THE COMPLEMENTARITY OF FEED RESOURCES FOR ANIMAL PRODUCTION IN AFRICA

PROCEEDINGS OF THE JOINT FEED RESOURCES NETWORKS WORKSHOP HELD IN GABORONE, BOTSWANA
4–8 MARCH 1991

Edited by

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APRIL 1992

African Feeds Research Network
PO Box 5689, Addis Ababa, Ethiopia

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ABSTRACT

These are the Proceedings of the last joint workshop of the Pasture Network for Eastern and Southern Africa (PANESA) and the African Research Network for Agricultural Byproducts (ARNAB), held in Gaborone, Botswana, 4–8 March 1991. This volume contains the three addresses delivered at the opening session together with 38 full texts and 12 abstracts of papers presented at the workshop. The scientific papers are grouped in three sections, corresponding to the main themes of the workshop. Thus 13 papers and five abstracts address various aspects of the use of forage legumes in animal nutrition and the nutritive value of planted and natural pastures; 18 papers and five abstracts deal with animal production systems based on crop residues and forage legumes; and nine papers and two abstracts are concerned with institutional and policy issues that affect integration of feed resource use on-farm.

At the end of the workshop the Steering Committees of PANESA and ARNAB, together with representatives of the sister network, the West and Central Africa Forage Network (WECAFNET), and agricultural scientists from all over Africa, agreed that the three networks should merge to form a unified network, called the African Feeds Research Network.

KEYWORDS

/Meeting report//feed resources//forages//feed legumes//crop residues//nutritive value//feed production//farming systems//animal performance//ruminants/ /browse plants/ – /feed treatment//supplementary feeding//feed concentrates/ /economic aspects//policies/

MOTS CLES

/Rapport de réunion//ressources alimentaires//fourrages//plantes fourragères/ /résidus de récolte//valeur nutritive//production alimentaire//systèmes agraires/ /performances zootechniques//ruminants/ligneux fourragers//traitement des aliments du bétail//complémentation alimentaire//concentrés//aspects économiques//politiques

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PREFACE

It is becoming increasingly evident that the future demand for food in sub-Saharan Africa will far exceed production levels. Already the sub-Saharan African market for animal products—meat and milk—is largely unsatisfied, and all forecasts indicate that the present trends towards increases in these markets will accelerate as human populations grow and urbanisation spreads.

Clearly, livestock production in sub-Saharan Africa needs to be increased substantially. But animals need to be fed too, and in many parts of the region, for many months of the year, there is simply not enough feed available. Thus animals are malnourished, often dramatically so. Hungry animals are unproductive animals. The problem, therefore, is how to ensure that livestock are adequately fed all year round.

The problem is not peculiar to sub-Saharan Africa. Seasonal feed shortages also exist in many other parts of the world: for instance, in the higher latitudes feed is scarce during the long, harsh winters. But considerable progress in improving animal nutrition has been made in such countries over the past 20 years. Some examples are the introduction of well-preserved winter silage in Finland; fodder feed in Denmark; supplemented high-dry-matter silage in The Netherlands; and preserved clover pastures in New Zealand.

Comparable progress is now urgently needed in sub-Saharan Africa. This will require excellent national agricultural programmes with well-trained and dedicated scientists and well-developed research facilities. But success is more likely to be achieved if the national programmes and scientists cooperate with each other in working towards common goals—especially in the present climate of limited resources. Such cooperation is the principal aim of a multidisciplinary collaborative research network. Three such networks have already been operating in the area of animal feed resources in Africa: the African Research Network for Agricultural Byproducts (ARNAB); the Pasture Network for Eastern and Southern Africa (PANESA); and the West and Central Africa Forage Network (WECAFNET). However, these three networks had several aims and activities in common, and it was felt by many network participants that it would be more efficient to amalgamate them into one pan-African network. This has now been done, and one of the functions of this workshop was to inaugurate the African Feeds Research Network.

The other function of the meeting was to provide scientists with an opportunity to present and discuss their individual research results and activities. As many of the papers in this Proceedings show, there is now a very considerable range of options available to the feed resources scientist; a wide range of forage germplasm, multipurpose trees, fertiliser, irrigation, agricultural and industrial byproducts, feed processing and conservation techniques, etc. But there is still much work to be done to alleviate what is the greatest constraint on animal production in sub-Saharan Africa—nutritional insufficiency.

This workshop was a most important occasion. It represented the start of a new phase in animal production in sub-Saharan Africa and its effects will, I believe, be felt for many years to come.

Finally I wish to thank the organising committee for planning the programme, the Government of Botswana for facilitating the meeting and Dr Martin Kyomo of SACCAR [Southern African Centre for Cooperation in Agricultural Research], whose work, over a long period of time, has greatly facilitated ILCA's development in southern Africa. I wish also to recognise the commitment of the International Development Research Centre of Canada to work on feed resources for the past number of years.

John Walsh
Director General
ILCA

ACKNOWLEDGEMENTS

Many people, ILCA staff and others, have made valuable contributions to the production of these Proceedings. In particular, we wish to thank Yayneabeba Tadessa, Mekdes Amaha, Genet Delelegn and Serk-Addis Asfaw for typing manuscripts; Jyl Stares for proofreading typed manuscripts; Sourou Adoutan for French translation of Abstracts; Tekleab H/Michael for design; Fithamlak Ademe for drawing the figures; and Mahmoud Saleh and the staff of the ILCA print shop for printing.

The editors

OPENING ADDRESSES

OPENING ADDRESS

The Honourable G M Oteng
Assistant Minister of Agriculture, Botswana

Mr Chairman, Director General of ILCA, distinguished guests, workshop participants, ladies and gentlemen.

It is a great honour and pleasure for me to have this opportunity to address the opening session of this workshop. I extend a warm welcome to those of you who have come to Botswana to participate in this important meeting and I hope that your stay here will be enjoyable and productive.

We in Botswana are highly honoured to have been requested to host this historic workshop. I say historic in the sense that this is the first workshop held by the African Feeds Research Network. This network is a result of the collaboration of three institutions; the Pasture Network for Eastern and Southern Africa (PANESA), the African Research Network for Agricultural Byproducts (ARNAB) and the West and Central Africa Forage Network (WECAFNET). It is our hope that your presence here in Botswana, and your deliberations throughout this week, will be of benefit to our livestock industry which, to a large extent, is still dependent on natural rangeland.

In sub-Saharan Africa, livestock production is an important component of the agricultural sector, as evidenced by the large herds and flocks in this region. Most of the people in our countries continue to depend largely on agriculture for their livelihood. It is unfortunate that, in most of Africa, the livestock subsector has remained traditional and largely undeveloped. Management is poor, reproduction and growth rates are low, there is a high incidence of disease, and we have very low offtake rates.

The productivity of the livestock sector in our part of the continent has remained almost static for the past two decades. In fact, some countries have reported negative trends. Apart from those factors I have already mentioned, this has mainly been caused by adverse climatic conditions, such as poor rainfall and droughts, and by increasing populations that have aggravated the over-exploitation of natural resources, especially land. The uncontrolled population increase has resulted in serious competition for land, and so less land is available for agricultural purposes. This has increased the problems of overstocking and hence of overgrazing of rangelands in most of our countries.

As a result, most of sub-Saharan Africa has, up to now, not been able to produce sufficient food to feed its people. In the livestock sector we are still net importers of milk and meat. With the current lack of foreign exchange, most of our countries cannot afford to import these important commodities, and so our people are faced with unbalanced diets and, in some cases, not enough food. We all know, of course, that inadequate diets and poor nutrition, especially of children, will eventually lead to problems in the development of our manpower resources.

We need not be reminded that it is our responsibility as nations to feed ourselves. We cannot blame others for our plight, and neither can we depend forever on the goodwill of the international community to donate food to feed our people. Instead, we must strive harder to seek solutions that will reverse the current trend and indeed improve food security in our respective countries and the whole region. We should therefore commend those national and regional organisations which are making efforts to improve livestock production and arable agriculture in our region.

The International Livestock Centre for Africa (ILCA) has for a long time been involved in research programmes that seek to improve livestock productivity. In order to address the requirements of the various types of livestock, ILCA coordinates several disciplinary networks focusing on, for example, cattle and small ruminant milk and meat, feed resources and animal traction. These networks help to streamline research programmes in order to avoid unnecessary duplication.

Nutrition is one of the major factors that influence an animal's productivity, and so we are pleased to note that all the disciplines under ILCA which deal separately with forages, pastures, crop residues and byproducts have decided to form one network, the African Feeds Research Network. This network will endeavour to provide all the information available on livestock feed. We therefore commend PANESA, ARNAB and WECAFNET for their collaborative efforts that finally led to the establishment of this unified network.

As I said earlier, the livestock industry in Botswana still largely depends on natural rangeland. I believe that this is also true for many other countries of sub-Saharan Africa. Most of our farmers have failed to appreciate the need to improve pastures and to incorporate pastures and forages, crop residues and byproducts in their livestock production systems. We need a great deal of information on types of feed resources which are available, on their suitability for various ecological zones, on their nutritive value and on how to preserve, store and utilise them properly. This information will assist us to promote the production and use of fodder among our livestock owners.

We hope, therefore, that these institutions and networks of ours, and you the scientists, will work hard to ensure that we have access to all the information we need. We also hope that there will be increased effort to strengthen national research institutions in order to develop their capacity to carry out this important task. In addition, we should pay particular attention to the training and development of our scientists and researchers, in order to improve their knowledge and skills.

One way of achieving this is through the promotion of interaction among you scientists, which will ensure the exchange of ideas and information.

Finally, I wish to take this opportunity to commend ILCA and the various networks for their efforts in organising this workshop and for deciding to hold it in Botswana. I hope that your deliberations here will be successful, and will add to all our efforts to continue to seek solutions to Africa's food problems.

Ladies and gentlemen, it is now my great pleasure to declare this workshop open, with Botswana's national slogan.

PULA PULA PULA

ADDRESS

Berhane Kiflewahid
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Mr Chairman, Honourable Minister, ladies and gentlemen.

I am grateful for this opportunity to present a brief overview of the role of the International Development Research Centre in livestock development in sub-Saharan Africa

The mission of the International Development Research Centre (IDRC) is to contribute to development through research and research-supporting activities. The Centre aims to assist in promoting the indigenously determined social and economic advancement of the developing regions of the world, with particular focus on the poorest people of those regions.

Within this mission, IDRC has two principal objectives: first, to support research which is directly relevant to Third World development and which has demonstrable links to the basic needs of the poor; and second, to assist developing countries to build and strengthen indigenous research and research-supporting capacity, at the national, but also at the regional, level, and mainly in terms of human resources. A strong national research capability is essential if the problems confronting development are to be adequately addressed.

IDRC addresses these objectives by focusing its activities in six main areas: agriculture, food and nutrition sciences; communications; earth and engineering sciences; health sciences; information sciences; and social sciences. IDRC also funds training in all these areas.

Agriculture, food and nutrition

The mission of IDRC's Agriculture, Food and Nutrition Sciences (AFNS) Division is to ensure access for the individual to food and other basic necessities through the sustainable use of renewable resources. The Division strives to achieve stable and sustainable increases in productivity while maintaining environmental integrity, and to increase income and employment opportunities.

The Division's budget is allocated to support research by scientists working in their own countries and national institutions. Support is also given to research by international and regional organisations if they are closely linked to research activities at the national level through networks such as the African Research Network for Agricultural Byproducts (ARNAB) and the Pasture Network for Eastern and Southern Africa (PANESA), both coordinated by the International Livestock Centre for Africa (ILCA).

The Division also gives high priority to disseminating research results and training research staff in developing countries. On average, 2–5% of project funds are allocated to dissemination of research results through publications and workshops. Most AFNS projects contain a specific training component which, on average, accounts for 10% of the project budget. Several young African scientists have been trained at postgraduate level through this support. For example, three animal scientists from Botswana's Animal Production Research Unit (APRU) have undertaken postgraduate training at Guelph, Canada. IRDC hopes that this small contribution is strengthening APRU's research capacity.

The AFNS Division's support to research is organised under six programmes and two units:

- Animal Production Systems Programme
- Crop Production Systems Programme
- Fisheries Programme
- Forestry Programme
- Post-Production Systems Programme
- Agricultural Economics Programme
- Environment and Sustainable Resources Management Unit
- Nutrition Unit

Of these, the Animal Production Systems (APS) Programme is of most relevance to this workshop. APS Programme activities focus on research into large and small ruminants, non-ruminants and animal feed resources, with emphasis on pasture and forage improvement and byproduct utilisation. Priority is given to research on cattle because of their large numbers in developing countries and their importance as sources of milk, meat and draught power, but the Programme is expanding its support to the small-ruminant sector as sheep and goats are also very important in African pastoral systems and thrive in areas that are not suitable for cattle, such as the very arid regions and tsetse-infested areas. APS Programme support is also provided to research on rabbits, pigs and poultry, which are vital to other farmers in many smallholder systems.

Globally, the strategy and priorities for research support are based on the farming system practised in the ecological zones identified, as well as on the potential for impact and use of research results by the beneficiaries. For example, major APS Programme research support in East and Southern Africa is targeted on the following zones:

- highly populated, high potential, high rainfall highland areas
- subhumid zones in coastal and hinterland areas
- semi-arid areas where livestock are the major source of food and cash income.

In sub-Saharan Africa the major constraint on livestock production is feeding. Animals subsist mainly on natural pastures which provide abundant grazing during the rainy season, but quickly mature and dry up with the onset of the dry season. It is estimated that in smallholder production systems in sub-Saharan Africa, up to 60% of available feed resources come from crop residues. However, their nutritive value is not adequate to sustain reasonable animal production. A great deal of research on animal feed resources is therefore needed if livestock production in the region is to be improved.

Supporting collaboration through networks

For the past six years IDRC has been collaborating with ILCA in the organisation and activities of PANESA and ARNAB. The networks have been successful in bringing together national and international efforts for research on the production and utilisation of feed resources on small-scale farms. We hope that the impact of these networks has not ended at the scientist level, but has also reached the farmers.

In March 1990, the steering committees of PANESA and ARNAB, and of the West and Central Africa Forage Network (WECAFNET), recommended a merger of the three networks into one African Feeds Research Network. The rationale for the merger was the recognition of the complementarity of their objectives and of the need for collaborative research by national scientists to ensure the effective use of available feed resources. Thus the general objective of the unified feed resources network is to support and strengthen the capabilities of national agricultural research scientists and institutions to conduct research with forages, crop residues and agro-industrial byproducts as the basis for the development of sustainable animal production systems. Specifically, the network aims to:

- promote collaborative research among participating institutions
- promote exchange of information among animal scientists
- train African scientists in applied research techniques

Links will be maintained with at least 10 other "centre" supported projects in the region and other networks in Latin America.

IDRC will contribute CAD$ 817 280 to the unified network's collaborative research programmes over the next three years (1991–93). This is a reflection of IDRC's commitment to African scientists.

Mr Chairman, Honourable Minister, ladies and gentlemen, thank you for giving me your attention.

KEYNOTE ADDRESS

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Mr Chairman, Director General of ILCA, IDRC Representative, network members, ladies and gentleman.

On behalf of animal scientists in the Southern African Development Coordination Conference (SADCC) region, I wish to extend our warmest welcome to you distinguished animal nutritionists. Gaborone is the headquarters of SADCC and the home of the region's Agricultural Research and Training Coordination Centre. We congratulate the organisers of this workshop, especially the International Livestock Centre for Africa (ILCA), for holding it in a country which has the highest per capita number of cattle in Africa. In Botswana, cattle, goats and sheep are marketed in such an organised manner that both small- and large-scale farmers can benefit from good returns from selling their animals.

The theme of this workshop, *The complementarity of feed resources for animal production in Africa*, is very appropriate now. Livestock mean food; and Africa's people desperately need more food. Africa has a higher proportion of undernourished people than any other region in the world, and also the greatest rate of population growth; so the numbers of hungry people are increasing all the time. The Food and Agriculture Organization (FAO) of the United Nations estimates that in 1969–71, 32.6% of Africa's population—86 million people—were malnourished; by 1983–85 the proportion had risen slightly, to a little over 35%, but by then the number of hungry people had increased dramatically, to 142 million! It is true that food production has increased in many developing countries over the past three decades, but hunger and malnutrition continue to affect the lives of up to one billion people in the Third World.

