100

Table 1 illustrates encouraging results recently obtained by Msalilwa *et al*. (2001) who showed that *A. anthelmintica* was highly larvicidal *in vitro* and could reduce gastrointestinal nematode eggs in the faeces of sheep by 81% at ten days post treatment.

On the other hand, there were unknown factors, which brought down the number of eggs significantly with the passage of time in all three groups, including the control group, see Table 2. Komwihangilo *et al*., (1995) have observed that *Albizia anthelmintica* is one of the plants used as fodder in Central Tanzania and, therefore, the animals could have inadvertently been taken to areas where this plant was available. However, the further reduction observed in the experimental and standard groups on day 28 can only be assigned to the drenched anthelmintics.

Table 1 Eggs per gram (epg) on selected days, post-treatment and the percentage change in epg

Groups	Days post treatment	epg	epg, % drop
Control	0	1,557	
	7	275	82
	14	304	81
	28	500	68
Albiza anthelmintica	0	1,313	
	7	557	58
	14	77	94
	28	71	95
Synthetic anthelmintic	0	2,473	
	7	77	97,100
	14	71	97
	28	11	100

Table 2 Multiple comparisons of differences in eggs per gram of faeces

Dependent variable	(I) Days	(J) Days	Mean Difference (I-J)	Std. Error	Sig. (*P*<)
Control	0	7	1282	383.4	0.001
		14	1253	375.1	0.001
		28	1057	393.0	0.009
Albiza anthelmintica	0	7	757	228.6	0.001
		14	1237	228.6	0.000
		28	1242	232.7	0.000
Synthetic anthelmintic	0	7	2467	722.3	0.001
		14	2402	735.1	0.002
		28	2463	735.1	0.001

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Appendix

Faecal counts, eggs per gram (epg) of animals undosed (control) or dosed with *Albiza anthelmintica* or a synthetic anthelmintic ([1]M=missing value, animal not seen on day of routine visit)

Day	Control group – Eggs per gram	*A. anthelmintica* - Eggs per gram	Synthetic anthelmintic - Eggs per gram
0	600	2400	1100
	7650	850	4700
	1000	700	550
	1400	1000	650
	900	1100	1050
	2400	1700	1250
	3100	1850	950
	700	850	650
	1200	2550	2500
	650	850	600
	700	2550	900
	700	850	600
	1050	1100	17250
	700	650	3000
	600	750	1350
7	100	900	
	300	0	0
	0	0	0
	0	1250	0
	100	0	0
	100	0	0
	0	2400	0
	1500	350	100
	0	0	0
	0	1000	0
	M[1]	150	0
	M	50	0
	800	150	0
	400	0	0
	M	2100	0
14	450	400	0
	550	0	850
	200	0	0
	0	0	50

Day	Control group – Eggs per gram	*A. anthelmintica* - Eggs per gram	Synthetic anthelmintic - Eggs per gram
	600	0	M
	650	0	0
	600	100	0
	300	0	0
	0	0	0
	200	0	100
	M	150	0
	M	300	0
	400	200	0
	0	0	0
	0	0	0
28	0	100	0
	700	0	0
	1000	100	0
	500	0	0
	900	50	M
	2300	50	0
	0	0	100
	100	0	0
	M	M	0
	0	50	50
	M	0	0
	M	0	0
	0	650	0
	0	0	0
	M	0	0

CAN FEEDING LOCALLY AVAILABLE PLANT MATERIAL RICH IN TANNINS REDUCE PARASITIC BURDEN IN RUMINANTS AND HENCE IMPROVE THEIR PRODUCTIVITY?

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Abstract

Gastrointestinal parasitic infections are a major constraint to small ruminant productivity in the tropics and subtropics, including Tanzania. This significantly reduces the economy and food supply to small farmers and their families. Earlier studies at the University of Nottingham (see for example Butter *et al.*, 2000) have shown that feeding the extracted tannin from Quebracho (used in the leather industry) dramatically reduces the parasite burden of infected sheep. Tannins often occur in high concentrations in browse plants and could be used to control gastrointestinal parasites.

A three-year project (R7424) funded by the DFID Livestock Production Programme, was, therefore, initiated in 1999 between Sokoine University of Agriculture (Tanzania) and University of Nottingham (UK) to study the possibility of using locally available plant materials or their extracts to reduce parasitic burden in small ruminants. This approach has the potential to yield a cheap and environmentally friendly alternative to using chemically based anthelmintics. This paper briefly outlines the project aims and achievements to date.

Introduction

Small ruminants contribute significantly to meat and milk production in Africa. In Tanzania, it is estimated that small ruminants contribute 17.1% of total meat produced and consumed and thus they contribute a significant proportion of the animal protein consumed by the rural sector. However productivity from these animals is low due to many factors, including poor nutrition, disease and worm infestation. Helminth infections are the commonest and most significant endo-parasite constraint to small ruminant production in Tanzania (Kasuku and Tibaijuka, 1987). Intestinal parasites not only cause mortality of the livestock but also reduce their productivity and increase the proportion of carcasses condemned at the abattoirs. These losses have major impacts on economy of small farmers and their families. Parasitic infection could until recently be controlled by chemical anti-helminths but resistance is now common and these substances are expensive. Resistance of helminths worms to some anti-helmintic agents has been reported in some areas of Tanzania (Kasuku and Tibaijuka, 1987; Ngomuo *et al.,* 1990; Msangi *et al.,* 1990). Due to problems associated with the high costs of

anthelmintic drugs and the development of worms resistance to some of these drugs, much interest is now directed in developing nematode control methods that do not rely on anti-helmintic treatment. Such alternative methods include selective breeding for resistant hosts, grazing management and nutritional manipulation. Use of naturally occurring constituents in forages is yet another alternative to the expensive drugs. Tannins, which are naturally occurring secondary metabolites in plants, could reduce worm burden. Research at Nottingham has shown that dietary inclusion of the condensed tannin in quebracho extract reduces egg output and worm burden in sheep infected with *Trichostrongylus colubriformis* (Butter *et al.*, 2000). Similar results have been obtained by others (Athanasiadou *et al.*, 2000). This project is examining the potential of using naturally occurring constituents of forage to reduce the impact of the parasitic infections. The results will indicate the potential for promoting this husbandry practice to small farmers of this region. In addition the results will indicate the desirability of extending this practice to other areas of the world.

Project objectives

Gastrointestinal parasites are one of the major causes of production losses in goats. Their control would improve the livelihoods (wealth and food supply) of farmers, many of whom are women, and their families. Objectives of this project include:

1. To develop and promote strategies for the allocation and management of on-farm and locally available resources in order to optimise livestock production and improve their contribution to the crop/livestock farming system.

2. To determine if naturally occurring plants or plant extracts can be used to control gastrointestinal parasites in goats and other small ruminants.

3. To develop simple, cost effective and environmentally friendly methods of reducing the extent of gastrointestinal parasites in small ruminants.

Expected project outputs

1. Quantitative assessment, including seasonal variation, of the condensed tannin content of locally available plant material used as feed for small ruminants in the Morogoro region of Tanzania

2. Evaluation of the effectiveness of locally available tannin containing plant material or extracts in overcoming the production losses caused by gastrointestinal parasites in small ruminants

3. Training of a Tanzanian research student to Ph.D. level to continue the long-term objectives of improving the wealth and nutrition of local families

4. Results to be disseminated nationally and internationally at scientific conferences and in refereed journals. If appropriate follow-up on-farm trials will be initiated.

Planned Research Activities

1. Assessment of condensed tannin content of a range of locally available plant material in Tanzania.

2. Conduct *in vitro* and *in vivo* studies to evaluate the effectiveness of tannin-containing plant materials or plant extracts in reducing parasite burden in small ruminants.

Progress

1. Assessment of condensed tannin content of a range of locally available plant material in Tanzania

Plant materials (leaves and bark) were collected, from different shrubs and trees, forbes and leguminous plants, in January and April 2000 to represent the dry and wet seasons. Their tannin content was assessed using the acid butanol reaction for condensed tannin. It is accepted that this test only gives a relatively crude estimate of the tannin content. Those plants and plant parts found to have high tannin content were then selected and sampled at monthly interval for a period of one year and their tannin content determined. The reason for monthly sampling and determination of tannin content is to see whether tannin concentration was influenced by season. Results from the samples, already analysed, indicate that there is seasonal variation in tannin concentration in leaves and this will be presented in another paper (Mushi *et al.,* these proceedings). Since tannins are known to reduce the degradation of feedstuffs in the rumen, the effect on rumen degradability of some of the plant materials which were potentially to be used in the control of parasitic infections was assessed. The results are also be presented in another paper, (Mushi *et al.*, 2002).

2. *In vitro* and *in vivo* studies to evaluate the effectiveness of tannin-containing plant material or plant extracts in reducing parasite burden in small ruminants

The effect of plant extracts on nematode motility and viability

Discussions with local scientists in Tanzania have indicated that some indigenous plants, e.g. Aloe, have anti-parasitic properties. There is also evidence that some plants are used in traditional medicine to control gastrointestinal nematodes. It is planned to investigate the effectiveness of extracts from plant materials found to have a high tannin content on parasites *in vitro*.

2.1 In vitro studies to evaluate the effectiveness of tannin extracts to Kill Haemonchus

Due to problems of routinely obtaining *Haemonchus contortus* worms, which involves sacrificing an animal, the mouse parasite, *Heligmosomoides polygyrus,* was used. Initial studies investigated the effect of quebracho tannin extract. In Tanzania, a tannin containing extract obtained from wattle/mimosa (*Acacia mearnsii)* is used in the local leather industry. Both tannin extracts readily killed the cultured parasites The mimosa extract was found to be the more potent.

2.2 In vivo feeding trials to determine the dose response efficacy of quebracho tannin against Trichostrongylus colubriformis and Haemonchus contortus

Previous work carried out at the University of Nottingham with quebracho tannin has consistently used concentrations of 40-50 g/kg to represent the levels typically found in plant material. However, lower concentrations of tannin may be equally effective. Two feeding trials using tannin incorporated in the feed at concentrations of 0, 2, 4, 5 and 8 % w/w of feed intake in experiment 1 and 0, 2.5, 5, and 8 % w/w of feed intake in experiment 2 were conducted using sheep artificially infected with *Haemonchus contortus*. Further studies, in which animals were drenched with quebracho tannin at 0 and 8 % w/w of feed intake were also conducted. The drenching method was found to be more effective in reducing faecal egg count and worm burden than the method of mixing in the feed. Thus the work, which will be done in Tanzania, will evaluate drenching with tannin extracts as well as feeding plant materials with a high tannin content. The goat will be used as the experimental animal reflecting the importance of the goat in this region.

3. Training

This is a major project component of the project.

3.1 One of the research team attended a three-week training course at the University of Nottingham, in November 1999, on methods for analysing condensed tannin in plant materials.

3.2 Training of a Tanzanian research student to Ph.D. level at the University of Nottingham and Sokoine University of Agriculture.

3.3 Dissemination of results in National and International Scientific conferences and in refereed journals. These are reported in the two subsequent papers in this volume. Two further publications are in preparation.

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EFFECT OF CONDENSED TANNIN EXTRACTS ON GASTROINTESTINAL NEMATODES OF SMALL RUMINANTS

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Summary

Experiments were carried out to investigate the effect of condensed tannins on gastrointestinal nematodes. In the first two trials (trial 1 and 2) mature and young parasite naïve sheep under artificial haemonchosis were offered a low protein diet containing varying levels of quebracho extract (QT), a model source of condensed tannins. In trial 1, thirty-five mature rams were assigned to five groups (n = 7); the control group received no QT whereas the rest received feed containing 1, 2, 4 and 8% w/w QT. Trial 2 had four groups of young rams (n =9), which received 0, 2.5, 5 and 8% w/w QT. All animals in both trials received a trickle dose of infective stage larvae (*L3*; *Haemonchus contortus*) to the end of the experiment. Faecal egg counts (FEC), feed intake and average daily body weight gain (ADWG) were monitored for about 2 months. Dietary inclusion of QT at the 8% level reduced FEC by 36 and 51% in trial 1 and 2 respectively. This was an indication that young and parasite naïve lambs in trial 2 were slightly more responsive to the effect of QT on FEC than mature sheep in trial 1. Although the effect of QT on FEC in trials 1 and 2 was not statistically significant, negative correlations (R2 = 0.81 and 0.64 respectively) between dietary QT level and FEC were observed. Feed consumption and ADWG were significantly reduced ($P < 0.05$) by dietary QT, while faecal water content and faecal output increased significantly ($P < 0.01$).

Two other studies, trials 3 and 4, were carried out to investigate short-term effects of QT on FEC and total worm burdens (TWB) of growing lambs under mono-specific and mixed nematode infections respectively. In the mono-specific infection experiment (trial 3), twenty parasite-naïve ram lambs were trickle-infected daily with *450 L3* of *H. contortus* larvae. Faecal egg outputs were monitored and on day 22 after the first dose of larvae the animals were randomly allocated into two groups (n = 10). The control group received a placebo drench (plain water) whereas the treated group received QT drench at 2.4 g QT kg^{-1} bodyweight (equivalent to 8% (w/w) QT in feed) for three consecutive days. All animals were sacrificed the following day and their abomasa removed for TWB assessment. The effect of QT on mixed nematode infection was investigated in a similar trial (trial 4), whereby 3 groups of sheep (n = 12) were challenged daily with *L3* as follows: *H. contortus* alone (Group H), *Trichostrongytos colubriformis* alone (Group T) or a mixture of both parasites (Group HT). FEC were monitored and on day 27 half of the animals in each group (n = 6) received the same dose of QT drench for three days and sacrificed as described before. Administration of the drench to sheep mono-specifically parasitised with *H. contortus* significantly ($P < 0.05$) reduced mean FEC of the treated group compared to the control group, a 91% reduction in FEC. Likewise, a significant reduction ($P < 0.01$) in TWB of the treated group, i.e., by 80%, following the three consecutive days of administration was evident. The QT drench was also effective under mixed infection in terms of FEC reduction whereby a significant ($P = 0.016$) drop in each group following QT drench administration was observed. The treatment was

more effective against mono-specific infection of *H. contortus* than that of *T. colubriformis* or under mixed infection. This finding was most conspicuous on the day of slaughter whereby the group x treatment x time interaction was significant ($P = 0.011$). The TWB data revealed an appreciable reduction in the TWB of *H. contortus* ($P < 0.05$) but not *T. colubriformis* ($P = 0.314$).

Direct effects of condensed tannins from QT and wattle extract (WT) to adult nematodes were also assessed under an *in vitro* viability assay. Adult mice nematodes, *Heligmosomoides polygyrus*, were incubated at 38 - 39 °C in either normal saline alone (control) or in normal saline containing varying concentrations of QT or WT. Viability of the parasites was monitored regularly and then expressed as per cent of worms surviving at a particular time interval. Wattle extract was about 4 times more potent than QT in all tested concentrations.

The current findings provide further evidence that condensed tannin preparations are toxic to the nematodes. Prolonged feeding on diets containing high levels of condensed tannins (CT) may be undesirable because of its association with a reduction in growth. Administration of QT as a drench was found to be more practical and offered a quick and best effect. The current QT dose can reduce faecal egg output and TWB of sheep parasitised with the abomasal nematode, *H. contortus*, but less so with the intestinal type, *T. colubriformis*. The latter species may require a higher dose or more days of drenching. The present findings suggest that it may be possible, with limited use of synthetic anthelmintics for use in the tropics, to design appropriate feeding strategies based on tanniniferous forage materials or extracts to alleviate nematode infections.

Introduction

Infections caused by gastrointestinal parasites are among the major drawbacks hindering livestock productivity world-wide (Parkins and Holmes 1989; Sykes 1994; Gill and LeJambre 1996). In tropical and subtropical regions, where the parasites are more abundant due to favourable environmental conditions, helminthiasis is even more devastating (Waller 1997). Moreover extensive grazing on native pastures, together with lack of supplemental nutrients to animals in these areas leads to low plane of nutrition and, therefore, increased susceptibility. Control of helminthiasis is mainly by chemotherapeutic means, with best results being obtained when this is integrated with proper grazing management and resistant animals. However, in the last 2-3 decades there has been over-dependency and misuse of the chemotherapeutic approach with consequent evolution of anthelmintic resistance (Ngomuo *et al*., 1990; Bjorn *et al*., 1990; Prichard 1994) especially among major nematode species. Apart from anthelmintic resistance, poor availability and affordability of anthelmintics to small-scale farmers in developing countries have compounded the problem (Hammond *et al*., 1997). It follows that a search for novel and more sustainable anthelmintics is the best approach to the control of helminthiasis. 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 (Niezen *et al*., 1993; 1998; Robertson *et al*., 1995). Furthermore recent studies have shown that dietary inclusion of the CT in quebracho extract (Butter *et al*. 2000; Athanasiadou *et al*., 2000) dramatically reduces egg output and worm burdens of sheep infected with *T. colubriformis*.

The main objective of the project is to determine whether locally available tanniniferous browse materials or readily available extracts from them can be used to control nematode infections in small ruminants.

Material and methods

Test parasites and condensed tannin source

The Moredun Research Institute, UK supplied the nematode parasites (*H. contortus* and *T. colubriformis*) as infective stage larvae (L3) suspension in distilled water; this was kept in culture tubes at 5 ºC until needed. Adult *Heligmosomoides polygyrus* used in the *in vitro* assay were freshly obtained each time from passage mice held at the University of Nottingham. Two sources of CT were used; quebracho extract (QT) powder from the barks of tropical heartwood (*Schinopsis balansae*) which was supplied by Hodgesons Chemicals Ltd, UK, and wattle (mimosa) extract (WT) from *Acacia mearnsii* prepared by Wattle Tannin Co., Tanzania. Both are commercial preparations for use in leather industries. The QT was thoroughly mixed in the feed prior to pelleting or dissolved in lukewarm water or saline depending on the type of experiment. The WT was dissolved in saline.

Housing and feed

Animals were kept in individual raised pens with slatted floors in a house maintained at an ambient temperature of 15 °C, with water *ad libitum*. The animals were offered a relatively low-protein (97g CP/kg) pelleted grass meal, to restrict live-weight gain.

Experimental

I Feeding trials

Two feeding experiments were conducted to investigate the effects of dietary condensed tannins in quebracho extract on faecal worm egg output and growth performance of sheep receiving a trickle infection of the intestinal parasite, *H. contortus*. Both experiments were similar except for the age of the animals and the daily feed allowance given. Experiment 1 used older sheep that have been to pasture and possibly had experience of intestinal worm infections whereas parasite-naïve growing lambs were used in the second experiment. In experiment 1 the feed allowance was offered at 4% of body weight whereas in experiment 2 it was set at 3% of body weight.

In experiment 1, thirty-five castrated rams (Charollais x Mule), initial live-weight 39.5 ± 0.5 kg, were randomly assigned into 5 groups (n = 7) and offered feed containing no QT (control), 1, 2, 4 or 8% w/w QT. Three weeks after the introduction of the experimental diets all sheep received a daily oral dose of 500 infective stage (L3) *Haemonchus* sp. larvae to the end of the trial. Feed consumption, body weight gain and faecal egg outputs were monitored. Experiment 2 used 36 young and parasite naïve (Finn x Dorset; mean live weight 23.6 ± 0.5 kg) ram lambs in 4 groups (n = 9) which received feed with no QT, 2.5, 5 or 8%w/w QT and were trickle infected daily with 400 L3 (*Haemonchus* sp.). Parameters were monitored as before.

II Drenching trials

Short-term effects of quebracho extract on FEC and total worm burdens of growing lambs under mono-specific or mixed gastrointestinal nematode infections were investigated in two separate experiments (trial 3 and 4). In the mono-specific infection experiment (trial 3), twenty parasite-naïve (Finn x Dorset) ram lambs, about 4 months old (41.9 ± 1.1 kg) were trickle-infected daily with 450 L3 larvae of *H. contortus*. Faecal egg outputs were monitored and on day 22 after the first dose of infective stage larvae the animals were randomly allocated into two groups. The control group (n=10) received a placebo drench (plain water) whereas the treated group received QT drench at 2.4 g QT kg -1 bodyweight (equivalent to 8% (w/w) QT in feed). After 3 days of drenching i.e., days 22, 23 and 24, all animals were humanely slaughtered on day 25 and worm burdens recovered from the abomasum for TWB estimation.

Effect of QT drench on sheep with mixed nematode infections (trial 4) was carried out in a similar manner. Thirty-six young (Mule x Charollais) rams, about 3 months old (40.6 ± 3.1 kg) were assigned into 3 groups (n = 12) and challenged daily as follows: *H. contortus* alone (Group H; 500 L3), *T. colubriformis* alone (Group T; 4000 L3) or a mixture of both (Group HT; 500 and 4000 L3 respectively). Faecal egg outputs were monitored and on day 27 after the onset of trickle infection animals in each group were blocked by FEC numbers and further subdivided into 2 groups (n = 6), i.e., control and treated. Quebracho extract drenching, slaughter and sampling were performed as for trial 3.

III *In vitro* studies

The *in vitro* studies were aimed at investigating the direct effects of condensed tannins upon survival of various stages of GI nematode parasites. Initially ensheathed infective stage larvae of *H. contortus* were incubated at 37 - 39 °C in phosphate buffered saline containing different concentrations of QT. Since survival of the larvae was not effected at all tested concentrations, the adult mice nematode *H. polygyrus* was used instead. It was not possible to routinely get a supply of the unsheathed *H. contortus* without killing an infected sheep each time.

Freshly obtained adult worms were incubated on petri dishes (about 10 -15 male and females) at 37 - 39 °C in QT or WT solutions of varying strengths, for a period of 48 hours. Quebracho extract solutions at 0, 0.5, 1, 2, 4, 8 and 12% (w/v) were tested and survival rates were recorded over different time intervals. Motility and viability of the parasites were 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, virtually, no reaction to touch was observed.

In an attempt to distinguish between the effects due to CT *per se* or to other compounds in the extract, polyethylene glycol (PEG; molecular weight 3000 - 4000, Fisons, UK) was added into the solutions. PEG is known to bind and inactivate condensed tannins so its addition into the culture solutions was expected to reverse any anthelmintic activity due to condensed tannins.

Statistical analysis

The data were analysed by Genstat 5 (Lawes Agricultural Trust, Rothamsted) statistical package. Faecal egg count data were analysed as a completely randomised design (split plot model) using one way analysis of variance (ANOVA) with treatments, i.e. groups, as factors and sheep as blocks. Linear and quadratic trends were also fitted using polynomial function to compare profiles among groups. Live-weight gain, faecal output and dry matter content were analysed as a completely randomised design with treatments and sheep as factors and block respectively. Worm burdens in the mixed infection trial were categorised as abomasal or intestinal worms and analysed separately.

Results

Effect of dietary QT on faecal egg output and growth performance of sheep during artificial haemonchosis (experiments 1 and 2 respectively).

Feed consumption and live weight

There was evidence of decreasing feed consumption ($P < 0.05$) especially for animals on QT containing feed in both experiments. This tendency appeared to be dose dependent as more

refusals were associated with feed containing 8% QT (Tables 1 & 2). Although mean live weights were similar among groups, average daily weight gain (ADWG) of animals on 8% QT, towards the end of experiment 1, was significantly lower ($P < 0.05$) than other groups. In experiment 2, both initial and live weight prior the introduction of experimental diets were similar ($P > 0.05$), this soon changed as a result of hyporexia in response to the presence of QT in feed. The ADWG were divided into three phases: the period from onset of experiment to introduction of experimental diets (phase 1); from introduction of the diets to commencement of trickle infection (phase 2); and finally the post infection period (phase3). Live weight gains were similar ($P = 0.17$) during phase 1 in all groups but remained significantly different ($P < 0.001$) in phases 2 and 3, with QT8 having the lowest value. There was a negative linear correlation ($R^2 = 0.92$), during phase 2, between ADWG and dietary QT inclusion level, i.e., ADWG decreased with increasing level of QT above 2.5% in feed.

Table 1 Effect of dietary QT on feed consumption, faecal egg output and growth performance of mature sheep during artificial haemonchosis (Experiment 1).

Parameter	QT0	QT1	QT2	QT4	QT8	SED (30 d.f)	*P* value	vs.QT %*
(%) Feed consumed	87[a]	92[a]	93[a]	88[a]	79[b]	3.491	0.004	-0.78
Total faecal outputg DM day $^{-1}$	502[a]	644[b]	880[c,d]	752[c,d]	691[b]	65.44	0.002	0.46
Faecal DM (%)	30.4[a]	29.6[a]	27.9[b]	29.4[a]	27.7[b]	0.685	0.001	-0.71
ADWG g day $^{-1}$								
Phase 1	170.2[a]	168.2[a]	152.2[a]	152.9[a]	148.1[a]	15.2	0.481	
Phase 2	207.3[a]	208.4[a]	208.8[a]	200.0[a]	196.3[a]	52.9	0.999	-0.92
Phase 3	232.9[a]	229.9[a]	223.4[a]	217.8[a]	140.9[b]	32.9	0.047	-0.94
All phases	203.5[a]	202.2[a]	194.8[a]	190.2[a]	161.8[a]	25.52	0.487	-0.98
Initial liveweight (kg)	30.6[a]	31.3[a]	31.6[a]	32.2[a]	33.0[a]	1.298	0.41	
After expt diet (kg)	46.0[a]	47.3[a]	46.7[a]	47.2[a]	46.6[a]	1.762	0.953	
Final liveweight (kg)	60.9[a]	62.1[a]	61.5[a]	61.0[a]	55.2[b]	2.951	0.161	-0.89

The results are means of 7 animals in a group, different superscripts within a row are significantly different ($p < 0.05$); * is a correlation value between a given parameter and dietary level of QT. Phases were considered as a period before introduction of experimental diets (phase 1), from the experimental diets to commencement of trickle infection (phase 2) and finally the post infection period (phase 3). Means with different superscripts within a row are significantly different ($p < 0.05$)

Faecal egg output

Faecal egg profiles of the sheep looked similar for both trials and are shown in figures 1 &. 2. Eggs were first observed 16 days after the first dose of larvae and outputs continued to increase reaching a peak about two weeks later. Egg outputs decreased gradually after peak but became irregular about day 40; this irregularity was marked by small surges in egg profiles regardless of treatment. Statistically, dietary inclusion of QT did not significantly ($P > 0.05$) reduce faecal egg outputs but diet x time interaction together with linear trends were significant ($P < 0.05$) indicating that as dietary load of QT increased, some points along the faecal egg profiles were significantly different.

