Sustaining Livestock in Challenging Dry Season Environments

Strategies for Smallscale Livestock Farmers

Proceedings of the third workshop on Livestock Production Programme Projects.
Ingwe Lodge and ICRISAT, Matobo, Zimbabwe. 26–28 September 2000

DFID Department for International Development

LPP
LIVESTOCK PRODUCTION PROGRAMME

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Edited by
T Smith and **S H Godfrey**

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Editors' Notes

This document summarises events, actions and conclusions of the third Livestock Production Programme (LPP) Workshop held at Ingwe Lodge and ICRISAT, Matobo, between 26-28 September 2000. In editing the contributions made by the main speakers and other participants, some omissions and misrepresentations of the facts may have been inadvertently made. For these we apologise.

Presentation of these Proceedings differs to those of the Second Workshop, in that here the emphasis is on specific groups of farmers, reflecting the mandate given to LPP, by DFID, to address the problems of disadvantaged farmers/livestock keepers. The groups identified and the order of presentation of projects addressing their specific needs are: crop/livestock farmers; smallholder milk producers; smallstock keepers; peri-urban and landless (including women); pastoralists and extensive rangeland farmers. This theme will be developed in the introduction.

The word 'beneficiary' is used throsughout the proceedings to mean smallscale farmers to whom the research outputs should be aimed at. It is recognised that 'beneficiary' is not always a popular term (as amongst other reasons it inaccurately implies research is a one-way process) and for this the editors apologise.

Zimbabwe is a target country for LPP activities. However, it has always been the intention that extension messages developed by the Zimbabwe cluster of projects should be disseminated on a regional basis. At this meeting we welcomed the participation of representatives from Mozambique and South Africa (see reports), those asked from Namibia and Zambia were unable to attend but have requested to be involved in future activities.

Many people should be thanked for their role in making the Workshop a success, including Dr S.Moyo and the staff of Matopos Research Station, Ephraim Gumbo, for administrative help before and during the Workshop, and the staff of Ingwe Lodge for looking after us during the Workshop. We are also indebted to Wyn Richards for his assistance in running the Workshop and in producing these proceedings. Lastly, thanks to all contributors of papers and discussion points, which make up the body of this publication.

Tim Smith and Sarah Godfrey

Participants of the workshop at Ingwe Lodge

Participants at the third day of the workshop: this was held at ICRISAT, Matopos. Participants included project teams and representatives from local NGOs.

Milking time at Matopos – The Jersey and Jersey cross-bred cows at Matopos are milked by hand once a day (project R7010).

Scarabaeinae K*heper nigroaenus* (probably). Credit: Delphine Aigreau. Project R7539

Testing the plough (project R7352)

Tools (project R7352)

***Acacia nilotica* tree and pods (project R7351)**

Acronyms

ADF	Acid detergent fibre
ADL	Acid detergent lignin
AFRC	Agricultural and Food Research Council
AHP	Animal Health Programme
ANOVA	Analysis of variance
ARC	Agricultural Research Council
AREF	Agricultural Research and Extension Fund
BAIF	Bharatiya Agro Industries Foundation
BASED	Broadening Agricultural services and extension delivery
BBN	Bayesian Belief Network
BCS	Body condition score
BF	Butter fat
CA	Communal Area
CAMPFIRE	Communal Areas Management Programme for Indigenous Resources
Cmo	Colephospermum mopane
Coa	Combretum apiculatum
CP	Crude protein
CSM	Cottonseed meal
CT	Communication team
CTB	Contil Single Donkey Toolbar
CTK	Contil Knife ripper
CTVM	Centre for Tropical Veterinary Medicine
DAP	Draught animal power
DDP	Dairy Development Programme
DFID	Department for International Development
DFIDCA	Department for International Development Office, Central Africa
DINAP	Direcção Nacional de Pecuária
DM	Dry matter
DMD	Dry matter disappearance
DMI	Dry matter intake
DR&SS	Department of Research and Specialist Services
DTC	Domboshawa Training Centre
DVS	Department of Veterinary Services
FAO	Food and Agriculture Organization
FTL	Forage tree legume
GLM	General linear models
GoZ	Government of Zimbabwe
Hh	Household
ICAR	Indian Council of Agricultural Research
IAE	Institute of Agricultural Engineering at Hatcliffe
LA	Lactic acid
LPP	Livestock Production Programme
MADER	National Directorate of Livestock of the Ministry of Agriculture and Rural Development
MADF	Modified acidic detergent fibre
MCC	Milk collection centre

ME	Metabolizable energy
MR	Magoye ripper
MRS	Matopos Research Station
NADF	Nabioal Association of Dairy Farmers
NANGO	National Association of Non-Government Organizations
NDF	Neutral detergent fibre
NGO	Non-governmental organisation
NPDAE	Northern Province Department of Agriculture and the Environment
NRI	Natural Resources Institute
NRIL	Natural Resources International Ltd
OMD	Digestible organic matter
OVI	Objectiviely Verifiable Indicator
PAAT	Programme Against African Trypanosomiasis
PEG	Polyethylene glycol
PRA	Participatory Rural Appraisal
PS	Palabana subsoiler
R&D	Research and Development
RDPC	Regional Dissemination /Promotion Co-ordinators
RG	Resource group
RMFI	Researcher-managed and farmer-implemented
RMSFC	Ram-pressed sunflower cake
RPLK	Resource Poor Livestock Keeper Group
RPT	Reading Pressure Technique
RTTCP	Regional Tsetse and Trypanosomiasis Control Programme
SPER	Serviços Provinciais de Extensão Rural (SPER), (Provincial Rural Extension Services)
SPP	Serviços Provinciais de Pecuária (Provincial Livestock Services)
TFP	Third furrow planting
TLC	Thin Layer Chromatography
TP	Total phenolics
TTCB	Tsetse and Trypanosomiasis Control Branch
VFA	Volatile fatty acids
VR	Village representatives
VIDCO	Village Development Committee
VSF-Europa	Veterinaires sans Frontieres-Europa
ZFU	Zimbabwe Farmers Union
ZR	Zimplow ripper

Opening Address For The Livestock Production Programme Workshop

David Mangemba

Agricultural Research Council, PO Box MP1140, Mount Pleasant Zimbabwe.

I wish to welcome you all to this Workshop and hope your deliberations will go well. I also wish to recognise the presence of the Deputy Director of the Department of Research and Specialist Services (DR&SS), the Manager of the Livestock Production Programme (LPP) and the natural resources representative from the Department for International Development, Central Africa (DFIDCA), for sparing their time to attend this Workshop.

I wish to preface my opening remarks by restating the roles of the Agricultural Research Council (ARC) for the benefit of those who might not be aware of them. The functions and roles of the ARC as articulated in the Agricultural Research Act, Chapter 18.05 are:

1. To keep under review agricultural research in Zimbabwe, with particular attention to the adequacy of such research for the needs of Zimbabwe
2. To promote all aspects of agricultural research and to ensure maximum cooperation between persons or authorities who are undertaking, or about to undertake, any form of agricultural research
3. With the approval of the Minister, to carry out agricultural research.

As clearly specified by the Act of Parliament, the ARC is only there to facilitate, not compete with, research and development institutions. the onus is on you to remind the ARC of its role whenever officials overstep their responsibilities.

The LPP is one of the many partners the ARC collaborates with as a means of ensuring that we achieve the above objectives. We are glad that this relationship continues to thrive.

The ARC is a stakeholder driven institution. It has managed to set up three broad-based commodity committees and eight provincial committees. The commodity committees deal with national, fundamental and strategic (macro) issues, while provincial committees deal with problem identification and solution development at a local level. Bread and butter issues are dealt with at provincial level, the most important and critical level in the ARC structure. This is the contact point with the grass roots (smallholder and communal area farmers) and it is the make or break point for the ARC.

The ARC has developed a five-year strategic plan with broad and generic agricultural opportunities and challenges. It is our hope that the plan will be dynamic. It will be reviewed and up-dated regularly to keep up with the needs of the consumers of our services. The document also contains detailed listings of provincial problems and challenges. It is up to Research and Development (R&D) personnel to take up the challenge and, together with the farmers, provide working solutions. The farmers now refuse to be called beneficiaries, as they are part and parcel of the participatory research and development process.

The ARC has set up a competitive fund, called the Agricultural Research and Extension Fund (AREF), with very elaborate procedures to supplement R&D. Relevant personnel will be invited to apply for funding in due course. The fundamental requirement for those seeking funding is proof that the R&D is demand driven. The role of the end-consumer of the R&D is critical. The AREF will give high priority to applied, adaptive and on-farm R&D with clearly demonstrated benefits to communities. Fundamental and basic research will also be funded to ensure continued development of new technologies or alternative strategies.

I hope the current projects are demand driven and the benefits from them will add value to the economic and social status of poorer communities in terms of food availability and income levels.

Thank you very much for continuing to invite the ARC to your Workshops. I promise that we will continue to support your efforts in every possible manner.

Introduction

J I Richards

Natural Resources International Ltd, Pembroke, Chatham Maritime, Chatham, Kent, ME4 4NN, UK.

Since I addressed the last meeting of the Zimbabwe cluster of DFID's LPP projects here in Matopos in February 1999, a number of developments have taken place on the world arena (Fig 1). For instance, the vast majority of the donors of livestock research have openly stated their commitment to the UN's International Development Targets, which address:

- Elimination of poverty
- Universal primary education
- Gender equality and empowerment of women
- Reduced infant and maternal mortality
- Improved access to reproductive health services
- Reduced environmental damage and losses.

The phenomenon of urbanization continues unabated such that equal numbers of the world's poor are predicted in the urban and rural environments by the end of the decade. Another feature to gain greater visibility is globalization which could (theoretically) give the developing countries greater access to world markets; this will provide opportunities/challenges to the agriculture and livestock sectors in the developing world to earn much needed foreign exchange. However, the implications of globalization on the poor is uncertain and there is concern in some sectors that they will be marginalized even further as a result. Finally, DFID itself has put even more pressure on Research Managers to ensure that the research projects they commission not only develop interventions which address the needs of small farmers to produce more commodities but also to assess the impact of such interventions on livelihoods.

In response to the foregoing, LPP has responded strategically and procedurally. Thus, it has changed the focus of its research to address the needs of five groups of poor livestock keepers: small-holder milk producers (cattle and goats); crop/livestock farmers (where the emphasis is on crop production but where livestock contribute through draught power, manure, household security etc); smallstock keepers (from bees to goats); landless livestock keepers (those with no land of their own, this may include women who do not have land in their own right but whose household may have land); and pastoralist communities, transhumance groups and poor extensive rangeland farmers. A review of completed projects dealing with these beneficiary groups (Fig 2) indicates where the Programme has focussed its attention in the past; equally, it indicates where the Programme needs to concentrate more effort over the next few years. As most of you will know, landless livestock keepers and pastoralists were the focus of the call for concept notes that LPP put out in July 2000. (The definition of these beneficiary groups is given in an annex at the back of these Proceedings).

LPP has also changed various procedures and processes in an attempt to address a new pro-poor strategy.

Thus, it now expects much greater assurance that the needs of poor farmers are being considered and that their needs are being ventriloquized through institutions which are truly representative of, and trusted by, the target beneficiaries.

Secondly, it requires prospective project teams to convene stakeholder meetings at the project design phase; attendance at such meetings of research, government, civil society and farmer representational groups should ensure the demand-led nature of the work and engender broad 'ownership' of project activities. In view of the need to consider livelihood and poverty issues, the involvement in projects of individuals with social development skills becomes a necessity; indeed, multi-disciplinary teams will become the norm in commissioned projects in future. In order to maintain contact with the stakeholder community, project leaders are also now encouraged to hold reporting/discussion meetings with them annually; this should re-enforce continued 'ownership' by a broad community of interests and ensure that projects are still addressing current issues.

Lastly, LPP has established a number of regional and in-country offices in order to increase the effectiveness of local management of project activities and to encourage greater collaboration and potential joint ventures with other institutions interested in livestock research for the poor. Thus, for the Zimbabwe cluster of projects, LPP has appointed a number of staff to undertake part-time duties: Drs Tim Smith and Benjamin Manyuchi have regional and in-country responsibilities respectively and Ephraim Gumbo runs a small secretariat for the Programme. Furthermore, Dr John Morton has been given responsibility to champion the dissemination and promotion of the 'Programme's' outputs and to give guidance to the individual project leaders in this area. Project leaders are encouraged to liaise with these individuals to assist them in implementing their projects and in disseminating and promoting the outputs.

Currently, LPP has 10 on-going projects in Zimbabwe; the outputs of which are reported in these proceedings. It is by far the largest cluster of projects that the programme has in any country. This reflects the confidence that we have in the national institutions and the calibre of the staff. With four more years to run on the current DFID Research Strategy, Zimbabwean institutions have much to gain and contribute. The emphasis will increasingly switch from strategic interventionist work to adaptive research and dissemination; as important will be the need to market the research products so that they are taken up by target institutions (Agritex, NGOs CBOs etc) and subsequently adopted by beneficiary farmers. Those who consider these activities not to be important or else not the responsibility of researchers are mistaken. A recent survey of over 800 research projects commissioned by various donors on livestock production in the developing world found that less than 3% of the projects had generated any impact on livelihoods. The major reasons quoted were:

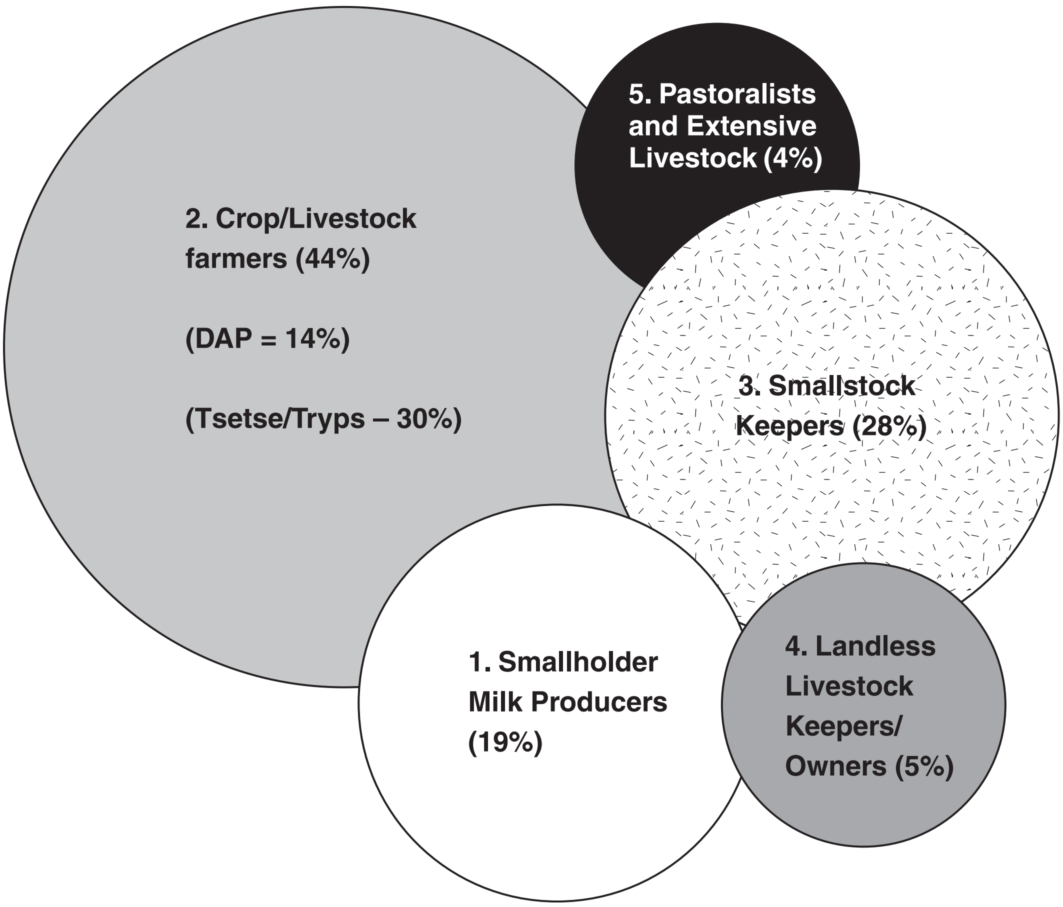
- Many of the research products were inappropriate for the needs and pockets of small farmers
- Insufficient institutions available to champion or represent the needs of poor farmers
- Pathways through which the research outputs needed to travel in order to reach poor farmers in an appropriate 'language' and format were poorly understood
- The risk averseness of most poor farmers and the lack of trust in which they hold government and non-governmental institutions had not been considered.

In other words, unless livestock researchers involved in development accept the responsibility not only to address and resolve technical /management problems but also involve themselves in research into ways of improving the promotion of those research products and their adaptation by the beneficiary, they had better start 'packing their bags'!

To end with, I trust that these regular Matopos Workshops have generated a culture of trust and respect between the individuals and institutions represented here today. In a world of decreasing research funds for livestock research, we are all charged with the responsibility of working with poor farmers in an attempt to resolve what seem to be increasing numbers of problems. A team approach to problem solving is often quoted as the most cost-effective. If we are to be successful in helping poor farmers resolve their problems (and helping ourselves professionally), we need to re-enforce the team approach. I trust that holding these meetings goes some way to achieving this. I wish you a successful meeting.

Figure 1: Global influences on resource poor livestock keepers (RPLKs) and on the commissioning of research by LPP

Figure 2: Portfolio of LPP projects commissioned since 1987, whose output addresses the needs of different beneficiaries (numbers in brackets represent percentage of projects)



Questions, Answers and Discussions

Poverty

Is targeting elimination of poverty a realistic venture under the current research thrust as the definition of poverty changes according to people's circumstances (e.g. USA and Africa). Should the focus be on improving living standards rather than poverty elimination?

The elimination of poverty is a laudable target. However, a far longer time horizon is needed to achieve this target than presently foreseen. By 2015 it will be clear what contribution livestock can make to poverty elimination and the useful knowledge, technologies and policies which have relevance. Institutional issues need to be developed at the same pace if research outputs are to have any influence on development and poverty elimination.

Perhaps people's vulnerability, for example access to food security, might be a better measure of poverty. There was also a debate as to whether research should be working with richer or poorer farmers. DFID have now put the emphasis on looking at the sustainable livelihoods of the poor.

Multidisciplinary teams

Researchers and extensionists need to build links with the farmers to see what will give them the confidence to take risks and this is where the need for social development awareness comes in. If the links are not made it is unlikely the technologies will be taken up. Project Leaders are aware of the need for increased social development involvement in the research projects, but there are concerns about the best way forward, as the cost of employing appropriate consultants can be high.

Risk

What is the definition of 'risk'? One Project Leader reported that the poorest farmers on his project saw Agritex and himself as a risk.

It is not always easy to reconcile the more traditional technical livestock research to all aspects of the farming system. However, in the past, technologies were developed to, e.g. enable the farmer to increase milk yield by 20%. However this did not take into account the fact that another part of the system might deteriorate, e.g. less money may be available for spending on arable inputs.

Crop-livestock Integration: The Dynamics Of Intensification In Contrasting Agroecological Zones (R6781)

Ian Scoones and William Wolmer

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Abstract

The project findings propose a challenge to the conventional 'evolutionary' view of agricultural change (and specifically crop-livestock integration) that sees different standard types of crop-livestock relationship emerging through an inevitable change in factor proportions resulting from population pressure. The results show that, while such a pathway of change may well be possible, it will only occur under certain institutional conditions. These are historically contingent and unpredictable, and will likely be highly differentiated by both agroecological and socio-economic settings. Thus in different places and for different people, the forms of crop-livestock change may be radically different, resulting in multiple pathways of change. Attempts to impose a deterministic and linear view will, it is argued, lead to inappropriate policies and technical solutions. By contrast an appreciation of multiple pathways of change, conditioned by institutional arrangements and differentiated by social group will allow researchers, planners and policy-makers to focus interventions more effectively, particularly given poverty reduction and sustainable livelihoods enhancement objectives.

Background

This project has explored the dynamics of crop-livestock interactions and integration in three countries in east, west and southern Africa (Ethiopia, Mali and Zimbabwe). Research has identified a range of pathways of crop-livestock integration in different resource endowment areas and traced their evolution over the last 50—100 years.

This project has differed from much previous work on the topic in that, as well as considering the three main technical elements of crop-livestock integration (use of manure for soil fertility; draught power for cultivation and transport; and crop residues for fodder), it has taken an explicitly anthropological/historical approach (for details see Scoones and Wolmer, in press). This has entailed an analytical focus on four particular elements:

Livelihoods: The study of cropping and livestock husbandry practices is embedded in a broader attempt to understand what might constitute sustainable livelihoods.

History: How particular key events and combinations of events have affected crop-livestock interactions and influenced trajectories of change.

Institutions: Uncovering the often invisible social arrangements underpinning farmers' and herders' activities and mediating access to the resources essential to crop and livestock management.

Social actors: The dynamics of crop-livestock interactions differ significantly not only by place but also by people; this research has mapped the contrasting experiences of different actors.

Understanding the social and institutional basis for agricultural change represents an important complement to conventional technical research in this area. The recognition of the failure of past technically-driven approaches has led to an emphasis on understanding such issues in the context of a broader understanding of 'sustainable livelihoods' and emphases on poverty reduction. This research responds to this demand for a particular issue where considerable research and extension effort has been, and continues to be, investigated.

Research was carried out in contrasting agroecological zones in three countries:

Ethiopia Wolayta, North Omo, Southern Ethiopia (in collaboration with the Sustainable Livelihoods Research Team, SOS-Sahel, FARM-Africa, Awassa Agricultural College).

Chokare Peasant Association (lowland, agropastoral)

Admencho Peasant Association (highland farming)

Mundena Peasant Association (lowland agricultural settlement site]

Mali *(in collaboration with the Institut d'Economie Rurale, Sikasso and Niono)*
Dalonguebougou, Segou [dryland farming/pastoral area]
Zaradougou, Mali Sud [cotton zone]

Zimbabwe *(in collaboration with the Institute for Environmental Studies, University of Zimbabwe)*
Chipuriro Communal Area (CA), Upper Guruve District, Mashonaland Central [highveld farming]
Neshangwe CA, Lower Guruve District, Mashonaland Central [Zambezi valley]
Ngundu, Chivi CA, Chivi District, Masvingo Province [intermediate zone]
Chikombedzi, Matibi II CA, Chiredzi District, Masvingo Province [lowveld farming area]

The research has identified different trajectories of change in each study site. These have been determined by the agroecological characteristics and the particular play of historical events in each location. Events such as war, the implementation of structural adjustment programmes and droughts have dramatically altered farmers cropping and livestock management strategies in the short-term, and pathways of change over the longer-term.

Agricultural research and extension recommendations relating to crop-livestock integration in all countries are still informed by a model of 'mixed farming' that is not always relevant to many African smallholder farmers. Technical recommendations focus on cattle manure, draught oxen and improved fodder management, thereby favouring the relatively better-off farmers following the recommended practices. Yet, as the examples from our findings show, many farmers are following strategies that diverge from this ideal model. If research and development policy is to engage with those following these diverse livelihood trajectories and alleviate rural poverty it needs to take account of this diversity and complexity and the importance of informal social arrangements in the pursuit of sustainable livelihoods.

Research Activities

During the first part of the project a literature review was prepared (Wolmer, 1997). This highlighted a number of hypotheses:

1. Rising human population densities will encourage intensification of production through crop-livestock integration and fertility transfer to crop lands (although this will be mediated by a range of other factors including market access, infrastructural development, tenure etc.).
2. In lower resource endowment areas, where the level of potential production is low and the temporal variability of production is high, the spatial scale at which integration occurs is large. By contrast, in higher resource endowment areas, where the level of potential production is high and temporal variability in production is low, the spatial scale at which integration occurs is likely to be small.
3. In high-resource endowment areas, where cropping areas occupy large percentages of the total land area and livestock fodder resources are in short supply, a greater proportion of livestock holdings will be as small ruminants, implying a form of nutrient cycling different to cattle based systems typical of the lower resource endowment areas. There will also be significant implications of increasing proportions of small ruminants in these drier areas as environmental conditions change and people are unable to restock with cattle following droughts.
4. Sustainable forms of crop-livestock integration, where soil nutrients are not depleted and cropland fertility is maintained, can be based both on relatively tight, closed nutrient cycles in higher potential areas, where fallowing is absent (e.g. stall-fed animals, cut and carry systems) and on much looser, more diffuse nutrient cycles in lower resource endowment areas where fallowing is possible (e.g. rangeland, supported animal populations, kraaling systems, manure exchange systems' etc.).
5. With differences in the spatial scale of crop-livestock integration, the institutional and organisational arrangements are likely to vary greatly. In highly productive systems, subject to low variability and operating at a small spatial scale, the benefits of individually run, privately owned, integrated farm systems with high levels of labour and capital investment will outweigh the costs. By contrast, systems of low production potential, subject to high variability and operating at a large spatial scale, low labour and capital investments, communal management of land-extensive resources and flexible institutional arrangements will be more appropriate.
6. The path of crop-livestock integration over time will differ between agroecological zones, depending on their resource endowments and population densities, and will be conditioned by the influence of conflicts and complementarities between crop farming and herding and the effects of government policy on prices, markets and infrastructural development etc. Therefore, appropriate policies and

development interventions for encouraging effective crop-livestock integration to inverse production and improve livelihood security will differ significantly between relatively high and relatively low resource endowment areas.

These themes were discussed by the research teams and a research design and methodology developed. A series of focussed themes and associated questions were identified to allow cross-cutting comparative analysis to be developed.

Comparative Study of Crop-livestock Interactions Based on Case Study Field Research

Field sites were identified in each of the case study countries in order to explore some of the key contrasts based on agroecological differentiation. A series of gradients of relative high to low natural resource endowment were identified in each country, with case study areas identified along these. In Ethiopia and Mali these sites coincided with the on-going Sustainable Livelihoods Programme work.

The case study research highlighted four key elements, drawing on the themes identified during the background review phase:

Livelihood contexts. An important part of the research involved developing an understanding of crop-livestock interactions within a broader livelihoods perspective. In all field sites, therefore, a detailed profile of existing livelihood systems was carried out. This identified a series of indicators for crop-livestock integration in each site. These were set within broader site descriptions, covering agroecological and socio-economic characteristics (Tables 1 and 2).

Table 1: Site characteristics

	Ethiopia			Mali		Zimbabwe			
	Admencho	**Mundena**	**Chokare**	**Dalongue-bougou**	**Zara-dougou**	**Chipiriro**	**Lower Guruve**	**Ngundu**	**Chiko-mbedzi**
Rainfall (mm/year)	1350-2500	900	500.0	300-450	900-1100	750-1000	350-900	550-800	330-660
Population density (No/km^2)	<500	53.0	23.0	11.0	30.0	71.0	c. 20	45.0	14.0
Cattle ownership (No)	3.5	3.0	14.5	20.0	12.0	4.4	5.1	4.6	9.2
Farm size (ha)	0.6	3.0	1.0	18.5	16.5	4.4	5.1	4.6	9.2
Major crops	Enset, root crops maize	Maize sorghum, cotton	Maize, sorghum	Millet, groundnut, cowpeas	Cotton, maize, millet, cowpea, fruit, groundnut	Maize, cotton	Cotton, gardening	Maize, gardening	Sorghum
Market access	Good	Recent main road	Poor	Poor	Good	Good	Fair	Good	Poor

Table 2: Indicators (% households, hh) of crop-livestock integration

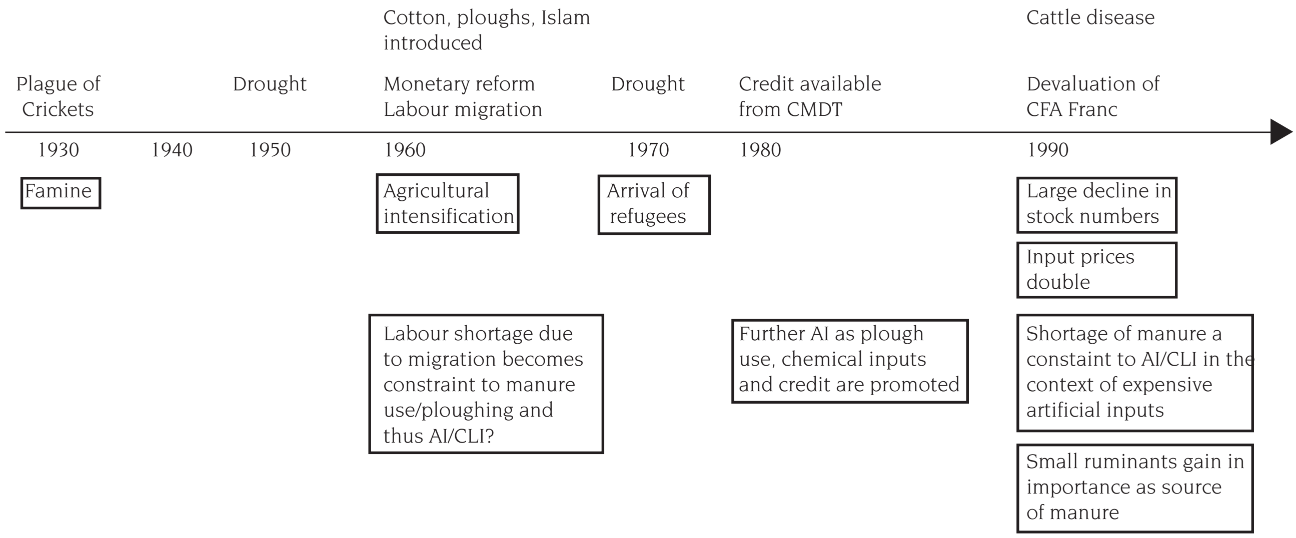
		Ethiopia			Mali		Zimbabwe			
		Admencho	**Mundena**	**Chokare bougou**	**Dalongue-dougou**	**Zara-**	**Chipiriro Guruve**	**Lower**	**Ngundu mbedzi**	**Chiko-**
Soil fertility	Manure use	87	91	11	100 (ss)* 57 (cattle)	75	35	2	50	0
	Fertiliser use	87	83	0	57	81	99	7	39	0
Tillage	Use of draught	96	79	79	100	92	91	49	90	45
Fodder Yes/No	Fodder crops grown	No	No	No	No	Some	No	Yes	No	Limited
(Y/N for practice, or %hh)	Crop residues	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	Cut and carry	Yes	Yes	Yes	Yes	No	92	0	15	4

*ss = smallstock

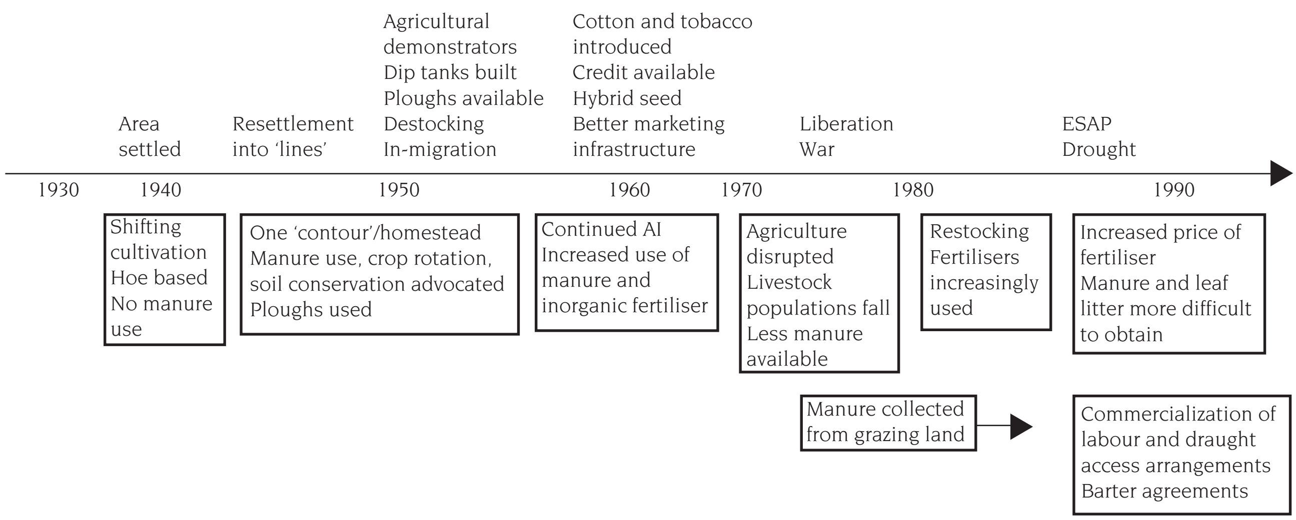
Historical dynamics: The historical precedents of the snapshot picture developed in the analysis of livelihood contexts, in order to understand longer term dynamics of change. Historical analysis of archival records, air photos, reports and other documentary sources was complemented by interviewing key informants in all case study sites. This allowed us to develop a time line of crop-livestock change and, most importantly, to identify key events that had shifted the broad pathway of change at key junctures. For example, in Zimbabwe the combination of structural adjustment and drought in the early 1990s resulted in major shifts in the crop-livestock system, with the growth of hoe-based gardening systems which responded to emerging market opportunities and the lack of draught power. In Mali, the devaluation of the CFA in 1994 had a major impact on the relative profitability of different cropping options. In the cotton zone, this resulted in increasing investment in cotton, but, with major fertiliser price hikes, the soil fertility strategy to support this had to increasingly rely on integrated options, including a rise in demand for manure. In Ethiopia, uncertainty over tenure rights has been a major feature over the last decades. With land reform and villagization in the Derg period, the pattern of settlement and agriculture in the study area changed significantly, with major implications for who controlled land and resources. A selection of such time lines are presented diagrammatically in Figures 1-2 below.

Figures 1-2. Examples of time lines of key events and crop-livestock pathways for Zaradougou, Mali and Chipuriro, Zimbabwe (AI = Agricultural Intensification)

Mali



Zimbabwe



One of the key findings of this historical analysis was that the assumed pathway of change was not linear or predictable. In contrast to conventional analyses that assume a progressive, evolutionary pathway towards a particular type of intensification and associated crop-livestock interaction, a wide range of pathways are evident. These have to be understood in context, as a wide range of factors, both exogenous and endogenous, affect how crops and livestock interact within small-scale farming systems.

Institutional processes. The way access to and control over the resources necessary for crop-livestock farming is mediated was a key aspect of the analysis. The role of institutions , understood as 'regularized patterns of behaviour which persist in society', is key. An institutional analysis pushed us to look at the way informal and formal arrangements interact, allowing different people to gain access to land, labour, draught power, manure, fodder, credit, capital equipment, and information. Thus across the sites informal institutional arrangements for gaining access to land, labour, draught power and manure are key. Table 3 provides a summary of some of the key institutions found in the study sites, across a range of scales from the household to the national level. Table 3 also shows how, in different ways, they mediate access to key resources. Detailed analysis at site level also showed how institutions interact, the power relations embedded in such arrangements and the gaps, conflicts and complementarities between different institutions across scales.

Thus pathways of crop-livestock change are intimately bound up with institutional arrangements. Despite similar agroecologies or comparable demographic patterns, across sites institutional arrangements governing access to resources can vary widely, resulting in quite different pathways of crop-livestock change. Pathways of change are, therefore, not deterministic, but affected by a range of historically located institutional factors.

Actors and differentiated strategies: Just as multiple pathways of change were identified across sites, within sites a whole range of other patterns of difference are found. A differentiated analysis across socio-economic groups highlighted how mainstream policy efforts are often focussed on a relatively small proportion of the whole population. The detailed analysis of the questionnaire survey, together with a range of individual case study profiles of farmers and farm families, highlighted how gender, age, wealth, ethnic and other differences are key to understanding how different people integrate crops and livestock. For example, in Mali ethnic differences in the Sahelian study site between Bambara farmers and Fulani and Maure pastoralists results in highly differentiated strategies. In Ethiopia, possession of wealth, reflected in access to land and draught power, allows very different options to be pursued by individual households. In Zimbabwe, gender differences are important, with women's strategies for managing smallstock, as part of both an individual and household farming enterprise, often underestimated.

Policy implications: Mainstream policy prescriptions across all three countries, reinforced by international research and donor funding, assume a particular pathway of crop-livestock change. This adopts the evolutionary model, that assumes a linear pathway from less to more integration, based on a mixed farming, individualized farm model. This has a long history in policy debates in all three countries (see Wolmer and Scoones, (2000) for a discussion on Zimbabwe), and remains unchallenged because of the dominance of the evolutionary approach to farming and livelihood system change.

This mainstream approach has a number of consequences for the way research and development is thought about and how priorities are set. A review of the research and extension priorities and recommendations in all case study countries revealed how a fairly narrow set of technologies and management techniques, that assumed a particular type of desirable mixed farming system, were on offer. At the same time, reviews in all countries also showed the limited adoption of such recommended approaches.

Typology of Crop-livestock Integration Dynamics in Semi-arid Africa, with Implications for Policy and Devel*pment Interventions

A number of identifiable crop-livestock integration strategies were selected for each site based on this socially differentiated analysis. Table 4 links these broad strategies to the type of technologies and management practices used by the social group who are following these most frequently. Such a summary, of course, conceals many other details, as in many cases individuals and households may pursue several strategies simultaneously. However, the summary data highlight how, in contrast to the standard research and extension recommendations that focus only on a very limited range, there is enormous diversity in strategies and pathways pursued between and within sites.

Table 3: Institutions mediating access to resources required for crop-livestock integration

	Land	**Labour**	**Draught power**	**Livestock**	**Manure**	**Feed**	**Credit equipment**	**Capital**	**Information**
Intra-household	Inheritance Subdivison	Family labour Borrowing/ Loaning	Teaming/ pairing	Inheritance loaning	Gifts	Family labour gifts and loans	Borrowing	Borrowing	Seasonal migration networks
Inter-household groups and practices	Customary access arrangements Sharecropping	Work parties Herding contracts Exchange for land	Work parties Teaming/ pairing Sharecropping Exchange for labour	Bride wealth Loaning Herding contracts	Farmer-herder exchange contracts	Communal grazing Exchange agreements	Savings clubs Farmer groups	Plough sharing Well-digging teams	Seasonal migration networks Farmer groups
Inter-household cash transactions	Local land sale and rental	Hiring	Hiring draught animal power Hiring tractors	Local markets		Local markets	Money lending	Local markets	
Formal organisations	Land tenure legislation	Church work parties	State schemes	NGOs State restocking Formal markets		Commercial feed markets	NGOs Co-ops Banks Parastatals	NGOs State aid	Extension services Vet Depts NGOs parastatals

Table 4. Multiple strategies, multiple pathways: Social difference and crop-livestock integration

Strategy	**Ethiopia**	**Mali**	**Zimbabwe**
Extensification	Rare (unless social network allows access to land)	Common on bush fields (group needs access to land: i.e. all of Zaradougou, only village and visiting Bambara)	Only richer groups in Neshangwe, Chikombedzi (need access to land and labour)
Capital Intensification and 'Mixed Farming'	**Global model:** Common for richer groups (requires infrastructure, extension support)	**Inorganic fertiliser and herd manure:** Common on village fields (needs wells, water-manure contracts, capital for NPK)	**'Mixed farming' model:** Common for richer groups ('Master Farmers') in Chipuriro, Ngundu, Neshangwe
	Irrigation: Rare (irrigable land is nearly all taken)	**Cotton-maize**	**Inorganic fertiliser and/or irrigation:**
	'Mixed farming' model: Common for richer groups	**(CMDT model, Mali Sud)** Only richer households can increase input use > rate of extensification (requires extension support)	Richer groups in all sites (requires contract farming, markets, subsidies, credit) 'Mixed farming' with donkeys and cows, not oxen:
		Cotton-maize, supported Ivoirian *plantations** Common in Zaradougou (requires large labour commitment) * Other off-farm capital sources may be valuable in other villages	Common in Chipuriro Ngundu, Neshangwe (result of migration, *tsetse, or drought*)
Separation Agriculture and Livestock	Common for richer groups	Common for groups without secure access to land (i.e. visiting Bambara)	Common in Neshangwe, Chikombedzi (non-livestock owners)
Labour Intensification	Common for poorer groups	Common for poorer groups	Common for poorer groups
	Common for all on at least *part* of farm	Common for all on at least *part of* farm	
Livestock Extensification & Agricultural Intensification	Common for all	Common for Dalonguébougou's Maures and Fulani (requires water-draught contracts)	Rare (limited by lack of grazing land)
Agricultural Specialisation	Common for all (requires markets)	**Vegetable garden focus** (requires markets, lineage access to *bas fonds*)	**Intensive gardening and 'niche farming':** Common in Ngundu, Chipuriro (requires markets, favours contract farmers and co-ops)
	Vegetable garden focus: Common for poorer groups	**Fruit production focus** (requires capital, markets)	

(Table 4 continued)

Strategy	Ethiopia	Mali	Zimbabwe
Livestock Specialization	**Cattle:**	**Cattle:**	**Cattle:**
	Rare except for richer Sidama (ethnically based livelihood, limited by disease, grazing/fodder)	Rare except for richer Fulani, Maures (ethnically based livelihood, limited by disease, grazing/fodder)	Rare except for richer groups, Chipuriro (pen fattening)
	Replacing Cattle with Smallstock:	**Smallstock fattening:**	**Smallstock fattening:**
	Common for poorer groups (needs markets)	Common for individuals (requires access to markets)	Common in Chikombedzi, Chivi, Chipuriro, especially men (requires local and external markets)
Abandon Agriculture	**Livelihood diversification**	**Livelihood diversification**	**Livelihood diversification**
(as coping or accumulating strategy)	Common for all	Common for all	Common for all
	Migration	**Migration**	**Wage labour:**
	Common especially for young	Common especially for young	Common for poor individuals
			Migration:
			Common for all

Of the range of existing strategies being pursued only a few are currently being supported by research and extension, with a wide range of technology and management options being ignored. In almost all cases the current focus is on the relatively better-off farmers.

The problem with a typology of this sort, however, is that it is static describing simply in a socially differentiated way the range of existing strategies. The historical and institutional analysis identified how things change, with different strategies being adopted over time. These are affected both by key events and by institutional arrangements mediating access to key resources (see above). Such changes, in turn, affect sustainable livelihood and poverty outcomes. The aim of externally generated development interventions are not to reinforce a particular *status quo*, but to encourage changes which reduce poverty and improve the sustainability of livelihoods. Thus in identifying institutional blockages and opportunities for change a range of other entry points for development intervention are identified. While particular technologies and management techniques remain important, a key lesson from the research is that the institutional setting must also be considered. To date this has been almost completely ignored in the development of research and development priorities around crop-livestock issues.

A close analysis of the institutional matrix, differentiated by site and by social group, provides an opportunity for identifying ways in which external interventions focussed on institutional issues might result in greater access to key resources, and so positive shifts in strategies that reduce poverty and improve sustainable livelihoods. Thus, for women farming goats (see above), it may not be a technical intervention that would result in the best outcomes for poverty reduction and sustainable livelihoods, but an institutional intervention that focussed on credit, allowing poorer women to purchase a first female goat and build up a flock. Similarly, an emphasis on land tenure security may be important if particular technologies are to be adopted that require long periods to result in a significant return. For those without access to certain resources, an emphasis on supporting sharing and loaning systems may be important, rather than emphasising a technology, that assumes a particular level of asset ownership (such as two-oxen ploughs, for example). A key aspect of assessing priorities for institutional interventions is the interaction between local, informal and larger (meso-/macro-) formal institutional arrangements. The case study research highlighted how, in a range of cases, too often such interactions were ignored, with external interventions either contradicting or undermining local institutions with detrimental consequences for poor and marginalised groups.

The approach developed by this project that combines a socially differentiated analysis of strategies, with an analysis of pathways of change which takes institutional issues to be central, potentially offers ways of developing a research and extension priority setting approach which takes poverty elimination priorities seriously. Given DFID's and other donors' emphasis on poverty reduction and sustainable livelihoods this could potentially have implications for the direction of funding for research and extension efforts.

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Effects of Harvest and Post Harvest Practices on the Production and Nutritive Value of Maize and Sorghum Residues in Zimbabwe (R6993)

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Abstract

To improve storage of stover for use as dry season cattle feed, roofed stores were built, by the project, and low cost stores have been designed and built by collaborating farmers in one field site. Farmers are also starting to adopt roofed stores at a second field site following extension efforts by the project. Farmers' reasons for being interested in improved stover storage are complex, but protection of stover from dry-season rains emerged consistently as important. Rainfall data suggest that one out of every two or three years dry-season rains could potentially damage stored stover, and farmers think that losses from open stores can be very large. The project has also demonstrated that maize stovers can become contaminated by mycotoxins, probably both before and during storage. It is unclear whether more subtle processes of quality degradation occur in stored stover, whether mycotoxin contamination can reach potentially hazardous levels and to what extent the roofed stores reduce or prevent losses.

Farmers are also interested in protecting stover from the sun, and preserving its nutritional qualities. Experimental evidence from the project does not support the hypotheses that the shade in roofed stores preserves nutritive values better than open stores. However, many farmer comments suggest they value roofed stores for keeping stover "green" and "moist", which may reflect decreased discolouration of stovers at the surface of the stack which possibly affects palatability and nutritive value of a proportion of the stovers in the store. Some farmers also saw roofed stores as a means of extending stover storage into the rainy season; and, in principle, as a means of utilising longer term storage as a hedge against periods of drought.

There appears to be increasing pressure on grazing lands within communal areas, except where formal or informal arrangements with local commercial farmers are possible. As fencing of harvested fields is not developing in either field site, it is expected that the storage of stover will increase as farmers seek to capture the benefits of their crop residues, currently openly grazed. If the development of stover storage is part of a wider process of crop-livestock integration, its adoption may be initially low and uneven, across and within communities.

Background

In Zimbabwean communal areas, native pasture remains the main source of nutrients for livestock in the wet season, whilst residues from crops grown for human food are used in the dry season (Mupunga and Dube, 1993). In Zimbabwe, maize stover is the most plentiful crop residue (Smith *et al.*,1990). For example, in 1987, communal area farmers harvested two million tonnes of maize residues compared to 80,000 tonnes of sorghum residues (Ndlovu and Sibanda,1990).

Crop residues are often wasted or inefficiently used in smallholder farming systems. Harvesting practices can reduce the availability of leaf material, whilst traditional methods of storage of crop residues provide little protection from the rain and sun. During the wet season, crops may be attacked by termites and by fungi capable of producing mycotoxins, whilst out-of-season rainfall can cause leaching of the soluble components, reducing the nutritive value still further. Mycotoxins can seriously affect animal performance and human health as they pass into the food chain through the milk. Previous studies in Zimbabwe, conducted by Wareing and Medlock (1992) at the Natural Resources Institute (NRI), identified a number of potentially mycotic, allergenic and mycotoxigenic species of *Aspergillus*, *Penicillium*, *Fusarium*, *Alternaria*, *Phoma* and *Cryptococcus* in maize and sorghum stovers. However, detailed mycotoxin analysis was not undertaken.

Rainfall And Possible Damage To Stover Quality

The benefits of covered stover stores will depend on the extent of losses which they are preventing, which in turn depends partly on rainfall. Rain followed by mould growth when stover is being stored, normally the June to August "winter" period, can cause severe damage to the stover, which could be largely prevented by using roofed stores. Monthly rainfall data from Matopos Research Station (MRS) was obtained for the 37 years prior to the project (1961 to 1997) to indicate the frequency and extent of winter rainfall and hence give some basis for estimating the benefits of using roofed stores.

Rainfall was recorded in 18 of the 37 years over the June to August period, there being no obvious pattern to the distribution of years with wet winter seasons. However, rainfall in this period is clearly common. Over the 37 year period June to August rainfall averaged 3.7 mm (s.d. 6.48 mm). Above average rainfall fell in 12 of the 37 years, the highest being recorded at 30.6 mm in 1982 (a year with a strong El Niño phenomenon). It is unknown what the relationship is between rainfall and extent of stover damage. Mists can occur which could facilitate mould growth even though recorded rainfall may be low. However, it appears reasonable to conclude that stover is exposed to rain-related damage in one in every two or three years. Protection from the sun, which discolours the stover and may reduce palatability and nutritive value, and increasing the storage period into the start of the wet season are additional advantages which occur every year.

The project purpose was to identify losses in nutrients of stovers harvested and stored under existing conditions and develop improved harvesting and storage practices which reduce these losses.

The three main developmental problems identified were:

(i) Shortage of roughage for cattle in smallholder systems in the dry season resulting in low productivity.

(ii) Low nutritive value of maize and sorghum stovers and contamination with mycotoxins, a potential health hazard.