The hunger problem cannot be solved merely by better physical distribution of food from areas with a surplus to those with a deficit. The real problem is the lack of purchasing power among the poor segments of the communities. A successful development strategy, therefore, must promote employment and increases in the purchasing power of the poor through an emphasis on the production of labour-intensive wage goods, particularly food. Since 1986, SADCC has adopted an agriculture-oriented strategy which stresses growth in rural labour-intensive sectors as the primary engine of overall economic growth. The sheer size of the agricultural sector in the region, which employs 40–80% of the total labour force, shows that technical change in this sector will have important macro-economic implications. Increased agricultural production not only increases domestic food supplies but also stimulates further rounds of employment growth in the service and urban sectors of the economy. Because of its output and employment linkage effects with the rest of the economy, agricultural growth helps to improve access to food supplies for both the urban and rural poor.

It is generally accepted that increased agricultural production is brought about by improved agricultural technology. Increased agricultural productivity provides a combination of benefits: increased profits for farmers; increased demand for labour; and lower consumer prices. Growth of this kind produces a net increase in national income that serves as an important engine for driving the rest of the economy. As incomes rise, and as families become more aware of the need for better nutrition, the relative character of food demand changes. Rising income causes food demand to shift to more preferred cereals and to highly income-elastic livestock products. In many African countries these demands have been met by increasing imports of livestock products; FAO trade figures show imports rising from US$ 43 million in 1960 to US$ 113 million in 1970 and then to US$ 680 million in 1980. However, because imports have been draining the scarce foreign exchange reserves of most countries, local production is now being encouraged.

The performance of the livestock sector in sub-Saharan Africa during the past two decades has been disappointing; indeed, livestock production has failed to meet consumption demands. Poor productivity is attributable to several factors, including inappropriate government policies, tsetse infestation in areas which would otherwise be ideal for livestock production, and pricing structures which favour urban consumers to the detriment of the rural producers, hence discouraging production.

In the past we used to conduct livestock research without paying too much attention to the needs of the livestock keepers. We neither addressed the issue of availability of markets for livestock products nor analysed all the other issues on the demand and supply sides of the equation. Consumers in all the countries of sub-Saharan Africa now understand the nutritive values of livestock products, especially to their children. And the farmers are ready to supply the needed items. However, feed availability seems to be the main bottleneck.

Traditionally, livestock producers, especially the small-scale ones who are the majority in most countries, were encouraged to provide all their animal feeds from their own farms. Fodder banks, crop residues, crop byproducts and animal wastes are examples of what can be produced on the farm. And alley farming and agroforestry are examples of recent technologies that can be used to produce animal feeds. But we now know that feeds produced on the farm cannot meet all the animals' requirements in terms of energy, protein, minerals and vitamins.

Some of the deficiencies must be met by feeding supplements which can only be produced outside the farm. Such supplements are often not available to small farmers. And even when they are available, they may be too expensive to make the enterprises profitable.

This workshop is concerned with increasing the productivity of livestock in sub-Saharan Africa through better feeding. I expect that we will all gain a lot of information on this vital subject. There are many questions to be asked, and answered. One might be how we can influence the producers of raw feed ingredients—cereals, fish meal, agro-industrial byproducts, etc—to produce these materials in large enough quantities to lower the cost of production and hence the price which the livestock keeper must pay. Another might concern the chemical compositions of all types of feeds, including those from rangelands; such knowledge will be of immense help in formulating guidelines on optimum feeding and supplementation regimes. And yet another might concern the availability of animal feeds to the African farmer.

At the 1989 Annual Meeting of the Consultative Group for International Agricultural Research, the Director General of ILCA stated that one of his Centre's thrusts would be focusing on the development of animal feed resources. He pointed out that between 1961 and 1984 about 51% of African byproduct feedstuffs were exported to developed countries. Although the figure might be slightly lower now, we need to study the factors which make our countries export feeds and at the same time import livestock products at a very high cost. Do we have among ourselves specialists on national and international markets and their trends? Do we have any influence on policy to stop such exports? In Botswana most of the livestock byproducts, such as bone and meat meal, are not exported; they are recycled back into the livestock production systems.

The African smallholder farmer is now ready to help meet the demand for more animal products by adopting new technologies for livestock production, from raising beef and dairy cattle to raising pigs, poultry and small ruminants. Feed requirements seem to be the greatest bottlenecks in his or her endeavours. Let us work with him or her on the utilisation of whatever feed resources are available, and let the knowledge of the nutritive values of individual and combined feeds be spread around so that livestock productivity may increase.

I wish this workshop every success.

PLANTED AND NATURAL PASTURES: COMPLEMENTARITY WITH LEGUMES

COMPLEMENTARITY OF FORAGES IN RUMINANT DIGESTION: THEORETICAL CONSIDERATIONS

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ABSTRACT

Ruminant livestock production in sub-Saharan Africa is based on forages as the major feed resource. Strategies on the utilisation of these feeds should aim at establishing an efficient rumen ecosystem in order to maximise fibre digestion and optimise microbial protein synthesis. An efficient rumen ecosystem requires fermentable nitrogen and energy sufficient to support the rumen microbial population. A pH of 6.5–6.8 is optimum and advantage could be taken of fibre buffering capacities to maintain the pH. Grasses have poor buffering capacities while legume forages have very good buffering capacities. Legumes appear well suited as forage supplements to grasses. Some examples of forage supplementation are reviewed.

RESUME

Complémentarité des fourrages dans la digestion chez les ruminants: considérations théoriques

En Afrique subsaharienne, l'élevage des ruminants est largement tributaire de la disponibilité des fourrages, lesquels constituent les principales ressources alimentaires du bétail. Les stratégies de mise en valeur de ces aliments doivent viser à établir dans le rumen des animaux un écosystème capable de faciliter la digestion de la cellulose ainsi que la synthèse des protéines microbiennes. Celui-ci doit contenir suffisamment d'azote disponible et d'énergie pour entretenir la flore microbienne du rumen. On peut se servir de la faculté stabilisatrice de la cellulose pour maintenir le pH, dont la valeur optimum se situe entre 6,5 et 6,8. Contrairement aux graminées, les légumineuses fourragères possèdent d'excellentes capacités stabilisatrices. Elles semblent particulièrement indiquées comme complément de rations de base de graminées. Quelques exemples de complémentation alimentaire de fourrage ont été analysés.

INTRODUCTION

Ruminant livestock production in most of sub-Saharan Africa is based on forages as the major feed resource. The term forage refers to herbaceous material including grasses, legumes, browseable trees and fibrous crop byproducts. In seasonally dry environments, the main limitations to animal production are the lack of green feed for at least half of the year coupled with the low nutritive quality of forages during most of the period of active pasture growth (Jones and Wilson, 1987). The low nutritive quality of the forage during the growth period is mainly due to environmental stresses such as high temperatures (Van Soest, 1988) and infertile soils (Roberts, 1987).

In recent years there have been several attempts to improve the nutritive quality of the forage resource base through propagation of species with high nutritive value (Dzowela, 1988). However, because of limited land, the quantities of such forages produced are not sufficient on their own to support the current livestock population. Judicious combinations of these feeds with the more abundant low quality forages are needed. This paper discusses the theoretical basis for such combinations.

ANIMAL UTILISATION OF FORAGES

The major determinant of livestock productivity is dry-matter intake which, in turn, is influenced by the palatability, chemical composition and physical attributes of the diet, assuming that the livestock are disease-free. The objective of designing diets must therefore be to optimise animal productivity; feed intake and animal response are not good indicators of quality. Thus, while laboratory analyses of the diets are useful, they are not essential to research progress.

Forage-based feeds yield nutrients to the animal mainly through the processes of fermentative digestion in the rumen. Strategies for the utilisation of these feeds should therefore aim to establish an efficient rumen ecosystem that will maximise the digestibility of fibre within the rumen and optimise microbial protein synthesis. Additional attention needs to be paid to supply of balanced nutrients post-ruminally, if high productivity is expected.

ESTABLISHMENT OF AN EFFICIENT RUMEN ECOSYSTEM

Microbial considerations

The fermentative digestion of fibre in the rumen is carried out by a mixture of bacteria (Mackie and White, 1990), protozoa (Demeyer, 1981) and fungi (Akin and Borneman, 1990). The role of protozoa has been the subject of great controversy which is outside the scope of this discussion (Mackie and White, 1990). Rumen microbes require a source of fermentable nitrogen, usually as ammonia although some species require preformed amino acids and peptides (Russell and Baldwin, 1978). The low nitrogen (N) content of most mature grasses points to a need to combine them with a forage with a high N content. The ideal N concentration in the rumen for efficient digestion has been variously estimated at 50–70 mg/litre (Satter and Slyter, 1974) and at 150–200 mg/litre (Krebs and Leng, 1984). These levels are not easy to maintain in stall-fed animals over a 24-hour period, particularly if the feed is mature grass and it is fed in insufficient quantities. Plant and protein degradation depends on the physical nature of proteins, their release from plant cells, the concentration of proteolytic enzymes and the time available for proteolysis. In tropical forages, more than 20% of plant proteins are present in structures such as the vascular bundle sheath which are resistant to microbial attack (Egan, 1985). The presence of tannins in legumes and browse species may also result in binding of proteins and thus inhibit microbial attack. This may not necessarily have a negative impact on the animal if the proteins can be released post-ruminally and thus be available to enzyme digestion (Mueller-Harvey et al, 1988).

Plant considerations

In the presence of adequate rumen N concentrations, microbes will ferment fibre to obtain energy for growth and synthesis of new cells. The byproducts of such fermentation include the volatile fatty acids (VFAs) acetate, proprionate and butyrate which are the main energy nutrients absorbed in the rumen. Degradation of specialised plant material by microbes varies from tissue to tissue, decreasing in the order: mesophyll and phloem > epidermis and parenchyma sheath > sclerenchyma and lignified vascular tissue (Akin, 1982). Tropical grasses have few mesophyll cells between vascular bundles (as a consequence of adaptation to a C–4 photosynthesis pathway) and have a high proportion of lignified vascular tissue. Both factors combine to lower the degradability of these grasses. As plant cells mature, their cell walls thicken and deposition of hemicellulose and lignin increases, further reducing degradability. Thus diets based on tropical grasses should be supplemented with forages high in readily degradable tissues.

In addition to adequate N and energy supplies, rumen microbes require a stable pH environment (6.5–6.8). Production of VFAs tends to lower the rumen pH and thus there is a need to buffer the rumen pH to the optimum level of 6.5–6.8. Forages encourage buffering through increased salivation (Van Soest, 1982) and by the buffering capacity and cation exchange of fibre (McBurney et al, 1986). Tropical grasses and straws have low ion-exchange and buffering capacities while tropical legumes and citrus have high ion-exchange and buffering capacities (Van Soest, 1988). Interestingly, in legumes this buffering capacity is due to the high lignin content of these species. Lignin has been found to have a high capacity for cation exchange (McBurney et al, 1986). This cation exchange is also important in mineral nutrition, a component of forage quality that is usually overlooked.

The chemical composition of the fibre is important in providing indications of fermentation rates. However, interactions between environment and plant physiology and growth are sufficient to render associations between fibre components and nutritive value unreliable (Van Soest, 1988). In general, a high content of neutral detergent fibre and lignin results in lower fibre degradation compared to a low content of both. Although legumes have more lignin than grasses they are degraded more, mainly because of their high N content and the fragility of their cell walls in addition to their good buffering capacities and higher content of readily degraded specialised tissues of mesophyll and phloem.

Tropical legumes and browse species also contain phenolics, other than lignin, which limit the digestibility of cell wall carbohydrates and proteins. Palatability of feeds is also usually affected (Reed et al, 1988). The most important non-lignin phenolic compounds seem to be tannins. Tannins help to inhibit attack on lignified tissues by fungi and bacteria (Barry and Blaney, 1987). Recent research indicates that condensed tannins are more important than hydrolysable tannins in affecting digestion of feeds (Reed, 1986). Use of browseable tree species as supplements should be done keeping in mind the possible negative effects of tannins.

The next section gives a few examples of the application of these principles in designing forage-based diets for ruminants.

APPLICATION OF THE THEORETICAL CONCEPT TO PRACTICE

One of the biggest challenges in feeding low quality forages is to increase their intake in animal diets. Chemical treatments, while successful, present several practical problems for smallholder agriculture. Addition of higher quality feeds to a poor-quality basal diet is more practicable. If the addition does not result in reduced intake of the basal diet, then the added feed is a supplement. If the addition results in reduced intake of the basal diet but an increase in total intake, then a substitution effect exists. Since high quality feeds are available in small quantities, it is preferred to use them as supplements rather than as substitutes.

A classic case of substitution is reported by Njwe and Olubajo (1989) who fed fresh Guatemala grass (*Tripsacum laxum*) with various combinations of cassava flour (up to 200 g/day) and groundnut cake (up to 150 g/day) to West African Dwarf goats weighing 9–15 kg. Total dry-matter intake increased with increasing additions of both cassava flour and groundnut cake. Intake of cell walls, acid detergent fibre and cellulose (all components of the basal diet) increased. Fresh Guatemala grass had adequate readily degradable carbohydrates and, having poor buffering capacity, was unlikely to prevent pH falling below 6.2 when supplemented with cassava flour (another source of readily degradable carbohydrate). Adding a protein source that was low in fibre did not improve buffering. It is worth noting that animal productivity in terms of liveweight gain was increased by substituting concentrates for the basal diet. The merits or demerits of this substitution then depend on the economic returns to the farmer.

An example of supplementation is given by Ayoade (1989) who fed maize bran (up to 200 g/day) to Malawi indigenous goats fed a basal diet of pigeon pea (*Cajanus cajan*) pods. Dry-matter intake of the pods was not changed by adding maize bran but total dry-matter intake, and digestibility of dry matter and organic matter, increased. Maize bran presumably supplied readily fermentable carbohydrates which provided energy to the rumen microbes and thus improved cellulolytic activity. The buffering capacity of pigeon pea pods ensured that rumen pH was not severely lowered and thus fibre digestion was not negatively affected.

Nuwanyakpa and Butterworth (1987) found that supplementing a diet of molasses and teff straw with varying levels of *Trifolium* hay increased total feed intake and apparent digestibility of dry matter, neutral detergent fibre and nitrogen. The results support the hypothesis that legume supplements enhance intake and digestion in ruminants. More important, they also indicate the value of forage with readily degradable tissue (*Trifolium* hay) as a supplement to crop byproducts with limited readily degradable tissues.

The value of using green forage, particularly leguminous forage, has been described by Ndlovu and Buchanan-Smith (1985), Dixon and Egan (1987) and Elliot and McMeniman (1987) based on stall-fed animals. No reports were found on grazing animals. A possible experiment would involve grazing/browsing on green forage for a limited time (say 1–2 hours) plus unlimited access to mature dry hay. Fodder banks could be used for the restricted grazing on green forage. This area requires further research.

CONCLUSIONS

Livestock productivity from forage-based diets can be improved by making use of current knowledge on the rumen ecosystem and on the qualities of different forage species

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EFFECT OF SUPPLEMENTING *CHLORIS GAYANA* HAY WITH THREE PROTEIN SOURCES ON THE PERFORMANCE OF WEANED CALVES

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ABSTRACT

An experiment was conducted to study the effect of kapokseed cake, cottonseed cake and sunflowerseed cake, fed as protein-source supplements to *Chloris gayana* hay, on the performance of weaned calves. Crude-protein intake was 421, 300, 426 and 395 g/day, and metabolisable-energy intake was 35.3, 34.0, 36.6 and 35.4 MJ/day, for kapokseed cake, maize bran, cottonseed cake and sunflowerseed cake, respectively. Both crude-protein and metabolisable-energy intake were significantly (P<0.001) different between treatments.

Calves receiving cottonseed cake had significantly (P<0.01) higher growth rates compared with the other treatments. Growth rates were 630, 490, 720 and 620 g/day for kapokseed cake, maize bran, cottonseed cake and sunflowerseed cake, respectively. When growth rate was adjusted to constant crude-protein and metabolisable-energy intake there were no significant differences between treatments, indicating that the three seed cakes were equally effective in promoting the growth rate of weaned calves.