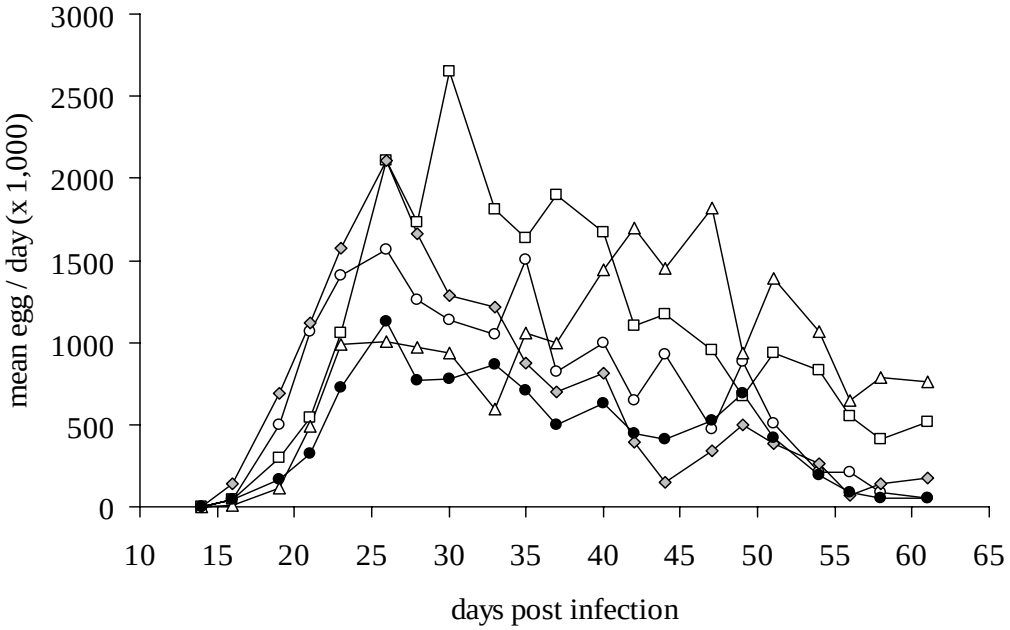

Figure 1 Total daily faecal egg output (eggs per day) of sheep artificially infected with *H. contortus* and fed various levels of quebracho extract. 0% (--○--); 1% (--□--); 2% (--Δ--); 4% (--◊--) and 8% (--●--) w/v quebracho extract. SED for comparing treatments = 42.7x10^{3,} df =30. (Experiment 1)

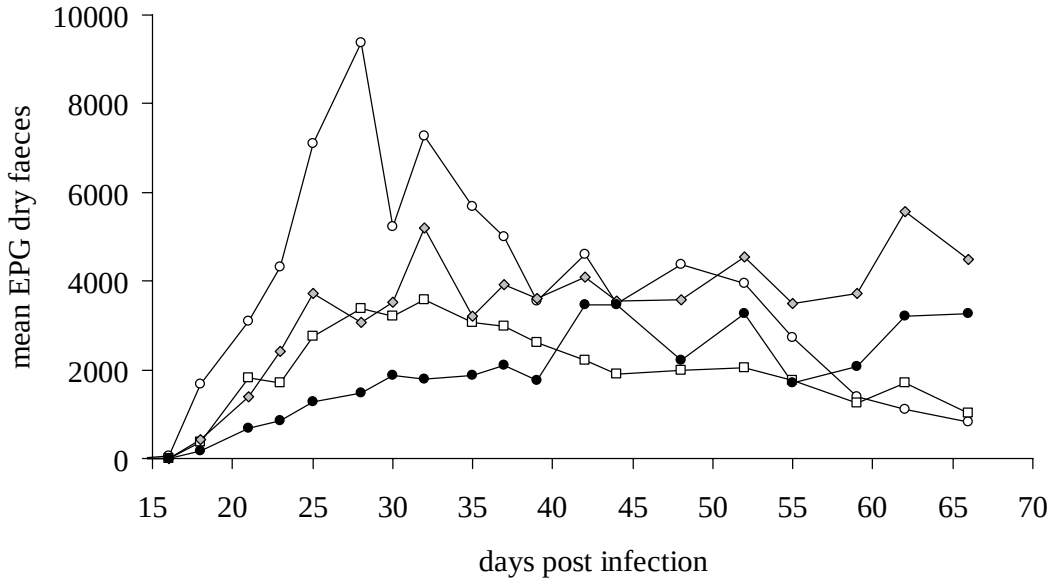

Figure 2 Faecal egg profiles (egg per gram dry faeces) during artificial haemonchosis, of parasite naïve ram lambs maintained on different dietary levels of quebracho extract; control (--○--); 2.5% (--□--); 5% (--◊--) and 8% (--●--) w/v quebracho extract. SED for comparing treatments = 1800, df = 32. (Experiment 2)

Faecal consistency

Dietary QT also increased water content of the faeces. The control groups had significantly lower ($P < 0.001$) faecal water content compared to the groups maintained on QT-containing diets (see faecal DM data, Tables 1 & 2). Moreover, visual examination revealed a tendency for loose brownish mucus-laden faecal material in the sheep receiving QT in a dose dependent manner. Dirty reddish-brown urine was a frequent observation that characterized groups on tannin rich diets.

Table 2 Faecal egg counts and growth parameters of parasite naïve lambs daily infected with 400 L_3 *H. contortus* and offered diet with varying levels QT (Experiment 2)

Parameter	QT0	QT2.5	QT 5	QT 8	SED (32 d.f.)	*P* value	vs.* QT%
Feed consumption (%)	99.8	100.0	100.0	93.5	1.444	< 0.001	-0.79
Faecal dry matter content (%)	32.8[a]	27.4[b]	26.9[b]	27.9[b]	1.6	0.03	-0.90
ADWG (g day $^{-1}$)							
Phase 1	196.1[a]	263.1[a]	241.9[a]	227.6[a]	29.7	0.17	
Phase 2	198.4[a]	215.8[a]	199.9[a]	30.1[b]	39.3	< 0.001	-0.80
Phase 3	196.2[a]	137.0[b]	124.6[b]	117.2[b]	13.5	< 0.001	-0.88
All phases combined	196.9[a]	205.3[a]	188.8[a]	125.0[b]	14.2	< 0.001	-0.84
Initial liveweight (kg)	24.3 [a]	23.2 [a]	23.4 [a]	23.7 [a]	1.15	0.803	
After 12 days on experimental diet (kg)	30.1[a]	31.2[a]	31.6[a]	27.1[b]	1.36	0.008	-0.58
Final liveweight (kg)	44.9[a]	42.5[a]	41.2[a]	36.4[b]	1.96	0.001	-0.98

The results are mean of 9 animals per group. Phases were considered as period from onset of experiment to introduction of experimental diets (phase 1), from the diets to commencement of trickle infection (phase 2) and finally the post infection period (phase 3). Means with different superscripts within a row are significantly different ($p < 0.05$).

Effect of QT drench on faecal egg output and total worm burdens of sheep during mono-specific and mixed nematode infections (experiments 3 and 4 respectively)

Faecal egg counts

Worm eggs were first observed in the faeces 17-18 days after the first dose of infective stage larvae. Experiment 3 showed two distinct egg profiles ($P < 0.01$) (Fig. 3); while the FEC of the control group increased progressively throughout the 10-day (day 16-25) monitoring period, the treated groups started to decline two days after the first QT dose. There was a significant reduction ($P < 0.05$) in mean FEC of the treated group on the day of slaughter (day 25), this was shown to be 91% lower than the control group. Experiment 4 revealed that QT drench had a significant reduction in FEC of sheep infected with *Haemonchus sp* (group H) but not with *Trichostrongylus sp*. (group T) or both (group HT). Comparisons of mean FEC between control and treated animals within each group revealed a significant reduction ($P < 0.05$) in groups H and HT but not in group T ($P = 0.181$). Percentage FEC reductions, as calculated on the day of slaughter (day 30), were 77, 35 and 23% for groups H, T and HT respectively. A peculiar trend whereby FEC dropped markedly a day after the drench and then started to increase towards the day of slaughter was observed in group T and was more conspicuous in group HT (figure 4a – c).

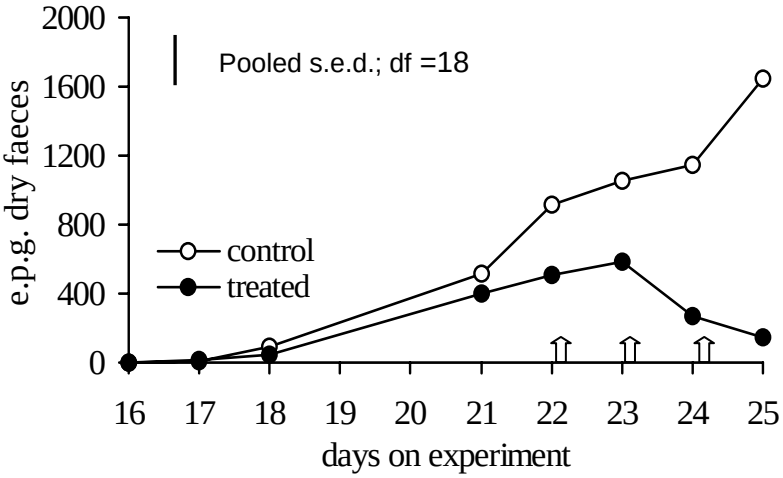

Figure 3 Effect of quebracho extract drench on faecal egg outputs of sheep parasitised with *Haemonchus contortus* alone, arrows show days of drench administration. (Experiment 3)

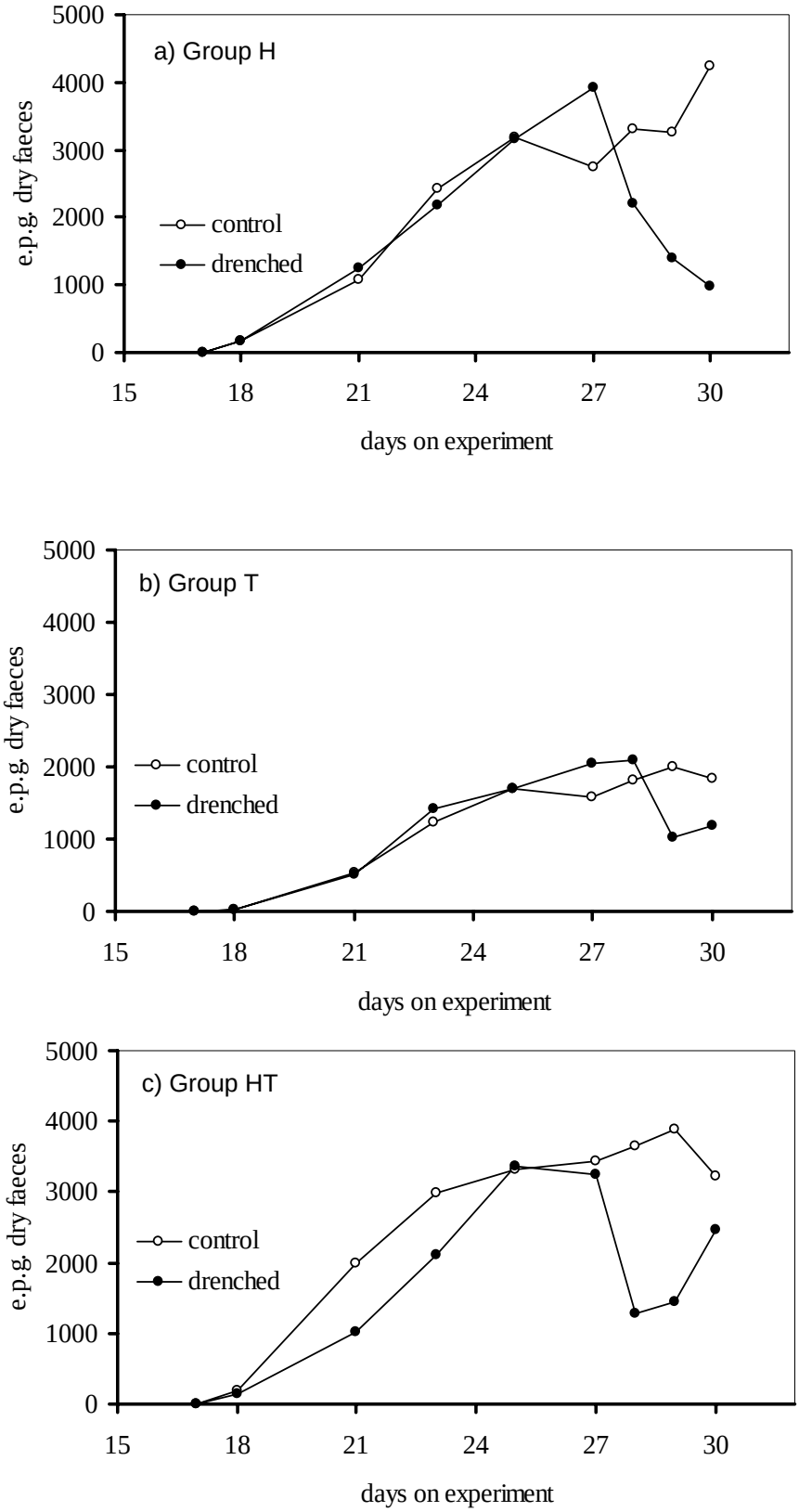

Figure 4a - c Faecal worm egg profiles of the three groups of sheep infected with either *H. contortus* alone (a), or *T. colubriformis* alone (b) or both species (c). Control [--o--] or drenched with QT solution at 2.4g kg-1 body weight [--•--]. SED for comparing treatments = 587, df = 30. (Experiment 4)

Total worm burdens

Total worm burden results (TWB) for mono-specific infection are shown in figure 5; there was a significant difference ($P < 0.01$) in the TWB, i.e., males, females and immature worms, between the control and treated groups. Comparison of mean TWB between the two groups showed a reduction of 80% after three consecutive days of drenching with QT extract. Treatment was not effected by sex of the worms as the treatment x sex interaction was not significant ($P = 0.61$), male-female ratios were 0.96 and 1.11 for control and treated groups respectively. The TWB results for the mixed infection are shown in Figure 6 and 7. Drenching with QT extract reduced TWB of *H. contortus* in group H by 33% ($P = 0.234$) and in group HT by 99% ($P = 0.015$). On the other hand the drench reduced TWB of *T. colubriformis* in group T by 39% ($P = 0.216$) but by only 12% ($P = 0.37$) in group HT. Although TWB reduction was observed in all drenched animals and affected both worm species, it was only with *H. contortus* under mixed infection (group HT) in which the treatment was shown to be statistically significant.

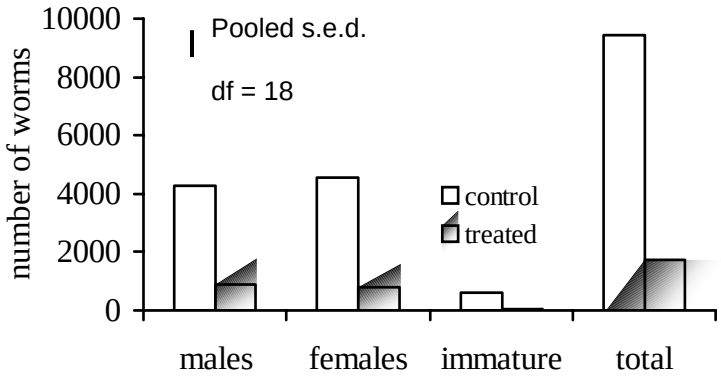

Figure 5 Effect of quebracho extract drench on total worm burdens (TWB) of sheep mono-specifically parasitised with *Haemonchus contortus*. (Experiment 3)

Changes in the gastrointestinal tract (GIT)

Reduced appetite and loose mucous faeces were a frequent observation on the day following the first dose of QT in all drench trials. Slight reddening of the abomasal-ileal region and tiny dark spots on Peyer's patches were evident in drenched animals on necropsy.

Direct effect of QT and WT solutions on different nematode stages (*in vitro* studies)

Incubation of L3 larvae of *Haemonchus contortus* in QT solutions of up to 37% did not show any toxicity to the larvae, however, this was not the case with *Heligmosomoides polygyrus* adults. The latter had its viability compromised at all levels of QT tested. The most effective concentration was 2% QT, which killed 50% and 100% of the worms within 18 and 36 hours respectively (Figure 8). The least effective solutions were 8 and 12% QT, which required about 35 hours for 50% of the worms to die and with both, about 15% of the parasites surviving the 48-hour incubation period. Males were more susceptible to the toxic effect of condensed tannins in QT than females. The addition of PEG in the QT solutions did not improve viability of the parasites.

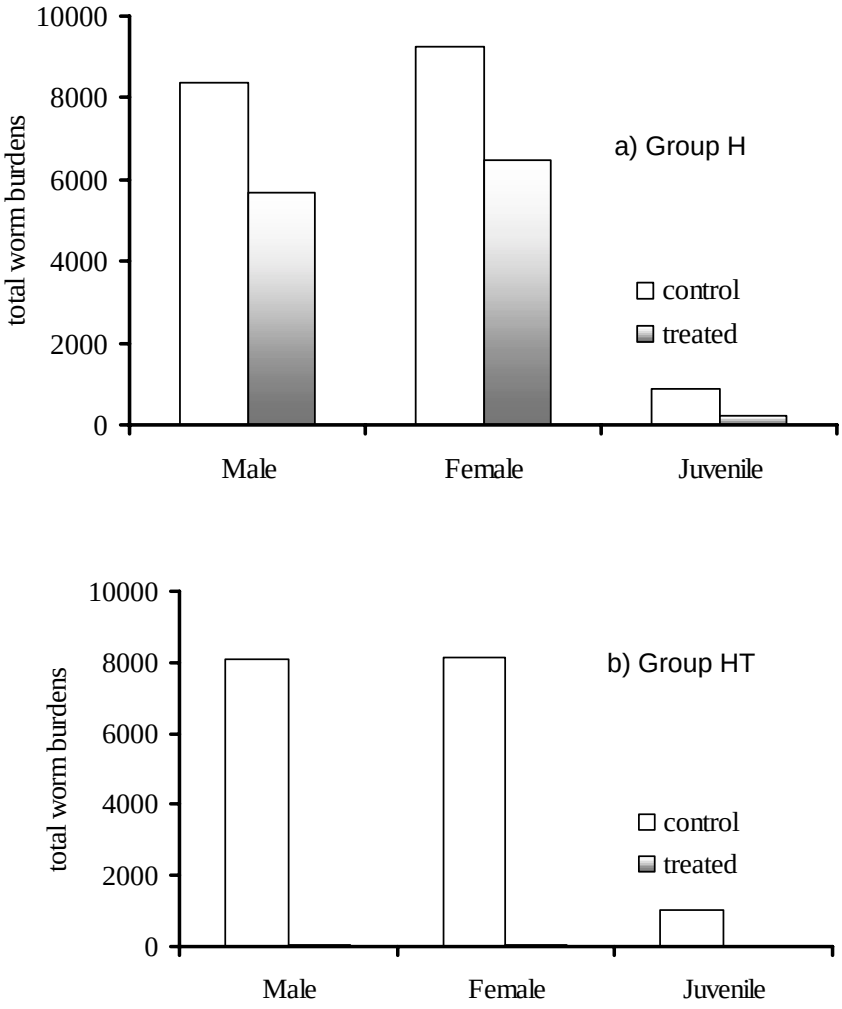

Figure 6a & b Total worm burdens of *H. contortus* recovered from animals of groups H (a) and HT (b) at slaughter. SED =154, df 20. (Experiment 4)

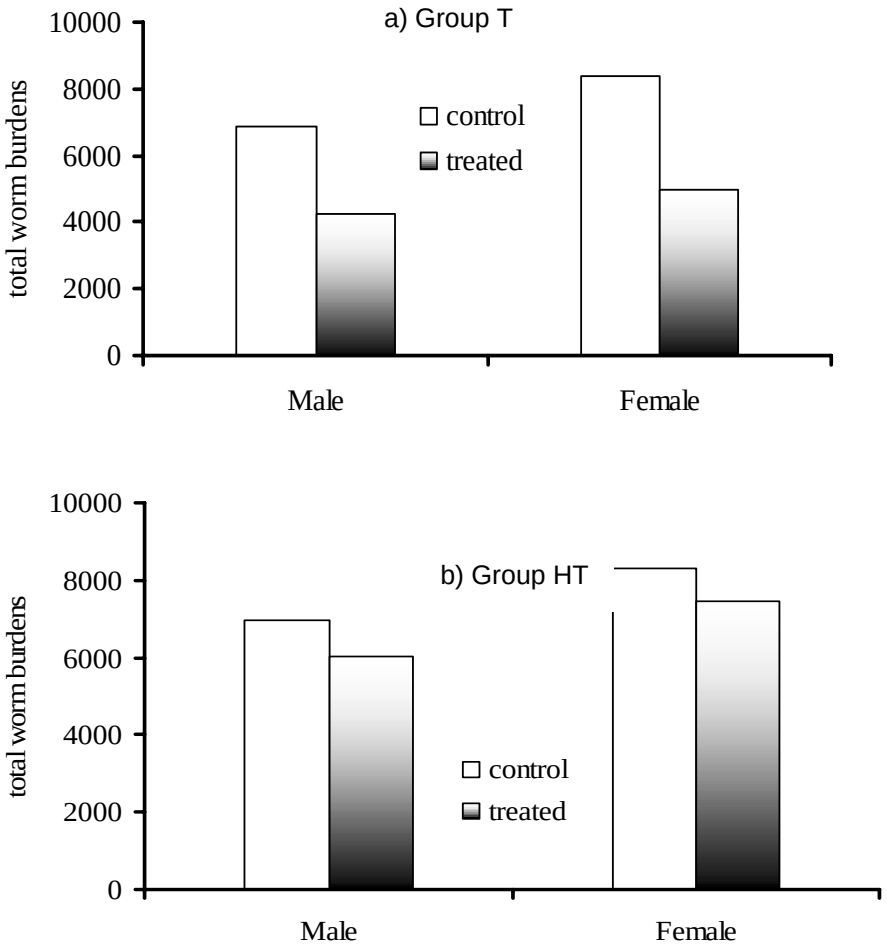

Figure 7a & b Total worm burdens of *T. colubriformis* recovered from animals of group T (a) and of group HT (b) on slaughter. SED = 1895, df = 20. (Experiment 4)

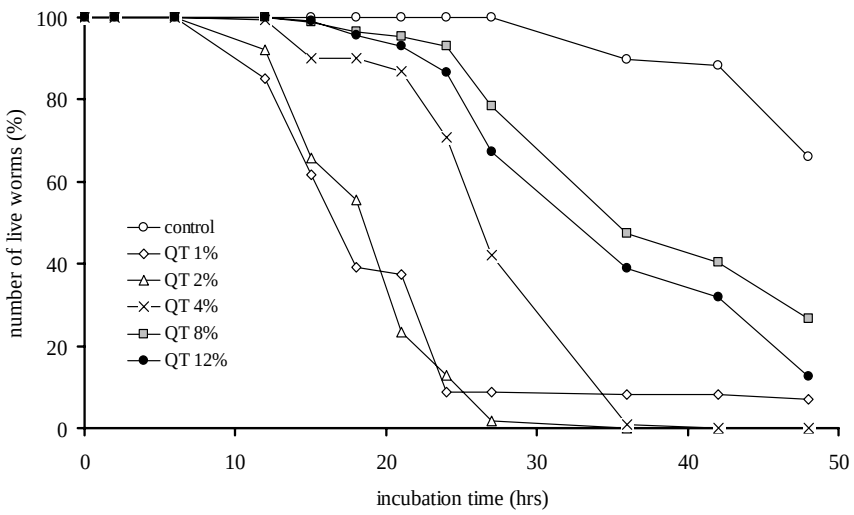

Figure 8 Survival of *H. polygyrus* in culture solutions containing different concentrations of quebracho tannin extract (QT) (mean of 3 experiments)

Wattle extract

The effects were similar to those of QT with the exception that WT was about 4 times more potent than QT (Figure 9). While it took more than 48h for all worms to die in most QT solutions, no worm survived the 10-h incubation in WT solutions. Addition of PEG to the WT test solutions only slightly affected the worm survival. On average PEG increased the time required to kill 50% of incubated worms (t50) by only an hour, i.e., it shifted the t50 from 2 - 3 hours to 3 - 4 hours. Only 10% of the parasites in WT solutions managed to survive the 10-hour incubation period as a result of PEG addition. This was similar to the result seen with QT. This may indicate that the WT and the QT preparations contain materials other than tannins that were toxic to worms.