(iii) Need for improved harvesting and post-harvest storage methods to reduce losses and fungal contamination on-farm.

The project then intended to disseminate improved methods to local farmers and facilitate their dissemination more widely.

Research Activities

Project Strategy

The strategy adopted was to select one field site for the construction of demonstration stores in year 1. Due to time constraints these had to be constructed by the project using materials that would almost certainly be too expensive for smallholder farmers.

In year 2, cheaper structures, using farmer participatory methods would be developed and constructed at the same site. Both years would be used for a technical evaluation of the impact of improved stores on feed quality. Improved techniques would than be extended to a second field site in year 3 using a farmer participatory approach, with level of uptake being an indicator of the appropriateness of the intervention.

Field Site Identification Surveys

Initial survey to identify field sites

The following criteria for selecting a site or sites were proposed:

- reasonable availability of maize and sorghum stover
- average or worse than average grazing pressure
- perceived farmer interest in better/longer storage of stover
- relative ease of access to MRS.

Gulathi is relatively near to MRS, and appeared to be a convenient field site for the work. After an introductory meeting and a series of individual semi-structured interviews with selected farmers, it was concluded that while it might be possible to carry out the research project as planned in Gulathi, it was very likely that better sites could be found, still within a reasonable distance of MRS. The main reason for rejecting Gulathi was a lack of perceived interest in better storage of stover.

It was recommended to carry out rapid appraisals as soon as possible in several further sites, including Bidi, at least one other lowveld location, Silozwi Communal Area, and areas east of the Old Gwanda Road.

Second survey of sites, conducted in Bidi, Irisvale and Silozwi

Supplementary surveys of 9 to 10 farms (per survey) were conducted in each of three areas considered to be likely candidates for the trial introduction and evaluation of improved stores for stovers. In all three areas the farms surveyed had about 2.4 ha under cereals, although at Bidi there was a more diverse range of cereals produced, possibly reflecting lower rainfall which favours production of sorghum and millet, which are more drought tolerant than maize. Other crops were produced in all three areas which can produce nutritionally valuable residues for ruminant feeds. Labour availability and crop residue production appeared to be similar in the three areas, although farm-to-farm differences within areas could be large. Again farm-to-farm differences in livestock holdings could be large, but there tended to be more goats in Bidi, more cattle in Irisvale, while livestock appeared to be generally less important in Silozwi (probably due to the importance of wood carving and craft activities linked to the Silozwi National Park tourist industry). These conclusions were also supported by the regional livestock data and general overviews of the three districts.

All the farmers agreed that the August to November period was when grazing was most restricted, and hence when stored stovers may be particularly useful. Stovers may be grazed in fields in August and September and taken from storage from September to November. Several farmers mentioned the belief that the first green flush of browse in the first two to four weeks of the rains can be harmful to animals, and hence that having stored stover to feed during this period can be advantageous. Since the 1992 drought led to the deaths of much livestock, particularly cattle, farmers also appear to be interested in storing feed as a hedge against future droughts.

Eight of nine farmers at Bidi stored stover, 9 of 10 at Irisvale and 9 of 10 at Silozwi (although it was said that stover storage was not so common here). Hence the storage of some stover is widely practiced in all three areas. Raised platforms ("Ingalani") in kraals are used for storage in Bidi, in Irisvale storage methods also include storage in bags and in an old water tank, while in Silozwi rocks are widely used as bases for storage. Practices between farms are variable.

All the farmers interviewed expressed an interest in improved and extended stover storage. The increased storage periods of interest ranged from 1 month to 1 year. At all three sites at least one farmer expressed interest in storing stover for as long as one year as a hedge against drought. Early/dry season rains and the effects of the sun were seen as the major reasons for storage by nearly all farmers. Late rains also caused some spoilage. Lack of labour was a commonly given reason for not improving stores, lack of money, know-how and not thinking about it were other reasons.

Sites where improved and possibly extended storage of stovers is most likely to be of use to farmers, and hence is most likely to be adopted, will be where:

- livestock, particularly cattle, are important
- cereals are grown on a sufficient scale to generate enough stovers for storage
- alternative dry season feeds are in limited supply
- where droughts could lead to losses of livestock.

All three of the sites surveyed had some of the desired characteristics. Bidi appeared to be the most marginal of the three sites, and appeared at the time to be the most suitable of the three for introducing improved storage. Although cattle numbers are currently fairly low due to losses in the 1992 drought, they are said to be increasing, due to increasing calving rates and purchases. Irisvale also appeared suitable, but its status as a Resettlement Area and information (subsequently revealed to be unfounded) on large-scale restocking loans of cattle from a parastatal appeared to be complicating factors. Silozwi was perhaps the least suitable as livestock appears to be a less important element of the mixed farming here, although it is said that cattle numbers are set to increase as more grazing land is being made available.

Therefore Bidi was chosen as the site for the initial trials, with Irisvale chosen for later farmer participatory trials.

Surveys of **Bidi District**

Identification of farms for initial trials

Further survey work was undertaken in April 1998 to identify 10 farms in Bidi which would be suitable and willing to collaborate with the first round of trials. A wider survey, conducted later, selected farms in Bidi more randomly to investigate harvesting practices and possible improvements. As the stover would need to be stored within a matter of weeks of identifying the collaborating farms, it was decided that the stores (Mark 1) would be constructed as quickly as possible to an essentially identical design on the 10 collaborating farms using materials which can be obtained quickly. This had the result that the first round of trials were with store designs too expensive for farmers to afford unassisted.

The initial trials demonstrated the impact of roofed stores. Maize stover is relatively large and heterogeneous compared to materials such as grains or maize cobs. Representative sampling was, therefore, of critical importance, but there was no scientific evidence to indicate a suitable sampling protocol. A major aim of the first years' trial was therefore to provide data on which the first year's protocol could be evaluated and an improved protocol identified, if required.

The 10 farms collaborating with the on-farm storage trial were identified by the local extension worker. The initial stover sample was taken and existing storage facilities reviewed. In all cases the harvest was much further advanced than was usual at that time of year because the rains stopped early, in January instead of March or April. As a result, the late sown maize had largely dried early in the fields, making the harvest poor. This had several implications. The early harvest limited the time available for the planning and construction of improved stores. The stovers were going into storage much drier than usual, making the leaf material more likely to fragment and be lost. Risk of mould attack and mycotoxin accumulation were conversely greatly reduced for this initial period. Stover (as well as grain) production was appreciably reduced. Green grazing was already starting to dry out, earlier than usual, indicating that stovers would have to be used earlier than usual. Therefore, particular pressure on feed resources such as stovers was anticipated during the 1998 dry season.

Outline designs were prepared for 5 x 4 m stores (for eight of the collaborating farms where space was not restricted) and for 3 x 3 m stores (for farms 4 and 10). The designs consisted of a corrugated asbestos sheeting roof supported by treated gum tree poles, materials purchased locally but probably too expensive for farmers to use for this purpose (although they are used for house construction). The larger stores cost about Z$7,000 in materials (about £256 at the then prevailing exchange rate).

Stover leaves are generally the most nutritious part of the stovers. However, this material can be lost during handling and storage reducing the nutritive value of the stover as a whole. All 10 participating farmers were asked whether, and confirmed that, leaf loss from stovers was a problem and what steps they took to reduce it. Fragmented leaves were very much in evidence in the fields and farmers were aware of their value as a feed. This material is grazed in the fields, so it is not necessarily all lost if it does fragment from the stover. Farmers will also pick up the material if possible and feed it to cattle. Leaf loss was a particular problem in 1998 due to the exceptionally dry conditions. Normally the stover leaves are still a little moist when they are stored which reduces leaf loss. Stovers can also be handled after rain or early in the morning, when there is a dew, as the leaves are moistened to minimise losses. Fencing can be used to trap leaves, but collecting the material is laborious. None of the farmers could suggest a practical way of reducing leaf loss under such dry conditions and it is difficult to see what can be done as the leaves dry out very much faster than the stems. As the stems must be dried enough to prevent mould damage the leaves must inevitably be very well dried and liable to fragment. There was awareness amongst the farmers that moist leaves were less likely to be lost by fragmentation.

Construction of Mark 2 Stores

Ten further households were identified to collaborate with the introduction of lower cost, Mark 2, roofed stover stores. They were asked to design their own stores using materials which were available to them. The project gave some assistance with the provision of some materials and labour if required, but the Mark 2 design was intended to be suitable for adoption without external subsidies. The collaborating farmers were all aware of the Mark 1 improved stores. The availability of thatching grass for the roof and the three longer mopane poles for the central supports of the structure (for a ridge style roof) were seen as the major constraints. The problem with thatching grass is that it has to be gathered (usually from Matobo National Park) almost a year in advance of store construction. These materials were, therefore, supplied in part by the project to facilitate the construction of these stores.

Stover Sampling and Laboratory Evaluation

A sampling protocol, based on earlier experiences of other commodities, were proposed for 1998. Based on the data obtained, a revised sampling protocol and experimental design was used in 1999. The samples obtained were coarsely ground, in Zimbabwe, after further drying as required. They were air-freighted to the UK where they were divided, ground to 1 mm as required, and stored in a chill store at 4°C prior to analysis.

Ideally, the stover in the store would have been left undisturbed between sampling times. In the on-farm situation this was not possible as farmers had to start using the stover towards the end of the storage period. Sampling, therefore, depended on the stover being mixed in the store. Farmers had been requested to do this, but this was not controlled by experimenters. The trial, therefore, represents a compromise between the advantages of on-farm trials in getting farmer reaction and realistic conditions, and the needs of scientific evaluation of stover quality.

Stover sampling 1998

For each farm, a sample of 50 stovers (about 5 kg) was taken systematically from the maize stover available on the farm, to give a composite sample representative of the stover as a whole. Samples were taken in April, immediately after harvest when it was still in the fields (standing or stooked), in June at the start of storage, and in September towards the end of the storage period. In June and September samples were taken from the roofed and traditional open stores from each farm. The June sample from the open store was collected as ten samples of 5 stovers each, taken from different parts of the store in order to estimate the variability of the samples (Fig 1).

Stover sampling 1999

Based on data from the 1998 sampling, a revised sampling protocol was put into effect in 1999. Three farms were selected from the 10 with Mark 2 stores. Ten replicate samples were taken from each store (traditional open store and the Mark 2 roofed store) at each of 2 sampling times, at the beginning (26–30 July 1999) and towards the end of the storage period (from 13 November 1999). The samples were dried and comminuted at MRS and shipped to NRI.

Laboratory Evaluation of Stover Samples

Stover samples were analysed for chemical composition, *in vitro* digestibility (by the gas production method) and for mycotoxins.

In vitro gas production

The protocol is based on the Theodorou *et al.* (1994) method. Gas production data was fitted to the France *et al.* (1993) model which estimates two rate constants, lag time and end point gas production. Additionally, dry matter disappearance (DMD) at the end of the 96 h incubation period was estimated by filtration. Means were calculated and ANOVA undertaken using Genstat. Data for the DMD, cumulative gas production after 96h incubation (CG96) and rate constant b of the France *et al.* (1993) model were analysed to explore differences between the samples.

Laboratory methods

Samples were analysed for moisture, acid detergent fibre (ADF), ash and crude protein by conventional methods.

Mycotoxins: In the first instance, a representative subsample was collected from each 1kg sample, and the samples combined to afford a composite sample, which was screened for mycotoxin contamination. The balance of each 1kg sample was further analysed if the composite sample contained significant levels of mycotoxin(s).

Figure 1 Sampling plan for collection of samples of maize stover

Each store to be sampled as follows:

1. Each 1kg sample to be composed of 10 stovers collected randomly from throughout the store, as follows:

— Divide the store, lengthwise, into *ten equal segments* using long canes as markers

— Beginning at one end of the store, collect a single stover from the *first segment*, as follows:

➢ Use three cards numbered 1, 2 and 3 to identify the sampling point within each segment

➢ **Firstly, randomly select** one **of the cards to identify the *surface* (NB samples are not collected from the two end surfaces):**

- Card numbered 1 = select near surface (to the person with the cards)
- Card numbered 2 = select top surface
- Card numbered 3 = select far surface

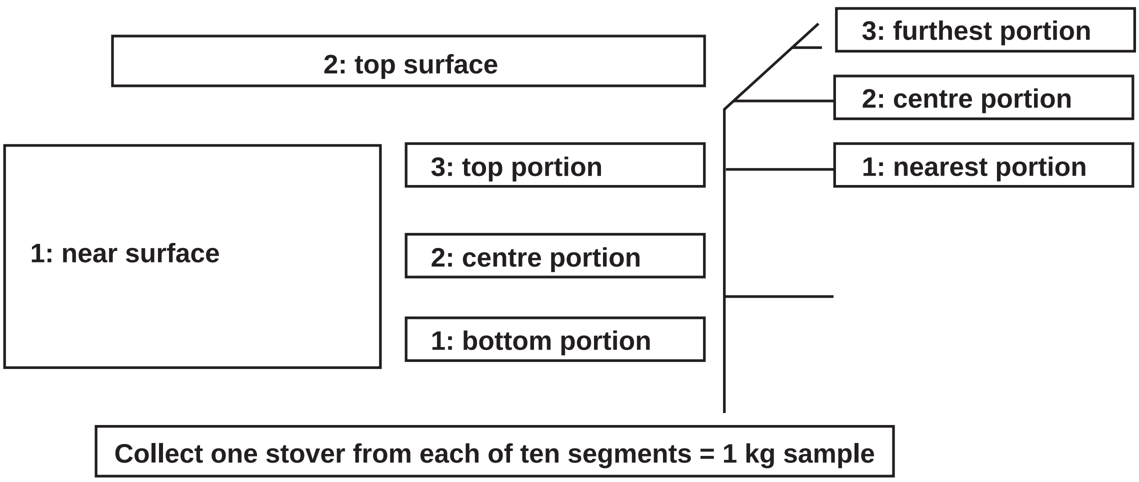
➢ **Secondly, randomly select** one **of the cards to identify the *portion* of the selected surface, assuming that each surface is divided into *three equal portions*:**

- Card numbered 1 = select bottom portion of near/far surface, or nearest portion of top surface (to the person with the cards)
- Card numbered 2 = select centre portion of any surface
- Card numbered 3 = select top portion of near/far surface, or furthest portion of top surface

➢ **Collect a** single stover**, from the identified *sampling point*, by removing the stover from any point within the selected portion**

2. Repeat the process for each of the *ten segments*, in order to produce a 1kg sample

3. Repeat the above steps, collecting a total of 10 x 1kg **samples from each store**



The following mycotoxins were determined using standard operating procedures, involving a combination of solid phase extraction clean-up and high performance thin layer chromatography (HPTLC) or high performance liquid chromatography (HPLC): aflatoxins B_1, B_2, G_1 and G_2, fumonisin B_1, deoxynivalenol, T-2 toxin, zearalenone, and ochratoxin A.

Survey of Farmer Opinions on Roofed Stover Stores in Bidi

All nine farmers building Mark 2 stores were interviewed in depth, by semi-structured checklist In September 1999, and eight Re-interviewed by checklist in February 2000. They were also interviewed during the questionnaire survey of November 1999, which allowed comparison of them to Bidi averages by several key parameters.

Wider Survey of Farmers in Bidi and Irisvale

Because the site identification exercise had tended to interview farmers already interested in stover storage, and because both phases of on-farm experimentation had used self-selected farmers, it was important to gain information on the extent and distribution of stover-related problems, and the potential for uptake of improved stores, from a more representative cross-section of farmers. An initial randomly sampled survey of 40 farmers in Bidi during the 1998 storage season was probably over-ambitious in design and failed to reveal significant patterns because of the very poor harvest. A simplified questionnaire survey was carried out in November-December 1999 with 31 farmers in Bidi and 41 farmers in irisvale. In 1998 Bidi farmers had been drawn at random from a list kept by the extension worker, partly for relief distribution purposes. Some names that did not represent functioning agricultural households (absentees and destitute old people) were excluded. Although imperfect, this sample was revisited in 1999 for convenience.

Irisvale, as a resettlement area, had centralised and reliable lists that could be used. The second then every sixth household was selected to give a total of 42 households. The survey asked a series of questions to obtain data on adult labour availability, crops planted, livestock holdings, crop residue storage, problems in storage and use.

Farmer Participatory Trials in Irisvale

This component was designed as an on-farm participatory trial, where the project would provide technical advice but would not subsidise any inputs of either materials or labour. It was planned to start extension activities in Irisvale in August 1999 with a field day in Bidi, to introduce the covered stores to Irisvale farmers and to allow farmer-to-farmer contact. In the event, a familiarisation visit to Irisvale in May 1999 found that one Mark 2 style roofed store was already at an advanced state of construction following extension activities by MRS and NRI staff.

The field day in Bidi was organised for 25 August 1999, with 211 people attending. These were mainly farmers from Irisvale, but included collaborating farmers from Bidi, Agritex extension staff, Natural Resources Board staff and chief's representatives. Three farms were visited, two with Mark 2 roofed stores, and one with a Mark 1 store. The three farmers described their experiences with the stores. Additionally, Mrs Mabel Ncube, the farmer from Irisvale who had constructed a roofed store, was asked to talk on her experiences with it. Presentations described the benefits of stover storage, the benefits of using roofed stores and methods of constructing them. There was opportunity for farmers to discuss the stores after the presentations and over lunch, provided at one of the collaborating farms.

Survey of Irisvale to Investigate Actual Levels of Uptake of Improved Stover Stores

In May 2000 project staff attempted to trace all the farmers in irisvale who had built or begun to build, improved stores, and interviewed them with a short checklist. Beside the farmer who had already built in 1999, two farmers had completed stores, 12 had begun building, and one could be judged about to build, a total of 16 farmers, or 6% of the irisvale population of 254 households. Another seven farmers who had considered building stores but abandoned the idea, were also interviewed with a modified checklist. Of these, three abandoned their plans in, or before, January 2000, and two in April-May 2000; no clear reasons were given by the other four.

Results and Discussion

Construction of Mark 2 Stores

Eight of the farmers constructed Mark 2 stores in 1999 as, spontaneously, did one of the farmers with a Mark 1 store. Seven provided (from the family or by hiring in) all the necessary labour, and two needed some assistance from the project due to labour shortages. Stores varied in sizes and dimensions depending on the capacities required by the farmers, the space available and their design preferences. The largest was about 7m x 5m, the smallest about 3m x 4m. Platforms were of a traditional style, but usually about 300 mm from the ground (lower than traditional platforms to increase the storage capacity). There were two styles of roof, one with a central ridge pole, the other more like a traditional hut roof with no ridge pole. Some had support poles at the centre, others not. A ridge pole was more popular for the larger stores.

Many of the materials such as poles can be gathered or were already lying around homesteads (such as string or nails). Six of the nine Mark 2 farmers used some hired labour, in most cases for the specialist task of thatching. The remaining three used only family labour, not costed in budgets reported to the project. As a result of all these factors, plus the variation in store sizes, reported cash outlays on building stores varied widely, from Z$20 to Z$2540, with an average of Z$1100 (approximately £20). This figure does not take into account the cost of the materials (main uprights and thatching grass) supplied by the project.

For illustration, the highest budget for a Mark 2 single store is given in Table 1.

Table 1: Construction costs for low cost (Mark 2) roofed stover store

	Z$
Nails	635
Long poles	250
Short poles	325
Beer	200
Roofing work	300
Thatching work	600
String	230
Total	2540 (approximately £42)

Labour for cutting poles, 2 days, not included

Irisvale farmers building stores during the 2000 storage season reported figures between Z$400 and Z$1500.

Laboratory Evaluation of 1998 Stover Samples

The complete sample set was obtained from eight of the collaborating farms. One farm was withdrawn from the experiment due to poor collaboration, all the stover in the open store was used at sampling time 3 for a second farm. Only data from the eight complete data sets are reported here.

In vitro gas production and composition

The extent of digestibility of the stover was estimated by DMD, rate constant b estimates its rate. Differences between farms, between treatments and between sampling times, and interactions between them, were highly significant ($P<0.001$) for both DMD and rate constant b (and similarly for other gas production parameters not shown here). Figures 2 and 3 show the overall trend across farms for DMD and rate constant b. There was on average a decline in both values from sampling time 1 to time 2, from the field to the start of storage, then an increase during storage which was similar for both stores.

The composition data (Table 2) indicated that there was a trend for crude protein (CP) content to decrease with time, and ash content to increase. This was consistent with the loss of leaf material with time leading to a reduction in CP, and dust blown onto the stover could account for the rising ash content. There were no apparent trends in either measure of fibre.

t-tests conducted on the composition data on samples from the two stores indicated no differences ($P>0.05$) between stovers in the open and covered stores at either sampling times 2 or 3 in respect of their ash, CP or NDF content. Differences in ADF contents achieved significance ($P<0.05$) at both times 2 and 3, with the ADF of the sample from the covered store being greater than that from the open store at both times.

Figure 2: Plot of mean values of *in vitro* DMD across farms for roofed and open stores

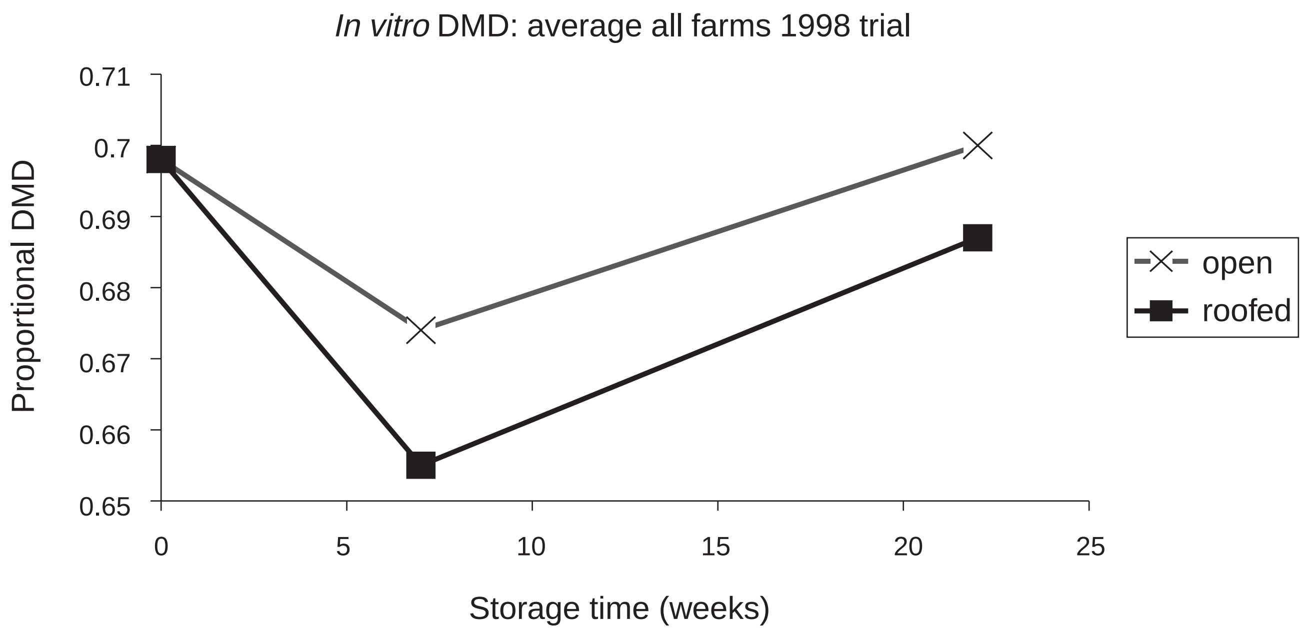


Figure 3: Plot of mean values of *in vitro* DMD across farms for roofed and open stores

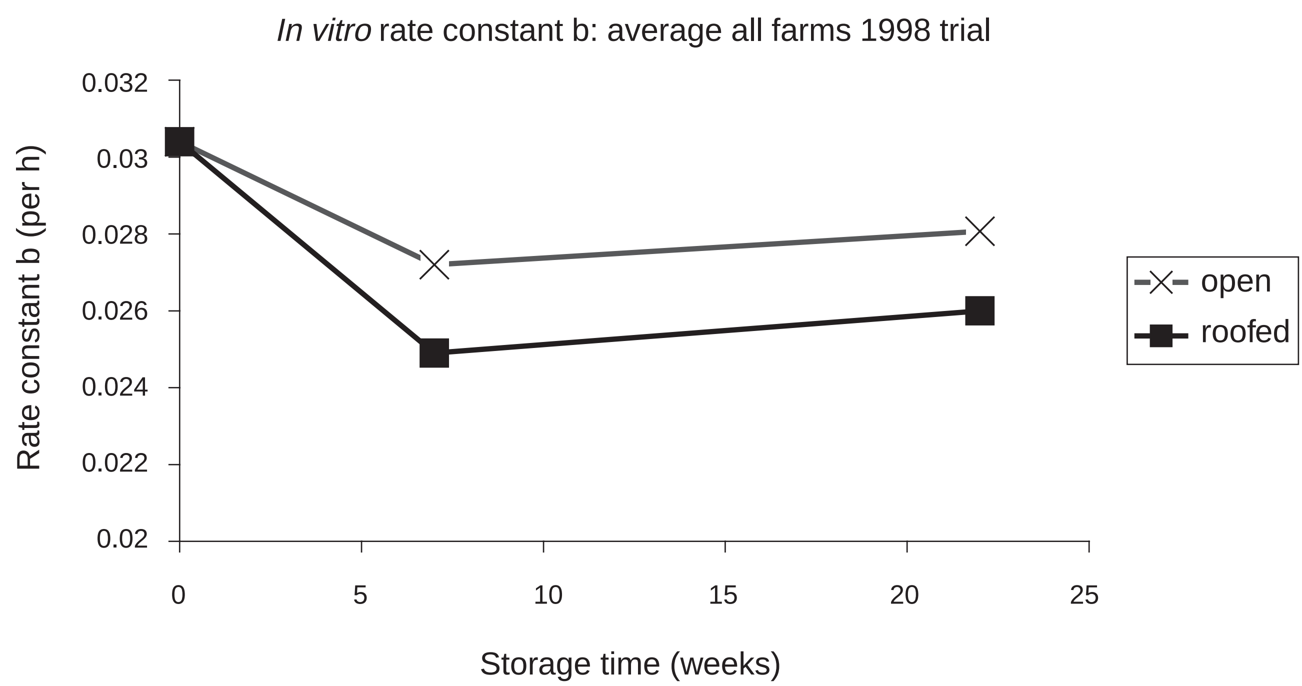


Table 2: Chemical Composition of stovers, averaged over farms (g Kg^{-1})

Store/time	Ash	Crude Protein	NDF	ADF
Time 1/in field	93	56	768	473
Time 2/open	101	38	783	488
Time 2/covered	114	42	800	513
Time 3/open	109	35	759	472
Time 3/covered	132	35	774	488
Time 2 both stores	108	40	791	500
Time 3 both stores	121	35	767	480

Overall, *in vitro* gas production and composition data indicated differences between the stover put into the open and roofed stores. There was no strong or consistent evidence that the stores themselves were affecting the *in vitro* digestibility or composition of the stover during storage between sampling times 2 and 3.

Mycotoxins

No mycotoxins were detected in the composite samples of stover collected in 1998.

Laboratory Evaluation of Stover Samples 1999

In vitro gas production and composition

Individual t-tests at the beginning and the end of the experiment, comparing open and covered stores at each time were used to estimate if differences were statistically significant ($P<0.05$; Table 3). Gas production parameters indicated no significant differences between stovers in the two stores at the first sampling time. Data indicated that the DMD of stover in the roofed store had higher values ($P<0.05$) than that in the open store in Farms 28 and 30, but there were no differences in Farm 22.

At Farm 30, DMD was significantly different at the beginning and end of the sampling period. With the initial values used as a covariate there were still differences ($P<0.05$) at the end of the experiment, with the open store giving higher values than the covered store. Looking at the responses of Farms 22 and 28, Farm 28 showed a trend of moving from no significant difference between stores to a significant difference at the end of the experiment, with stover in the covered store giving an increased gas production. However, this trend was not apparent in the DMD data which indicated higher initial DMD for the stover in the open store but no differences at the end of storage. In both cases differences were relatively small. Farm 22 showed no difference ($P<0.05$) throughout the storage period.

Table 3: Separate comparisons at beginning and end between new and existing stores: in vitro gas production

Variable	Farm	*Late July 99*		*Mid Nov 99*	
		Open	*Covered*	*Open*	*Covered*
DMD	28	**0.698**[a]	**0.711**[a]	0.703	0.699
	30	**0.662**[b]	**0.695**[b]	**0.696**[c]	**0.714**[c]
	22	0.653	0.645	0.664	0.670
B	28	0.027	0.028	**0.031**[d]	**0.028**[d]
	30	0.031	0.032	**0.029**[e]	**0.032**[e]
	22	0.030	0.028	0.031	0.031

Statistically significant differences ($P<0.05$) between pairs of values shown in bold with same superscript.

Mean values for the chemical components of the stovers sampled are given in Table 4 together with the statistical significance of the differences between stovers from open and roofed stores at the beginning and end of the storage periods.

Table 4: Separate comparisons at beginning and end between new and existing stores: chemical composition

Variable	Farm	*Late July 99*		*Mid Nov 99*	
		Open	*Covered*	*Open*	*Covered*
CP	28	21.9	24.4	22.9	22.3
	30	**20.6**[a]	**27.5**[a]	**19.8**[b]	**22.9**[b]
	22	37.6	38.6	35.6	34.8
ADF	28	468	456	**495**[c]	**476**[c]
	30	**522**[d]	**490**[d]	**507**[e]	**484**[e]
	22	538	525	553	530
Ash	28	**110.2**[f]	**90.6**[f]	**141.8**[g]	**106.6**[g]
	30	**154.5**[h]	**126.7**[h]	115.7	117.9
	22	193.8	172.8	177.5	160.7

Statistically significant differences ($P<0.05$) *between pairs of values show in bold with same superscript.*

Trends differed between the three farms. Samples from Farm 22 did not differ ($P>0.05$) between stores at the beginning or end of storage, neither were there differences ($P>0.05$) between stovers from the same store sampled at different times. On Farm 28, similarly, no differences ($P>0.05$) were observed in CP. For ADF, values rose during storage ($P<0.05$) in both stores. Ash content fell in both stores. There were large differences in CP, ADF and ash for stovers in the open and covered stores at the start of the storage period (all differences significant, $P<0.01$) for Farm 30. However, there was little evidence of changes during storage, only the differences in ash content for samples from the open store achieving significance ($P<0.05$).

For none of the parameters analysed were there consistent improvements in *in vitro* digestibility associated with storage in either the covered or open stores. Differences observed were relatively small, and probably of little or no practical consequence even when statistical significance was achieved. From the 1999 data it was concluded that, under the weather conditions prevailing at the time of the trial, there were no demonstrable differences between the performance of the open and covered stores.

Mycotoxins

The mycotoxin contents of the composite and 1kg samples of comminuted stover, collected in 1999, are described in Tables 5 and 6 below.

Table 5 Mycotoxin Result (µg/kg), combined samples, Time 1, 1999.

	Farm/ Store Type					
Mycotoxin	**Farm 28 open**	**Farm 28 covered**	**Farm 30 open**	**Farm 30 covered**	**Farm 22 open**	**Farm 22 covered**
Aflatoxin B_1	0	0	0	0	0.8	1.6
Aflatoxin B_2	0	0	0	0	0	0
Aflatoxin G_1	0	0	0	0	0	0
Aflatoxin G_2	0	0	0	0	0	0
Fumonisin B_1	109	267	129	116	199	752
Zearalenone	0	0	0	0	65	73

The interpretation of the data is based upon the assumption that each of the participating farmers evenly distributed their stover between their traditional and Mark 2 stores, as requested. Furthermore, since the stores were not dismantled during sampling, the samples collected during Visit 1 were, unavoidably, collected from the exterior of the stack. However, given the freshness of the stack it may be assumed that the samples collected were reasonably representative of the whole store. Moreover, a significant proportion of the individual stovers collected extended into the heart of the store.

The Time 2 composite samples contained low levels of ochratoxin A and aflatoxin B_1, and higher levels of fumonisin B_1 (Farms 22 & 28). Zearalenone occurred at the highest concentration (especially the traditional store at Farm 22). The balance of the 1kg samples collected from the traditional store at Farm 22 were also additionally analysed for zearalenone. The contamination range was 40 to 609 μg/kg, with a mean of 279 μg/kg, which corresponded closely to the zearalenone content of the composite sample (268 μg/kg).

Given the results for Time 2, and the relative potencies of the toxins, the composite samples generated by the Time 1 sampling visit were analysed for the aflatoxins, fumonisin B_1 and zearalenone. The samples from both stores at Farm 22 contained low levels of aflatoxin B_1 and higher levels of zearalenone, whereas all the farm stores were contaminated with fumonisin B_1. The highest level of the latter occurred within the Mark 2 store of Farm 22.

Table 6: Mycotoxin Result (μg/kg), combined samples, Time 2, 1999.

	Farm/ Store Type					
Mycotoxin	**Farm 28 open**	**Farm 28 covered**	**Farm 30 open**	**Farm 30 covered**	**Farm 22 open**	**Farm 22 covered**
Aflatoxin B_1	0.5	0.9	0.3	2.1	0	0.3
Aflatoxin B_2	0	0	0	0	0	0
Aflatoxin G_1	0	0	0	0	0	0
Aflatoxin G_2	0	0	0	0	0	0
Fumonisin B_1	32	24	0	0	11	38
Ochratoxin A	0	4.3	0	3.8	0	2.2
Deoxynivalenol	0	0	0	0	0	0
T-2 Toxin	0	0	0	0	0	0
Zearalenone						
a) Combined	135	0	47	10	**268**	73

'0' = Not detected

The following conclusions may be drawn:

- All farm stores were contaminated with low levels of aflatoxin B_1 and fumonisin B_1. However, the apparent reduction in fumonisin B_1 levels during storage could reflect the changes in the composition of the store that occurred between the two sampling visits, rather than toxin degradation
- All farm stores, apart from the Mark 2 store at Farm 28, were contaminated with zearalenone. It appears that the zearalenone content of the traditional stores at each of the participating farms increased significantly between visits although, again, the increased levels could reflect changes in the composition of the store that occurred between the two sampling visits rather than a real increase in contamination
- All levels of contamination were below those considered hazardous to livestock, or hazardous to humans consuming livestock products, as defined by national and international regulations and guidelines.

Rainfall in 1998 and 1999

Rainfall data for Kezi, the district administrative centre for Bidi, is given in Table 7 for 1998 and 1999. For both years there was no rain at all in the April to August period. Rainfall in September was very low, in October there were some heavy rains (>10mm in a day). In 1998, the stover sampled at the latest sampling time had not been rained on at all during storage, while in 1999 the stover had been exposed to one heavy day's rain (13.5 mm on 27 October 1999) and light rain (3 mm of rain or less) on a total of six days from late September to the mid November 1999 sampling.

Therefore, the lack of differences in the performance of the open and roofed stores was probably due to the lack of rain to facilitate a true test of the stores' performance.

Table 7: Monthly rainfall (mm) at Kezi for 1998 and 1999. (Months when stover sampled shown in bold)

Year	1998	1999
Jan	165.3	108.1
Feb	14.0	60.2
Mar	25.6	48.0
Apr	**0**	0
May	0	0
June	**0**	0
July	0	**0**
Aug	0	0
Sep	**1.0**	1.3
Oct	29.0	16.5
Nov	65.3	**107**.0
Dec	137.8	93.8
Total	438.0	434.9

Questionnaire Surveys of Farmers in Bidi and Irisvale

Key findings in each site are summarised and compared below (Table 8):

Table 8: Summary and comparison of key findings, Bidi and Irisvale (hh=household)

	Bidi (n=31)	Irisvale (n=41)
Average number of adults available for work on farm	4.1	3.4
hh keeping cattle*	26%	88%
Average cattle holding	12.50 (cattle-owning hhs)	18.06 (cattle-owning hhs)
	3.23 (all hhs)	15.85 (all hhs)
Average goat holding	10.74	5.34
Average donkey holding	3.29	1.85
hh buying livestock feed	0%	34%
hh buying livestock salt	19%	7%
Planting choices – cereals	97% planting maize, sorghum, pearl millet. 16% households planting finger millet.	100% planting maize. 13% planting sorghum, 5% planting pearl millet
Planting choices- other	94% bambara nut, 84% groundnut.	82% bambara nut, 72% groundnut.
	Cowpea, sunflower	Cowpea, sweet potato, sunflower, sugar peas, coffee
area of maize, ha	0.7	2.4
area of sorghum, ha	0.8	n/a**
area of groundnut, ha	0.3	0.2
area of bambara nut, ha	0.3	0.3
Average total planted area, ha	2.8	3.1

Table 8 continued

	Bidi (n=31)	Irisvale (n=41)
Major cultivation problems - maize	1. drought/poor rainfall too much rain/waterlogging 2. poor fertility/lack of fertiliser/ manure	1. drought/poor rainfall stalkborer 2. poor fertility/lack of fertiliser/manure
hh using traditional stoves (ingalanis) -maize	26%	21%
hh using traditional ingalanis - sorghum	19%	0%
hh using traditional ingalanis - groundnut	29%	1%
hh who had heard of roofed stores	84%	49%
hh who had seen roofed stores	71%	39%
hh building or planning to build roofed stores	23%	15%
Reasons for not having built roofed stores	shortage of time/labour shortage of grass 3. no animals	Shortage of time/labour Shortage of grass Lack of info./confidence
hh storing green stover/ stover from green maize	1%	0%
hh reporting spending time or money building/repairing stores	13%	24%
hh salting, chopping or mixing stover	19%	27%
hh recording losses of stored stover	26%	1%
Months stover most likely to be fed from store	September October August	1. September October 3. August
Months stover most likely to be named as most	1. September 1. October 3. August	1. September 2. October 3. August
hh who would like to feed stover into November	16%	7%

**Bidi data expressed as percentages; n=31. Irisvale data expressed as percentages; n=39 for questions relating to 1998 crop planting and 1999 residue storage specifically, and n=41 for other questions.*

*** Only 5 farmers in Irisvale cultivated sorghum, with a total area of 1.4 hectares, a negligible amount when averaged across 39 farmers.*

Storage practices and problems

Responses on crop residue storage practices (Table 9) underestimate the extent, virtually universal, to which crop residues are grazed in the field. Assuming no-responses indicate no storage structures, these figures show that traditional ingalanis (open platforms) and other storage structures are only maintained by about 25% of households in Bidi, 20% in Irisvale (with a further 20% improvising storage in huts, kraals or gardens around the homestead in Irisvale). The table allows for a small number of multiple responses. “Other” refers either to storing residues in a goatshed, or in feeding to goats immediately after picking (of groundnuts).

Table 9: Crop residue storage practices (hh=households)

Practice	Maize	Sorghum	Ground-nut	Maize	Sorghum	Groundnut
		Bidi			Irisvale	
hh responding	25	27	25	37	3	27
Grazed in field	13	21	9	21	3	15
Stored in tree	5	1	6	1	0	0
Traditional store (Ingalani)	8	6	9	8	0	2
Roofed Ingalani	1	1	0	0	0	1
Other/unclear	1	0	2	8	0	9

In Bidi, 26 of the households had heard of roofed stover stores and 22 had seen a roofed store, not surprising given project activity over two storage seasons. Two households claimed to be building stores, and five were planning or wishing to build stores. Of all those building, wishing or planning to build, plus the Mk2 household in the sample, only three were cattle-keepers. Sixteen households (including one building and one planning to build) gave clear answers as to why they had not built stores: most important were lack of time or labour, and difficulty in obtaining thatching grass. However, such reasons are likely to work in combination, and it is probable that lack of animals was an unspoken reason for many households.

In Irisvale, 20 of the households had heard of roofed stover stores and 16 had seen a roofed store. Two households were building stores, and four were planning or wishing to build stores. Fourteen households (including one building and one planning to build) gave clear answers as to why they had not built stores: most important were lack of time or labour, and difficulty in obtaining thatching grass (table 10). However, such reasons are likely to work in combination.

In Bidi, 4 households had suffered unintended losses of stored stover to livestock (one when a groundnut hay store fell down in the wind). Four households reported other forms of storage loss: to sun (two households – to sorghum and to groundnut), termites and “weevils” (all three crops), and aphids (sorghum). Spoilt stover was put in the kraal in one case. Four households in Irisvale reported losses of stored maize stover (two from rain, one from sun, one from termites). None reported losses of stored sorghum stover or groundnut hay. Spoilt stover was used as manure in three cases, put in the kraal in one case.

Table 10: Reasons, given by householders for Not Building Roofed Stores

Reason	Bidi	Irisvale
Shortage of time/labour	4	6*
Shortage of grass	4*	3
Shortage of poles	1	0
Lack of information/ confidence	2	2
No animals	3	0
Waiting for MRS to build	2	0
Shortage of money	0	1
No scotchcart	0	1

** included households building or planning to build.*

The months during which stover from the store was fed, and the months during which stored stover was the most important feed for livestock, are given in Table 11.

Table 11: Storage Calendars, Bidi (hh=households)

	Months	J	A	S	O	N
Bidi	hh reporting stover fed from store	4	6	9	8	4
	hh reporting stover most important feed	1	4	11	11	3
Irisvale	hh reporting stover fed from store	1	9	12	12	6
	hh reporting stover most important feed	0	3	12	11	2

This can be compared to data on when farmers practice in-field grazing of stover (Table 12, taken from the non-random rapid appraisals of 9 farmers in early 1999 in Bidi, 10 farmers in early 1998 in Irisvale).

Table 12: Use of in-field grazing (hh=household)

	Months	J	J	A	S	O	N
Bidi	hh reporting use of in-field grazing	0	1	5	7	5	0
Irisvale	hh reporting use of in-field grazing	2	6	7	7	3	1

Five households in Bidi, three in Irisvale, would like to continue feeding stover into November; the implication is that they are unable to do so because of storage losses or insufficient stover being available. If the data are reliable, this finding puts into context previous findings from informal surveys that feeding stover at the end of the dry season and at the very beginning of the rains is important: in practice a small proportion of a random sample of farmers have enough stover to do this.

As could be expected from Irisvale's relatively privileged status as a Resettlement Area, there are major differences between the two sites. Bidi farmers, still apparently not recovered from cattle losses in 1991-92, have now suffered heavy losses of goats to disease and parasites. Average livestock holdings in Irisvale are far higher, and much more concentrated on cattle (11 households own cattle but not goats, which is virtually unheard of in communal areas). Over a third of Irisvale households, and no households in Bidi purchase livestock feed (excluding salt). This supports what we already know about the more commercial orientation of at least some livestock producers in Irisvale. In both sites, there appears to be free grazing, at least within villages or neighbourhoods, of harvested fields. Although a number of farmers regard this state of affairs as a problem, it seems unlikely to change (e.g. through fencing). In the long run this favours the adoption of stover harvesting and storage.

Perhaps surprisingly, total cultivated area was not on average very different in the two sites, although it was more unequally distributed in Bidi. The Bidi farming system gives equal importance to maize, sorghum and pearl millet, while the Irisvale farming system is very heavily centred on maize to the exclusion of other cereals. Bambara nut and groundnut are important minor crops in both. In Irisvale, there is a greater range of minor crops cultivated by one or two farmers in the sample.

As regards storage practices, the surveys demonstrated that only a minority, although a significant minority, in either area, currently invest effort in building and maintaining crop residue storage structures. In Bidi, around one-quarter of farmers have traditional ingalanis. In Irisvale, farmers are less likely to have traditional ingalanis, but more likely to store stover ad hoc in huts, kraals or around the courtyard. However, Irisvale farmers are more likely to experiment with salting stover or mixing it with more nutritious feed (27% compared with 19%), and in spending time or money building or maintaining residue storage structures (24% compared with 13%).

Within each community, it is hard to identify at this stage easy indicators for readiness to adopt improved storage. Average cattle holding was not significantly higher than average for those reporting spending time or money on storage structures in either community, and in Bidi a number of those maintaining storage structures had no cattle. Households investing in storage tended to have more adults available than the average (5.4 against 4.1 in Bidi, and 4.7 against 3.4 in Irisvale (table 8)); combined with results from the following two activities they do point to the importance of labour as a constraint on adoption of improved stores.

Evaluation of Improved Stores by Collaborating Farmers in Bidi

In May 1999, the Mark 1 stores were all being actively used for stover storage and were clearly valued by farmers. On Farm 5, a Mark 2 store had also been built to increase the storage capacity of roofed stores for stover. By September 1999, on two of the collaborating farms identified for Mark 2 stores (Farms 21 and 25), a second Mark 2 store was also constructed on the farmers' initiative. These additional Mark 2 stores received no subsidies or materials from the project. Three farmers had no other store: the rest had one or more unroofed stores.

Compared with the Bidi average from the 1999 questionnaire survey, the Mark 2 farmers tended to have more labour availability (4.4 compared to 4.1 adults available for work on farm), higher acreages planted to maize (2.5 compared to 1.01 ha.) and higher total planted areas (9 compared to 3.64 ha.). More significantly, they had much higher average livestock holdings. All were cattle-owners, though their cattle holdings were lower than the average for the 26% of Bidi households who keep cattle.

One issue raised by several farmers was the difficulty of gathering wood for construction, as they may have to spend time negotiating with others who assert various claims over trees and fallen timber near their homesteads.

Despite a variety of pre-harvest problems, farmers were generally satisfied with the quality of stover entering the store. Seven (of nine) farmers had stooked their maize, for periods of between one week and one month. Three farmers stored maize stover in their roofed store to the exclusion of sorghum stover, and three farmers stored groundnut hay alongside cereal stovers. Stover was fed on average for a period of 3.5 months (though farmer recall seemed hazy), starting late July in one case, late August or September in most cases. Most farmers finished feeding in November, one carried on into December and one into January. The farmers stopped feeding stover when it had all been eaten, except for one who had stover spoilt because of a leak in the roof (and dumped it in the kraal) and one who noted that animals would not eat stover when grazing became available.

In February, five farmers reported no storage problems and no losses. One reported loss of a cartload of stover when the store roof leaked, one reported minor termite problems, controllable with ash, and one reported problems of straying animals eating about half the stover. This farmer also reported that the store had collapsed; it is not clear whether before, during or after the losses to animals. This information can be compared to farmers' estimates of average yearly losses of stover from open stores, especially losses to dry-season rains, obtained by a simple piling method in September 1999. Four estimates, apparently for runs of years including some with dry-season rains and some without, ranged from 56% to 77%, though some other farmers downplayed the frequency of years with damaging rains and by implication total losses. One Irisvale farmer gave an estimated average of 25% over a run of years.

In September, when interviewing was more detailed and memories fresher, four farmers referred to stover keeping, or even improving its colour, especially in comparison with traditional unroofed stores. One saw this as particularly important for green mealie stover, which the animals prefer. Four farmers noted that stover in the Mark2 stores was dry, but in at least three of these cases, this was probably because the stover had entered the store dry.

Farmers had found a number of other uses for the stores, in particular storing grain and seeds of various crops (particularly important as unseasonal rains led to a risk of premature germination), thatching grass, and as a rain-shelter for goats and sheep.

Farmers were asked to agree or disagree with a number of statements on stover storage. The very high levels of agreement on all statements suggest this method was fairly flawed, so results should be treated with caution. All agreed that the stores preserved stover from rain and sun (one had had rain damage, but from a store not properly built). Six agreed that the stores preserve stover from termites: two noted that this depends on what farmers do to control termites.

All agreed that the stores: encouraged them to store stover they would otherwise have left in the field; prevented stored stover becoming useless; allowed them to store stover longer than previously; allowed them to feed more stover each day. These can perhaps be interpreted as expressions of general agreement with the principle of storing stover, rather than reflections of each farmer's own advantages from storing stover. All but one farmer agreed that the stores allowed them to feed animals they would not otherwise have fed, and five farmers specified donkeys, goats, sheep and cattle other than draught animals. All agreed that the stores meant that the stover was more attractive to animals; seven specifically mentioned that it was not sunburnt or rain-damaged, that it was kept "fresh and new", still had the greenish colour normally lost to sun, was more nutritious than stover stored in-field etc. One farmer mentioned protection against termites. All agreed that the stores kept stover moist.

Six farmers thought the stores would stand for five or six years, in two cases with the caveats; as long as it is not attacked by termites, or if it was repaired. One store had collapsed, and another farmer gave a more cautious response of two years. This farmer had already reported a termite problem in September but taken no action.