RESUME

Effet sur les performances de veaux sevrés de la complémentation de foin de* Chloris gayana *avec trois sources de protéines

Une expérience a été effectuée en vue d'étudier l'effet, sur les performances de veaux sevrés, de l'utilisation de tourteaux de kapok, de coton et de tournesol comme sources de compléments protéiques de foin de Chloris gayana. *La consommation de protéines brutes était de 421, 300, 426 et 395 g par jour et celle d'énergie métabolisable de 35,3, 34,0, 36,6 et 35,4 MJ par jour respectivement pour le tourteau de kapok, le son de maïs, et les tourteaux de coton et de tournesol. Les différences de consommation de protéines brutes et*

d'énergie métabolisable étaient significatives (P<0,001). Les taux de croissance des veaux recevant du tourteau de coton étaient significativement supérieurs (P<0,01) à ceux des veaux soumis aux autres régimes alimentaires. Les chiffres enregistrés étaient de 630, 490, 720 et 620 g par jour, respectivement pour le tourteau de kapok, le son de maïs et les tourteaux de coton et de tournesol. Une fois ces taux corrigés des variations de la consommation de protéines brutes et d'énergie métabolisable, il n'y avait plus de différence significative entre les traitements, ce qui signifie que ces trois types de tourteaux se valent en ce qui concerne la croissance des veaux sevrés.

RUMEN DRY-MATTER DIGESTIVE EFFICIENCY OF CAMELS, CATTLE, SHEEP AND GOATS IN A SEMI-ARID ENVIRONMENT IN EASTERN AFRICA

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ABSTRACT

The degree of degradability and utilisation of forages by ruminants may vary between forages and between animals, the latter as a result of passage rate and basal diet. In the semi-arid environment of northern Kenya, the quality of forage decreases considerably during the dry season, and consequently rumen dry-matter digestibility (RDMD) of forages by livestock is also reduced. A study comparing RDMD of major forage species by camel, cattle, sheep and goats showed no significant differences between animal species within seasons, except for the camel whose RDMD of grass was significantly lower than that for the other herbivores. Comparisons between seasons showed that RDMD was lowest in the very dry season in all species. Overall, camels, and to a lesser degree goats, had superior DMD to sheep and cattle across seasons. The very dry season (January–March) is the crucial period for a high quality forage supplement intervention for all livestock species; cattle suffer the most due to their high reliance on grass, the least nutritive of the forage components during this period.

RESUME

Digestibilité de la matière sèche dans le rumen chez les camélidés, les bovins, les ovins et les caprins dans la zone semi-aride d'Afrique de l'Est

Chez les ruminants, le degré de dégradation et d'utilisation des fourrages dépend du type de fourrage. Il est en outre fonction de l'espèce animale, compte tenu notamment de l'importance du rythme de passage des aliments ainsi que des caractéristiques de la ration de base. Dans la zone semi-aride du nord-Kenya, les fourrages s'appauvrissent considérablement au cours de la saison sèche, ce qui se traduit par une baisse de la digestibilité de la matière sèche dans le rumen des ruminants. Cette étude a été effectuée pour comparer la digestibilité de la matière sèche des principales espèces fourragères dans le *rumen chez les camélidés, les bovins, les ovins et les caprins. Aucune différence significative n'a été enregistrée entre les différentes espèces au cours d'une même saison, exception faite des camélidés chez lesquels la digestibilité des graminées était significativement inférieure à celle des autres herbivores. Quelle que soit l'espèce animale considérée, la digestibilité de la matière sèche était minimum au cours de la saison très sèche. Toutes saisons confondues, la digestibilité de la matière sèche des camélidés et, dans une moindre mesure, des caprins, était supérieure à celle des ovins et des bovins. Quelle que soit l'espèce animale considérée, la saison très sèche (janvier– mars) constitue la période critique de complémentation, les bovins connaissant alors une situation particulièrement difficile compte tenu de leur préférence marquée pour les graminées, plus pauvres que les autres espèces fourragères en cette période de l'année.*

INTRODUCTION

Ruminant animal production contributes substantially to the world's human food supply, especially in those marginal areas where pastoralism is the order of life. This is mainly due to the ability of ruminants to convert carbohydrates found in the fibrous parts of plants to high quality human foods. The nutritive value of forages for ruminants depends on the ability of rumen microorganisms to break down the plant cell wall and ferment the carbohydrates (Nelson et al, 1976). The degree of degradability and utilisation of forages by ruminants varies between forages (Duble et al, 1971: Utley et al, 1971) and between animals, the latter as a result of passage rate (Hennessey et al, 1983) and basal diet (Lindberg, 1981; Weakley et al, 1983). Most researchers employing the nylon-bag technique (van Dyne, 1962) to study ruminant digestion use a specific basal diet so as to minimise any variations between animals and different trial periods within animals. However, while the results gained do indicate relative dry-matter digestibilities (DMD) of forages, they do not represent natural conditions where the animals are free-ranging and there is variation in basal diets and hence in DMD efficiencies.

In semi-arid and arid tropical ecosystems, the quality of forages decreases greatly during the dry season (Migongo-Bake and Hansen, 1987). Since the basal diet influences DMD in the rumen (Weakley et al, 1983), all herbivores should perform poorly at this time, but the animals that will perform best will be those with higher digestive efficiencies. At other times of the year, inherent differences in diet selection of different herbivore species might lead to variation in basal diets and hence in the DMD of forages.

The aim of this research was to find out whether, for free-ranging livestock species, differences in basal diet between species within seasons, and within species between the green and the dry seasons, led to any significant differences in DMD efficiencies for given forage species. This would aid in decision making on when an intervention, such as use of dry-season forage reserve, would be most appropriate. The study was carried out in a semi-arid area of Marsabit District, Northern Kenya, in 1981/82.

MATERIALS AND METHODS

Animal species

Four castrates, a camel (*Camelius dromedarius*), a steer (*Bos indicus*), a sheep (*Ovis aries*) and a goat (*Capra hircus*) were fitted with rumen cannulae and used for dry-matter digestion trials using the nylon-bag technique (van Dyne, 1962; Ørskov et al, 1988). Throughout the experimental period, all four individuals appeared to be as healthy as animals not included in the trial. The experimental animals grazed on open range every day and were watered at the normal watering rates for livestock in the region when water is readily available (green season), namely every seventh day for camels, every third day for sheep and goats and every other day for cattle.

Forage species selection, collection and preparation

The sources of forages used in the trials included trees/shrubs, sub-shrubs and grass. The selection was based upon thorough feeding observations (Buechner, 1950) to determine the most preferred species. Species observed to be selected most by the four herbivores were collected once every month; only parts eaten were collected. The samples were air-dried at the prevailing daily temperature (between 20 and 40°C) until no further weight loss was observed. They were then ground in a Wiley mill through a 1-mm screen and subsamples were used in the digestion trial. Forage species preferred by one animal species were also used for digestion trials in the other three species so as to compare the digestive efficiencies of the four animal species for similar forages in the range. A standard sample of *Chrysanthemum cineariaefolium*, a forb, was used as the control forage in all of the trials.

Nylon-bag degradability trials

The nylon-bag technique is a simple, cheap and direct method of evaluating feeds, especially where laboratory facilities are not available (Ørskov et al, 1980). The method gives a rapid estimate of the disappearance of the tested feedstuffs in the rumen, and also allows the disappearance of the tested sample to be studied with respect to time. It is therefore possible to link the degradation of a feed with its retention time in the rumen (Ørskov et al, 1980). However, the nylon-bag technique only estimates the dry-matter disappearance rate (DMDR) of feed from the bag; it gives no direct information on the chemical nature or the nutritive value of the tested feed.

The number of bags used in digestion trials is a function of their size and weight, and different authors have used different numbers in different animal species (Miles, 1951; Mehrez and Ørskov, 1977; Rutagwenda, 1989). In this trial, the number of bags and the incubation times used were a compromise between two factors: a large enough sample for effective analysis; and the retention of a microbial environment in the rumen that was as normal as possible.

The nylon bags used in this trial were 4 x 7 cm in size. The quality of the nylon material (50 threads per cm; pores between the threads could not be seen using 400x magnification) was such that solids could not enter or leave the bag (Johnson et al, 1982). Samples (2 g) of the forage to be tested and of the control forage were put into preweighed (nearest 0.01 g) nylon bags; five replicates were used for each forage. The samples were incubated for 48 hours (Nocek, 1985; Walli et al, 1988). After incubation the bags were thoroughly washed until the water coming out of the bag was clear (Mehrez and Ørskov, 1977; Demeyer et al, 1982, Varga and Hoover, 1983; Fadlalla et al, 1987). After washing, the bags were squeezed to remove excess water (Playne et al, 1978; Varga and Hoover, 1983) and then air-dried at the prevailing daily temperature (between 20 and 40°C) until no further weight loss was observed. They were then weighed to the nearest 0.01 g and the weight of the sample determined by subtracting the weight of the bag.

RESULTS

Seasonal RDMD comparisons between the four herbivore species are shown in Table 1. There were no differences between the species in RDMD of forages from trees/shrubs and sub-shrubs. However, camels were significantly inferior digesters of grasses compared with the other herbivores. The RDMD of the sheep and steer were affected the most across seasons while the goat and the camel showed least variation. The majority of the significant differences observed within species were between the second green and the second dry seasons, the wettest and driest, respectively, of the study period.

DISCUSSION

Average rainfall over the study area during the four seasons of the study period was:

- first green season (April–June): 76 mm
- first dry season (July–September): 0 mm
- second green season (October–December): 182 mm
- second dry season (January–March): 17 mm

Although there was no rainfall during the first dry season, overcast skies for most of the period meant that it was less dry, in terms of negative effect on vegetation, than the second dry season when cloudless skies resulted in more

Table 1. *Seasonal rumen dry-matter digestive efficiency of the camel, steer, goat and sheep in a semi-arid region of northern Kenya*

	Dry-matter digestive efficiencies (%)							
	First green season		First dry season		Second green season		Second dry season	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Trees/shrubs								
Camel	76.4	15.0	70.3	9.0	78.1	5.9	63.6	10.0
Steer	76.7	23.7	71.2	18.4	80.9	5.9	61.3	2.8
Goat	76.3	14.7	71.7	6.9	84.0	5.3	54.8	12.2
Sheep	76.7	14.7	60.8	7.4	85.5	4.2	62.9	4.7
Number of plant species	10		11		12		11	
Sub-shrubs								
Camel	71.2	14.1	55.7	15.2	69.7	11.0	58.4	11.6
Steer	69.4	15.8	69.8	11.9	76.0	11.3	54.5	9.6
Goat	69.9	17.1	65.0	17.2	77.4	6.7	59.1	9.2
Sheep	64.7	18.1	64.6	14.6	70.4	13.0	60.8	9.0
Number of plant species	11		11		11		10	
Grasses								
Camel	54.1	10.8	49.6	3.1	55.4	11.5	49.1	7.2
Steer	74.4	6.6	59.4	7.8	64.4	5.7	60.9	6.6
Goat	71.1	8.7	59.8	0.9	69.0	4.4	59.1	4.1
Sheep	69.8	8.7	65.1	13.1	66.8	5.1	60.5	6.3
Number of plant species	17		16		17		17	

direct radiation and hence greater evapotranspiration. This led to reduced forage availability and quality through death above-ground of grasses and most sub-shrub forage species.

Because the study area was in a remote semi-arid region, it was considered unwise (because of the high risk of wound infection) to fistulate more than one individual per species until survival and continuous good health of the fistulates was established. Figroid et al (1972), working with rumen-fistulated steers, noted that although some variation was found between steers, it was a small part of the overall variance in the nylon-bag technique when relative values between treatments were considered. This suggests that the error introduced into the digestion trial results through the use of one animal should not be large as long as several replicates are used and the standard deviation of these remains small. Five replicates per trial were used in this study.

The type of diet consumed by an inoculum donor has been shown to affect *in vitro* digestion (van Dyne, 1962). Other research (van Keuren and Heinemann, 1962; Hopson et al, 1963; Neathery, 1969; Weakley et al, 1983) has shown that *in situ* digestion of forages is influenced by the type of forage fed to the host animals. The livestock species observed in this study grazed on a common open range. RDMD values were not significantly different (P>0.05) between the steer, sheep and goat within seasons. This suggests that although the diet compositions of these animals varied, the quality of the diets did not differ much and so the rumen microbial populations were probably similar, both quantitatively and qualitatively. Although the camel was not significantly different from the other species in RDMD values for forages from tree/shrub and sub-shrub components, its RDMD values for grasses were lower, often significantly so (P<0.05). Maloiy (1972) reported that camels, which are chiefly browsers, tended to have a lower dry-matter digestive efficiency than zebu cattle on low quality hay. According to Hofmann (1973), true ruminant and pseudo-ruminant (eg, camels) browsers have rumen structural components adapted to a diet that has a high content of cell solubles but is also high in lignin. The low RDMD efficiency of camels on grass is probably a result of low populations of cellulolytic microbes in the rumen since grass forms a minimal part of their diet in this ecosystem. In Somalia, however, camels' diets consist chiefly of grass (Newman, 1979), and so it would therefore be worthwhile studying the dry-matter digestive efficiency of grass, and the composition of rumen microbial populations, of these animals.

Hopson et al (1963) observed that the digestibility of forages in dacron bags was significantly higher when alfalfa was fed than when grass hays were fed. Annison and Lewis (1959) noted that a higher quality diet results in a more dense and vigorous rumen microflora as compared to a low quality diet. According to Weakley et al (1983) differences among diets in supporting different rates of *in situ* dry-matter disappearance are probably due to a combination of rumen microbial and physical factors that are subject to changes in the diet. The quality of forages in the semi-arid region of East Africa decreases rapidly in the dry season. While the observed low quality of grasses results mostly from low crude-protein levels (Lindberg, 1981; Van Soest, 1982; Migongo, 1984), that in browse is mostly due to anti-quality factors such as lignin and tannins (Van Soest, 1982; Reed, 1983).

The observations in this study indicate that when seasons are extremely dry and forage availability and quality are low, the RDMD values are also very low. This suggests that there is a limit to the extent that animals can select for a high quality diet that is scarce and still meet their daily rumen fill. Sheep, like goats, have been shown to increase the particle retention time in the reticulorumen during the dry season, thus allowing lengthy degradation of the forages in their diet (Rutagwenda, 1989). Camels are mixed feeders but rely mostly on browse. However, they have been shown to increase their intake of the grass in the dry seasons (Migongo-Bake and Hansen, 1987). Thus camels may be forced to feed on grasses when they come across small fields of these (as are common in the area of study) so as to maximise their dietary intake. Therefore, it is the differences in the seasonal extremes that determine the extremes in forage availability and possible degree of selection.

CONCLUSIONS

While livestock in open range might select for high quality forage to maintain a relatively similar basal diet quality from season to season, the extent to which they can do this and still maximise their intake becomes significantly reduced in extremely dry seasons when forage biomass and its quality are low. This would result in a low quality basal diet, a less dense and less vigorous rumen microflora and hence very low DM digestion such as was observed in the very dry season in northern Kenya, the area of this study. This study showed that the dry season (January–March) is the crucial period for high quality forage supplement intervention for all livestock species, and that cattle suffer the most due to their high reliance on grass, the least nutritive of the forage components during the this period. Camels, followed by goats, fare better, in terms of RDMD, than sheep and cattle, and appear to be better adapted in the utilisation of available feed resources across seasons.

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SEASONAL CHANGES IN LIVESTOCK DIETS IN A SEMI-ARID ENVIRONMENT IN NORTHERN KENYA

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ABSTRACT

Dietary preference studies of indigenous animals in Isiolo District, northern Kenya, showed that cattle mainly depended on grass and ate fewer plant species than other livestock species; camels and goats preferred to browse in all seasons; and sheep selected more grasses in the wet season but consumed more browse in the dry season. There was a dietary overlap between camels and goats and between cattle and sheep; the lowest overlap was between cattle and camels. Dietary overlap between animals generally increased durnng the dry season. The different feeding behaviour and variable dietary overlap of different animal species suggest that a multi-species grazing system might help to stop further degradation of already degraded areas.

RESUME

Variations saisonnières de la composition des rations des animaux d'élevage dns la zone semi-aride dans le nord-Kenya

Il ressort d'études effectuées sur les préférences alimentaires des animaux de race locale dans le district d'Isiolo au nord-Kenya que les bovins préféraient les graminées et consommaient moins les autres espèces végétales que les autres espèces d'animaux; quant aux camélidés et aux caprins, leur préférence allait aux ligneux, quelle que soit la saison; enfin, les ovins préféraient les graminées pendant l'hivernage et les délaissaient pour les ligneux pendant la saison sèche. Les camélidés étaient proches des caprins par le goût tandis que les ânes se rapprochaient plutôt des bovins; les divergences les plus prononcées (moins de 1% du temps consacré à l'alimentation) avaient été observées entre ces derniers et les camélidés. D'une manière générale, les préférences des différentes espèces se rapprochaient au cours de la saison sèche.