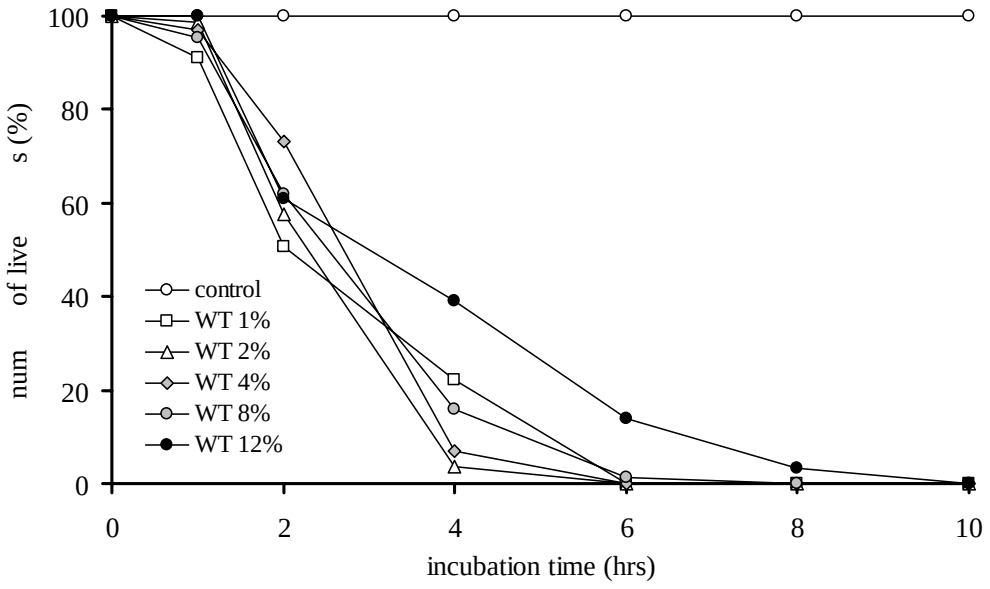

Figure 9 Survival of *H. polygyrus* in culture solutions containing different concentrations of wattle (mimosa) tannin extract (WT) (mean of 3 experiments)

Discussion

The current results are some further evidence of anthelmintic activity of condensed tannin preparations. Dietary inclusion of QT (experiments 1 and 2) appreciably reduced FEC of sheep with haemonchosis but surprisingly this changed towards the end of trial (Fig 1 and 2) suggesting that prolonged feeding with relatively high levels of CT may result in resistance by the worms. Animals on 8% QT feed had lower ADWG than others but again this was a result of anti-nutritional effects of CT as explained above. Drenching trials were carried out to address some of the shortcomings of the feeding experiments. The QT drench caused a significant reduction in both FEC and TWB of sheep infected with *H. contortus* alone (experiment 3). Reduction with *H. contortus* was also seen in experiment 4, although the magnitude was different between the single and the mixed infections. Larvae of *T. colubriformis* showed only a little response to QT drench (experiment 4). When a similar trial was carried out in sheep (Athanasiadou *et al*., 2001), the same dose of QT drench was found be effective against *T. colubriformis* but not *H. contortus*, i.e. opposite to the current observations. It should also be noted that tannins are very heterogeneous compounds and differences in these data indicate that their biological effect might also be variable. It should also be noted that addition of PEG did not greatly reduce the toxicity of the tannin preparations *in vitro*; an indication that compounds other than CT in the extract might be responsible for observed toxicity.

Physiological changes in the GIT following administration of QT drench, i.e., increased faecal water content and mucus secretion, were undesirable but they might have contributed

towards dislodging and eventual expulsion of worms. The QT dosage can be adjusted to reduce some of the deleterious effects.

The studies presented here support the current view that tannin preparations have anthelmintic properties but further work is still required to confirm this and to devise the appropriate dose levels. The possibility of using feeds containing plant materials high in tannins needs also to be explored.

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DICHROSTACHYS CINEREA PODS AS A PROTEIN SUPPLEMENT FOR GOATS FED ON HAY BASED DIETS

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Abstract

Studies were conducted to investigate the potential of *Dichrostachys cinerea* pods as protein supplements. Bulk *D. cinerea, Acacia erioloba, A. erubiscens, Piliostigma thonningii* and *A. nilotica* pods harvested in August 2000 were used for chemical analyses and an *in vitro* tannin bioassay. Chemical analyses were carried out to estimate the level of N, tannins and fibre in the pods. The pods were then evaluated using the *in vitro* gas production technique as a tannin bioassay, by incubating pods, with or without a tannin-binding agent, polyethylene glycol (PEG). Increase in gas production upon adding PEG was used as a measure of tannin anti-nutrient activity. *Dichrostachys cinerea* pods gave the highest response to tannin inactivation (over 200% increase in cumulative gas production), followed by *A. nilotica*. *Dichrostachys cinerea* and *A. nilotica* pods were selected for further evaluation of tannin inactivation methods *in vivo,* however, due to limited resources only one species could be evaluated at a time. This paper reports the *in vivo* evaluation of *D. cinerea.* Alkaline and PEG treatments were evaluated *In sacco* and in a nitrogen balance trial with goats offered *D. cinerea* pods. Milled (2 mm screen size) treated and untreated pods were incubated in nylon bags in the rumens of goats fed on a grass hay diet supplemented with mixed pods. Treated pods had significantly higher soluble fractions, rates of degradation and effective degradabilities of nitrogen (outflow rate 0.05) compared to the untreated pods. Treated pods were used as supplements for goats fed on a basal diet of grass hay. The supplements were compared to a commercial goat feed (goat meal) and a control treatment where goats were unsupplemented. Supplementation significantly increased both the intake of hay and N retention. The control group were in negative N balance. Supplementing with PEG treated pods significantly increased hay intake compared to the untreated pods, while there was no difference between the alkaline treated pods and the untreated ones. However, untreated pods gave a higher N retention value compared to the treated pods and this value was the same as that with goat meal. This suggests that there is no need to ameliorate the tannins in *D. cinerea* pods before feeding, as these are beneficial to the protein nutrition of the animal. PEG treatment may have resulted in excessive protein degradation in the rumen and increased N loss through the urine.

Introduction

The utilisation of protein rich leguminous trees and shrubs as protein supplements can counter the seasonal shortage of good quality forage for livestock in Zimbabwe. The long dry seasons (up to 7 months) are characterised by reduced quantity and quality of feed resources. In semi-arid areas, trees and shrubs are the only cheap source of protein for

livestock, thus maximising their use can help improve the productivity of livestock in the smallholder farming communities. Due to perennial feed shortages, the semi-arid areas have a large goat population whose productivity is considered to be low (Kusina and Kusina, 1999). The goat has been ranked the most important livestock species in these areas. Browse leaves are mostly available to the animals during the wet season and early in the dry season. However, as the dry season progresses, browse leaves become scarce and pods /fruits become available. Dry and mature pods are, therefore, important as a dry season protein supplement. However, the potential of tree pods to be used on a large scale is limited by the presence of anti-nutritional factors such as tannins (Tanner *et al.,* 1990; Mlambo *et al.,* 2000) and cyanogenic glycosides.

It is important that the nutritional effect of tannins is well understood before the intensive use of tree pods as protein supplements is recommended. The role of tannins in livestock nutrition is poorly understood. This is compounded by the use of quantitative assays that fail to relate to the biological activity of the tannins. It is important to understand the structure/activity relationship of tannins but this may not be possible in the often poorly equipped laboratories found in agricultural research institutions in developing countries. It is, therefore, imperative that simple, cheap and reliable tannin assaying techniques are developed that can be routinely used to screen the diverse tree species, which are potential protein sources for the resource-poor livestock keepers. In addition, it is also important to develop and evaluate cheap ways of ameliorating the anti-nutritional effects of tannins in those tree species where the utilization of pods is limited by the presence of tannins.

In this study the effect of tannin inactivation on the nitrogen balance of goats fed *D. cinerea* pods as a supplement is evaluated. They are compared with a commercial goat feed (goat meal). Polyethylene glycol (PEG) and sodium hydroxide (NaOH) are used as tannin inactivation agents. It is important to note that these two tannin-inactivating agents are expensive and, therefore, it is not practical for poor farmers to use them. Cheaper substitutes, such as wood ash, are available for alkaline treatments and these are being evaluated.

Materials and Methods

Pods

Dichrostachys cinerea pods used for chemical analyses and *in vitro* tannin bioassay were harvested at Matopos Research Station, Bulawayo, Zimbabwe, in August of 2000. Pods used for the nylon bag and nitrogen balance trials were harvested from the same site in August of 2001. Pods were knocked off trees with the aid of sticks and collected into sacks. Samples intended for N and tannin analyses were ground through a 1 mm screen while samples for the *in vitro* tannin bioassay, nylon bag trial and other chemical analyses were ground through a 2 mm screen. Pods and grass hay used in the nitrogen balance trial were ground through a 15 mm sieve.

Chemical analyses

Dry matter (DM) content was determined by drying 1 g of sample in an oven set at 100 °C overnight. Nitrogen content of nylon bag residues was determined by the macro-Kjeldahl method while the N content of other samples was determined using the total combustion method with the Dumas Elemental Analyser. Neutral detergent fibre (NDF) and acid detergent fibre content (ADF) were determined by the method of Goering and Van Soest, (1970), while acid detergent insoluble nitrogen (ADIN) content was obtained by determining the N remaining in the ADF fraction using the total combustion method. Tannin analyses were carried out on a 70% aqueous acetone extract. Total phenolics were determined colorimetrically by reacting the extract with the Folin-Ciocalteau reagent and measuring absorbance at 650 nm. Gallic acid was used as a standard. Ytterbium precipitable phenolics

were determined by precipitating phenolics in the extract with trivalent ytterbium in the presence of triethanolamine at 4 °C for 2 hours according to the method of Reed *et al.* (1985).

In vitro tannin bioassay

Pods were incubated, with or without PEG, using the Reading Pressure Technique (Mauricio *et al*., 1999). Approximately 1 g of sample was weighed into each serum bottle and incubated with a buffer and rumen fluid for 96 hours. PEG-4000 was dissolved in the buffer to give an inclusion rate of 200 mg PEG per gram sample. Two sets of buffer were prepared, one with PEG and the other without. Gas pressure was measured at 2, 4, 6, 8, 10, 12, 15, 19, 24, 30, 36, 48, 72, 96 hours post-incubation. Gas pressure readings were then converted into gas volume using a predictive relationship between gas pressure and gas volume derived by Mauricio *et al.* (1999):

$\mathbf{G_p} = 0.18 + 3.697\ \mathbf{P_t} + 0.0824\ \mathbf{P_t^2}$,

where $\mathbf{G_p}$ = predicted gas volume (ml)

$\mathbf{P_t}$ = gas pressure reading at time t (psi)

Gas volume was corrected for substrate dry matter (DM) and gas produced from blanks.

In sacco N degradation

Based on the results of the *in vitro* tannin bioassay, it was concluded that the tannins, which were likely to cause problems if tree pods were to be fed on a large scale, were those from *D. cinerea* and *A. nilotica* tree species. However, these are the two most common tree species whose yields are consistent annually and, therefore, they were selected for further evaluation. Due to limited resources, each will be evaluated separately, making a between species comparison impossible.

Alkaline treatment was carried out by soaking 1 kg of *D. cinerea* pods overnight in 2 l of distilled water (this was sufficient to wet the entire sample, producing a thick paste, ensuring that no leaching of the sample occurred) in which 60 g of NaOH pellets had been dissolved to give 6% NaOH on a weight-to-weight basis. Treatment with PEG consisted of dissolving 200 g of PEG-4 600 (Aldrich Chemical Co. Inc, USA) in 2 l of distilled water and mixing the solution with 1 kg of *D. cinerea* pods to give a PEG application rate of 200 mg/g. The mixture was left to react overnight. The treated material was then spread onto polythene sheets and sun-dried for 24 hours.

To determine *In sacco* degradation of DM and N, about 5 g of each treated pod sample was weighed into a pre-weighed nylon bag (6 * 12 cm, pore size 40 µm). Duplicate bags were then incubated in the rumens of goats. The goats were fed on a grass hay diet supplemented with 200 g mixed pods per day, for 85 days before the trial started. All the bags were placed in the rumen at the same time (except zero-hour bags) and withdrawn sequentially at 4, 6, 12, 24, 36, 48, and 72 hours. They were then frozen until all bags had been withdrawn at the end of the period. Together with the 0 h bags, incubated bags were washed, in a semi-automatic washing machine with cold water, three times in cycles of ten minutes. Washed nylon bags were then dried in a forced-draught oven at 60 °C for 48 hours. The bags were then cooled in a desiccator and weighed. About 1 g of the residue was used to determine N disappearance.

Calculations and statistical analysis

The disappearance of DM and N was calculated using the following formulae:

$$\text{DM Disappearance} = \frac{(OSBW - BW) * DM1 - (RSBW - BW) * DM2}{(OSBW - BW) * DM1}$$

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:

$$\text{N Disappearance } (\%) = \frac{(\%N1 * OSW * DM1) - (\%N2 * RSW * DM2)}{\%N1 * OSW * DM1}$$

where:

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

A non-linear model (Orskov and McDonald, 1979) was fitted to the degradation data. This gave estimates for the soluble and insoluble fractions as well as the rate of degradation. Effective degradability of N was calculated after assuming a 0.05 outflow rate. The effect of pod treatments was obtained by subjecting the data to a one-way analysis of variance using the general linear models (GLM) procedure. Separation of treatment means was done using the Bonferroni t-test.

N balance trial

Material and methods

Thirty castrated Matebele goats weighing on average 27.4 kg (s.d. = 2.5) were divided into five weight-balanced groups. Five diets were randomly allocated to the five groups of goats (Table 1). The goats were then penned individually in metabolism crates measuring 120 cm long, 54 cm wide, and 90 cm high and raised 90 cm above the floor. The crates were fitted with feeders and drinkers. 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% m/v (Cooper Zimbabwe, Pvt Ltd) using a 10 ml syringe.

Groups 1, 2 and 3 received supplements of either treated or untreated, ground (15 mm screen) D*. cinerea* pods. Group 4 received a goat meal supplement (National Foods Pvt Ltd,

Bulawayo, Zimbabwe) as a positive control, while group five received no supplement, as the negative control. Pod treatments were done as outlined above for the nylon bag trial. The adaptation period was 21 days, while the collection period lasted 7 days.

Feed, faeces and refusals were both analysed for OM, N, NDF, ADF, and ADIN to get an estimate of the intake and digestibility of these constituents while urine was analysed for N only. The difference between N intake and N output in faeces and urine was used as the measure of N retention.

Statistical analysis

Analysis of covariance was carried out to check if initial weight had a significant effect on any of the measured parameters. The effects of supplements on all variables were obtained by a one-way analysis of variance using PROC GLM of SAS. The following linear contrasts were analysed:

1. No supplement versus all supplements
2. Untreated pods versus treated pods
3. Alkaline treated pods versus PEG treated pods
4. Commercial goat meal versus untreated pods

Results and Discussion

Chemical analysis and *in vitro* bioassay

The chemical composition of tree pods are shown in Table 1, while Table 2 shows the fermentation responses of pods from different tree species to inclusion of a tannin binding agent, PEG. The results in Table 1 show that the six tree species differ significantly in chemical composition. *Dichrostachys cinerea* and *A. nilotica* have the least quantities of both NDF and ADF while in terms of N content these two species ranked third and fourth. *Acacia erubescens* had the highest N content followed by *A. erioloba*. More than half (53%) of *A. nilotica*'s N content is insoluble in acid detergent solution, suggesting low availability to microbial fermentation in the rumen. About 29% of total N in *D. cinerea* is bound to ADF. The level of ytterbium precipitable phenolics in *A. nilotica* (61%) should be a cause for concern as the tannins could reduce the productivity of goats if fed in large quantities over a long period. It is evident that there is a positive correlation between ytterbium precipitable phenolics and total phenolics assayed by the Folin-Ciocalteau reagent.

Table 1 Nitrogen, Neutral detergent fibre (NDF), Acid detergent fibre (ADF), Acid detergent insoluble nitrogen (ADIN), Ytterbium precipitable phenolics (YbPh) (g/kg DM) and total phenolics (TPFOL) (µg gallic acid equivalent /mg DM) content of *Acacia* and other tree pods

Species	NDF	ADF	Nitrogen	ADIN	YbPh	TPFOL
Acacia erubescens	542.6	326.1	27.1	6.7	149.2	1.4
A. erioloba	415.1	248.2	21.3	3.8	359.3	5.6
A. nilotica	236.4	150.6	14.6	7.8	607.0	11.6
Piliostigma thonningii	493.4	284.3	13.5	4.2	370.2	6.4
Dichrostachys cinerea	441.3	230.6	19.9	5.7	370.2	6.6
S.E	7.63	3.11	1.13	0.62	10.41	0.32

Table 2 Cumulative gas production of PEG treated and untreated tree pods after 12, 24 and 36 hours of incubation

	Cumulative gas production (ml/g OM)								
Species	**12h**			**24h**			**36h**		
	No PEG	PEG	% [1]	No PEG	PEG	%	No PEG	PEG	%
Acacia sieberiana	44	81	*86*	73	142	*95*	101	178	*76*
A. erubescens	40	50	*25*	73	86	*19*	93	106	*14*
A. erioloba	52	76	*45*	86	121	*40*	114	147	*29*
A. nilotica	28	64	*130*	49	102	*110*	65	129	*98*
Piliostigma. thonningii	51	115	*126*	98	164	*68*	132	184	*40*
Dichrostachys cinerea	17.0	64	*276*	31	107	*242*	43	138	*224*

[1]% percentage increase in gas production due to PEG treatment

Results in Table 2 show an increase in gas production when PEG was included in the fermentation bottles for all the species. As expected, *A. erubescens*, whose tannin levels were the least, had the lowest response to PEG inclusion. However, *A. nilotica,* with the highest level of tannins had a lower response to PEG inclusion than *D. cinerea* (224% increase in gas production at 36 h compared to 98% for *A. nilotica)*. This seems to suggest that tannins from *D. cinerea* are more reactive as inhibitors of *in vitro* fermentation than tannins from *A. nilotica*. It might also mean that most tannins in *A. nilotica* are bound to protein (high NDIN content), thus inactivating them exposes protein to fermentation. Fermentation of protein causes less gas production than that of carbohydrates (Cone and van Gelder, 1999) hence the response to PEG inclusion was not as high as expected.

The use of PEG revealed that tannins reduced fermentation of tree pods either through direct toxicity on microbes or by making the fermentation substrate unavailable to the microbes. However, it is important to note that the inhibitory effect of tannins *in vitro* might be more severe than *in vivo*. Although PEG was effective in reversing the suppressive effects of tannin on *in vitro* fermentation, its use could lead to excessive protein degradation in the rumen resulting in low dietary rumen-escape protein. It is still not clear whether the ability of tannins to improve the supply of protein post-ruminally is a function of quantity or type of the tannin.

In sacco degradability

Table 3 shows degradabilities of DM and N while Figure 1 shows the N degradability curves of treated and untreated *D. cinerea* pods.

Table 3 *In sacco* disappearance of dry matter and N of treated and untreated *Dichrostachys cinerea* (Dci) pods incubated in the rumen of Matebele goats

Component	Parameter‡	Untreated	NaOH treated	PEG treated	SEM
Dry matter	a	26.4[a]	29.3[b]	42.8[c]	0.69
	b	48.3 [a]	36.4 [b]	32.8 [b]	2.21
	c	0.032 [a]	0.039 [a]	0.058 [b]	0.0049
	PD	74.7	65.7	75.6	-
	ED	44.5 [a]	43.5 [a]	59.7 [b]	1.22
Nitrogen	a	47.5 [a]	52.8 [b]	61.8 [c]	1.71
	b	43.1 [a]	29.0 [b]	27.9 [b]	1.71
	c	0.036 [a]	0.068 [b]	0.116 [c]	0.0151
	PD	90.6	81.8	89.7	-
	ED	64.7 [a]	68.8 [b]	81.0 [c]	0.53

In a row, means with the same superscript are not significantly different (*P*<0.05*)*

‡Units: For Dry matter a, b, PD and ED are measured as% of DM, for Nitrogen a, b, PD and ED are measured as% of N incubated. PD : Potential degradability (PD = a + b)

ED: Effective degradability ($ED = a + \frac{b * c}{k + c}$) (outflow rate of solids assumed to be 0.05)

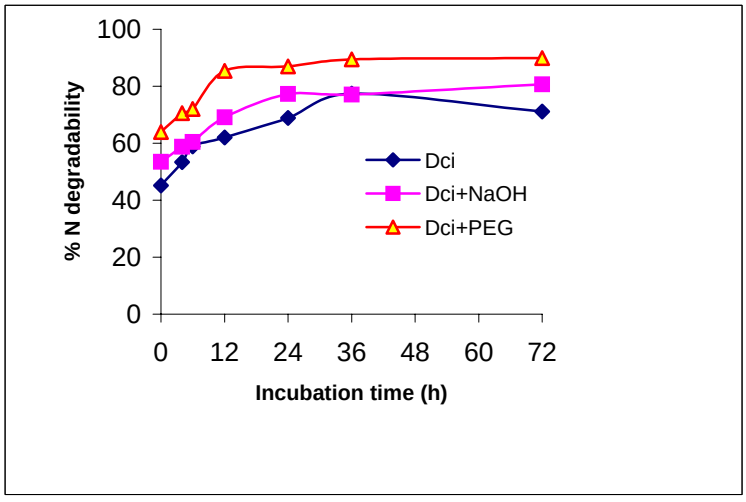

Figure 1. *In sacco* nitrogen disappearance for treated (NaOH and PEG) and untreated *Dichrostachys cinerea* (Dci) pods

Dry matter degradability

Treating *D. cinerea* pods increased the soluble (a) and decreased the slowly degradable (b) fractions, the effects of PEG being greater than NaOH. Alkaline treatment did not significantly increase the rate of degradation of the slowly degradable fraction and effective degradability. Pods treated with PEG had significantly higher rates of degradation and effective degradability.

Nitrogen degradability

PEG and alkaline treatments significantly increased the soluble fraction, rate of degradation and effective degradability of N. Between the treatments PEG treated pods had significantly higher values than alkaline treatments. All the treatments decreased the slowly degradable fraction to a similar extent.

These findings suggest that tannin inactivation using PEG improves the fermentation of protein in *D. cinerea* pods. Although alkaline treatment improves some degradation parameters, the small level of improvement makes practical application questionable.. However, it is possible that at 6%, the sodium hydroxide level used could have been too high to have resulted in the formation of artefacts, which could have resulted in lower degradability parameters. We are currently carrying out experiments in which the optimum level of sodium hydroxide for tannin inactivation is being sought.

N balance trial

Organic matter and N intake

Goats consumed all their supplements after the 21-day adaptation period. Supplementation significantly ($P < 0.05$) increased grass hay intake with goats on PEG treated pods and goat meal supplements consuming most hay. Total N intake varied between groups due to differences in N content of the supplements. Alkaline and PEG treated pods had less N compared to untreated pods, due to the dilution effect. Goats on untreated pods consumed the highest N intake (9.6 g/day) followed by goats on goat meal, while goats on alkaline and PEG treated pods consumed 7.8 and 7.7 g/day N respectively. Unsupplemented goats consumed 1.6 g N/d.

Table 4 Daily organic matter (OM) and N intakes and flows in goats fed grass hay with treated (NaOH, PEG) and untreated *Dichrostachys cinerea* pods

	Untreated	NaOH	PEG	Goat Meal	None
No. of animals	5	6	6	6	6
Average weight (kg)	26.9	27.6	27.6	27.7	27.0
	± 1.10	± 1.21	± 1.21	± 1.21	± 0.89
OM intake					
Supplement (g)	172.6	126.8	178.4	163.3	-
Grass Hay (g)	445.3[a]	466.4 [ab]	474.8[b]	474.3[b]	333.9[c]
Total OM intake (g)	617.9	593.2	653.2	637.7	333.9
N intake					
Supplement (g)	6.5	4.6	4.4	5.9	-
Grass Hay (g)	3.1	3.2	3.3	3.2	1.6
Total N intake (g)	9.6 [a]	7.8[b]	7.7[b]	9.1[c]	1.6[d]
Faecal output					
OM (g)	278.2 [a]	293.3 [a]	297.3 [a]	275.6 [a]	132.6 [b]
Nitrogen (g)	3.9 [a]	3.9 [a]	4.0 [a]	3.6 [a]	1.5 [b]
Urine					
Nitrogen (g)	0.7 [a]	0.7 [a]	1.5 [b]	0.4 [c]	1.9 [d]
OM digestibility	0.55[ac]	0.50 [b]	0.54 [a]	0.57 [c]	0.60 [d]
N retention (g)	5.0 [a]	3.2 [b]	2.3 [c]	5.1 [a]	-1.8 [d]

In a row, means with the same superscript are not significantly different (P<0.05)

N output

Faecal N output was similar for the supplemented groups but was lower (P<0*)* in the group that did not receive any supplements. Goats on the goat meal supplement had the least urinary N while the unsupplemented group had the highest amount of N in urine. Among the pod supplemented groups, goats on PEG treated pods had twice the level of urinary N (1.5 g/day).

Organic matter digestibility and N retention

Organic matter digestibility (OMD) was highest in the unsupplemented group while OMD for the groups on goat meal and untreated pods did not differ significantly. While N retention was negative for the unsupplemented group, goats on the commercial goat meal and untreated pods had the highest N retention values. Goats on treated pods retained less N compared to those on untreated pods. PEG treated, therefore, did not improve N retention. Among goats fed supplements, the group fed on PEG treated pods retained least N. This could have been due to excessive protein degradation in the rumen and subsequent N losses through urine. This could also be the reason why goats on PEG treated pods had higher urinary N values. Tannins inhibit protein fermentation in the rumen and N excretion is shifted from urine to faeces (Reed and Soller, 1987; Mishra and Rai, 1996). Indeed, Carulla (1994) reported that, at similar N intakes, PEG addition was linearly associated with reduced N (microbial, non-microbial and total) flow to the duodenum, reduced faecal excretion and reduced N retention. PEG treatment result in an increase in the rumen degradable protein (RDP) fraction as seen in the *In sacco* experiment. Waghorn *et al*. (1987) found that PEG treatment resulted in higher rumen ammonia, less nitrogen reaching the abomasum and ileum. Nunez-Hernandez *et al*. (1991) reported that sheep and goats fed PEG-treated forage at a rate of 2.3 g/g tannins had

higher rumen ammonia concentrations than those fed control forage. The animals also had lower faecal but higher urinary N excretion than those fed control forage. They however, could not demonstrate any differences in N retention. If a high concentration of rumen ammonia is not synchronised with a good supply of energy, blood urea recycling/turnover to the rumen is low. N losses are more likely to occur through urinary excretion. In this experiment, no effort was made to match N supply with energy because the objective was to simulate likely feeding conditions affordable to smallholder farmers. However, it is likely that the poor N retention in the group fed PEG treated pods was a result of increased N supply, which was not synchronised with energy supply in the rumen.