All but one of the farmers felt the benefits received from the store in the current season made it worthwhile. The other (who had expected the store to stand only for two years) gave no response to this question or a similar one on expected future benefits. All but the farmer whose store had collapsed were intending to use the store again next season. One said he would use it only for late-planted maize, as the early crop had (by February) already been "drenched". All but one farmer stated or implied that they were prepared to invest time and money on the store next season, and one specified a readiness to invest time. Two were cautious about investing money, noting it would be difficult to find, and would only be spent if major repairs were necessary. One farmer implied she might roof her traditional store.

Uptake of Improved Stores in Irisvale

In September 1999, following the Field Day held in Bidi to present the roofed stores to farmers from Irisvale, 31 farmers expressed an interest in building a roofed store in the 2000 season. In May 2000, 15 farmers had started construction or obtained materials, plus one further farmer who still said that he would build a roofed store but who had taken no action as yet to do so. Therefore, about 6% of the 254 households in Irisvale were intent on adopting the roofed stores, but few stores had been completed. By September 2000 two stores had been completed and three structures had been completed but had not been thatched. Additionally, one farmer was keeping stover in a pre-existing roofed building as a result of the extension efforts. Farmers building came from eight of Irisvale's nine villages. Comparisons with data on a random sample survey (41 farmers) of Irisvale, in November 1999, are given (Table13).

Table 13: Comparison between Irisvale farmers adopting roofed stores and average farmers (hh=household)

	adopting farmers	Irisvale average
no. of adults available to work on farm	4.0	3.4
hh livestock holdings:		
Cattle	27.3	15.9
cattle (adjusted)*	18.8	—
Goats	4.5	5.3
Sheep	1.3	0.2
Donkeys	4.0	1.9

**One of the adopting farmers had 154 cattle, the adjusted average excludes this herd. This farmer was not in the questionnaire sample for Irisvale, so that figure has not been adjusted.*

The adopting farmers have a slightly higher number of workers per farm, and more sheep and donkeys. Once adjusted for one outlier, their average cattle-holding is remarkably similar to the Irisvale average for cattle-keeping households. Three of the four farmers most advanced in store construction gave information on the areas of maize they had planted: 1.2, 2.0 and 2.4 hectares respectively, consistent with the 41-farmer average of 2.3. The adopters were asked to name three reasons for building. These have been grouped and ranked by the number of times a reason was named as primary (Table 14).

Table 14: Reasons for roofed store adoption ranked by adopters in Irisvale

Most important constraint only
To keep feed from rain damage = To keep feed properly (non-specific)
To feed animals in the dry season
To keep stover from the sun = to keep stover green/fresh = to feed dairy animals/get milk in dry season = to keep more animals = farmers envied Bidi farmers

The main reasons are clear: to protect stover from rain and sun, in order to feed animals in the dry season. Among farmers failing to build, the most important reasons were a general desire to store stover properly, and to keep it green and nutritious.

The four farmers most advanced in store construction, and apparently no others, had all used hired labour for gathering poles. Two of these were also buying thatching grass. One farmer was planning to use old corrugated iron for roofing, the only clear example of a material other than thatching grass being used. One farmer specified that he was helped by Dairy Group members in collecting poles.

Roughly measured areas of the stover platforms varied between 5 and 33 m^2, with an average of 16.3 m^2, and the height of the platforms varied between 0.3 m and 1.4m, with an average of 0.85 m.

Three farmers gave information on the cost of stores, varying from Z$400 to Z$1500, with hired labour the chief or only item for all three.

Farmers were asked to name up to three problems encountered in building stores. Responses have been grouped and are ranked below, the most important constraints at the top (Table 15):

Table 15: Problems in building stores identified by adopters in Irisvale

Most important constraint only	
shortage of labour/time	shortage of poles
lack of transport	shortage of thatching grass

Shortage of labour is clearly the most important constraint, followed by shortage of thatching grass. Of course, most of the constraints are interdependent: shortage of labour could be circumvented with cash, and the scarcity of the gathered materials mean that the labour demands of gathering them are felt more acutely. Among those who had failed to build, the reasons were mainly (9 out of 12 total responses) to do with lack of labour/time, demands from other activities, old age or ill-health, although one farmer included lack of stover as a secondary reason. Five of those failing to build still wished or planned to build next season. One was unable to build because of her responsibility for looking after orphans.

There is an on-going process of crop-livestock integration in the communal areas of Matebeleland. Some farmers in Bidi were practising long-distance transhumance as late as 1974, but an expanding human population resulting in increased areas of cultivation have made this impossible. There appears to be increasing pressure on grazing lands within communal areas. As fencing of harvested fields is not developing in either Bidi or Irisvale, the harvesting and storage of stover may increase, as farmers seek to capture the benefits of their crop residues, currently openly grazed.

If the development of stover storage is part of a wider process of crop-livestock integration, its adoption may be initially low, and uneven across and within communities (Morton *et al.*, 1997; Scoones and Wolmer, 2000). In Bidi, while the self-selected trial farmers were enthusiastic about the stores, their accounts of others' reactions, and data from a broader sample, suggest that only a small minority is at present ready to invest cash and labour in improved stover storage. In Irisvale 6% of farmers showed intent to adopt roofed stover stores, a significant degree of uptake given that there were no subsidies offered. The planned project extension until March 2002 will continue to promote and monitor the uptake of roofed stores in Irisvale. Within each community, household labour availability is likely to be the key factor which distinguishes early adopters.

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Questions and Answers

Was the point of storage of stover to keep the stover wet or dry?

The point is to keep the stover dry as rain spoils stover. When asked, farmers said that 35-77% were losses due to rain. It is thought that this amount is exaggerated so the project is estimating it at 25%. It was suggested that a controlled experiment be carried out to see what would happen when the stover was wet.

Some farmers said they preferred the stover when it was green, although so far the project had not worked out the reason for this preference.

Loss also occurred when the farmers harvested their stover, a lot would be left on the ground or would be lost by trampling. This was an issue that was thought of at the start of the project, and one that farmers are already aware of.

It was suggested that as most dry seasons have trivial amounts of rain, it would be desirable to establish the relationship between rainfall during the dry season and biomass losses.

Despite there being some indication of mycotoxins in the stover, did animals still like to eat it?

Mycotoxins do not appear to affect palatability but the effect of mycotoxins on the nutritional status of the stover was not known. The project was not planning to look at palatability because it was felt that that was an issue for farmers to decide. In general, farmers would say that the animals would refuse to eat mouldy stover.

One person reported that while monitoring the animals on stover projects it had been noted that in some areas the only food available for the cattle was the stover, so they had to eat it and seemed to do well on it.

The issue of mycotoxins is very important. For example, alkalines can be used to treat the mycotoxins.

Had mycotoxins found in the stover reached the toxic level and if so, had they been found in the milk?

Mycotoxins had not been found in the animal feeds to date.

As labour is a constraint for these farmers why not use polythene sheets for covering the stover?

The project aims to introduce improved stores (which might incorporate plastic sheets). The project places no restriction on the type of material used to build the stover, it is for the farmers to choose.

How many farmers had residues left at the end of the dry season?

This would be a variable amount. There was not much stover left by the end of the season: the first year's dry season started early, and stover was needed earlier than usual.

What is the size and capacity of the Mark 2 store?

The size varied between farms, how much stover was to be harvested and the number of animals to be fed. Generally there would be 30-50 cubic metres of storage space available.

Should the approach be combined with other 'residue technologies', e.g. NH_3 (urea) treatment?

Some farmers already use urea treatment. There is scope for using the stores for more than one use. Good stover contains 4-5% CP. The most nutritious part of the stover is lost in the fields. The farmers are using the stores for storing good stover. Some of the farmers are planning to treat stover with urea.

What were the effects of stover storage on animal performance and nutrient losses?

No animal feeding trials had taken place yet. The project did not pick up any difference in nutrient loss during the *in vitro* analysis. The farmers appear to be particularly interested in feed sustainability.

As well as focussing on the effects of water on the nutritive value of stover, the effects of the sun also need to be studied. Stover needs to be kept away from the sun to reduce nutrient loss and build up of fibre.

Optimising Draught Animal Power for Crop Production (R7352)

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Abstract

Ploughing before ripping was found to reduce bulk density by up to 15% in the top 12cm of the soil. Penetration resistance was reduced resulting in an average decrease in draught requirements of the order of 10%. This is likely to reduce demand for draught animal power (DAP), thus enabling smallholder farmers to establish their maize crops early. There was no evident difference in weeding demand between the no-till and the ploughed plots. All spans were capable of pulling the renovated and properly set plough. The quality of work was improved through correct setting and reconditioning. Implement handling and control improved leaving the operators and animals less stressed. Farmers' normal planting methods (TFP) reduced crop emergence, as seed was placed at a greater depth.

Introduction and Background

About 90% of the draught power requirements for agriculture for the smallholder farming sector are derived from animals (MLA, 1995). Evidence strongly indicates a positive correlation between cattle ownership and crop production (Shumba, 1984; Scoones, 1992; Francis, 1993, 1996). Smallholder farmers depend on DAP for farm operations, mainly field operations (tillage) and transportation. The two main tillage operations are land preparation (primary tillage) and weed control (secondary tillage). In Zimbabwe, the effects of recent droughts have reduced the availability of draught power. The shortage of DAP is now one of the major constraints to increased crop production in communal areas.

Various factors affect the efficiency of animal draught tillage systems and these depend on specific farmer situations. The draught animal, harness, implement, operator and the soil are the five components in an animal draught tillage system. Each of these components has its characteristics and the performance of the system depends on how these five components interact (Inns, 1994). A large proportion of smallholder farmers are unsure of how to use or maintain their ploughs and cultivators. They complain of the difficulties of land preparation with the consequent downstream effects for weeding as well as work stress on both themselves and their animals. This means scarce draught energy is wasted.

The use of the mouldboard plough has also come under scrutiny from conservationists and environmentalists. It is associated with land degradation, soil impoverishment and delayed land preparation that translate into poor yields. For these reasons, some regard the use of the plough as unsustainable (Elwell, 1991), while some regard it as a "necessary evil". Rippers and ridgers have been introduced and developed to "replace" the plough and reduce draught requirement.

Implement use is a cause of concern in both current practice and in the application of innovative methods for conserving soil and moisture, weed control and enhancing soil fertility (mulching and use of green manures), now emerging from basic research. These innovations are dependent on the efficient use of existing implements, as well as the ability of farmers and rural artisans to adapt their implements to perform new tasks.

The current project attempts to address some of the problems highlighted above. The project builds upon work already undertaken in the identification of farmer recommendation domains by previously funded LPP work in Zimbabwe (Improving the Productivity of Draught Animals in sub-Saharan Africa, R5926), but considers these in the light of the livelihoods approach, which embraces farmer-owned assets (natural, financial, human, social and physical). The project is split into several research activities to allow for a thorough evaluation of the issues.

Objectives

The overall goal of the project is to improve performance of livestock (including draught animals) in semi-arid crop/livestock and livestock production systems. This will be done through developing and promoting 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 system. Two aspects of the research are being reported on: 1) evaluation of rippers and cultivators; 2) evaluation of DAP systems.

1. Evaluation of Animal Drawn Rippers and Cultivators in Maize Production in Zimbabwe: On-station Work

Objectives

To assess the performance of a range of rippers available in Zimbabwe for crop establishment in terms of draught power requirement, field efficiencies, depth of work, crop establishment and yields.

To assess the performance of different cultivators available in Zimbabwe for weeding and the impact of different tines in terms of draught power requirements, field efficiencies, depth of work, weeding efficiency and crop yield.

Methodology

Sites. Field trials were conducted at Domboshawa Training Centre (DTC) and the Institute of Agricultural Engineering at Hatcliffe (IAE) (Table 1).

The granitic sands found at DTC are typical of soils found in most smallholder farming areas of Zimbabwe, whereas the red clays at IAE are typical of the commercial farming areas of Zimbabwe.

Table 1: General site data for the Domboshawa Training Centre (DTC) and the Institute of Agricultural Engineering (IAE)

	DTC	IAE
Natural Region	II	II
Mean annual rainfall (mm)	801	801
Soils	Coarse grained granitic sand	Red clays
Average water holding capacity (AWHC) of soil (% volume)	12%	16-20
Cultivation depth (mm)	75 - 200	230
Prone to drought	Yes	No

Treatments Six designs of ripper tine and two ploughs were tested. These comprised the BSP ripper (BSP), the Zimplow ripper (ZR), the Magoye ripper (MR), the Palabana subsoiler (PS), the Contil Knife ripper (CTK) and the Contil Single Donkey Toolbar (CTB). The two ploughs were the standard plough and the BSP light-weight plough (BSPP).

The test crop used was maize. Prior to land preparation weeds were slashed to ground level and the weed trash removed. This was based on the assumption that under smallholder farming conditions, the weeds would either be grazed off after harvest or burnt.

Experimental design. The trials were laid out in a randomized split plot design with primary land preparation as the main plot factor with crop establishment techniques using the ripper times as the split plot factors replicated four times (for further details see Mbanje *et al.* 2000).

Results and Discussion

To date, only the data from DTC has been analysed.

Effects of tillage treatment on the performance of implements. Primary land preparation had a significant impact upon the dry bulk density and penetration resistance of the soil. Overall ploughing significantly reduced both dry bulk density and penetration resistance, compared to no-till plots. There were, however, no significant differences in volumetric water content, probably due to the heavy rains received in the 1999/2000 season. The differences in soil physical properties had a marked influence on the draught forces obtained for the different implements, depth and width of soil disruption, and work rates. Whilst the draught forces obtained on the no-till plots were higher for the majority of rippers the opposite was true for the depths and width. The CTB had the least draught force requirement, depth and width of soil disturbance, but had the highest field efficiency (70%)in both the no-till and ploughed plots. This is probably due to easy turning at the headlands and the steady speed that is maintained by a donkey.

Effect of tillage treatment on plant population and weeding efficiency. Average plant populations per hectare of all the plots were generally lower than those recommended for maize. There were no significant differences in plant population between the no-till and the ploughed plots where seed was placed in the rip lines. Third furrow planting (TFP) population was lower than that after ripping, probably due to the fairly deep planting depth. In most cases plots, higher weights of weeds were found on the no-till plots than on the ploughed plots. This, however, did not result in a difference in weeding demands between the no-till plots and ploughed plots.

Residual effects of tillage treatment on soil conditions. No-till plots had significantly, higher penetration resistance than plots that had been overall ploughed. Highest penetration resistance was observed on the plots that had been planted with the Magoye ripper.

2. Evaluation of Draught Animal Power Systems for Maize and Cotton Production on Smallholder Farm in Masvingo Province

Objectives

- To determine the ownership and condition of tillage implements: and ownership patterns, types and availability of draught animals, used by smallholder farmers
- To establish the level and type of training received by smallholder farmers in operating, repairing and maintaining tillage implements
- To determine the draught requirements of tillage implements and relate them to implement condition and setting in on-farm maize and cotton production systems.

Methodology

The research approach comprised four separate but inter-linking components. These included:

- Focus group discussions with farmers in pre-selected areas
- Assessment of the condition of farmers' ploughs at the start of the field trials and their subsequent renovation
- Field trials in which 15 farmers participated in six separate areas. A test plot on each farmer's site was split into two equal sub-plots which were then subjected to ploughing with a farmer's plough without reconditioning and setting (A) and after reconditioning and setting (B).

For details of the experimental procedures see Koza *et al.* (2000).

Result And Discussion

Focus Group Discussions. Farmers in all the study areas experienced a shortage of DAP. Four to six oxen per household were viewed as necessary for ploughing.

Few farmers possessed adequate skills in proper setting, use and maintenance of their implements.

Plough inspections and renovations. It was found that the most frequently replaced parts were shares and landslides, with drawbar hitch assemblies needing to be replaced for over half the ploughs.

The cost of renovations averaged 24% of the cost of a new plough (US$25), equating to about 0.16 tonnes of maize at the current price of US$112/tonne. Overall the costs ranged from a low of 3% to a high 49% of new plough. Female-headed households' ploughs had slightly lower renovation costs than male-headed households, despite the fact that repair work is usually carried out by men.

Field trials. Most farmers used four animals to plough. The potential of animals to pull averaged at 781N (Newton, the standard unit of force in the SI system) and 1171 N for two animal and four animal spans respectively. All spans were capable of pulling the plough during the trials under varied soil conditions.

On the paired plots, depth of ploughing increased by 32.2 mm and width by 11.4 mm after reconditioning and setting. Typically, farmer-set ploughs operated at a depth of 109 mm and width of 273 mm, whereas after reconditioning this increased to 141 mm and 287 mm, respectively.

It was noted that draught requirements increased after reconditioning due to an increase in penetration and depth of ploughing. Surprisingly, the work rates did not differ significantly. Work rates averaged 0.11ha/hr on 'A' plots and 0.10 ha/hr on 'B' plots. Mean field efficiency increased by 8.4% in the 'B' plots.

Farmers perceptions of the trials. Farmers indicated several advantages and disadvantages of the comparative trials. Seed emergence was improved in the 'A' plots due to shallower ploughing, whereas in the 'B' plots , where the plough was easier to handle, it achieved better penetration, inversion and weed burial. The main disadvantage found in the 'B' plots was that of poor seed emergence due to deeper ploughing, whereas in the 'A' plots , parts of the land were left unploughed and there was poor burial of weeds. Also, in the 'A' plots maize wilted more easily in drought conditions.

Other Activities

The project is on-going and the reported results are preliminary. Three sets of research activities are underway over and above those already reported. These three, which are part of the research agenda, are:

- Evaluation of cultivators for weed control. The work could not be done this past season because of the heavy rainfall and the delayed start of project work
- Assessment of green manure for purposes of improving soil fertility. Part of this work has been done and soil analysis is due to start soon
- Assessment of knowledge transfer and dissemination of DAP techniques to smallholder farmers.

The results of the current work point towards potential improvements of smallholder farmers if they were to adopt some of the innovative practices applicable to their own circumstances. It is hoped that the available options can be consolidated by more work this coming season.

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Questions and Answers

What did farmers think about having to plough 1.2 ha in order to pay for the repairs of their ploughs?

That was an equivalent average cost. The cost of spares varied according to the state of the plough but so far in the project, the collaborating farmers have not had to pay. Some of the repairs are expected to last a number of seasons but it will be interesting to see whether farmers decide that maintaining their ploughs is a worthwhile investment.

How many hours of ploughing were required to reduce the performance of the plough from new (or repaired) to the state of ploughing inefficiency commonly demonstrated by poor farmers?

This depends to a large extent on the type of soil. Information from farmers at some of the locations suggests that for the two most replaced parts (i.e. shares and landslider) the frequencies were shares, 2 per season; landsliders, 2 every 3 seasons. Typically, these would have cost 110 Z$ and 145 Z$ respectively (in May 2000).

What were the sources of variation in the yield resource groups (RG) 1-4?

The project team believed the factors shown in the 'understanding livelihoods table' (see below) to be the most significant sources. The better-resourced groups are able (and willing) to invest more in crop production and achieve higher returns. Owning draught animals is key to planing at the optimum time and thereby increasing the likelihood of good yields.

Table 1: Comparison of different resource groups

Understanding livelihoods: Household resources (n = 750)				
	RG1	**RG2**	**RG3**	**RG4**
% of households	22	38	25	15
Cattle owned	9.9	3.2	0.3	0
Donkeys owned	2.0	1.1	0	0
Implements owned	Full range	Plough	Plough	None
Arable area (ha)	2.9	2.4	2.1	1.7
Maize harvested (kg)	1250	520	390	255
Cash expenditure on crops (Z$ pa)	1691	1034	670	482
Income from crops (Z$ pa)	2039	836	436	132

It was proposed that it would be good to know what the actual sources of variation of crop yield between resource groups were.

The project team explained that the data should be able to provide some indicators, however, the emphasis of the research is on the operation, working efficiency and maintenance of animal-drawn implements, rather than on differences between resource groups. It may not be possible to desegregate the effects of adequate DAP from the other enhanced inputs that the better-resourced farmers are able to supply.

It was suggested that an analysis of the RG1-RG4 groups could be assessed in terms of wealth/poverty status in previous times/years thereby looking at variability issues.

The project team will try do carry out the historic profiling in future farmer meetings.

Staff at various institutions had been involved in training farmers to set their ploughs correctly and wanted to know if there had been any follow-up.

Agritex have been training the extension workers to give the farmers the correct knowledge. Some of the farmers have been trained directly. Some of the farmers interviewed attended the course. At the most recent workshop, farmers say they stop doing what they are told if someone else provides an alternative.

The issue of farmers' knowledge of agronomy was raised.

The project team includes an agronomist and the farmers involved display knowledge of agronomy. A recent project workshop for farmers was conducted in Shona; the issue of germination was discussed and farmers had displayed considerable knowledge on the subject. The issue of depth given the variability of the sun had been studied by the research team.

What are the implications of the project on rural poverty, given that as, to all intents and purposes farmers in RGs 3 and 4 do not have draught power animals (oxen and donkeys).

Many farmers subcontract their animals, often using local barter arrangements for payment.

Use of smallstock and movement between resource groups: the table showed that people in RG3-4 had no livestock, but had smallstock had been included in the survey it would be interesting to see how many people had moved into different resource groups.

The table is included in a more detailed report published by Silsoe Research Institute and CARE. The report looks at all aspects of livelihoods. The movement of people between resource groups is most dependent on the number of people in the household and their age; generally the younger, larger families tend to be poorer. The biggest source of income is from people trying to sell their labour and the next is from the sale of crops.

How much does animal traction contribute to yield difference, and does the yield amounts shown in the table included the changes (i.e. increases) that had occurred due to the implementation of the project's work.

It was suggested that the biggest problem for farmers in the RG3 and 4 groups was being able to get oxen, therefore, by enabling these farmers to get oxen their livelihoods would be improved.

Could the farmers use local blacksmiths to keep their equipment in good condition?

This would be a good solution but the farmers do not appear to be keen on buying materials produced by the local blacksmiths.

This could mean that the value of R7352's research was only aimed at those who can afford the shoes and tools. It was suggested that a project was needed that included training the blacksmiths.

It was found that blacksmiths were constrained by not being able to get hold of the equipment, therefore, if the blacksmiths had better provision of materials, the quality of their work might improve and the farmers might be more likely to use them.

Participation, Adaptation and Learning By Doing — Progress in Participatory Development of Community Based Management Plans for Livestock Feed Resources in Mahuwe Ward, Zimbabwe (R7432)

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Abstract

Progress in achieving project objectives of enhancing the well-being of residents of Mahuwe Ward, Guruve District through improved management of common pool vegetation resources is presented. Following several PRA activities a local co-ordinating committee was elected and assisted with the employment of village representatives and a communication team.

In a series of workshops community members defined community objectives for common pool vegetation resources. These objectives were then ratified by the community at several public meetings. Thereafter workshops were held to identify the factors that affected achievement of the most important of these objectives. Several modelling workshops were then held to identify the relationships between key processes and the achievement of objectives.

A vegetation map was developed by project staff using interpretation of aerial photographs and a community map was developed by community representatives using orthophotographs. These will be validated to establish the utility of both approaches to the project objectives.

A questionnaire survey was implemented to provide baseline data for the project as well as to provide data on local people's attitudes at the start of the project. The questionnaire was also implemented in adjacent wards to provide benchmark data for assessing the effect of the project on changing attitudes and behaviours.

Introduction

Initiated in January 2000, this participatory research project sought to assist communities in Mahuwe Ward, Guruve District of Zimbabwe to enhance their well-being through improved management of common pool vegetation resources. The project sought to facilitate and improve the processes though which local community leaders and community members completed the following core activities:

- Articulation of their management objectives for their common pool vegetation resources
- Identification of best bet management strategies to achieve these objectives
- Identification of the institutional changes required to implement and sustain the best bet management strategies
- Design an implementation plan for the management strategy.

The project sought to achieve these objectives through a carefully designed programme of research, modelling and communication that engaged local community representatives as partners in the research process and enhanced their capacity to carry out the above activities.

Mahuwe Ward, comprising six villages (VIDCOS) in Guruve District is one of the many CAMPFIRE Wards within the semi-arid Zambezi valley. Wildlife and the management of natural resources for economic gain are not new to these communities. But the wards in the eastern Zambezi valley have faced a steady stream of immigrants who seek to stake a claim in the last land frontier of Zimbabwe. Coupled with the declining macro-economic conditions and political turmoil of the first half of this year, the project faces many challenges as it seeks to assist the members of Mahuwe Ward define a set of management goals and then chart a course to achieve those goals.

In this paper we review the project progress to date and present some of the preliminary results. The paper begins with a brief review of project activities since inception in January. Thereafter we highlight some of the key results that have been achieved to date and in the final section we outline major activities that are planned for the next quarter.

Progress in Achieving Objectives

Following several PRA sessions in the Mahuwe Ward a local co-ordinating committee was elected and assisted in the employment of local village representatives (VRs) and a communication team (CT).

A series of workshops were held to identify community objectives with regards the common pool vegetation resources as well as the major factors affecting access to, and productivity of, these resources. The different resource (vegetation) types in the Ward were defined and mapped and their use in space and in time was noted. The objectives defined in these PRAs were presented to the entire community at a series of meetings to seek broad consensus that these were indeed, the objectives that the community sought in managing their vegetation resources. .

The problem of what scale to use as the focus unit of management was not finally resolved and remains a complex and as yet unresolved issue. In some instances it appeared that the VIDCO was the appropriate unit of management. At other times it appeared the Ward, or even a collection of Wards, were the appropriate units. It was eventually decided that the Ward would be the focal unit but it was recognised that different villages in the Ward faced very different problems and might require different solutions or management plans.

In a series of workshops and field activities local and scientific vegetation maps were developed for locally identified vegetation types. A Bayesian belief network model was also developed of the factors affecting the supply of grazing and browse to local livestock.

Two separate vegetation-mapping activities were carried out. In the first the researchers used air photographs to develop a vegetation map of the Ward. In the second local community representatives converted the community sketch map to a georeferenced map.

Ongoing throughout the process has been a set of activities designed to distil the core elements of each project activity and communicate these back to the community. It is our belief that to have a broad based management strategy adopted we need to change attitudes as a precursor to changing behaviours. Thus different communication tools have been used and tested at key points in the process.

Preliminary Results

Livestock Movements-initial PRA

Local informants presented patterns of livestock movements that indicate variations by season, by animal species and by availability of graze and browse resources within and across the VIDCOs and Wards. Maps showing the livestock movements by species and seasons were developed (e.g. Figure 1). Different graze and browse resource types were identified (Table 1) and their availability in each of the six VIDCOs was noted.

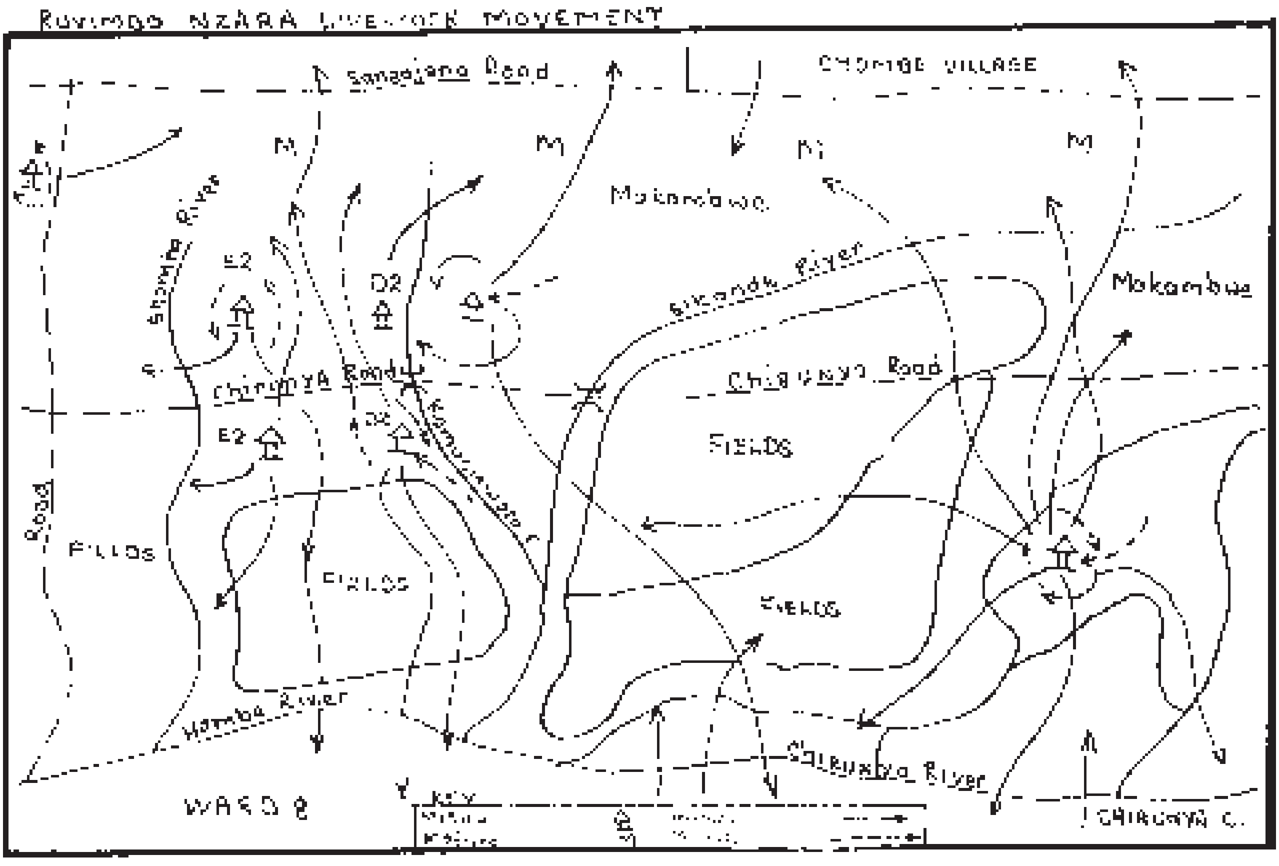
Table 1: Availability of different vegetation resource types in each of four VIDCOs in Mahuwe Ward

		VIDCO		
Graze and browse resource	**Bazooka**	**Nhamoinesu**	**Mufandaedza**	**Ruvimbo**
Valley floor	Yes	Yes (limited)	No	Yes
Around homestead	Yes	Yes	Yes	No
Mountain/ escarpment	Yes	No	Yes	No
Riverine	Yes	Yes	Yes	Yes
Makambwe (pans)	Yes	No	No	Yes
Fields	Yes	Yes	Yes	Yes

During the dry season, there was no restriction on where animals grazed or browsed in any of the VIDCOs. Animals moved freely (unherded) within and outside the VIDCOs and ward in pursuit of grazing, browse, crop residues and water. However, goats did not move very far away from the homesteads, especially to the mountain areas, irrespective of the season. Goats were able to survive on graze and browse around the homesteads and crop residues in the fields. This movement pattern was similar to what happened during drought years. Animals, including goats moved much further away from the homesteads during exceptionally dry seasons. An example of mapped movement patterns for a drought year in Ruvimbo VIDCO is shown in Figure 1.

A much more complex movement pattern existed during the rainy season. During the rainy season, there was control of livestock movements to various sources of browse and graze. These sources were around homesteads, flat or normal grazing areas, Makambwe (seasonal pans), riverine areas and the mountains of the escarpment. However not all VIDCOs had access to each of these sources during the rainy season. Availability of resources and livestock movements during the rainy season, during the dry season and during droughts were detailed for each VIDCO.

Figure 1: An example of a PRA map showing cattle (Mombe) and goat (Mbudzi) feeding patterns in Ruvimbo VIDCO during a drought year (Nzara).



Livestock Herding-PRA

The herding and management of livestock was done at individual household level although some farmers had “Madzoro” arrangements (shared herding) based on personal relationships. There was also a lot of tethering of animals, especially goats and draught animals. There were ‘village police’ in all the vidcos who were responsible for informing farmers when to start or stop herding grazing livestock. These ‘police’ operated mainly on orders from the village chairpersons. This set up appeared to be ineffective, however, as there were no powers of enforcement and some farmers were still releasing animals before harvesting was complete.

Management Unit-PRA

Farmers with adequate grazing in their vidcos wished to stop cross-boundary (i.e. Vidco or ward boundary) grazing but there were no mechanisms to prevent it. These vidcos would also prefer the vidco to be the management unit rather than the ward or combinations with other vidcos. These sentiments were expressed in Ruvimbo and Bazooka vidcos. However, Mufandaedza and Nhamoinesu preferred to operate at ward level or in combination with adjacent vidcos as they had very much smaller grazing areas available to them and lacked access to some key resource areas.

Problems Associated with Livestock, Graze and Browse Management-PRA

Farmers mentioned several problems, which were similar in all the vidcos but varied in seriousness depending on the location of the vidco and availability of grazing resources. The problems included: Shortages of drinking water for the animals in the dry season and droughts: Inadequate grazing due to haphazard settlements and burning of grass in the dry season; stock theft; axing of animals straying into neighbours fields; untimely release of animals before harvesting was completed leading to crop damage; disease; killing of animals by predators such as baboons and hyenas; and people and animals competing for borehole water during the dry season.

Community Resource Management Objectives

At the second major workshop each group of VIDCO representatives were asked to identify their VIDCO’s objectives for common pool vegetation resource management. These were presented in plenary and the following combined list was agreed upon:

1. To conserve natural, grazing and browse resources.
2. To protect and respect the traditionally sacred places, spirit mediums and traditional leaders.
3. All residents to be aware of their rights pertaining to the use of common pool resources.
4. Residents to appreciate the importance of wise use of natural resources to benefit future generations.
5. To generate income from the natural, grazing and browse resources.
6. For future generations to learn from these resources.
7. To carry out research on how best to manage and use natural, grazing and browse resources in partnership with other interested parties.
8. To carry out reclamation work so as to protect and improve the status of natural resources.

Vegetation Resources: Types, Uses and Factors Influencing Productivity

Ten major vegetation types were identified across the Ward (Table 2). At the ward level, the most important of these were Mopani (mopane woodlands) followed by Hova (riverine), Makomo (mountain), Matimba (old fields) and Tsangarawe (rocky areas) in terms of area and importance for livestock and people. This pattern prevailed in Bazooka VIDCO. However some of these vegetation types did not exist in all VIDCOs. For example, Nhamoinesu and Ruvimbo did not have access to the mountain (Makomo) vegetation type. In Mufandaedza the Mopani vegetation type constituted only a very small area compared to Makomo, Hova and Matimba. Hova was the most important for both livestock and people in the VIDCOs after Mopani. The areas of vegetation types and their importance to livestock and people varied according to VIDCOs. Each of the vegetation types was scored to reflect their relative areas and their relative importance to both humans and livestock.

At both ward level and in all the vegetation types there were more tree species than grass species. A total of 49 tree species and 31 grass species were identified in the ward. However the distribution within the different vegetation types varied. The number of different tree species was highest in the Makomo (18), Makambwe (16), Madyo (11) and Tsangarawe (10) vegetation types.

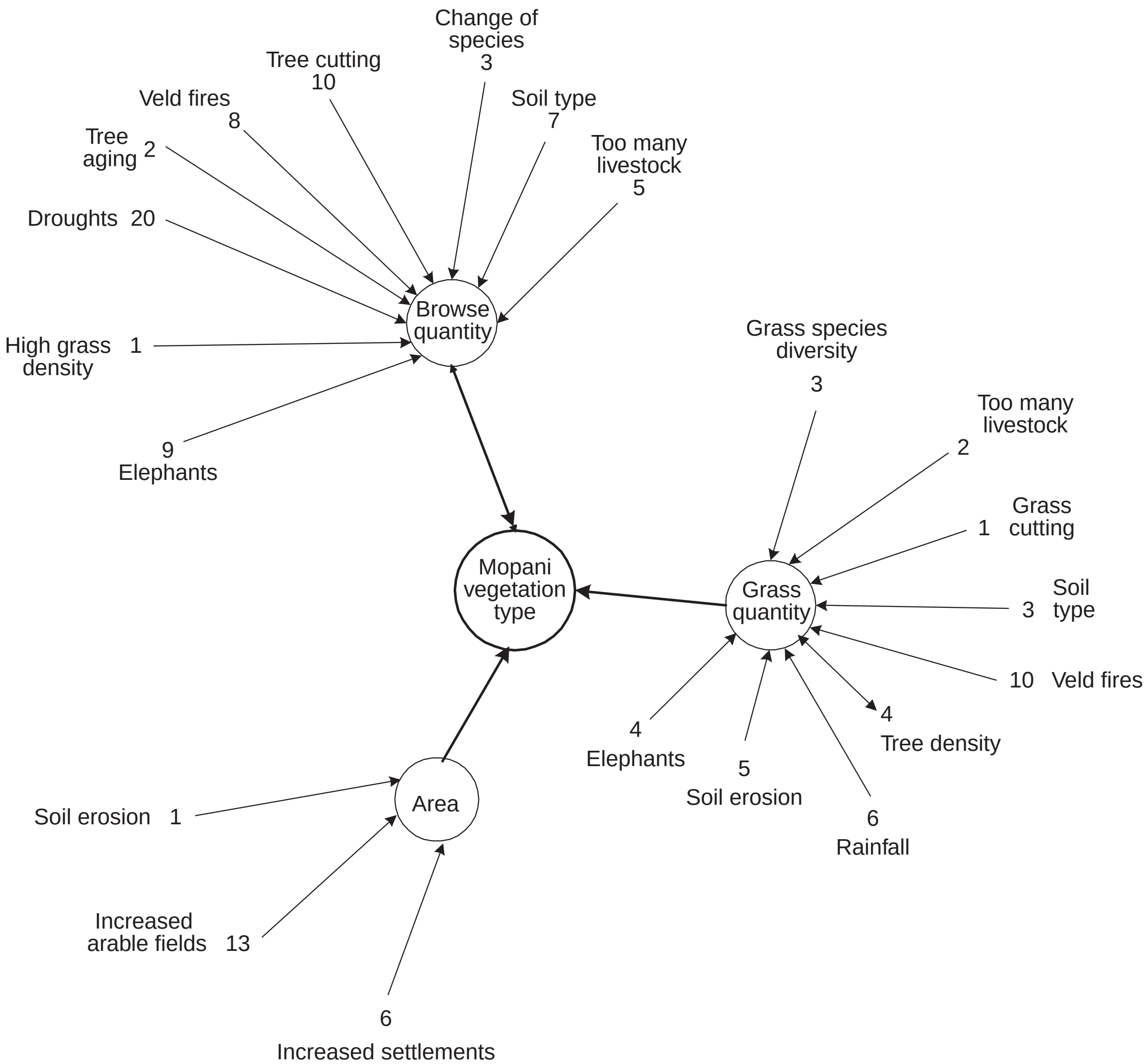
Table 2. Major vegetation / land types described by informants in Mahuwe Ward.

Vegetation type	Description
Mopani	Mopani trees dominant. Other tree and grass species exist.
	Best soils for crop production.
Tsangarawe	Stony and gravel areas with some trees and bushes and poor vegetation cover.
	Aristida grass species present. Low value areas.
Kakomo kakapori	Sacred areas in Nhamoinesu and Ruvimbo.
	Just a small hilly area with various tree and grass species.
Makambwe	Seasonal pans.
Jesse (Tsokoto)	Thickets with little grass growth.
Madyo	Heavy self-churning clay areas. Very fertile.
	Mainly grass and limited tree growth.
Gokoro	Sodic soil areas. Some trees and grasses.
Makomo (Mountains)	Mountains of the Zambezi Valley escarpment with various tree and grass species.
	Sub-divided into crest and valleys.
Hova	Rivers and their banks.

The number of different grass species was highest in the Makambwe (13), Makomo (11) and Mopani (9) vegetation types. There were virtually no tree and grass species in the Gokoro and Matimba areas.

The goods and services obtained by households from each of the vegetation types were considered in detail for only six vegetation types identified by the VRs. These were selected mainly because of their prevalence in the ward and importance to livestock and people. Goods and services from each vegetation type were listed and scored for their relative overall importance in each vegetation type. Although there was variation in the different goods and services from each vegetation type, there was considerable consistency in the top four or five.

Figure 2. Example of spidergram showing the factors affecting productivity of vegetation resources in M*opane* vegetation type, Mahuwe Ward. Scores reflect the relative importance of each factor with the highest score reflecting the greatest impact.



For each of the six main vegetation types, the participants scored the availability of the main goods and services over a 20 year period, using the current supply rate as the standard. Thus for the current period, a constant figure of one was used and availabilities of the goods 10 years ago and 10 years into the future estimated and scored relative to the score for the current time. The indexes given were scored within each vegetation type only and are not comparable across different vegetation types. Although a definite decline in the availability of goods and services was apparent, these indexes did not reflect the real quantities available and the balance between supply and demand for the goods and services today and in the future. Most of the goods and services were shown to have declined over the past 10 years and were expected to decline in the future across all the vegetation types.

The main causes of the decline in the supply of goods and services were identified as the increase in human and livestock populations in the ward. These had resulted in increased and haphazard settlements on grazing lands, increased cutting of trees for firewood, home building and increased cutting of grass for thatching and brick burning.

The factors affecting the productivity of each vegetation resource were identified. Three components of productivity were identified: area of the vegetation type; quantity of grazing; and quantity of browse. The dominant factor affecting the area of Mopane woodland areas was the increased conversion of these areas to arable lands. Veld fires and rainfall were seen as the dominant factors influencing the quantity of graze in the Mopane woodlands and drought, tree cutting and elephants were seen as the dominant factors affecting available browse (Fig 2).

Objective Refinement and Activity Identification

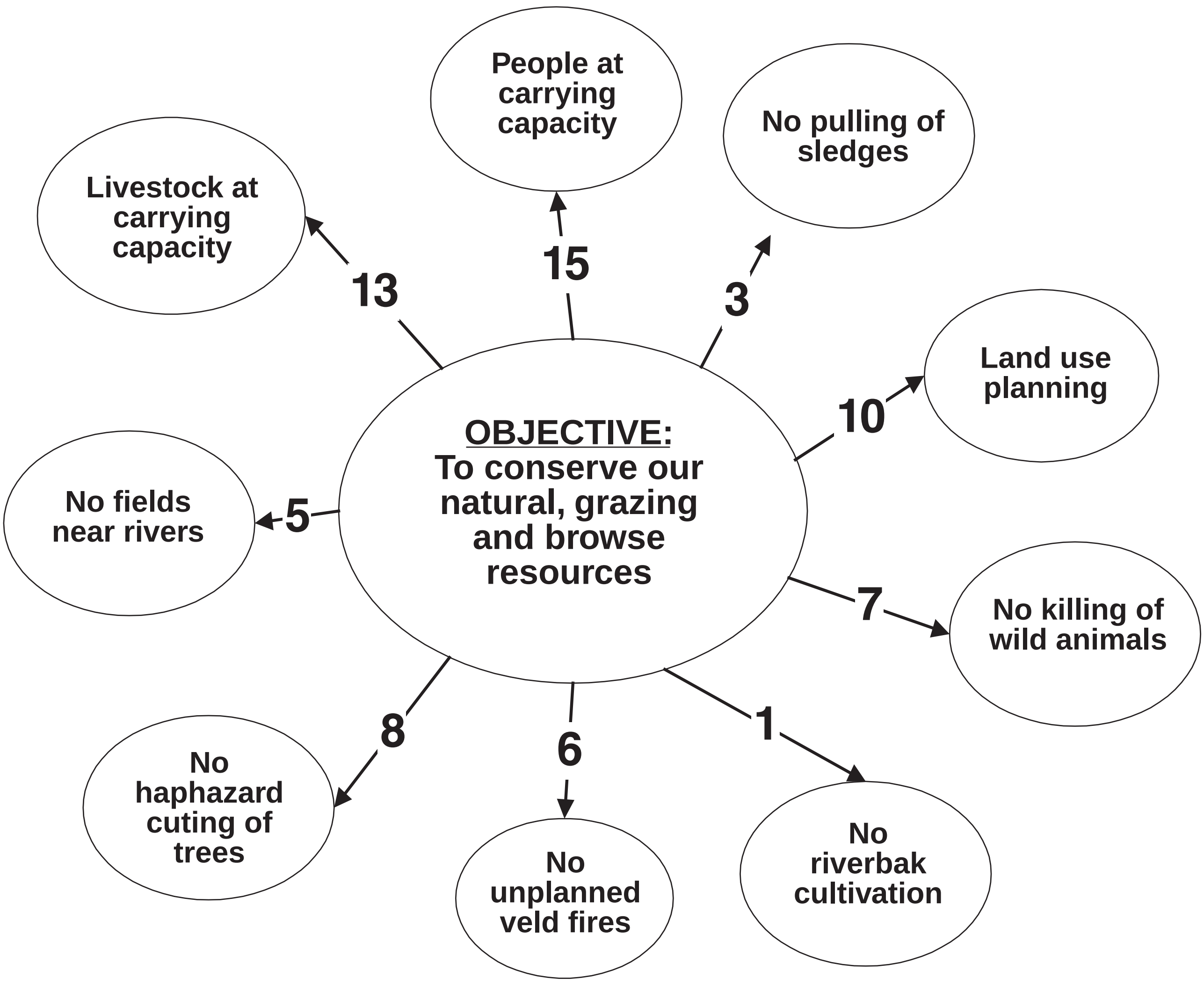
It was recognised that the original set of objectives set by the Ward representatives were at a level of resolution that provided little tangible guidance for project activities. A hierarchical approach to objective setting was used to refine the detail in objectives through setting sub-objectives and where necessary sub-sub-objectives.

At the modelling workshop held in Mahuwe the objectives that had been agreed upon by the whole community were ranked and scored to identify the most important. The most important objectives were:

1. To conserve our natural, grazing and browse resources.
2. Residents to appreciate the importance of wise use of natural resources to benefit future generations.
3. For future generations to learn from these resources.

The sub-objectives of the first, conservation objective are shown in Figure 3.

Figure 3. Sub-objectives with their relative importance scores for the board objective of resource conservation. The highest scores reflect the most important objectives.



It was recognised that the third most important sub-objective (land use planning) would need to be fulfilled in order to achieve each of the two most important sub-objectives (people at carrying capacity and livestock at carrying capacity) and it was, therefore, left out of further deliberations, requiring a focused workshop and set of activities on its own. The workshop thereafter focused on the two most important objectives, livestock and humans at carrying capacity.

The participants were asked to refine the definitions of each to make them unambiguous. The objective for people at carrying capacity was defined as:

"To stop accepting new settlers in Mahuwe Ward by 2003."

Then the objective for livestock at carrying capacity was redefined as:

"To adopt a grazing systems management plan in Ward 7 (i.e. Mahuwe Ward) by the year 2003 that would ensure the provision of adequate grazing resources for livestock."

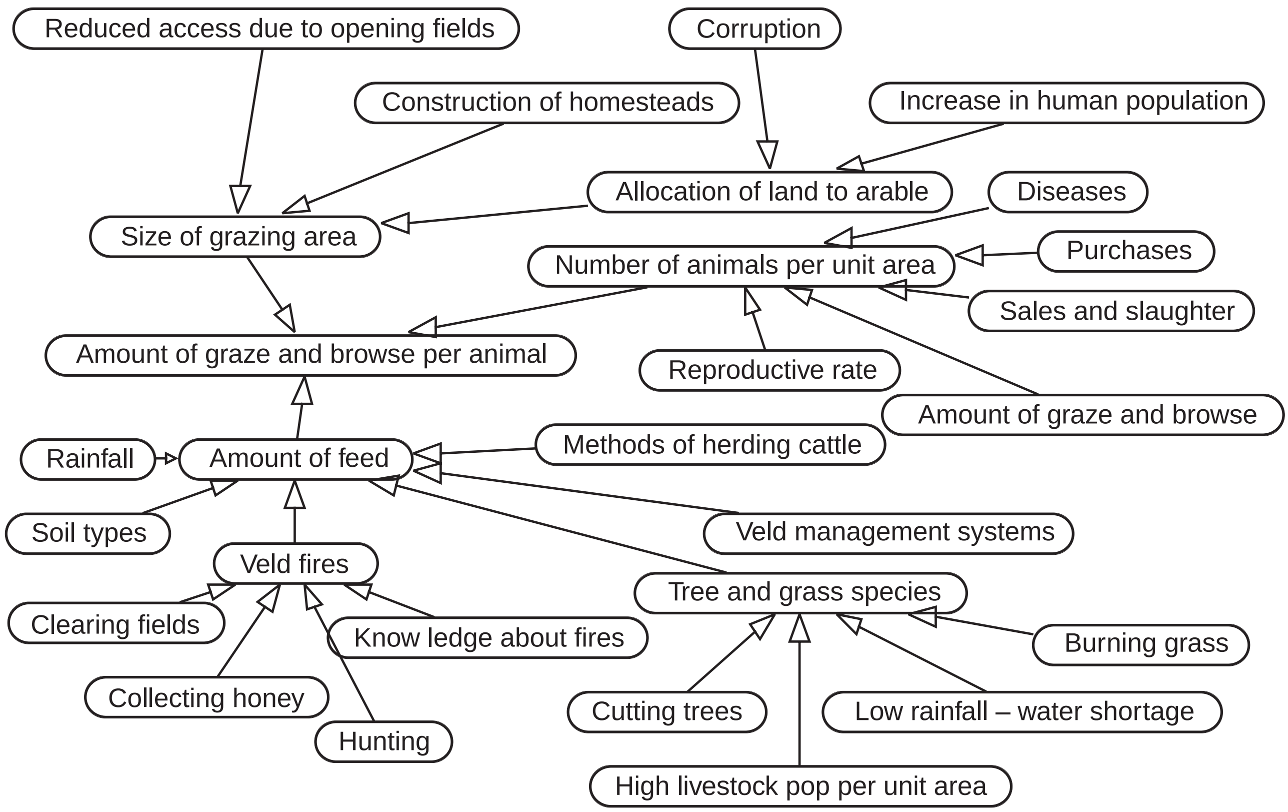
The third sub-objective was redefined as:

"Demarcation of our area into grazing, residential, fields and kraals in all six VIDCOs[1] *of* Ward 7 *by the year* 2002, *accepted by the people."*

The workshop participants were then asked to define what factors affected the achievement of each objective. It was recognised that the second objective had in fact two sub-components; the first was the development of the grazing systems management plan and the second was the acceptance of the plan by the community. Thus the workshop group were asked to develop spidergrams to address both these issues.