Etant donné la diversité des comportements alimentaires et des convergences observées entre les diverses espèces animales, l'association de diverses espèces végétales sur les parcours dégradés devrait permettre de freiner ce phénomène de dégradation.

INTRODUCTION

In many arid and semi-arid areas of the world, uneven rainfall distribution leads to wide fluctuations in the quantity and quality of forage available to animals. In northern Kenya, for example, which has a bimodal rainfall pattern with the long rains in March to May and the short rains in November and December, forage is plentiful during and immediately after the rainy seasons, but becomes scarce during the dry season, when some annual forages may disappear altogether (Herlocker, 1979; Rutagwenda, 1989). Different animals have evolved various mechanisms for coping with fluctuations in feed quality and availability (Langer, 1988). Some select high-quality plants to feed on (Hofmann, 1973; Kay et al, 1980); others improve the digestion of poor forage by prolonging the retention time of feed particles in the forestomach (Van Soest, 1982; Van Soest et al, 1988); and some adopt both mechanisms.

This paper describes the diets selected by animals in northern Kenya, and how different animal species cope with dry seasons in this environment. It also suggests strategies for feeding animals during dry seasons.

MATERIALS AND METHODS

Study area

The study was carried out at Ngarendare research station in Isiolo District, Kenya, 310 km north of Nairobi, at an altitude of 1100 m; annual rainfall here averages 510 mm. The vegetation of the study area is a thorn-bush savanna dominated by various *Comiphora*, *Grewia* and *Acacia* species. There is also a sparse cover of annual grasses, herbs and shrubs. *Acacia* woodlands and dense bush dominated by *Grewia* species are found along seasonal water courses, and perennial grassland is found on the flood plains. Almost 400 different plant species have been identified in the grazing area of approximately 100 km^2 (W Schultka, Department of Botany, University of Giessen, Germany, personal communication).

Experimental animals and their management

The animals used in the study were two breeds of sheep, the Red Masai and the Somali Blackhead (body weight 19–55 kg); two breeds of goats, the Small East African and the Galla (body weight 23–47 kg); Small East African zebu cattle (body weight 185–375 kg); and camels (*Camelus dromedarius*, body weight 350–620 kg). All animals were male castrates.

The animals were herded and watered according to traditional practices in the area, but were also treated against internal parasites three times a year and were provided with a mineral lick in the enclosure all the times.

Vegetation biomass estimation

Vegetation biomass in the grazing area was estimated once a month. An area was selected that appeared to represent the general grazing range, and three 100-m transects were laid out in three different directions starting from a central point. Along each transect 1-m^2 quadrats were placed at 10-m intervals and the plant material in each quadrat was clipped. The clipped vegetation samples were dried (first in the field and later at 70°C overnight in the laboratory) and the weights were recorded.

Dietary preference

Feed preferences were assessed by direct observations (Buechner, 1950; Schwartz, 1988) made every two weeks from 1984 to 1988. Six sheep (three of each species), six goats (three of each species), six camels and six cattle were observed for 10 minutes each between 0900 and 1100 hours. The time spent by each animal feeding on one plant was recorded to the nearest five seconds; the plant species and the part of the plant eaten were also noted. On each observation day, samples of the three plants most preferred by the animal were collected for chemical analysis and nylon-bag degradation studies.

Dietary overlap between animal species was calculated according to Rutagwenda et al (1990).

Chemical analysis

The 42 plant species most preferred by the animals were chemically analysed. Altogether 202 samples (34 grasses and 168 dicotyledons) were analysed for acid detergent fibre (ADF) and acid detergent lignin (ADL) according to Van Soest (1963; 1982) and Van Soest and Wine (1967). The cellulose content of the plants was calculated as the difference between the ADF and the ADL contents. The crude-protein content of the plants was determined by the standard Kjeldahl procedure.

Degradation of the selected plants (nylon-bag technique)

In the degradation experiments, eight sheep and eight goats (four of each breed), fitted with rumen fistulae, were used to test 285 samples (76 grasses and 209 dicotyledons) of 53 plant species (11 grasses and 42 dicotyledons) using the nylon-bag technique.

Plant samples collected during the feeding observations were dried at 70°C for 24 hours and ground in a Wiley mill to pass a through a 2-mm screen; the samples were tested two weeks after collection from the field. The nylon bags used measured 15 x 7 cm and were made from a fine grade (pore size 35 μm) of nylon material (Linker KG, Kassel, Germany) according to the procedure described by Ørskov et al (1980). A 5-g sample of ground plant material was weighed into each bag, the bags were tied with a nylon string, and five bags were fixed to a nylon washing line. The five bags on one line were introduced into the rumen at intervals and removed simultaneously (Nocek, 1985) to give incubation times of 6, 12, 24, 48 and 72 hours for single bags. After the bags were removed from the rumen they were washed with tap water until the effluent was clear, dried (first in the field and later at 70°C for 24 hours) and weighed, and the dry matter disappearance was then calculated.

RESULTS

Vegetation biomass

The vegetation biomass of the herb layer (excluding browse) varied according to the rainfall pattern, from 2000 kg/ha during the rainy season to as low as 700 kg/ha during the dry season.

Number of plants consumed

Animals spent different times feeding on individual plants. The number of plants which occupied 90% of the feeding time of the animals, and the proportion of time spent feeding on dicotyledons (browses), during the dry and wet seasons are shown in Table 1.

Cattle ate fewer ($P<0.001$) plants species in both seasons than other animal species, and fed on fewer ($P<0.001$) plants during the dry season than during the wet season. There were no differences in the number of plant species eaten by sheep, goats or camels.

Cattle spent less time feeding on dicotyledons than other animal species. Both cattle and sheep spent much more time feeding on dicotyledons in the dry season than in the wet season. Goats and camels spent most of their feeding time on these species in all seasons.

Dietary overlap

The time spent by different animal species feeding on similar plants during the dry and wet seasons is given in Table 2. Camels and cattle had the lowest dietary

Table 1. *Number of plants which occupied 90% of the feeding time and time spent feeding on dicotyledons*

Animal species	Dry season: Number of observation days	Dry season: Number of plant species Mean	Dry season: Number of plant species SD	Dry season: % of total time feeding on dicotyledons	Wet season: Number of observation days	Wet season: Number of plant species Mean	Wet season: Number of plant species SD	Wet season: % of total time feeding on dicotyledons
Cattle	10	1.8	0.4	17	21	7.3	2.6	28
Sheep	15	26.5	5.1	35	18	26.0	3.2	82
Goats	15	25.8	4.2	86	18	27.0	2.1	84
Camels	6	28.0	5.1	90	28	29.0	3.0	92

overlap in all seasons. Camels and goats, and cattle and sheep, spent about 50% of their feeding time on similar plants during the dry season. Dietary overlap tended to increase during the dry season.

Degradability of selected plants

There were no differences between sheep and goats in the dry-matter disappearance rate (DMDR) of plant samples in the rumen. There were, however, differences in DMDR between plant species. The 285 plant samples tested were divided into three groups according to their DMDR at 48 hours:

- Group 1: plants with DMDR less than 50% at 48 hours (low quality)
- Group 2: plants with DMDR of 50–70% at 48 hours (medium quality)
- Group 3: plants with DMDR greater than 70% at 48 hours (high quality)

Table 2. *Dietary overlap between animal species*

Animal species	Dietary overlap (% of total feeding time): Dry season Mean	Dry season SD	Wet season Mean	Wet season SD
Camels – cattle	3.3	3.3	8.5	3.3
Camels – sheep	30.5	5.4	14.2	6.9
Camels – goats	47.5	5.4	12.4	4.6
Cattle – sheep	49.6	5.7	20.1	5.9
Cattle – goats	12.6	3.3	23.3	4.0
Sheep – goats	36.6	9.0	43.0	6.7

The number of observations days in the dry and wet seasons, respectively, were: cattle (10,21); sheep (15,18); goats (15,18); camels (6,28)

Table 3. *Time spent feeding on plant species of the three quality groups*

Animal species	% of total feeding time					
	Dry season			Wet season		
	Group 1	Group 2	Group 3	Group 1	Group 2	Group 3
Cattle	90	10	–	60	31	9
Sheep	40	25	35	25	30	45
Goats	15	35	50	7	35	58
Camels	1	19	50	–	45	55

The time spent feeding on plants of different quality groups is shown in Table 3. Cattle and sheep spent more time feeding on poor quality plants, and less time on medium and high quality plants, during the dry season than during the wet season. Cattle never seemed to feed on good quality forage during the dry season. Goats spent much more time feeding on medium and high quality plants than on low quality ones during both seasons. Camels never selected a diet of low quality during the wet season, and spent very little time on such diets in the dry season. Obviously goats and camels are better able to select higher quality plants than are cattle and sheep.

DMDR of individual plants

The DMDR of three monocotyledon species collected repeatedly during the dry and wet seasons were compared (Figure 1). The DMDR was significantly ($P<0.001$) higher during the wet season than during the dry season, indicating that the quality of monocotyledons was lower during the dry season than during the wet season.

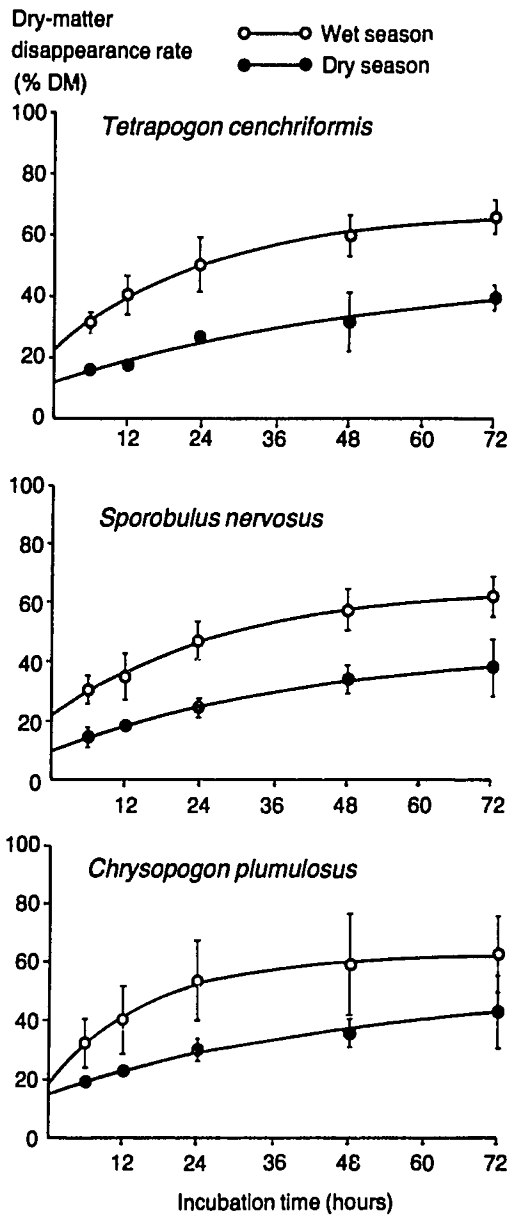
The DMDR of dicotyledons did not differ greatly from season to season (Table 4).

Chemical analysis of the selected diet

The crude-protein (CP) content of the diet selected by the animals was higher during the wet season than during the dry season (Table 5). The CP content of the diets of cattle during the wet season was about twice that during the dry season. However, the diet of cattle had a lower CP content than that of other animals during all seasons. For the other animals, CP content of the diets was already high during the dry season.

The estimated cellulose content of the diets of cattle was high during the dry season and decreased during the wet season (Table 5). For the other animals cellulose content was low and did not change much between seasons.

Figure 1. *Dry-matter disappearance rate of three grass species which were selected repeatedly during wet and dry seasons*



Source: Rutagwenda (1989)

Table 4. *Dry-matter disappearance rate (DMDR) (mean of eight samples) of two representative dicotyledons* Vernonia cinerascens *and* Indigofera spinosa *collected during the dry and wet seasons*

Incubation time (hours	Dry-matter disappearance rate (% DM)			
	Wet season		Dry season	
	Mean	SD	Mean	SD
Vernonia cinerascens				
6	59.2	2.7	52.9	5.5
12	69.3	9.9	70.3	4.6
24	77.7	11.7	76.8	11.7
48	82.1	11.7	81.5	11.7
72	76.9	6.5	76.7	6.6
Indigofera spinosa				
6	42.0	3.9	37.7	3.1
12	51.4	5.1	49.7	3.8
24	61.4	8.5	61.4	3.2
48	66.5	6.1	68.5	1.7
72	68.8	4.8	68.3	1.5

Table 5. *Crude-protein and cellulose contents of the diet*

	Crude-protein content (% dry matter)		Cellulose content (% dry matter)	
Animal species	Dry season	Wet season	Dry season	Wet season
Cattle	4–5	10–12	37–40	32–36
Sheep	9–11	11–13	20–29	21–25
Goats	11–14	17–22	15–22	16–22
Camels	14–17	18–22	14–22	14–17

DISCUSSION

This study in northern Kenya agrees with reports from other areas (Hoppe et al, 1977; Coppock et al, 1986) that different livestock species select diets of different compositions. Cattle always prefer grasses (monocotyledons). Sheep are intermediate feeders; they prefer grasses during the wet season when these species are of good quality and are available in sufficient quantities, but as the dry season starts they switch to feeding on dicotyledons. Goats and camels are mainly browsers, spending over 80% of their feeding time on dicotyledons.

Dietary overlap (potential competition between animal species for available forage) is low between cattle and camels at all times, but high between camels and goats and between cattle and sheep during the dry season. Dietary overlap may not be critical during the wet season when forage is abundant, but during the dry season competition may reach critical proportions if animals depend on few plant species. These findings suggest a means of improving range management and reducing pressure on vegetation in overgrazed arid and semi-arid areas, namely adopting multi-species grazing systems whereby animals with different feeding strategies are kept together. For example, keeping cattle and camels together should lead to improved forage utilisation, as cattle would use grass not used by camels and camels would use browse not used by cattle.

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PERFORMANCE OF ASSOCIATIONS OF *BRACHIARIA RUZIZIENSIS* WITH *DESMODIUM INTORTUM, DESMODIUM UNCINATUM* AND *STYLOSANTHES GUIANENSIS* AT DSCHANG, CAMEROON

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ABSTRACT

The chemical composition, total dry-matter and crude-protein yield, and the grass/legume ratio, were evaluated in a trial involving *Brachiaria ruziziensis* planted alone or in associations with the legumes *Desmodium uncinatum, D. intortum* and *Stylosanthes guianensis*. Plots were cut back after a regrowth interval of two months. Results indicated significant increases in yields of total dry matter (388–524%) and crude protein (403–1012%) from grass/legume treatments over sole plots of *B. ruziziensis*. The proportion of legume dry matter in grass/legume mixtures ranged from 25 to 38%. The crude-protein contents of *B. ruziziensis* from mixed grass/legume treatments and from sole plots were not significantly different. Mixtures of *B. ruziziensis* with *D. intortum* and *D. uncinatum* were outstanding in total dry-matter and crude-protein yield.

RESUME

Performances de cultures associées de* Brachiaria ruziziensis *avec* Desmodium intortum, Desmodium uncinatum *et* Stylosanthes guianensis *à Dschang (Cameroun)

La composition chimique, la teneur en matière sèche, le taux de protéines brutes et le rapport graminées/légumineuses ont été déterminés dans un essai réalisé sur Brachiaria ruziziensis *en culture pure ou en association avec les légumineuses* Desmodium uncinatum, D. intortum *et* Stylosanthes guianensis. *L'intervalle entre coupes était de deux mois. Il ressort des résultats enregistrés que les rendements en matière sèche (entre 388 et 524%) et les taux de protéines* *brutes (entre 403 et 1012%) étaient plus élevés sur les parcelles à association graminées–légumineuses que sur les parcelles à* B. ruziziensis *en culture pure. La part des légumineuses dans la matière sèche des mélanges graminées–légumineuses variait de 25 à 38%. La teneur en protéines brutes de* B. ruziziensis *n'était pas significativement différente entre les parcelles de cultures associées et celles de culture pure. Les rendements en matière sèche et la teneur en protéines brutes des mélanges de* B. ruziziensis *avec* D. intortum *et* D. uncinatum *étaient exceptionnellement élevés.*

INTRODUCTION

The high nitrogen content of leguminous species contributes to improving the nutritional quality of the diet of grazing ruminants. The presence of legumes in pasture also increases the nitrogen content of grass species through subterranean absorption from leguminous roots. Moore (1962) reported that the nitrogen content of young *Cynodon plectostachyus* plants increased from 1.8 to 2.4% in association with *Centrosema pubescens* while Jones et al (1967) also reported increases in nitrogen content of *Paspalum plicatulum* from 0.8 to 1% and 1.2 to 1.4% when associated with *Macroptilium atropurpureum* and *Lotononia bainesii.*

It has also been observed that association of legumes with grass species tends to increase total dry-matter yield per hectare. Whitney and Green (1969) reported that association of *Digitaria decumbens* with *Desmodium canum* and *Desmodium intortum* resulted in dramatic increases in total dry-matter and crude-protein yields.