Conclusions

The use of PEG for *in vivo* tannin inactivation needs to be further evaluated especially with regards the rate of application. High rates of PEG are likely to reduce the quality of protein by allowing excessive protein fermentation. However, it is important to note that the beneficial effects of tannins may not be a function of quantity per se. In light of the findings in this experiment, results from *in vitro* tannin bioassays need careful interpretation. However, the fact that untreated D. cinerea pods matched a commercial feed, goat meal, in terms of N retention, OM digestibility and grass hay OM intake suggest that this tree species can be used by smallholder farmers in place of expensive commercial products. The only inputs required are milling of the pods and storage.

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ACACIA AND OTHER TREE PODS AS DRY SEASON FEED SUPPLEMENTS FOR GOATS

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Abstract

Most rangelands in Zimbabwe are dominated by *Acacia* and other pod, or fruit, producing trees, including *Dichrostachys cinerea*, *Colophosperm mopane*, genera of *Pilliostigma* and *Guibortia*. These trees produce nutritious pods which are high in crude protein. The pods ripen during the dry season and can be used to supplements livestock when there is an inadequate supply of feed on rangelands. At present, smallholder farmers rarely use browse pods as supplements to livestock, especially goats. Feeding trials using browse pods have been undertaken on station to determine intake and assess the performance of lactating goats and their progeny. Information generated is being demonstrated in the rural areas by organizing cooperating farmers to host feeding trials using different browse pods of their own choice. Results of on-station work are presented.

Introduction

In Zimbabwe the feed related factors that limit productivity vary at different times of the year (Sikosana and Maphosa, 1995). Early in the dry season, feed quality deteriorates rapidly, followed by a reduction in quantity, as a result of high grazing pressure and senescence. Average dry season grazing contains less than three per cent crude protein (Elliott and Folkema, 1961). This seasonal undernutrition results in poor growth rates in growing animals, death occurring in severe seasons, and a low off take rate. Feed supply is the most pervasive constraint in livestock production (Winrock International, 1993). The available feed resources across the country are natural rangelands, crop residues and cultivated pastures. Seasonal fluctuation in feed supply is a problem in all ecological zones.

Livestock, including goats, in the drier ecological zones depend on natural rangelands, containing a variety of grasses and vegetation dominated by browse species. Studies at Matopos Research Station have shown that goats spend up to 60-70 % of their feeding time browsing (Sibanda 1986). Browse can be eaten as fresh leaves, dried leaves and ripe pods. Browse pods are high in nutritive value (Ncube and Mpofu, 1994; Tanner, Reed and Owen, 1990) and can be used as supplements with low quality roughages. Most rangelands in Zimbabwe contain *Acacia* species and other pod, or fruit, producing trees namely *Dichrostachys cinerea, Colophosperm mopane*, and genera of *Piliostigma* and *Guibortia.*

Distribution of *Acacia* species in Zimbabwe

In Zimbabwe, *Acacia* species are found mostly in arid savanna (Natural Regions (NR) IV and V) with a few in wetter regions (Timberlake, Fagg and Barnes, 1999). The most common

Acacia species in Zimbabwe are: *A. karoo, A. tortilis, A. nilotica, A. erubescens, A. erioloba, A. robusta, A. gerradii, A. rehmanniana, A. galpinii, A. nigrescens, A. Faidherbia albida*. Other browse species include the genera *Pilliostigma* and *Giubortia,* and *D. cinerea.*

Use of *Acacias* in Zimbabwe

Timberlake, *et al.,* (1999), have reviewed the uses of *Acacia* species in livestock production. Leaves, pods and young shoots are utilized by both domestic livestock and wildlife. *Acacia* browse trees provide forage throughout the year. Before the rains they provide a much needed browse flush and during the dry season provide pods. *Acacias* produce nutritious pods that ripen and fall during the dry season when there is little forage apart from low quality forage. Species with indehiscent pods, such as from *A. erioloba, A. nilotica, A. tortilis and A. Faidherbia albida,* can be collected and stored for feeding later in the dry season to pregnant and lactating goats and other livestock. The crude protein of these pods ranges from 10-15 per cent. Smallholder farmers rarely offer supplements to their goats, although it is probably the most important factor affecting performance. Supplementing small ruminants with browse improves survival rates of the young.

One of the major disadvantages of browse as a livestock feed is the presence of perceived anti-nutritional factors such as phenolic compounds, of which tannins represent a large part. Their toxicity can be reduced by boiling the pod, milling, or mixing with sulphur or molasses (Steyn, 1934; Timberlake, 1980).

Other use of browse trees

*Dichrostachys cinerea*r pods are used to treat asthma and *A. tortilis* can be used to as a dressing for burns (Kindness *et al.,* 1999).

Farmer knowledge on pods

Most farmers appreciate the idea of collecting pods to supplement goats during the dry season, although some lack understanding of the benefits of pods to livestock (Kindness, *et al.*, 1999, report of participatory rural appraisal (PRA) undertaken at the start of this project.

Feeding trials on-station

Between May 1999 and December 2001 experiments have been undertaken to determine intake and assess the performance, including growth rates of progeny, of lactating goats supplemented with pods. In the experiments reported here different browse pods are being tested as supplements for goats during the dry season. Such information will be useful to goat farmers who cannot afford to buy concentrate feeds.

Experiment one

Forty-five indigenous female goats were divided randomly into three groups. Two groups were supplemented with crushed pods of A*. erioloba* or *D. cinerea*, one group was unsupplemented. Supplements offered were 200g/day/animal, 45 days before and 45 days after kidding.

Results

Birth weights and weaning weights of kids were significantly different (P<0.05) across treatments (Table 1). Twin-born kids had both lower birth and weaning weights, except for

kids weaned in the group where does were supplemented with *A. erioloba*. Supplementation with *D. cinerea* improved kid growth rates and survival rates.

Table 1 Kid birth and weaning weights (kg, single(s) and twins (t)) and mortality rates (s, t) after supplementation for 45 days before and after kidding (Year 2000)

		Acacia erioloba	***Dichrostachys cinerea***	**Non-supplemented**
Birthweight	s	2.3 (n=6)	2.7 (n=8)	2.9 (n=11)
	t	2.1 (n=20)	2.3 (n=10)	2.2 (n=12)
s.e.m		0.11	1.12	0.05
Weaning weight	s	5.4	11.8	10.6
	t	8.2	9.5	6.4
s.e.m		0.56	0.13	0.77
Kid mortality %	s	50	0	0
	t	15	0	16

Experiment two

Animal management is similar to the first experiment except that five browse species are being offered, reflecting greater availability. Animals are either supplemented with pods of *A. erioloba, D. cinerea, A. nilotica, A. tortilis*, or *A. erubescens*. One group is not supplemented. The experiment is on-going. Kid birthweight are shown in Table 2.

Table 2 Kid birth weights (kg) of single(s) and twins (t) after supplementation for 45 days before and after kidding (Year 2001)

Birth weight	***Acacia erioloba***	***Dichrostachys cinerea***	***A. nilotica***	***A. tortilis***	***A. erubescens***	***Non-supplemented***
s	2.9 (n=7)	3.1 (n=5)	2.8 (n=7	2.8 (n=6)	3.2 (n=6)	2.8 (n=7)
t	2.5 (n=14)	3.5 (n=14)	2.4 (n=14)	2.5 (n=18)	2.4 (n=14)	2.3 (n=16)
s.e.m	0.09	0.10	0.08	0.09	0.15	0.10

Experiment three

Dry matter intake was measured in 30 castrated male goats, housed in metabolism crates. There were five animals per treatment.

Results

Goats supplemented with cottonseed meal (CSM), *A. erioloba* and *D. cine*rea had the highest (*P*<0.001) intake of supplements (see Table 3). Lower intakes of *A. nil*otica may have been due to anti-nutritional factors and needs further investigation. Digestibility and nitrogen retention were highest (*P*<0.05) in animals supplemented with CSM, *A. erioloba* and *D. cinerea*.

Table 3 Daily intakes, (g/DM/day and gDM/kgW $^{0.75}$), dry matter digestibility (%, DMD) and N retention (g/d, NR) of hay and supplements fed to castrated male goats.

	Cottonseed meal	*Acacia erioloba*	*A. erubescens*	*A. nilotica*	*Dichrostachysci nerea*
Live weight(kg)	26.4	26.8	26.0	24.4	26.7
Daily pod intake:					
DM	183	183	138	44	182
DM/kgW$^{0.75}$	15,7	15.6	12.0	3.9	15.5
Daily hay intake					
DM per day	529	555	540	468	662
DM/kg$^{0.75}$	45.4	47.1	47.1	42.6	56.3
Total daily intake					
DM	712	738	679	511	844
DM/kg$^{0.75}$	61.2	62.6	58.9	46.6	71.8
DMD	0.55	0.54	0.51	0.49	0.57
NR	5.8	2.1	1.3	-0.5	3.03

Experiment four

Forty indigenous female goats were randomly allocated to four groups. Two groups were fed supplements of *D. cinerea* pods, the other two were not supplemented. One group receiving a supplement and one non-supplemented group were hand milked once a day. The other two groups were not milked.

Results

Kids from the supplemented and not milked had the highest *(P*<0.05) growth rates (Table 4).

Table 4 Birth weights (kg) of single(s) and twins (t) born kids and kid mortality rates (s, t), from does supplemented with *D. cinerea* (after supplementation for 45 days before and after kidding) and non supplemented (Year 2000)

	MS[1]	nMS[2]	MnS[3]	nMnS[4]
Birth weight	2.84	2.65	2.41	2.39
Weaning weight	8.85	9.79	7.42	7.95
Kid mortality%				
S	0	0	0	0
T	17	0	14	38

[1]MS, Milked, Supplemented

[2] nMS, Not milked, Supplemented

[3]MnS, Milked, not supplemented

[4]nMnS, Not milked, not supplemented

Faecal worm egg counts

The worm burden in does supplemented with browse pods has been monitored (Figures 1 and 2).

Indigenous female goats in the feeding trials reported above were also monitored for levels of worm infestation, by counting the eggs per gram (epg) of faeces. Faecal samples were collected monthly from the rectum of each animal from the start of feeding, 45 days before kidding and 45 days post-partum.

Figure 1 shows generally low levels of epg in all animals, both fed and non-fed. However, in December 1999 high levels of epg were recorded and animals had to be dosed with a proprietary anthelmintic to reduce them.

In early September 2000, does were dosed and feeding commenced shortly afterwards. At the end of October 2000, low levels of epg were recorded in the supplemented animals, but non-supplemented animals had high levels of epg. All animals were dosed at this stage.

It appears that some browse pods can have a positive effect in controlling levels of worm infestation. Individual species of browse pods need to be tested at different levels against known levels of worm infestation.

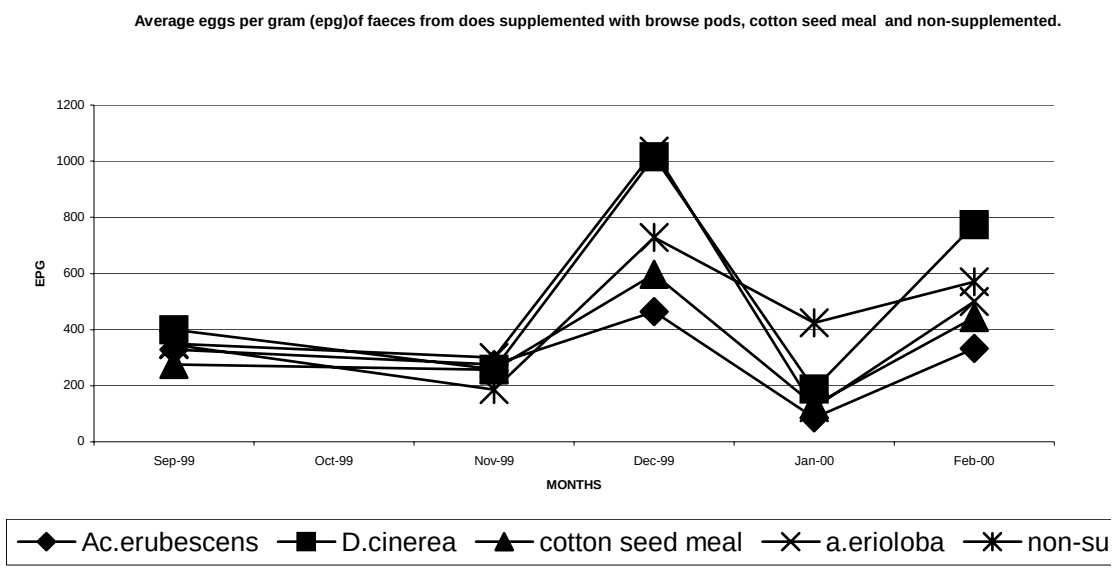

Figure One

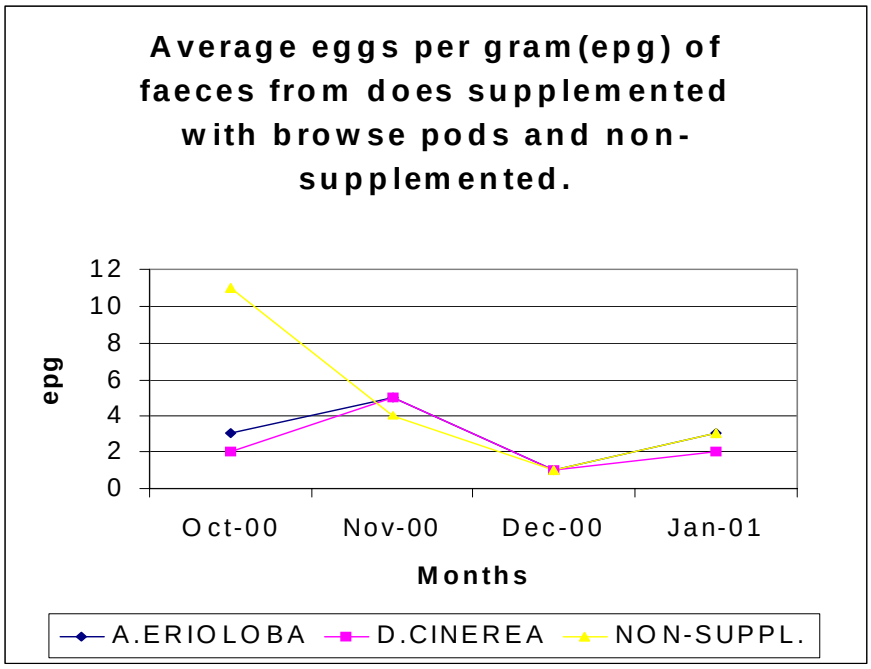

Figure 2

On-farm activities (2001-2002)

The current status is:

- Number of farmers involved: 78
- Number of animals being monitored: 318 lactating goats
- Average number of goats being monitored per farmer ranges from 5 –10 animals.
- Different farmers were using the following pods species: *A. erubescens, A. nilotica, A. tortilis*, and *D. cinerea*.

From the farmers' comments intake of *A. nilotica* pods by the goats was low. Goats preferred whole pods rather than crushed pods. Another comment was that kid survival and growth had improved through the supplementation, despite the fact that some of the kids are being eaten by jackals.

Some farmers have expressed the wish to finish young kids for sale (markets for goats need to be explored).

An evaluation form has been distributed to farmers who have been feeding their goats with pods. The form is composed of two simple questions:

1. farmers comments on the feeding of goats during the current dry season
2. farmers comments on what they would like to see being done under this programme, in the near future.

Measurements collected so far

- Monthly doe and kid weights
- Rainfall records on the sites for monitoring pod yield.

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IMPROVING PRODUCTIVITY OF GOATS DURING THE RAINY SEASON IN RURAL KARNATAKA

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Abstract

In Dharwad District of Karnataka, India, goats are managed under an extensive management system and are given very little supplementary feed. They are never dewormed. There is evidence of low productivity of goats caused by high kid mortality, poor growth rate in kids, high abortion rates, heavy parasitical infestation and low levels of milk production especially during the rainy season. To address the problems facing resource-poor goat keepers an attempt was made by the Participatory Technical Development (PTD) team to develop two participatory technologies, namely deworming and supplementary feeding in two successive years.

The study on deworming revealed that all does tested were positive for endo-parasitical infestation during the periparturient period. Deworming with Fenbendazole or *Mucuna pruriens* pods (locally available herb pods covered in 'hairs' or 'trichomes') significantly reduced the parasitic egg count on the seventh day after treatment, while in the untreated animals the egg count increased significantly. No significant difference was observed between birth weight of kids of treated or control does. Significant differences in growth rate were noticed in kids of dewormed does as compared to untreated animals. No significant difference was seen in kid mortality in the first month after birth, whereas at 120 days of age mortality was significantly higher in kids of control does than in those of treatment does. The technology for effective control of parasites with *Mucuna pruriens* needs to be further refined for use in the field.

Supplementation with locally grown cereals and legumes (sorghum+horsegram) or with *Prosopis juliflora* pods during late pregnancy and early lactation, reduced kid mortality and led to higher birth weights of kids, and higher weight gain in does. *Prosopis juliflora* pods were found to be a good substitute for grains. Collection and storage of *P. juliflora* pods during summer helps to conserve a feed resource for use when feed is scarce.

It was concluded that both the technologies, deworming and supplementation with tree pods, can improve the productivity of small ruminants.

Introduction

India has the highest goat population in the world. At the 1997 livestock census, the goat

population in Karnataka was 6.2 millions, with Dharwad District having 64,639 goats (survey, 1997). The goat is a versatile small ruminant and is considered as 'a poor man's cow', because it is multipurpose and adaptable to different conditions. Goats are kept by poorer members of the community, because of low purchase and maintenance costs and the prolificacy of goats (UAS, Dharwad 1996).

Although the goat population is increasing in Karnataka, productivity is constrained by high rates of kid mortality. In the rainy season abortions, low rates of growth and poor milk yields are common. Goat keepers (men and women) together with researchers jointly identified reasons for low productivity of goats through Participatory Rural Appraisal (PRA). These included heavy parasitical infestations and feed shortages during the rainy season, particularly in pregnant does.

In Karnataka goats are reared under an extensive management system and are given very little supplementary feed. Most of the grazing takes place in harvested fields, along road sides, river banks, in forests and on hill slopes. Goats are not dewormed.

There has been no systematic study conducted on goats in Karnataka (UAS, Dharwad, 1996), to address the problems faced by goat-keepers. Thus researchers from the project, together with goat keepers, decided to develop technologies to address the problems of parasitic infestation and undernutrition in the rainy season.

Performance of does and kids after deworming with *Mucuna pruriens* pods (trichomes) and fenbendazole during late pregnancy and on the day of kidding

Background

Helminthic infection is fairly common in goats (Singh 1996). This leads to competition for a common pool of nutrient in the gastro-intestinal tract or blockages in the absorptive mechanism due to the toxin liberated by the intestinal parasites (Jana Nayak and Bhatacharya, 1991; Sharma and Kidwai, 1971). Infection can cause substantial losses to goat owners, ranging from unthrifty animals to death (Luginbuhl, 1998). Pregnant does show a preparturient rise in the number of eggs of gastrointestinal parasites, with increased shedding of eggs, around the time of kidding, described as a survival strategy of the parasites, by infecting a new generation kids (Smith and Sherman, 1994). Mobini (2000) also reported increased activity of internal parasites during late pregnancy, leading to reduced milk production in does (Wilkinson and Slark, 1987). Dhar *et al*. (1982) found increased numbers of strongyloid eggs in pregnant and lactating ewes, thus transmitting the infection to lambs.

Various workers (Mobini, 2000; Smith and Sherman, 1994; Wilkinson and Slark, 1987) have recommended deworming pregnant does two to three weeks before kidding to avoid periparturient increase in egg numbers. In dairy cattle, Mathew (1987) recommended deworming on the day of calving.

It is virtually impossible to prevent helminthic infection in goats although their effects can be minimised through deworming, which lowers the parasitic load, decreases pasture contamination, promotes faster growth and reduces kid mortality (Villar and Llemit, 1985). Deworming may also transfer immunological substances from does to kids, as found from cows to calves (Deshpande *et al*., 1991).

In 2000, a team of researchers from the Natural Resources Institute (NRI) and BAIF, together with goat keepers of Nigadi, Devarhuballi and Benkankatti studied the effectiveness of deworming on the performance of does and kids. An objective of the trial was to convince the local communities of the benefits accruing from deworming. The pregnant does were

dewormed with Fenbendazole (7.5 mg/kg. body weight) 15 days to 1 month before kidding and on the day of kidding. The study was conducted on 50 pregnant does. Comparatively lower kid mortality (8%) was noticed in the dewormed group than in the control group (18%). Birthweights were similar in both groups (2.0-2.1 kg). A significant difference ($P<0.01$) in growth rate of kids was seen between the groups one month after kidding, kids from dewormed does being heavier. The cost benefit ratio of the treatment was found to be 1:35. However, anthelminthics are often unavailable in the villages, and when they are often lack the resources to purchase them. Therefore, it was considered necessary to find alternative locally available deworming agents for use by the goat keepers.

During the discussions with the local communities, it was found that a caste specialising in buffalo keeping, known as the Gawalis, who are settled in remote forest have long been using the trichomes from the pod of a local creeper, *Mucuna pruriens*, for deworming. It was, therefore, decided to validate the efficacy of this local plant.

Materials and Methods

A trial was conducted from 21/05/2001 to 06/10/2001, in Dharwad District of Karnataka.

Selection of villages and farmers

Three closely linked villages with common grazing areas, Nigadi, Benkankatti and Devarhuballi, were selected for the study. The PTD team selected 18 research partners (goat keepers), the majority being smallholders and the remainder landless goat keepers. Each partner had three or more does in the advanced stages of pregnancy and due to kid in the rainy season.

Selection and identification of animals

Seventy eight does, meeting the requirements of the study (4 to 4.5 months pregnant) were selected. Animals were randomly allotted to three treatment groups, each consisting of 26 does, balanced for age (1 year to mature), and initial live weight (20, 25, 30 , 35, 40 , 45 Kgs). Names and identification marks of the animals (does and kids) were recorded in consultation with all the family members. Horns were colour painted to identify does within their groups. (T1, red; T2, yellow; T3, green).

Treatments

Does were either untreated or dewormed in late pregnancy (15 days to 30 days before kidding) and again on the day of kidding.

1) T1 (C), Control. Does were not dewormed.

2) T2 (MPT). Does were dewormed with trichomes of *Mucuna pruriens* pods, mixed with jaggery solution, at 20 mg/kg body weight.

3) T3 (F). Does were dewormed with fenbendazole at 7.5 mg/kg body weight

Dose rate of trichomes of Mucuna pruriens pod

In discussions with the goat keepers and one of the buffalo keepers, a dose rate of 20 mg/kg body weight was agreed. A buffalo keeper demonstrated how to remove trichomes from pods, as they can cause irritation, and the quantity he used for dosing buffalo calves of 25 kg. body-weight. Scraped material was weighed and the dose rate decided.

Collection of Faecal samples

Faecal samples from 20 pregnant does before and seven days after treatment were collected and analysed to determine the parasitic burden. Faecal pellets, collected directly from the anus, were preserved in a 10% formalin solution before testing. Representative samples were collected from all three villages. Care was taken to collect faecal samples for all treatment groups from goats belonging to the same goat keeper.

Observations

Does were weighed fortnightly to monitor the weight change before and after kidding. Kids were weighed at birth, and then weekly for one month. For weighing goats were placed in a sling (gunny bag cloth), which was then suspended from a spring balance.

Kid mortality, over the same period, was recorded. Goat keepers and researcher maintained separate records, to reflect their individual interests.

Analysis

Egg counting was done by the method of Stoll. This data, birth weights and differences in regression coefficient for growth rate of kids were tested, using the students 't' test. Kid mortality was subjected to the chi square test. Incomplete observations were not considered for analysis.

Results and Discussion

Table 1 gives the number of does completing the trial, a small number having dropped out because of sale, death or transfer.

Table 1 Number of the does starting and completing the trial

	T1 (C)I	T2 (MPT)	T3 (F)
Start	26	26	26
Finish	24	24	23

Effect of deworming on endoparasites

All pregnant animals had some parasitical infestation (Table 2) around the periparturient period, as reported in other studies (Smith and Sherman,1994; Mobini 2000). Eight types of termatodes and nematodes were observed. Strongyloides sp. and Haemonchus sp. were most common (Table 3).

Table 2 Status of parasitic infestation in pregnant does during the preparturient period

No. of Samples	Range (no. of eggs/doe)	Average no. of eggs/doe
20	400 - 1600	820

Table 3 Prevalence of different parasites in the pregnant does under trial

Endoparasites	No. of eggs/gram of faeces /doe	%
Strongyloides sps.	255	31
Haemonchus sps.	195	24
Chabertia sps.	135	17
Bunostomum sps.	85	10
Oesophagastmum sps.	60	7
Trichuris sps.	60	7
Fasciola sps.	20	3
Cooperia sps.	10	1
Total	820	100

Parasitic faecal egg counts reduced significantly on the seventh day after deworming in both MPT and F groups, but they increased significantly in the control group (Table 4). The herbal anthelminthic (MPT) was as effective as the commercial antihelminthic (F).

Table 4 Faecal parasitic egg counts in does on the day of dosing and seven days after dosing

Group	No. of does	Av. No. of eggs/g of faecal sample		Difference (day 0-7)	't' value	'P' value
		Day 0	Day 7			
T1 (C)	6	717	983	+ 267	- 5.59	.003
T2 (MPT)	7	971	271	-700	9.72	.0001
T3 (F)	7	757	114	-643	6.03	.0009

Birth weight of kids

There was no significant effect of deworming on birthweight of kids. Does receiving MPT gave birth to slightly heavier kids than the control group (Table 5). The results confirm those of the previous trial (BAIF/NRI Goat Research Project 2000).