Once these factor spidergrams (e.g. Fig 4) were developed the workshop participants defined the states that each node in the spidergram might adopt. Thereafter the relationships between factor states in each of the input variables and the core objective state were defined. These relationships

Figure 4. Spidergram represents of local views of the factors affecting the available graze and browse per animal in Mahuwe Ward. Weights not shown.



provided the basis for development of a Bayesian Belief Network (BBN) (Jensen, 1996). Research staff developed the computer implementations of the BBNs during the evening and workshop participants manipulated these the following day (e.g. Fig 5).

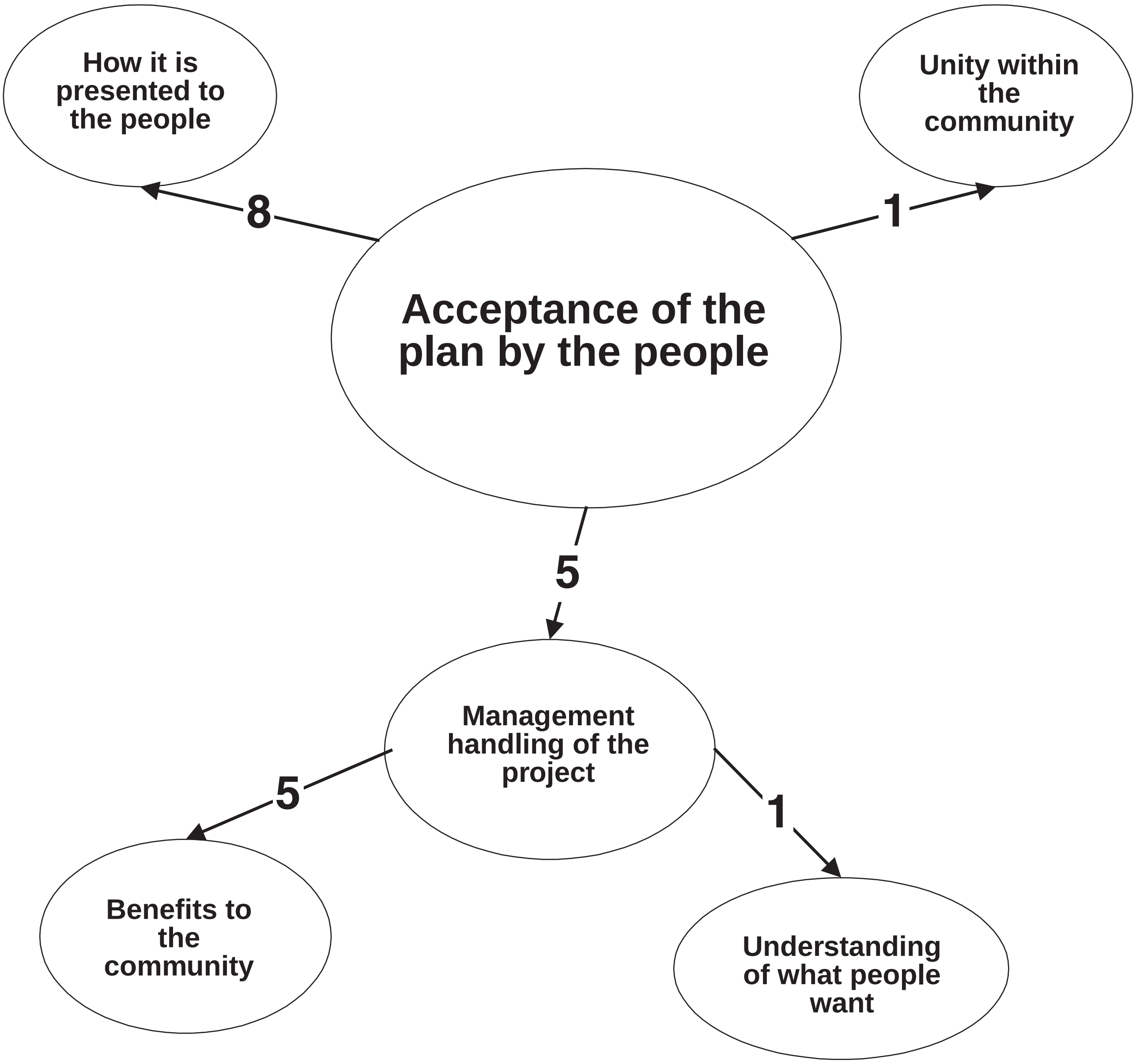
In August a baseline questionnaire instrument was implemented with 770 households being interviewed within the ward and a further 260 in adjacent wards.

Dissemination

In Parallel With These Field Activities The Communication Team Had Developed And Tested Different Mechanisms For Communicating Project Outputs To Community Members And Participants. To Date Experiments Have Included Work With Posters, Pamphlets, Meetings And Theatre. A Formal Evaluation Of These Experiments Has Been Conducted.

The Project Has Also Communicated The Activities To The International Scientific Community At The International Society For Ecological Economics Meeting In Canberra, Australia (Bousquet E*t Al.*, In Press) As Well As To The Cgiar Centres In A Meeting In Penang, Malaysia (Lynam E*t Al.*, In Press). Locally A Newsletter Article For The Agritex Newsletter Is In Press (Chinembiri E*t Al*, In Press) And A Popular Article Has Been Submitted To A Local (Harare) Daily Newspaper.

Figure 5. Factors affecting the local acceptance of management plans developed through the research process. Scores reflect the relative importance of each component with highest scores being the most important.



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Questions and Answers

Does the project team have any specific technological interventions that may increase productivity in the area?

The focus of the work was looking at whether the herding patterns defined the paddocking system.

Earlier the issue of influences on communities that make them more tolerant to new ideas had been discussed. Would project R7432 be doing this, or indeed, did they think it important?

In essence, the project would be looking at that, because in order to facilitate community-scale changes, the whole community needs to be on board.

Is there an interface between extension teams and traditional dissemination tools?

The team hoped that this is a process for extensionists to work with. Part of the project is highly technology-driven, part of it is less technology-driven, so ultimately it must be a joint collaborative decision with the community that defines the most appropriate interventions. The project team originally anticipated improving use of grazing and browse resources through improved herding and fire management practices.

How was the project team able to get livestock owners to participate in such a holistic exercise, in relation to the issue of grazing resources?

The team was trying to get the local people to buy in to the project. As yet there was no specific technology to pass on. There will be a committee of livestock and non-livestock owners. The team will evaluate current institutions and simulate what is likely to be needed in the future, therefore, farmer choice will be a key factor.

As one of the key objectives of the local community is to prevent new people extending the community does the project leave itself open to the support of protectionism against an expanding population? Have scenarios been built into the project to enable appropriate changes to be made in community planning to prevent conflict with newcomers?

This was exactly why the project team had moved to working on facilitating the adaptive capacity of local managers, attempting to enhance their capacity to clearly and correctly identify problems, design and build solutions, monitor their impacts and then iteratively refine this process.

Were cattle still viewed traditionally or as generators of income?

Although it was not clear, the primary need appears to be DAP. The project is trying to find out what other needs people have.

Is it possible to measure changes in biomass production/reduction from the vegetation due to the impact of livestock numbers?

Two parallel systems are required for this, a scientific one and a more simple one that the farmers could use. In the initial design of the project it was thought that only one system was needed, but the farmers said that they should also be involved which is why there are two systems.

Who was taking charge of the communities in which the project working, was it the traditional or political leaders?

The project is working with the council. The co-ordinating committee included traditional leaders, council leaders and other individuals. However, recently the government has given more responsibility to the traditional leaders. Discussions were held with the communities as to how the leadership should be reorganised. In general the committees increased in size and were run by the traditional leaders.

Reproductive Performance of Indigenous and Cross-Bred Cows Developed for Milk Production in Semi-arid Regions and the Effect of Feed Supplementation (R6955)

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Abstract

On-station studies showed that supplementary feeding improved reproductive performance in both indigenous and cross-breds. Cross-breds produced more milk than indigenous cows. On-farm, supplementary feeding greatly improved milk yield and improved fertility. In spite of the high cost of concentrate feed, its use was cost effective in terms of current milk production alone. Improvements in fertility offer considerable extra return, and could result in an extra pregnancy and lactation in the subsequent year. However, future emphasis should be geared towards supplementation using conserved forages, which is the subject of a related project (see papers under R7010, these Proceedings). The results indicated the short-term benefits of introducing more Jersey cross-breds on-farm. The proportion of exotic blood in the cross-breds needs to be carefully controlled and there is a need for a concerted effort towards selective breding of indigenous cows for improved milk production. Farmers participating in the study gained considerable knowledge on reproductive and general cow management.

Introduction

Smallholder dairy production was introduced in Zimbabwe partly as a vehicle for rural development. Prior to 1999 smallholder dairy projects that were established by the dairy development programme (ddp) were in provinces other than matebeleland north and south. Matopos research station launched a cross-breding programme in 1991 to provide dairy cross-breds especially for farmers in these two provinces. The farmers´ interest in embarking on smallholder dairy farming was overwhelming. However, little is known of the reproductive performance and milk production of these crosses in the drier regions of Zimbabwe. In this study milk production and reproductive performance of nkone, tuli and their jersey crosses and the effects of giving supplementary feed were evaluated.

Materials And Methods

The trials were performed under controlled (MRS) and field (Gulathi and Irisvale) conditions.

On-station trials. These were conducted over three seasons, from September 1997 to July 2000. A completely randomised factorial treatment design with two factors was used. The factors were bred (indigenous (Nkone and Tuli) and their cross with Jersey (predominantly F1s)) and diet. Diet had two levels: the basal diet comprising grazing of natural grass and browse alone; and the basal diet supplemented with dairy meal (2 kg/day per cow). The cows receiving supplementary feed were fed individually up to a maximum of 60 days post-breding.

Heat detection was conducted from 05.00 hours in the morning to 18.00 hours in the evening. The cows were bulled at the first observed oestrus occurring on or after 60 days post partum. Sweeper bulls were introduced 60 days after the last cow had calved to ensure that no cow was bulled before 60 days post partum and that all cows had been bulled. Pregnancy diagnosis, by rectal palpation, was performed in June 1998, 1999 and 2000.

During the first season, the cows were milked once a day, by hand in the absence of the calf, and milk yield was recorded at every milking. A calf race enabled milking in the presence of the calves during the second season but no suckling was permitted. Cow numbers were reduced by half during the third season to facilitate suckling before milking. Milk samples were taken three times (Monday, Wednesday and Friday) weekly from all experimental cows. The concentration of progesterone in milk was determined by solid phase radioimmunoassay using a kit (Diagnostic Products Corporation, Los Angeles, CA).

The following measurements were taken: number of observed oestrous events; interval to first ovulation; oestrus detection rate; conception rate; interval to conception; embryo loss; milk yield; body condition scores and body weights were recorded once every fortnight.

On-farm trials. At Irisvale and Gulathi, milk production and reproductive performance were monitored from October 1998 to July 2000. Only farmers belonging to the Irisvale or Gulathi Dairy Associations participated in the trial. Farmers recorded milk yields daily. Body weights and body condition scores were recorded once every fortnight. Farmers were trained to detect oestrus every day. At least one lactating cow per farmer was given 2kg per day dairy meal supplementary feed. Pregnancy diagnosis by rectal palpation was performed in June or July 1999 and 2000.

The experimental cows at Irisvale were a mixture of Tuli, Nkone and crosses of these breds with Sussex, Brahman and Friesland.

In Gulathi, the cows were mostly of the Tuli, Nkone and non-descript breds. A few of the cows were crosses between Jersey and Tuli or Nkone.

In both Irisvale and Gulathi, milk samples were collected three times per week and preserved with potassium dichromate until subsequent progesterone analysis. The progesterone profiles were used to determine the time of ovulation, conception and embryo/foetal loss.

Statistical Analysis

In fertility studies the most important response variables often involve time, e.g. time from calving to ovulation time to conception, and calving interval. These observations are referred to as survival times and can be affected by events such as death of the cow before the event of interest, or withdrawal due to other causes (e.g. owner of cow no longer interested in study). Our interest in such data involves comparisons of survival times for different groups of cows (e.g. different breds or different treatments).

Survival times data cannot be analysed using standard statistics, firstly because the distribution of data is often markedly skewed or far from normality in some other way. The second, and perhaps more important reason is the presence of censored observations. These arise because, at the completion of the study, some cows may not have reached the endpoint of interest (ovulation, conception, calving etc.). Consequently their survival times are not known. All that is known is that the survival times are greater than the amount of time the cow has been in the study.

Survival Analysis is a technique used to analyse survival times data mainly because it uses information on all cows, whether or not they have ovulated or conceived by the end of the study, unlike standard regression procedures. Thus the loss of valuable information is minimised.

Results

On-station Trials

*Reproductive performance***.** Results from the 1997/98 season showed that the reproductive performance of cross-bred cows was superior to that of indigenous Tuli and Nkone cows. They had higher oestrus detection rates, conception rates and lower foetal loss rates (Table 1). The higher oestrus detection rate could be genetic. It is known that *Bos indicus* and Sanga type cattle are more prone to silent oestrus than *Bos taurus* cattle.

Table 1: Oestrus detection rate, conception rate and embryo loss (%) for indigenous and cross-bred cows in the control and supplemented treatment groups.

	Indigenous	Cross-breds		
Diet	Control	Supplemented	Control	Supplemented
[1]Oestrus detection rate(%)	20[a]	43[b]	59[c]	59[c]
[2]Conception rate (%)	47[a]	30[a]	44[a]	70[b]
[3]Embryo loss (%)	10[a]	57[a]	38[a]	0[b]

[1]No. *of heats observed expressed over the total number of ovulations determined from progesterone profiles.*

[2]No. *of cows diagnosed pregnant through rectal palpation expressed as a percentage of all cows in the treatment group.*

[3]No. *of cows that lost embryos after conceiving expressed as a percentage of all cows that had conceived.*

Survival analysis showed no evidence of earlier ovulation in the cross-bred dairy cows than the indigenous cows. However, it should be stressed that bred differences were confounded with other differences in covariates and management practice (as can be seen in Table 2). Consequently, the possibility that bred differences would exist under the same management practice and covariates cannot be ruled out. There were indeed significant differences in all three covariates between the indigenous and cross-bred cows (Table 2).

Table 2: Covariate means for Indigenous and Cross-breds at first parity

Covariate	Indigenous	Cross-bred	Significance Level
Age	3.03	2.29	0.1%
Bodyweight	334	270	0.1%
Condition score[1]	3.23	2.62	0.1%
Date of calving[2]	-55	-39	0.5%

[1] BCS = *body condition score on a scale of* 0 *to* 5, 0 = *emaciated*, 5 = *very fat*.

[2] *Day calved after nominal start of the calving season* (1 October).

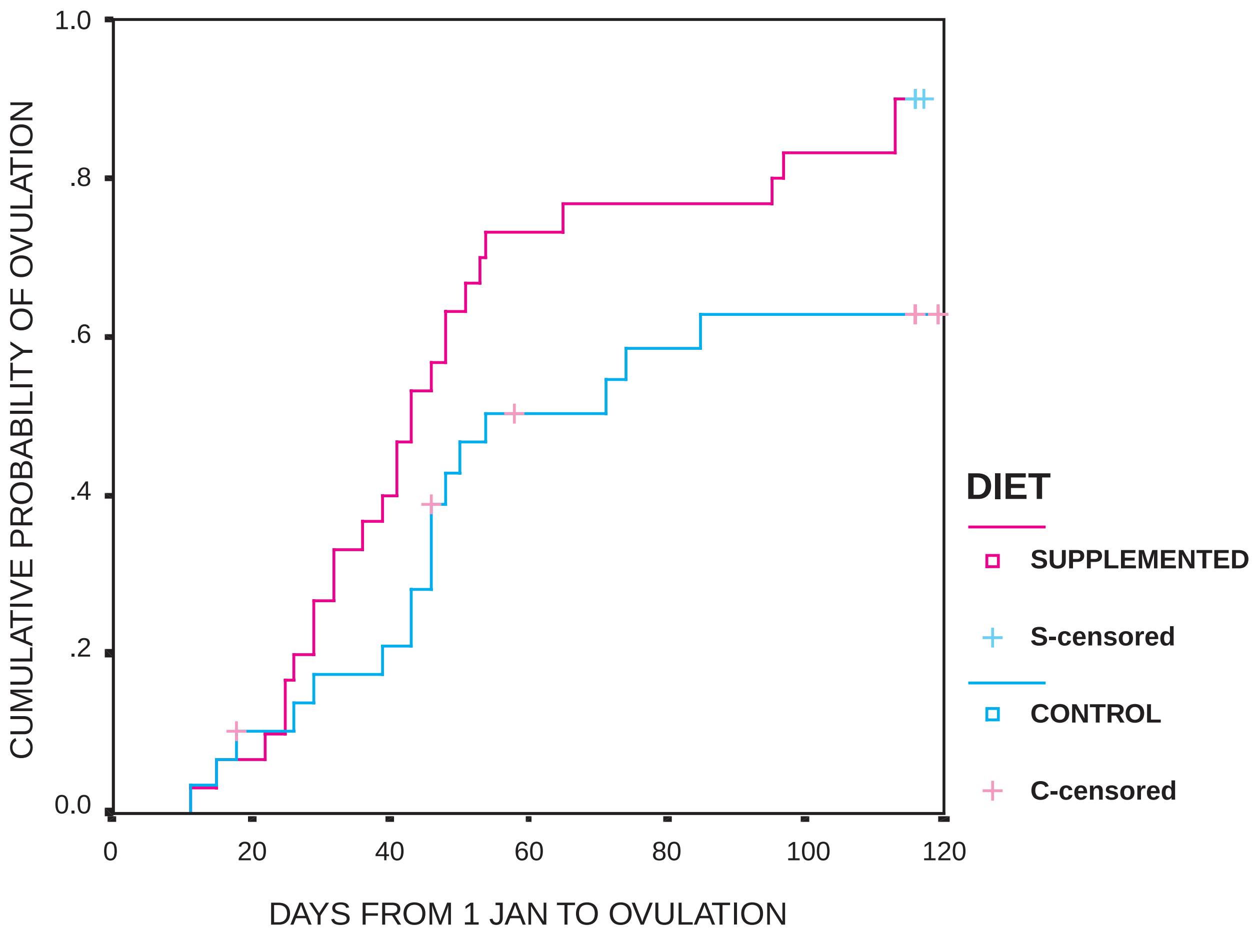
Regression models relating each of the three covariates to bred and age were highly significant. The fact that indigenous cows calved earlier in the season than cross-breds was because the indigenous cows came from a different herd under different management (i.e. indigenous heifers were bulled a month earlier than the cross-bred herd).

Supplementary feeding, with 2kg/day of a commercial dairy meal (14% crude protein), with the basal diet of veld grazing significantly shortened the interval from parturition to first ovulation. (Table 3 and Figure 1).

Table 3: Summaries of ovulation patterns by diet and bred

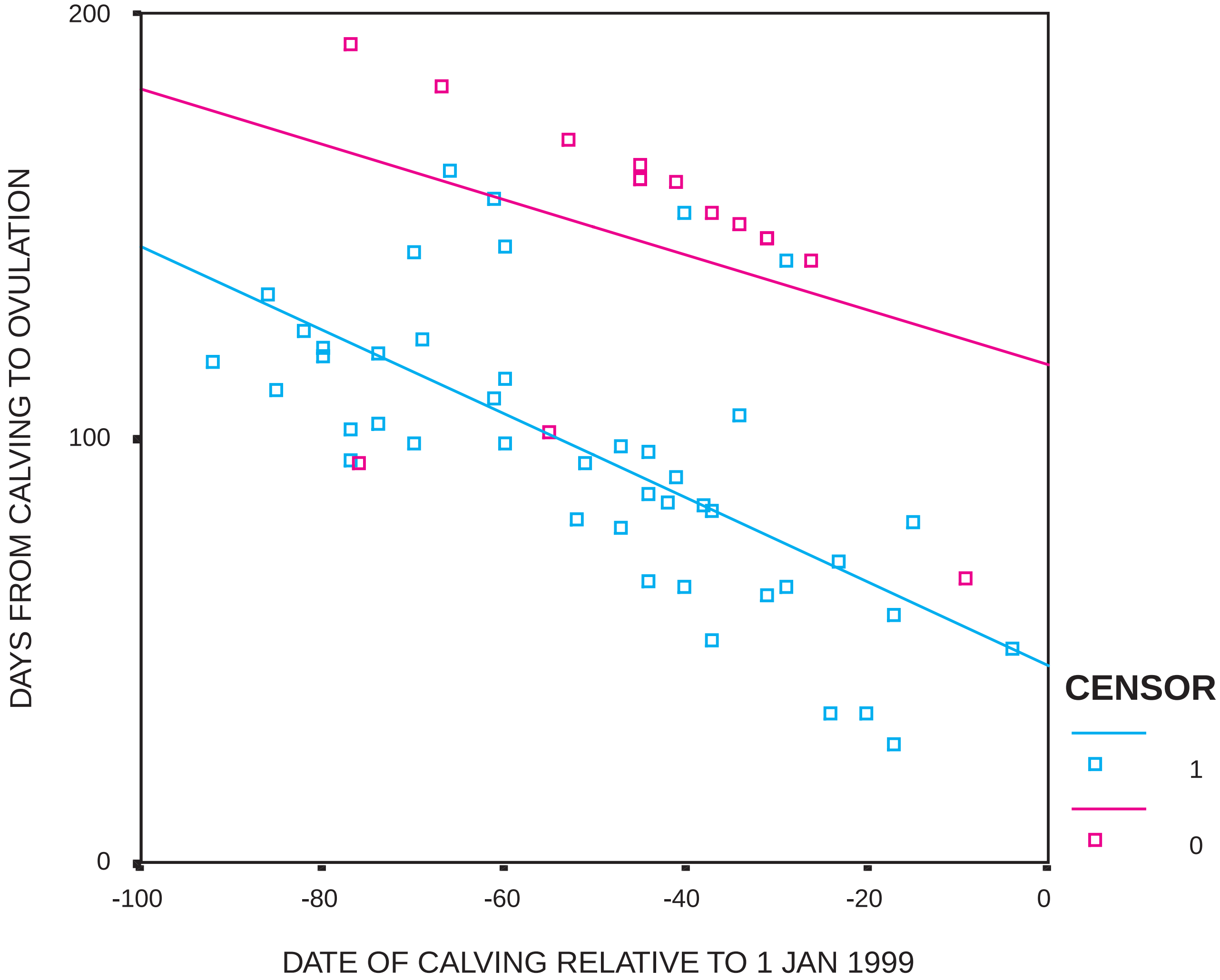
	Date for x% ovulation					
Group	50%	S.E.	75%	S.E.	Prob. of ovulation by day 113 (Apr 25)	S.E.
Supplemented	43 (13 Feb)	3.8	65 (7 Mar)	32.4	0.90	0.055
Control diet	54 (24 Feb)	15.6	N/A	N/A	0.63	0.095
Indigenous	46 (16 Feb)	4.2	85 (27 Mar)	18.1	0.81	0.068
Cross-breds	50 (20 Feb)	2.9	N/A	N/A	0.71	0.099

Figure 1: Cumulative ovulation probability by diet



The positive impact of nutrition on shortening the post partum anoestrus period is also demonstrated by the fact that cows calving in December and early January have the shortest post-partum anoestrus periods (Figure 2).

Figure 2: Relationship between date of calving and post partum anoestrus period (on-station)



Key: Censor 1 are those cows that had ovulated by the end of the trial
Censor 0 are those cows that had not ovulated by the end of the trial

There was abundant good quality grazing during this period which may explain why cows that calved during this period ovulated earlier post partum than those that calved prior to December.

Supplementary feeding also significantly increased oestrus detection rate in indigenous cows and conception rates in cross-bred cows. Fertility data for the 1998/99 and 1999/00 seasons is still being analysed.

Milk production. Milk yield was generally low. Cross-breds produced more milk than indigenous cows (Table 4). All cows had been hand milked once a day in the absence of their calves. It is likely that milk let down was not optimum in the absence of the calf, especially for indigenous cows. In 1998/99 a calf race was constructed alongside the milking race. It was anticipated that the presence of the calf without suckling would improve milk let down. The results showed that there were no increases in milk yield in the cows across breds. If anything milk yield was lower although this can be explained by the fact that 1998/99 season was poorer than the previous season. In 1999/2000 calves were allowed to suckle their dams and mean daily yields increased by three-fold from indigenous cows. Some of this increase may have been due to the particularly high rainfall in that season, but the yield increase in the cross-breds was less marked (Table 4).

Table 4: Milk yield (l/d) for cross-bred and indigenous cows over three seasons

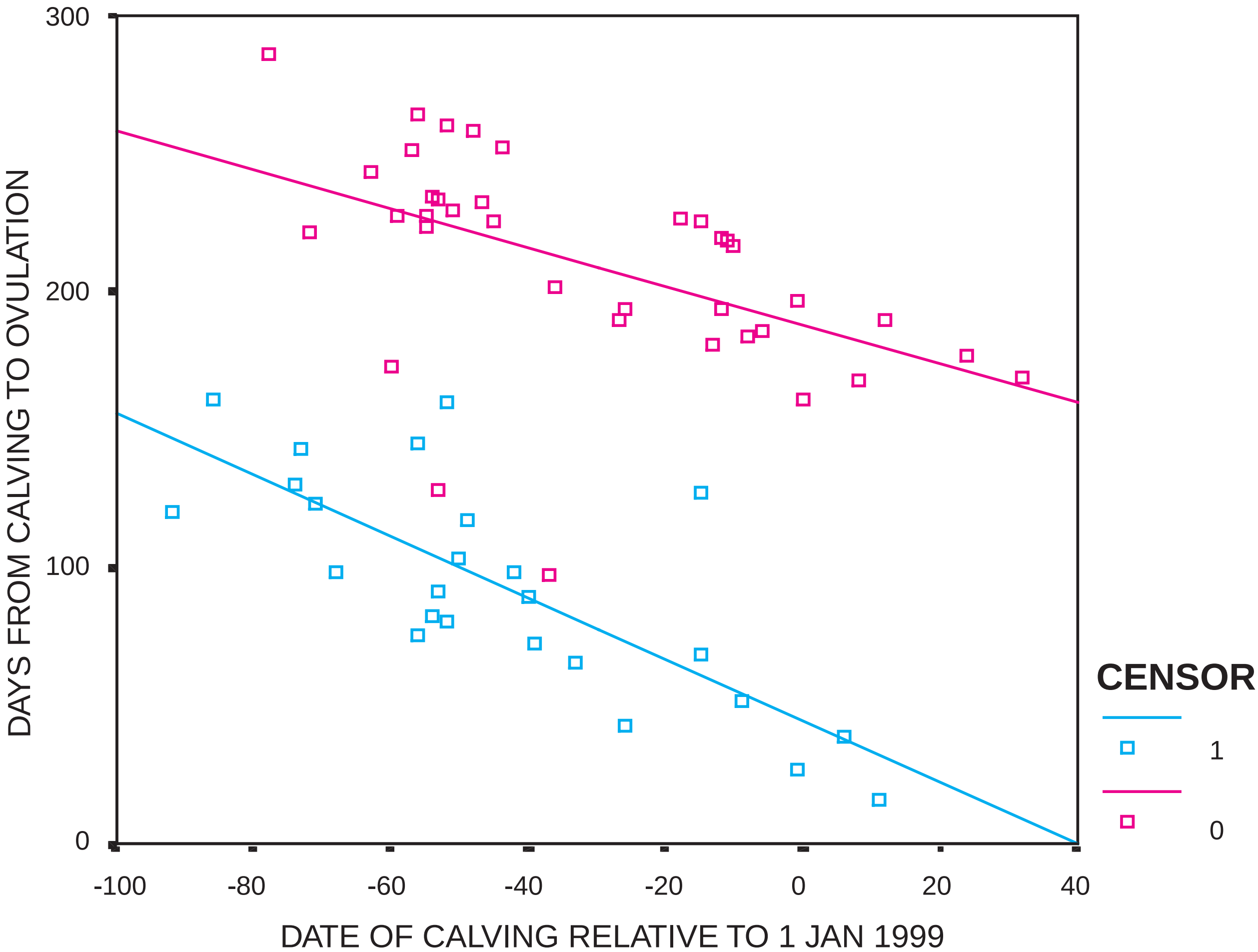
	Cross-breds	Indigenous
Season		
1997/98	2.4 ± 1.2 (n = 45)	0.6 ± 0.28 (n = 38)
1998/99	1.8 ± 1.0 (n = 38)	0.6 ± 0.23 (n = 43)
1999/00	3.1 ± 0.6 (n = 20)	1.9 ± 0.49 (n = 20)

On-farm Studies

Irisvale

Reproductive performance. Supplementary feeding did not significantly improve the proportion of cows cycling post-partum. However as was the case on-station, nutrition seemed to have an effect on the length of the post-partum anoestrus period since cows that calved in December and January had shorter periods of post-partum anoestrus (Figure 3).

Figure 3: Relationship between date of calving and post-partum anoestrus period (Irisvale cows)



Key: Censor 1 are those cows that had ovulated by the end of the trial
Censor 0 are those cows that had not ovulated by the end of the trial

The percentage of observed oestrus increased with supplementary feeding (Table 5), as was observed on-station.

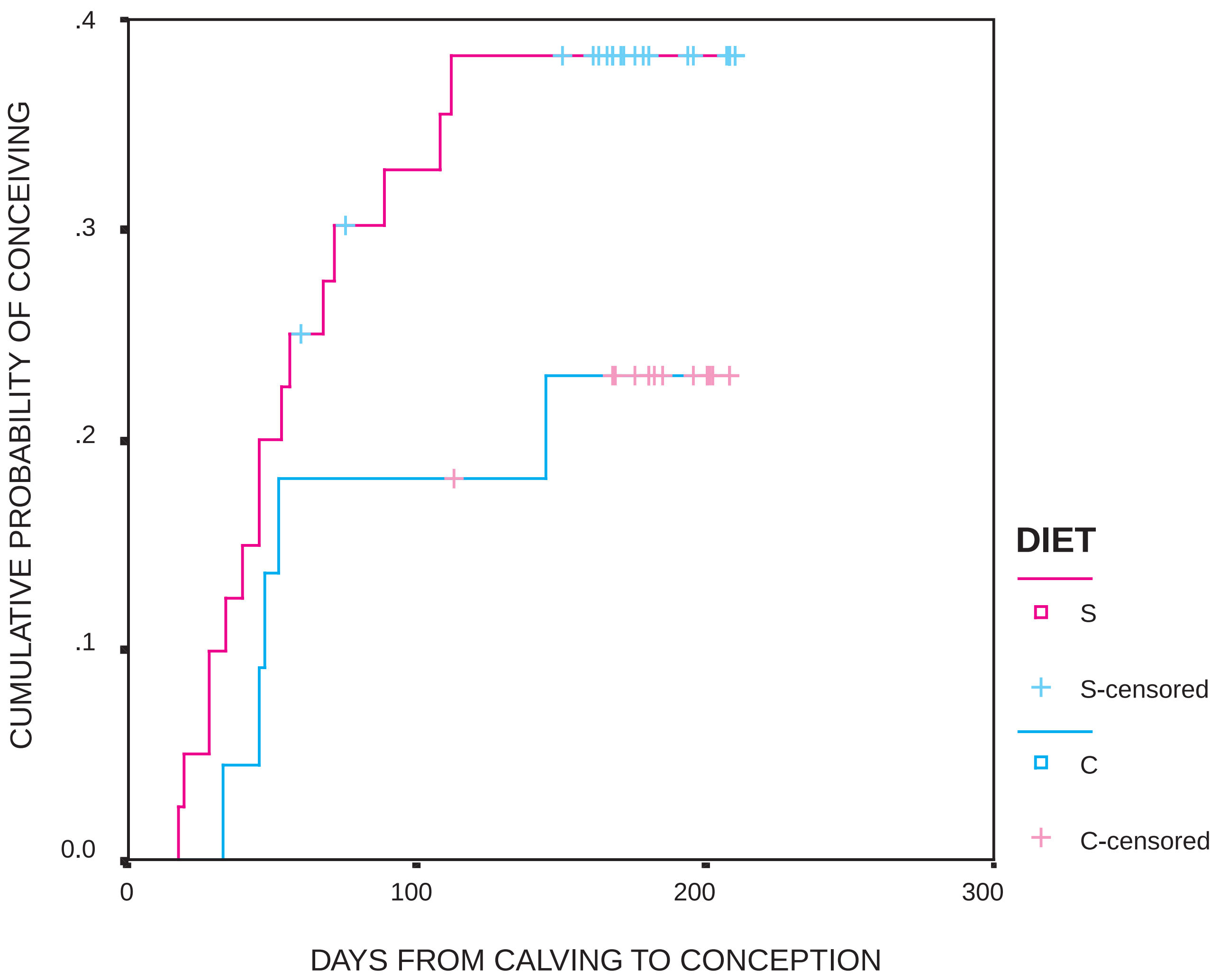
Table 5: Reproductive performance data for Irisvale cows

	Control	Supplemented
Number of cows	22	40
Mean body condition score	3.1 ± 0.25	3.1 ± 0.37
Mean body mass (kg)	408 ± 53	413 ± 53
Percentage of observed oestrus (%)	10	30
Conception rate (%)	36	42.5

[1] BCS = *body condition score on a scale of* 0 *to* 5, 0 = *emaciated*, 5 = *very fat*

Supplementation improved the probability of conception from about 24% to 39% (Figure 4), albeit insignificantly. Due to random allocation of diets to cows, mean body masses and body condition scores were not significantly different for the two treatment groups.

Figure 4: Cumulative ovulation probability by diet



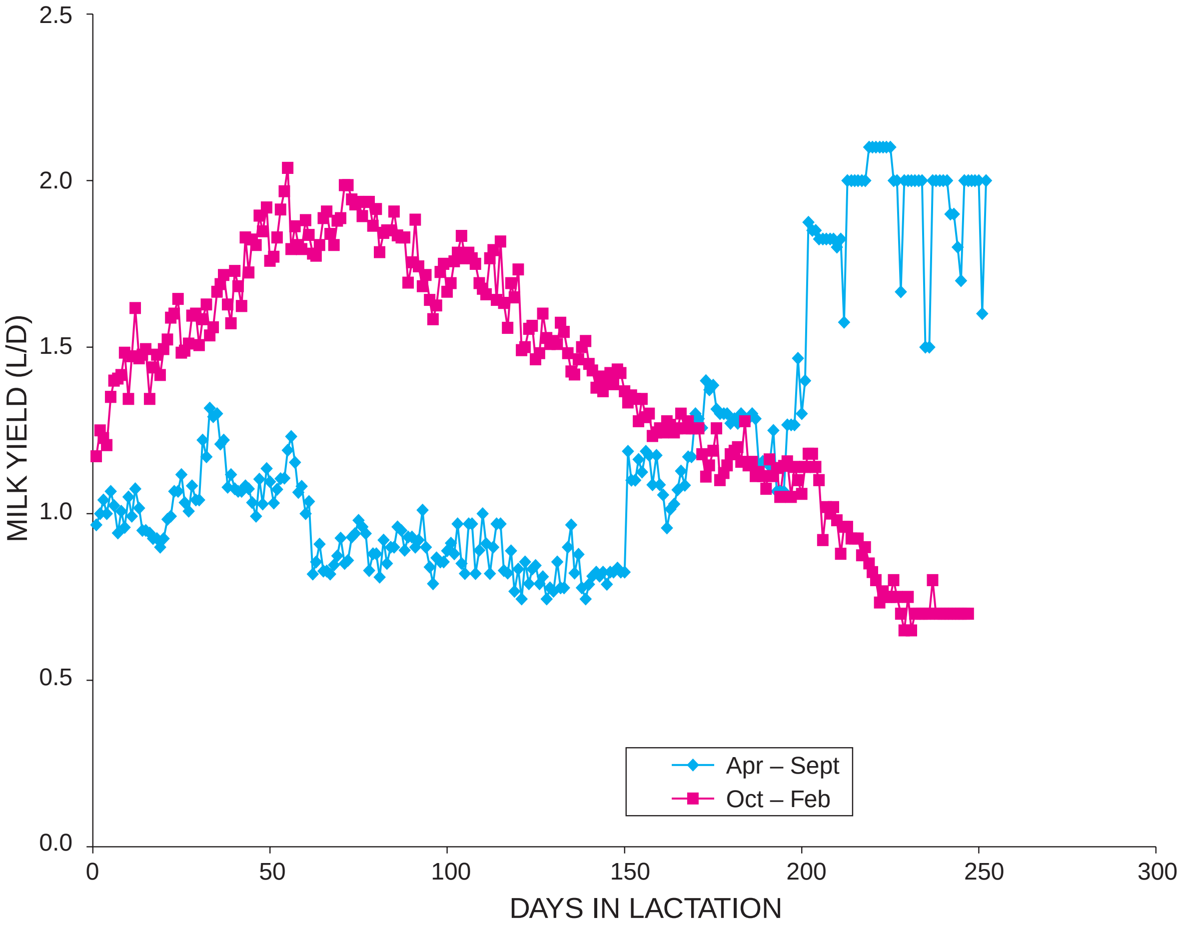
Milk production. The results from all three seasons showed that supplemented cows produced approximately three times more milk than control cows (Table 6).

Table 6: Milk yield data for Irisvale cows over three seasons

	Average milk yield (l/d)	
Calving season:	Control	Supplemented
October 1998 – February 1999)	1.2 ± 0.5 (n=22)	3.0 ± 1.2 (n-40)
April 1999 – September 1999)	1.0 ± 0.3 (n=12)	2.7 ± 1.2 (n=12)
October 1999 – February 2000)	1.5 ± 0.6 (n=18)	3.8 ± 1.5 (n=33)

The effect of nutrition on milk yield was clearly demonstrated by the fact that cows calving between April and September gave low milk yields during early to mid lactation but milk yield increased around November (Figure 5). The cows generally calved throughout the year with 68% calving between October and January and 32% calving during the dry season (April to September).

Figure 5: Lactation curves for control cows calving between April and September and between October and February.



Gulathi

Reproductive performance and milk yield. Mean body weights and body condition scores were lower than those for Irisvale cows (Table 7).

Table 7: Milk yield (l/d) and reproductive performance data for Gulathi cows monitored over two seasons.

	1998/99 season	1999/00 season
Average milk yield	1.2 ± 0.9	1.3 ± 0.8
Average bodymass	282 ± 37	264 ± 24
Average body condition score	1.9 ± 0.5	1.8 ± 0.5
Oestrus detection rate (%)	6	—
Conception rate (%)	8	9
Calving rate (%)	3	—

[1] BCS = *body condition score on a scale of* 0 *to* 5, 0 = *emaciated*, 5 = *very fat*.

The conception rates were very low for both the 1998/99 and the 1999/00 seasons (*although it is given in the table*) (8% and 9% respectively). Results from progesterone analysis revealed that all the cows that failed to conceive had not resumed cycling by the end of the season. The oestrus detection rate was 6% in the first season. The grazing was deficient especially in the dry season thus explaining the low reproductive performance of the cows.

Forage supplementation

Reproductive performance and milk production in Gulathi were largely influenced by the poor nutritional levels. Thirty per cent of the experimental cows in the second season had received approximately 4kg fresh silage per day for at least three weeks prior to calving. This level of supplementation did not have any effect on milk yield and reproductive performance. Much higher levels of supplementation are likely to yield positive results.

Acknowledgements

The help of staff at MRS and farmers in Gulathi communal area and Irisvale resettlement area is acknowledged.

Questions and Answers

How could the project justify business when it takes 2kg of concentrate to get 2 litres of milk?

A 2kg supplement produced 3 litres of milk. Costing showed that there were still some financial benefits to non-commercial farmers, therefore, if the bred is right the farmer can get even more benefit from the feed provided. Significant improvements in reproductive performance had been noted.

Was there an effect of bred on milk quality?

This factor had not yet been analysed.

How did the project ensure that supplementation was given to the designated cows and not the control animals?

It was necessary to trust the farmers; in addition, frequent monitoring also helps to pick up any errors. At the start of the project the management team sat down with farmers and explained the objectives of the project.

Does the project know how well cross-breds replace indigenous cattle at draught animal power (DAP)? If they are mainly used for work, how much DAP can they do? When animals work they create a lot of body heat, although local breds are more heat tolerant than exotic ones.

As long as indigenous cows are adequately fed, DAP does not have a bad effect on reproduction, this may not apply to cross breds.

Comments on cross-breds

- Cross-breds are encouraged for a specific trait, a misuse of cross-breds is not wanted
- The work of the project is timely because there might be large scale restocking of communal farms, the correct information needs to be supplied to the communal farmers
- A central source of research findings on genetic materials might need to be to be co-ordinated (amongst donors), for example in one area people had animals donated from DANDIA but they were not of the appropriate bred
- Farmers cannot be prevented from obtaining cattle when NGOs donate them. A nucleus-breding project needs to be developed, because research shows different animals have different traits, but the financial backing for the nucleus herd does not exist. If you try to stop farmers getting donations you will meet with resistance. But, there is scope to include the genes of some of the pure animals we have. The subject is bigger than what we are discussing here. There is the issue of genetic material, how should its use be safeguarded?
- An example was given from a meeting which took place a while ago in Uganda, where the Minister of Agriculture castigated the donor community: in the 1960s there were 17 definite breds, now there are only 2, biodiversity has been lost thorough cross-breding. Political strife meant that donor agencies brought in large numbers of exotic cattle. Cross-breding can be a danger, it needs to be prescribed as a ‘package’, i.e. including husbandry and management etc.
- Some work in the 1970s was carried out on indigenous breds in Zimbabwe (Shona, Nkone and Tuli). The findings showed that the smaller cow (Shona) needed less food in the dry season; if all the evidence is there, how can the message be passed on to the farmers?

Forage Production and Conservation for Dry Season Feeding of Dairy Cattle in the Semi-arid Region of Zimbabwe: A Summary of Recent Work (R7010)

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Abstract

Trials on the feasibility of producing and conserving high-quality forages at low cost are on-going. Results indicate that suitable silage can be produced using adapted forages and legumes in semi-arid areas, in sufficient quantities to feed supplements to smallholder dairy cows through the dry season and, in a good year, into lactation. More information is needed on supplementary feed for smallholder-owned dairy cows, in severe drought conditions. However, 6 kg silage dry matter (dm) per day fed for two months before calving significantly improved body condition, while 3 kg silage dm per day fed for one month prevented severe loss in condition and possible death.

Introduction

The potential for improved livelihoods from the production and sale of milk from cattle in semi-arid areas of Zimbabwe is good, provided the major constraint of insufficient feed in the dry season is overcome. On-station trials, over three years, have shown that high yields, of up to 10 tons of silage DM per ha, can be produced from intercropping forage sorghum or pennisetum and herbaceous legumes (Titterton *et al*. 2001). Affordable technology has been developed for smallholders to ensile those forages, in a suitable form for women and children to handle. Subsequently, this technology has been tested in participatory and verification trials on farms. Trials to determine optimum silage feeding strategies are on-going. The inclusion of forage legume tree protein as an alternative to herbaceous legumes has been tested.

Review of Recent Trials

Verification trials (researcher controlled and farmer managed) and participatory trials (farmer controlled and managed, researcher monitored) were carried out on the production and conservation of intercropped forages and herbaceous legumes for dry season feeding of dairy cows in Gulathi communal area in Matebeleland South Province (Mhere, *et al*., 2001). Yields and quality of silage were similar to those achieved in on-station trials. Liming appeared to have no benefit. On 19 farms in the wet area 5.3 tons silage DM per ha. were produced on 0.2 ha. in the first season and 6.3 tons on 0.4 ha. in the second season (102 and 176 bags of silage per farm). This was sufficient to supplement two animals for three months, in a drought year, or six months in a good year. On 17 farms in the dry area, 1.8 tons silage DM (36 bags) were produced per farm in the first season and 3.4 tons silage DM (83 bags) in the second, sufficient to supplementing two animals for one month in a drought year or two and a half months in a good year (Mhere, *et al*., 2001). Animals supplemented for one month in the first year on very poor grazing (due to drought) maintained a body condition score of 2.0 at calving. All animal supplemented survived to the rains while some cattle died on control farms where silage was not available. Lactation records and fertility data are being analysed.

Farmers decided that supplementation in 2000 will take place at the same time as in 1999, since the dry season was mild, leaving surplus silage to be fed as a supplement during lactation. Active dissemination (Mhere, 2001) has led to many other communities claiming that they intend to produce silage for milk production.

While ensiling of forages on smallholder dairy farms has proved feasible, supplies of silage will be limited in some years due to drought and erratic rainfall. It is important to determine how best to feed the silage to realise maximum returns in output per cow (milk yield and fertility) to the farmer. In a feeding trial on Matopos Research Station, indigenous and cross-bred Jersey-indigenous cows, on natural rangeland, were supplemented with one or two bags of silage per day, or *ad libitum* silage and no grazing, for two months pre-calving. Their body condition, lactation yields and persistency post-calving were compared with unsupplemented cows (control group) (Nyoni, *et al*;, 2001). There was a significant improvement in body condition score (BCS) at calving when two bags or *ad-lib* silage were fed (Table 1).

Table 1: Body condition score at calving (score 1-5) of indigenous and cross-bred cows offered silage (kg dry matter (DM) per day) for 60 days pre-calving

Type of cow	No silage	3 kg DM (1 bag)	6 kg (2 bags)	*ad lib*, 12 kg (4bags)
Indigenous	2.5	2.5	3.3	4.0
Cross-bred	2.0	2.0	2.4	3.5

Bred effect was marked: indigenous cows were in better condition at calving. However, in both breds, improved body condition at calving did not result in higher milk yields or greater lactation persistency. There is more likely to be an effect on fertility. Metabolite and progesterone profiles to measure the effect of body condition at calving on energy balance and fertility post-calving are being prepared. Energy balance will be indicated by trends in serum glucose and non esterified fatty acids from one week pre-calving to four months post-calving.

Forage legume trees are relatively drought-tolerant perennials. However, they contain tannins. A study was carried out to see if ensilage would reduce the anti-nutritional effects of these tannins and if protein from tree legumes could replace other protein sources in dairy cow rations. Titterton *et al*. (2000) showed that the fermentable and nutritional quality of silages containing maize mixed with *Calliandra*, *Acacia*, *Glyricidia* and *Leucaena* varieties were good; however tannin activity was not measured.

Forage from *Acacia* and *Leucaena* trees, already established at the University of Zimbabwe farm, were mixed with maize and ensiled. In a feeding trial, dry matter intake, milk yield and quality from Holstein dairy cows fed on the cereal-forage tree legume silage were compared with those of cows fed on cereal silage and concentrates (Mugweni, *et al*., 2001). Cereal-forage tree legume silage replaced commercial feed supplements without loss in milk yield and quality. If fermentation through ensilage does reduce the protein and fibre binding, that are caused by tannins, the potential for forage tree legumes as conserved forage is very high, especially in semi-arid areas.