The objective of this study was to determine the effect of associating *Brachiaria ruziziensis* with *Desmodium intortum*, *D. uncinatum* or *Stylosanthes guianensis* on total dry-matter and crude-protein yield, grass to legume ratio and nitrogen content of *B. ruziziensis*.

MATERIALS AND METHODS

The study was carried out at the University Centre of Dschang, Cameroon (altitude about 1500 m). Climatic data for Dschang are given in Table 1.

Brachiaria ruziziensis was planted in sole stand or with a legume, *Stylosanthes guianensis*, *Desmodium intortum* or *D. uncinatum*, in a randomised complete block design having four treatments and five replicates. The size of each plot was 6 x 4 m, and all plots were separated by a 1-m wide path.

Drills of *B. ruziziensis* were alternated with those of leguminous species at a spacing of 1 m. After planting the plants were allowed to establish and completely cover the soil surface before data collection commenced. All plots were cut back and allowed a regrowth period of 60 days before they were harvested for data collection. The cutting height was 10 cm. Only the central 2 m^2 area was harvested to avoid border effects. After harvest of each plot, the

Table 1. *Rainfall and mean temperatures at Dschang, Cameroon (1500 m altitude), 1989*

Month	Number of rainy days	Monthly rainfall (mm)	Temperatures (°C)		
			Minimum	Maximum	Average
January	2	9	11.5	27.0	19.3
February	0	0	13.1	28.6	20.8
March	11	133	15.3	28.4	21.8
April	18	126	16.4	26.7	21.5
May	18	173	16.0	25.7	20.8
June	22	286	15.7	24.8	20.2
July	23	168	15.7	23.4	19.5
August	27	278	15.7	23.7	19.6
September	24	321	15.7	24.9	20.3
October	20	140	15.5	25.4	20.4
November	6	20	14.7	26.5	20.6
December	1	11	13.7	27.0	20.3
Total	172	1655			

total fresh weight of forage and of the *B. ruziziensis* and legume fractions were determined. Samples (500 g) of fresh forage were collected for laboratory chemical analysis to determine contents of dry matter, ash, crude protein, crude fibre, ether extracts and nitrogen-free extracts. The data obtained were statistically analysed using the procedures of Steel and Torie (1980) for analysis of variance; differences between treatments were determined using the Duncan's multiple range test.

RESULTS

The effect of associating *B. ruziziensis* with various legume species on dry-matter yield is indicated in Table 2. Dry-matter yield of *B. ruziziensis* was significantly ($P<0.05$) higher in associations with legume species than in sole plantings. The dry-matter yield of *B. ruziziensis* was higher ($P<0.05$) when associated with *D. uncinatum* than with either *D. intortum* or *S. guianensis*. There were differences ($P<0.05$) in the proportions of the legumes in the mixtures, *S. guianensis* being the most abundant.

The presence of legumes in plots plants with *B. ruziziensis* boosted total dry-matter production by up to 524%.

Table 3 shows the effect of legumes on total crude-protein yield and crude-protein content of *B. ruziziensis*. Total crude-protein yields from grass–legume

Table 2. *Effect of association of* Brachiaria ruziziensis *with legumes species on dry-matter yield*

Treatment	Grass DM (kg/ha)		% Grass		Legume DM (kg/ha)		% Legume		Total DM (kg/ha)		% Increase in DM yield compared to control	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
B. ruziziensis (control)	1792	221	100		–		–		1 792	221	–	
B. ruziziensis + *D. intortum*	6918	116	67.6	8.5	3316	96	32.4	6.9	10 234	1956	471	51
B. ruziziensis + *D. uncinatum*	8426	894	75.3	11.3	2764	265	24.7	8.6	11 190	1221	524	63
B. ruziziensis + *S. guianensis*	5373	769	61.5	5.9	3365	315	38.5	5.9	8 738	999	388	38

mixtures were significantly (P<0.01) higher than from sole grass plots, and plots with *D. uncinatum* yielded significantly (P<0.05) more crude protein than plots with the other two legumes.

Differences between crude-protein content of *B. ruziziensis* from control plots and from plots with legumes were not significant.

DISCUSSION

The higher total dry-matter and crude-protein yields from mixtures of legumes with *B. ruziziensis* than from grass monocultures agree with work by Whitney and Green (1969) who found similar yield improvements in work on *Digitaria decumbens* associated with *Desmodium intortum* and *Desmodium canum*. The increase of crude-protein yield may be attributed to the nitrogen-fixing ability of legumes, and the effects this has on nitrogen content of associated grass species.

The presence of legumes in pastures has two important beneficial effects. First, it reduces the need to provide nitrogen supplements to grazing ruminants. And second, the nitrogen-fixing capacity of legumes in pastures offers a cheaper alternative to expensive nitrogenous fertilisers. However, the supply of seed material may constitute an important constraint that needs to be overcome.

Contrary to observations by Moore (1962), Jones et al (1967) and Birch and Dougall (1967) that the N content of grass increased when planted in association with legumes, the present study did not find significant differences in N content of *B. ruziziensis* in monoculture or mixed with legumes. This is probably a reflection of late harvest of forages, at the stage of seeding, when reserves of nitrogen in roots, stems and leaves have been mobilised for seed production. Harvesting earlier, especially before flowering, may provide a more meaningful assessment of the effect of legume mixture on grass nitrogen content.

Table 3. *Effect of association of* Brachiaria ruziziensis *with legumes on the crude-protein content of the grasses and average crude-protein yield of plots*

Treatment	Crude-protein yield (kg/ha)		% increase compared to control		Crude-protein content of *B. ruziziensis* (%)	
	Mean	SE	Mean	SE	Mean	SE
B. ruziziensis (control)	113	17	–		6.30	0.45
B. ruziziensis + *D. intortum*	851	250	468	78	5.38	0.41
B. ruziziensis + *D. uncinatum*	1166	204	777	103	7.08	1.04
B. ruziziensis + *S. guianensis*	754	142	408	88	5.62	0.24

CONCLUSIONS

The contribution of legumes to improving the crude-protein yield of pasture is evident. This greatly improves the quality and quantity of the ruminant diet during the dry season when the nutritional quality of grasses is poor. Different intervals of cutting need to be investigated to determine the optimal time for harvesting grass–legume mixtures for feeding to ruminant livestock. The introduction of legumes to pastures and farming systems is one of the cheapest ways by which the poor countries of the world can sustain soil fertility. This will obviously have a positive impact on ruminant productivity.

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STYLOSANTHES PROTEIN FODDER BANKS FOR RUMINANT PRODUCTION IN MALAWI

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ABSTRACT

Livestock production in Malawi is seriously affected by feed shortages during the long dry season, at which time growth rates and body weights are reduced. Also, reproductive activities coincide with low protein supply, as most calves and kids are dropped during the dry season. *Stylosanthes* spp, unlike most other legumes, grow successfully under many ecological conditions, including infertile acidic soils. Several methods for introducing *Stylosanthes* spp into natural pastures have been evaluated with success. With dry-matter yields of more than 5 t/ha, and crude-protein contents of more than 12%, these legumes have shown potential for arresting body weight changes during the dry seasons. Thus fodder banks of *Stylosanthes* spp seem a possible cheap source of supplementary protein, compared with expensive commercial supplements such as cottonseed, groundnut and sunflower cakes. The national implications for pasture and soil stability, increased herd size and the supply of red meat are discussed.

RESUME

Mise en place de banques fourragères de* Stylosanthes *en vue de l'élevage des ruminants au Malawi

L'élevage est sérieusement affecté par les pénuries d'aliments du bétail que connaît le Malawi au cours de la longue saison sèche caractérisée par un ralentissement de la croissance et une baisse du poids des animaux. Résultat de taux de fécondité élevée des femelles, la plupart des veaux et des chevreaux naissent au cours de la même période. On peut recourir aux banques fourragères de Stylosanthes *pour résoudre le problème de l'insuffisance des protéines, lequel coïncide avec une période de fortes activités reproductrices. En effet, le* Stylosanthes *constitue une source bon marché de protéines, comparée aux tourteaux de coton ou d'arachide dont la production est tributaire de la pluviosité.*

En outre, contrairement à la plupart des autres légumineuses, Stylosanthes *est adapté à de nombreux environnements, y compris les sols acides pauvres. Plusieurs méthodes d'introduction de* Stylosanthes *dans les pâturages naturels ont été évaluées avec succès. Des rendements de plus de 5 t/ha et des teneurs en protéines de plus de 12% ont été enregistrés et son fourrage permettait aux animaux d'améliorer leur état physique. Enfin, cette étude a en outre permis d'évaluer les conséquences, à l'échelle nationale, de l'introduction de* Stylosanthes *sur la stabilité des parcours, la taille des troupeaux et l'offre de viande rouge.*

THE VALUE OF INDIGENOUS BROWSEABLE TREE SPECIES IN LIVESTOCK PRODUCTION IN SEMI-ARID COMMUNAL GRAZING AREAS OF ZIMBABWE

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ABSTRACT

A study was carried out to evaluate the nutritive value of indigenous browseable trees and to determine the patterns of utilisation of these trees by cattle and goats in two semi-arid areas. These trees are of good nutritive value: both leaves and pods have a high content of crude protein (7–28%) and low to medium content of neutral detergent fibre (11–64%). Livestock eat leaves in the wet months of November to February and pods in the dry months of May to September. Tree species that produce both leaves and pods thus contribute substantially to the diets of livestock in the areas studied. The results indicate that the current recommended stocking rates for these areas need to be reappraised as they were calculated excluding the contribution of trees/browses. More research on the propagation and utilisation of these species is required.

RESUME

Valeur nutritive des espèces de ligneux fourragers en animale dans les pâturages communaux des zones semi-arides du Zimbabwe

Une étude a été effectuée en vue de déterminer la valeur nutritive des espèces de ligneux fourragers rencontrées dans les deux zones semi-arides du Zimbabwe ainsi que leur mode d'utilisation par les bovins et les caprins dans ces régions. Ces ligneux ont une bonne valeur nutritive dans la mesure où leurs feuilles et *leurs gousses sont riches en protéines brutes (7–28%) et pauvres ou moyennement riches en fibres NDF (11–64%). Les animaux consommaient les feuilles pendant l'hivernage (novembre–février) et les gousses en saison sèche (mai–septembre). Par conséquent, les espèces ligneuses produisant à la fois des feuilles et des gousses entrent pour une part importante dans l'alimentation des animaux dans ces régions. Au vu de ces résultats, les charges recommandées pour ces zones doivent être révisées dans la mesure où elles ont été calculées sans tenir compte de l'importance des ligneux et des arbres fourragers dans l'alimentation des animaux. Des études supplémentaires s'avèrent nécessaires sur la dissémination et l'utilisation de ces espèces végétales.*

INTRODUCTION

The semi-arid communal areas of Zimbabwe, Natural Regions IV and V (Vincent and Hack, 1960), are characterised by low rainfall and poor sandy soils. Cropping consistently fails in these areas, and so livestock production is the dominant agricultural activity. Livestock management is rudimentary and consists mainly of herding the livestock in the veld. Grass is limited and only available in the rainy months of December to March. Indigenous browseable species play an important role in the survival of livestock in these regions, particularly during those months when grass is unavailable.

However, most research on livestock feeds and feeding in Zimbabwe has concentrated on cereal crop grains (Topps and Oliver, 1978), agricultural byproducts (Ndlovu and Manyame, 1988; Smith et al, 1990) and protein supplementation (Sibanda, 1990), all of which are either unavailable or available only in very limited quantities in semi-arid areas. Very little is known about the nutritive value of indigenous browseable tree species. This study therefore aimed to evaluate the nutritive quality of such trees and to establish patterns of their utilisation by cattle and goats throughout the year.

MATERIALS AND METHODS

Study sites

The study was carried out at two sites in the Gwanda District of Matebeleland South Province in Zimbabwe (29°E, 21°S).

Site 1 was Wenlock Communal Area in Natural Region IV, at an altitude of 900–1200 m. Annual rainfall is 450–650 mm; average temperatures are 22–30°C in summer and 10–16°C in winter. The vegetation of the area is the dry Miombo woodland (FAO/UNESCO, 1978) and is dominated by *Terminalia sericea* and *Julbernardia globiflora* trees. Other tree species, such as *Colophospermum mopane*, *Combretum* spp, *Kirkia acuminata*, *Sclerocarya caffra* and *Acacia*, *Albizia* and *Grewia* species dominate in the dark gneiss-derived soils.

Site 2 was the Gwaranyemba-Gwanda-Dibilishaba Communal Areas in Natural Region V, at an altitude of 600–900 m. Annual rainfall here ranges from 300 to 500 mm, and average temperatures are 25–34°C in summer and 14–22°C in winter. The vegetation of the area is the Mopane Tree Savanna, dominated by *Colophospermum mopane* on the alkaline soils and *Combretum apiculatum*, *Kirkia acuminata*, *Adonsonia digitata* and *Sclerocarya caffra* on dolerite-derived soils. *Acacia*, *Albizia* and *Grewia* species are found on dark gneiss-derived soils as at Site 1. The only grasses found at both sites are annuals, such as *Boscia*, *Aristida* and *Panicum* spp.

In both areas cattle and goats are the dominant livestock species and on average each farmer owns 10–17 head of cattle and 10–20 goats. The normal stocking rate is 3–4 ha/tropical livestock unit (TLU: 1 TLU = 250 kg liveweight), which is considered excessive based on the recommended stocking rate of 5–6 ha/TLU.

Data collection

A total area coverage approach was used in order to have a spatial representation of the areas. Key informants, identified among farmers, agricultural extension workers and part-time farmers, were given formal questionnaires on utilisation of indigenous tree species. Hand-clipped samples of leaves, twigs and pods of browseable tree species were collected throughout one calendar year: samples were analysed for crude protein (CP) and neutral detergent fibre (NDF) using AOAC (1985) methods. Patterns of utilisation of different parts of browseable tree species were determined from visual observations by the researchers with the assistance of the key informants. Distribution (density and occurrence) of the tree species was assessed in selected representative locations within each site.

RESULTS

Many of the tree species were common to both sites, but site 1 had a higher overall tree density than site 2 (Table 1). At both sites, leaves were the tree parts most utilised by livestock.

Chemical analysis of the tree parts eaten by the animals (Table 1) showed high CP and low to medium NDF contents. In the two species in which leaves were analysed at different stages, NDF content increased and CP content decreased with maturity. For *A. nilotica* and *D. cinerea*, leaves had a higher CP and lower NDF content than pods.