Table 5 Birthweights (kg) of kids

Trial Group	No. of kids	birthweight	't' value	'P' value
T1,Control	32	2 .12		
T2, MPT	28	2 .28	1.26	.2110
T3, F	28	2 .23	0.79	.4330

Although differences in birthweight were not significant, kids from supplemented does grew faster than those from unsupplemented does in weeks 1-4 (Table 6). There was little difference between supplements (MPT and F). This could be because of a lower parasitic load in dosed mothers during the preparturient period, resulting in reduced parasitic infestation of her kids (Smith and Sherman, 1994) and more milk available for the kids (Wilkinson and Slark, 1987).

Table 6 Weight (kg) at birth, in weeks 1-4 and between birth and week 4 (0-4)

	Birth	Week 1	Week 2	Week 3	Week 4	0-4
T1,Control	2.1	2.8	3.2	3.7	4.1	2 .0
T2, MPT	2.3	3.0	3.7	4.2	4.9	2 .6
T3, F	2.2	2.9	3.6	4.2	4.8	2.6

Mortality of kids

A Chi-square test showed that mortality at 120 days of age was significantly higher in kids of control does than in those of treatment does, but there was no significant difference at 30 days (see Table 7).

Table 7 Mortality of kids from birth to four months of age

	No. of kids born	No. of kids died[1]			Mortality rate (%)
		1-30 days	31-120	Total	
T1, Control	35	3	11	14	40.0
T2, MPT	31	3	2	5	16.1
T3, F	30	2	4	6	20.0

[1] accidental deaths were not included in the analysis.

Weight loss of trial does after kidding

There was slightly more weight loss in the control group, compared to the supplemented groups, although this was not significant (Table 8).

Table 8 Weight (kg) of does after kidding and the change in weight at week 4

	No. of animals	After kidding	Week 2	Week 4	Change
T1, Control	24	26.4	25.0	25.0	-1.4
T2, MPT	24	28.3	27.2	27.1	-1.2
T3, F	23	26.2	26.3	25.2	-1.0

Conclusions

Infestation with parasites was prevalent in the area. Deworming with Trichomes of *Mucuna pruriens* pods significantly reduced the faecal parasitic egg count on the seventh day after deworming, similar to that achieved with the commercial product, Fenbendazole.

Four months after birth mortality in the kids of control group does was at least double that of kids from does in the treatment groups, but one month after birth there was no difference. This result is in contrast to the previous trial with Fenbendazole, in which a significant difference was observed after 30 days.

In the first month of lactation weight change in does was similar in all groups. No significant

difference was observed in birthweight of kids, due to the treatments. Growth rates in kids from treated does were significantly improved, but there were no differences between treatments. The use of MPT, a highly cost effective alternative to proprietary products, needs refining, especially the dose rate for different classes of stock.

Performance of does and kids after supplementation with *Prosopis juliflora* pods and a mixture of sorghum and horse gram

Background

Goats, particularly pregnant and lactating does, do not like to graze when it is raining, even though there is an abundance of vegetation, because they abhor getting wet. (Rai and Chorey 1965). Goat keepers are aware of this. They also think the low dry content of wet season fodder is associated with lower nutrient content. These are associated with lower milk production, lighter kids and higher kid mortality in the rainy season.

In 2000, the PTD team of researchers from NRI and BAIF and goat keepers of the region, decided to test the effectiveness of feeding 200 gms of sorghum and Horse gram mix, before and during early lactation, on the performance of does, kid mortality rates and growth of kids. The study was conducted on 34 pregnant does due for kidding in the rainy season.

The study found a significant difference (chi-square = 10.124) in kid mortality between the supplemented and non-supplemented groups. Supplementation with a sorghum+horse gram mix reduced kid mortality by 37%. Higher birthweights were noticed from the treated does (2.4 kg) over the control (2.1 kg.). Supplemented does gained more weight (0.3 kg) than unsupplemented (-0.6 kgs). There were fewer abortions in the treated (9%) compared to the control (28%) group. The PTD team decided to search for alternative local feeds that could replace the cereal-pulse mix, as these are also consumed by people. Use of *Prosopis juliflora* pods was considered as they had shown good results in trials elsewhere in India (Conroy *et al*., 2001).

A trial was conducted in the rainy season of 2001, using *P. juliflora* pods as a supplement for prepartum and early lactation does. The objective was to test its effect on kid mortality, and also on: weight loss in does after kidding; birthweight; and growth rates of kids.

Materials and methods

The trial ran from 18/03/2001 to 23/12/2001, in Dharwad district of Karnataka.

Selection of villages and research partners

Three villages, Naiknoor, Shelwadi and Boganoor, all close to each other and with shared grazing, were selected. The PTD Team selected 21 research partners, most being landless goat keepers. All the partners had at least three does due to kid in the rainy season.

Animals

A total of 72 does gave 24 per treatment. Identification marks and names of animals were recorded. Horns were painted according to treatment(T1, blue; T2, yellow; T3, red). Goats were placed in a sling and weighed on a spring balance.

Treatments

Goats were randomly allocated to treatment, with the proviso that at least one goat from each keeper appeared in treatment group, and age of goats was balanced across groups:

T1, control, goats were not supplemented (C)

T2, does were supplemented with 250 g *Prosopis juliflora* pods/day (JP)

T2, does were supplemented with 200g of a mixture of sorghum + horse gram/day (SHG).

Collection and preservation of feeding materials

All the material required for feeding was procured locally. *Prosopis juliflora* pods were collected in summer and, after being thoroughly dried, they were stored in gunny bags for subsequent use. In order to avoid pest infestation, they were preserved in neem (*Azadirachta indica*) leaves, and there was weekly fumigation of the store with green leaves of neem.

Observations

Does were weighed every two weeks to monitor the weight change before and after kidding. Birth weights and weekly weight gains of kids from birth up to one month of age were recorded. Kid mortality was recorded from birth for four weeks. Records were maintained separately by partners and researchers.

Analysis

Regression coefficients for kid growth rates were tested for significance, using the student's 't' test. Incomplete observations were not considered for analysis.

Results and discussion

The initial number of does in the trial was reduced by sale, death or transfer (Table 9).

Table 9 Numbers of does starting and finishing the trial

Selection / Group	T1 (C)	T2 (JP)	T3 (SHG)
Initial	24	24	24
Final	22	21	22

Growth of kids

Birthweight of kids from does receiving *Prosopis juliflora* pods supplementation was a little higher than compared to control and T3 (Table 10). Weight gain was also higher for T2 at four weeks, than for kids in the control group, suggesting does receiving pods were producing more milk (Anttila et al., 1993). There were no differences in weight gain between the T1 and T2 groups.

Table 10 Kid weight (kg) at birth and in the first four weeks of life

	No of kids	Birth	Week1	Week 2	Week 3	Week 4	Gain, birth-week 4
T1 (C)	29	1.9	2.8	3.6	4.2	4.8	2.9
T2 (PJ)	23	2.1	3.4	4.1	4.8	5.3	3.2
T3 (SHG)	28	1.9	3.0	3.9	4.5	5.1	3.2

Mortality of kids

Very low mortality rates were observed (Table 11), suggesting the trial period does had sufficient to eat, the lower than expected rainfall allowing adequate browsing time.

Table 11 Kid mortality between birth and one month of age

	No. of kids born	No. of kids died
T1 (C)	31	-
T2 (PJ)	27	-
T3 (SHG)	36	1 (3%)
Total	94	1 (1%)

Weight loss of does in the first month of lactation

Does receiving *P. juliflora* pods lost less weight than those receiving sorghum and horse gram mixture or on control (Table 12), suggesting pods supplied more nutrients, that were deficient (e.g. protein) than the sorghum/horsegram mixture. Anttila *et al*., (1993) found that animals fattened when receiving *P. juliflora* pods.

Table 12 Weight (kg) of does and weight loss in the first month of lactation

	No. of does	After kidding	Week 2	Week 4	Loss, kidding-week 4
T1 (C)	19	30.07	28.06	26.24	3.83
T2 (PJ)	18	32.18	30.52	28.84	3.34
T3(SHG)	16	32.5	30.22	28.71	3.79

Conclusions

The following conclusions were drawn from the study:

- Supplementation resulted in higher birthweights of kids, faster growth rates and less weight loss in does
- *Prosopis juliflora* pods are found to be a good substitute for grains
- Livestock keepers are willing to be involved in research, provided it addresses their immediate needs

- Livestock keepers can also make positive contributions to the development of relevant technologies

- Indigenous knowledge can give valuable leads to developing adoptable technologies.

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PARTICIPATORY GOAT TRIALS IN INDIA: EXPERIENCES AND LESSONS

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Introduction

Scientists have acquired a tremendous amount of knowledge about feed resources and ruminant production, nutrition and health in tropical countries. Despite this, the adoption of technologies developed by researchers has been poor, in relation to:

- enhancing fodder production and improving grazing management systems (Acharya and Bhattacharya, 1992; Sidahmed, 1995); and
- animal health treatments (drugs and vaccines).

This is partly because technologies have often been developed without the involvement of the intended users, and without an adequate understanding of their farming systems and constraints. Constraints on any of the factors of production, land, labour or capital, can inhibit take-up of new technologies. By definition, such constraints are most severe among resource-poor livestock-keepers, for whom effective new technologies are most needed.

Constraints affecting livestock feed technologies

Some examples of these are: (a) insufficient land may make it impossible to grow fodder crops, because the farmer does not have enough arable land and fodder crops would compete with food or cash crops; (b) insufficient labour may make stall-feeding, based on cut-and-carry, an unattractive option; and (c) scarcity of cash may discourage livestock-keepers from purchasing inputs, such as green fodder, compound feeds or concentrates.

Livestock health technologies

Government veterinary services in developing countries, although they may be free of cost in principle, tend not to reach resource-poor farmers. In India, extension services are characterised by biases that result in them tending to neglect poor rural livestock-keepers, and particularly goat-keepers (Matthewman *et al*., 1997). Most extension organisations focus on large ruminants “almost to the complete exclusion of other species” (ibid). They also tend to focus primarily on intensive systems; and to be concentrated in higher potential areas. In other words, livestock-keepers in relatively remote areas, particularly those with smallstock, are unlikely to be reached by state veterinary services.

There is a need, therefore, to develop health-related technologies based on locally available materials or expertise. Where these technologies are based on indigenous technical knowledge they are generally categorised as ethnoveterinary medicine. They include: improved housing, technologies for the treatment of wounds, and materials with anthelminthic properties for de-worming animals. Participatory technical development (PTD) has a vital role to play in developing such technologies.

The potential advantages of farmer participation

A participatory approach to technology development can help to ensure that new technologies are appropriate to farmers' and livestock-keepers' needs and circumstances, and hence increase the likelihood of adoption (Conroy *et al*., 1999; Reijntjes *et al*., 1992). Livestock research and development work has tended to lag behind crop production work in the development and application of methods for PTD. It is clear from reviewing the literature on PTD or farmer participatory research (FPR) that there are relatively few documented examples of projects in which livestock are a central focus (Chambers *et al*., 1989; Clinch, 1994; Okali *et al*., 1994; van Veldhuizen *et al*., 1997). Perhaps only five per cent of case studies have a livestock focus. However, there has been increasing recognition that livestock research needs to give greater emphasis to farmer participation (Sidahmed, 1995); and some researchers now believe that "participatory approaches are mandatory" for the development of forage options (Peters *et al.,* 2001).

Greater participation of the intended users can mean that:

- Applied and adaptive research will be better oriented to farmers' problems
- Farmers' knowledge and experience can be incorporated into the search for solutions, and highly inappropriate technologies can be 'weeded out' early on
- The performance of promising technologies developed on-station can be tested under 'real-life' agro-ecological and management conditions
- Researchers will be provided with rapid feedback on the technologies tested, and promising technologies can be identified, modified and disseminated more quickly, reducing the length of research cycles and saving time and money
- Farmers' capacity and expertise for conducting collaborative research is built-up and becomes a valuable resource for future research programmes (Conroy *et al*., 1999).

The BAIF/NRI Goat Research Project (R6953)

Since October 1997 BAIF Development Research Foundation (India) and the Natural Resources Institute (UK) (NRI) have been managing a four-year research project (R6953), funded by the UK Government's Department for International Development's Livestock Production Programme, to identify and address feed-related constraints affecting goat production in India. The project has been working in various semi-arid regions, including south Rajasthan and Dharwad District, Karnataka. The project has worked primarily with poor people, belonging to scheduled castes or scheduled tribes, who either have small farms or are landless.

The project aims to develop technologies to ease or remove the constraints identified, based primarily on a *collaborative* relationship with goat-keepers, as described in Table 1. A collaborative approach is more participatory than the *contract* and *consultative* modes, which have probably been the ones most commonly used in on-farm livestock research (the degree of farmer involvement increases in the modes to the right hand side of the table). This paper focuses on two of the most promising technologies developed by the project. It then discusses: (a) the prospects for adoption of these and other technologies investigated by the project; (b) issues relating to control groups; and (c) challenges associated with achieving a high degree of participation by livestock-keepers.

Finally, it identifies what conclusions can be drawn, and lessons learned, from the project's experiences.

Table 1 Four Different Modes of Farmer Participation in Agricultural Research

1. Contract	2. Consultative	3. Collaborative	4. Collegiate
Farmers' land & services are hired or borrowed: e.g. researcher contracts with farmers to provide specific types of land	There is a doctor-patient relationship. Researchers consult farmers, diagnose their problems and try to find solutions	Researchers and farmers are roughly equal partners in the research process & continuously collaborate in activities	Researchers actively encourage & support farmers' own research & experiments

Source: Biggs, 1989.

Methods

Diagnosis and needs assessment

The BAIF and NRI project team began by doing surveys in several villages in three districts of north-west India. The surveys involved rapid rural appraisals with groups of goat-keepers, using semi-structured interviews and mapping and diagramming. The surveys generated descriptions of the goat production and feeding systems. In PTD it is essential to identify priority needs: simple ranking was used to identify major problems and their relative importance, and the results of the ranking were generally cross-checked with other survey findings. This was sometimes followed by participatory problem tree analysis[1] to gain a deeper understanding of the nature of the constraint.

If an important feed-related problem was identified through the group discussions, more detailed livestock productivity data (e.g. on kid mortality) were often sought subsequently through individual interviews, as such data can help to identify critical periods in the nutrition of the animals. However, the project found that conventional methods based on farmer recall, such as "herder recall" and "progeny history" (Waters-Bayer and Bayer, 1994), tended to produce unreliable information.

From the second year onwards this kind of data was collected using the 'participatory herd history' method[2], a new method developed by the project that is based on the use of cards to symbolise each goat in the herd. It involves making an inventory of the current herd, and working backwards over 1-2 years to document what changes to the herd have taken place and when, either in terms of acquisitions or removals, and hence the productivity of the animals. Each card has a picture of the animal drawn on it, with the sex indicated in the case of adults. A calendar, covering one or two years up to the present, is constructed on the ground, showing the seasons, months and important festivals. Several rows are made below the temporal headings, one for each adult doe. Representing the herd pictorially in this way facilitated recall by the goat-keepers and reduced the potential for misunderstanding between them and the researchers.

The trials

The project then established some 'in village'[3] trials to address the problem identified. The first few trials focused on supplementation of feed at critical points in time, but more recent

[1] The use of this and other PRA methods is described in a recent publication of the project (Conroy, 2002).

[2] For further information about this method, see Conroy, 2002.

[3] Some of the participating goat-keepers were landless, so the usual term, 'on-farm', is not appropriate.

trials have included treatment with anthelmintics. A summary of some of the trials is given in Table 2.

Table 2 Some Trials on Goats Conducted by project R6953

Challenge addressed	Treatment / technology tested	Timing of treatment	Key indicators	Monitoring period/duration of trial
Poor reproductive performance of female goats (low conception rate)	Tree pods supplement (initially combined with barley)	Daily for 10 weeks during scarcity period(mid-May to end July)	Conception and number of kids born	7-8 months, from mid-May to December
High kid mortality in rainy season	Dewormer: - commercial OR - based on locally available material	Applied to does in late pregnancy and on day of kidding	Mortality during first 60 days after kidding Growth rates	2-3 months
High mortality in kids (< 60 days) in rainy season (in Karnataka)	Feed supplement	Applied to does in late pregnancy and on day of kidding	Mortality during first 60 days after kidding Growth rates	2-3 months
High mortality of young goats (6-9 months) in the rainy season (in Rajasthan)	Urea molasses granules (UMG)	Daily for 10 weeks during late dry season and early rainy season (mid-May to end July)	Mortality during early rainy season	4 months
Faster growth of young male goats to increase income	Barley supplement	Daily for 2-3 months for goats aged 3-6 months	Sale price and weight at time of sale	About 9 months – from start of treatment to age at which most males had been sold
Earlier sexual maturity of young females, to increase no. of kids produced	Barley supplement	Daily for 2-3 months for goats aged 3-6 months	Age at which females reached sexual maturity	About 15 months – from start of treatment to age at which females came into heat or conceived
Seasonal water scarcity constrains milk production	Water trough constructed near dry season grazing area	Used during dry season	Increase in milk yield. Improved condition.	3 months

The process of designing, monitoring and evaluating the trials was intended to involve goat-keepers actively. The trials were designed with a treatment and control group in the same village, so that a 'with and without' comparison could be made. This has been done by either: (a) by selecting different goat-keepers of similar socio-economic status for the two groups; or (b) having treatment and control animals belonging to the same owner. Non-experimental variables have not been controlled in any way, and, apart from applying the treatment, goat-keepers have been encouraged to follow their normal practices.

The project team concluded at the outset that it would be necessary to subsidise treatments to some extent, in order to: (a) encourage participation; and (b) to compensate people in the

treatment groups for any potential risk to which their animals might be exposed, and for the time they contributed to the monitoring of the trial. People in the control groups were also provided with material incentives of a different nature that would not affect the outcome of the trial (e.g. provision of a breeding buck). However, the project team also considered it important that goat-keepers contribute to the costs of the treatment, as a demonstration of their interest in the technology to be tested and the problem being addressed. The project's approach has been to phase out subsidies where technologies prove to be effective.

Monitoring and evaluation

In most trials there has been a two-pronged monitoring system, comprising: fortnightly monitoring of goat productivity parameters (e.g. milk production); and monthly meetings with participants to discuss how the trials were progressing. The former provides quantitative information, while the latter provides qualitative information, including the goat-keepers' perceptions of how the animals are responding to the treatment and any issues that are concerning them. One or more literate persons from each trial village has been given training by the project in how to measure and monitor the relevant goat productivity parameter(s), and has been paid for doing this. Joint evaluation meetings with participants (from both the treatment and control groups) have been held at the end of the trials.

Two Case Studies

There is not space to describe all of the trials in this paper. The focus is on describing the trials involving the two most promising technologies.

Case Study 1: The use of tree pods to improve kidding rates

In Bhilwara District of Rajasthan there was evidence that feed scarcity in the dry season could be acting as a constraint on the reproductive performance, particularly conception rates, of goats belonging to poor people. In on-farm trials in 1998 and 1999, breeding does were fed a mixture (250 grams/day) of *Prosopis juliflora* pods and barley for 10 weeks, during the later part of the dry season when fodder scarcity is most acute. The pods were collected when they appeared on the trees in April and early May and stored for use later. In 2000 and 2001 similar trials were conducted, but this time the treatment (again 250 grams/day) was entirely *P. julifora* pods.

The mature does in the treatment groups had higher conception and twinning rates than those in the control groups, and hence higher kidding rates. The mean number of kids per doe in the treatment groups was significantly higher than that in the control groups, providing clear evidence that the treatment results in does producing more kids than they would otherwise have done. Using *Prosopis juliflora* pods alone gave better results than a mixture of pods and barley.

Case Study 2: The use of a local plant material as a dewormer[4]

In the Karnataka project area high kid mortality during the rainy season was identified by goat-keepers as their main problem, and the project conducted trials in 2000 and 2001 to address this. It was hypothesized that the kid mortality was linked to the worm burden of the does at that time. Two treatments have been tested: (a) a commercial de-wormer, *Fenbenzadole*; and (b) a locally available material known to have antihelminthic properties. There is evidence that mortality rates are higher for kids of does that have a heavy worm burden, so the treatments were given to does in late pregnancy and on the day of kidding.

[4] See pp 77-86 these proceedings

The locally available material that was used was the trichomes (hairs) from the pods of a leguminous creeper, *Mucuna pruriens*: the dose, which is mixed with a lukewarm sugary solution (jaggery), is 20 mg per kg body weight. The idea of using this material came from the fact that members of a local caste specialising in buffalo-keeping were known to use it. There was very little mortality in kids less than one month old, even outside the treatment groups, probably due to the low rainfall; but among kids aged 31-120 days there was higher mortality in the control group. Both treatments were very effective in reducing the worm burden of the does (shown by analysis of faecal samples before and after their use), and hence in improving their condition. In addition, the kids of does in the treatment group grew faster than those of does in the control group, which is thought to be because the former group were producing more milk.

Discussion

The section above 5 focused on the two most promising technologies developed by the project, and hence gives a rather rosy and not entirely representative picture. This section aims to remove any false impressions by discussing project experiences overall.

Prospects for adoption of technologies

The *Prosopis juliflora* pods technology has excellent prospects for widespread adoption by poor livestock-keepers in India because: the pods do not have to be purchased; this tree is found across a large area of the country; the trees grow on common lands and by roadsides; and the collection time occurs at a time of the year when many livestock-keepers are not particularly busy. The cost:benefit ratio for this technology is in the range 1:2.5 to 1:5, depending on the assumptions made.

Both of the deworming treatments have very favourable cost: benefit ratios. The participating goat-keepers said that in future they expect to use the *Mucuna pruriens* treatment, rather than the commercial one, because no cash expenditure is required. *Mucuna pruriens* is also quite widely distributed in India, and the labour required to collect the necessary number of pods is minimal.

The prospects for adoption of some other supplements tested by the project, such as barley and urea-molasses granules (UMG) (see Table 2), are not good. Barley is valued by goat-keepers as a high quality supplement, but there are problems with its adoption. If the barley is grown by the farmer it competes for plot space with other crops, notably wheat, which is an important staple: so more food for the goats means less food for the family. If barley has to be purchased, a similar dilemma arises for the family over allocation of scarce resources.

Although UMG makes use of a locally available waste material, molasses, it was more expensive (per kg) than other high quality supplements, such as barley or groundnut cake. In addition, livestock-keepers had a general preference for the traditional products.

Control group issues

Importance of control group

Some research trials have two or more treatment groups, but no control group, the comparison being between the different treatments. However, the project's experience shows that it is important to have a control group. This is because without a control group, it would be necessary to make a 'before and after' comparison, and these can be misleading due to inter-annual variability. For example, data collected in year 1 might reveal high kid mortality in the rainy season; while data collected during a trial in year2 might show that mortality was very low in both of the two treatment groups. It would be easy to assume that this was due to the treatments, when in fact it could be due to inter-annual differences in rainfall patterns. If it

was due to the latter this would only be clear if the trial had a control group in which mortality was similarly low.

Pros and cons of different control group arrangements

When making 'with and without' comparisons, between treatment group and control group animals, it is important that proper care is taken to minimise inter-animal variations. For example, in a feed supplementation trial it would be important that the general diet of the animals from the two groups was broadly comparable. This can be difficult to achieve if the owners of the control group animals are different from the owners of the treatment group animals. The former could be wealthier, on average, and hence giving their animals more purchased supplements; or control group members could be grazing their goats on different (and superior) pasture land to that of treatment group members. Both of these situations have arisen in trials of the BAIF/NRI project.

It is easier to avoid bias by having animals from different groups within the same herds, rather than making a 'between herds' comparison. However, the 'within herd' approach can be problematic for certain types of treatments, particularly ones involving feed supplementation, as there is a risk that control group animals will get access to the treatment feed. Nevertheless, it can work if the owner understands and agrees with the purpose of the trial design; and if there is a good rapport between the researchers and the livestock-keepers, and frequent visits by the researchers.

Degree of goat-keeper participation

Achieving a high degree of participation by livestock-keepers was a major challenge, and was not achieved in all of the trials. Livestock-keepers are likely to lack confidence and trust to begin with, while researchers may find it difficult to give up their conventional status of experts who know the solutions to farmers' problems.

Addressing of a priority need

The researchers generally sought to address a priority need of the goat-keepers. However, in a few of the trials it is questionable whether the project actually succeeded in addressing a priority need of theirs, due to inadequate discussions with them about the precise nature of the constraint and, or, the suitability of the proposed treatment to address it.

Determination of treatment

In PTD, ideas for technologies to be tested are expected to be provided by participating farmers, as well as researchers, but in most of the project's trials it was the researchers who identified the type of supplement to be used. Nevertheless, this was based on knowledge of livestock-keepers' experiences with similar technologies in other localities. In most trials, the participants appeared to agree that the proposed treatment was a sensible one, and contributed 33-100 % of the cost of the treatment.

Factors hindering a participatory approach

It is important to be aware of, and to address, factors that may hinder the adoption of a participatory approach. These include (see also Conroy et al., 1999): (a) researchers lacking experience and orientation in PTD; (b) researchers not thinking in terms of the profitability of treatments; (c) researchers lacking awareness of constraints on goat-keepers' factors of production (capital, labour and land); (d) researchers not being fully committed to a participatory approach; (e) pressure to move quickly from the diagnosis and needs assessment phase to the establishment of trials (due to the short lifetime of some projects), resulting in inadequate needs assessment; (f) small project budgets, resulting in insufficient

staff time to encourage full farmer involvement; (g) late scheduling of project activities (related to previous point); and (h) staff turnover and involvement of inexperienced staff.