Further Studies

A second feeding trial is comparing indigenous, cross-bred (F_1) and back cross (F_2) cows in their response to supplementation with silage in the dry season, before calving (HL), in lactation (LH), both (HH) or neither (LL). Simultaneously, in Gulathi, response to feeding silage in both periods (pre-calving; lactation) will be compared to that from no silage (control). From these studies, recommendations to farmers on silage feeding strategies will be made. Farm field days and demonstrations will continue. A manual for farmers and a video for extension workers and farmers on production, conservation and feeding silages is in preparation.

The trials reported above show it is possible to produce high-quality, low-cost silage in sufficient quantities to sustain two indigenous dairy cows over the dry season in semi-arid areas. Results from participatory on-farm trials show that, even with severe drought, enough silage can be produced to maintain animals until the rains. In a good year there is enough silage to both sustain cows up to the rains, their time of calving, and for two months of lactation.

Very little research in the production of forage tree legumes in the semi-arid areas of Zimbabwe or their inclusion with forage sorghum or pennisetums for ensilage has been done. Forage tree legumes tolerate drought and are perennial. Chopped crop residues ensiled with urea and molasses also offer a source of reasonable quality dry season roughage. With poor and erratic rainfall, food security is essential for dairy cows, especially cross-bred animals, if dairy production is to be sustainable. With improvement in livelihoods from dairying, the population of cross-bred cattle is likely to increase in semi-arid areas. This will lead to changes in herd composition as, with a change to profit-oriented livestock husbandry, farmers realise the market value of cross-bred heifers and draught oxen. Nutrient requirements of these differing classes of animals should be researched and feeding strategies planned accordingly.

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On-farm Assessment of Forage Yields and Silage Quality of Intercropped Drought Tolerant Cereal and Legume Forage Crops (R7010)

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Abstract

It was concluded that intercropping cereals and legumes for silage produced high yields of good quality silage that were sufficient to supplement two cows during the dry season. The simple technology of ensiling in bags was successfully tested under farm conditions. Farmers showed confidence in the technology through nearly doubling the area planted to forage in just two years. Forage production, by farmers using their cropping land, was found to be a way of increasing the livestock carrying capacity of the communal grazing. The major benefit derived by the farmers participating in these studies were herd growth by 60% of farmers and improved livestock condition due to better nutrition.

Introduction

Farmers in the semi-arid areas of Zimbabwe keep cattle and milk them for their own consumption, but in the dry season, natural grazing is inadequate and cows dry off. If continuous rather than seasonal milk production is to be ensured and sustained, then production and conservation of good quality forages must be intensified. Conserving the natural pasture for the dry season is difficult because communally owned grazing lands cannot support livestock during this period and, being communally owned it is logistically difficult for the livestock farmer to cut natural pasture for conservation (Titterton *et al.*, 2000; Mhere *et al.*, 2001). Producing forage intensively in the farmer's field, which is protected and managed by the owner, could solve this problem.

The objective of this on-farm study was to verify an identified system of high quality forage production and conservation with active participation of farmers. It was hypothesised that it is feasible to intercrop high yielding and ecologically adapted cereal forages with herbaceous legumes for the purpose of producing high yields of forage for silage, under on-farm conditions in the Gulathi area of Matobo communal lands.

Activities

Informal Diagnostic Survey

This was carried out in the Gulathi area during the winter months of the 1998/99 season with the objective of understanding the different crop-livestock systems, constraints and potentials in an informal, intensive way combining field observations, discussions and interviews with farmers. A number of farmers in the community had been in contact with the station since the 1995/96 season.

Among the major constraints, lack of adequate grazing land, dry season feed shortages and soil fertility featured prominently. However, Matopos Research Station had over the years been involved in forage production, conservation and utilisation research activities, which could contribute towards alleviating these identified constraints.

On-farm Study (1): Forage Yields and Silage Quality of Hybrid Pennisetum or Sorghum (Sorghum Bicolor) (Moench) Intercropped with Cow Pea (Vigna Ungiculata) (Walp) or Dolichos Beans (Lablab Purpureus) (Sweet) under Limed and Unlimed Soil Conditions in the Gulathi Communal Lands.

Materials and methods

Treatments. These consisted of two cereals (Sorghum and hybrid *Pennisetum*), two legumes (cow pea or dolichos bean) intercropped in alternate rows. Two villages that differed by degree of water logging (wet, W; dry, D) were selected for the study. All forages were planted with and without agricultural lime application. A factorial arrangement of treatments in a split-split plot design which had one replication per farm in the 1998/99 season and 2 replications per farm in the 1999/2000 season. Data from the first season and second season was subjected to analysis of variance (ANOVA). The study was researcher-managed and farmer-implemented (RMFI), whose scope was limited to verifying productivity of the identified system of forage production.

Results

Forage yields. Considerable differences between the wet and dry areas were recorded with the wet areas producing more forage in both seasons (Tables 1 and 2). In the second season, crop growth was very impressive. However, after January 2000, waterlogging caused lodging of the sorghums, which were swamped by the dolichos bean. Higher cereal and legume forage yields were recorded during the second season (Table 2) than often recorded in on-station trials (Mhere *et al.*, 2000) Both legumes grew well and contributed about 30% of the combined yields in both wet and dry areas. Legume yields averaged over all treatments were 5.0 t/ha. Ensiling mixtures with that amount of legume has resulted in good quality silage on station (Titterton, *et al* 2000).

Effects of lime application. No significant effects of lime on forage yields were recorded during the first year. In the second season, limed plots gave higher yields than unlimed, this being more consistent in the wet areas. Adding lime did not seem to affect both the legume yields and the contribution of legumes towards combined dry matter.

On-farm Study (2): Farmer-managed and Farmer-implemented Forage Production for Silage Using Sorghum and Hybrid Pennisetum Intercropped with Cow Pea and Dolichos Bean in Alternate Rows During the 1998/99 and 1999/2000 Seasons.

Materials and methods

Treatments. In the two areas, used in the first on-farm study, and concurrent with it, a farmer managed study, to assess biomass production of the 4 crop combinations used in the first trial, was conducted on large plot areas ranging from 0.15 to 0.4 ha, in two seasons (1998/99 and 1999/2000). Thirty farmers took part. All plots were limed at 550 kg /ha. and dressed, at planting, with 200 kg/ha of a compound fertiliser supplying 8N: 14P_2O: and K_2O.

Biomass from each of the four intercrops was harvested by hand, weighed to determine yields, sampled for further analysis with the rest being ensiled in strong polythene bags with a capacity of 50kg. Air exclusion was done by hand pressing and then sealed airtight by strings. The bags were stored in storerooms that were rat proof. During the first year hand operated chaff cutters were used and diesel operated cutters in the second season.

Results

The silage from the farmers' fields had protein levels of 65-90 g/kg DM; dry matter of up to 400g/kg; pH of 4.2 - 4 .8; NH_3-N % of total N of 9-11%; Ash, ADF and NDF of 110-130, 380- 410 and 510 - 610 g/kg DM, respectively.

During the second season, (1999/2000) 63 tonnes of silage were ensiled in 4771 bags. Each farmer made an average of 1.75 tonnes of silage in 132 bags. Average weight of each bag was 14 kg. As in trial 1, the wet areas recorded higher yields in both seasons. There were positive changes in the land planted to these forage crops which in a way revealed the impact the technology had on the farmers.

On-farm Study (3): Preliminary Feeding of Indigenous Cows Using Mixed Crop Silage

During the first year, 62 pregnant cows from 25 farms were fed with silage made by the farmers. The other farmers did not have pregnant cows and used the silage for draught animals and goats. The preceding rainy season was characterised by low rainfall in both areas (Table 3).

The concerns of the farmers to feed other animals, in addition to those that were pregnant, were accepted. The decision to feed all animals was based on the need to ensure survival of the herd, due to lack of grazing because of poor rains. The projects then monitored one or two pregnant cows per farm for 1.5 to 2 months, during which the cows were fed 4kg silage a day. This was considered to be a supplement on account of its good quality. Body weights, and condition scores were taken every 14 days.

Preliminary Results

Fed animals maintained body condition, with some gaining weight. Conception, re-conception and milk yields of the fed animals were monitored during the 1998/1999 season. The number of bags of silage available determined the length of the feeding period. The availability of silage in a drought year encouraged farmers to increase the area of land, management and yields of these forage crops during the 1999-2000 season.

Information Dissemination: 1998/99 Season

Towards the end of silage feeding during the first year, the projects organised a 'Farmer to Station' visit where the Gulathi farmers viewed the on-station feeding and discussed in detail their views, feelings, comparisons of the 4 feeding treatments.

The on-farm work at Gulathi during the 1998-99 season was very useful as a first year when farmers tested the intercropping agronomy and silage technology. Consultative meetings discussed the impact of the project activities from 1997-98 to 1998-99 seasons, which have led to wider awareness within the community and beyond.

Many enquiries on how to either join, get involved with, or start a similar project in the East, South and South-west of Gulathi have been received and those making enquiries seem to be conversant with what is taking place at Gulathi. These activities have raised awareness and changed the general perceptions towards dairy production by other stakeholders in Matabeleland (Mhere, in press).

The National Dairy Development Programme (DDP) together with an NGO (AFRICA NOW) has taken up the project for further funding and development. This will allow construction of a milk collection centre (MCC), employment of a resident project officer and purchase of improved animals and other activities.

Linkages among the main collaborators (Matopos Research Station, Agritex, Veterinary Department, University of Zimbabwe and the Department of Environmental Health) have been strengthened considerably.

Information Dissemination: 1999/2000 Season

Farmer training and Information Dissemination workshop 15.04.2000

A farmer led workshop was held to extend findings, share experiences, and build interaction and communication techniques of information exchange from farmer-to-farmer. Five groups were represented and a total of 75 participants attended.

a Farmer to farmer visits

Gulathi farmers hosted farmer groups from Wenlock (Gwanda), Irisvale, Esigodini, and Natisa.

b Farmer to station

A field day jointly organised by the project and the National association of Dairy farmers was attended by 26 producers on 28 April 2000.

c New initiatives

Four new projects were initiated within the Matobo district influenced by the project at Gulathi. These are Gulathi (Lukadzi x2), Vulindlela Ward (Lushumbi), Dema Ward (Natisa). In addition 3 wards in the Gwanda district are mobilising to initiate similar ventures.

d Strengthening of Linkages

Among the original collaborators: Agritex, Veterinary Department, Department of Health, and the District Council and DDP continue to be involved. New linkages have been established with three NGOs: Masiye training camp in Silozwi; ENDA Zimbabwe in the Dema and Vulindlela Wards; and Ethandweni children's' home in the Whitewaters / Natisa area.

Discussion

The differences in productivity among the treatments in the first year (19998/99) were largely, due to very low rainfall and delayed planting. These differences were not just confined to the experimental plots but were evident in the other 30 farms, resulting in double the yield in the wet, compared to the dry area, demonstrating the overriding effect of soil moisture on plant growth. In the second season differences in productivity among the six farms were attributed to individual farmer management, soil and factors other than rainfall.

The content of legumes in the intercrop biomass was similar to that recorded at Matopos on sandy soils, similar to those of Gulathi (Mhere *et al*, in press). The results showed that it was possible to intercrop cereals and legumes for silage within the smallholder sector. Ensiling mixtures where the legume content is about 30% of the biomass resulted in good silage quality in on-station trials (Titterton *et al*, 2000).

Effects of lime application were not evident during the first year due to very low rainfall and delayed planting. Although it is not a widespread practice in smallholder systems of Zimbabwe, lime application does create favourable growing environments for most crops by neutralising the hydrogen ions, that when in high concentrations, cause soil acidity. The second season showed some improvements in forage yields due to liming.

Although results of the feeding carried out in the first season were preliminary, the maintenance of body condition and weight are indications that animals can be sustained during harsh dry seasons. Post calving performance would be expected to be much better than that of unsupplemented cows.

The overwhelming response by different communities to the farmer-centred strategies used here clearly showed the relevance of the subject dealt with. It also showed the compatibility of the technology with the individual farmer problems, with local ecological, socio-cultural and economic conditions of these communities who view milk production as a vehicle for change. Dissemination activities attempted in this project showed the importance of farmer involvement in the whole process. It also showed that open communication and strong multidisciplinary teams are essential for appropriate technology development and testing.

Table 1: Soil characteristics of the two areas prior to planting in the 1998/99 season

Area	Soil colour	pH[1]	Mineral Nitrogen[2]	P_2O_5 [3]	Exchangeable Cations			
					K_2O	Ca	Mg	Total
1. Dry	Pale brown	4.2	18	14	0.05	0.50	0.24	0.79
2. Wet	Light brown	4.5	25	47	0.08	0.63	0.30	1.01

[1] pH determined in 0.01M Calcium Chloride

[2] Mineral Nitrogen after incubation (Ammonium + Nitrate)

[3] Available P_2O_5 by resin extract

Table 2. *Dry matter yields (tons) of sorghum (SG) and hybrid pennisetum (HP) intercropped with cowpeas (CP) and dolichos beans (DB) under on-farm conditions during the 1998/99 and 1999/2000 seasons*

	Wet area							Dry area							
	Lime applied			No lime applied				Lime applied			No lime applied				
Farmer	**1**	**2**	**3**	**1**	**2**	**3**		**4**	**5**	**6**	**4**	**5**	**6**		
1998/1999 season															
HP + CP	17.9	8.7	5.8	21.9	8.6	10.6		9.1	2.8	2.8		7.3	5.3	2.5	
HP+DB	17.5	6.4	11.0	17.6	6.6	12.5		9.1	4.2	1.7		4.7	4.7	2.7	
SG+CP	18.5	15.1	9.8	25.0	5.2	10.6		5.4	5.0	2.3		4.8	4.0	2.4	
SG+DB	11.9	10.4	10.1	15.0	5.3	10.9		4.1	4.2	2.3		3.9	3.2	3.0	
Mean		16.4	10.1	9.1	19.9	6.4	11.1		6.9	4.1	2.7		5.2	4.3	2.7
1999/2000 season															
HP + CP	31.5	19.0	22.4	29.3	16.4	14.8		20.7	27.6	7.9		26.9	14.8	6.7	
HP+DB	21.0	16.9	27.7	34.0	17.3	15.9		17.3	21.5	10.5		34.9	21.7	7.1	
SG+CP	26.7	14.5	11.1	15.6	10.0	10.1		14.2	22.9	5.5		10.1	23.3	6.3	
SG+DB	13.5	25.6	9.2	16.0	14.0	6.9		11.4	19.7	6.6		9.3	19.9	5.5	
Mean		**23.2**	**19.0**	**17.6**	**23.7**	**14.4**	**11.9**		**15.9**	**18.3**	**7.6**		**20.3**	**19.9**	**6.4**

Table 3: Rainfall (mm) recorded in the Dry and Wet areas of Gulathi during the growing season of 1999/99 and 1999/2000 seasons.

Month	**Wet area 1998/99**	**Dry area 1998/1999**	**Wet area 1999/2000**	**Dry area 1999/2000**
October	16	0	15	6
November	44	36	184	110
December	115	50	139	269
January	84	56	227	197
February	62	46	465	413
March	40	43	76	86
Total	**361**	**231**	**1056**	**1081**

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Effect of Mixed Cereal-Legume Silages on Milk Production from Lactating Holstein Dairy Cows (R7010)

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Abstract

Mixed silages of good quality can be produced to partially replace commercial feed supplements without loss in milk yield or quality. However, there is need to ascertain from the responses in low yielding dairy cows, especially cross breds, whether there is potential to replace commercial feeds with mixed forage tree legumes and increase profits. The rate of substitution will depend on the relative costs of ensilage and commercial feeds. Judging from the performance of the mixed silages in this experiment, it is possible to recommend their use for replacing dairy feeds in the diets of heifers and dry cows. Further work into the types of phenolic compounds and their quantities, as affected by ensilage, are needed in order to improve the management of tannins, thereby enhancing protein supply from tanniniferous forages for milk production.

Introduction

In the smallholder dairy sector of Zimbabwe commercial feeds account for over 60% of total production costs (ARDA, 1999). Dairy producers would benefit if the amounts of commercial feeds used could be reduced without a decline in yield and quality of milk.

Traditionally silage has been made from cereals and grasses although legume silages have been produced (Dunn, 1991; Beauchemin *et al.*, 1994; Okine *et al.*, 1993; Belibasakis *et al.*, 1997). Cereal silages are rich in energy but low in crude protein (CP) ($\pm$ 7%) whilst the converse is true for legume silages (Catchpole and Henzell, 1971). Titterton *et al.*, (1997) found that the CP of mixed maize and legume silage (40 - 60% maize with 60 - 40% legume) was greater than maize silage alone. Titterton *et al.*, (2000) successfully ensiled mixed forage tree legumes (FTLs) with maize and the CP of the mixed silages was reported to be comparable with that of commercial feeds, being 17.2% for maize-leucaena and 18.7% for maize-acacia silages.

Although FTLS are protein-rich forages, they often contain significant levels of anti-nutritional substances such as tannins and toxic chemicals (mimosine) that interfere with digestion and utilisation of protein, minerals and carbohydrates in ruminants (Rittner and Reed 1992). However, some anti-nutritional factors can be inactivated or removed by ensilage. James and Gangadev (1990) reported that the mimosine content of *Leucaena leucocephala* decreased significantly due to ensilage. In the light of these findings, a hypothesis was put forward that ensilage reduces the amount and effect of active tannins.

In this study the quality of mixed silages and the effect of partial substitution of a commercial dairy meal and maize silage with the mixed silages on dry matter intake, milk yield and milk quality were assessed. Economic implications of such substitutions are discussed in terms of savings on costs of supplementary protein.

Materials and Methods

Crops and harvesting. The FTLs used in this experiment were *Acacia boliviana* (Acacia) and L. *leucocephala* (Leucaena) from coppices harvested in 1999. The coppices were cut when more than 25% were at the flowering stage and at a height of about 0.7 m. The leaves were stripped by hand from the branches and twigs. A long-season white maize variety, SC709, was used. The crop was managed as a commercial maize crop, in terms of fertilizer application, weeding and pest and disease control. Harvesting was by hand and a motorised chaff-cutter was used to chop the maize into lengths of about 15cm.

Ensilage process. The crop was ensiled in 50kg plastic bags. Five kg of freshly chopped maize was thoroughly hand mixed with 5 kg of the respective freshly cut legume. The mixed forages were then packed in the plastic bags and compacted by hand, to exclude as much air as possible, and then tied by a string to ensure air-tightness. The material was left to incubate in a room for seven weeks before samples were taken for laboratory analyses. Concurrently, maize from the same crop was ensiled in a bunker. This silage provided the basal diet for the trial animals.

Samples and sample preparation. Two kg samples were taken from each batch of the respective legume and chopped maize. All the batch samples were then thoroughly hand mixed before three 2 kg samples were taken for laboratory analyses. Samples of freshly mixed maize-legume material were also taken. Three 0.5kg samples of the dairy meal were also taken for laboratory analysis.

Two of the three fresh 2 kg samples of the silages were stored in sealed plastic bags in the freezer. One of the samples of each was immediately used to determine dry matter (DM) content. The oven-dried samples were then ground through a 1.5mm screen and stored at room temperature until subsamples for laboratory analysis were taken after thorough mixing by stirring with a glass rod.

Laboratory analyses. The analyses were made on samples of the mixed silages, bagged maize silage, bunker maize silage and the dairy meal. The parameters analysed on the fresh material and the silages included neutral detergent fibre (NDF) modified acid detergent fibre (MADF), CP and ash. All analyses were done in duplicate. Dry matter was also estimated: fresh forages and silages were dried in a forced air oven at 60°C for 48 hours; and dairy meal in an oven at 105°C for 24 hours. Crude protein content was determined by the Kjeldahl method (MAFF, 1985). Fermentation characteristics of silages, pH, ammonia nitrogen (NH_3-N), volatile fatty acids (VFAs), and lactic acid (LA) were also determined (MAFF, 1985).

Ration formulation. Rations were formulated to give an overall CP content of 13% and a metabolizable energy (ME) concentration of 10MJ/kg (estimated from forage analysis and the AFRC, 1993). The bunker silage was the basal diet for the experimental animals. A commercial dairy meal was used to balance the rations for CP and energy content and it also ensured that mineral requirements were met. The diets consisted of 10kg treatment silage, 20+kg of basal maize silage (from the bunker) and 6.5 to 10.5kg of the dairy meal (19.6% CP and 13MJ/kg ME). Table 1 gives a summary of the rations used in the study.

***Table 1: Requirements (dry matter intake,* DMI; *crude protein,* CP) *and amounts of feed offered, to the three groups of cows, of diets containing maize silage* (MZ) (*basal diet and control*) *and the treatment silages, maize-leucaena* (ML) *and maize-acacia* (MA), *together with dairy meal* (D).**

Silage	Requirements			Feeds used (kg DM/d)			Nutrients offered			Concentration	
Type	DMI (kg)	ME (MJ)	CP (kg)	Trt silages	Basal MZ	D	DM (kg)	ME (MJ/kg)	CP (kg)	ME (MJ/kg)	% CP
MZ	18.2	167.5	2.0	2.7	6.2	7.3	16.2	183.9	2.1	11.6	13.1
ML	18.9	159.0	1.8	2.8	6.2	6.3	15.3	171.4	2.0	11.6	12.9
MA	18.6	1723.0	2.1	3.4	6.2	7.2	16.8	189.3	2.2	11.6	13.0
SD	1.95	16.91	0.30	0.32		1.46	1.52	20.34	0.20	0.10	0.15

Animals and treatment allocation. Twelve Holstein dairy cows, with an initial live-weight of 610 kg (± 71), and all in mid-lactation (days in milk 166 (± 27)) were used. The animals were arranged into four groups of three animals each according to parity. The three cows in each group were randomly allocated to one of the three treatment silages i.e. maize (control), maize-leucaena and maize-acacia. All the experimental animals were then randomly allocated to individual feeding troughs in the feeding shed.

Feeding system and measurements. The cows were given three meals per day, at 06:00, 12:00 and 17:00 for a period of 21 days of which 14 days were for adaptation followed by 7 days of data collection. Animals were allowed at least 2 hours feeding time after which the refusals were removed and weighed. The treatment silage (10 kg) was fed at 06:00. At 12:00 and 17:00 the cows were given 10 kg of the basal bunker silage. The dairy meal allocation was given in three equal portions, one at each meal time. Refusals were removed after each feed and daily DM intake (DMI) calculated. Water was available between meals. Milk yields were recorded at each (am and pm) milking.

Milk samples and laboratory analyses. Milk sampling was done twice per week, during morning and afternoon milking. Twenty ml samples were stored in bottles containing a Bromopol (2-bromo, 2-nitropraine, 1,3 Diol + Natamycine) preservative tablet to prevent any spoilage before chemical analysis. The milk samples were analysed for butter fat (BF), lactose, protein, and total solids using a Bentley 2000 infrared milk analyser.

Statistical analysis. Fermentation characteristics and nutritive composition was analysed using SAS (1994) procedures for a completely randomised design as represented by the model below.

$R = m + T_i + E_{ij}$ Where R = response variable (e.g. dry matter, crude protein, pH etc),

m = overall mean, T_i = treatment effect (i = 1, 2, 3),

E_{ij} = random error.

For the feeding trial, SAS (1994), general linear models (GLM) procedures for a completely randomised block design were used for the analyses of DMI, milk yield and milk composition data. The following model was used for data analysis:

$R = m + P_i + T_j + E_{ijk}$ Where: R = response variable (DMI, milk yield, protein, butterfat, lactose and total solids),

m = overall mean, P_i = effect due to parity (i = 1, 2, 3,4),

T_j = treatment silage effect (j = 1, 2 or 3), E_{ijk} = random error.

The differences among the means were assessed by Tukeys method.

Results

Silage fermentation characteristics. Silage fermentation quality was assessed by DM content, pH, lactic acid (LA), VFAs and NH_3-N content (Table 2). The DM content of the silages was similar (P>0.05). Bagged maize silage had the lowest pH followed by maize-acacia and bunker maize silages, with similar values, and maize-leucaena silage had the highest pH value (P< 0.05). NH_3-N per cent in relation to total nitrogen in the silage was similar (P>0.05) for all silages.

Bagged maize silage had significantly higher LA concentration than the two mixed maize FTL silages (Table 2). The volatile fatty acids that could be identified by the GLC method were acetic acid (AA), propionic acid (PA), n- and iso-butyric acids (BA) and iso-valeric acid. Acetic acid and PA amounts did not vary between silages (P>0.05). The amount of acetic acid in the mixed maize-FTL silages was double that of the maize silage when expressed as a percentage of the total organic acids in the silage. The n- and iso-butyric acid levels across the silages varied (P<0.05), with both being highest in the maize silage followed by mixed maize-leucaena silage and mixed maize-Acacia silage. Iso-valeric acid could not be detected in the maize silage but was in appreciable amounts in the mixed maize-FTL silages.

Nutritional composition of the silages and the meal. The NDF content of the silages were not different but they all differed from that of the meal (P < 0.05) (Table 2). Bagged maize silage and mixed maize-Acacia silage had similar MADF whilst bunker maize silage and mixed maize-leucaena had higher MADF. The dairy meal had the highest D value followed by the bagged maize silage, mixed maize-acacia silage, bunker maize silage and the mixed maize-leucaena silage. The estimated D value of the bagged maize silage was different from that of the maize-leucaena and the bunker maize silage (P<0.05) but similar to that of the maize-Acacia silage. The D value of maize-acacia silage did not differ (P > 0.05) from that of the bunker silage and the mixed maize-leucaena silage. The same trend was found with estimated metabolizable energy values.

The CP content of maize-acacia silage was the highest whilst the bunker maize silage was the lowest. The CP content of the dairy meal was similar to that of mixed silages although maize-Acacia had a greater CP content, significantly higher than that of maize-leucaena silage (P<0.05) (Table 3). The ash content was highest (P<0.05) in the mixed maize-leucaena silage followed by the bagged maize silage and then the dairy meal with similar levels to those of the bunker and the mixed maize-Acacia silages.

Dry matter intake. The cows given mixed maize-Acacia and maize silage (control) ate more than those fed the mixed maize-leucaena silage (P<0.05) (Table 4).

Milk yield and quality. Milk yield (Table 4) was higher (P < 0.05) in cows fed mixed maize-Acacia and maize silages than in animals on mixed maize-leucaena silage. However, milk composition in terms of BF, lactose, protein and total solids was similar (P>0.05) across treatments.

Table 2: The Fermentation characteristics of the silages

Silage Type	Bunker maize	Bagged maize	Maize-leucaenae	Maize-acacia	Standard Error of Means
Dry matter (DM, g/kg)	309[a]	271[a]	276[a]	339[a]	12.3
PH	4.5[b]	3.7[c]	4.8[a]	4.5[b]	0.02
NH_3-N (g/kg DM)	9.59[a]	7.46[a]	10.09[a]	8.09[a]	0.756
Organic acids (g/kg DM):					
Acetic acid	Nd	9.56 [a]	9.91 [a]	7.76 [a]	0.485
Propionic acid	Nd	1.00 [a]	0.99 [a]	0.72 [a]	0.076
iso-butyric acid	Nd	3.10 [a]	2.24 [ab]	1.75 [b]	0.149
n-butyric acid	Nd	0.96 [a]	0.68 [ab]	0.47 [b]	0.067
iso-valeric acid	Nd	—	2.34 [a]	1.59 [a]	0.386
Total organic acids	—	87.87	49.46	41.29	

Note: [1] Nd = Not determined

All values are least square means except for total organic acids.

Values with different superscripts across the rows are significantly different (P<0.05).

Table 3: Dry matter (DM, *g/kg fresh*) and nutritive composition (*g/kg* DM) of the forage tree legume silages in relation to maize silage and a commercial dairy meal.

Feed Type	Bunker maize	Bagged maize	Maize-leucaena	Maize-acacia	Dairy meal	Standard error of means
DM	309[a]	271[a]	276[a]	339[a]	865§	12.34
CP	65.0[c]	71.2[c]	176.0[b]	208.7[a]	196.9[ab]	0.45
NDF	665.0[a]	608.2[a]	658.4[a]	602.6[a]	420.0[b]	17.52
MADF	353.5[a]	304.4[b]	357.4[a]	318.6[b]	98.9[c]	4.43
ME	9.3[c]	10.2[b]	9.2[c]	10.0[bc]	13.0[a]	0.13
Ash	5.6[b]	6.6[ab]	7.4[a]	5.6[b]	5.6[b]	0.23
*Digestibility (%)	57.9 [c]	63.8 [b]	57.6 [c]	62.2 [bc]	90.7 [a]	1.50

Note: *Values with different superscripts across the rows are significantly different* (P<0.05)

§ *The value was not included in the separation of the means.*

**The values were calculated using* MADF (*Givens et al*, 1989).

Table 4: *Dry matter intake* (DMI/100 *kg live-weight*), *milk yield* (*kg/d*) *and milk composition* (%) *in cows fed mixed cereal-legume silages.*

	Maize silage (control)	Maize-leucaena silage	Maize-acacia silage	Standard error of means
DMI	3.3[a]	3.1[b]	3.3[a]	0.03
Milk yield	7.0[a]	14.1[b]	15.7[a]	0.69
Butterfat	3.6[a]	3.7[a]	3.6[a]	0.11
Protein	4.0[a]	3.4[a]	3.5[a]	0.05
Lactose	4.6[a]	4.67[a]	4.4[a]	0.04
Total solids	12.5[a]	12.7[a]	12.4[a]	0.16

Values with different superscripts within rows differ significantly ($P<0.05$).

Discussion

Silage fermentation quality. The quality of the mixed silages produced appeared satisfactory, in that the DM was within the recommended range, for maize and grass silages of 21 – 32 %. Dry matter indicates the bulkiness and the subsequent feeding value of a feed. In silages a match between high DM (25% to 32%) and high nutrient content is required. For ruminants, DM has a bearing on rumen fill and thus voluntary feed intake. This in turn influences the rate of passage and overall digestibility of a feed. pH values of less than five were achieved in the mixed silages; NH_3–N was also low, being <11% of total N in the silage (Catchpole and Henzell, 1971). The pH values were similar to those found by Titterton *et al.* (1999). The variation in the pH and the NH_3–N values could be explained by seasonal variation of the quality of the material and the harvesting and ensiling techniques followed in each case.

Tjandraatmadja *et al* (1993) also gave the following standards for tropical silages, pH should be less than 4.2, LA levels of 50%+ of total organic acids, BA levels of less than 0.5% of DM and NH_3–N of less than 10%. According to these criteria the quality of the bagged maize silage was good whilst those of the mixed maize-FTL were satisfactory.

It is generally believed that leguminous forages have high buffering capacity, which would result in relatively high pH values in silages made from such material (Uchida and Kitamira, 1987). The pH values achieved in this study seem to suggest that when the legume (FTL) is mixed with maize that has high levels of fermentable carbohydrates the buffering effect is reduced and desirable pH levels are achieved. These findings also confirm the technical feasibility of mixed maize-legume silages. The pH, LA, BA, NH_3-N, levels in this experiment indicate that there was little proteolytic decomposition and putrefaction, even by temperate standards. The plastic bag silo technology may have contributed to the production of good quality silage because it seems to provide better anaerobic conditions than bunker maize silage. This can be confirmed by the fact that the amount of the NH_3-N expressed as a percentage of total N in silage, which gives a reflection of the extent to which the decomposition of nitrogenous compounds has taken place, was low (<11%) in all samples, including the mixed silages, where there was a higher level of proteins. High LA, low pH and low NH_3-N levels found in this experiment suggest that there was little proteolysis of the protein. However, a good fermentation process does not depend on the type and quality of the forage crop only, but also on harvesting and ensiling techniques (Stefanie *et al.* 1999).

Nutritional composition of the silages. The CP of the mixed silages (17 – 21%) is comparable to that of commercial dairy feeds giving them an advantage over maize silage (6.8%), as reported by Titterton *et al.* (1999), although the values in this study were slightly higher. However, the efficiency of utilisation of the CP in mixed silages is not guaranteed due to perceived interference from polyphenolic compounds. Therefore, the feeding value of mixed silage can best be judged from animal performance. The CP content and the availability of protein in any livestock feed is important in that it has a bearing on supplementary requirements for this expensive nutrient.

The NDF levels of the mixed maize-FTLs were within the range for some forage silages in the tropics. For example, guinea 'A' grass silage in Sri Lanka had 69.9-71.9 NDF (Panditharatne *et al* 1986), napier grass silage in Thailand had 64.2 - 70.2 NDF (Shinoda *et al.* 1999). The MADF of forages and silages should be within the 22-50% range as suggested by Slater (1991). The lower the MADF, the higher the energy level in a forage or silage. The levels found in this study are within this range and this indicates that the mixed maize-FTL silages have a potential to replace the silage from such traditional crops maize and sorghum, if other factors are ideal. It is important to note that the NDF and MADF levels are dependent on the maturity stage of any given forage, since they are essentially indicating the levels of cell wall components, mainly the cellulose, hemicellulose and lignin (for NDF), and cellulose and lignin (for MADF).

Similarly DM and CP of a silage all depend on the type and stage of maturity of the crops at the time of ensiling, method of harvesting and technique of ensiling. Feeds with high fibre content have low digestibility and hence are of poor quality. The MADF of the bagged maize silage and that of the mixed maize-acacia were similar and so were those of the bunker maize silage and that of the mixed maize-leucaena silage but they were all within the 22-50% range suggesting that quality is acceptable. If NDF is considered, the picture is different, with all the four silages having a similar concentration (Table 2). In this regard MADF seems a better indicator of potential digestibility of silage than NDF.

The ash content of the mixed silages was comparable to that and the maize silage of the dairy meal, that contained added minerals for lactating dairy cows. Mixed maize-leucaena silage had a significantly higher level of the ash than the dairy meal and other silages used in this study. This suggests that there may be no need to add commercial mineral supplements if mixed silages are fed to moderately yielding dairy cows.

D*ry matter intake*. There was no difference between the DMI of maize-acacia and the maize silage demonstrating the potential of the mixed maize-acacia silage as a source of protein in dairy cattle feeding. Dry matter intake is an important parameter in assessing the nutritive value of a feed or forage. The CP content of a feed influences DMI because it tends to improve palatability. However, CP content alone can not be responsible for high DMI because the energy content of the feed also plays an important role since animals eat to satisfy their energy requirements (Syed and Leaver, 1999). The DMI reflected the influence of NDF, MADF and digestibility levels in the experimental treatment silages (see Table 2). The low DMI of the maize-leucaena silage could have been due to high fibre levels resulting in the rumen fill effect. In this study it seems that the DMI has been influenced by the fermentation quality of the silages.

M*ilk yield and quality*. Milk yield and quality are influenced within bred, by stage of lactation, parity, and animal size and body condition at calving within bred in addition to the type and level of feeding. Rations that stimulate high milk yield will depress BF% and boost TS. High levels of feeding tend to stimulate high milk yields and lactose but depress BF, protein and minerals. Conversely under-feeding results in high BF, protein and minerals and low milk yield and lactose (Slater, 1991). In this study maize silage resulted in milk yields similar to those of the maize-Acacia silage, indicating that the mixed silage has the potential to replace the maize silage. However, the value of the mixed silages, on-farm, cannot be guaranteed as this depends on the prevailing economic situation. Low DMI seemed to have affected the milk yield from the maize-leucaena silage. Milk yields from animals supplemented with L. *leucocephala* hay were higher than those from animals fed A. *angustissma* and C*alliandra calothyrsus* hay supplements (Hove, 1999). These findings suggest that the processing done prior to feeding influences the performance of forages. Sun, oven or freeze drying have varying effects on tannin levels (Ahn *et al.*, 1989), thus affecting DMI and subsequent the milk output. In this experiment ensilage seems to have had varied effects on tannin levels depending on the type of forage.

There were no differences in the quality of milk across the treatments, although Kumagai *et al.* (1993) suggested that milk yield and composition in dairy cows might be influenced by the source of roughage. The present study agrees with the conclusions drawn by Khorasani *et al.* (1996), that dairy cows can maintain similar milk yields, despite marked differences in the type of end products arising from carbohydrate and protein digestion. Chenais *et al.* (1993) carried out similar studies using mixed maize-red clover silage and lucerne silage and found that the mixed silage increased milk yield compared to the maize silage alone (control) but lucerne silage was out-performed by the control. The same authors also reported that the legumes compared to the maize silage lowered milk fat and protein levels.

Bequette *et al.* (1993) reported that protein supplementation resulted in increased milk output although there was a significant proportion of protein channelled to the mammary gland for tissue growth. These varying results indicate that there is need for more research into the subject of mixed silages and their influences on milk yield and composition in given environments. This is important, since the quality of milk has an influence on processing it into milk products. Long-term studies are needed to determine the effects of mixed forages on udder development and the subsequent milk yields.

The advantages of the mixed silage can be expressed in terms of savings in costs, compared to using commercial feeds, while the disadvantages are reduced milk yields. The substitution of commercial feeds by FTLs must allow for the full costs of ensilage and the cost of commercial feeds

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Body Condition Score and Lactation Responses in Indigenous and Cross-bred Cows in Smallholder Dairying Systems in a Semi Arid Area of Zimbabwe (R7010)

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Abstract

Body condition score (BCS) and lactation response were assessed in 20 indigenous and 20 Jersey indigenous cross-bred dairy cows, in a smallholder situation, in a semi arid area of Zimbabwe, after supplementation with sweet sorghum-lablab silage in late pregnancy. Cows were fed daily no silage (control), 3kg silage dry matter (DM), 6kg silage DM or *ad lib* silage for two months. The BCS of the supplemented groups were higher ($P < 0.05$) at calving than the unsupplemented group. The BCS of the cows in the 6kg DM silage and *ad lib* groups were higher ($P < 0.05$) throughout the post-partum monitoring period than the 3kg DM and control groups. The cows in the 3kg DM silage group were not significantly different from the unsupplemented group between 2 and 18 weeks after calving. The indigenous breds had higher BCS ($P < 0.05$) throughout the monitoring period than the cross-breds. Within bred there were no differences ($P > 0.05$) in BCSs, except between the Jersey-Tuli and Jersey-Nkone crosses, four to eight weeks after calving. Milk yield and lactation length was unchanged ($P > 0.05$) across the treatment groups. However, cross-bred cows gave more milk over a longer lactation period ($P < 0.05$) than the indigenous cows. It is concluded that supplementation before calving improved body condition, there was no improvement in milk yield.

Introduction

Numbers of commercial dairy farmers have declined, from 581 in 1980 to 328 in 1999. Milk production is around 180 million litres per annum while demand is 350 million litres (DDP, 1999). The dairy development programme (DDP) is encouraging smallholders to make up this shortfall in production, but many of their farmers are smallholders in semi-arid areas and, therefore, have severe dry season feeding difficulties (Mupunga and Dube, 1993; Machaya, 1994; Mupeta, 1999). Home-grown feeds are the most cost-effective sources of supplementation. For semi arid areas, sweet sorghum is preferred to maize, because greater drought tolerance results in higher yields (Havilah and Kaiser, 1992). However most smallholder farmers have no experience with forage conservation (Mupeta, 1999).

The small hardy indigenous breds, Mashona, Nkone and Tuli, form the basis of the smallholder herd. However, they have not been selected for milk yield, that is low (Mupunga *et al*,. 1993). The most suitable bred or cross-bred has still to be identified. This study seeks to assess the benefits of dry season supplementation of cows, before calving, as an option to improve bcs and subsequent milk production.

Materials and Methods

Site. The study was conducted at Matopos Research Station, in Matebeleland South Province of Zimbabwe. The site lies 20°S and 28°E and is 1340m above sea level. The mean maximum temperatures in summer are around 30°C and in the cool dry season around 20°C. The area receives low to moderate annual rainfall (570mm), mainly during the rainy season, between November and March. The area also experiences periodic droughts. The vegetation is mainly savannah woodland with acacia trees and shrubs being the predominant tree species. The pasture quality and quantity varies seasonally, being very good and abundant in the rainy season, but turning poor and scarce in the dry season (Ward et al, 1979). At the time of this study there was a drought (rainfall, 380mm) which reduced the yield and quality of silage (Titterton *et al*., in press).

Animals. A total of 40 primi- and multiparous cows, 20 indigenous (10 Tuli and 10 Nkone) and 20 Jersey cross-breds (10 Jersey x Nkone and 10 Jersey x Tuli) were selected. Their initial body weight was 363 ± 52 kg and body condition score 2.5. Supplementation was offered from late August (two months before their estimated calving date) to November 1999. Data collection continued to July 2000. During the lactation period, calves suckled briefly in the morning, before milking, and were allowed to run with their dams after milking until separation in the evening. This is similar to smallholder practice.

Silage. The silage was produced from intercropped sweet forage sorghum (sugargraze) and *Lablab purpureus* (Dolichos beans) made in plastic bags using a technology developed by Titterton *et al*., (in press) (chemical composition is shown in table 1).

Table 1. Dry Matter (DM) (*g/kg*), *chemical composition* (*g/kg* DM), *pH*, ME MJ/*kg and ammonia* N (AN) *of the sweet sorghum – lablab silage.*

DM	CP	Ash	ADF	NDF	MADF	DOM	pH	ME	AN
370	93.3	110	350.3	611	45.2	55.6	4.1	8.34	7.3

Treatments. Cows were allocated by bred to the four silage (sweet sorghum-lablab) supplementation levels. The four dietary treatments were as follows: 1),unsupplemented (control); 2), 3kg DM (one bag) silage /cow/d; 3), 6kg DM silage (2 bags) silage/cow/d; and (4), *ad lib* silage(average 12 kg, or 4 bags)/cow/day. The first three groups had access to natural rangeland. From calving, all cows received 2 kg /d of a 14% crude protein dairy meal.

Body condition scores. These were monitored weekly from the start of the supplementation period until 18 weeks after calving. The five-point scale (1-emaciated and 5-obese; Mulvany, 1981) was used. The same two people scored the cows on each occasion. Scoring was carried out by palpation of the transverse vertebrae and tail head to estimate the amount of fleshing, or fat cover in these two areas.

Lactation. Milking commenced 8 days after calving to ensure all the colostrum was available to the calves.. The cows were hand milked once a day, in the morning, and milk yield was recorded. Prior to milking, calves were allowed momentary suckling to stimulate the milk let-down response. Milking continued until the yield fell to 0.2 kg/d.. The lactation length was recorded as the number of days, from the eighth day after calving until the cow was dry..

Statistical analysis. Data on milk yields and lactation length were analysed using the GLM procedure of SAS (SAS, 1994). The model used was:

Yijkl = ì + Ti + Bi + (TB)ij + Pk + eijkl

where Yijkl = milk yield, lactation length; ì = population mean; Ti = fixed effect of supplementation level (I=1,2..4); Bj = fixed effect of bred (j=1.2..4); (TB)ij = supplementation level x bred interaction; Pk = fixed effect of parity (1and2); eijkl = random error.

Body condition score data, being discrete data were subjected to square root transformation (Gomez and Gomez, 1984) before the trends were analysed using the PROC MIXED procedure of SAS (SAS, 1994) for repeated measures analysis. The model used was :

Yijklmn = m + Ti + Bj + Pk + Wl + (TxB)ij + (TxW)il + (TxBxW)ijl + (BxW)jC(TxB)ijm + eijklmn Where:

Yijklmn = response variable (body condition)m = population mean; Ti = fixed effect of level of supplementation (i = 1,2..4);Bj = fixed effect of bred (j = 1,2,..4); Pk = fixed effect of parity(k = 1,2); Wl = fixed effect of time (week) (l = 1,2 …..20 weeks); (TxB)ij = treatment x bred interaction; (treatment x time interaction; (TxBxW)ijl = treatment x bred x time interaction; (BxW)jl = bred x time interaction; C(TxB)ijm = random effect of m^{th} cow in the i th group and j^{th} bred, Eijklmn = random error.

Results

Because severe drought limited the growth of legumes, their inclusion rate in the silage was lower than anticipated, thereby reducing both yield and quality of the silage. During the trial one cow, in the control group, died. Her data was discarded.

Effect of prepartum supplementation on body condition scores.. At calving, cows in the supplemented groups had higher BCS ($P < 0.05$) than the control group . In all treatment groups, cows lost condition in early lactation, before beginning to recover five weeks-post calving. Treatment 2 (3 kg silage DM) cows had BCSs higher ($P < 0.05$) than the control group up to two weeks post-partum, after which the scores remained similar ($P > 0.05$) to the end of the monitoring period. The change in BCS from pre-feeding to calving was significant ($P < 0.05$) with the control group losing most and the *ad-lib* group gaining most (figure 1).

Figure 1: Changes in body condition scores in cows unsupplemented or supplemented before calving.

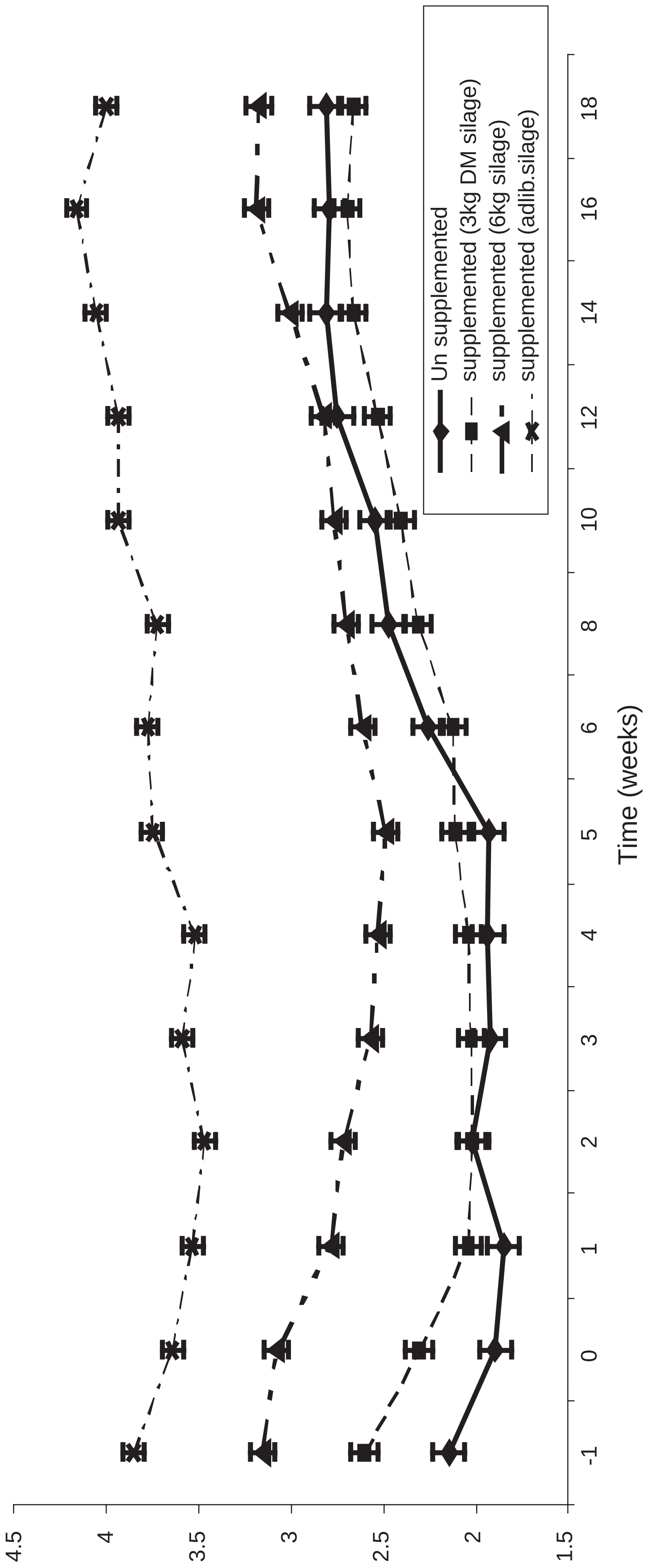
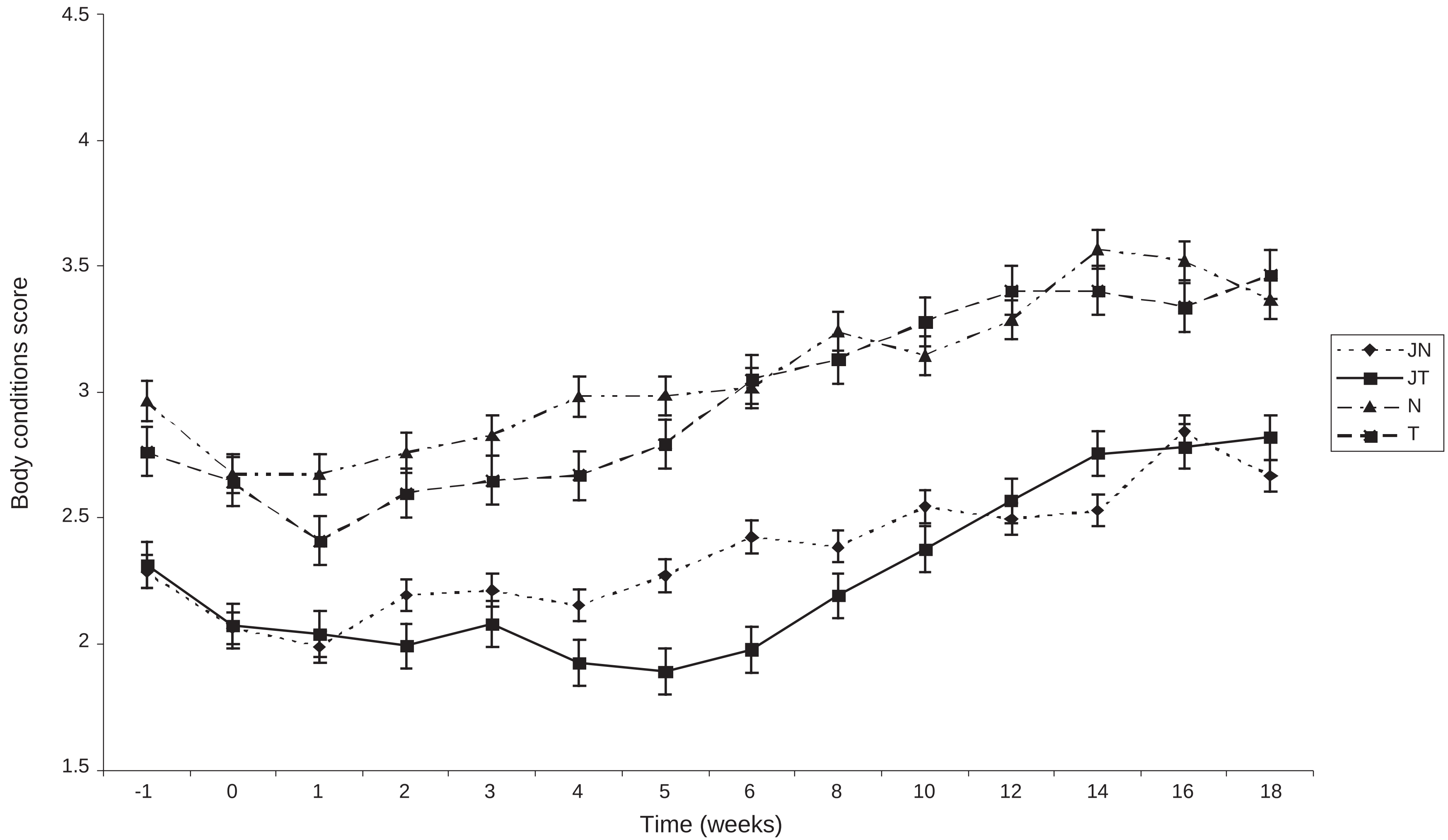


Figure 2: Changes in body condition scores in the indigenous (Nkone) (N) & Tuli (T)) and cross-bred cows (Jersey (J) x Nkone and Jersey x Tuli) from 1 week before calving to 18 weeks after calving.