Patterns of utilisation of browseable trees by cattle and goats are shown in Table 2. Cattle fed mainly on leaves between October and January while goats fed on leaves between December and March. Pods were preferred by both cattle and goats in the months of June to September. Cattle ate species like *C. mopane* and *D. cinerea* almost all year round while goats mostly ate *Acacia* spp and *D.*

Table 1. *Densities, occurrences and crude protein (CP) and neutral detergent fibre (NDF) contents (of the parts utili~ed by livestock) of browseable tree species*

	Approximate tree density (trees/m^2)		Occurrence (fraction of locations visited)			Chemical content of parts used (%)	
Species	Site 1	Site 2	Site 1	Site 2	Parts used	CP	NDF
Acacia nilotica	0.2	–	2/4	–	Leaves Pods	11.25 7.31	13.20 33.14
Acacia tortilis	1	2–3	3/4	5/5	Leaves	19.12	–
Afzelia quanzensis	–	0.002	–	1/5	Leaves	19.74	50.96
Colophospermum mopane	3	1	2/4	3/5	Early leaves Mature leaves Dry leaves	18.46 15.42 14.86	44.16 47.58 56.90
Combretum apiculatum	1	0.01	3/4	5/5	Leaves	21.50	18.34
Combretum hereroense	1	0.007	2/4	1/5	Leaves	8.51	19.27
Combretum imberbe	–	0.001	–	1/5	Leaves	13.00	28.20
Commiphora africana	–	0.003	–	2/5	Leaves	17.64	–
Dichrostachys cinerea	1	0.01	4/4	3/5	Leaves Pods	28.54 13.98	45.93 54.54
Grewia bicolor	1	1	3/4	5/5	Leaves	21.12	60.71
Grewia flavescens	–	1	–	1/5	Leaves	11.45	32.40
Kirkia acuminata	–	0.003	–	3/5	Leaves	8.11	11.80
Lonchocarpus capassa	0.2	–	1/4	–	Early leaves Mature leaves	22.29 12.72	59.08 63.83
Piliostigma thonningii	0.4	–	3/4	–	Pods	7.87	55.37
Terminalia sericea	1	–	2/4	–	Leaves	9.15	20.23

cinerea all year round. Leaves of *Grewia* spp were eaten in the wet months of December and January, while leaves of *A. quanzensis*, *K. acuminata* and *P. thonningii* were eaten in the dry months of June to October.

DISCUSSION

Tree density seems to be affected by rainfall; site 2 had a lower tree density than site 1. While tree density is important ir indicating the amount of biomass available to livestock, CP and NDF contents indicate the quality of the biomass; in general, feed quality increases as CP content increases and/or NDF content decreases. On this basis, the *Combretum* and *Acacia* species and *K. acuminata* are good quality browses. The role of *C. apiculatum* in livestock production is limited by its low density. There is a need for research to study the possibility of

Table 2. *Tree parts eaten by cattle and goats during the year*

	J	F	M	A	M	J	J	A	S	O	N	D
Cattle												
Acacia nilotica						P	P	P	P			
Acacia tortilis						P	P	P	P			
Afzelia quanzensis							L	L	L	L	L	
Colophospermum mopane	L				D	D	D			L	L	L
Combretum apiculatum					L	L				L	L	L
Combretum hereoense	L	L										L
Combretum imberbe											L	L
Commiphora africana										L	L	L
Dichrostachys cinerea	L	L	L	L	P	P	P	P	P			L
Grewia bicolor	L					D	D	D			L	L
Grewia flavescens	L											L
Kirkia acuminata							L	L	L	L	L	L
Lonchocarpus capassa										L	L	
Piliostigma thonningii						L	L	L	L			
Terminalia sericea											L	L
Goats												
Acacia nilotica	L	L	L			P	P	P	P			L
Acacia tortilis	L	L	L			P	P	P	P			L
Dichrostachys cinerea	L	L	L	L	L	P	P	P	P			L

P = Pods; L = Leaves; D = Dry leaves and pods

seeding and propagating *C. apiculatum*. Unavailability notwithstanding, cattle eat *C. apiculatum* leaves for five months of the year, indicating that the leaves are quite palatable to them.

Of the tree species that serve as livestock feed throughout the year, *C. mopane* is the most interesting. In October–December, *C. mopane* produces reddish brown young leaves that livestock eat avidly, but only after they have been cut and wilted for a day or two; mature green leaves are not eaten at all. The dry leaves are often covered with sweet-tasting mucilage, produced by insects, which apparently enhances their palatability. No information is available on the chemical composition of the mucilage. Research is needed to establish optimal utilisation of *C. mopane* which is highly drought-resistant and has a high CP and moderate NDF content.

The other tree species eaten by livestock throughout the year is *D. cinerea*. Cattle browse on the leaves from December to April, and on pods from May to

September. The pods are not processed in any way, and this lack of processing could reduce their effective utilisation.

Acacia species are thorny and only goats, which have pointed snouts and mobile lower lips, are able to avoid the thorns and browse on the leaves. Cattle only eat the pods from *Acacia* species.

The abundance of pods in the dry months of June to September partly accounts for the survival of livestock during this time, even though, according to official stocking rates, these areas are overstocked. Official stocking rates were calculated without taking into account the contribution of browseable trees.

It is interesting that cattle at both sites eat tree parts for 10 months of the year. Bovines, as a species, are grazers, but the cattle indigenous to these areas have adapted to the shortage of grazing and have become facultative browsers.

There is need for more intensive laboratory evaluation of these browseable tree species, not only on their CP and NDF contents but also on potential anti-nutritional factors. At present very little information is available on the presence of polyphenolics in these species, even though these compounds are known to affect digestibility and utilisation of forages (Barry and Manley, 1986).

CONCLUSIONS

The results of this study show that browseable trees are highly nutritious and contribute substantially to the diet of livestock in these communal areas. However, stocking rates were calculated excluding the contribution of trees. Incorporating this contribution in the calculations could clear up some of the contradictions between the people's need for livestock and policy-makers' fears of environmental degradation if livestock numbers increase.

More research is needed on the propagation of these browseable tree species and on technologies to increase their productivity and utilisation. The current trend of introducing non-indigenous tree species at the apparent expense of the indigenous ones should be re-evaluated.

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PERFORMANCE OF SHEEP AND GOATS WITH OFFSPRING ON SEMI-ARID SALTBUSH (*ATRIPLEX NUMMULARIA*)–GRASSLAND RANGES IN THE EARLY DRY SEASON

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ABSTRACT

Fifteen sheep and 15 goats, each suckling a single offspring, were allocated to three grazing treatments: *Atriplex nummularia* shrubs plus undisturbed annual ground vegetation (GV) (T1: control); *Atriplex* plus GV reduced by herbicide spraying (T2); and *Atriplex* plus reduced GV plus concentrate supplement (T3). The proportions of GV in the diets were 75% in T1 and 50% in T2 and T3.

Dry-matter intake and free-water consumption were measured over 40 days together with milk production and changes in liveweight and body solids. Dry-matter intakes and liveweight changes of ewes plus lambs were 106 g/kg $LW^{0.75}$ and –31 g/day in T1, 80 g/kg $LW^{0.75}$ and –93 g/day in T2 and 78 g/kg $LW^{0.75}$ and –37 g/day in T3: the corresponding values for does plus kids were 104 g/kg $LW^{0.75}$ and +44 g/day in T1, 88 g/kg $LW^{0.75}$ and +34 g/day in T2 and 94 g/kg $LW^{0.75}$ and +38 g/day in T3. All mothers lost weight and body solids. Goats drank less water than sheep. The milk production of does was almost three times that of ewes. Goats tended to utilise *Atriplex* diets better than sheep.

RESUME

Performances de brebis et de chèvres allaitantes élevées sur parcours d'*Atriplex nummularia *et d'herbages en zone semi-aride au début de la saison sèche

15 brebis et 15 chèvres, allaitant chacune un petit, ont été soumises à l'un des trois régimes alimentaires suivants: Atriplex nummularia *plus de la végétation* *naturelle (témoin)*(T_1)*;* Atriplex *plus de la végétation naturelle en partie détruite par pulvérisation d'herbicide* (T_2)*; et* T_2 *plus un complément de concentré* (T_3)*. La végétation naturelle sur pied entrait pour 75% dans la ration* T_1 *et pour 50% dans les rations* T_2 *et* T_3*.*

Les consommations de biomasse de matière sèche (MS) et d'eau ainsi que les variations du poids vif, du poids sec et de la production de lait ont été mesurées sur une période de 40 jours. La consommation de MS et la variation de poids vif ont été déterminées pour la mère et son petit pris ensemble. A cet effet, les chiffres enregistrés chez les ovins étaient rospectivement de 106 g/kg $PV^{0,75}$ *et –31 g/j avec la ration* T_1*, 80 g/kg* $PV^{0,75}$ *et –93 g/j avec* T_2 *et 78 g/kg* $PV^{0,75}$ *et –37 g/j avec* T_3*. En ce qui concerne les caprins, les valeurs correspondantes étaient respectivement de 104 g/kg* $PV^{0,75}$ *et +44 g/jour avec la ration* T_1*, 88 g/kg* $PV^{0,75}$ *et +34 g/jour avec* T_2 *et 94 g/kg* $PV^{0,75}$ *et +38 g/j avec* T_3*. On a enregistré une baisse du poids vif et du poids sec chez toutes les mères. Quant à la consommation d'eau, elle variait de 1,3 à 4,5 kg par kilo de MS ingérée et était plus élevée chez les ovins que chez les caprins. Les chèvres produisaient près de trois fois plus de lait que les brebis. Enfin, l'utilisation de ces rations contenant du fourrage d'* Atriplex *était généralement meilleure chez les caprins que chez les ovins.*

INTRODUCTION

Halophytic shrubs of the genus *Atriplex*, particularly *A. nummularia* (oldman saltbush), tolerate high levels of salt in soil and water and resist low and high environmental temperatures and droughts (Pasternak et al, 1986; Uchiyama, 1987). With its remarkable phytomass production and regrowth after browsing, and its relatively high crude-protein content and apparent high digestibility coefficients, this shrub might be a valuable protein supplement to nutrient-deficient herbage on rangelands and in arid and saline zones.

Results of previous studies on the effect of *Atriplex* on livestock performance have been inconsistent. In some grazing experiments in Australia, Chile and Israel, no or only temporary advantage could be attributed to the presence of saltbush (eg, Benjamin, 1980; Benjamin et al, 1986; Leigh, 1986). Only from South Africa and Libya it is reported that the addition of *Atriplex* to the diet of sheep substantially increased their liveweight (Jacobs and Smit, 1977; Dumancic et al, 1982).

Goats are reported to be more efficient utilisers of tree and shrub vegetation than sheep (Merrill and Taylor, 1981) but little information is available on their performance on *Atriplex* diets. Goats also appear to drink less water per unit liveweight than sheep (Ghosh, 1987). This is of interest for management decisions, as the ingestion of considerable amounts of salt via *Atriplex*, and the accompanying increase in water consumption (Wilson, 1966; Arieli et al, 1989), may restrict the use of this shrub as feed in arid environments.

This paper reports on a comparative study of the responses of sheep and goats to *Atriplex* diets with varying proportions of ground vegetation or concentrate supplement. The parameters assessed were liveweight, chemical body composition, milk production and intake of free water and dry matter.

MATERIALS AND METHODS

The experiment was carried out at the Migda Experimental Station in northern Negev, Israel (longitude 34° 35′ E; latitude 31° 22′ N; altitude 100 m) during the early dry season (24 March to 20 May 1988). The site is situated in a semi-arid area with a mediterranean type steppe climate and annual rainfall of 270 mm (SD=70 mm), all of which falls between November and April. In 1983, a 3-ha field had been planted with *A. nummularia* shrubs at a density of 1056 shrubs/ha. In summer 1987 the plantation was grazed until the shrubs were completely defoliated. They had a good biomass regrowth before the experiment began. The field was divided into three equal sections, one for each treatment, and each section was subdivided into two plots, one for sheep and one for goats. Two of the sections were sprayed with a herbicide to reduce the availability of natural herbaceous ground vegetation and one was left undisturbed. Ground vegetation consisted primarily of annual and perennial grasses and a few forbs and thistles.

The experimental animals were German Mutton Merino x Awassi x Finnish Landrace sheep and Damascus x Local Black Bedouin goats. Fifteen ewes and 15 does, each suckling a single offspring, were selected and, within each species, were divided into three equal groups by matching for date of parturition and liveweights of mothers and offspring. The three groups of each species, consisting of five mothers with their five offspring, were then allocated to one of the following grazing treatments:

- *A. nummularia* shrubs and undisturbed ground vegetation without supplementary feeding (T1)
- *A. nummularia* shrubs and reduced ground vegetation without supplementary feeding (T2)
- *A. nummularia* shrubs and reduced ground vegetation plus concentrate supplementation (T3).

Treatment T1 represented good ground vegetation biomass availability after a winter with high rainfall, while treatments T2 and T3 represented biomass availability following a drought.

Animals began grazing at about 0800 hours and were corralled at the end of the day at about 1600 hours, at which time mothers in the T3 groups were individually fed 300 g pelleted concentrate feed (consisting mainly of maize, barley grain and soy). The animals changed to the next replicate plot when all the shrubs in their respective plot were completely defoliated, even if some ground vegetation still remained. Therefore, the total number of grazing days was not equal for all treatments. Grazing times on T1, T2 and T3 were, respectively, 47, 44 and 44 days for sheep and 47, 44 and 48 days for goats.

Before and after grazing in each plot the animals were separated from feed and water and the adults were injected intramuscularly with about 1 mg tritiated water (TOH), at the rate of 5 μCi/kg liveweight, four hours after separation; the exact dosage of TOH was determined by weighing the syringes before and after the injection. Blood samples (10 ml) were taken from the jugular vein before the TOH injection and again after a further fast of 12 hours when TOH had equilibrated. At times of blood sampling all animals were weighed to the nearest 0.5 kg to determine shrunk liveweight.

Plasma was separated by centrifugation and stored at –4°C. Duplicate sub-samples (100 mg) of plasma per animal were weighed to the nearest milligram into counting vials. The samples were mixed with 5 ml of Bray's scintillation fluid and stored in the dark for 24 hours. Samples, and diluted TOH standards, were counted for radioactivity in a Kontron liquid scintillation counter for three minutes. The results were corrected for quenching and background activities and expressed as disintegrations per minute (dpm). When radioactivity of plasma duplicates differed by more than 5% a new set of duplicates was prepared.

The following formulae were used to calculate body water space labelled by tritium dilution (TOH space) and body solids:

$$\textit{TOH space (kg)} = \frac{(dpm/mg\ standard) \times (mg\ TOH\ injected)}{(dpm/mg\ plasma\ sample) \times 1\ 000\ 000}$$

Body solids (kg) = liveweight (kg) – TOH space (kg)

The average daily dry-matter intake was calculated from the difference of estimated biomass of the vegetation components before and after grazing in each plot. Shrub biomass was estimated by the method of Seligman et al (1986) and ground vegetation biomass was determined by the calibrated weight estimate method of Tadmor et al (1975).

Samples of feedstuffs were dried and ground to pass through a 1-mm screen. Crude protein (N x 6.25) was determined by the Kjeldahl method and crude ash was obtained by incinerating at 550°C for four hours. The *in vitro* digestibility of feedstuff dry matter was determined by the method of Tilley and Terry (1963).

Water troughs equipped with swimmer automates supplied groups of animals separately. The flow of water was measured with an automatic water meter. Drinking water was available *ad libitum*, but access to the troughs was restricted to one hour after grazing commenced in the morning and one hour at the end of the day.

Daily (24-hour) milk production was estimated four times in each group. Two methods were used. In one, offspring were separated from their mothers for 12 hours and then weighed on an electronic balance, accurate to 25 g, before and after suckling. The process was repeated after another 12 hours of separation. In the second method, mothers were separated from their offspring for 12 hours and then injected with 5 ml of oxytocin per animal. Afterwards, their udders were milked out by hand and the amount of milk was measured volumetrically. Total milk produced per day per mother was calculated by summation.

Three-way analyses of variance were carried out for different criteria using species, treatment and replicate as independent variables. Computations were done using the statistical package Statview–512.

RESULTS AND DISCUSSION

Nutritive value of feedstuffs

Crude-protein and crude-ash contents and *in vitro* digestibility of *A. nummularia*, ground vegetation and concentrate feed are summarised in Table 1. (The *Atriplex* samples analysed comprised 25% soft terminal twigs and 75% leaves; these were the proportions of the plant parts seen to be eaten by the animals.) The crude-protein content of *Atriplex* (10.5%) is at the lower end of the expected range (Beadle et al, 1957; Kandil and El Shaer, 1989). The digestibility of *Atriplex* (73.3%) is, however, slightly higher than expected (Benjamin et al, 1986. 1987a; Silva-Colomer et al, 1986). The ground vegetation remained green for about 10 days at the beginning of the experiment but then dried out within eight days.

Dry-matter intake

Dry-matter intake was measured for each "production unit" (mother and offspring) rather than for individual animals. Results are shown in Table 2.

Intakes were highest in T1, where the high proportion of ground vegetation in the total diet represented good biomass availability after a winter with high rainfall. In T2 and T3, where the ground vegetation was artificially limited to represent a drought year, total intakes decreased but the share of *Atriplex* increased. The intake depression was more pronounced in sheep than in goats. Feeding the concentrate supplement (T3) increased total intake of goats but suppressed intake of *Atriplex*. In sheep fed the concentrate, total intake decreased slightly.