Factors facilitating increased participation

A high degree of participation is not usually possible from the outset. However, if researchers are committed to achieving it there is likely to be a gradual shift along the spectrum towards greater participation. In the experience of the BAIF/NRI project this may be due to one or more of the following factors:

- Development of positive rapport between researchers and participants when successive trials are conducted in the same village
- Improved understanding by the researchers of problems or opportunities
- The efficacy and profitability of the technologies is demonstrated, or improved through modifications and
- Technologies found to be ineffective are abandoned.

Conclusions and lessons learned

1. The experience of this project confirms the widely held view that the more and the earlier farmers and livestock-keepers are involved in the research process, the more rapidly appropriate technologies will be identified.

2. To ensure the active involvement of goat-keepers in PTD, it is essential that the research is addressing a need that they regard as important. Accurate identification and understanding of priority needs by researchers is likely to require considerable time and effort, but this is thoroughly justified.

3. Technology development is a gradual and iterative process. Thus, a number of trials may be required before a technology is developed that meets livestock-keepers' priority needs and is suitable for adoption.

4. The project's experience suggests that one should avoid cash-based treatments when working with very poor people. For them, it is important to draw on materials that are locally available on their farms or in the nearby environment; or which can be introduced easily.

5. It is important to take steps to promote a participatory approach by the project, programme or agency. Some specific steps are listed below.

(a) Any project will need at least one "process champion", preferably with prior experience of PTD, who strives to ensure that the project team adopt and maintain a participatory process. Social science researchers and development workers are usually (but not always) better suited to this role than natural scientists.

(b) The BAIF/NRI project sought to upgrade researchers' capacity to undertake PTD by providing relevant training, in the form of one-week courses in PTD, to members of the research team.

(c) Exposure visits to other PTD projects (not necessarily involving livestock) would also be very beneficial.

(d) The BAIF/NRI project introduced a procedure at the mid-project stage whereby, before any trial was authorised, the researcher was required to complete a protocol, and to provide, *inter alia*:

- evidence that the researcher has done a thorough needs assessment (upon which the case for the trial is based) and understands well the problem or opportunity; and

- quantified estimates of the cost of the proposed treatment and the likely or possible benefits, indicating good prospects for the treatment to be profitable.

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COMMUNITY-BASED GOAT PRODUCTIVITY IMPROVEMENT IN CENTRAL AND SOUTH MERU DISTRICTS OF KENYA: CHARACTERISATION OF FARM RESOURCES AND CAPACITIES FOR KEEPING LOCAL GOATS OR DIFFERENT GRADES OF CROSSBRED GOATS

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Abstract

A survey was conducted in Central and South Meru Districts in the Eastern Highlands of Kenya. The objective of the survey was to identify the biophysical and socio-economic characteristics of farmers that might influence the adoption of different types or grades of crossbred goats. A questionnaire was administered to a total of 129 individuals and eight farmer groups. Of the respondents, 64% were women and 36% men, indicating a high level of female participation. Eighty per cent of the respondents have land holdings of less than 2 ha, and more than 75% of this is allocated to crop production. Goat rearing is becoming popular with most households as a source of milk, fast growing goats for sale and as a coping strategy for farms too small to sustain a cow. Farmers keep small flocks of goats, ranging from one to four goats per household. The majority of farmers feel that they can manage cross-bred goats despite their meagre resources.

Introduction

Increasing human population, dwindling farm sizes and less productive local animals in the eastern highlands of Kenya has led to intensification of farming in the mixed crop-livestock production systems in the region. Resource poor farmers in the Eastern highlands are finding it difficult to maintain traditional livestock holdings of local goats and cattle of low productivity. Keeping livestock, and goats in particular, for resource poor farmers, can make important contributions to the farming systems, livelihoods and the welfare of smallholder farmers. Small land sizes suggest keeping fewer, but improved, livestock genotypes. Introducing an improved genotype through cross-breeding for smallholder farmers has been carried out by both NGOs and Government, Cartwright (1984), Bradford, (1981); Davendra, (1988), Shelton, (1978). Crossbreeding programmes with goats, particularly in developing countries, have usually increased productivity by increasing milk production, lactation and fat yields and lactation length while decreasing fat percentage, Shelton, (1978).

However the degree of improvement is dependent upon the genetic potential of the indigenous breed and the level of management available. Crossbreeding has also been shown to be a strategy for quicker benefits than those obtainable through selection, Cartwright, (1984), but if not properly planned, it can lead to disappointing results.

Sands and McDowell *(*1978*)* have also pointed out that management, particularly with regard to nutrition, limits the amount of improvement realised through cross-breeding. They noted that the increase in lactation yields is only 54% of that expected when averaging the production of the exotic parental, line in its temperate habitat, with that of the indigenous tropical parent and adding on a 73% increase due to heterosis. They further noted that cross-bred animals were fed only about 1.8 times their maintenance needs and are unable to produce at their maximum genetic potential and smallholders generally feed their livestock only about 1.1 to 1.2 times their maintenance requirements. At this rate of feeding they concluded that cross-breds would perform no better than indigenous livestock. The approach should, therefore, be to introduce cross-bred goats and improved management as a comprehensive technology package to small-scale resource poor farmers.

Goat rearing has become popular among the resource poor smallholder farmers in mixed crop livestock production systems in the Eastern Highlands of Kenya. Their popularity is due to the fact that they are a source of cash incomes, household milk and manure.

FARM-Africa, an NGO working with smallholder goat keepers, has introduced a community-based goat improvement initiative with the main objective of improving family income and nutrition, thereby improving the livelihood of smallholder farmers. The strategy to achieve this has been the importation of the British Toggenburg goat, an established dairy breed for upgrading of the local less productive goats.

A survey was carried out between October 2000 and April 2001 among farmers in the project area to characterise the farmers.

Objectives of the study

The objectives of the survey were to identify the biophysical and socio-economic characteristics of the farmers that might influence the adoption of different types or grades of crossbred goats. Furthermore, the aim of the survey was to categorise these farmers in three distinct groups, based on their resource endowment, of Low, Medium and High management systems, for the long term monitoring of goat productivity.

Material and methods

A survey was conducted in Meru Central and South Districts, between October 2001 and April 2001, through a questionnaire administered to both individual and group respondents. Both were randomly selected but ensuring that the main ecological zones in the study area were represented. A total of 129 individuals and eight groups were interviewed. The types of resources considered in the questionnaire were:

(a) Land and the enterprises on it

(b) Farm labour, skilled, unskilled, children and women

(c) Capital Income level, capital base

(d) Entrepreneurship skills and experiences

(e) Physical location of the farm

(f) Level of goat technical know-how.

In group interviews the objective was to get a general overview of the groups, membership and their understanding of goat production. Nearly all members of the groups (94%) attended these interviews. Four groups were picked at random from each district, giving a total number of members in group interviews of 144. A total of 128 individual members of various groups were also interviewed.

Results and discussion

Farm Characteristics

Out of the 128 respondents, 64.1% were women, 33.6% were men while 2.3% were the sons of farmers. This correlates well with the gender participation during group interviews, where more women than men participated, an indication that dairy goats are mainly managed by women. From the survey, it was also clear that the groups are composed of mainly married families (95.3%), an indication of cultural stability that can contribute to reducing management conflicts among the members. This high level of female participation indicates that introduction of dairy and, or, dual-purpose goats may be an appropriate strategy to empower women and hence improve household food security.

In terms of the size of land owned, the study shows that most of the farmers have small holdings with most of them having less than 5 acres (75%). The study also shows that the main ways of attaining land are inheritance (over 70%), renting (2%), land purchase (5%), allocation by the government, clan land and some farmers being given land by friends. It was also noted that most farmers have only one parcel that was inherited from parents. Of the respondents, 53.9% own only one parcel of land while around 39.8% own two parcels. It was noted that most of the second parcels were rented (18.0%), 15.6% inherited and only 10.9% purchased. Also, most of the respondents (65%) indicated that land for agricultural production is inadequate. It is evident that land is one of the most limiting factors of agricultural production and the farmers are resource poor and, therefore, unable to purchase more. The high level of land inheritance with little land purchase implies that there is a need to appropriately conserve and manage appropriately the available smallholdings for sustainable agricultural production.

Most farmers may be unable to keep dairy cows and hence dairy and, or, dual-purpose goats may be the best option for them. With some clan land and land given by friends there is also a strong indication that some strong socio-cultural networks still exist in the community. These can be exploited during extension of appropriate interventions for improved goat productivity.

The study also indicates that most of the land is allocated to crop production. Over 80% of the land is allocated to crops and only 5% to livestock production. This, therefore, implies that the land allocated to livestock production is not adequate to supply enough forage for goat production. Hence, their potential productivity will not be realised, calling for an intervention that can boost high yielding and quality fodder production. This constraint of an inadequate amount of high quality fodder was also identified in all the group interviews. Farmers recommended introduction of forages such as e *lucaena, calliandra, sesbania* sp. etc., that are high yielding and contain relatively large amounts of protein.

Livestock production is usually carried out close to the homestead, even for those who own more than one parcel of land. However, the criteria that farmers apply in selecting where to keep their livestock was not clear. Though most of the land is allocated to crop production, it was clear from the group interviews that the returns from dairy goat production is far higher than from any of the crop enterprises. The study was conducted in the main marginal coffee zone and, therefore, most of the land was allocated to coffee when the market prices were high and farmers are yet to find an alternative enterprise.

Capital

Household infrastructure includes farm buildings, animal structures, water systems and fences. Most of the farm structures are predominantly semi-permanent. With buildings and animal structures 62% and 69%, respectively, are semi-permanent (timber walled houses with iron-sheet roofs and animal sheds made of non-durable posts and other local materials), compared to 20% and 5% respectively of permanent buildings and animal structures (block walled houses with iron sheets and animal structures made of durable posts) . On the other hand, most of the respondents have non-permanent or traditional fences, made of indigenous natural shrubs (48%), 31% semi-permanent (poor quality posts) and 15% permanent (durable posts with barbed wire). This high proportion of the households having semi-permanent and non-permanent (traditional) buildings, animal structures and fences is a further indication of their poor resource base (low to medium wealth groups). There may also be a need to train farmers on how to construct less capital- intensive goat structures that depend on locally available resources.

The survey also showed that very few households have access to piped water (39%). Almost half of the respondents (48%) depend on rivers located at a distance from the households, with 31% depending on seasonal canals. The remainder of the households depends on other sources of water, such as springs. It was noted during the group interviews that lack of adequate water near the homestead is a limiting factor to dairy goat production due to their high water requirement. This places a heavy burden on women, leaving little time for other activities related to goat production. The problem of lack access to water directly and indirectly affects dairy goat productivity and should not be treated in isolation of other constraints within the system.

The study also revealed that most households depend mainly on farm income (83%) with very few depending on off-farm income (16%). A negligible proportion (1%) have both farm and off-farm incomes. This high dependence on farm income implies that very few of the family members have off-farm employment and hence there are few remittances from outside the farm. This places a high risk on the livelihoods of these households because they cannot be cushioned from the shocks of vagaries of the weather (e.g. drought) and this highly affects the productivity of all the farm enterprises.

Labour

Most (over 85%) of the farm labour comes from the family and hired labour. Family labour alone accounts for 40%, while labour exchange accounted for a meagre 5%. Women provide most (>85%) of the family labour on-farm on a permanent basis while men and children mainly provide family labour on a discontinuous basis, while not hired out or not in school, respectively. Hired labour is mainly casual (up to 80%), especially during peak periods of labour demand. Peak labour periods include planting, weeding, harvesting and, to a lesser extent, seedbed preparation. Such periods occur in October to April, which includes the long rains. This is the period when family labour is usually deficient, hence the need for hiring labour from outside. Besides, hiring out, other ways of coping with labour deficiencies include: staggering farm activities, especially those that are not tightly linked to periods of rainfall; exchanging labour, whereby two families or more come together to work on each others' farm; and also getting help from relatives. Labour surplus is experienced during the third quarter of the year (July to September) during which families can hire out their services, pay less or lay off their casual workers, or engage in non-farm activities as a way of rationally utilising the excess labour.

Family labour is allocated to food crops (30%) and livestock (25%). Overall the dairy goat is allocated less than 10% of the family labour and non-farm activities take most (45%). While allocating family labour, most (50%) farmers tend not to consider labour intensiveness or time sensitivity of the enterprise. Forty-five percent of the hired labour is used in specialised and general farm activities such as building construction, digging trenches for water and bush clearing. On the other hand, less than 10% of the hired labour is used on dairy goats, mainly to fetch feed.

Daily wages range from fifty to one hundred Kenya shillings ($1.28) per person irrespective of gender. However, gender influences family labour allocation, in that women tend to concentrate on farm-based and domestic chores, while men opt for non-farm activities where the financial returns are higher. The domestic chores include fetching of firewood and water, and preparing meals for the family.

Given that, dairy goat enterprises are currently profitable and that family and hired labour are usually available, it can be concluded that labour may not be a major constraint to dairy goat production in the study area.

Farm enterprises

The enterprises include crops (food and cash) and livestock. Mixed crop-livestock enterprises were the majority (50%). Livestock were mainly allocated to the land near the homesteads. Up to 25% of the farmers did not have cattle and of those who had cattle, 50% had one or two, while 19% had three or four, with the remaining 6% having five or more. Most of the cattle were dairy types kept mainly (70%) for milk, for home consumption and sale. Those who did not have any dairy cattle gave the reasons as: lack of money (70%); unfavourable climate (19%); inability to manage or lack of technical knowledge (4%); and no land (<4%). This indicates that despite the small land sizes, the majority of the farmers who currently do not keep dairy cattle feel that, with adequate funds, they could. Of the farmers who keep dairy cattle, 36% were getting <1 litres /cow/day, while the majority (57%) of the cows gave between 2 and 9 litres/cow/day. This indicates that on average the productivity of the dairy herd in the study area was low.

Dairy goats

Numbers of goats

Sixty-five per cent of smallholders own between one and four dairy goats. Dairy goats became available in 1996; a lot of farmers acquiring them in 1997, and the numbers are still increasing. This indicates a strong interest in the dairy goat project in the study area. The majority (60%) of the dairy goats were purchased, while 40% were from the project.

Reasons for keeping goats

The reasons given for keeping the dairy goats were, milk production for home consumption (65%), milk for sale (30%) and for meat and milk (<5%). This confirms why the majority (95%) of such goats are kept within the farms. According to the farmers interviewed, 55% felt that the numbers of dairy goats are increasing in the area, while 27% feel their population has remained constant and the rest (18%) felt they are decreasing in number. Goats are disposed of through sales (52%) and deaths (15%).

Goat milk utilisation and prices

Of the farmers interviewed, 50% have started milking goats, getting an average of 1.5 litres per day per goat, which is used within the household. About 5% sell the milk, and the remaining 45% have not yet started to milk. For the goat milk sold, over 80% of the respondents indicated that its price compares favourably with that of cows, while about 10% indicated that goat milk fetched higher prices than cows' milk. Goat milk is sold at Kshs 20 per litre compared to Kshs 17 per litre of cows' milk. This is further confirmed by all respondents thinking that the demand for goats' milk was increasing.

The goats owned by the respondents were cross-bred (40%), local Meru goats (30%), local Galla goats (20%) and Toggenburg (<10%), indicating that the local goats were being upgraded. The herd size ranged from one to four goats, with the majority (>55%) having one

goat, while 6% and 10%, had three and two goats, respectively. The farmers (80%) emphasised that their greatest need is for a productive goat. Given a choice, they would go for a cross-bred that produces the greatest amount of milk and is also adapted to the local conditions. The cross-breds currently available mainly first crosses (F1s). Less than 10% of farmers indicated that they would select a pure-breed goat, such as the Toggenburg.

Sale of dairy goats

About 40% of farmers have started selling goats, mainly cross-bred, fetching up to 4200/= Kenya shillings (US$55) for a ten month old male goat. The respondents indicated that local goats fetch a quarter of that price at the same age. The decision to sell a dairy goat is mostly (80%) made by both wife and husband. Only in 15% of the respondents did the wife make that decision alone, while the husband alone was (5%). This is, however, different from the sale of milk, where the decision whether or not to sell is usually made by the wife. Decisions on the use of income from the sale of dairy goats are taken jointly in 80% of cases, either taking the decision alone accounting for the remainder.

Feeding of dairy goats

Most farmers interviewed (70%) feed their goats on local forages and they are aware of, and using, fodder conservation techniques such as haymaking. However, conservation of fodder is constrained by shortages (70%), lack of storage space, no time for baling, goats not being productive and no goat to feed. Thirty per cent of farmers are not aware of any conservation methods. Other conservation methods used include storing stovers and beans haulms on platforms and baling. The majority of farmers indicated that they would like to be trained in fodder conservation methods, because they also recognise that nutrition is a major factor in goat productivity. Although these farmers have cross-bred dairy goats, they feel that further improvement is possible.

Most feed deficiencies occur during the months of July, August and September, while feed surplus occurs during the months of April, May and June, and again in October, November and December, the second and fourth quarter respectively. Farmers have methods of coping with both deficiencies and surpluses. About 35% of the respondents purchase feeds while 15% use stored feed. The remainder borrow feed, tether their goats or collect fodder from riverbanks etc. During times of surplus 40% of respondents indicated that they practised conservation, while another 40% did not know what to do with the surplus and the remaining 20% either gave it away or sold it. This implies that if farmers can intensify their forage conservation efforts, then a continuous supply of feed is possible. The study indicates that a lot of feeds are wasted during periods of surplus.

Source of feeds

Up to 60% of feed for goats is produced on the farm and only 25% is purchased. The balance (15%) comes from neighbours' plots and river banks etc.

Management of dairy goats

From the interviews, the respondents ((50%), indicated that the management of dairy goats is the responsibility of the women, while 40% take joint decisions. However, the decision on the utilisation of the milk is left to the woman, even where the management is shared. This implies that promotion of dairy goat technology is a sure way of empowering women to take a bigger role in family affairs.

Household income and nutrition

Of the 128 respondents interviewed, 45% indicated that they milk their goats and this has greatly improved the nutritional status of their household. About 52% have not yet started

milking and 3% said that they have not experienced any improvement. However, all the respondents indicated that they perceive benefits from the goats. These include income from the sales, milk for home consumption, manure, faster growth rates of crossbred kids and a rapid increase in goat numbers.

Constraints to dairy goat production

Constraints to dairy goat production were listed as follows: diseases; 35%, fodder shortages, 25%; lack of funds to buy dairy goats 10%; and drought, less than 5%. Sixty per cent of the respondents had knowledge of veterinary procedures, fodder storage, zero grazing and intensification of feeding. The remainder claim not to have experienced any serious constraint.

Sources of information

Up to 75% of the respondents indicated that their only sources of information on dairy goats were extension staff and FARM-AFRICA. Currently extension provides 80% and FARM-AFRICA less than 20% of the information on dairy goats. This confirms that the implementation of the project has been a joint effort between FARM-AFRICA and the Ministry's Extension Department. Only about 5% of respondents obtained information from group members. This implies that despite the several training and study tours that have taken place, farmers have not, contrary to expectations, passed on any information or new ideas to fellow members.

Dairy goat improvement.

Most respondents felt that management of dairy goats could be improved by more farmer-training (40%) and improved feeding (35%). Other ways of improving dairy goats were mentioned, including provision of credit services to enable more farmers to buy goats.

Conclusions

From the survey it appears that the main objectives and benefits of keeping dairy goats are:

- Provision of milk to the household
- Provision of fast growing goats for sale
- Coping strategies for small farms
- Dairy goats are highly prolific, giving farmers increased numbers for sale
- Dairy goats compare very well with local cattle, 1.5 litres of milk per day from goats versus 2 litres from local cows
- Goats able to withstand some underfeeding
- Cross-bred goats command better prices than local goats and cattle
- Labour is not a major constraint to goat production in the study area

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THE CONTRIBUTION OF GOATS TO THE LIVELIHOODS OF RESOURCE POOR CROP AND LIVESTOCK KEEPERS IN NEPAL, AND THE USE OF BANMARA AS A FORAGE FOR GOATS

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Abstract

The contribution that goats make to the livelihoods of resource poor livestock keepers (RPLK) in Nepal was estimated in two communities (one, Makawanpur, in the hills and one, Dhanusha, in the plains) through a participatory rural appraisal (PRA) exercise. It was revealed that goats are most valued for the contribution that they make to household expenses, which was the most important livelihood objective for these communities. A constraint to goatkeeping identified in the past is the shortage of forage in the dry season. An invasive weed called banmara (*Chromolaena odorata*, CO, in the plain and *Eupatorium adenophorum*, EA, in the hills) grows throughout the year, and could be used to ease the forage scarcity, but its voluntary intake by goats is low. A range of treatments to increase the voluntary intake of banmara was investigated. *In vitro* organic matter degradability was increased from 0.464 to 0.496 and 0.501 respectively when EA was either wilted or soaked in cold water for 2 h. The corresponding values for CO were 0.364, 0.458 and 0.405. The predicted dry matter intake of EA (assessed using the short term intake rate technique) was 318 g/d. This was reduced to 189 g/d if the banmara was tied in bunches above the goat's head. Soaking or wilting for up to 16 h also reduced predicted intake. However, if EA was wilted for 24 h, predicted intake was increased to 465 g/d. Soaking for 24 h, however, still resulted in a lower intake (260 g/d). It is concluded that wilting banmara for 24 h increases its voluntary intake by goats. Adopting this technique could help to increase the effective availability of forage at the end of the dry season, and thereby help to increase the contribution that goats are able to make to the livelihoods of RPLK at this difficult time of year.

Introduction

Goats are an important component in the livelihoods of rural people in Nepal, especially those of poor and medium resource endowment. Unlike most other livestock species, there are no cultural restrictions in the keeping of goats and this results in them being numerically one of

the most important classes of livestock. It is estimated that there are a total of 6.3 million goats kept in Nepal, compared with 0.9 million sheep, 3.5 million buffalo and 7 million cattle (Sherchand, 2001). Goats are kept for meat and manure, and are also used as a form of security since they can be sold to raise cash when necessary. The very resource poor may also look after other people's goats, and share the kids that are produced with the owner of the goat (Bhandari *et al*., 1986).

Goats are taken out to browse in the forest and on common land during the day, and are then brought in at night. They are usually provided with more forage in the evening, which is cut and carried to them, and placed either in an X-shaped rack or put on the floor. Constraints associated with goat keeping in Nepal include the shortage of forage in the dry season, and the susceptibility of goats to disease, particularly during the wet season. The shortage of forage in the dry season is made more acute as the pressure for land increases, and as invasive weeds out compete more palatable and nutritious forages. One such invasive weed is known as 'banmara' or 'forest killer'. It has been identified as *Chromolaena odorata* in the plains (or Terai) of Nepal, and as *Eupatorium adenophorum* in the mid hills. These plant species invade degraded land and, being allelopathic, prevent the regrowth of other forest species (Gieh and Sajise, 1980; Jha and Yadav, 1985). However, a potential advantage of these plants is their ability to stay green throughout the year so that they are a potential source of forage in the dry season. There was no evidence of toxicity when *E. adenophorum* was fed to ruminant animals, but voluntary intake of this plant by goats (Aryal *et al*., 1994) and calves (Verma *et al*., 1987) was low. If a simple and appropriate treatment of banmara could be done on farm to increase its acceptability to goats, then this would increase the effective availability of forage in the dry season and could help overcome one of the constraints to goat production in many areas.

The objectives of this part of the project were, therefore, firstly to determine the contribution that goats made to the livelihoods of resource poor crop and livestock keepers (RPCLK) in Nepal, and secondly to develop and evaluate a means of increasing the intake of banmara by goats.

Material and Methods

Livelihoods analysis

To assess the contribution that goats make to the livelihoods of RPCLK, an initial participatory rural appraisal (PRA) was conducted in the project areas. The study included twelve communities, four from each of three sites. One site was in the Terai (Dhanusha district), and two were in hill locations (Makawanpur and Kavre). The aim was to select a range of communities that would represent social diversity (by choosing communities of different ethnic group or caste) and with a variety of livelihoods choices.

Two teams were used, one for the Terai and one for the hill sites. Each team was composed of one person who was local to the study area, while the others were experienced PRA facilitators. In each community, four exercises were carried out. Firstly, a short community meeting was held to introduce the project and the PRA process. After this, social and resource mapping involving as many people as possible from the community was done, and then a livelihoods strategies matrix was constructed, being done separately by groups of men and women. Objectives and activities were scored by each community, and these were analysed to determine their relative importance. Finally there was a wrap-up session, in which the community was thanked, information was fed back, and the community's willingness to participate in a longer term study was investigated.

In vitro characterisation of forages

To determine the effect that simple treatments of banmara would have on the chemical composition and nutritive value of the plant, samples of both *C. odorata* and *E. adenophorum* were collected in November, 2000. Each sample was divided into three, and either left untreated (U), soaked in water for 2 h (S) or spread out and left to dry in the sun for 2 h (W).

All samples were then oven dried (60^0C) and ground (1 mm screen). The samples were analysed for crude protein (CP), ether extract (EE), acid detergent fibre (ADF) and neutral detergent fibre (NDF). They were also incubated with buffered rumen fluid for 72 h, and the organic matter degradability (OMD) after this time was estimated.

Feeding trials

A range of treatments were screened using the short term intake rate (STIR) technique to assess the effect of treatment on potential dry matter intake. Eight does (initial live weight 13.8 kg) were used in this experiment. They were fed a basal diet of (g/kg live weight, fresh weight basis) khanayo 53, napier 60 and banmara (*Eupatorium adenophorum*) 11. They were adapted to this diet for 14 d before commencing the estimation of the short-term intake rate of banmara.

Treatments of banmara that were investigated were untreated banmara (UTB), soaking in water for 2 (S2), 16 (S16) or 24 h (S24), wilting for 2 (W2), 6 (W6), 16 (W16), 24 (W24) and 48 h (W48) and hanging untreated banmara in bunches (B) above the goats' heads.