The indigenous (Tuli and Nokone) had higher BCS ($P < 0.05$) than the cross-breds (Jersey x Nkone and Jersey x Tuli) from calving to the end of the monitoring period 18 weeks later. Between the indigenous groups there were no differences ($P > 0.05$) in the BCS, except for week 1 and week 4 post calving. The Jersey Nkone and Jersey Tuli had similar BCS ($P > 0.05$) except between weeks 2-8 after calving, when BCS of the Jersey Nkone was higher ($P < 0.05$) (Figure 2).

Milk yield. The cross-bred cows had higher daily and total lactation yields and longer lactations ($P < 0.05$) than the indigenous breds. Between the two indigenous (Tuli and Nkone) breds and between the two types of cross-bred there were no differences ($P > 0.05$) in milk yield and lactation length (Table 2). Supplementation did not affect milk yield or lactation length (Table 3).

Table 2: Milk yield (kg) and lactation length (d) in indigenous (Nkone, N; Tuli, T) *and cross-bred* Jersey (J) *cows.*

	Breds			
	JN	JT	N	T
Daily milk yield	$2.8^{a} \pm 0.20$	$3.27^{a} \pm 0.18$	$1.1^{b} \pm 0.19$	$1.2^{b} \pm 0.19$
Lactation yield	$650^{a} \pm 46.8$	$760^{a} \pm 38.9$	$230^{b} \pm 40.0$	$248^{b} \pm 49.4$
Lactation length	$247^{a} \pm 11.0$	$242^{a} \pm 9.0$	$195^{b} \pm 9.7$	$195^{b} \pm 10.0$

Least square-means with the same superscript in a row are not significantly different ($P > 0.05$)

Table 3: Milk yields (kg) and lactation lengths (d) for cows (indigenous, Nkone (N) and Tuli (T); cross-bred Jersey (J)) at four levels of silage supplementation

		Supplementation levels			
	Bred	Control	3kgDM /d	6kgDM /d	Ad-lib 12 kg/d
	JN	$599^{1a} \pm 89.6$	$621^{1a} \pm 70$	$630^{1a} \pm 89.6$	$760^{1a} \pm 89.6$
Lactation yield	JT	$660^{1a} \pm 70$	$875^{2a} \pm 87$	$775^{1a} \pm 85$	$731^{1a} \pm 75$
	N	$234^{2a} \pm 85$	$311^{3a} \pm 70$	$213^{2a} \pm 70$	$164^{2a} \pm 89.6$
	T	$304^{2a} \pm 89.6$	$122^{3a} \pm 85$	$335^{2a} \pm 70$	$232^{2a} \pm 75$
	JN	$2.8^{1a} \pm 0.41$	$2.7^{1a} \pm 0.32$	$2.5^{1a} \pm 0.41$	$3.3^{1a} \pm 0.41$
Daily milk yield	JT	$2.7^{1a} \pm 0.32$	$3.7^{1a} \pm 0.41$	$3.2^{3a} \pm 0.39$	$3.2^{1a} \pm 0.35$
	N	$1.1^{2a} \pm 0.39$	$1.6^{2a} \pm 0.32$	$1.1^{2a} \pm 0.32$	$0.7^{2a} \pm 0.41$
	T	$1.4^{2a} \pm 0.41$	$0.8^{2a} \pm 0.39$	$1.6^{12a} \pm 0.32$	$1.3^{2a} \pm 0.30$
	JN	$237^{1a} \pm 21$	$237^{1a} \pm 16$	$250^{1a} \pm 22$	$262^{1a} \pm 22$
Lactation length	JT	$246^{1a} \pm 16$	$233^{1a} \pm 21$	$259^{1a} \pm 21$	$230^{1a} \pm 18$
	N	$216^{1a} \pm 20.5$	$191^{21a} \pm 17$	$204.5^{1a} \pm 17$	$168^{2a} \pm 22$
	T	$221^{1a} \pm 21.6$	$163^{2a} \pm 21$	$209^{1a} \pm 19$	$185^{2a} \pm 18$

Means with same letter in each row are not significantly different and means with the same number in each column are not significantly different ($P > 0.05$)

Discussion

When the cows calved, those in the unsupplemented group had lost more condition than the supplemented groups. This confirms the findings of Topps, (1977) that cattle in the tropics lose weight in the dry season due to the poor quality of natural pastures, often with crude protein contents as low as 3%. Two of the supplemented groups (6 kg silage DM/D and a*d-lib* silage) gained condition by the time of calving, thus showing that at these levels sweet sorghum-lablab silage was effective in reducing dry season nutritional stress. The indigenous cows had higher BCS than their cross-bred counterparts, probably due to an inherent ability to utilise lower quality feeds more efficiently (Hunter and Siebert 1990). Similarity between unsupplemented and supplemented cows in terms of milk production and lactation length could be an indication that an improved BCS at calving does not give any milk yield advantage for indigenous and cross-bred cows. The poor milk yields could also have been due to poor grazing during the post calving period.

High yielding cows must calve with adequate reserves for mobilisation to help meet energy and protein requirements of early lactation (Erb *et al*., 1990). However, Mupeta, (1999) in his study of Zimbabwean smallholder owned cows reported that B*os indicus* cattle gave priority to maintenance of body condition rather than milk production. Jingura (2000) working with smallholder cows reported that cows were not milking 'off their backs'. Khombe *et al*.,(in press) also state that indigenous cows on a higher plane of nutrition do not produce more milk but tend to put on weight. In this study, however, slight mobilisation of body tissues occurred, as evidenced by the drop in BCS, especially in the unsupplemented and 3kg silage groups. Because of a lower ability to mobilize body reserves for milk production, B. *indicus* cows and their crosses may not be able to utilise fat reserves in early lactation to the same extent as B. *taurus* cows.

The milk yields obtained (Table 3) in this study are slightly higher than those reported for the same breds by Hamudikuwanda *et al*., (in press) (0.7 kg and 2.47kg/ day for indigenous and cross breds respectively), but lower than the 5.5kg/day for cross-bred cows reported by Mupeta (1999). The lactation length of 194 days for indigenous cows was slightly higher than the 150 days reported by Mupunga and Dube (1993) and 180 days by Henson, (1992). The lactation length of 243 days in this study is comparable with the 250 days for the cross-bred cows reported by Mupeta (1999).

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Questions and Answers

What was the mean nutritive value of the silage produced, in particular, crude protein and dry matter? Had wilting prior to ensiling been tried?

Crude protein was as high as legume maize silage, dry matter is 28%. Wilting did not have much effect due to the drought.

What is the time taken to harvest and process the silage?

This had been monitored since 1998: three hectares takes 8 days for 3 people to process. This is difficult to measure in relation to browse as the project used machinery. Also, increased labour is involved in stripping the trees although once the leaves are stripped they do not have to be chopped.

Has socio-economic analysis had been carried out?

Cost benefit analysis based on 1999 costs show the cost of 1 bag of silage is equal to the sale value of 7kg of milk.

How does the use of arable land for forage production affect the balance in the system?

This will be assessed at a later stage.

Is there more than one method of storing silage other than using plastic bags?

The use of plastic bags was due to feedback from the DDP. Plastic bags are easier for women to use.

Profit calculation

Care should be taken to make the silage well: adequate protein (i.e. not sugar alone) is required, which is why legumes were grown with the forage sorghum. There is an estimate of $5 profit per bag, this is worked out of as the average cost of buying the meal, minus the cost of the production of silage, and the cost of the bag. The project team are carrying out fuller cost investigations as part of the project.

Could silage be blended with dairy meal and other concentrates? In South Asia, the idea of making silage in bags is revolutionary.

Yes, but probably at the point of feeding to allow careful use of expensive concentrates.

Increasing the Productivity in Smallholder Owned Goats on Acacia Thornveld 1 Goat Feeding Strategies (R7351)

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Abstract

The current status of goat production and farmers' attitudes to feeding them *acacia* and other pods has been established. Variability in the annual production of pods, both species and quantity, was observed and will be noted for the duration of the project. Locally favoured species of pods are often decided by availability. The reasons for differences in animal performance attributable to pod species need investigating, as do methods of overcoming these constraints.

Introduction

Over the last 20 years numbers of goats have increased in Zimbabwe, particularly in the drier areas (Dept. of Veterinary Services, 1997). However, productivity is severely constrained by high kid mortality and low growth rates in young goats. Nutritional stress is greatest in the dry season, which ranges in length from five to 10 months, and during the early rains, when sudden drops in temperature and drenching rain, coupled with availability of browse only, stresses both kids and does (many livestock deaths due to poverty occur at this time).

Dry-season supplementation has long been recognised as necessary (Williamson and Payne, 1978). Does supplemented during the dry season reared more kids and lost less weight than those not supplemented (Prasad *et al*., 1995). With grazing kapeters, supplementation supported growth during the dry season (Sikosana and Maphosa, 1997), but most farmers do not have the resources to purchase feed and must seek local alternatives. Much of the natural rangelands of the drier areas of Zimbabwe are characterized by trees of *Acacia* species and those closely allied to them. In well-managed rangeland these trees could produce between 2.5 and five tonnes of pods (whole fruits, seeds plus hull) /ha/yr (West, 1950), many of them being edible and rich in protein (Tanner *et al*., 1988; Ncube and Mpofu, 1994). Timberlake *et al*. (1999) found that smallscale and commercial farmers regularly collect pods to use as high-protein feed in the dry season. They classify *Acacia erioloba*, *A. erubescens*, *A. nilotica* and *A. tortilis* as present in the 'greater Bulawayo area' and as 'Acacia dry woodland species'.

To assess farmers' perception of pods and to evaluate their potential to relieve dry-season feeding constraints in goats the following activities were undertaken: participatory rural appraisal (PRA) study; collection and analysis of pods; and feeding trials, that will continue for another season.

Activities

PRA Study

Two districts were selected, and within each two distinct areas comprising one or two wards: Matobo in Matabeleland South (Wards 3 and 11); and Bubi in Matabeleland North Province (Wards 3, 16 and 11, 15) (Kindness *et al*., 1999). Sales of live animals and meat were given as the major reasons for keeping goats, with milk and manure production also considered important. Overall, feed shortages, together with disease and stockthefts, were ranked as major constraints to production. Feeding shortages occur in the dry season, between June and November, with July to October the most critical months. Grasses, the nutritive value of which falls rapidly in the early dry season (Elliott and Fokersten, 1961) are either not available or in short supply. Crop residues are available, but those that have been stored tend to be kept for the cattle.

Pods (whole fruits) are collected and fed, between August and October in both districts (fallen pods are eaten between May and August, by which time the ground is bare) (see Tables 1 and 2). Preference by goats for the pods used in this study were ranked by the participating farmers (Table 3). Of the farmers interviewed, up to 66% claimed to collect pods (one ward was exceptional, in that only 4% collected them). Marketing pods was not common in the wards surveyed, but had taken place in 1992 (severe drought). Timberlake *et al*. (1999) found that A. *tortilis* pods were sold in the Gwanda (Matabeleland South) area.

Pod Collection and Availability

The study found pods are being collected for two reasons:

1) To facilitate storage and subsequent feeding

2) To estimate pod yield.

To achieve this, six 100m^2 plots were established, four in Matobo District and two at Matopos Research Station. Each plot has five 5m wide transepts, in which specific trees have been tagged, either for pod yield measurement or for 'individual tree analysis' (V. Mlambo, unpubl. data). The assistance of A. Illius and colleagues (R6984) is acknowledged.

Casual observation suggested that pods were available, but detailed observations during the past two dry seasons reveal that the presence of a specific type of pods cannot be assumed. Heavy rains in November and December 1998, knocked flowers off early flowering species before pollination, largely destroying crops of A. *nilotica* and A. *tortilis* pods. In February 2000 the excessively heavy rain that affected Southern Africa, from Mozambique through to Botswana, completely destroyed what appeared to be a heavy crop of A. *tortilis*. More information is required on the fruiting patterns of both species and individual trees (Table 4). Within an area all the major bearers of edible fruits are considered important (if they are available they are used, Kindness, *et al*. 1999), and for these reasons this study has been extended beyond Acacias to include *Dichrostachys cinerea* and *Piliostigma thonningii* (both common to semi-arid areas of Southern Zimbabwe, with pods that are eaten by cattle and wildlife: Coates Palgrave, 1983), but varieties with dehiscent pods, e.g. A. *karroo*, have not been considered.

Feeding Trials

Between May 1999 and August 2000 two experiments were undertaken to determine intake and assess the performance of lactating goats supplemented with pods, and the growth of their progeny, the first concerned feeding supplements of pods to lactating does with access to natural grazing, the second was a metabolism trial.

Experiment One

Materials and methods. Sixty indigenous female goats were divided randomly into five groups. Three groups were supplemented with crushed whole pods of either A. *erubescens*, A. *erioloba*, or D. *cinerea*; one group received cottonseed meal (CSM) as a positive control; and the fifth group was unsupplemented. Supplements were given at the rate of 200g/day /animal of air-dry feed and offered for 60 days before and 60 days after kidding.

Results and discussion. Numbers of kids born were low during this season, both on-station and on-farm. The disappointing performance of the experimental group, both does and kids, is likely to be related to adverse pre-experimental conditions, resulting from a severe dry season. Kids from does fed CSM were the heaviest ($P<0.001$) (Table 5). Weaning weights of kids were highest from the group fed CSM and the non- supplemented group. The lowest weaning weights were attained by kids from the group supplemented with A. *erubescens*. Browse pods from A. *erioloba* and D. *cinerea* could be an alternative supplement for goats during the dry season. More work is needed to test these pods by giving a uniform basal diet in addition to browse under a controlled management system so as to assess the contribution of pods to the diet.

Experiment Two

Materials and method. Dry matter intake was measured in 30 castrated goats, housed in metabolism crates (digestibility and nitrogen retention were also measured and analysis is in progress). There were five animals per treatment. Animals were offered either: crushed pods of A. *erioloba* (CP 14.6%), A. *erubescens* (CP 15.2%), A. *nilotica* (CP 11.5%), D. *cinerea* (CP 19.5%) or CSM (CP 40.8%). All animals were offered hay (CP %, 2.3) *ad libitum* and water was available at all times.

Results and discussion. Goats receiving supplements of CSM, A. *erioloba* and D. *cinerea* had the highest ($P<0.001$) intake of supplement. Goats receiving D. *cinerea* ate most hay (661g DM/day), giving this group the highest daily intake (Table 6).

The lower intakes of A. *nilotica* compared to other pods may be due to anti-nutritional factors (Tanner *et al.* 1990). Manyuchi, Ncube and Smith (1990) found that ground A. *nilotica* pods could be used in place of maize meal as a supplement for lambs. However, the use of these pods to supplement goats has not been widely reported, most of the field evidence of their acceptability referring to cattle and wildlife (Coates Palgrave, 1983; Timberlake *et al.* 1999)

Table 1: Goat feed calendar for Matobo District in Matabeleland South Province (Kindness et al., 1999)

	J	F	M	A	M	J	J	Au	S	O	N	D
Feed shortage						*	*	*	*	*	*	
Stored pods								*	*	*		
Stored crop residues								*	*	*		
Fallen leaves/pods					*	*	*	*				
Grazed crop residues				*	*	*						
Dry leaves and grass				*	*	*						
New shoots										*	*	
Green leaves/grass	*	*	*	*	*						*	*

Table 2: Goat feed calendar Bubi District in Matabeleland North Province (Kindness et al.1999)

	J	F	M	A	M	J	J	Au	S	O	N	D
Feed shortage						*	*	*	*	*	*	
Stored pods								*	*	*		
Stored crop residues								*	*	*		
Fallen leaves/pods					*	*	*	*				
Crop residues in field				*	*	*						
Dry leaves and grass				*	*	*						
New shoots										*	*	
Green leaves/grass	*	*	*	*	*						*	*

Table 3: Preference ranking for pods of different tree species (Kindness et al., 1999)

Rank	Matobo, Ward 3	Matobo, Ward 11	Bubi , Wards 3 & 16	Bubi, Wards 11 & 15
1	*Acacia tortilis*	A. *tortilis*	A. *nilotica*	D. *cinerea*
2	*Ziziphus mucronata*	A. *nilotica*	A. *tortilis*	A. *tortilis*
3	A. *erubescens*	A. *erubescens*	D. *cinerea*	A. *karroo*
4	*Dichrostachys cinerea*	D. *cinerea*		A. *nilotica*

Table 4: *Name (local name), flowering (f) and pod ripening (p) time, pod availability (1999 (1) and 2000 (2) seasons), seed:pod ratio (1 and 2) and crude protein (CP) content of whole fruits of selected species*

Name[1] (*Latin*, local)	Flowering and pod-ripening[1]	Pod availability	Seed:pod ratio	CP %
***Acacia erioloba* (iwohlo; umwhohlo; camel/giraffe thorn)**	*f*. Aug-Oct *p*. Early dry season (often stored for one year)	1. Good 2. Good	46:54	14.7
***Acacia erubescens* (uguwe; gowe)**	*f*. Sept-Oct *p*. Early	1. Good 2. Limited	26:74	15.2
***Acacia nilotica* (isanqawe; umtshanga)**	*f*. Oct-Jan (can flowe r twice, 2-3 months apart) *p. during dry season*	1. Good 2. Limited	44:56	11.6
***Acacia tortilis* (isanqawe; umsasane; umlaladwayi; umshishene; umtshatshatsha)**	*f*. Nov-March, following rain *p*. May to July	*p*. May to July 2. None		
***Dichrostachys cinerea* (ibahangali)**	*f*. Oct-Jan *p* . May- Sept	1. Good 2. Good	28:72	19.5
***Piliostigma thonningii* (ihabahaba)**	*f*. Dec-Feb *p*. June-Sept	1. Limited 2. Limited	30:70	11.4

[1] *Coates Palgrave* (1983); *Timberlake et al.* (1999)

Table 5: *Birth and weaning weights (kg) of single (s) and twin (t) kids, kid mortality (s; t) and reconception rate of does, after supplementation for 60 days before and after kidding*

	Cottonseed Meal	Acacia. erubescens	A. erioloba	Dichrostachys cinerea	Un-supplemented
Kid birth weight(kg)	s. 2.8 t.	s. 1.7 t.	s. 2.0 t.	s. 2.0 t.	s. 3.0 t. 2.2
Kid weaning weight(kg)	s. 10.2 t.	s. died t.	s. 9.0 t.	s. 6.3 t.	s. 9.5 t. 11.0

Table 6: Total intake (g/DM/day) and intake per kg metabolic live-weight (gDM/kgW $^{0.75}$) of young castrated goats

	Cotton-seed meal	*Acacia erioloba*	A. *erubescens*	A. *nilotica*	*Dichrostachys. cinerea*
initial weight (kg)	26.4	26.8	26.0	24.4	26.7
Pod intake:					
gDM/d	183.0	183.2	138.4	43.7	182.0
gDM/kg$^{0.75}$	15.7	15.6	12.0	3.9	15.5
Hay intake:					
gDM/d	529.4	554.8	540.2	467.6	661.6
gDM/kg$^{0.75}$	45.4	47.1	47.1	42.6	56.3
Total intake:					
gDM/d	712.4	738.0	678.6	511.2	843.6
gDM/kg$^{0.75}$	61.2	62.6	58.9	46.6	71.8

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2. Chemical Composition and In Vitro Fermentation Characteristics of Acacia and Other Tree Pods (R7351)

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Abstract

Tree pods (fruits) are being evaluated as dry season protein supplements to complement low quality cereal crop residues and dry veld grass. Antinutritional compounds (e.g. tannins) can occur in large quantities in pods and are being investigated. Polyethylene glycol (PEG) has been used to determine the effects of tannins on *in vitro* fermentation characteristics. Increased gas production and digestible organic matter (OMD) values in response to the addition of PEG showed that tannins inhibited *in vitro* fermentation of fruits (pods) and separated fractions (seeds and hulls). Very low levels of tannins resulted in no response to the addition of PEG. However, response of fruit fractions with higher levels was not directly proportional to tannin quantity. This suggests that the chemical composition of the tannins is important in determining their reactivity *in vitro*. Thus colorimetric assays for phenolic compounds alone do not fully explain the variation in the gas production and degradation characteristics of tree fruits treated with PEG.

Feeding trials are being conducted to assess the nutritive value of pods as supplements for goats. If the presence of tannins causes antinutritional effects in the animal, cheap, locally occurring materials will be sought to inactivate the tannins.

Introduction

In the dry season low quality cereal crop residues and dry grass are usually the only feeds available to livestock in Zimbabwe. Dry, ripe *acacia* and other tree pods (fruits) are potential protein supplements for animals in the dry season. . Secondary plant compounds such as tannins and cyanogenic glycosides may limit the utilisation of tree fruits as protein supplements. Tannins have been associated with a reduced availability of nutrients while cyanogenic glycosides are known to be toxic. Use of *in vitro* gas production techniques has allowed a rapid initial assessment of the fermentation characteristics of feedstuffs and, therefore, their potential nutritive value. As polyethylene glycol (peg) is a highly specific tannin-binding agent, a change in *in vitro* gas production and degradation will indicate the presence of tannins. This study evaluates *in vitro* gas production and degradation characteristics of separated fruit components using peg to establish tannin effects. This information, together with a chemical characterisation of the tree pods, will assist in the interpretation of the responses obtained from feeding the pods as protein supplements..

Materials and Methods

Pods were obtained from *Acacia nilotica*, *A. erubiscens*, *A. erioloba*, *Dichrostachys cinerea*, and *Piliostigma thoningii*. With the exception of *D. cinerea* (pods were not separated), chemical analyses were carried out on the whole fruit and the separated components (seeds, hulls). The seed to pod ratios were determined by weight. The samples were initially ground to pass through a 2mm screen for the analysis of neutral detergent fibre (NDF), acid detergent fibre (ADF), acid detergent lignin (ADL), acid detergent insoluble nitrogen (ADIN) (Goering and Van Soest, 1970), and for *in vitro* gas production and degradation studies. The samples were further ground to pass through a 1mm screen for the determination of nitrogen (N) (Dumas combustion method using the Carlo Erba Elemental Analyser 2100), total and water soluble carbohydrates, total phenolics (Folin-Ciocaltaeu reagent), proanthocyanidins or condensed tannins (CT) (Butanol-HCl), ytterbium precipitable phenolics and neutral detergent fibre-bound proanthocyanidins (NDF-CT) (Butanol-HCl reaction of NDF).

Thin Layer Chromatography (TLC) of the extracts was used to characterise the phenolic compounds further. Phenolic and tannin compounds were extracted from finely ground samples (1mm) using 70% aqueous acetone. The extract was then spotted on 5*5 cm cellulose plates and the chromatogram was developed using two solvents. An assay for catechin, epicatechin and condensed tannins with Vanillin-HCl spray showed that all the seed fractions contain high molecular weight condensed tannins, which did not move from the origin. Other sprays used in this study were the ferric ion reagent (detects phenolic compounds), potassium iodate reagent (detects gallic acid and its esters) and sodium nitrite reagent (detects ellagic acid and its esters).

In vitro gas production and degradation of the pods was estimated using the Reading Pressure Technique (RPT) (Mauricio *et al*., 1999). The separated fruit components were incubated with and without PEG-4000, as described by Makkar *et al* (1995) except that the PEG was dissolved in the buffer solution to give a concentration of 1g PEG per gram dry matter (DM) of sample. Pressure readings were taken at 2, 4, 6, 8, 10, 12, 15, 19, 24, 30, 36, 48, 72 and 95 hours post-incubation. Samples with and without PEG were incubated in triplicate for each of the withdrawal periods (24, 48 and 95 hours) to determine organic matter degradation (OMD). After incubation samples were filtered through pre-weighed glass-sintered crucibles. The residue was oven-dried (100°C) for 24 hours and weighed before being ashed at 500°C overnight to determine OMD.

Results and Discussion

Chemical composition

Table 1 shows preliminary data of the chemical composition of fruits and their components. The seed to pod ratios (by weight) were 46:54, 26:74, 44:56 and 30:70 for A. *erioloba*, A. *nilotica*, A. *erubiscens* and P. *thoningii*, respectively. The seed fraction has the highest nitrogen content in all tree species, ranging from 25.3 (A. *nilotica*) to 58.5 g/kg DM (A. *erubiscens*) (Table 1). The seed fraction contains the lowest amount of ADIN compared to other pod fractions. The proportion of fibre bound nitrogen (ADIN) is highest in the hull fraction with 64.5% of total nitrogen in A. *nilotica* hulls being ADIN. The ADL fraction is also lowest in the seed fractions of all the tree species. However, accurate measurement of ADL is dependent on complete oxidation of the fibre components, a factor that will be checked in later experiments. Neutral detergent fibre and ADF levels were low in the seed fractions with the exception of A. *nilotica* seeds, whose NDF and ADF content is higher ($P<0.05$) than that of the hull fraction. This is consistent with the findings of Tanner and co-workers (1990) for A. *nilotica* fruits.

The seed contains most of the protein of tree fruits. For tree species with small sized seeds, the proportion of seeds passing through the alimentary tract undigested is high (Tanner *et al*., 1990), thereby reducing nitrogen availability to the animal. It is, therefore, important to quantify the proportion, by weight, of the seeds to the whole fruit as well as estimating the proportion of undigested seeds passing through the alimentary tract for each tree species. This information will assist in the identification of tree pods that may need to be ground before being fed to goats.

The highest level of total phenolics (TP), expressed as gallic acid equivalents (GE), was found in the pod and hull fractions of A. *nilotica* (11.63 and 10.68g GE/mg DM respectively). Generally, pods and hulls of all species had the higher levels of total phenolics compared to the seed, with the exception of A. *erubiscens*. This could be because the hulls protect the seed from microbial attack and herbivory. The high levels of phenolic compounds might also be the cause of the high levels of ADIN values found in hulls. It is possible that tannin-protein complexes form a significant part of ADF in the hull fraction and thus contribute to the relatively high nitrogen in the ADF fraction. P*iliostigma thonigii* gave the highest absorbency readings from CT and NDF-CT. With the exception of A. *erubiscens* seed, all other seed fractions had the lowest CT levels. However, the seed fractions, except that of P. *thonigii*, had the highest level of NDF-CT indicating that a higher proportion of the CT in the seed fraction could be fibre bound or is present in the seed coat.

Results of TLC revealed catechin and epicatechin in the fruit and hull fractions of A. *erioloba* and A. *nilotica*. A*cacia erubiscens* hulls gave negative reactions with all sprays suggesting either no, or very low, polyphenolic content (Table 2). A*cacia erubiscens* fruit and A. *erioloba* seeds gave a negative reaction with the potassium iodate spray showing that these two fractions do not contain gallic acid. The thin layer chromatograms of P. *thonigii* showed a positive reaction only at the origin with Vanillin-HCl and Ferric ion sprays. This indicates the presence of high molecular weight tannins in this species.

In vitro gas production bioassay

Treatment with PEG increased (P <0.05) the amount of gas produced by most fruit components (Table 3). Addition of PEG, however, did not affect (P >0.05) gas production from A. *erubiscens* fruit and hull fractions, which also had the lowest levels of phenolics (Table 1). A significant (P <0.05) species by fraction interaction showed that the extent to which PEG treatment improved gas production in the fruit fractions largely depends on the tree species.

The effects of PEG on OMD are shown in Table 3. A*cacia erubiscens* and D. *cinerea* fruits, seeds and hulls had low degradabilities, possibly due to high NDF, ADF and ADL levels. Slightly larger differences in OMD of PEG treated and untreated samples were observed with 24h degradation values for most species. At 95h, OMD values did not differ greatly between the treated and untreated samples. However, the degradation values of PEG treated samples are probably an underestimate. This is because PEG-tannin complexes are insoluble in boiling water, most organic solvents, neutral and acid detergent solutions (Makkar *et al*., 1995), and may have been retained in the crucible as undegraded matter. This may have resulted in artificially low degradability values from samples to which PEG was added.

Future Work

The effect of tannins on the *in vitro* fermentation characteristics of tree pods was established through the use of PEG. Generally, inactivation of tannins resulted in increased gas production and OM degradation. However, inactivation of tannins with PEG cannot be used by smallholder farmers for improving the nutritive value of tree fruits due to its high cost. The next step, therefore, is to find alternative and cheaper ways of inactivating the tannins, hence the experiments outlined below.

- Tree pods will be soaked in water or sodium hydroxide solution in an attempt to inactivate the phenolic compounds, thus making the protein contained in the pod more readily available to the animal. Assuming a response the approach will be developed to use sodic soil and wood ash solutions
- A determination of *in vitro* improvement in the nutritive value of pods by comparing the effects of PEG, alkaline solution (determined above) and water treatments on *in vitro* gas production and degradation characteristics of ground pods
- I*n vivo* estimation of the nutritive value of treated and untreated pods, as protein supplements for goats.

Table 1: Total carbohydrates (TCHOS), Neutral Detergent Fibre (NDF), Acid Detergent Fibre (ADF), Acid Detergent Lignin (ADL), Nitrogen (N) and Acid Detergent Insoluble Nitrogen (ADIN) content (g/kg DM), total phenolics (gallic acid equivalent mg/mg DM), total condensed tannins (CT) (AU_{550nm}/10mg DM) and fibre-bound tannins (NDF-CT) (AU_{550nm}/10mg NDF) content of separated fruit components

Species	Fraction	TCHOS	N	ADIN	NDF	ADF	ADL	TP	CT	NDF-CT
Dichrostachys cinerea	Fruit	3.47	19.85	5.67	441.28	230.63	65.80	6.56	1.68	0.25
Acacia erioloba	Fruit	13.46	21.25	3.85	415.07	248.19	38.20	5.63	0.37	0.06
	Hulls	15.76	9.40	2.90	499.22	315.92	53.05	6.09	0.36	0.05
	seeds	6.21	35.80	7.65	262.59	157.82	34.61	1.70	0.21	0.11
A. *erubiscens*	fruit	2.49	27.10	6.68	542.63	326.12	101.84	1.35	0.24	0.10
	hulls	1.93	14.05	5.28	659.06	394.07	115.00	0.60	0.14	0.0
	seeds	3.32	58.50	10.71	246.41	132.09	33.96	1.58	0.56	0.14
A. *nilotica*	fruit	22.82	14.65	7.81	236.42	150.58	41.50	11.64	0.60	0.07
	hulls	27.86	11.90	7.68	227.29	149.47	45.22	10.68	0.65	0.05
	seeds	4.25	25.30	6.57	356.16	193.05	44.09	2.33	0.39	0.05
Piliostrigma. Thoningii	fruit	9.70	13.45	4.18	493.43	284.33	81.21	6.43	2.05	1.29
	hulls	11.30	10.10	6.22	501.59	296.86	87.84	5.06	1.85	1.39
	seeds	4.35	31.70	9.50	377.70	129.57	44.72	5.20	1.61	0.38
S.E.M		**0.32**	**1.05**	**0.60**	**7.59**	**3.12**	**2.94**	**0.33**	**0.02**	**0.03**

Table 2: Detection of phenolic compounds in separated fruit fractions using different spray reagents on thin layer chromatograms

Species	Fraction	Spray reagents			
		Vanillin-HCl **(Condensed tannins)**	Ferric ion **(Phenolics)**	Potassium iodate **(Gallotannins)**	Sodium Nitrite **(Ellagitannins)**
Dichrostachys cinerea	fruit	+[1]	+	+	+
Acacia erioloba					
	fruit hulls	+	+	+	+
	seeds	+	+	+	+
A. *erubiscens*				+	
	fruit hulls	+	+	-[2]	+
	seeds	–	+	–	+ –
A. *nilotica*					
	fruit shulls	+	+	+	+
	seeds	+	+	+	+
Piliostigma thoningii					
	fruit hulls	+	+	+	+
	seeds	+	+	+	+

[1,2]+ *indicates positive reaction to spray reagent, - indicates negative reaction*

Table 3: Cumulative gas production (ml) (95-*h* Gas Volume), percent increase in cumulative gas volume (% increase) and organic matter degradability (OMD, *g/g*) of PEG treated and untreated separated fruit fractions at 24, 48 and 95 hours post-incubation

Species	Fraction	95-h Gas Volume			24-h OMD		48-h OMD		95-h OMD	
		Without PEG	With PEG	% increase	Without PEG	With PEG	Without PEG	With PEG	Without PEG	With PEG
Dichrostachys cinerea	Fruit	47.98	155.77	224.66	0.34	0.39	0.37	0.39	0.39	0.48
Acacia erioloba	Fruit	130.42	163.83	25.62	0.42	0.52	0.54	0.59	0.55	0.65
	Hulls	110.32	136.56	23.79	0.36	0.46	0.49	0.48	0.51	0.51
	Seeds	111.37	166.30	49.32	0.47	0.51	0.59	0.70	0.70	0.83
A. *erubiscens*	Fruit	101.84	115.19	13.11	0.42	0.44	0.49	0.50	0.49	0.49
	Hulls	79.45	79.31	0	0.30	0.28	0.33	0.31	0.35	0.33
	Seeds	129.72	174.03	34.16	0.70	0.79	0.84	0.82	0.86	0.83
A. *nilotica*	Fruit	78.79	149.47	89.71	0.60	0.68	0.62	0.76	0.69	0.79
	Hulls	53.56	139.16	159.82	0.66	0.68	0.67	0.74	0.70	0.77
	Seeds	118.88	154.67	30.11	0.43	0.56	0.62	0.74	0.74	0.84
Piliostigma thoningii	Fruit	143.28	192.59	34.42	0.44	0.47	0.56	0.50	0.56	0.51
	Hulls	157.54	202.07	28.27	0.45	0.46	0.57	0.49	0.58	0.52
	Seeds	106.17	201.18	89.49	0.30	0.62	0.42	0.68	0.52	0.71
S.E.M		**4.68**						**0.01**	**0.01**	**0.01**

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Questions and Answers

What were the reasons for the high kid mortality?

During the dry season in the communal areas the animals get very weak. A supplement is now added post-partum.

Discussion took place about the role of supplements in addition to acacia. It was pointed out that in the unsupplemented trial reported here goats appeared to be doing as well as the control ones.

What are the benefits for the farmers?

The farmers already know that pods are good for the goats and that A. *tortilis* is the best. If farmers want to use other pods it involves a lot of work. It might be better for them to pick lots of tortilis and sell it.

Some farmers were already aware of the benefits of pods. However, pod production appears more variable than originally thought. To rely on one species, especially A. *tortilis*, is not advisable.

One of the objectives of R7351 is to reduce kid mortality: what actions was the project taking to address the reduction? Was poor nutrition the main cause of mortality?

By supplementing does before and after birth so that the quality and quantity of their milk was improved, kid mortality would decrease. There might be a link between climatic stress and nutritional status.

Was housing for goats had been looked at during the data collection, and if not could it now be included?

The kraals are open but when goats kid they are housed inside when the weather is hot. Earlier work at Matopos suggests that housing should be part of a management package.

Is access to milk or the birth rate the constraining factor with kid mortality, e.g. if a doe produced triplets would two be sacrificed in order to feed the third? Is survival related to birth-rate?

It is a combination of birth rate and nutrition. When a doe gives birth to triplets most die anyway, those weighing less than 2kg being most likely to die.

Is the common practice for farmers to sacrifice kids?

At Matopos farmers were asked to pay more attention to triplet births to give the kids more chance of surviving.

One of the important issues raised at the previous workshop was the yield of pods per hectare in the communal areas. The browse project (R6984) is collaborating with R7351 to estimate pod yield; could the project team provide any data?

It was difficult to obtain this data from communal areas and the estimates needed further work.

Professor Illius suggested a survey[1] that would have found measurements of pod yield and tree density in a non-invasive way. He stated that it was important to collect this data. Mr Sikosana said that this had been a very time-consuming exercise and some measurements had already been taken. Indeed, some data had been collected by enthusiastic farmers involved in the project.

It was suggested that as the trees would be of different ages, tree biomass should also be measured. Fresh leaves would be of better quality than older leaves.

Clarification of what had been measured in R7351 was requested.

For the purpose of the project it was only the pods that had been looked at. The Project Leader said that as far as he was aware, the major published work on tree pod yield was from the 1950s (O. West).

The older leaves would have different nutrient qualities to younger pods. The pods are a distinct group because you collect enough from the trees. The possible collection method is to fence off the tree and collect them.

In an average year in the project's area, there is always enough food for goats to eat as they are able to eat a wider variety of substances than cattle. When people talk about 'insufficient nutrients' for goats maybe this is due to goats having insufficient time to browse and, therefore, the management of the goats also needs to be studied.

This would not totally apply to the communal areas as often there is no browse available in the dry season.

Had the project team discovered any ethnoveterinary uses of pods during their PRA exercises?

None of the farmers in the survey had mentioned any ethnoveterinary practices. Sometimes people will indicate that a tree is valuable but do not give a reason for it; you are only likely to know this information if you have lived in the area for a long time. Pods are said to be good for treating ringworm but the project team was unaware of any documentation on this. Farmers use the leaves to treat internal parasites.

Was the information gathered during the PRA exercises documented as ethnoveterinary medicine is now a big issue for researchers/development agencies etc?

As the older generation is dying and younger people move away from farming this knowledge is becoming less well known. The Forestry Commission was suggested as the best source of information on ethnoveterinary issues.

Alternative uses of pods: if all pods are harvested for goats, will other animals suffer? (this concern was also expressed last year)

No, total pod yield is many times in excess of that needed to supplement the current goat herd. However, some communities may need to restrict outsiders collecting pods from their areas.

A representative of the farmers asked if it was possible to get breding stock from Matopos.

This is not possible because most of the animals are government property, but when the station needs to sell them this is done at auction. However the station is now getting interested in exchanging male stock and plans to raise males and exchange them with the farmers. The station has two breds of goats; Mashone (small) and Matabele, but there could be different strains within the two. The FAO have a programme to characterise the goats.

[1] Professor Illius agreed to give details of the research methods to Mr Sikosana

The Use of Oilseed Cake from Small-Scale Processing Operations for Inclusion in Rations for Peri-Urban Poultry and Small Ruminant Production (R7524)

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Abstract

The development of poultry feeds in rural areas has been constrained by lack of information on the feeding value of potential protein sources such as sunflower cake produced by the ram press. The ram-pressed cake is high in fibre, protein and fat, and is a valuable source of energy, lysine and methionine for poultry. Selective sieving of the cake can reduce the fibre level by approximately 28% and increase the protein level by 15%. *In vitro* digestibility studies (gas production) indicate that the ram-pressed cake may be slowly degraded in the rumen.

Introduction

Small-scale pressing of oilseeds is well established, but information on the use of the oilcakes in small-scale livestock production is unavailable. The project will enable peri-urban and rural livestock producers to make the best utilisation of sunflower oilseed cakes in local feeds. The high level of fibre in oilcake is a constraint to its inclusion in poultry feeds. Simple technologies for separating the fibre fraction will be investigated and the performance of broiler feeds based on reduced-fibre oilcakes evaluated. Oilcakes are valuable sources of protein for small ruminants on nitrogen deficient diets. Little is known of the digestibility characteristics of ram-pressed sunflower cake and the effect which the relatively high fat levels may have on rumen function. The income generating potential of oilcake-based small-scale livestock production will be evaluated.

Project Progress

Developments have been made in four areas:

1. Socio-economic analysis of poultry and small ruminant production in Zimbabwe.
2. Improving the facilities for feeding trials with goats and poultry at Henderson Research Station.
3. Analytical data on feed raw materials for feeding trials.
4. Experimental studies in fibre removal from Ram-Pressed Sunflower Cake.

1. Socio-economic Analysis of Poultry and Small Ruminant Production in Zimbabwe

Studies were conducted in four poultry and small ruminant producing areas of Zimbabwe, two communal and two peri-urban (Hanyani-Mlambo, 2000). Peri-urban areas were Domboshava, which borders Harare, and Esigodini, which borders Bulawayo. Selected communal areas were Muzarabani and Chivi Districts. Surveys revealed that about 95% of peri-urban and communal families keep poultry, and the majority of indigenous poultry producers in communal areas are women. Indigenous poultry are reared under a scavenging system where inputs for housing, breding and feeding are minimal, and productivity is low. Hybrid birds are reared by the richer, more educated farmers. In typical communal areas, only 10% of farmers are involved in hybrid poultry production. Approximately 70% of hybrid producers reside in peri-urban areas and 30% in communal areas. Hybrid poultry production systems are run strictly on business lines, and may be broilers, layers or mixed systems. Flock sizes ranged from 25-1800 birds, with a mean of 159 birds. In contrast the mean indigenous flock was 21 birds with a range of 2-110. Occasionally indigenous birds are fed spoiled grain, oilseeds or household scraps. There was no evidence of the provision of compounded feed to indigenous birds to enhance their growth or egg laying performance. Most eggs are retained for regeneration of the flock.

Small ruminant production is based on a scavenging / browsing system, with minimal supplementary feed.

Chicken meat is preferred to goat meat, but some consumers prefer the tender meat from hybrid birds, rather than the more mature and tougher texture of indigenous birds. Indigenous birds may be more than five months of age before slaughter compared with a hybrid slaughtered at 7-10 weeks, at a live weight of approximately 2 kg.

Many producers considered that the rearing of both poultry and small ruminants was an insurance mechanism to provide food in times of drought, vagaries in the weather or other adverse factors within the local farming system.

2. *Improving the Facilities for Feeding Trials with Goats and Poultry at Henderson Research Station*

Henderson Research Station has a good infrastructure for conducting controlled animal feeding trials. However, although the buildings are sound they required upgrading to enable measurements of the individual feeding characteristics of goats and the group feeding of poultry to be conducted. Project funds were dispersed for this upgrading, and revisions to pens are near completion. Since poultry studies will include the comparative performance of commercial broilers and indigenous birds a small egg hatcher has been purchased to enable eggs collected from rural areas to be hatched under controlled conditions.

Six hundred kg of sunflower seed of a local variety, 'Pannar' (a high oil hybrid), have been ram-pressed at Henderson in readiness for the preparation of feeds.

Efficiency of oil extraction from sunflower seed:
The efficiency of oil extraction from the ram press is a function of human effort, appropriate setting up of the press, the temperature of the seed and its varietal characteristics. For the experimental material: 100 kg seed of 43.2% oil content yielded 85 kg cake of 33% oil content and 15 kg of sunflower oil.

3. *Analytical Data on Feed Raw Materials for Feeding Trials*

Samples of ram-pressed cake and prospective feed materials for poultry and goat feeding trials have been analysed for chemical composition, and where appropriate for *in–vitro* digestibility by the gas production method. (Tables 1,2 and 3)

Raw materials for use in poultry diets will include sunflower cake, soyabean meal, maize, minerals and vitamins. It is expected that 75-80% of the raw materials for poultry production can be sourced from a peri-urban or rural farm. For goat trials, all raw materials can be sourced from rural or peri-urban areas. These are sunflower cake, sunflower heads, maize stover and groundnut tops, together with access to vegetation for browsing.

The amino acid analyses of sunflower ram-pressed cake obtained from village sources is similar to that of seed pressed at Henderson, and confirms the relatively low levels of lysine and methionine in this raw material (0.7% and 0.4% respectively). Supplementation of sunflower with additional sources of protein, such as soya bean meal, which are high in lysine, methionine and cystine, will be necessary to obtain reasonable growth performance of poultry.

I*n vitro* digestibility studies imply that, relative to sunflower heads, groundnut tops and maize stover, sunflower ram-pressed cake will not be rapidly degraded in the rumen. This may be a function of the high fat content in the cake giving a degree of protection against microbial degradation. Feeding trials will indicate the levels of fat in the sunflower cake which may depress rumen function.

4. *Experimental Studies in Fibre Removal from Ram-pressed Sunflower Cake*

Fibre levels of 20% in sunflower cake are potentially limiting the inclusion of this material in poultry diets where the target fibre level in the final feed is approximately 6%. Any reduction in fibre will cause a corresponding increase in protein and oil, which may assist in increasing the inclusion level of sunflower cake in the diet. Trials have been conducted at NRI and Henderson to determine whether sieving can remove fibre from sunflower cake to any significant level.

The results of the trials are presented in Table 4 and may be summarised as follows: screening through a 1mm screen can reduce the fibre level in sunflower cake by 40%, but the yield of this material is low when compared to the amount of energy and time used to produce it. Sieving through a 1.4 mm screen produces a fine product with a 28% fibre reduction and 15% increase in protein. The fraction passing through the sieve represents 30% of the original material and is a feasible product to produce.

While the fraction passing through a 2 mm screen appears to give a similar product to that obtained by a 1.4 mm screen, there was a greater sensitivity needed on the part of the operator not to force as much as possible through the screen. A 1.4 mm screen will more likely be a promising compromise. The fine, lower fibre and higher protein material passing through the sieve can be used for poultry feed. The coarser retained fraction can be used for goats.