Table 1. *Crude-protein and crude-ash contents and* in vitro *dry-matter digestibilities of feedstuffs*

	Crude protein (%)		Crude ash (%)		*In vitro* dry-matter digestibility (%)	
Feedstuff	Mean	SD	Mean	SD	Mean	SD
Atriplex nummularia	10.5	1.55	25.2	1.66	73.3	3.51
Ground vegetation						
Green	8.9	0.28	9.0	0.77	75.2	0.69
Dry	5.0	1.35	7.5	0.99	44.1	3.89
Concentrate	15.4	0.68	7.7	0.56	81.4	1.21

Table 2. *Daily dry-matter intakes of sheep and goats*

	Content in total diet (%)		Dry-matter intake per production unit (mother + offspring)							
			Ground vegetation (g/day)		*Atriplex* (g/day)		Con-centrate (g/day)	Total	
Treatment	Ground vegetation	*Atriplex*	Mean	SD	Mean	SD		g/day	g/kg $LW^{0.75}$ per day[a]
Sheep									
T1	72.6	27.4	2401	238	907	375	0	3308	106.2
T2	51.9	48.1	1248	197	1157	92	0	2405	80.4
T3	43.5	43.6	1018	255	1020	135	300	2338	77.6
Goats									
T1	72.6	27.4	1944	193	734	413	0	2678	104.4
T2	49.7	50.3	1099	231	1113	99	0	2212	88.1
T3	48.9	38.3	1148	110	899	89	300	2347	93.6

[a] Mean metabolic weight calculated as mean $LW^{0.75}$ of mother plus mean $LW^{0.75}$ of offspring
T1 = *A. nummularia* shrubs and undisturbed ground vegetation without supplementary feeding
T2 = *A. nummularia* shrubs and reduced ground vegetation without supplementary feeding
T3 = *A. nummularia* shrubs and reduced ground vegetation plus concentrate supplementation

Water intake

Daily free-water intakes of sheep and goats and their offspring are shown in Table 3. Average absolute water intake remained constant within species, irrespective of treatment, with goats drinking less than sheep. This constancy does not mean that water intake was unaffected by treatment; the reduced dry-matter intake, and therefore the reduced water demand, in T2 and T3 obviously just compensated the increased water requirements with enhanced *Atriplex* intake. Actually the ratio of water to feed intake rose in T2 and T3. Sheep were more affected than goats.

With time, and therefore increasing temperatures and decreasing moisture content of the ground vegetation, water intake increased significantly ($P<0.01$). In sheep in T2, for example, the absolute water intake almost trebled, from 3.6 to 9.5 kg. This effect largely masked minor influences from species or treatment.

Other studies of sheep on *Atriplex* diets have found water-intake values of 1–8 kg/head or 0.5–5.9 kg/kg DMI (Wilson, 1966), 4–8 kg/head (Jacobs and Smit, 1977) and 7.9 kg/head or 10.3 kg/kg DMI (Arieli et al, 1989). For goats, values of 0.5–1.6 kg/head (Hassan et al, 1982) and 3–4 kg/head or 4–6 kg/kg DMI (Kandil and El Shaer, 1989) are reported. Ghosh (1987) quotes several sources where goats had lower water requirements than sheep under similar

Table 3. *Mean daily water intake and ratio of water to feed intake of sheep and goats*

	Water intake per production unit (mother + offspring)			
	kg/day			
Treatment	Mean	SD	kg/kg DMI[a] per day	kg/kg $LW^{0.82}$ per day[b]
Sheep				
T1	6.44	2.35	1.95	0.16
T2	6.23	1.58	2.56	0.16
T3	6.71	2.21	2.98	0.17
Goats				
T1	5.27	2.18	1.94	0.16
T2	5.25	1.46	2.34	0.16
T3	4.99	2.14	2.14	0.16

[a] Total dry-matter intake, including concentrate
[b] Mean metabolic weight calculated as mean $LW^{0.82}$ of mother plus mean $LW^{0.82}$ of offspring
T1 = *A. nummularia* shrubs and undisturbed ground vegetation without supplementary feeding
T2 = *A. nummularia* shrubs and reduced ground vegetation without supplementary feeding
T3 = *A. nummularia* shrubs and reduced ground vegetation plus concentrate supplementation

conditions (values in the ranges 0.09–0.19 kg/kg $LW^{0.82}$ in goats and 0.11–0.21 kg/kg $LW^{0.82}$ in sheep). In the present study water intake on a metabolic weight basis was not different between sheep and goats but absolute water intake and the water to feed intake ratio were lower in goats. In general the values are very comparable to those of Ghosh (1987), although those were not established on *Atriplex* diets.

Milk production

Milk production of ewes and does, as determined by two methods, is shown in Table 4. The two methods did not produce constantly different or similar results, and neither method could be clearly preferred over the other. Theoretically, the oxytocin method should give slightly higher values as the residual milk in the udder, which is not normally released, is included.

Several factors, such as the difference in time between sampling days and therefore possibly different milk production, and minor technical disturbances (wind, spillage), made both techniques rather crude and, given the high standard deviation of the data, it was not possible to quantify the influence of diet treatment on milk production of ewes or does. However, in both cases the methodology was good enough to show huge differences in milk production between ewes and does. On average, kids received almost three times as much milk as lambs did (618 vs 224 ml) and this difference was clearly reflected in the higher weight gains of kids compared to lambs.

Table 4. *Milk production of ewes and does, measured by two methods*

	Milk production (ml/day)				
	Weighing		Oxytocin		
Treatment	Mean	SD	Mean	SD	Average
Ewes					
T1	280	220	116	112	198
T2	170	157	296	234	233
T3	200	160	280	180	240
Does					
T1	860	540	538	98	699
T2	610	417	442	203	526
T3	650	366	610	187	630

T1 = *A. nummularia* shrubs and undisturbed ground vegetation without supplementary feeding
T2 = *A. nummularia* shrubs and reduced ground vegetation without supplementary feeding
T3 = *A. nummularia* shrubs and reduced ground vegetation plus concentrate supplementation

Liveweights

Mean liveweights and liveweight changes of ewes, lambs, does and kids are presented in Table 5. Initial liveweights within a class of animal (ewes, lambs, does, kids) were not significantly different (P>0.05). Between species and between classes of animals there were significant differences (P<0.05). All mothers lost weight; all offspring gained weight. On a production unit (mother plus offspring) basis, sheep lost weight and goats gained weight in all treatments.

Gains of kids tended to decrease on reduced ground vegetation (T2) compared to T1, but losses of does remained constant. For sheep, gains of lambs were constant but ewes lost weight significantly. Compared to T2, concentrate supplements (T3) improved performance of all classes of animals except does.

Differences between treatments were not significant (P>0.05). Nevertheless, they seem to be real as they largely correspond to the pattern found in the milk production and feed intake results.

In a similar trial at the same site in the wet season, lactating ewes lost 147 and 18 g/day at high and low stocking rates, respectively, while their suckling lambs gained more than 200 g/day. The animals browsed about 700 g DM/day from shrubs including *Atriplex*; although little ground vegetation was available they received 1.5 kg concentrate per ewe (Benjamin et al, 1987b). Compared to that result, a maximum average loss of 120 g/day per ewe and a gain of 27 g/day per lamb in T2, where no concentrate was given and ground vegetation was limited, seems a rather good performance at a low input level. In a study by Dumancic et al (1982), ewes fed in pens on cut-and-carry *A. nummularia* or *A. halimus* showed liveweight changes of 10 and –27 g/day, respectively.

Table 5. *Mean liveweights and liveweight changes of ewes, lambs, does and kids*

Treatment	Ewes	Lambs	Ewes + lambs	Does	Kids	Does + kids
Liveweight at start of experiment (kg)						
T1	49.3	27.1	76.4	38.0	20.3	58.3
T2	51.4	27.1	78.5	38.7	20.2	58.9
T3	49.6	25.6	75.2	38.0	20.5	58.5
Liveweight change during experiment (g/day)						
T1	–57a	26	–31	–37	81	44
T2	–120b	27	–93	–32	66	34
T3	–80a	43	–37	–40	77	38

Within a column and data set, means followed by the same letter, or no letter, do not differ significantly (P>0.05). Species always differed significantly (P<0.05)

T1 = *A. nummularia* shrubs and undisturbed ground vegetation without supplementary feeding
T2 = *A. nummularia* shrubs and reduced ground vegetation without supplementary feeding
T3 = *A. nummularia* shrubs and reduced ground vegetation plus concentrate supplementation

Body solids

Mean body solids and their changes in ewes and does are shown in Table 6. All mothers lost body solids. Both ewes and does lost more body solids in T2, where ground vegetation was limited, than they did in T1. The relationship confirms the losses in liveweight of these groups. The heavy loss in liveweight of ewes in T3 is not reflected to the same extent by a loss in body solids. It is possible that ewes profited relatively more from the concentrate supplement than does did.

Table 6. *Mean body solids and their changes in ewes and does*

Treatment	Ewes	Does
Body solids at start of experiment (kg)		
T1	14.7a	9.4a
T2	18.0b	11.2b
T3	14.2a	11.4a
Change in body solids during experiment (g/day)		
T1	–100a	–60a
T2	–175b	–98b
T3	–9c	–94b

Within a column and data set, means followed by the same letter do not differ significantly (P>0.05). Species always differed significantly (P<0.05)

T1 = *A. nummularia* shrubs and undisturbed ground vegetation without supplementary feeding
T2 = *A. nummularia* shrubs and reduced ground vegetation without supplementary feeding
T3 = *A. nummularia* shrubs and reduced ground vegetation plus concentrate supplementation

The absolute values for body solids are probably underestimated as they were calculated from the TOH dilution space, and the TOH space may overestimate actual total body water (Panaretto and Till, 1963; Donnelly and Freer, 1974). A correction factor might be applied but it would affect the results equally and the relative change would remain the same. The daily losses of body solids were higher (except for ewes in T3) than the losses in liveweight. This means that the animals melted down their body fat reserves and incorporated water to the extent of around 50 g/day. In other studies where *Atriplex* was a major part of the diet, both sheep and goats increased the proportion of water in their bodies (MacFarlane et al, 1967).

CONCLUSIONS

In the early dry season *Atriplex*–grassland pastures can provide enough nutrients to does and kids for combined net weight gain, but not to ewes and lambs. Hence, goats tend to utilise *Atriplex* diets better than sheep do.

Goats tend to drink less water than sheep, and to have a lower water to feed intake ratio, when fed *Atriplex* diets, although their milk production is higher than that of sheep.

Even small amounts of concentrate improve the performance of mothers and offspring fed diets containing about 50% *Atriplex*.

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RESPONSES TO A *PENNISETUM PURPUREUM* (NAPIER GRASS) BASAL DIET HARVESTED AT TWO DIFFERENT HEIGHTS AND FED WITH THREE LEVELS OF *LEUCAENA* FORAGE TO CROSSBRED DAIRY COWS IN THE SUBHUMID TROPICS

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ABSTRACT

Smallholder dairy production based on zero-grazed Napier grass (*Pennisetum purpureum* cv Bana) fed to crossbred *Bos taurus* x *Bos indicus* cows has been introduced to tropical subhumid East Africa. *Leucaena leucocephala* forage offers a cheap, convenient source of supplementary protein. Thirty-six Ayrshire/ Brown Swiss x Sahiwal cows with one to four previous lactations and which calved during the period 26 March to 2 August 1990 were stall-fed individually to evaluate the effects of harvesting height of Napier grass (1.0 or 1.5 m) and level of *Leucaena* supplement (0, 4 or 8 kg fresh weight) on dry-matter (DM) intake of Napier grass, total DM intake, liveweight change and milk yield. The study began on day 15 of lactation and lasted 98 days. Average daily milk yield and liveweight during the second week of lactation were covariates for milk yield, and for DM intake and liveweight change, respectively. Harvesting height of Napier grass significantly ($P<0.001$) affected Napier fodder and total DM intakes, liveweight losses and average daily milk yield. Supplementation with *Leucaena* tended to increase Napier fodder intake, significantly ($P<0.001$) increased total DM intake and reduced liveweight loss, and increased ($P<0.05$) milk yield. The results indicate the importance of stage of harvesting of Napier fodder and the benefits from *Leucaena* supplementation in attaining an acceptable level of performance from crossbred dairy cows in the subhumid tropics.

RESUME

***Effet sur des vaches laitières métisses d'un aliment de base de* Pennisetum purpureum *(herbe à éléphant) récolté à deux hauteurs de coupe complémenté avec trois niveaux de fourrage de* Leucaena**

L'alimentation à l'auge de vaches métisses Bos taurus x Bos indicus *avec des rations de base composées d'herbe à éléphant (*Pennisetum purpureum*) a été récemment introduite dans les petites exploitations laitières de la zone tropicale subhumide de l'Afrique de l'Est. Les fourrages de* Leucaena leucocephala *constituent une source bon marché de complémentation protéique. 36 vaches Ayrshire/Brown Swiss x Sahiwal qui avaient connu de une à quatre lactations dans le passé et avaient vêlé entre le 26 mars et le 2 août 1990 avaient été individuellement alimentées à l'auge en vue d'évaluer l'effet de la hauteur de coupe de l'herbe à éléphant (1 m et 1,5 m) et du niveau de complémentation de* Leucaena *(0,4 et 8 kg de fourrage) sur la consommation de matière sèche de* Pennisetum, *la consommation totale de matière sèche, les variations de poids vif et la production de lait. L'expérience a démarré au 15^{e} jour de lactation et a duré 98 jours. La production moyenne de lait par jour et le poids vif enregistrés au cours de la deuxième semaine de lactation étaient les covariables respectivement de la production de lait d'une part et de la consommation de matière sèche et des variations du poids vif de l'autre. La hauteur de coupe avait un effet significatif (P<0,001) sur la consommation de matière sèche totale et de matière sèche d'herbe à éléphant. L'apport de* Leucaena *se traduisait par un accroissement de la consommation d'herbe à éléphant, une augmentation significative (P<0,001) de la consommation totale de matière sèche, une baisse significative (P<0,001) des pertes de poids et un accroissement (P<0,05) de la production de lait. Ces résultats fônt ressortir l'importance du stade de coupe de l'herbe à éléphant et les avantages d'une complémentation de* Leucaena *pour les performances des vaches laitières métisses en zone tropicale subhumide.*

INTRODUCTION

A major constraint on dairy development in coastal subhumid Kenya is the inadequacy of feed resources available on the mixed crop–livestock smallholder farms targeted in the Ministry of Livestock Development's National Dairy Development Programme (NDDP). Soils are free-draining and low in organic matter and fertility, factors which limit the productivity of forages.

Natural pasture is scarce and of poor quality, and its availability in the future may be further restricted by subdivisions of farms into smaller units. Land tenure is freehold. Significant quantities of crop byproducts, with the exception of copra cake and maize bran, are not available. Cash shortages often limit the purchase of these concentrates by smallholder farmers.

To address these problems the Kenya Agricultural Research Institute and the International Livestock Centre for Africa carry out collaborative research on feed resources at the Regional Research Centre, Mtwapa, near Mombasa. The research focuses on developing systems with minimal purchased inputs which can intensify and sustain the production and utilisation of forages. The zero-grazing package extended by the NDDP to smallholders is the target, and the objective is to have profitable milk production through producing, on-farm, adequate quantities of good quality dry matter for feeding throughout the year.

A review of past on-station forage research at the coast indicated the potential of Napier grass (*Pennisetum purpureum* cv Bana), the legume shrub *Leucaena* and some herbaceous legumes. Experiences with these forages on farms supported by the NDDP, and the absence of research-based management recommendations, showed that on-station agronomic trials were required. The agronomy research concentrates on improving soil fertility and water-holding capacity through growing the Napier grass in an alley farming system utilising *Leucaena* hedgerows, combined with intercropped herbaceous legumes and the application of slurry (manure) (Mureithi, 1990).

The animal nutrition research is integrated closely with the forage agronomy programme. Its objective is to develop feeding systems for zero-grazed cows utilising the forage species from the agronomy programme. The experiments have measured feed intakes, liveweight changes and lactation performance of dairy cows fed a basal forage (Napier grass) diet supplemented with protein using locally produced feeds, especially legume forages, and the local crop byproducts copra cake and maize bran.