Following the adaptation period, the STIR values for each treatment were estimated. Estimates of STIR were made on Monday, Wednesday and Friday of three consecutive weeks. The protocol used to estimate STIR was to feed, on a testing day, 25% of the day's allocation of feed. After 1 h, all feed was removed from the bowl, and 4 h later a sample (500 g fresh weight) of the test feed was put before the doe. The doe was then closely observed for 5 minutes, and the time spent actively eating was recorded using a stopwatch. At the end of this 5 minute period, all the feed was removed from the bowl and the refusals weighed. After 20 minutes the process was repeated with a second test feed. Four banmara treatments were tested with each doe on each testing day. At the end of the testing period, the remaining 75 % of the day's allocation of feed was offered.

The STIR value for each feed was calculated using the equation:

$$\text{STIR (g DM/min/kg metabolic body size)} = (W_1\text{-}W_2)/(T\text{x}M^{0.75})$$

where W_1, W_2 are the dry matter weights (g) of offered and refused feed respectively, T is the time (min) spent actively eating and M is the liveweight (kg) of the animal.

The predicted dry matter intake of each feed was then calculated using data supplied by Dr D.L. Romney (pers. comm.) in which observations of STIR for a range of different feeds and mixtures were regressed with observed dry matter intakes of the feeds. The equation used was:

$$\text{Predicted dry matter intake (PDMI, g DM/kg liveweight}^{0.75}) = (82.9\ \text{STIR}) + 17.9$$

This was then converted to predicted dry matter intake (g DM/head/day) by multiplying PDMI by $M^{0.75}$. The effect of treatment on estimates of STIR and PDMI (g/head day) was estimated using analysis of variance, after taking account of the effect of animal and day.

The two most promising treatments were then further investigated in a longer term feeding trial to determine the effect of treatment on the voluntary dry matter intake of banmara. The analysis of these data is still underway.

Results and Discussion

Livelihoods analysis

Results from the PRA identified the meeting of household expenses as being the most important livelihood objective. This was followed by the acquisition of protein and fertiliser, the payment of loans and contribution to savings, paying for social activities, the purchase of tools and animals, and construction. Livelihood activities that contributed to these objectives were identified as wage labour and the sale of alcohol, other jobs off farm, agriculture, the keeping of goats, the keeping of other livestock, and the cultivation of cash crops.

The contribution that these various activities made to these objectives were scored from 0 to 4 (0 being an activity that did not contribute in any way to that objective. The contribution that goat keeping made to the different livelihoods objectives is summarised in Table 1. Goats are an important contributor to livelihoods objectives, particularly the most important one of meeting household expenses.

Table 1 The mean score across communities for the contribution that goats make to different livelihoods objectives

Objective	Mean score (0-4)	Standard deviation
Household expenses	3.5	0.21
Protein and fertiliser	2.1	0.92
Loans and savings	2.2	1.07
Social activities	1.8	0.94
Tool and animal purchase	1.8	0.58
Construction	0.5	0.50
All	2.0	0.21

In vitro characterisation of banmara

The chemical composition of the untreated and treated banmara samples are presented in Table 2. Soaking or wilting had little effect on most chemical constituents. However, it did reduce the ADF/NDF proportion. Soaking reduced the proportion by 0.060 and 0.024 for *Eupatorium adenophorum* and *Chromolaena odorata* respectively. The effect of wilting was even greater; 0.102 and 0.130 for *Eupatorium adenophorum* and *Chromolaena odorata* respectively. This would suggest that soaking to some extent, and wilting to a greater extent, would increase the digestibility of these plants.

Table 2 Chemical analysis of banmara

	Chemical composition, g/kg DM					
	Organic matter	Crude protein	Neutral detergent fibre (NDF)	Acid detergent fibre (ADF)	ADF/NDF	Ether extract
Eupatorium adenophorum						
Untreated	929	111	492	449	0.912	30
Soaked	924	114	485	413	0.852	38
Wilted	926	118	494	400	0.810	34
Chromolaena odorata						
Untreated	979	146	533	506	0.949	28
Soaked	918	161	546	505	0.925	30
Wilted	929	133	525	430	0.819	25

There was a significant interaction (P<0.001) between the effect of species and treatment on the organic matter degradability of banmara (Table 3). While soaking increased the

digestibility of *Eupatorium adenophorum*, it had no effect on *Chromolaena odorata*. However, as was indicated by the chemical analysis, wilting was effective at increasing the digestibility of both species.

Table 3 Estimation of the *in vitro* digestibility of banmara

Sample	*In vitro* digestibility of organic matter
Eupatorium adenophorum	
Untreated	0.464
Wilted	0.496
Soaked	0.501
Chromolaena odorata	
Untreated	0.364
Wilted	0.458
Soaked	0.405
SEM	0.0392

Feeding trial

The results of this experiment are summarised in Table 4. Soaking banmara, or tying it in bunches above the animal's head tended to reduce intake. However, wilting banmara for 24 or 48 h significantly increased intake (P<0.001). Wilting banmara for 48 h increased STIR by a factor of 2.6, and predicted dry matter intake by a factor of 2.1.

Table 4 The effect of treatment on the short term intake rates and predicted dry matter intakes of banmara by goats

Treatment	Short term intake rate, g DM/min $kg^{0.75}$	Predicted dry matter intake, g/d
Untreated	0.369	318
Bunches above head	0.189	224
2 h soaking	0.225	239
16 h soaking	0.101	174
24 h soaking	0.258	260
2 h wilting	0.238	248
6 h wilting	0.315	290
16 h wilting	0.220	240
24 h wilting	0.630	465
48 h wilting	0.973	654
SEM	0.0870	45.7
Significance	***	***

Conclusions

Goats have an important role to play in the maintenance of livelihoods of RPCLK in rural Nepal. One of the constraints to goat productivity is the shortage of dry season forage, and

this could be alleviated to some extent by the wilting of banmara as this increases the acceptability of this noxious, but available, weed as a feed for goats. However, very little banmara is fed to goats (partly because of the low voluntary dry matter intake of the fresh plant) and the impact that this technology would have on its own is probably limited. Other issues that need to be addressed, therefore, include improving the nutritive value of the whole diet in the dry season. An investigation into the effect of wilting other forages (more commonly fed to goats in this project area) has shown that OMD is also increased in these forages as well. Another constraint to goatkeeping in these areas is the high rate of illness and death that occurs in goats in the early part of the wet season. Managing the change from the dry to wet season to improve the health of goats at this time is, therefore, another area that needs investigation. This would help improve the livelihoods of RPCLK in these areas, as many goats are sold at this time for a low price because of illness. If these forced sales could be avoided, there would be an improvement in the livelihoods of the farmers, and this has been identified by the communities as being a research requirement.

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IMPROVING THE LIVELIHOOD OF RESOURCE-POOR GOAT FARMERS IN SOUTHERN AFRICA THROUGH STRATEGIC DRUG AND NUTRITIONAL INTERVENTIONS AGAINST GASTRO-INTESTINAL NEMATODE INFECTIONS

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Abstract

The Department for International Development (DFID) Animal Health Programme (AHP) is to fund a project (R8151) in South Africa from April 2002 for three years. It will test the hypothesis that under the farm management and agro-ecological conditions found in the resource-poor areas of the Republic of South Africa (RSA), 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 an *ex ante* analysis to collect baseline socio-economic data, and on-station and on-farm trials. The first hypothesis is that a strategic treatment administered before the peak in faecal egg counts will lead to a lower worm burden and hence better production. The second hypothesis being tested is that supplementation with urea-molasses blocks leads to increased microbial protein post-ruminally. Less protein is then diverted from bone, muscle and fat deposition towards the processes of regeneration, repair and mounting of an immune response (in parasitised animals) and hence body weight is maintained. The third hypothesis to be tested, and which will provide particularly novel information, is that the interaction between appropriate nutritional supplementation with molasses-urea blocks and strategic anthelmintic treatments for gastro-intestinal parasitism will lead to measurable improvements in goat productivity. These three hypotheses will be investigated at Onderstepoort Veterinary Institute during the first year of the trial. The results of this trial will then be tested in the field and will investigate the fourth hypothesis that the benefit to production of the improved feeding and drug treatments will not be unduly affected by extrinsic management practices in a selected agro-ecological zone. The project includes the dissemination of current information on worm control during the course of the project as well as the results of the proposed research programme 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 gastro-enteritis 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 (Vatta *et al*., 2002) in these resource-poor areas.

The application of a strategic drug treatment for the control of parasitic gastro-enteritis 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).

Partly to slow down the rate of development of anthelmintic resistance, which is widespread in the commercial sheep farming sector of South Africa (Van Wyk *et al*., 1999), attention has been directed more recently towards a holistic approach to parasite management involving sustainable integration of options which reduce the reliance on frequent chemotherapy. 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 the RSA are to be established in the present project, the effect of the interaction between nutritional supplementation, drug treatment, gastro-intestinal nematode infections and goat productivity will also be examined. This information is currently almost totally lacking and needs to be quantified.

In the resource-poor farming situation, it appears that strategic treatments are not administered, but the practice could be promoted. Given that *Haemonchus* egg counts peak in about February, a strategic treatment might be appropriate in early December. Importantly the treatment would also be given at a time which should not promote the rapid development of anthelmintic resistance since there would be adequate numbers of susceptible infective nematode larvae on pasture to dilute any larvae derived from eggs laid by resistant worms remaining in the goats after treatment.

A clinical assay, the FAMACHA© system, for the identification and subsequent treatment of sheep suffering from haemonchosis by examining the ocular mucous membranes has been developed in South Africa (Malan *et al*., 2001). This has recently been shown to have a test sensitivity of 76-85% in goats (Vatta *et al*., 2001) and will be promoted amongst participating smallholder farmers as part of the holistic worm-control approach. This should allow farmers to identify more accurately those goats for which the strategic and nutritional interventions do not suffice and which consequently require additional symptomatic anthelmintic treatment.

Supplementation of protein has been shown to enable parasitised sheep to compensate for the loss of endogenous protein and to allow them to mount an effective immune response. This occurs particularly in cases where the host normally has access to food low in protein (Kahn *et al*., 2000) such as occurs in the resource-poor areas of South Africa during winter. The promotion of nutritional supplementation should be particularly well received by resource-poor farmers since the effects (improvements in body condition, increased live weight, improvements in reproductive capacity, etc.) are immediately visible.

A cheap source of nitrogen is that derived from non-protein nitrogen compounds such as urea and some resource-poor farmers are feeding diets in the dry winter season which include crop residues, maize grain and relatively cheap molasses-based, non-protein nitrogen supplements. Supplementation with non-protein nitrogen sources such as urea increases microbial fermentation of poor quality roughage which leads to increased amounts of microbial protein post-ruminally. Supplementation of sheep by means of urea-molasses

blocks leads to higher daily dry matter intakes, weight gains, higher body condition scores and mitigates the effects of endoparasites (Anindo *et al*., 1998).

Research hypotheses

The project will test the hypothesis that: under the farm management and agro-ecological conditions found in the resource-poor areas of the Republic of South Africa (sub-Saharan 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.

This general hypothesis gives rise to four specific hypotheses which will be addressed through on-station and on-farm experiments, 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 leads to increased 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 of an effective immune response. This in turn leads to less protein being diverted from bone, muscle and fat deposition and hence maintenance of body weight.

Hypothesis 3. That the interaction between appropriate nutritional supplementation with urea-molasses blocks and strategic anthelmintic treatments for gastro-intestinal 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.

In the first year of the project, an *ex-ante* analysis will be carried out by gathering data in South Africa, in collaboration with a socio-economist. 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 suggested management changes are indeed cost-effective and acceptable.

Faecal egg count reduction tests will be used to assess the efficacy of the four anthelmintic groups available in South Africa (namely benzimidazoles, macrocyclic lactones, levamisole/morantel group and salicylanilides) before an anthelmintic is chosen for the trial. The test is based on the calculation of the reduction in faecal egg counts of treated animals compared with those of untreated controls at 10-14 post-drenching (Coles *et al*., 1992).

Animal health packages

Information, on a variety of topics, has been developed by the Animal Health for the Developing Farmers Programme of the Onderstepoort Veterinary Institute (OVI) into posters, information booklets, slide sets and 'infotoons', for use by extension workers working with

resource-poor farmers. Information on topics such as internal and external parasites, the correct use of remedies, and basic stockmanship procedures such as castration and hoof trimming will be provided to resource-poor farmers participating in the on-farm trials, and where appropriate and possible to neighbouring farmers and at information days for farmers. Information on topics such as supplementary feeding, strategic treatment and the correct use of worm remedies still need to be developed into posters and brochures.

Experimental programme

Experiment 1 (on-station)

The purpose of this trial is to quantify, under the conditions at OVI, the effect of urea supplementation in ameliorating the negative effects of gastro-intestinal 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 improved feed/strategic anthelmintic treatment. This will investigate hypothesis 4.

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.

Assessment of uptake and impact will be conducted through recognised participatory methods. The project will arrange for a farmers' day half-way through the on-farm work and invite neighbouring farmers to see the work being done on the two project farms, explain what is being done and assess their level of interest and willingness to pay for such interventions. The exercise will be repeated at the end of the trial.

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.

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COMMUNITY BASED FORAGE DEVELOPMENT PROGRAMME: THE EXPERIENCES OF THE FARM AFRICA GOAT PROJECT IN ETHIOPIA

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Abstract

In an effort to have a viable goat enterprise at smallholder farmers' level the Dairy Goat Development Project merge with the community-based forage development programme as one of its main undertakings. This paper discusses the adoption of forage innovations by the project beneficiaries taking into account the pre-project and post-project periods in two of the Eastern Hararghe sites, Awbere and Gursum. In the area where the study was conducted, 28 households (65% of the respondents) developed forages, both legumes and grass species; 24 households (56%) maintained a plot containing sweet potato; and 35 households (81%) used both the forage and sweet potato as goat feds in 1994. Similarly, in those households (n=14) who participated in the second phase fattening trial in 1996/7, 36%, 43% and 93% of them had elephant grass, forage legumes and sweet potato respectively.

Post-project period assessment indicated that in 1999 out of 71 households observed, 58 (82%) had forages, 32 (45%) grew sweet potato and 63 (89%) maintained both forage and sweet potato. Likewise in the year 2000 of 78 households who took part in the study, 43 (58%), 53 (68%) and 71 (91%) had one or more of legumes, forages and sweet potato, respectively. The uptake during the implementation periods and there afterwards seemed quite reasonable as it was consolidated further by extensive establishment of multipurpose crops like sweet potato. The only exception to this was forage legumes, which declined from 56% in 1994 to 6% in 1999 and 2000.

As forage development is a new innovation it needs to be followed up and essential support must be available. The indigenous knowledge of the community and the screening of potential local feed resources like sweet potato must be looked into. In addition, any forage development initiatives must include the community's full participation.

Background

The Dairy Goat Development Project (DGDP) was first launched by FARM Africa in September 1998 after the identification of the importance of the goats in the mixed farming system of the high and mid-altitude areas of Ethiopia. The pilot project was initiated in Eastern Hararghe, Oromia region. Three years later, it was extended into the Southern region. In all, the DGDP operated for nine years. It was phased out in June 1997 and the new goat project (GP) took over just over one year later, in August 1998.

The objective of the DGDP was to improve family welfare in small-scale mixed farming systems

by improving the productivity of goats managed by women through increased income and milk consumption. The project worked with the poorest, most deprived, economically weak farmers in the community. It encouraged women to voluntarily and actively be involved in the goat improvement programme. Because smallstock, including goats, are traditionally kept by women, the project began with encouraging women to adopt the practice of growing livestock fodder. This was activated by providing two local goats to those identified by the community as the poorest. Local goats were given on credit at a low rate of interest. Over time and with further extension support and animal health education, group members were encouraged to use exotic goats to improve their stock. The project has worked with 1,500 household heads and their families in seven districts of Southern and Oromia regions.

Project components

- Establishment of women's group
- Forage and feed development
- Distribution of local goats on credit
- Training of women as paravets and private drug shop establishment
- Establishment of credit and savings groups
- Training of women, development agents and specialised staff
- Cross-breeding of exotic goats with local breeds for farmers distribution
- Establishment of contractual private goat producers and rendering support
- Establishment of community-based buck stations to provide pure-bred exotic bucks
- Public awareness programme.

Forage development

In the densely populated areas in which the project works, cultivation is encroaching on communal-grazing areas reducing livestock feed supply. Hence there is an urgent need for forage development combined with increased control of grazing livestock. Cut and carry feeding systems have to be adopted soon. However, there is limited space available for growing forage. These areas are also frequently hit by drought. Thus, the forages promoted must be drought tolerant and be grown in areas where they don't compete with food crops, i.e. around the house, along the edge of fields, under-sown in maize / sorghum and inter-cropped in permanent plantations etc. The forage development strategies promoted for goats are backyard pasture, forage strips and under sowing annual and permanent crops. Emphasis is also given to forage legumes in order to improve the quality of the natural diet, which may have a high proportion of poor quality crop residue. Furthermore, the beneficiaries were given hands-on training and presented with options to promote effective utilisation of locally available feed resources.

Forage development activities had been implemented in Ethiopia by different institutions for a decade. However, there was very little well-documented information to show how far the outputs of these previous efforts were adapted, or whether they are sustainable. It is, therefore, the

intention of this paper to impart knowledge based on the pioneer work of the Dairy Goat Development Project.

Methodology

Information was reviewed from the project monitoring report. This included:

During the project implementation period

- Final report of phase 1
- Fattening trial in phase 2, Awbere and Gursum, Eastern Hararghe. This trial involved 14 households (hh) for one year.
- Feed inventory document, 1996-7.
- Rapid survey result about forage status by some of the collaborating households in Awbere and Gursum, (53% of them, i.e. 43 hh out of 78 hh in 1994).

Period after the project withdrawal - after 2-3 years

- Assessment in October 1999, Awberea and Gursum. This involved 71 hh (63%) of the 113 hh beneficiaries in Awbere and 35% of the 205 hh beneficiaries in Gursum districts.
- Feed resource inventory especially that of developed forages and sweet potato. This involved a total of 78 hh in Awbere, Gursum in November 2000. This also constituted 68% of the beneficiaries in Awbere and 38% in the Gursum district.
- The goat management practices of the project beneficiaries have also been assessed, together with the presence or absence of extension support from the District Agricultural Development Office. This site was selected for the survey because the beneficiaries showed an optimum uptake of forage initiatives and ongoing monitoring of milk off-take. The data was expressed simply as a percentage of the total sample and comparisons were made between events before and after the withdrawal of the DGDP.

Results and Discussion

Prior to the withdrawal of the DGDP

By the end of the project, 900 hh (60% of project beneficiaries) out of the total of 1,500 hh beneficiaries had successfully established their own forage plants using the strategies of their choice. It was noted that 210 hh had their own backyard tree nurseries, 226 hh undertook under-sowing, 249 hh had established backyard forages and 215 hh had developed live fences, or hedges, around the boundaries of their farmyards (FARM Africa 1997). The adoption of the forage innovation was interesting, particularly among the project beneficiaries of the Eastern Hararghe sites. At that time 90% (80 hh) of the 89 hh in Kombolcha and 78% (160 hh) of the 215 hh in Gursum had successfully established forage plants (see Table 1).

The uptake of the innovation was not uniform. In arid areas like Konso, where livestock feed scarcity and deterioration in quality is marked, the people are entirely dependant on locally available feeds like *Terminalia* species ('Woibeta') and *Moringa olifera* ('Shiferaw'). This may be related to socio-economic constraints, such as the small farm size and very dry weather conditions. However, it should also be noted that a cut and carry feeding system is in common use with farmers returning from their field work carrying heavy bundles of forages (FARM Africa 1994). It is likely that the circumstances in Konso were not fully understood by project personnel, a common problem facing development institutions when they work at the grassroots level. Diana (1998) stressed that a key first step in any development initiative is to understand local knowledge and networks and to build on these, rather than to attempting to replace them with new initiatives.

Table 1 Forage establishment by the project beneficiaries before the withdrawal of the dairy goat development project (DGDP)

DGDP sites	Total number of beneficiaries	Backyard	Farm boundary	Under-sowing	Backyard nurseries	Total number of beneficiaries adopting 1 or more strategies	% (total adopting / total number of beneficiaries)
Gursum	205	65	95	0	20	180	88
Kombolcha	89	30	50	0	0	80	90
Deder	161	0	0	70	52	122	76
Kindukoisha	660	87	70	126	50	333	50
Konso	190	0	0	30	45	75	39
Boloso sore	124	15	0	0	43	58	47
Dalocha	71	52	0	0	0	52	73
Total	1500	249	215	226	210	900	

Table 2 Households (hh) with forage and sweet potato in 1994

Description	Total number of respondents	hh expressed as % (total number of observations = 43)
hh with no forage	8	19
hh with tree legumes (TL)	24	56
hh with sweet potato (SP)	24	56
hh with elephant grass (EG)	28	65
hh with either SP, EG or TL	35	81

The project has been exploring the community's participation as a prime mover of forage development from the outset. In their brief socio-economic assessment in DGDP Eastern Hararghe sites, Bekele and Kassa (1994) (Table 3) observed that some of the forage development strategies have met with encouraging acceptance.

Table 3 Inventory of available forages (% of households) during the second cattle fattening trial in Awbere and Gursum in 1996-7

Month	Forage		
	Tree legumes or forage legumes	Elephant Grass	Sweet Potato
April 1996	2	2	14
May	3	3	13
June	4	8	11
July	5	4	13
August	7	5	12
September	6	5	13
October	5	5	13
November	6	5	13
December	7	4	13
January 1997	8	5	11
February	8	6	13
March	6	4	13

Period after pullout

Inventory in 1999

From 113 beneficiaries in Awbere and Gursum, 71 hh (63%) took part in the survey. Of these 58 hh (82%) had introduced forages (grass and legumes). Sweet potato crops were grown by 32 hh (45%) and 63 hh (89%) ensiled forage and, or, sweet potato. Those households who grew a sole legume and combined it with grass were few (6%, Table 3). When they were asked whether they received any forage development extension services from the Ministry of Agriculture, all indicated that they had not received any information since the withdrawal of the DGDP. Goat management consisted of 59 hh (84%) practicing tethering, 6 hh practicing free roaming and the remaining 6 hh (8%) practicing a combination of tethering and free roaming at different periods of the year.

Table 4 Households (hh) with forage and sweet potato in 1999

Description	Total number of respondent households (n = 71)	%
hh with no forage	8	11
hh with tree legume (TL)	4	6
hh with sweet potato (SP)	32	45
hh with elephant grass (EG)	58	82
hh with either TL, SP or EG	63	89

Inventory in 2000

From this study it was concluded that 45 hh (58%), 53 hh (68%) and 71 hh (91%) had forages and sweet potato or a combination of the two respectively. This result, however, contradicts the observation made by Ayalew (2000) that those households keeping cultivating forage was 5%. However his result is comparable to the current findings for forage legumes, which were found in 6% of hh. In the case of sweet potato, people were observed cultivating and using these extensively, both for human food and livestock feed. According to the current study, it was concluded that the proportion of households utilising sweet potatoes rose from 56% in 1994 to 68% in 2000. This might be because more smallholder farmers are realising the potential benefits of this crop, especially in combating the seasonal shortages and fluctuations in the supply of animal feed. According to the study carried out by Patterson *et al.* (1992), sweet potato vines can effectively overcome the regular fluctuation in feed quantity and quality in Kenya. Their quality is the result of high levels of palatability, digestibility and crude protein, making it a suitable crop for incorporating, where it is applicable, into forage development packages. Furthermore, to promote efficient water utilisation and soil stabilisation at the smallholder farmer level, the cultural practice of sweet potato cultivation, especially as practised in Hararghe (traditional tie-ridge) is appropriate.

Because the DGDP beneficiaries represented the poorest in their respective communities, with as many as 25% of them being widows, and the majority of them had less than half a hectare of farm land including their backyard plots (Ayele 1994 and 1999), the adoption rates for improved forages and sweet potato are high.

Table 5 Households (hh) with cultivated forages and sweet potato in 2000

Description	Households	% (n = 78)
hh with no cultivated forages	7	9
hh with tree legumes (TL) with or without EG	5	6
hh with elephant grass (EG)	45	58
hh with sweet potato (SP)	53	68
hh either TL, EG and, or, SP	71	91

Conclusions

There are many factors that could lead to an acceptable level of success in any of the forage development initiatives. Perhaps one of the major factors is the full participation of the communities. Thus, it is recommended that a process approach, which allows the communities to participate in all stages of the forage development cycle, i.e. from planning to the implementation and evaluation stages is adopted in future projects. This will be the basis for sustainable feed resources development. Communities also need options on how to combine traditional practices with forage development initiatives.

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INVOLVING FARMERS IN RESEARCH TECHNOLOGY DEVELOPMENT

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Abstract

A brief review of participatory research technology development is given and a case study of low cost technology for forage handling is presented. In this case study, agricultural research technology developed with farmers in Northern Tanzania showed that farmers have rarely been involved in technology development. PRA techniques were used in a research project that aimed at developing strategies for improving the utilisation of forages to increase profitable milk production on smallholder farms. PRA results showed that maize stover was the main dry season feed resource and that use of this forage was constrained by high transportation costs from lowlands (area of production) to highlands (area of consumption). A technology involving use of a wooden box measuring 0.75 x 0.5 x 0.4 m to manually bale maize stover and other dry forages such as rice straw, bean straw and dry roadside grass was developed with farmers. The box produced bales of average weight 12 kg. Bales increased the load of stover transported in a 1.0 t pick-up truck by 63% and reduce transportation costs by 33%. Stripping the stover and baling only the leaves, sheath and husks increased the edible stover transported from 80 kg to 380 kg per 1.0 t truck load. Compared with loose stover, baled stover is easier stored and facilitates more accurate feed budgeting.

Introduction

Agricultural research technology development in developing countries, for many years, was based only on the scientists' conception with little or no involvement of the farmers, the clients of the research outputs. As a result of this approach, most of the technologies developed were not client oriented and in most cases they failed to fit into the farming systems where they were introduced. Poor dissemination techniques also contributed to low adoption rates.