Proposed Feeding Trials

Poultry:

Phase 1

- Hybrids vs Indigenous stock using commercial starter and finisher feeds

  Start date: December 2000

Phase 2

- Increasing levels of sunflower as ram-pressed sunflower cake (RPSFC) in balanced feed for finishers, but using a commercial starter
- Increasing levels of RPSFC in balanced feeds for starter and finisher

Goats:

- Stall-fed complete diets based on RPSFC, maize stover, sunflower heads, groundnut tops, minerals.
- Stall-fed + browse + RPSFC
- Browse +RPSFC
- Browse only

Table 1: Nutritional value (of feed raw materials)

a) For poultry feeding trials:

Raw material	Oil	Csrude Protein	Crude Fibre	Lysine (%)	Meth. + cys.(%)	Ca (%)	P (%) (MJ/kg)	ME
RPSFC[12]	32.6	20.3	20.2	0.7	0.8	0.2	1.0	12.3
Maize	4.0	9.0	3.0	0.3	0.4	—	0.3	14.2
Soya bean meal	1.0	44.5	5.5	3.0	1.4	0.3	0.6	9.4
Fishmeal	4.0	65.0	—	5.0	2.5	6.2	3.0	11.5

b) For goat feeding trials:

Raw material	Oil (%)	Crude Protein (%)	Crude Fibre (%)	Ash (%)	ME (MJ/kg)
RPSFC[1]	32.6	20.3	20.2	4.3	11.1[3]
Sunflower heads	14.7	13.4	31.6	6.1	7.4
Groundnut tops	2.1	12.6	34.3	15.2	7.6
Maize stover	1.2	4.0	39.9	6.2	7.1

[1]RPSFC = *ram-pressed sunflower cake*

[2]*Potential limitations in* RPSFC: *high fibre and high fat*

[3] *estimated at* 90% *of poultry* ME

Table 2: In-vitro digestibility of feed raw materials for goat feeding trial
(Rate of gas production with time)

Feed material	Peak gas production rate (ml/hour)	Time at peak gas production (hours)
Maize stover	6.0	14
Groundnut tops	8.5	12
Sunflower heads	12.5	14
RPSFC[1]	4.5	5

[1] RPSFC = *ram-pressed sunflower cake*

Table 3: Amino acid composition of ram-pressed sunflower cake (RPSFC)
(g/100g dry matter)

	Village produced RPSFC	Henderson produced RPSFC
Taurine	0.03	0.03
Hydroxyproline	0.07	0.07
Aspartic acid	1.74	1.68
Threonine	0.74	0.69
Serine	0.78	0.71
Glutamic acid	3.52	3.44
Proline	0.84	0.79
Glycine	1.31	1.06
Alanine	0.87	0.82
Cysteine	0.41	0.34
Valine	1.03	0.97
Methionine	0.45	0.41
Isoleucine	0.84	0.78
Leucine	1.29	1.19
Tyrosine	0.47	0.40
Phenylalanine	0.90	0.86
Hydroxylysine	0.01	0.02
Histidine	0.53	0.46
Ornithine	0.02	0.02
Lysine	0.77	0.67
Arginine	1.62	1.57
Tryptophan	0.26	0.23

Table 4: *Removing limitations for ram-pressed sunflower cake* (RPSFC): *effectiveness of fibre separation from* RPSFC *by sieving*

Screen size		Fibre	Oil	Protein	%
RPSFC		20.2	32.6	20.3	100
1.0 mm	Retained	22.8	29.4	15.7	88
	Through	11.7	35.0	26.9	12
1.4 mm[1]	Retained	22.9	29.6	18.6	70
	Through	14.5	32.2	23.1	30
2.0 mm	Retained	25.4	29.8	14.1	76
	Through	15.0	33.4	23.1	24

[1]At 1.4 *mm*: 28% *reduction in fibre*,
15% *increase in protein*

Reference

HANYANI-MLAMBO, B.T. (2000). Demand for livestock fed and benefits for the poor: A Zimbabwean case study. P*roject Report* M*arch* 2000. Natural Resources Institute, Chatham, Kent, UK. pp 17.

Questions and Answers

Could poultry avoid hulls? If so, intake of the feed would be different to the gross amount analysed

Separating the kernels from hulls would not be very practical but the project could attempt it. The project was also going to introduce fishmeal into its control. It would take 5-10 minutes to sieve 1kg of sunflower cake in order to reduce fibre content.

As the mortality of chickens was very high (approximately 60%), was sunflower cake being suggested as a supplement? Did that mean the main cause of death was lack of nutritious feed?

There were lots of reasons for the high death rate (e.g. Newcastle disease). The requirements for additional feed came from the women involved in the project. It could be that as well as more than 20% of feed coming from a local source, some of the women realise that they are currently buying concentrate that includes substances they already have access to, suggesting there is no need to buy the concentrate.

Did the project team think that smallstock (poultry and goats) keepers have the required knowledge and skills in feed rationing to utilise the range of feed supplements the project was proposing during the course of the year?

A lot of the women involved have sufficient knowledge. From the project's point of view, the Project Leader would like to give a supply of feed to be used at different times throughout the year. No major changes occur in the oil, e.g. aflotoxins, so this can be used over a period of time.

Would indigenous chickens also be used in the study?

The commercial chickens were being used as part of the control. One of the advantages of indigenous chickens over commercial ones is that they are able to eat more fibre. The project is getting different messages from the participants: some of the women want indigenous chickens and some want commercial ones. It might turn out that it is better for the women to focus on the hybrid chickens and let the indigenous ones scavenge. It was explained that the project did not know how many different breds of chickens there were or what their respective productivity was but the University of Zimbabwe was looking into this. Work is also taking place at Henderson Research Station on indigenous chickens.

Some years back work was carried out on indigenous chicks reared under communal conditions. The information was never published. In the early 1980s someone tried to write a paper and published it. Unfortunately they only monitored indigenous chickens and did not have any control chickens so it was difficult to get the paper published.

A representative from one of the NGOs explained that the NGOs and farmers had noticed a reduction in the number of chickens in homes. The NGOs are trying to assist communal farmers in re-introducing chickens into their homes, but do not know if they are doing it the right way or not.

What sort of chickens would the peri-urban farmers would be using?

A survey had not yet been carried out on the peri-urban farmers, but the project team thinks that the information generated so far will also be of interest to them. It is likely that commercial birds will be used.

Many smallstock farmers were not aware of the benefits of sunflower oil and, therefore, do not grow it. The cost of milling will be estimated. There were women who offer their mill as a service. Some of the women do not know what to do with the cake. There is no way of putting a value on the cake.

Were there management systems to accompany the different breds of chicken, i.e. indicating the type of feed they should be eating?

As most of the chickens used were scavenging ones this information was not available. The chickens have different requirements depending on their age and there is a lot of competition between the groups. If a management system could be set up so that the young chicks were kept separate from the rest they might have more chance of survival.

Use of Tanniniferous Feeds to Improve Smallholder Goat Production: Project to Link R7424 (Tanzania), R7351 (Zimbabwe) and R6953 (India) to Increase Dissemination, Outputs and Impact (R7798)

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Abstract

Project R7798 links projects R6953 (India), R7424 (Tanzania) and R7351 (Zimbabwe), through a series of workshops, exchange of publications and a newsletter. Exchange of technical information and methods of dissemination will enhance local impact of each project, thus benefiting smallholder smallstock owners. The first workshop took place in India, in September 2000.

Background

In all tropical livestock production systems characterized by defined wet and dry seasons, inadequate feeding in the dry season is a major constraint to productivity. Parasitic infections of the digestive tract also limit output. Smallholders rarely have the resources to purchase feed supplements or anthelmintics, especially for small ruminants such as goats.

The use of tree pods and fruits (*Acacia* sp.; *Prosopis juliflora*) as dry season supplements for goats is being investigated in three projects (R7424, Tanzania; R7351, Zimbabwe; R6953, India). The projects in India and Zimbabwe are seeking to improve goat productivity through feeding protein supplements at critical times in the feeding/production cycle. The Tanzanian project is investigating beneficial effects of tannins, in controlling intestinal parasites.

Although these projects are separated geographically, there are common threads between them:

- They address problems faced by crop/livestock farmers; specifically goat keepers
- They are based in semi-arid conditions
- The three environments are characterized by naturally occurring pod bearing trees.
- Dissemination and uptake is the priority output.

However, without the financial resource to generate linkages between the projects, each would continue in at least partial ignorance of the others. This link project is an opportunity to break down these barriers, to the advantage of farmers, extension and research staff, through a 'value-added' component to each project.

Objectives

- More efficient and targeted research associated with the three projects to increase their impact
- Additional extension messages and dissemination pathways for use of tanniniferous feeds as anthelmintics and protein supplements for goats in semi-arid regions
- Additional dissemination pathways resulting from the link project workshops.

Beneficiaries

Resource-poor goat owners in the semi-arid regions of the three countries. Research and extension staff and NGOs will also benefit.

Activities

- Workshops will be held in each of the participating countries (the first has already taken place in India, in September 2000). These workshops will include site visits and discussions with all stakeholders
- A newsletter will be prepared and circulated to stakeholders within the three countries and other interested parties
- Experimental protocol and publications will be circulated between the projects.

Meeting in India

A group of six (three each from projects R7351 and R7424) joined the Indian group at Udaipur, and attended the 'Workshop on Participatory Research on Goat Feeding Systems and Silvipastoral Development on Common Lands in North-West India' (11-13 September 2000). The participatory on-farm research project in which P*rosopis juliflora* is being used as a supplement for breding goats was discussed, with emphasis being given to the institutional and socio-economic aspects of this type of intervention. This was followed by two days of field visits and discussions.

The three projects address issues relevant to crop/livestock farmers in semi-arid areas. Wealthier farmers own cattle (also buffalo in India) as well as goats. At the sites visited the following points were noted:

- Land pressure appeared high
- Composition and role of local committees/institutions was important
- Farmers were classified both by wealth and caste
- Women farmers appeared to be disadvantaged
- Goats milk was very acceptable, especially for use by the household (market value was less than cow or buffalo milk, probably because the fat content was lower)
- Purchased concentrate feeds for goats were common among the wealthier livestock owners, concentrates often being fed in conjunction with P. *juliflora* and A. *nilotica*.

All projects are addressing areas of common concern in all three target countries. Topics in which we can work together include:

- Processing pods (using appropriate technology for grinding and treatment to mitigate possible adverse effects of tannin/linkages)to maximise the nutritive value of these feed resources
- Estimations of pod yield, both within (specific trees/soil type)and between species and across years (fruiting pattern/climatic variation)
- Agreement on chemical, in vitro and in vivo assessments of pods
- Difficulties of on-farm research, both in setting up and monitoring, together with ensuring the active participation of the relevant disciplines. The complexities of communication across two or more languages should not be under estimated
- Methods and pathways for dissemination, especially at the farmer/village level.

Further Information

BUTTERY, P.J., DAWSON, J. and WAKELIN, D. (2000). Can feeding locally-available plant material rich in tannins reduce parasitic burden in ruminants and hence improve their productivity (R7424). In: *Livestock Production Programme* (LPP) *Project Year Book* 2000 - 2001. Richards, J.I. (ed.) NRIL, Chatham Maritime, Kent, ME4 4NN, UK.

BUTTERY, P.J., OWEN, E. and CONROY, C. (2000). Use of tanniniferous feeds to improve smallholder goat production: project to link R7424 (Tanzania, R7351 (Zimbabwe) and R6953 (India) (R7798). In: *Livestock Production Programme* (LPP) *Project Year Book* 2000 - 2001. Richards J.I. (ed.) NRIL, Chatham Maritime, Kent, ME4 4NN, UK

CONROY, C. (2000). Easing seasonal feed Scarcity for small ruminants in semi-arid crop/livestock systems through a process of participatory research (R6953). In: *Livestock Production Programme* (LPP) *Project Year Book* 2000 - 2001. Richards, J.I. (ed.) NRIL, Chatham Maritime, Kent, ME4 4NN, UK.

SMITH, T., MUELLER-HARVEY, I. and OWEN, E. (2000). Increasing the productivity in smallholder owned goats on acacia thornveld (R7351). In: *Livestock Production Programme* (LPP) *Project Year Book* 2000 - 2001. Richards, J.I. (ed.) NRIL, Chatham Maritime, Kent, ME4 4NN, UK.

Questions and Answers

Elaboration of the on-farm trials in India

The project team had been very surprised that the Indian researchers did not carry out on-station trials but there was no research station nearby where such trials could be carried out. R6953[1] is using on-farm feeding trials because they are working with an NGO, Bharatiya Agro Industries Foundation (BAIF). If the Indian Council for Agricultural Research (ICAR) had been involved the trials would have been on-station. Concern was expressed as to the application of the results of the on-farm trials in other situations.

The two pods (P. *juliflora and* A. *nilotica*) being used in India are known to be eaten by the animals and are considered to be safe. If treatment of pods could be done cheaply their value would be improved.

Why, as they work with goats, were ICAR not involved with the project?

ICAR had been invited to the link project meeting but did not attend. ICAR is very research oriented.

Would improved nutrition encourage reproduction?

The work in India had taken place during the breding season. In Zimbabwe, goats had access to pods during the early dry season. In India the main pod is P. *juliflora* which Zimbabwean farmers do not have. It was suggested that sugar cane could also be used as a supplement, if there was a lot in the area.

Acacia nilotica; comments from Dr Mueller-Harvey.

Preliminary data suggested some problems with A. *nilotica*. Tree composition can change over years and it might be safe to use in India. However, some animals have died in Ethiopia as a result of eating it. Farmers say that A. *nilotica* is the preferred pod for cattle: if it is extrapolated as a food source from cattle to goats the analysis must be up to date.

Digestibility figures would soon be available on the pods (see report for R7351).

Had the treatment of soaking and fermenting been used?

No.

[1] R6953: 'Easing seasonal feed scarcity for small ruminants in semi-arid crop/livestock systems through a process of participatory research'

The Effect of Control Operations Against Tsetse on the Incidence of Bovine Trypanosomiasis in Zimbabwe (R6625)

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Abstract

The project 'Livestock/wildlife interactions in areas of tsetse incidence and tsetse prevalence' collected a set of data from the archives of the Tsetse and Trypanosomiasis Control Branch (TTCB), Harare. These data however did not cover the whole of Zimbabwe and a project extension was granted to extract the remaining data and complete the GIS so as to provide a unique and readily accessible resource. The information covers the effects of control operations against tsetse on the incidence of trypanosomiasis in Zimbabwe during 1980-1998. The intention is to publish a paper on the epidemiology of trypanosomiasis in Zimbabwe as well as providing a unique dataset which will form a base for planning future tsetse control operations in Zimbabwe. The data, along with that from the original project is also relevant to other African countries undertaking or contemplating large scale tsetse control programmes in the context of developing and promoting sustainable, environmentally-beneficial and cost-effective strategies for control of trypanosomiasis.

Delivery of Original Outputs

The three original outputs listed below have all been completed:

- Changes in land use since 1984 in two areas of differing tsetse occurrence quantified. Additional data on tsetse and trypanosomiasis was generated by this project. Further analysis would add a valuable added output
- Socio-economic interactions between tourism, farming practices (especially livestock), and wildlife management identified and effects on land use quantified in two areas of contrasting tsetse occurrence
- Key indicators for evaluating probable effects of tsetse clearance on dynamics of livestock/wildlife interaction over time produced.

Linkages with Other Projects Funded by DFID (Other Renewable Natural Resources Research Programmes, Dfid Technical Cooperation) or Other Funding Agencies (European Union or Other Bilateral Programmes)

DFID-funded Projects

Collaborative Research on the Environmental Impact Socio-economic Impacts of Tsetse and Trypanosomosis Control in Southern Africa (R5874h 1994-1997)

DFID Animal Health Programme (AHP) Projects

- Preliminary Studies of The Effects of Host Physiology on the Efficacy of Cattle as Baits for Tsetse Control (R6559; 1996-98)
- Cattle Management Practices in Tsetse-affected Areas. (R7173; 1998-2000)
- Improving the Control of Tsetse: The Use of DNA Profiling to Establish the Feeding Responses of Tsetse to Cattle. (R7364; 1999-2002)

DFID TC-funded Projects

- Zimbabwe Insect Pest Management initiative: (1991 – 1997)
- Tsetse Post-Project Support (1997 – 1999)

Specific objectives of the project extension and additional impacts on achievement of the programme output

The aim of this project is to extract the remaining data from the TTCB archives and complete the GIS, so as to provide a unique and readily accessible resource documenting the effects of control operations against tsetse on the incidence of trypanosomiasis, in Zimbabwe during 1980-1998. This information will provide a basis for planning future tsetse control operations in Zimbabwe and other tsetse-affected countries in east, central and southern Africa, and thus contribute to the project purpose of developing and promoting sustainable, environmentally-beneficial and cost-effective strategies for control of trypanosomiasis

Evidence for the demand or need for the extension, and the pathways for the uptake and promotion of the project outputs

In Zimbabwe

Tsetse and trypanosomiasis left unchecked could potentially occupy ~200,000 km^2 of Zimbabwe. However, the Government of Zimbabwe (GOZ) has maintained one of the most effective tsetse control operations in Africa, and currently only ~30,000 km^2 are infested. The GOZ continues to give high priority to tsetse control, without which over one million cattle in communal areas and a further 92,000 on commercial farms would be at risk. The GOZ budget for tsetse control includes Z$87 million (~US$1.6 million) from GOZ and US$1.6 million from the EU (not Regional Tsetse and Trypanosomiasis Control Programme (RTTCP) funds).

Zimbabwe is currently undertaking a fundamental review of the funding and organisation of its veterinary services, and the country's tsetse control strategy and the role of the Department of Veterinary Services (DVS) in this is being debated (Shereni, 1999). A full analysis of the benefits of various control strategies will be of great assistance in this process.

In Africa

Elsewhere in Africa the relative merits of different control methods are being widely debated, as illustrated by the various papers and correspondence produced by the Programme Against African Trypanosomiasis (PAAT) forum (http://www.fao.org/paat/html/home.htm). This debate is influencing the design and implementation of both donor and government supported tsetse control programmes and hence will ultimately have an impact on trypanosomiasis-affected farmers throughout Africa. To be effective, the debate needs to be informed with objective data on the efficacy of various control techniques and operations. This project will provide such data.

Dissemination

A workshop will be held in Zimbabwe, in 2001, to disseminate and discuss final results with the staff of the DVS, which is currently the sole authority responsible for controlling tsetse in Zimbabwe. The results will also be disseminated within the Zimbabwe DVS via the existing promotion pathways operated (Mr Mangwiro). Regionally, the results will be disseminated by inviting scientists and stakeholders from RTTCP and neighbouring countries to the workshop. Internationally, the results will be disseminated via existing professional links, by a paper published in an international refereed journal and by producing data suitable for free access via the paat website.

Outputs from the Extended Project

The effects of tsetse fly control on the incidence of Bovine trypanosomiasis will be analysed and made available to the target audience through reports, journal and conference papers. The output of the project extension will be a complete GIS analysis of the effects of tsetse fly control operations on the incidence of trypanosomiasis in Zimbabwe during the period 1984 –1998.

Project Activities

Research activities will include:

- Extraction of data on tsetse control operations and incidence of trypanosomiasis for North-east and North-west Zimbabwe (Zimbabwe)
- Incorporation of data into a GIS for further analysis (UK)

- Analysis of the occurrence of trypanosomiasis in space and time in relation to tsetse control activities (UK and Zimbabwe)
- Presentation of the analysed work for publication in an international journal (UK)
- Presentation of the results at a workshop for those involved in control of tsetse and trypanosomiasis in Zimbabwe, surrounding countries and international organisations
- Provision of the digital GIS coverages to those involved in control of tsetse and trypanosomiasis in Zimbabwe, surrounding countries and international organisations, including the online PAAT Information System.

Questions and Answers

Is CAMPFIRE (Communal Areas Management Programme for Indigenous Resources) successful where agriculture is not successful and can the two co-exist?

There is a very significant conflict between agricultural and campfire activities and it is hard to see how they could co-exist because, as agricultural production increases, the more wildlife will be pushed into the national parks. Campfire activities do not add much to household income, e.g. people use campfire money to spend on tsetse treatment because they want to increase the numbers of cattle.

Instead of thinking of campfire, maybe the issue of domesticating wildlife should be considered: e.g. farmers in the communal areas have incorporated guinea fowl and wild birds into the farming system.

If agriculture is to increase, wildlife will be pushed into the park.

Once animals are in the park, consideration must be given to keeping them there, thus increasing the safety of people, crops and livestock.

Environmental Variability and Productivity of Semi-arid Grazing Systems (R6984)

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Abstract

Browse production and utilisation is being studied using a combination of controlled experiments and field studies in communal areas in Southwest Zimbabwe. Browse production is a substantial component of total forage production in semi-arid rangeland, and appears to vary less in response to climatic variation than grass production. Goats are the main livestock species using browse, due to the relatively low rates of intake achieved by cattle while browsing. Modelling studies show that dry season forage resources are the principal determinant of the numbers of livestock that can be supported by semi-arid rangeland. Accordingly, future work must focus on using browse to best effect as a strategic supplement during the dry season.

Project Description

Livestock production in semi-arid rangelands is limited by the variability of forage supplies caused mainly by annual variation in rainfall. Browse is often a key resource in rangelands, but little is known about its productive capacity. Effective range assessment techniques and management strategies are needed to address the environmental variability of semi-arid rangeland systems.

The project has three parts:

1) Evaluating the seasonality and variability in the production of browse in relation to rainfall and soil.

2) Examining browse utilisation by foraging cattle and goats, especially during nutritional bottlenecks, and determining the dietary and nutritional outcomes. These studies will be used to develop field assessment techniques and to test and improve the model of rangeland dynamics currently in use.

3) The model will be developed into a decision-support system for analysis of management options and assessment of rangeland capacity.

Project Goal

Relationships between productive capacity of rangelands and climatic and other environmental variability identified and incorporated into management strategies.

Background

According to rangeland extension agencies, the priorities for research in semi-arid rangeland are: Strategies for dealing with drought, and better range management and assessment techniques, especially taking account of browse. Staff at the department of agricultural, technical and extension services (Agritex) and the department of research and specialist services (DR&SS) stressed that the production and utilisation of browse was the largest unknown factor in range assessment, yet it was obviously an important part of forage resources. Their views formed the basis of this project.

Variability

The key characteristic of semi-arid environments is their high temporal and spatial variability. Annual and seasonal variability of rainfall is the main cause of the wide variation in primary production. The accompanying drought-induced mortality reduces the mean size of livestock populations and causes substantial economic loss. Climate change threatens to exacerbate these. Spatial variability in vegetation production and utilisation is also due to variation in soil texture, hydrology and distance from surface water. The challenge is to derive management strategies that can exploit spatial variation to buffer temporal variation.

Browse

This can be a major constituent of livestock diets throughout the year, but is especially important in the dry season, during droughts, and under most communal grazing conditions. Although browse is a significant and dependable (compared with grasses) component of forage resources, the assessment of its productive capacity for livestock is hampered by the very limited knowledge of browse production, its response to rainfall, seasonality, and its utilisation by different classes of livestock. This is a severe constraint on effective land use planning.

Development of Effective Management Strategies

Response to climatic variability is impeded by lack of a systems framework for analysing livestock stocking policies and management practices. Effective decision-making requires that the important biological components of rangeland systems (i.e. the response of woody and herbaceous components of rangeland to rainfall and of animal responses to vegetation composition) are quantified and analysed in a systems context.

Progress After Two Seasons

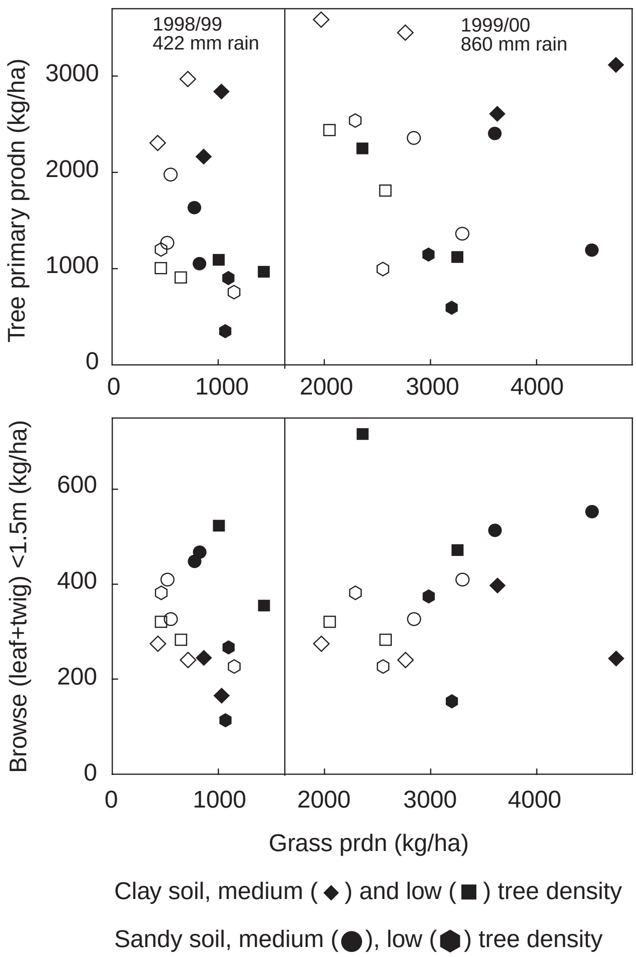
We have now completed two seasons of field research, and some preliminary results are available.

1. Browse Production (Emilia Mukungurutse)

A. Effects of rainfall, soil and topography

Primary production and soil moisture are being measured in 16 plots, four each on sites with low or medium tree density on both a sandy or clayey soil (see Fig 1).

Figure 1: Browse production in two years at a site on Matopos Research Station



Total production by trees (leaf, twigs and wood) did not vary much between two quite different years, but grass production did respond to the higher rainfall in 1999/00. There is an inverse relation between tree and grass production in each year.

About 400 kg/ha of browseable material (defined as leaf and twig within 1.5 m from the ground) was produced in each year. Some of the remaining leaf (c. 650 kg/ha) would become available at leaf-fall.

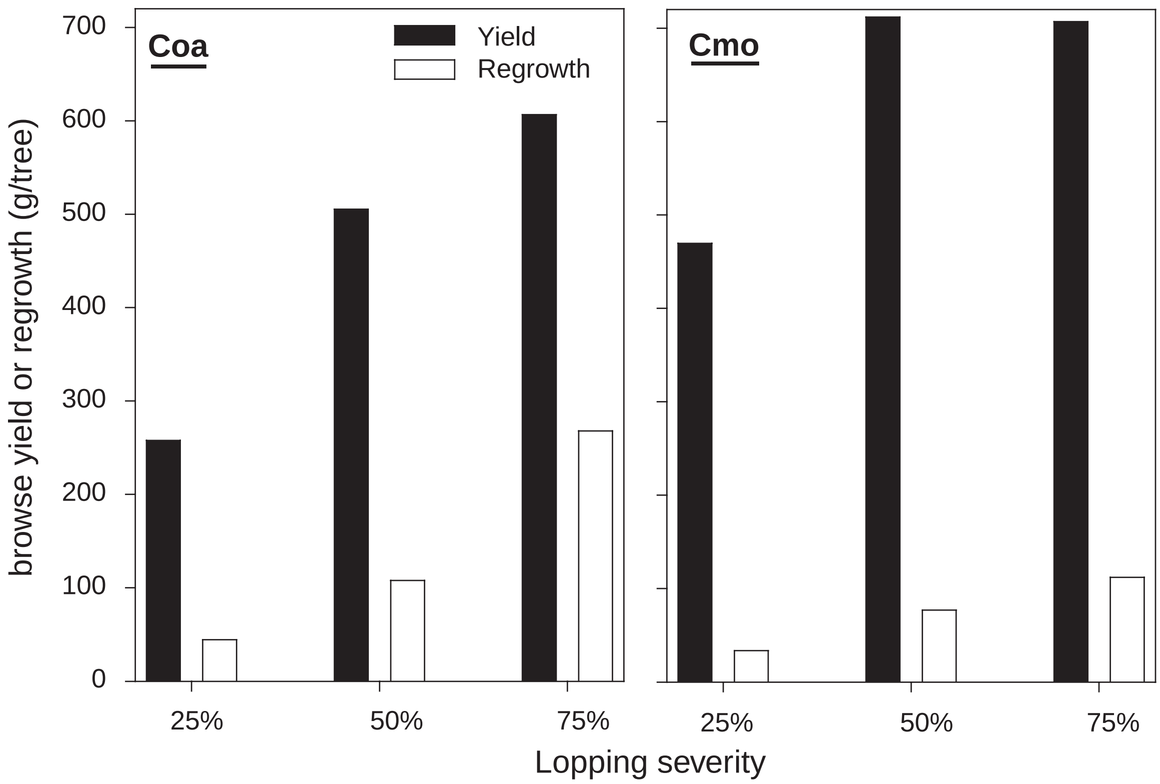
Open symbols show plots with artifically-reduced grass cover.

B. Management of browse resources for dry-season fodder in Communal Areas

Methods of using browse need to be improved. Stakeholders and farmers have identified lopping of branches of *Colephospermum mopane* (Cmo) and *Combretum apiculatum* (Coa) as a means of producing browseable material in October, when other forages are in critically short supply. In a pilot experiment, initiated in Bidi communal area, we examined browse yields and regrowth at four severities: the removal of 0%, 25%, 50%, 75% of the canopy. Treatments will be repeated in subsequent years, and production and survival of the trees monitored. Branches fed to livestock were left on the ground and were found to offer safe sites for re-colonisation by grasses and tree seedlings that would otherwise have been eaten, suggesting a useful spin-off from the practice of lopping.

Evidently, lopping provides small amounts of forage at critical times of year (see Fig. 2.). The forage has the greatest potential as a source of N. The harvesting regime that gives the highest and most sustainable long-term yield needs to be determined.

Figure 2: Browse yield and re-growth to lopping of two tree species.



Conclusions: Browse production is a substantial component of forage resources, and may be more resistant to climatic variability than grass. Ways need to be found to utilise it sustainably.

2. *Browse Utilisation by Cattle snd Goats (Zivayi Magadzire)*

A. Evaluation of browse species, and comparison with grass

To compare intake rates in cattle and goats, they were offered branches of eight important browse species and patches of five grass species separately to four animals of each species. The preliminary results (Table 1) clearly show that, because bite size is similar for the two animal species when browsing (unlike when grazing), intake rate per unit metabolic body mass is much lower in cattle. This suggests reasons why cattle are less inclined to browse than goats

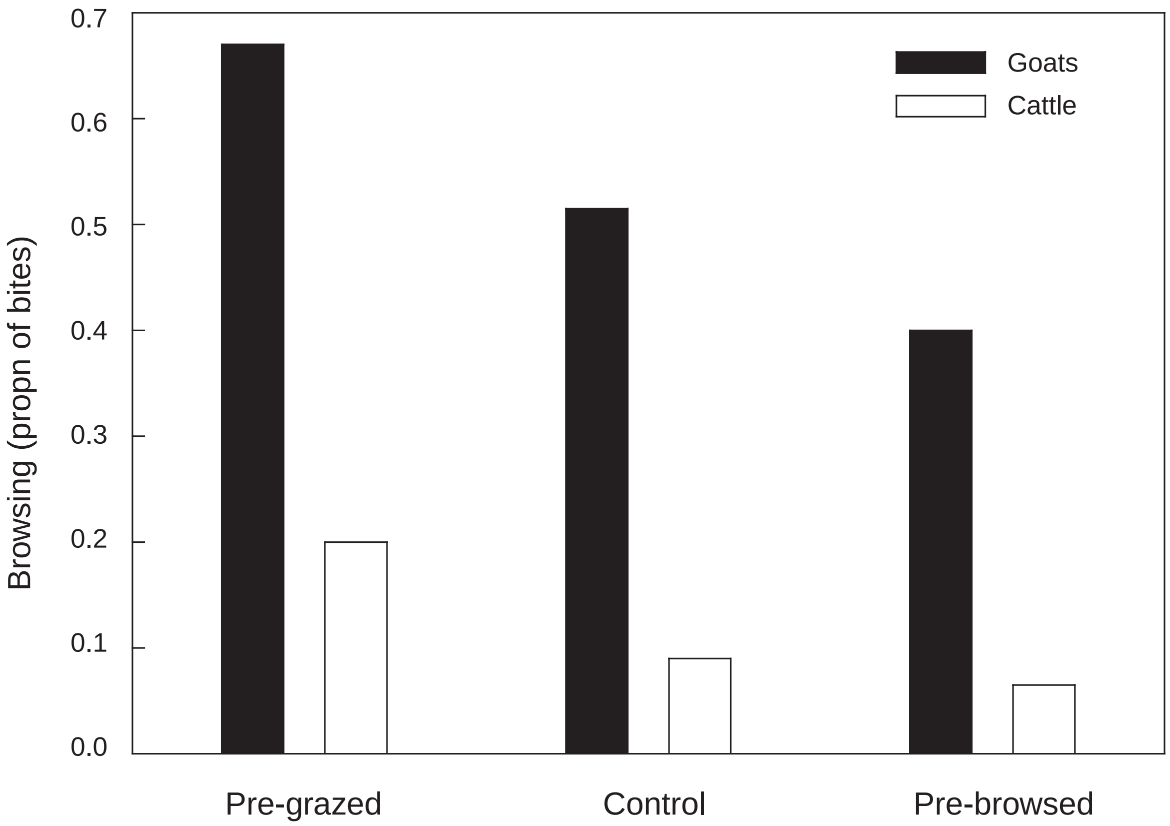
Table 1: Foraging behaviour of cattle and goats when feeding on browse and grass

	Bite rate (min^{-1})		Bite mass (g DM)		Intake rate (g/min/kg $W^{0.75}$)	
Browse:	*Cattle*	*Goats*	*Cattle*	*Goats*	*Cattle*	*Goats*
Acacia karoo	16	40	0.4	0.3	0.1	1.3
Acacia geradii	21	40	0.4	0.3	0.1	1.3
Combretum apiculatum	16	14	2.3	0.8	0.5	1.0
Dichrostachys cinerea	19	33	1.1	0.7	0.3	2.5
Grewia monticola	22	15	1.8	0.7	0.5	1.0
Rhus pyroides	18	17	1.2	0.9	0.3	1.6
Securinega virosa	23	24	0.8	0.4	0.2	1.0
Ziziphus mucronata	15	20	0.7	0.7	0.1	1.4
Browse mean	**18.8**	**25.4**	**1.1**	**0.6**	**0.26**	**1.4**
Grasses:						
Cymbopogon plurinodis	11	9	5.2	1.3	0.7	1.0
Chloris virgata	10	10	8.3	1.1	1.0	1.0
Heteropogon contortus	7	7	9.4	2.1	0.8	1.1
Panicum maximum	11	8	6.1	3.1	0.9	2.0
Themeda triandra	10	10	5.0	1.9	0.7	1.5
Grass mean	**9.8**	**8.8**	**6.8**	**1.9**	**0.8**	**1.3**

B. Effects of browse availability on diet selection by cattle and goats

Preliminary results (figure 3) from a field experiment, conducted in April 1999, Sept. 1999 and July 2000, show that both cattle and goats increased the amount of browsing in paddocks that had been treated to reduce grass abundance by pre-grazing with cattle, and decreased browsing in paddocks pre-browsed by goats. Cattle spent up to 20% of their time browsing when grass was depleted, compared with nearly 70% by goats.

Figure 3: Foraging behaviour is affected by forage depletion in cattle and goats



C. Use of browse resources in Communal Areas

This work was also initiated as a result of discussions at the first workshop. The objectives are to determine the activity pattern of cattle and goats in mixed-species grazing on communal rangeland and to determine the utilisation of browse by cattle and goats by season. The work was conducted in Bidi (South of Matopos) during 1999 and 2000, with three observations of one week's duration at different times in the dry season: March, June, and September of each year.

Browsing takes up a small proportion of the time of cattle. It increased from March to June because in March, grass, the preferred resource, was still available. By June, the fields were open to the animals and they had access to stover and this took up a large proportion of their time. In September, there was very little browsing because leaves from Mopane trees had been consumed by worms and farmers started supplementing with stored stover. Cattle offered stover in the morning attempted to graze (mainly grass stems) later in the day, as browse was limited.

In all the months, goats spent more time on intake activities than cattle (Table 2). Browsing took up about half of the time of goats. In March, the goats grazed for a considerably longer period of time but this fell sharply in June, picking up a little in September. Stover is not an important food resource for goats, but they eat it when the fields are first opened.

Cattle use a much narrower range of browse species (Table 3). This could partly be explained by the fact that goats travel more than cattle and, therefore, increase their access to other resources. Cattle walked between 2.6 and 5.1 km/day, and goats between 6.2 and 9.0 km/day.

Table 2: Percentage of observation time spent on each activity by cattle and goats when not in kraals.

	Cattle			Goats		
	March	**June**	**Sept.**	**March**	**June**	**Sept.**
Browsing	1.4	4.5	0.9	45.5	56.5	58.5
Grazing	59.0	28.0	59.7	30.8	6.7	11.4
Eating stover		35.1	4.0		5.3	0.7
Chewing			0.4			
Ruminating	14.4	5.4	2.2		7.0	6.3
Walking	15.8	12.5	18.1	13.4	17.1	14.9
Watering		1.1	1.3	3.3	4.3	2.1
Standing	2.2	4.2	10.2	2.0	2.1	4.2
Playing		1.4	1.3			
Disturbance		0.3	0.9			
Lying down	7.2	7.4	0.9	5.0	1.1	2.1

Table 3: *Species selection of grass and browse by goats in 1999 (expressed as proportion of total species counts made).*

	Cattle			Goats		
	March	**June**	**Sept**	**March**	**June**	**Sept**
Browse:						
Acacia erubescens				4.0	20.8	
Azanza gackiana			0.9	1.6	5.8	
Acacia galpini					13.3	
Acacia nilotica			4.4	3.2	1.7	
Acacia tortilis			15.9	7.1	1.7	
Boscia albitrunca				0.8	0.0	
Combretum apiculatum		2.8		13.5	2.5	
Combretum hereroense					4.2	
Combretum imberbe				1.6	4.2	
Dichrostachys cinerea				0.8		
Grewia monticola				0.8		
Lonchocarpus capassa	1.3				0.8	
Cassia abbreviata				2.4		
Colophospermum mopane	3.4	4.6	1.4	16.8	27.0	4.2
Euclea divinorum					0.8	
Gardenia spatulifolia				0.8	1.7	
Peltophorum africana				0.8		
Sclerocarya birrea			8.0	3.2		
Strychnos madagascariensis	0.0	0.4	0.7		1.6	
Terminalia sericia				1.6		
Ziziphus mucronata					18.3	
Forbs			12.4	7.1	0.0	
Unknown species					1.7	
Grasses:						
Aristida barbicollis	25.3	14.6	75.0	25.6	1.6	5.0
Cynodon dactylon	35.6	12.6	1.4			2.5
Chloris virgata	13.8	5.4			2.4	
Dichanthium papillosum		12.5				
Eragrostis rigidior	16.1	9.2	0.0	8.0	0.8	1.7
Heteropogon contortus	4.6					
Panicum coloratum	1.1			7.1	2.4	1.7
Panicum novemnerve				0.8		
Unknown spp			0.9	0.8	6.7	
Solanum incanum				4.8		
Stovers:						
Groundnut leaves	0.4					
Bamara nuts				0.8		
Maize	51.5	6.3		0.8		
Millet				1.6		
Sorghum				5.6	0.8	

Grass species diversity is low in Bidi communal rangeland, despite the large area covered by the work. In June and September, the range of species of grass which were selected by cattle declined as grass biomass became depleted. In September, *Aristida barbicollis* and *Dichanthium papillosum* became important because they are the most abundant and are not consumed as much immediately after the rains when more preferred species are available.

Out of the large selection of browse species available, cattle choose only a few, the common factor being that the tree species selected are all broad-leaved. *Lonchocarpus capassa* is considered as a 'reserve' by the farmers because it is evergreen and too tall for goats (and cattle) to reach. Although *Combretum apiculatum* and *Strychnos* were not defined as a reserve, the trees of this species in the area are generally tall and the former is also almost evergreen.

Goats used a wide range of trees. Some, such as *Strychnos*, *Gardenia* spp and *Lonchocarpus* are consumed as fallen leaves because the browse on these trees is out of the reach of goats. *Sclerocarya birrea* has fruits which the animals consume whole, although the hard seed appears not to be digested. Forbes form an important part of the goat diet even when they are dry. There is a wide range of species, especially in fallow lands.

Livestock have resource niches which they use when forage becomes scarce. For example, *Cynodon dactylon* is found next to the dam and is green when other grasses are dry (but there is a limitation to its intake because it forms a carpet making it difficult to bite). Other niches include the stover in the fields, as well as the grass which grows on the contours. In the same fields, some farmers allow trees to grow (rather than stumping them) because they know the value of them to their livestock. Most of the *Strychnos* is found in the fields and fallow lands. Species such as *Acacia tortilis* do not grow beyond about a metre in height, but would be more productive if they were allowed to grow in the protection of the fields.

The selection pattern of the animals is not fixed. Although data collected in September 2000 are not presented, they show that there was more grass in 2000, following the heavy and prolonged rains of the wet season. Cattle, therefore, grazed most of the time and did not receive stovers. Farmers who tried supplementing with stovers noticed that the animals rejected them (they were rained on heavily, so probably the quality was poor). There were still some areas with green grass and sedges. Mopane still had green leaves, and for the goats, there were a lot of green forbs.

The observed diets (Table 3) may be compared with the ranking given by farmers in a PRA conducted in 1998 (Table 4)

Table 4: Ranking of preference of browse by cattle and goats.

Ranking	Cattle	Goats
1	*Combretum apiculatum*	*Acacia tortilis*
2	*Grewia monticola*	*Boscia albitrunca*
3	*Combretum herrerense*	*Ziziphus mucronata*
4	*Strychnos innocia*	*Colophosperum mopane*
5	*Lonchocarpus capassa*	*Combretum herreroense*
6	*Colophosperum mopane*	*Grewia monticola*

Conclusions:

Intake of browse by cattle is low, especially when scarce, that of goats is high. For both cattle and goats, the importance of browse depends on the relative abundance of other resources (grass, forbs, and stover). Within browse species, the potential as feed for cattle depends on the ratio of thorny to broad-leaved species: range assessment depends on the target animal species. Intake and diet selection are the largest variables in the nutrition of free ranging animals. Therefore, any work directed at improving the nutrition of free ranging animals must recognise and address these variables.

3. Decision Support Modelling of Semi-arid Rangeland (Andrew Illius and Collaborators)

This consists of modelling the effects of climatic and spatial variation on livestock systems, in order to conduct policy analysis. Two studies have been completed.

A. Livestock offtake strategies under climatic variability

Ways of 'tracking' environmental fluctuations could be of value in limiting drought-induced mortality and increasing output. A range of tracking policies, designed to tackle climatic variation, using a simulation model of a semi-arid grazing system were examined. These compared annual sales designed to limit stocking rate, pre-emptive sales triggered by insufficient rainfall, and variable sales and stocking-rate regimes determined by the current season's rainfall. Although the flexible stocking strategies did reduce mortality losses, compared with fixed stocking, they did not increase average annual sales. The main reasons for this are that major losses of stock are associated less with one-year than with two-year droughts, which are difficult to track, and that de-stocking can be really effective only if the productive potential of the herd can be re-established more rapidly than is possible from depleted herd resources. Tracking policies also increased inter-annual variability of sales and hence cash-flow. For subsistence pastoralists, the traditional policies of maintaining the maximum number of breding stock, and of hoping that most of them will survive drought, may be as close as 'opportunistic' management can get to dealing with drought.

***Message*:** Flexible stocking strategies alone are not likely to be successful in coping with droughts.

B. The role of 'key resources' in maintaining livestock populations

It has been suggested that climatic variation has the effect on the dynamics of arid and semi-arid grazing systems of reducing animal numbers below the level at which they have much impact on vegetation or soils, and that spatial heterogeneity in resource availability serves to buffer herbivores against climatic variation. Modelling was used to test these hypotheses and to examine the interacting effects of temporal and spatial variability in plant production on animal population dynamics and defoliation intensity. The model distinguishes areas of the range that are accessible during wet and dry seasons, and examines the effect of seasonal restrictions in foraging area.

It was established that the animal population is in long-term equilibrium with dry-season resources (so-called 'key resources'), on which it depends for survival. In contrast, the size of the available wet-season range had virtually no effect on year-round carrying capacity. Increasing degrees of variability in primary production on areas used by animals for surviving the dry season increased the annual variation in animal abundance and reduced the mean. By comparison with a stable environment, for which the model predicts virtually stable animal numbers and constant, low defoliation intensity, variation in annual rainfall causes wide fluctuations in animal numbers and defoliation intensity. Under climatic variation, animal numbers can build up enough to impose much higher defoliation intensities than under a constant regime. Periodic intense defoliation is a consequence of climatic variability which is likely to make these environments more, not less, prone to ecological change. A high ratio of dry season to wet season resources may support a sufficiently large animal population to impose non-trivial defoliation impacts on the outlying range.

Message: The carrying capacity of rangelands is very largely governed by the availability of dry-season forage resources.

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Questions and Answers

How did the project reconcile the concept that summer carrying capacity limits livestock productivity with their findings that dry season feeding limits animal survival?

The project believes that the opposite applies: the key factor is determining the number of animals is the dry season because the amount of resources available then determines the number of animals that can survive. In the wet season there is often an excess of animal feed but there are not enough animals. The dry season feeding issue is the bottleneck.

Do these findings mean that conservation practices should be given a higher profile?

Yes. Excess resources need to be captured and then utilised during the dry season. When animals' lifestyles are supplemented, the number of animals that can be carried during the dry season is being artificially increased. If this practice continues it could have disastrous ecological implications.

Were there any intentions to promote browse production, because that is the limiting factor?

This is the next phase of the project: the project team needs to find ways of increasing browse; this is very low in communal areas because of the need for fuel wood and the high numbers of animals in the wet season. New ways need to be found for increasing browse production. Trees around cultivated areas have been found to grow well and produce a lot of leaves, an important dry season feed.

What about cut and carry?

This had been looked at in the lopping experiment but the results were disappointing. The team needs to look at what method of lopping would produce the best results.

What about the sustainability of lopping and the time needed to carry out the study?

There are two aspects to consider: population aspects on trees, severe lopping could kill the trees; biomass dynamics, the project team should be able to answer this question in a few years time. However a large study on mortality would need to be carried out which is probably not viable within the existing funding framework.

There was agreement over the value of browse in the dry season, but disagreement about the wet season information. In rural areas, productivity is very low so it is not expected for animals to be productive or maintain their weight during the dry season. The model was specifically looking at whether carrying over of resources from the wet season had an effect on the dry season resources. It is true that wet season reserves are important for growth and repair.

It was suggested that an approach be taken to look at integrated farming systems so that modelling takes into account other issues. Wet season as well as dry season resources should be studied. One person felt that scientists are now being left behind by the farmers because the farmers are carrying out their own research.

The Project Leader agreed that the project was approaching the stage at which it should look at the other, more integrated issues.

DFID are focussing on resource-poor farmers and current information shows that farmers prefer to sustain their livelihoods, rather than increase productivity. Guidance was given in the past to farmers to cull their stocks, but farmers were not keen because in terms of surviving droughts, survival at large is the best option. Culling would be right, but for a different clientele. The alternative approaches faced by livestock keepers to the challenges of the dry season are to sell off animals, thereby providing more feed for the remaining animals to maintain production or maintain all the animals and accept reduced productivity and possibly mortality. For resource-poor farmers the second option is the best bet; for resource-rich farmers the first option is possibly best.

How robust is the model in describing the wet season and the duration of rainfall? Could it measure the impact of the length of the dry season?

The model is good at using variable data, e.g. it looks at variable rainfall, but it is fixed in the dry season.

Could the model be applied to draught animal management strategies, for example, if the price of animals falls, would demand increase?

This economic modelling is being carried out, local elasticity of price also needs to be taken into consideration. If it is a very local market the price will decrease if everyone wants to sell their animals, however if it is linked to the national market people might be able to sell their animals at a higher price. At the national level, cold storage facilities would need to be in place in order to preserve meat sold at the onset of drought.

What about the bottleneck in the model? How can the model assist the farmer in decision making?

The increase in livestock numbers would increase pressure on the range in the growing season. Debate on whether livestock cause rangeland deterioration, i.e. maintain a lot of animals in mixed farming systems, means farmers are not responding to range resources which could be ecologically undesirable.

Effect of drought on destocking

The livestock keepers have to take a gamble and try to predict how bad the drought will be, and whether it is more worth their while to sell their animals or hold on to them; if selling, they have to predict which animals will be best to sell. Normally if there is a drought, farmers try to adapt their practices e.g. with the rumour of El Nino two years ago, farmers planted different crops. However the predictions were not accurate, the crops were not successful and the farmers lost out. Accurate predictions are not available.