In recent years, there has been a growing awareness of the need to complement the traditional approach to agricultural research and development with a new approach based on the concept of “rural innovation”. The approach emphasises the need to promote “farmer involvement in research technology development,” if we want to effectively achieve the objectives of poverty reduction and sustainable development. The reasons for the emergence of this new approach are related to several important changes that are taking place in the present context of agricultural research and production.

The first one refers to the limitations that are being confronted in the effective impact of agricultural research and the loss of “technological dynamism” (i.e. technology developed in one country failed to perform in another country) in developing countries.

Secondly, trade liberalisation is leading to a market situation where the local farmer has to compete with cheap food imports. Local farmers are thus faced with an increasing requirement to be competitive, even in the local market. To be competitive and yet produce at a profit requires low cost technologies that are developed to maximise the use of locally available resources.

Thirdly, the demand structure for agricultural products is rapidly changing for many reasons, including the availability of processed foods of various types and the move towards organically produced foods. This is leading to the increasing importance of the post-harvest phase and of agro-industries. Post-production operations account for more than 55% of the economic value of the agricultural sector in developing countries and up to 80% in developed countries. Agro-industries of different types are becoming the basis of socio-economic development in rural areas, and they play a critical role in meeting the objectives of food security and poverty eradication, through the generation of employment and income in the rural sector.

Other changes that are taking place are related to such aspects as the shift in emphasis from quantity to quality of production, where the characteristics of the products, and thus quality control, are becoming very important, and to the increasing demand for organically produced products. Organic farming is based on the use of local natural biological control of both field and storage pests, on increasing soil fertility and on conserving the environment. Research to develop techniques to ensure sustainable organic farming cannot be effective if local farmers are not fully involved.

Participatory Technology Development (PTD) with farmers

Small-scale farmers often have within their social, economic and environmental circumstances, technologies that it would be wise to preserve. In many traditional systems farmers themselves have been researchers, selecting the best crop varieties from those locally available, and improving animal breeding through controls. Critchley *et al.,* (1994) reviewed the state of knowledge of farmers and prospects for building on traditions and local knowledge. The author provided a new way for looking at farmers' perspective in terms of soil and water conservation that was feasible and accepted in the community. Reij *et al.,* (1996) brought to public prominence some 27 African case studies of local resource management practices, which have stood the test of time. It is also realised that the scientific and development community has much to learn from what farmers do (including characterisation of technologies, how they work, why they work and how they fit the production system and give support to rural livelihoods). In turn the scientific community has things to offer. These offerings can be categorised as facilitation of scientific and economic analysis of what farmers do, supporting adaptation of techniques to achieve greater, easier or more economic production and facilitation of access to technologies or resources which may alleviate constraints to adoption of local or improved practices. There is, therefore, an explicit link between evaluation, or analysis, of performance of local practices, explaining their contribution in dissemination and, thus, relieving the constraints to adoption. All these call for activities and methods to encourage participation of men and women farmers in developing agricultural technologies. This is the essence of 'participatory technology development' (PTD). In principle, under PTD there is usually an outsider whose role is to initiate the process of agricultural research development. The outsider may make use of various participatory methods and tools that will ensure maximum participation of farmers. The participatory methods, tools and techniques used have been summarised in the literature addressing Participatory Rural Appraisal (PRA).

PRA as basis for involving farmers in agricultural research development

PRA makes use of a wide range of tools and techniques. Theis and Grady (1991) listed 36 different tools and techniques that can be used in conducting a good PRA study. However, the authors pointed out that any given PRA will not use all of the techniques listed. Chambers (1994) noted that the more developed and tested methods of PRA include participatory mapping and modelling, transect walks, matrix scoring, well-being grouping and ranking, seasonal calendars, institutional diagramming, trend and change analysis, flow and causal diagrams and analytical diagramming. Some PRA tools are suitable for data collection (e.g. direct observation, secondary data review, semi- structured interviews and photographs) while others are better for data analysis (e.g. analysis group discussions, innovation assessment, livelihood analysis). Other tools are suitable for both (e.g. social mapping, ranking, construction of diagrams). It is important to note that the best PRA tools are those that should allow full involvement of the local people. It is therefore a duty of the PRA team to select the most appropriate and useful set of techniques each time a PRA is carried out.

Basic PTD framework

It should be emphasised that agricultural research 'technology' needs to be taken in its broadest sense. In PTD, technology should not be understood only as covering agricultural tools, crop varieties and land husbandry practices, but should also include thought constructions (such as cultural codes and forms of management and co-operation). The basic PTD framework has been reviewed by van Veldhuizen *et al.,* (1997). In many ways the framework outlines the relationship and roles of stakeholders that is to be expected under PTD, and modalities of sustaining the PTD process. The roles, entry points and relationship in PTD have been simplified by Forrester (1998) as:

- Improving the situation by farmers' own potential (discover opportunities for improvement within their environment)
- Focus on skills and knowledge (rather than material inputs and money)
- Trying out things that work
- Joint effort-extension agents working together with farmers
- Exploratory mindset rather than analytical: exploratory versus analytical. (Exploratory refers to how the situation can be improved while analytical refers to what the problem is)
- Diversity of outlook.

Strengths and weaknesses of PTD

The strengths and weaknesses of PTD, which in many ways reflect what is expected in technology adoption by farmers, are summarised in Table 1.

Table 1: Strengths and weaknesses of participatory technology development (PTD)

Strengths	Weaknesses
Indigenous technology is respected and promoted. Encourages farmers to be innovative. Incorporates farmers' wishes. Makes use of cheap and locally available material. Technology is easy to adopt and spread. Empowers individual farmers and rural communities. Strengthens link between farmer, extension worker and researcher. Farmer experimentation directs the research agenda. PTD ensures sustainability of technology. Involves farmers in all stages of technology development.	Initially it takes more time and resources Site specificity limits the spread of technology PTD requires a culture of openness and sharing. Some village cultures hinder the PTD process Requires skills, change of attitude and flexibility of thought on the part of both farmers, extension and research staff, which is often lacking Unsystematic experimentation may lead to false conclusions

Facilitating technology development with farmers

In facilitating technology development with farmers two main themes evolve:

- Supporting and sustaining farmer involvement in the experimentation phase
- Farmer-to-farmer visit and learning as well as farmer-to-farmer extension.

Supporting and sustaining farmer involvement in the experimentation phase is partly the role of the donor funding the project. As shown in Table 1, the rationale for the experimentation phase is to focus on experiments that farmers can manage and evaluate themselves, and on those that give results on which farmers can base sound decisions. Through involvement in these activities, farmers improve their capacity to adapt their agricultural practices. This is achieved through skill development and group building, leading to linkages with other communities and organisations, thus enabling exchanges of information.

Farmer-to-farmer visits as well as farmer-to-farmer extension is aiming at disseminating developed technology to a wider public. However, the dissemination messages must be presented in a format easily understood by farmers. Popular pathways of dissemination include leaflets, posters, banners and comics that can be distributed to many farmers through the available local channels and communication mechanisms.

Local channels for disseminating a concluded technology

Local channels that may be useful in disseminating an extension message include religious groups, traditional groups, primary school pupils, local markets, agricultural shows, farmers' field days and routine village meetings. Posters may also be placed in public meeting places such as dispensaries, co-operative society shops and local brew bars.

Phasing out of outsider support after PTD

As indicated earlier, the role of an outsider is to initiate the process of agricultural technology development. Withdrawal of the outsider should be smooth and, if possible, by stages so that it does not disturb the adoption and diffusion of the technology. Usually, after developing the technology with farmers, the outsider (often the PRA team) passes the project over to extensionists, whom are working more closely with farmers. The role of extension agents will change as farmers become more aware and actively seek advice, rather than, as now, wait to be given some.

A case study of technology developed with farmers in northern Tanzania

Since the inception of pasture and forage research in Tanzania, in the early 1930s, a number of improved technologies on production, upgrading, storing and feeding of forages have been developed. However, farmers in many parts of Tanzania have not adopted the improved technologies for a number of reasons. One of the foremost reasons is the conventional approach used in carrying out research, whereby researchers develop recommendations based on their preconceived ideas of the problems facing the farmers and how these should be solved. Farmers have rarely been involved in technology development. The failure to involve farmers in technology development has resulted in a lack of, or low adoption, even if these technologies found a channel to reach farmers. In most cases farmers have found that the technologies disseminated are inappropriate and do not fit into their farming system due to resource requirements and, sometimes, social barriers that were not considered before.

In recent years an increasing number of projects have started considering farmers in research technology development so as to increase the likelihood of adoption. The techniques used to involve farmers in research are Participatory Rural Appraisal (PRA) and Farmer Participatory Research (FPR). PRA is used to gather information to determine the farmers' perception of their problems. Analysis of PRA data can then be linked to FPR in the further development of the project as the appropriate technologies to solve identified problems are researched, trailed to and tested with farmers.

A research project (R6619) that aimed at developing strategies for improving the utilisation of forages to increase profitable milk production on smallholder farms, used a PRA approach followed by FPR. The PRA identified several constraints to utilisation of forages available on farm. The identified constraints were then ranked by farmers to determine those that were more severe and needed immediate research. The top ranked constraint for smallholder farmers in Kilimanjaro residing in Pe1 (perennial mixed home garden farming) and Mc2 (Small scale mechanised mixed farming) was the high transportation cost of maize stover and other crop residues. The crop residues are obtained in the lowlands, 15 – 20 km away from the homesteads in the highlands where the dairy animals are kept. In an FPR that followed the PRAs, a low cost technology of handling, transporting, storing and budgeting of the dry forage for dry season feeding was developed.

In the 1980s, previous research projects in the area had also identified the problem of high transportation cost of crop residues that are transported as loose material in 1.0 t pick-up trucks and tractor-trailers. Due to the bulky characteristic of the residues only a small amount could be accommodated in the trucks. Furthermore, transporting the residues as loose

material could pose some traffic problems, due to extensions made on the body of the vehicle to increase the amount of stover carried.

As a solution to the perceived problem, the previous research projects introduced tractor operated hay balers to reduce the bulkiness of the stover for transport in the pick-up trucks. The baling option proved to be successful, but the operating costs for the machinery used was high and resource-poor smallholder farmers were unable to adopt this form of technology. The FPR carried out in the area (Hai District in Kilimanjaro) identified the use of manual box baling as an alternative farmer-evaluated strategy to solve the problem of residue bulkiness and, therefore, to increase the pay-load of a 1.0 t pick-up, leading to reduced costs of transportation.

The technology involved use of a wooden box to manually bale maize stover and other dry forages such as rice straw, bean straw and dry roadside grass.

Procedure for manual baling of dry forages

- Make an open wooden box measuring 75 x 50 x 40 cm
- Insert two sisal twines in the box and make sure the ends extend upward and outside the sides of the box
- Fill the box with stover and compress, by trampling, until the box is full
- Join the two ends of each twine and tie them tight to ensure a strong bale
- Remove the bale from the box by holding the box by its sides and push the bale out.

Some key findings in the use of the technology developed with farmers

Research findings and evaluation of the manual box baling technology showed that a wooden box measuring 0.75 x 0.5 x 0.4 m could produce bales of average weight 12 kg. Farmer practice of transporting loose stover in a 1.0 t pick-up truck showed that the truck is able to carry a load of 160 kg of loose material. The same truck could load up to 22 bales giving a total of 260 kg stover, an increase of 63 %. After taking into consideration the cost of labour used in baling, the technology revealed that costs of handling and transporting stover could be reduced by 33 %.

The technology enables farmers to transport bales in a communal truck, and, as with bags of grain, only pay for the amount being transported. This could be of benefit to resource poor farmers in the low wealth group that could not afford hiring the whole truck. The bales also allow for easier storage and more accurate feed budgeting.

Road side grasses, harvested by women and children for use in cut and carry systems, can also be transported in the same way.

The cost effectiveness of the technology was further improved by the stripping of stover to separate the stem from the leaf sheath and husks, the most nutritious and edible parts of the maize residue. By baling these without the stem, the load in 1.0 t pick-up truck was increased to 380 kg.

It is therefore recommended that farmers adopt manual box baling of maize stover and other dry forages so that they can cheaply transport these feeds, easily store them and more accurately feed budget.

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USE OF NUCLEAR AND RELATED TECHNIQUES TO DEVELOP SIMPLE TANNIN ASSAYS FOR PREDICTING AND IMPROVING THE SAFETY AND EFFICIENCY OF FEEDING RUMINANTS ON TANNINIFEROUS TREE FOLIAGE: SUMMARY OF THE SECOND MEETING OF THE IAEA CRP (D3.10.22) GROUP IN PIRACICABA, BRAZIL, 19-23 NOVEMBER 2001

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Background

This co-ordinated research project (CRP) consists of two phases: the first (started 1999) to identify and develop repeatable methods of tannin assays and to seek correlations with animal performance indicators; the second (started 2002) to develop viable and simple techniques for the efficient use of tanniniferous forages, allowing farmers to increase the output of ruminant livestock products (draught power, milk and meat)

The objectives of the meeting were to review the progress made and plan studies for the second phase. It was attended by 10 research contract and agreement holders, the Scientific Secretary of the Project, and 10 staff members and students of the host institution.

Review of first phase

The tannin assays and standards used in the first phase are summarised in Table 1.

Table 1 Tannin assays and standards used in the first phase of the coordinated research project

Assay	Suggested standard
Gallotannins by rhodanine method	Gallic acid
Gallotannns by HPLC	Gallic acid
Condensed tannins (butanol-HCl-ion method)	Anthocyanidin (leucocyanidin)/cyanidin chloride
Total phenols and total tannins (Folin-Ciocalteu method)	Tannic acid
Protein precipitable phenolic assay	Tannic acid
Radial diffusion assay	Tannic assay
Filter paper-BSA-Ponceau S assay	Tannic acid
Radio-labelled protein binding assay	Tannic acid

(for the last two assays, results were also expressed as mg bovine serum albumin/mg dry leaf sample)

A further tannin bioassay measured both gas and microbial mass production between 16 and 24 h of incubation, when tanniniferous foliage was incubated, using an *in vitro gas* production method, with or without polyethylene glycol (PEG, molecular weight 4000-6000).

Tannin levels and activity were characterised in 48 tree leaves and browses, of which 10 were also used for *in vivo* assessments.

Results of analysis were used to decide on the methods to be used as routine in the second phase. The correlation between digestible N and the assays undertaken was best with the following: total phenol; total tannins; condensed tannins; radiolabelled BSA (a simplified iodine method is being developed and should be ready for use early in 2002); response (%) in gas production from the addition of PEG. With the short-term *in vivo* trials used in this phase, intake was poorly correlated with the tannin assays, suggesting that tanniniferous forages need longer adaptation periods, *in vivo*, than other forages.

Recommendations and plans for the second phase

Based on the results from the first phase, the following tannin assays were recommended for use in the second phase:

- Total phenols
- Total tannins
- Condensed tannins
- Radiolabelled BSA method
- PEG as a tannin inactivator (measure percentage increase in gas production)

Plans were developed by the five existing contract holders to select tannin-rich materials either used by, or available to farmers with the following objectives for: use as feed supplements (*in vivo* studies); creation of strategic feed reserves (studies on storage conditions); detanninfication of tree leaves. These will be research station studies, in order to establish biological responses. Other areas identified for studies include: mechanisms of adaptation to tannins; fate of PEG in the soil; development of a radiolabelled BSA-based model to investigate the mechanism of tannin interactions in the gastrointestinal tract, and the

possibilities for enhancing protein use in ruminants. The results of these studies could form the basis of technical cooperation projects at a later stage, thus directly involving farmers.

Further reading

MAKKAR, H.P.S. (in press) International Atomic Energy Agency (IAEA) TECDOC. IAEA, Vienna, Austria.

PROTOCOL FOR FAECAL EGG COUNTS

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Intestinal worm parasites release eggs that pass out with faeces. Examining faeces for eggs allows detection of infection, and counting the numbers of eggs provides an estimate of the level of infection present. Faeces should be collected from the rectum if possible, or immediately after they have been passed. Eggs must be counted before they hatch, so if faeces cannot be processed immediately they should be kept cool, preferably on ice.

If there are many eggs present they can be detected in a thin smear on a microscope slide under a low power (X10) objective. Alternatively, a small amount of faecal material (<5g) can be broken up in 10-15 x the volume of water, filtered through a mesh (laboratory sieve or tea strainer) and a small sample of the filtrate examined under the microscope. If the precise weight of faeces, the precise volumes of water used and sample taken are known, a rough quantitative measure of the numbers of eggs per gram (EPG) can be calculated:

$$\text{No of EPG} = \text{No counted} \times \frac{\text{Volume of Water}}{\text{Weight of Faeces} \times \text{Volume of Sample Counted}}$$

An improved way of detecting eggs or of calculating EPG requires a concentration technique, in which the eggs present in the sample are allowed to float up in a solution with a high specific gravity (e.g. saturated NaCl or Zn $(SO_4)_2$ or 40% sugar solution)

Concentration technique (based on the McMaster method)

Egg detection

Fresh faeces are collected and mixed. A small sample of <5g is broken up in 10-15X the volume of water and then filtered through a sieve or tea strainer. A sample of the filtrate is poured into a centrifuge tube and centrifuged at 1500 rpm for 2/3 minutes. The supernatant is discarded and a small amount of salt or sugar solution added to resuspend the sediment. The tube is then filled with salt or sugar solution and the contents thoroughly mixed. The tube is then allowed to stand for 5-10 minutes or centrifuged at 1500 rpm for 2 minutes. A sample is withdrawn from the surface of the suspension by pipette and placed on a microscope slide for examination under a low power objective

Egg counting

This requires the use of either McMaster-type counting slides (2 or 3 chambers) or capped plastic 4ml cuvettes. The former (Eggs-Acto™ are available from E. Krecek, Focal point, PO Box 12832, Onderstepoort 0110, South Africa, e mail <krecek@icon.co.za>), the latter from any scientific equipment supplier. Fresh faeces are collected and mixed.

For the McMaster method a sample of 3g of faeces is broken up in 42ml of water and then filtered through a sieve or tea strainer. A sample of the filtrate is poured into a centrifuge tube to 1 cm from the top and centrifuged at 1500 rpm for 2-3 minutes. The supernatant is discarded and a small amount of salt or sugar solution added to resuspend the sediment.

The tube is then filled to the same level as the original suspension and the contents thoroughly mixed. A sample is withdrawn by pipette and used to fill the counting chambers of the McMaster counting slide. After a short period, to allow the eggs to float upwards and the debris to sink (approxinately 5 minutes), the number of eggs visible within the measured areas of the counting slide is counted under the low power of a microscope.

For the cuvette method a small sample is taken from the mixed faeces (<5g), broken up in water (20ml/g faeces) and then filtered through a sieve or tea strainer. Exactly 10 ml of filtrate is poured into a centrifuge tube and centrifuged at 1500 rpm for 2/3 minutes. The supernatant is discarded and 10 ml of salt or sugar solution added to resuspend the sediment. After mixing, the cuvette is filled completely to give a meniscus and then carefully capped to exclude air bubbles. After a period of time to allow the eggs to float upwards and the debris to sink (approx. 15 minutes), the numbers of eggs visible under the top surface of the cuvette are counted under the low power of a microscope. If the number of eggs is too large to count comfortably then the sample can be further diluted with saturated salt and the cuvette refilled.

The EPG for the sample is calculated as follows:-

McMaster method. The volume represented by two counting areas of the counting slide is 0.3ml. If 3g of faeces are mixed with 42 ml of water initially to give 45ml of suspension, the EPG value is the number of eggs counted x 50.

Cuvette method. The cuvette has a volume of 4 ml. The EPG value is, therefore, the number of eggs counted x 5 (if a 10 ml starting sample is used). If there is further dilution necessary the multiplier is changed accordingly.

OUTPUTS FROM THE WORKSHOP: THE FUTURE

The session was lead by a discussion team consisting of Louis Mtenga, Peter Buttery, Emyr Owen, Wyn Richards and Tim Smith.

Objectives of the meeting

The common purpose of those contributing to the meeting was identified as **developing sustainable management strategies for smallstock keepers**. They should be regarded as the target group, smallstock being the channel to improving their livelihoods, through increased productivity, incorporating both improved health and nutrition.

This meeting has aimed to promote 'added value' to individual projects by initiating on-going contact between teams through a continuous exchange of ideas and results. The development process within projects is exemplified by the example from Nepal, where participatory rural appraisal (PRA) has modified activities identified in stakeholder meetings, whilst leaving the objectives unchanged. The bringing together of a parasitologist with nutritionists has generated thoughts for modification of the South African project at the critical planning stage, thus demonstrating the need to 'talk' both within and across programmes (in this example the DFID Livestock Production Programme (LPP) and the DFID Animal Health programme (AHP).

Access of livestock keepers to stock

There is much in common between the Mgeta project and that at Meru in Kenya (see report by C. Ahuya in these proceedings). With donor funded breeding programmes, it is likely that the sponsor will influence the choice of the exotic breed(s) to be used. Both projects are faced with the problem of maintaining the F1 cross, to cash in on the effects of heterosis, and, at the same time, reducing the ill-effects of inbreeding. Donors, such as Heifer Project International (HPI) take the dangers of inbreeding into account in their planning. While some exotics are performing well, this is often because the natural environment has been ameliorated, a course of action not always available to smallholder farmers. There has been no cost/benefit analysis of cross-breeding in goats.

Selection within breed is a slow process and farmers are usually looking for a 'quick-fix' hence therefore, the popularity of crossbreeding. However, the Food and Agricultural Organization (FAO) and the International Livestock Research Institute (ILRI) are concerned with the conservation of indigenous livestock. Matopos Research Station has been working with ILRI to identify the mechanism responsible for 'adaptation' in cattle.

In Tanzania there is a change of emphasis from cattle to goat ownership. The problems of maintaining crossbreeding programmes are emphasised in cattle because of the long generation interval, low numbers in smallholder owned herds and a lack of resources to purchase. There have been several crossbreeding studies, both in East and Southern Africa and Australia. The data from cattle recording schemes in Tanzania and Southern Africa are available. The importance of links with breed and herd book societies was stressed.

Dissemination

Over the next two or three years the Livestock Production Programme will concentrate on the

promotion of research results. The mechanisms of upscaling of relevant interventions to farmers need researching, as does the methodology of dissemination. The following points were stressed:

- The need to know why farmers adopt an intervention
- Marketing of research is often poor, usually being too scientific
- Those promoting interventions must gain the confidence of donors and recipients
- To encourage a sense of ownership within a project, disseminators should be included from the outset
- Civil Society groups (e.g. women's and farmers' groups, churches, schools, donors) and relevant government departments should be regarded as stakeholders
- Project outputs should, where possible, be generic.

The issue of farmer training was raised and the meeting was assured that money is now being made available for this.

Publication of Link Meeting Proceedings

A goat keepers' website is to be established with LPP funding. The proceedings will be placed on this, without photographs to assist down loading/printing. A small number of hard copies and a compact disk (CD) will also be available.

General Comments

Techniques, methodologies and products coming from projects should be available, where possible to be e-mailed (see list of participants for e-mail addresses).

Standardization of techniques across projects is desirable, especially in the description and analysis of tannins. The presence of dietary tannins has implications both for animal health (worm control) and nutrition. Linkages with other programmes (e.g. IAEA) working in this area are encouraged. Farmer orientated projects require simple functional tannin assays.

A protocol for counting faecal worm eggs will be included in the Proceedings.

Most reported PRA studies have been carried out on crop production. There are now (2002) guides covering livestock keepers (*Participatory Technology Development with Livestock Keepers* and *Participatory Situation Analysis with Livestock Keepers,* Czech Conroy, Natural Resources Institute, Chatham Kent, UK).

Future of the Link Project

The original three link project members[1] have now increased to six, and the original emphasis on the use of tree products has broadened to addressing the problems faced by goat keepers. It is logical to think of the group as a cluster addressing the needs of a specific group

[1] LPP Projects R6953, R7351 and R7424

of livestock keepers. The original objective, that through collaboration a greater flow of targeted information should be available to farmers, has not changed.

The next meeting is planned to take place in Kenya in 2003. Representatives of target institutions and LPP projects will be asked to attend.

ILRI and FAO are cataloguing indigenous breeds of domestic livestock and identifying those at risk, a potential starting point for a programme to counteract the effects of inbreeding. Matopos Research Station is involved with this and, with ILRI, in identifying the mechanisms involved with adaptation.

The role of exotics in smallholder livestock production, against the potential for selection within indigenous livestock was questioned but there is no simple answer. Farmers want rapid solutions to their problems, and exotics, and their crosses are being introduced. However, selection within indigenous breeds should be encouraged, with preservation of those characteristics allowing them to thrive in adverse conditions.

PARTICIPANTS AT THE WORKSHOP

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PROJECT DETAILS

R number	Title	Lead Organisation	Collaborating Organisations	Project leader	Start date	End date
R6953	Easing seasonal feed scarcity for small ruminants in semi-arid crop/livestock systems through a process of participatory research	NRI	BAIF	C Conroy	Oct-97	Mar-02
R7351	Feeding goats with *Acacia* and other pods	University of Reading	NRI, Matopos	T Smith	Apr-99	Mar-03
R7424	Tannins and parasites	University of Nottingham	Sokoine University	P Buttery	Oct-99	Dec-02
R7632	Increasing the contribution that goats make to the livelihoods of resource poor livestock keepers in Himalayan forest region	ADAS	NARC, New Era	C Rymer	Oct-00	Dec-04
R7634	Goat productivity in Meru, Kenya	FARM Africa	KARI, University of Nairobi	C Ahuya	Apr-00	Mar-03
R7798	Link project R7424, R7351, R6953	University of Nottingham	NRI, University of Reading	P Buttery	Jul-00	Mar-03
R8151	Improving the livelihoods of resource-poor goat farmers in southern Africa through strategic drug and nutritional interventions against gastro-intestinal nematode infections	Onderstepoort Veterinary Institute	CTVM, University of Pretoria,	A Vatta	April 02	March 05