Environmental Risks of Insecticide-treated Cattle in Semi-arid Livestock Systems (R7539)

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Abstract

The use of pyrethroids as cattle treatments (pour-ons) to control tsetse is now widespread in Zimbabwe. However, there is evidence that pyrethroid residues in dung are poisonous to dung beetles that facilitate the dispersion and breakdown of dung pats, a principal source of soil enrichment. Trials in Zimbabwe have shown that pyrethroid residues are present in cattle dung. Studies of the effects of these are in progress but large scale field trials have been curtailed because of the current situation in Zimbabwe.

Background

In the last few years the strategy of encouraging smallholder operated methods of tsetse control has meant that the application of pyrethroids to cattle has become the preferred control technique. Experience in Zimbabwe and elsewhere has shown that the technique is highly effective, on its own or as a complement to the use of artificial baits treated with pyrethoids. However, although the application of pyrethroids to cattle is simple in itself, it can produce several complications. One of these is suggested by the preliminary demonstration, in 1998, that the dung from treated animals can be toxic to dung beetles in Zimbabwe, in accord with findings in Australia, America and South Africa. These indications were worrying because smallholder farming relies heavily on beetles and other dung fauna to realise the agricultural benefits of cattle manure. Hence, in January 2000 the Natural Resources Institute (NRI) began a three-year project to address the risks to dung fauna. In Year 1, the period now approaching completion, the main aim was to confirm the existence of the risk. In Year 2 it is planned to elucidate the means of avoiding or minimising the risk, and in Year 3 the intention is to assess the efficacy of these means.

Progress to date

Work in Year 1 has so far demonstrated that deltamethrin can be found in the dung of cattle treated with Decatix® and Spoton® in January (wet season), April (late rains) and July (dry season), at Rekomitjie Research Station in the Zambezi Valley. The pyrethroid occurred at concentrations of about 0.01—0.5 ppm in the wet weight of the dung produced in the first week after treatment, but after two weeks had fallen to undetectable levels, *i.e.*, <0.005 ppm. The insecticide persisted in contaminated dung pats for several weeks, the concentration rising several-fold as the pats became dryer with age. Dung from treated animals was highly toxic to a range of beetle species for about 10 days after the treatment was given. Field and laboratory assays with dung containing various concentrations of deltamethrin and alphacypermethrin indicated that the LC_{50} (24h)[1] for beetles is about 0.1 ppm, but about 0.5 ppm for dipteran larvae. Studies on its toxicity to termites are in progress. Methods of assessing the way that pyrethroids may affect the behaviour of dung fauna are being examined.

Unfortunately, the limited funding of the project and the present turmoil in Zimbabwe make it impossible to conduct large field trials of the effects that insecticide treatment of cattle might have on the abundance of dung fauna populations and on the prevalence of undegraded pats. However, predictive modelling of the observed toxicity of contaminated pats suggests that the cattle treatments could severely depress the populations of many types of beetle and dung-frequenting flies, especially when, as in Zimbabwe, the cattle are treated regularly for many years and over areas of many thousands of square kilometres.

[1] LC50 Lethal Concentration killing 50% of population exposed for 24 h

Conclusion

In overview, the work in year 1 of the project is on course. The risks to the natural degradation of dung seem sufficiently serious to justify the planned attempts to minimise them.

Questions and Answers

Does the project see insects becoming adapted to chemicals with the risk that in the future ecological disasters could occur?

There is a possibility that dung fauna will become resistant to insecticides, but that would mean that the creatures survive, i.e. not a disaster. The more serious problem may be that ticks become resistant to pyrethroids, so removing the effectiveness of some of the tick dips.

Public and private control

It was suggested that a blend of public and private means of tsetse control was needed. Zimbabwe is seen as a good example for the rest of Africa in terms of tsetse control.

Pour-ons

The problem with pour-ons was, for example, the number of cattle (important assets) protected against tsetse. Therefore, the need to supplement with baits up along the Zimbabwean border, will mean a dependence on government for funding.

Cattle dips: Does the risk from insecticides also apply to cattle dips as a means of contamination?

Cattle dips also posed a contamination risk. The insecticide might be passed on when applied at the anus. The project intends to address these questions.

Vetaid in Mozambique

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Abstract

Vetaid is active in four african countries, including mozambique. It is a community orientated NGO, endeavouring to improve peoples' lives through increased contribution from their livestock. Projects address problems of livestock production from nutrition, management, disease, input of resources and infrastructure. Farmer training is also addressed. Activities in Mozambique started in 1990. Following the collapse of the livestock sector in the civil war, there is now the added challenge of recovery after the floods of early 2000.

Background

VETAID is a Non-Governmental Organisation (NGO), specialising in community based livestock development with poor people who are either partly or totally dependent on their livestock for their survival. The organisation is based in Edinburgh.

VETAID was founded in 1989 by a group of students and staff members from the Centre for Tropical Veterinary Medicine (CTVM), at Edinburgh University, but is registered as an independent NGO.

VETAID is a member of the umbrella organisation Veterinaires sans Frontieres-Europa (VSF-Europa), which is comprised of similarly minded NGOs from 10 European countries dedicated to community-based livestock development in poorer areas of the world. At present VETAID has ongoing projects in:

- Mozambique
- Tanzania
- Somaliland
- Uganda

In addition, we are at the planning stage for new projects in South Africa and Malawi and hope to commence work there during 2001.

Other countries of operation in the recent past have included:

- India, where a project with milking buffalo has been taken over by the local NGO partner, SPEECH, and is continuing to operate
- Afghanistan, where activities were terminated because of insecurity
- Southern Sudan, where VETAID activities under the UNICEF 'Operation Lifeline Sudan Programme' were absorbed into the work of sister organisations within VSF-Europa, namely VSF-Belgium and VSF-Switzerland.

VETAID also has two projects being implemented in the United Kingdom. These are:

- A Development Education Project, aimed primarily at students of agriculture and veterinary medicine, to inform them of the importance of livestock in the lives of the poor in developing countries
- An evaluation project to assess the impact of community based livestock development work, both of VETAID and others, on the lives of poor communities, in terms of improved food security and increased incomes from livestock.

Vetaid in Mozambique

VETAID has been operational in Mozambique since 1990. At present there are projects in four provinces, namely Maputo, Gaza, Inhambane and Tete. The project work focuses on sustainable, community level livestock development. During project implementation the involvement of local partners is essential. These include:

1) Government agencies, such as district and provincial livestock and extension services
2) Local NGOs, where VETAID's technical expertise is combined with the community level linkages of local organisations in project implementation
3) Community based organisations, such as women's groups, church groups, farmers' associations, etc, where we try to combine the project work with their own activities in such a way as to strengthen both.

VETAID's principal objectives in Mozambique are:

- Improved food security for rural families
- Increased incomes from livestock development
- Sustainable rural livelihoods, especially through livestock development.

Mozambique is in the process of recovering from a long and bitter civil war and as a consequence is facing many problems. In the livestock sector, the principle problems which the country faces are:

1. Low levels of Livestock holdings in the Family Sector

There was an 80% decline in the size of the national cattle herd between 1980 and 1992, directly as a result of the civil war. The goat population also declined drastically and donkeys have become quite scarce, but census data are not as readily available or reliable as for cattle.

The low levels of livestock holdings result in a lack of draught power for both cultivation and transport of agricultural produce to rural markets.

In addition, Mozambique has little local production, resulting in high levels of imports, from neighbouring countries, of meat, eggs and other animal products for consumption by the urban population. South Africa and Swaziland are major suppliers.

2. Collapse of Government Livestock Services

For most smallholders, in rural areas, there are few, if any, opportunities for veterinary treatment of their animals. Government livestock vaccination campaigns are irregular and patchy in coverage. Extension and advisory services are weak, with a focus on crop production and on the more fertile coastal areas, whereas most of the smallholder livestock owners live in the dried interior zone.

As a result of the war there has been either destruction, or poor maintenance, of livestock infrastructure, such as dip tanks, veterinary diagnostic laboratories, holding pens in markets, etc.

3. The Rural Marketing System for Crops and Livestock is Weak

Due to the war there has been a breakdown of contacts between rural producers and urban traders. These are re-establishing themselves, but progress is slow.

There has been a lot of destruction or poor maintenance of market infrastructure, such as stores, loading ramps, weighing facilities, holding pens, etc.

There is also a marked lack of dissemination of market information to rural producers, especially on livestock prices and availability.

Generally, rural transport and access to markets is very poor.

4. Loss of Livestock Management Skills

As a result of the civil war, many rural people were relocated in government controlled urban areas or became refugees in neighbouring countries. This has resulted in loss of livestock management skills and failure to pass on existing skills to younger farmers. These people must now be reintegrated into livestock and agricultural production systems.

Vetaid's recent activities in Mozambique

These include:

1. *Collaboration with*

Direcção Nacional De Pecuária (Dinap) (National Directorate Of Livestock Of The Ministry Of Agriculture And Rural Development (Mader)); Serviços Provinciais De Pecuária (Spp) (Provincial Livestock Services); Serviços Provinciais De Extensão Rural (Sper), (Provincial Rural Extension Services).

Also Local Partner Ngos, Such As Kulima, Agir, Pasco And Community Based Organisations In The Project Locations.

2. *Restocking*

- Over recent years VETAID has been very much involved in community level restocking projects. This has involved local purchase or importation of appropriate cattle breds from South Africa and Zimbabwe for distribution to the family sector in Mozambique
- The establishment of credit schemes for appropriate community level restocking of families with cattle or goats
- Provision of training and extension to farmers, whether part of restocking schemes or not, on livestock health and production
- Promotion of Animal traction, provision of oxen on credit, as well as agricultural implements and carts.

3. *Community Based Animal Health*

- Training of promotores de pecuária (village livestock promoters). These are community based paravets, locally selected, for participation in the training programme
- Establishment of simple village veterinary pharmacies, managed by the paravets and controlled by community representatives. These are run on a cost-recovery basis
- Community based vaccination campaigns against newcastle disease in poultry.

4. *Rehabilitation of Livestock Infrastructure*

- Repair and re-equipment of veterinary diagnostic laboratories in Xai Xai, Chokwe, Maxixe and Tete. Unfortunately the laboratory in Xai Xai has since been totally destroyed by the floods of February and March 2000
- Repair of cattle dip tanks damaged during the war. Construction of treatment corridors as an alternative to dip tanks.

5. *Institutional Support to the Provincial Livestock Services* (SPPS)

- VETAID has provided veterinary laboratory equipment and materials to the provincial diagnostic laboratories Tete, Gaza and Inhambane
- Veterinary laboratory technicians have been trained in simple laboratory diagnostic techniques; what they cannot deal with is sent to the national laboratory in Maputo
- The programme has carried out training on extension methodology for district level staff of the livestock and extension services
- There has been training provided on the Management of Rural Development for chief of the SPP of Gaza and Inhambane provinces
- Provincial veterinary staff have received training in veterinary epidemiology.

6. *Rehabilitation of Rural Markets*

This is an area of great importance for livestock development in mozambique but is only now becoming part of vetaid's activities with work due to commence in January 2001. This will mainly involve:

- Rehabilitation of basic market infrastructure; weighing facilities, loading ramps, etc
- Re-establishment of trading linkages between rural producers and urban traders
- Formation of farmers marketing groups, in order to be able to supply sufficient quantities of produce to interest traders
- Collection and dissemination of livestock marketing information.

7. *Basic Research on Livestock Production, Health and Economic*

As part of ongoing project work in mozambique and elsewhere, vetaid regularly carries out research on livestock health and production and on the socio-economics of smallholder livestock production. The purpose of this research is to be better able to advise the communities we work with and, also, for vetaid and other implementing agencies to better understand the context in which people live.

Vetaid is eager to continue and to expand this aspect of the work and to form operational partnerships with other organisations and institutions carrying out similar research activities in neighbouring countries.

Other Aspects Discussed Included:

- What is the level of cattle resistance to ticks as a result of the poor vet management practices?
- VETAID advocates strategic dipping at important times of the year to maintain stability
- Do the farmers in the discussion groups ever ask for tractors or traction services? If not, would that be attributed to their being realistic about what is viable or because VETAID is associated with the livestock sector?
- What is was the order of priority for livestock re-stocking in relation to wealth ranking in the recovery period after the war?
- Are the paravets and their pharmacies effective in the control of animal diseases without the use of the cold store or refrigeration?

On-farm Research and Development in Northern Province, South Africa

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Abstract

The programme, 'Broadening Agricultural services and extension delivery' (BASED), is taking place in six pilot village communities.

Poultry. Farmers have organised themselves into groups, with a committee. They are undertaking rearing and marketing of indigenous chicken. They have been trained to vaccinate against Newcastle disease and are purchasing their own vaccines.

Ruminants. The most important species are cattle and goats. Individual farmers and interest groups receive management training . Draught animal power (DAP) is rated as highly important, and demonstrations are held in villages to encourage the correct use of implements. Farmers are encouraged to test a range of implements to assist them choose appropriately when purchasing their own. Courses to demonstrate the correct management of donkeys, including the correct use of harness, are also held for farmers (awareness of the importance of donkeys as suppliers of DAP is increasing in South Africa).

Background

The Northern Province Department of Agriculture and the Environment (NPDAE) has developed and is focusing, within the following framework, on Cornerstones for the management and delivery of effective livestock services:

Programme

Animal Health

- Efficient animal health services
- Access to these services.

Institutions

- Strengthening local livestock organisations
- Capacity building for farmers and their associations
- Prioritisation of farmers' problems
- Easy access to institutions and services.

Livestock Breding

- Appropriate breding strategies
- Access to good sires
- Improvement/selection of indigenous breds.

Marketing

- Home consumption vs selling
- Effective marketing services
- Good market information and infrastructure
- Easy accessibility to markets
- Realistic pricing policies
- Markets that are farmer and customer friendly
- Identification of potential outlets for livestock produce.

Extension and Dissemination

- Participatory extension approaches
- Provision of a basket of options and solutions for farmers
- Farmers to participate in planning delivery of services
- Build on farmers' experience in problem solving
- Encouragement to farmers to build their own agendas
- Recognition of the importance of indigenous knowledge and encouragement of its appropriate use.

Use of Participatory Rural Appraisals (PRA) and On-farm Research

- Encourage, through PRAs, sharing knowledge, leading to farmer defined researchable problems.
- Development of appropriate research programmes in which farmers have a sense of 'ownership'. These programmes should include:
  1) On-farm trials where possible
  2) Participatory research support programmes
  3) An effective monitoring and evaluation system.

Identified Research Areas

- Development of a community based resource management capability
- Veld management
- Water management
- Utilisation of by-products
- Livestock-feeding strategies
- Feeding allied to grazing management
- Game management and tourism.

Institutional Development

- Staff development
- Farmer training, including financial management
- Identification of, and training in, techniques to add value to livestock output before marketing
- Development of client-orientated services
- Access to land.

Other Aspects Discussed Included:

- Women are beginning to talk and participate more in the group meetings
- What is the extension: farmer ratio in the North Eastern Region?
- What measures were being taken as a result of the withdrawal of free dipping (previously funded by the Government) in the area?
- Had there been a change in policy to promote DAP after the withdrawl of subsidises on tractor power?
- Are goats important in the region, and are they milked or just used for meat?

Introduction to the Livestock Production Programme Dissemination Strategy and Issues for Zimbabwe and Southern Africa

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Abstract

The role of the Livestock Production Programme (LPP) has evolved over time to the current position, where LPP can fund some dissemination of its own outputs, commission research into constraints on dissemination and initiate pilot approaches that can be adopted by governments and donors. Key questions for this strategy, in general and with specific reference to Southern Africa, especially Zimbabwe, are set out. At the Workshop these questions and the ways forward were discussed for the following target audiences: crop-livestock farmers, smallholder dairy farmers, smallstock keepers and policy-makers.

Livestock Production Programme (LPP) Approach to Dissemination

The LPP approach to dissemination can be said to have passed through three major phases:

1. Up to the early 1990s, most projects had disseminated their outputs through scientific journals, as expected by the Programme. There was an assumption that outputs would eventually be disseminated to farmers through national extension services, but projects were not expected to actively assist in this.
2. From the mid-1990s there was more of an onus on projects to identify, at the time of application, the dissemination methods they would use and the target organisations who would assist in dissemination. Dissemination methods started to became more varied (Morton 1996).
3. From 2000, dissemination and research on dissemination have become core activities of the Programme.

This does not mean that LPP has a mandate for mass extension, but that it can fund some dissemination of its own outputs, research into constraints on dissemination and initiate pilot approaches that can be adopted by governments and donors.

This year three "Regional Dissemination / Promotion Co-ordinators" (RDPC) have been appointed by LPP. They are:

- John Morton, NRI, for Southern Africa and India
- Chris Garforth, University of Reading, for East Africa and Bangladesh
- Simon Anderson, Imperial College at Wye, for Latin America and Nepal.

The role of an RDPC is defined as:

> *"supporting the LPP with appropriate co-ordination and intellectual inputs in order to improve the dissemination and promotion of knowledge, technologies and policies on livestock production for resource poor livestock keepers and their communities"*

The role is supportive and catalytic and does not replace the ordinary decision-making processes of the Programme Manager and the Programme Advisory Committee. At present, funding of the RDPC role is modest.

Observable verifiable indicators (OVIs) for the RDPC role can be summarised as follows:

- Development of a dissemination/promotion strategy for LPP (by 2001)
- Monitoring and evaluation indices for assessing the uptake of knowledge by target institutions and the impact of knowledge on the poor (by 2002)

- To contribute to the following LPP outputs by 2005:
  - ➢ Effective processes/channels/linkages for disseminating information between farmer and researcher identified
  - ➢ Endogenous knowledge/technology base of resource poor livestock keepers logged and driving forces which facilitate adoption of 'new' knowledge understood
  - ➢ Knowledge/technology gaps affecting livelihoods identified and appropriate and prioritised research commissioned
  - ➢ Effective target institutions identified with the trust of resource poor communities.

The LPP overall dissemination strategy can be represented in the diagram proposed by Simon Anderson (Figure1). However, this diagram has to be interpreted in the light of circumstances in each country or region: the national context and the state of LPP's portfolio.

Dissemination strategy was discussed in an e-mail conference[1] held in April 2000. Several important questions were raised for the strategy in general and for specifically for Zimbabwe and Southern Africa.

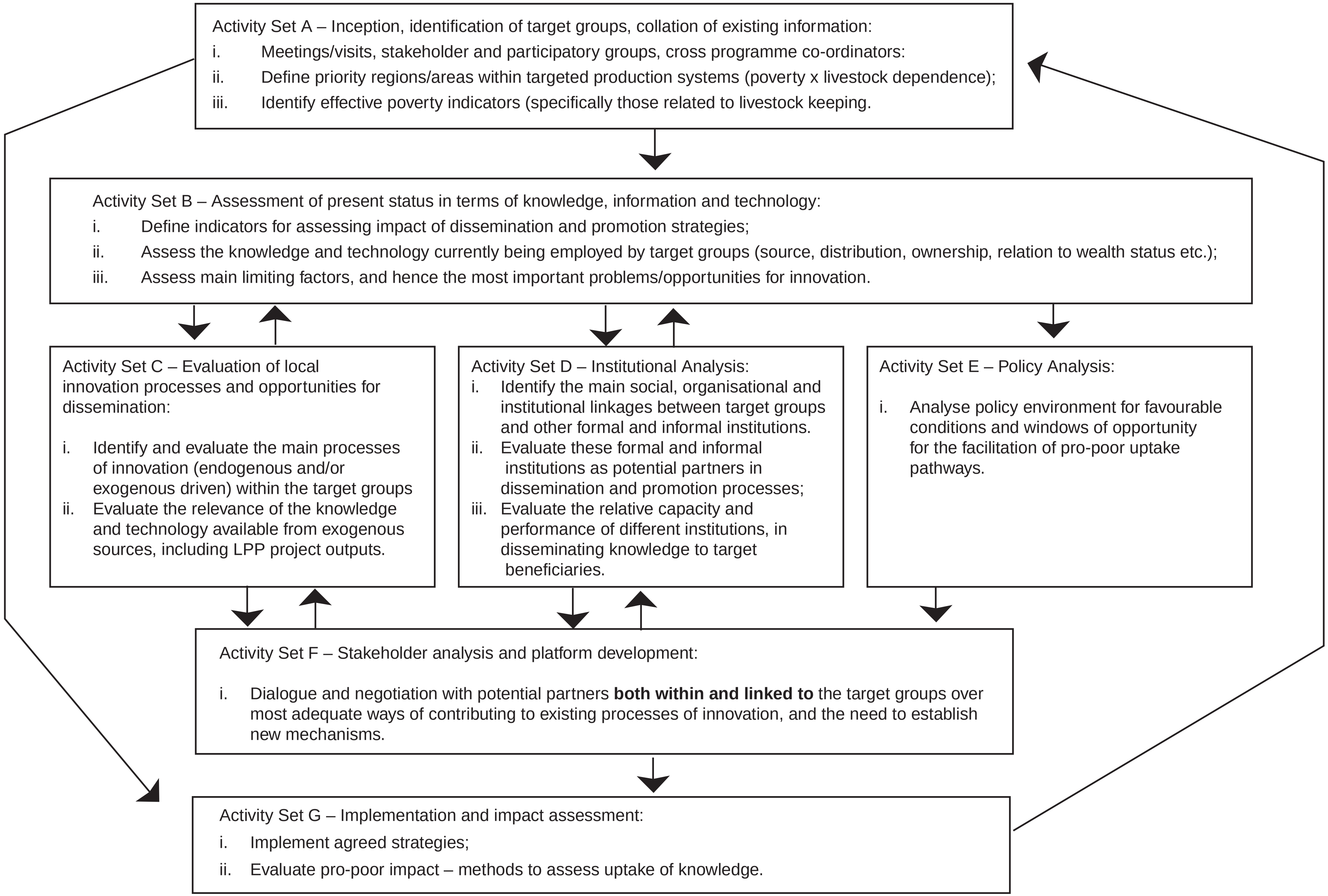
[1] The text below is an extract from the introduction to the e-conference

It has been proposed that an e-discussion is held between interested parties prior to the LPP Dissemination Co-ordinators meeting in early May… You are invited to participate as actively as you are able over the next few weeks….The onus of the first week's work will be upon John Morton, Chris Garforth and myself to produce responses to the what, who and how questions set out in the document for the regions for which we are responsible. In the second week those with specific regional expertise are asked to respond to the first draft responses.

This will be an iterative process and we hope that by the 21st April we will be in the position to draft preliminary versions of the programme and regional logframes on dissemination and promotion strategy development for discussion at the meeting in early May.

Please send all correspondence to all on the list. Should you not wish to participate and do not want to receive the ensuing emails please let me know and your name will be taken off the list.

Figure 1. Proposed activities for the development of LPP pro-poor dissemination strategies



*Activity sets A and B will be commissioned as short-term non-competitive studies. Activity sets C, D & E will be commissioned through an open-call process.

General Questions

1) *Should an* LPP *dissemination strategy focus only on the dissemination of* LPP*-generated knowledge*?

The general feeling of most contributors to the e-mail conference was that it would be neither right nor possible to do this. Livestock producers needed a basket of knowledge that might derive from LPP outputs, the outputs of other research, indigenous knowledge and general good husbandry. Pragmatically however, LPP as a research programme does not have a mandate or funds from DFID to carry out mass extension but to pilot dissemination approaches, building on its own outputs. LPP-generated knowledge will be central to a dissemination strategy, but not the only knowledge involved.

2) *Are the major issues for dissemination specific to livestock knowledge or generic*?

Some in the e-mail conference felt that the important issues cut across Natural Resources sub-sectors and were generic to livestock, crop protection, post-harvest etc. There is some obvious truth in this view and LPP must co-ordinate with other DFID research programmes, but in the speaker's view there are also important issues specific to livestock production: the likelihood that government extension personnel would have less livestock than crops knowledge, the other organisations (particularly veterinary) involved, the greater complexity and smaller degree of seasonality of livestock knowledge compared to crop knowledge etc. (Morton *et al.* 1997).

Zimbabwe: *Features and Questions*

Given that all LPP's Southern African projects are based in Zimbabwe, it seems reasonable to base a dissemination strategy there. However, a number of aspects of the national context need to be borne in mind.

Communal Area (CA) farming in Zimbabwe can be characterised as undergoing processes of crop-livestock integration under increasing land pressure. As we now know from the LPP-funded work (project R6781) of Ian Scoones and his colleagues (Scoones and Wolmer 2000), these processes are complex and diverse, with strategies varying between households and between communities. This implies a major need for targeting of dissemination at household and at community level.

Compared to many countries in Africa, Zimbabwe has relatively high literacy rates. The CA farmers have well-established patterns of using commercial inputs (principally hybrid seed, less so with livestock inputs). Both these facts open up possibilities for dissemination.

Rural Zimbabwe is characterised by high rates of (mainly male) labour migration, to towns, mines and neighbouring countries. This has led to high proportions of *de facto* and *de jure* female-headed households, which presents both challenges and opportunities to extension. It also increases the vulnerability of rural households to economic shocks in the urban and industrial sectors of the economy. The vulnerability of rural households to HIV/AIDS should also be mentioned here.

The national extension service, Agritex, although severely under-resourced, remains a major player, with a high calibre of frontline staff. The LPP already has well-established collaboration with Agritex. While the smallholder dairy sector is very small, the Dairy Development Programme (DDP), which is the major arm of government working within it, also has close ties to LPP. Both sets of ties should be built on. However, LPP needs to become acquainted with other organisations that are, or might become, involved in dissemination of livestock knowledge.

There are also several major questions that need to be asked about an LPP dissemination strategy for Zimbabwe:

1. *Given* LPP's *mandate to work with the poor, who are the poor*?

There are two possible views on this. One is that, while there is strong variation in wealth (livestock and other) within CAs, all farming in CAs is defined by the colonial history of limiting Africans to small, crowded, fragmented and environmentally marginal reserves. Consequently CA farm households can in general be regarded as "poor". The other view is that LPP needs to focus much more closely on specific sub-groups of CA farmers, particularly those owning only smallstock, and/or female-headed households.

2. ***Have our existing projects dealt with the poor? Have they been demand led? Do we need a new sort of project, or better dissemination of existing projects?***

The overall LPP strategy emphasises the integration of dissemination with new and more participatory approaches to needs assessment and project identification. Current projects in Zimbabwe could be argued to be fairly well focussed on poverty, and as having been identified in accordance with CA farmer needs.

3. ***What institutions transmit livestock knowledge to the poor? Which of them do the poor value and trust?***

Fieldwork in Kenya had shown the importance of starting with the farmers and identifying the organisations they are in contact with, and the degree of trust placed in them. In Zimbabwe we have little idea of farmers' relations with organisations other than Agritex.

4. ***Are LPP outputs relevant to policy-makers and how can they be transmitted to them?***

It seems that many of the Zimbabwean projects were either producing outputs mainly directed at policy makers (tsetse and land-use) or had broader implications for policy (past projects on DAP). Given the well-known constraints on policy-makers' time, what was the best way of disseminating this knowledge.

5. ***How can Zimbabwean experience (research projects and analysis of dissemination strategies) be made relevant to the rest of the region?***

Some Possible Activities

Activities suggested through the email conference to initiate the dissemination strategy were discussed.

Review of secondary data on livestock-keeping and poverty.

In the light of question 1 above it would be worth investing in work, primarily on existing secondary sources such as national poverty surveys, which answered questions such as: what proportion of CA farmers fall below a national poverty line (variously defined)? What levels of livestock ownership are associated with a defined poverty line.

Fieldwork on existing information channels.

Participatory fieldwork to answer question 3 above is also an option

Needs assessment with current target institutions (Agritex, DDP) and other potential target institutions.

LPP could take the view that Agritex and DPP were already privileged target institutions, and evolve, in partnership with them, projects that addressed their constraints on dissemination. This would need to be balanced by work with other target institutions as yet unidentified.

Dissemination to policy makers.

Where information was relevant to policy makers, LPP could fund policy briefings or similar.

References

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SCOONES, I. AND WOLMER, W. Pathways of Change: Crops, Livestock and Livelihoods in Africa. *Report for LPP, Institute of Development Studies, University of Sussex* (in press).

Group Discussions of Dissemination Issues Relevant to Zimbabwe

The full group discussed the five questions about a strategy for Zimbabwe as set out above. The discussion concentrated on:

Who are the poor?

Discussion took place as to how 'poor' should be defined – were people resource-poor, needing empowerment or was food security the defining issue? It was noted that resettlement farmers are also poor.

Have existing projects dealt with the poor?

The group agreed that existing projects dealt with the poor. It was recommended that slightly richer farmers should also be targeted to prevent them from slipping into the 'poor' category.

Have existing projects been demand-led?

It was suggested that suggested that mid-term reviews should take place to ensure that the projects were targeting the needs of the poor. It was pointed out that 'demand-led' did not necessarily mean that the needs of the poor were being met, as they might not be aware of, or able to articulate, their researchable constraints.

The issue of whether the poor feel ownership of the project activities is also an important aspect to consider. Dialogue is needed between researchers and beneficiaries and the researchers need to be clear about who is speaking on behalf of the poor, i.e. are they working with the most appropriate target institutions?

A representative from project R7010 said that farmers talk about 'our project' at field days, and local committees have been set up that include farmers.

The example of the stover project (R6993) was given, where the farmers had taken the initiative of building stover stores for themselves.

A representative from project R7351 said that when he carried out PRAs on the goat project he handed out exercise books to the farmers, to record herd data. All the farmers completed the exercise in the first year.

Which institutions transmit livestock knowledge to the poor?

Two such institutions are Agritex and the University of Zimbabwe. Farmers' Organisations, e.g. ZFU, have livestock components but their coverage is a major limiting factor. Some research institutions directly transmit knowledge to farmers.

However, the messages should be going far wider, and many more community groups, e.g. churches and women's groups, should be involved.

Policy makers need to be given the research findings. Policy should be discussed with the stakeholders. It was felt that some of the projects have not done enough packaging of results for the government.

Break-out Groups

Participants were then divided into four break-out groups, concerned with dissemination to:

- Crop-livestock farmers
- Smallholder dairy farmers
- Smallstock owners, and
- Policy-makers.

They were asked to describe current and potential target institutions and dissemination processes and issues arising.

Crop-livestock Farmers

Current agents for dissemination include

- Agritex
- NGOs
- Church Groups
- Women/Youth Groups
- ZFU
- Tertiary Institutions
- Schools.

Individual projects currently produce

- Materials to train trainers (e.g. extension workers)
- Materials to train farmers
- Projects need to be given adequate time to complete production of these materials.

A national workshop should be organised by LPP for extension agents on dissemination and the packaging of options (not just LPP outputs). Neighbouring countries should be invited, via contact NGOs

Dissemination products/media needed include

- Videos
- Pamphlets
- Worldwide web
- Practical demonstrations
- Radio
- Theatre
- Newspapers.

Further issues that arose in general discussion were:

- The need to engage someone to review literature to devise packages for dissemination
- Farmer-to-farmer linkages and practical demonstrations generate most confidence amongst farmers.

Smallholder Dairy Farmers

Method of dissemination needed

- Demonstration units
- Exchange visits
- Field days
- Leaflets
- Manuals
- Video-clips
- Radio and TV programmes
- Individual consultant visits
- Drama groups.

Partners for LPP

- Agritex
- DDP
- Dairy Services

- ZFU
- Smallholder Dairy Farmers' Association
- NADF
- Churches
- Schools
- NANGO
- Agricultural Institutions
- Traditional Leadership and Political Leadership
- Partners will need proper training.

Questions were asked of whether there was any chance of cost-recovery for delivery of services/inputs: it was stated that farmers are prepared to pay and are already paying for some services.

It was also asked whether current partners have the potential to produce TV and radio programmes. One reply was that there was potential, but equipment was required. Not all scientists have the ability to write leaflets, design manuals or write plays etc., but they should be able to get assistance from Agritex.

Smallstock Owners

Current methods of dissemination include

- Field days
- Agricultural shows
- Newspapers and radio
- Farmer attachment
- Networks (such as SRNET)
- Existing organisations.

New options include

- Providing additional resources
- Reviving the mobile information unit
- A central database
- Agritex being housed at research stations
- Strengthening linkages at directorate level
- Television programmes
- Production of leaflets.

In discussion the importance of researchers training farmers (especially women) to train other farmers was emphasised, especially as farmers trust each other. It was also noted that it is difficult for one person (researcher or extension agent) to disseminate outputs relating to crops, livestock, marketing, processing etc.

Policy Makers

- "Policy" can be made at a number of levels:

Global	P ⇑		Donors
	O ⇑		
	L ⇑		
	I ⇑		
	C ⇑		
	Y ⇑		
National			Ministers
Provincial			Resident Minister
Local			Council
Village			Chiefs/Headmen
Household			(Technology)

- Technology is typically adopted at household level (but may be adopted at higher levels eg village diptanks). Any technology may have policy implications at a higher level (hence upward arrow in the diagram). These levels define the form of policy dissemination.
- Policy needs to be packaged - LPP and project holders are not currently well-equipped: a packager is needed.
- Approach: we need to consider whether we are "broadcasting" information or "bombarding" selected policy-makers, and the best dissemination pathways to put over policy advice.

General Discussion Points

Browse, Pods *and* Lopping: Questions Referring to Projects R6984, R7351 *and* R7432

How long does it take to pick the leaves?

In the past, a lot of money was spent on casual labour to remove the leaves for feeding to experimental animals. In practice it is very easy to harvest leaves from browse, the branch is cut and dried, then the next day shaken so that the leaves fall off. A cement floor aids the collection.

What are the long term effects of repeated lopping?

If browse is used as a supplement, not so many trees will be needed, therefore, it would be necessary to maximise production of the browse. It was suggested that trees should be grown on the homesteads particularly for feeding purposes; however there might be some resistance. The protection of the trees needs to be considered.

In the early 1990s work was carried out at Matopos on the regeneration of bare patches. The best method was covering the bare ground with brush. However, this technique was not taken up by farmers because they said they did not have enough brush available.

How would farmers handle the lopped leaves?

From a management point of view; to make leaves more accessible, both for lopping and browsing, some of the trees could be removed.

The biomass of the leaves should be considered in addition to their size. If the available biomass is not very high, maybe it is not worth the effort to lop them.

In parts of India branches are lopped and then immediately suspended for the goats to feed on.

Leaf removal has not hampered tree growth at Matopos.

The farmers were asked how feasible it is to plant trees on the 'corridors' between farms. The farmers said they would need to know how many trees were needed to feed the animals.

It was suggested that the answer depends on the land area covered, work so far shows that l00kg dry matter is available.

Will collection of pods affect regeneration of trees?

The amount of pods collected versus pods produced is very small. A lot of pods are eaten on the ground and will go through the animal and, therefore, possibly set seed elsewhere

The issue of rights to trees: for example, who is able to lop from them, was raised.

It was explained that an informal survey had been carried out. It was agreed that a code of conduct exists, people are not allowed to cut down tress but can lop from them. This appears to be more of an issue at village level, and may not apply throughout the communal area.

As this code of conduct is organised at village level, it would be appropriate for some areas to be fenced off. Villages would need to calculate carrying capacities: and then decide who in the village would make the decision to say no more trees can be cut down.

It was pointed out that the discussion had assumed that most of the grazing lands are kept as communal property, but it is known that in a lot of communal areas communal property leads to open access, which in itself can be a problem. Ultimately, if, for instance, pods are found to be that useful, who will enforce the village boundaries?

General Discussion Points

Length of Projects

DFID's research projects usually last for 3 years; DFID expects Project Leaders to demonstrate the impact of their technology by the end of the project. However, 3 years is seen as too short a time by many people in which to demonstrate the real impact of the technology (real impact is beyond adoption and is when the technology is being used in a sustainable way by the farmers).

The Programme Manager advised the meeting that although 3 years may seem too short a time scale, DFID does want research to demonstrate some immediate impact. Natural resources work is in competition with other development disciplines, for instance health and population, and projects in these fields are able to demonstrate impact in a shorter time. DFID have a contract with the UK Treasury and have to continually report on what is being done with treasury funding, which is why DFID are keen that all areas show some impact.

Monitoring

What happens if a project did not show significant results. Is there a mechanism in place whereby projects are monitored to predict their impact? May be projects should aim to produce lots and lots of technologies and then progress on the ones that the farmers show an interest in.

The LPP does have monitoring mechanisms in place e.g. quarterly and annual reports and will be expanding on these in the coming years.

Joined Up Working

The research findings presented so far should not be viewed in isolation but as part of the larger picture. It should be recognised that some of the technologies will take longer to develop than others and that there should be a strategy behind the commissioning of projects. It was felt that the bureaucracy involved in getting a project commissioned put some people off applying and reduced people's creativity.

The discussion seemed to be focussing on single interventions e.g. DAP, silage etc; the programme needs to think about how to design a decision support system to include all these technologies in a single toolbox. The LPP is not a law unto itself but is part of DFID; 20% of the LPP budget is allocated to strategic research for new ideas. However, there is pressure from DFID to reduce this amount and the LPP needs to satisfy the client.

Mr O'Neill provided the group with an anecdote from R7352's stakeholder workshop that took place the previous week. The farmers at the workshop had taken him to task for not having more farmers involved in the on-farm trials. The farmers thought that the research was good but it was not fair that not more farmers had the opportunity to take part. This example highlights the difficulty in defining the difference between research and development.

Appendix

THE AGRICULTURAL RESEARCH COUNCIL OF ZIMBABWE and THE UK DEPARTMENT FOR INTERNATIONAL DEVELOPMENT

WORKSHOP ON LIVESTOCK PRODUCTION RESEARCH

Ingwe Lodge/Matopos Research Station/ICRISAT
Bulawayo, Zimbabwe

Tuesday 26 September – Thursday 28 September 2000

PROGRAMME

DAY 1, TUESDAY 26TH (Ingwe Lodge)

OPENING SESSION *Chairperson:* ***Dr P. Nyathi***

08.30-12.45	Opening of workshop:	Dr David Mangemba (welcome) Dr Wyn Richards (Purpose) Dr Tim Smith (Admin)
10.00-10.30	Coffee	

WORKING SESSION 1

(Project Reports: Each presentation to be a maximum of 30 minutes, including discussion time.)

CROP-LIVESTOCK FARMERS *Chairperson:* ***Dr H. Hamidikuwanda***
Rapporteurs: ***Z Magadzira***
L Nyoni

10.30-12.30	1)	Optimising draught power (R7352)
	2)	Community management plans for lstock (R7432)
	3)	Risks from insecticides (R7539)
		Discussion/future action
12.30-13.45	Lunch	

WORKING SESSION 2

SMALLHOLDER DAIRY FARMERS: *Chairperson:* ***Mr D Dube***
Rapporteurs: ***S Ncube***
V Mlambo

13.45-15.15	4)	Storage of stovers (R6993)
	5)	Silage from adopted forages (R7010)
	6)	Reproduction of crossbred cattle (R6995)
15.15-15.45	Tea	
15.45-16.30	Discussion/future action	
17.00-18.00	Project Management Meeting	
19.00	Workshop Briai	

DAY 2, WEDNESDAY, 27TH: (Ingwe Lodge)

WORKING SESSION 3

SMALLSTOCK KEEPERS *Chairperson:* ***Dr C. Mutisi***
Rapporteurs: ***B Mombeshore***
O Mhere

08.30-10.00	7)	Oilseed cake/poultry (R7524)
	8)	Acacia pods for goats (R7351)
	9)	Link project (R7798)
		Discussion/future action
10.30-11.00	Coffee/Tea	

WORKING SESSION 4

RANGELAND FARMERS *Chairperson:* ***Dr B Manyuchi***

Rapporteurs: ***J Sikosana***
P Magwali

11.00-12.30 10) Environmental variability/grazing systems (R6984)
11) Livestock/wildlife (R6625)
Discussion/future action

12.30-13.45 Lunch

WORKING SESSION 5

REGIONAL INTERESTS IN LIVESTOCK PRODUCTION

Chairperson: ***Dr T Smith***

13.45-14.45 1) Mozambique
2) South Africa
3) Zambia
Discussion/future action

14.45-15.45 Dissemination/Promotion coordination initiative
(J Morton)
Discussion/future action

15.45-16.15 Tea

WORKING SESSION 6

WORKING GROUPS (*action for dissemination/promotion of research products*)

Chairperson: ***Dr J Morton***

16.15-17.15 1) Crop-livestock farmers
2) Smallholder dairy farmers
3) Smallstock farmers
4) Rangeland livestock farmers

17.15-18.00 Plenary session:
1) Crop-livestock farmers
2) Smallholder dairy farmers
3) Smallstock farmers
4) Rangeland farmers

DAY 3, THURSDAY, 28th: (ICRISAT CONFERENCE ROOM)

WORKING SESSION 7
(Short presentations (10 minutes + 10 minutes questions)

STAKEHOLDER MEETING *Chairperson:* ***Mr F. Chinembiri***
Rapporteurs:

08.30-09.00 Introduction/welcome (Dr Wyn Richards)

09.00-13.30)
1) Crop-livestock farmers
2) Smallholder dairy farmers
3) Smallstock farmers
4) Rangeland livestock keepers

10.30-11.00 Tea/coffee: Time to view displayed material

13.30-14.30 Lunch

WORKING SESSION 8

PROJECT VISITS (MATOPOS RESEARCH STATION)

Chairperson: ***Dr S. Moyo***

14.30-17.00 Project visits

17.00-18.00 Station club open

Resource Poor Livestock Keeper Groups

Smallholder Milk Producers

This focus group includes owners/keepers of 1-2 milking cows or buffaloes (plus followers) or 6-8 milking goats across all production systems (semi-arid, forest/agriculture, high potential and peri-urban). This is often the system that resource-poor farmers aspire to (because of the obvious advantage of daily cash incomes from the sale of milk); however, because of its focused nature, it is a high-risk system that is dependent on inputs and capital.

The LPP plans to maintain a limited research interest in this livestock keeper group (10%), particularly on strategic issues which affect vulnerability, environmental issues and dissemination issues. It will cultivate closer strategic links with ILRI's smallholder dairy programme and identify a niche role to play in this high profile activity.

Crop/Livestock (Mixed) Farmers

This is the largest grouping of livestock keepers in the developing world. In areas with communal grazing, farmers may get their main income from livestock while in other areas, where soils allow, crop production will be the main source of income. Economics and markets also affect the decisions to focus on crop or animal products. The type of livestock varies widely while the production system can be extensive or intensive. The important point is the synergy between crop production and livestock. The crops benefit from the manure and the draught power while the livestock use feed resources such as cereal stovers which would otherwise go unutilised. This synergy suggests that mixed farming is the most efficient way to use available resources. Cattle and buffalo are the most important species as they can provide draught power and manure. Non-ruminants like pigs and poultry are useful in that they can scavenge around the homestead. In view of the size and importance of crop/livestock farming in the developing world, LPP intends devoting some funding (10% of budget) in support of this RPLK group.

Smallstock Keepers

This is somewhat of an artificial group as they are normally (but not exclusively) a sub-set of crop/livestock farmers. Small ruminants, pigs, poultry and other animals such as rabbits, guinea pigs, bees etc are normally the preserve of women. They are found under both intensive and extensive conditions. They are used for a myriad of purposes: Religious, ethnic, social, and are readily slaughtered for local consumption or sold to meet a cash need. Smallstock represent the basic tools to enable resource poor stakeholders (particularly women) to quickly source funds for food, school fees, etc. Smallstock keepers are normally among the poorest of rural people and are normally risk averse. In view of the relevance of these small animals to escape from poverty scenarios, the LPP will focus considerable attention on this group of RPLKS (20%).

Landless Livestock Keepers/Owners

Landless owners/keepers of livestock are to be found almost everywhere in the developing world. On the outskirts of cities and in the cities themselves, cattle, sheep, goats, poultry and pigs scavenge household waste and residues from feed processing plants. The ruminant species also rely on forage cut and carried from roadsides and common land/forests. The meat, milk, eggs so produced are a considerable source of income for livestock owners as they can readily be sold for cash. Landless owners/keepers also occur in rural areas; these tend to keep larger cattle and buffalo and let them out for draught power purposes. Women are also normally included under the landless subtitle. Whereas most work on the land, they are effectively landless under most developing country cultures as land ownership and inheritance is normally vested in men. In Africa, the AIDS crisis has changed this situation somewhat and women are now, 'by default', becoming landowners. Landless livestock keepers are among the poorest of the poor and are normally risk averse. LPP intends to focus the largest proportion of its budget on this RPLK group (40%).

Pastoralists And Transhumant Livestock Keepers

Traditional pastoralists, nomads and transhumant groups are predominantly found in the arid and semi-arid zones. Their livestock include cattle, camels, sheep, goats and donkeys. Although these animals are normally maintained for subsistence purposes (meat, milk and milk products, blood, urine etc for food, and hair and hides sometimes for sale), products are often exchanged/bartered for other products such as grain and other necessities. The living standards of people tend to be at or just above subsistence levels and a major goal of the community is food security and survival of a way of life. Previous research on this RPLK group has been sporadic and has a poor track record. However, with its new inclusive approach, LPP intends to spend considerable effort (20% of budget) in commissioning appropriate research on this group.

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Summary of Evaluation Forms

Thank you to everyone who completed an evaluation form. The comments below summaries the points raised. Comments in italics are responses to the points made

Summary Of Evaluation Forms

Venue

- Choose a larger, less isolated one

Per Diems

- People would like to receive per diems for attending the meeting

Prior To The Meeting

- Participants should receive abstracts from projects upon confirmation of attendance

At the next workshop abstracts of presentations will be available

Participants

- Invite commercial farmers, more stakeholders, people from other research stations. Farmers could be transported at project expenses to encourage them to attend.

The fuel shortage meant that fewer people than anticiapted were able to attend the meeting in September 2000. There is also the danger that too large a workshop inhibits inclusive discussions.

Presentations

- Representatives of the project team, and not just project leaders, should give presentations.

Several projects already had presentations given by more than one member of the project team, other project leaders should note this point.

- Projects should submit a poster relevant to the stakeholders
- Only projects with tangible outputs should present and other 'pipeline' projects should just be listed or briefly mentioned. If NGOs want to know more about these they can ask and be directed to the relevant project personnel.
- Time-weighting of presentations according to size and stage of project
- Presentations should give more practical and less academic solutions
- More time should be provided for the reporting of technical findings
- Projects should report their dissemination message and the means by which they will disseminate it
- More time should be given for the dissemination of results
- Presentations need to be more focused towards stakeholders
- Talks should be output-focused, not experimental
- There should be more time available for structured discussions
- Farmers who have participated in the research should be invited to talk about their experiences in the research process
- Project presentations should conclude with dissemination messages in bullet points
- Too much repetition.

Projects / Topics

- Review of impact of recently finished projects
- Tactics/strategies for stronger linking with bilateral programme
- Continue with reports from adjacent countries
- Organise more link projects, e.g. forage/dairy links in Kenya, Tanzania and Zimbabwe
- Northern Province, South Africa, will be keen to participate at the next meeting.

Other

- Day 3 presentations needs to be more general and appropriate to NGOs and farmers
- A list of participants could be handed out during the course of the workshop for networking purposes rather than waiting for the proceedings which could take months to come out.
- Per diem to be paid to participants
- Projects should produce a one page fact sheet or dissemination type article for the NGOs to be able to take from the Workshop
- It would be helpful if participants could receive abstracts of projects in advance, upon confirmation of attendance.
- Expose participants to developments 'in situ'
- Hold the meeting in the wet season so that people can comment on agronomy projects e.g. R7352
- Discussion on dissemination was good
- Can workshop photos be sent to station staff
- Hold a field visit
- Need to work more with CBOs and NGOs.

The timing of workshops is difficult. The wet season is not possible for some projects. Comments regarding field visits, farmer participation etc, are noted. The fuel situation curbed activities at this workshop.

Sustaining livestock in challenging dry season environments: strategies for smallscale livestock farmers is a summary and synthesis of a meeting held at Ingwe Lodge, Matobo, and ICRISAT, Matobo, Zimbabwe in September 2000.

DFID's Livestock Production Programme is currently funding a cluster of research projects based in Zimbabwe, looking predominantly at dry season feeding strategies. The research outputs are applicable to crop livestock farmers, rangeland farmers and smallstock (goat and poultry) farmers. The research outputs are applicable to regions outside Zimbabwe (for example, India and South Africa).

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NR INTERNATIONAL

LPP LIVESTOCK PRODUCTION PROGRAMME