An experiment in 1989 with Jersey cows supplemented with 300 g crude protein (CP) showed that dry-matter (DM) intakes and milk yields were similar whether the protein supplement was supplied by copra cake or fresh *Leucaena* forage. This result suggested that reasonable performance could be achieved by supplementing a Napier basal diet with only a legume forage, which could be produced cheaply and conveniently on-farm. Consequently during 1990 an experiment was carried out to evaluate the effects on cow performance of level of *Leucaena* supplement and of the harvesting height of the Napier basal fodder.

MATERIALS AND METHODS

Study site

The experiment was carried out at the Regional Research Centre, Mtwapa, Kenya, 20 km north-west of Mombasa in the coastal lowland coconut–cassava agro-ecological zone (Jaetzold and Schimdt, 1983). During the study period, March to November 1990, mean monthly minimum and maximum temperatures were 20–24 and 24–27°C, respectively, and relative humidity was high. During most of the experiment there was good rainfall and fast Napier grass growth.

Animals

Thirty-six Ayrshire/Brown Swiss x Sahiwal cows of known breed composition, previous performance and service dates were purchased from a large local dairy farm. They were representative of the crossbred dairy population found on smallholder farms at the Kenya coast. They had had one to four previous lactations. The cows were housed in a well ventilated zero-grazing unit where they were fed chopped Napier fodder and some copra cake and maize bran until calving. They were treated with the trypanocidal prophylactic drug isometamidium chloride (Samorin), and drenched with levamisole hydrochloride/oxyclozanide (Nilzan) against internal parasites. They were sprayed weekly with a diamidide acaricide (Triatix) to control tick-borne diseases.

Diets

Napier grass (*Pennisetum purpureum* cv Bana) was harvested daily at heights of 1.0 or 1.5 m, chopped with a motorised chopper into pieces about 20–50 mm long and mixed thoroughly before feeding. *Leucaena* forage (about 280 g crude protein/kg DM, 250 g DM/kg fresh matter) was harvested from well-established hedgerows of the variety K28. It was cut in the evening for morning feeding and in the morning for the afternoon feeding. Stems thicker than 5 mm in diameter were removed from the forage before feeding.

Experiment procedure

The 36 cows were allocated to two groups with greater or less than 50% Sahiwal genes. Cows from each group were then assigned at calving to treatment groups in a 2 x 3 factorial design to evaluate the effects of harvesting height of Napier (1.0 or 1.5 m) and level of *Leucaena* supplement (0, 4 or 8 kg fresh weight). Where possible the six treatment groups were balanced for postpartum body weight. All cows had good body condition. The cows calved between 26 March and 2 August and the experiment began on day 15 of lactation and lasted 98 days.

The cows were confined in individual stalls in the zero-grazing unit. Body weights were recorded the day after calving, and weekly thereafter before morning feeding. The cows were hand-milked at about 0500 and 1500 hours and the milk production recorded. Water and mineral lick (19.95% Ca, 11.76% P, 10.26% Na, 0.16% Cu) were available at all times. Napier fodder was offered at least twice daily to ensure constant availability of the fodder for *ad libitum* feeding. From day 15 of lactation, the cows were fed according to treatment group, the *ad libitum* Napier fodder, harvested at a height of 1.0 or 1.5 m, supplemented with 0, 4 or 8 kg fresh weight of *Leucaena* forage. Feed refusals were weighed and recorded before milking on the following day. There were no

Leucaena refusals. The *Leucaena* forage offered and the Napier fodder offered and refused were sampled weekly on consecutive days; half of each sample was dried at 85°C for laboratory analysis and the other half at 105°C for dry-matter determination. Blood was sampled every fortnight to screen for trypanosomes, and other health measures were taken as necessary.

Statistical analysis

Dry-matter (DM) intake of Napier, total DM intake, body weight change and milk yield were analysed using the General Linear Model (GLM) for covariance analysis of the SAS (1987) computer package. The linear model included the independent variables, calving period (before or after the end of May), breed group, Napier harvesting height, level of *Leucaena* supplement and the interaction of the latter two factors. Second-week body weight was a covariate in the analyses of DM intake and liveweight change. Average daily milk yield in the second week of lactation was a covariate for milk yield.

RESULTS

Only results for the production traits are presented here. Laboratory analyses giving the digestibility, metabolisable energy and protein levels of the forage samples are not yet available. These laboratory results will determine the final interpretation of, and conclusions from, the results for the production traits.

All cows were in good health throughout the experiment, with the exception of one cow which had to be replaced early in the experiment because of severe mastitis, and another two cases of metritis which responded quickly to treatment.

Feed intake

Dry-matter intake of the basal Napier fodder was significantly ($P<0.001$) affected by the harvesting height of the Napier grass (Table 1). The provision of the *Leucaena* forage supplement did not significantly affect Napier dry-matter intake. Not only was there no substitution effect, but there was an indication of some stimulation of Napier intake when cows received the *Leucaena* supplement. Consequently total DM intake was significantly affected ($P<0.001$) both by harvesting height of Napier and by level of *Leucaena* supplement.

Despite the large effects of Napier harvesting height and level of *Leucaena* supplement there was no significant harvesting height x supplement interaction. However, there were indications in the latter period of the experiment that interactions may have been important.

When expressed as a proportion of body weight, total DM intake for the six dietary combinations ranged from 1.8 to 2.8%.

Table 1. *Mean daily Napier fodder and total (Napier plus* Leucaena*) dry-matter intakes of lactating crossbred cows fed* ad libitum *Napier fodder harvested at 1.0 or 1.5 m supplemented with 0, 4 or 8 kg fresh* Leucaena *forage from day 15 to day 112 of lactation*

		Mean dry-matter intake (kg/day)	
Treatment	n	Napier	Total (Napier plus *Leucaena*)
Napier harvest height (m)			
1.0	18	9.3	10.5
1.5	17	6.8	7.9
SE		0.29	0.29
F-test of probability		P<0.001	P<0.001
***Leucaena* supplement (kg)**			
0	12	7.8	7.8
4	11	8.2	9.3
8	12	8.2	10.4
SE		0.35	
F-test of probability		ns	P<0.001

Body weight changes

Body weight losses occurred in all treatment groups, but the losses were more marked in weeks 3 to 9 of lactation than later (Table 2).

There were no significant, nor apparently important, harvest height x *Leucaena* supplement interactions for body weight change.

Milk production

Over the 14 weeks of the experiment both harvest height of Napier and level of *Leucaena* supplement had significant effects (P<0.001 and P<0.05, respectively) on mean daily milk yield (Table 3). Napier fodder harvested at 1.0 m rather than 1.5 m gave on average 1.7 kg (25%) per day more milk, with a greater advantage (32% compared to 18%) in the second half of the experiment. Similarly there was a differential response to level of *Leucaena* supplement during the two halves of the experiment. The supplement did not affect mean daily milk yield during weeks 3 to 9 of lactation when body weight losses (Table 2) were marked, but it did have a significant (P<0.01) effect on milk yields in weeks 10 to 16 when body weight losses were lower. In the latter period, each 4 kg of fresh *Leucaena* (about 1 kg DM) gave a response of about 0.8 kg more milk.

There were no significant Napier grass harvest height x level of *Leucaena* supplement interactions, but there were indications that in the latter half of the experiment responses to *Leucaena* supplementation were higher in cows fed Napier fodder harvested at 1.5 m.

Table 2. *Mean body weight changes for lactating crossbred cows fed* ad libitum *Napier fodder harvested at 1.0 or 1.5 m supplemented with 0, 4 or 8 kg fresh weight* Leucaena *forage from day 15 to day 112 of lactation*

	Mean body weight change (kg)					
	Days 15–63		Days 64–112		Overall	
Treatment	n	Mean	n	Mean	n	Mean
Napier harvest height (m)						
1.0	18	–8	18	–8	18	–16
1.5	18	–30	17	–18	17	–48
SE		6.3		4.4		7.1
F-test of probability		P<0.01		P<0.05		P<0.001
***Leucaena* supplement (kg)**						
0	12	–37	12	–18	12	–55
4	12	–10	11	–10	11	–20
8	12	–10	12	–10	12	–20
SE		7.9		5.5		9.0
F-test of probability		P<0.01		ns		P<0.01

Table 3. *Mean daily milk yield for lactating crossbred cows fed* ad libitum *Napier fodder harvested at 1.0 or 1.5 m supplemented with 0, 4 or 8 kg fresh weight* Leucaena *forage from day 15 to day 112 of lactation*

	Mean milk yield (kg/day)					
	Days 15–63		Days 64–112		Overall	
Treatment	n	Mean	n	Mean	n	Mean
Napier harvest height (m)						
1.0	18	9.4	18	7.8	18	8.5
1.5	18	8.0	17	5.9	17	6.8
SE		0.30		0.35		0.30
F-test of probability		P<0.001		P<0.001		P<0.001
***Leucaena* supplement (kg)**						
0	12	8.6	12	6.0	12	7.2
4	12	3.7	11	6.8	11	7.6
8	12	8.9	12	7.7	12	8.3
SE		0.36		0.42		0.36
F-test of probability		ns		P<0.01		P<0.05

DISCUSSION

This work set out to test the hypothesis that reasonable dairy cow performance could be achieved by supplementing a basal diet of Napier fodder with only a legume forage. Major improvements in performance were observed in cows fed Napier fodder harvested at 1.0 m height, supplemented with 4 or 8 kg fresh weight of *Leucaena*. Cows fed this diet had high DM intakes (approaching 3% of body weight) which enabled them to maintain body weight and produce about 1000 kg milk in less than the first three months of lactation. With reasonable subsequent nutrition a total lactation yield of at least 2000 kg could be expected.

The results highlight the important contribution legume forages can make to achieving reasonable performance and to improving the utilisation of basal forage diets. The higher level of *Leucaena* supplement gave on average 15% more milk over the period of the experiment. The lack of response in the earlier months may be explained by the greater mobilisation of body reserves by cows not receiving *Leucaena* compared with those that were given the supplement. Thus the main effect of *Leucaena* in early lactation was to reduce the loss of body weight. In the third and fourth months of lactation the effect of the supplement on milk production was large, with each 1 kg of *Leucaena* DM stimulating the production of about 0.8 kg of milk. Thus *Leucaena* supplementation can make a very efficient contribution, both biologically and economically, towards improving cow performance.

In the absence of laboratory analyses of the forages used in the experiment, calculations based on expected values indicated that the diets were deficient in energy. A small quantity of an energy-rich concentrate, maize bran, for example, would therefore allow cows supplemented with *Leucaena* to utilise the available protein more efficiently and produce more milk very cost-effectively. This hypothesis was tested in a subsequent experiment which is now being analysed.

In the context of the smallholder, the legume is also expected to play an important complementary role in improving the stability and sustainability of Napier yields. As mentioned in the introduction, the agronomic studies, which run concurrently with the nutrition research, evaluate the productivity and sustainability of fodder production systems combining shrub and herbaceous legumes grown in association with Napier grass. These studies will quantify the output per unit area of sole stands of Napier grass and *Leucaena* and of their mixed stands and intercrops with herbaceous legumes.

The importance of these agronomic studies is emphasised by the large effect on cow performance of the harvesting height of the Napier fodder. By quantifying the yields of Napier harvested at different heights throughout the year, and then feeding those Napier fodders to cows in experiments similar to that reported here, it will be possible to assess the relative productivities of the systems in terms of output per area and per cow. When labour inputs are included in the calculations, an economic evaluation can be applied and recommendatio developed.

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PERFORMANCE AND MANAGEMENT OF SHEEP ON RHODES GRASS–STYLO PASTURE IN NIGERIA

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ABSTRACT

An experiment was designed to study the effect of stocking rate on dry-matter yield and animal performance on Rhodes grass–stylo (*Chloris gayana* cv Callide–*Stylosanthes guianensis* cv Cook) pasture over three grazing periods (1986–1989) at Shika, Zaria, Nigeria. Sheep were continuously grazed at 12, 18, 24, 30 and 36 sheep/ha during the late wet to mid-dry season for 154 to 210 days in each grazing period.

Stylo was eliminated after the first grazing period. Rhodes grass was still dominant after three grazing periods. Yields of green and dead materials fell as stocking rate increased. Daily liveweight gain decreased as stocking rate increased and, gradually, as grazing progressed. Problems of managing sheep on pasture, with respect to animal age and weight, time to commence grazing and to give supplementary feed, and routine health practices, are discussed.

RESUME

Performances et gestion d'ovins élevés sur pâturage d'herbe de Rhodes et de* Stylosanthes *au Nigéria

Une expérience a été effectuée à Shika dans la région de Zaria (Nigéria) en vue d'étudier l'effet du taux de charge sur la production de matière sèche d'un *pâturage d'herbe de Rhodes (*Chloris gayana *cv. Callide) et de* Stylosanthes (Stylosanthes guianensis *cv. Cook) ainsi que sur les performances d'ovins élevés sur ce pâturage. Conduit pendant trois périodes de pâturage (1986/89) longues chacune de 154 à 210 jours et allant de la fin de la saison humide au milieu de la saison sèche, cet essai a porté sur des taux de charge de 12, 18, 24, 30 et 36 animaux par hectare.*

La légumineuse a été éliminée dès la fin de la première période de pâturage alors que l'herbe de Rhodes demeurait l'espèce dominante à la fin de la troisième période. La production de matériel végétal, qu'il soit vert ou sec, baissait avec l'accroissement du taux de charge. Les gains moyens quotidiens diminuaient progressivement au fil du temps et au fur et à mesure qu'augmentait le taux de charge. Les problèmes liés à la gestion des élevages ovins sur pâturage ont été examinés, notamment en ce qui concerne l'âge et le poids des animaux, le choix du moment d'accès au pâturage ou aux aliments complémentaires ainsi que les interventions sanitaires de routine.

INTRODUCTION

The present system of sheep production in the Northern Guinea Savanna zone of Nigeria is based on indoor feeding, grazing of natural or sown pastures or a combination of these. The grazing of sown pastures is limited to universities, research institutions and a few private farms where the performance of sheep can be better evaluated.

There have been few grazing trials in Nigeria to determine productivity of pasture, especially with sheep. In the humid zone, Sumberg (1985) grazed West African Dwarf sheep on natural fallow regrowth in an integrated alley-farming system sown to *Leucaena leucocephala* and *Gliricidia sepium*, and reported that 16 and 8 ewes could be supported per hectare during the wet (June–November) and dry (November–March) seasons, respectively. He recorded a liveweight gain of 218 kg/ha from ewes supplemented with concentrate during the dry season.

This study reports the effect of set stocking at the rates of 12, 18, 24, 30 and 36 rams/ha on the yield of a Rhodes grass–stylo pasture and on animal liveweight gain.

MATERIALS AND METHODS

The experiment was carried out at the National Animal Production Research Institute at Shika in the Northern Guinea Savanna zone of Nigeria. Climatic data for the study area during the study period are presented in Table 1. The soils at Shika are classified as ferruginous tropical soils (Klinkenberg and Higgins, 1968).

The animals used in the trial were Yankasa rams, the most common breed of sheep in this ecological zone.

Table 1. *Climatic data for Shika and Samaru (10 km from Shika) during the grazing periods, 1986-1989*

	1986/87	1987/88	1988/89
Shika			
Rainfall (mm)			
During grazing period	420	253.5	88
Total annual	1071	1151	1066
Rainy days			
During grazing period	19	20	9
Total annual	38	47	19
Samaru			
Screen temperature (°C)			
August	23.9	24.5	-
September	24.0	25.4	24.3
October	24.3	24.3	23.4
November	22.8	22.1	21.9
December	19.8	21.4	20.0
January	21.5	21.2	17.1
February	24.7	23.8	20.7
March	27.3	28.4	-

A mixed pasture of Rhodes grass (*Chloris gayana* cv Callide) and stylo (*Stylosanthes guianensis* cv Cook) was sown at the study site in August 1985. Seed was hand broadcast at the rate of 5 kg pure germinating seed (PGS)/ha: the grass:legume seed ratio was 3:7. Phosphorus (30 kg/ha) was applied as single superphosphate at establishment and again in July before each grazing period. The pasture was set stocked on 21 August 1986 for 210 days, on 25 August 1987 for 196 days and on 12 September 1988 for 154 days. Herbage in each paddock was cut back in May before each grazing period to remove uneven growth. Five stocking rates—12, 18, 24, 30 and 36 rams/ha—were arranged in a randomised block design with two replicates. Stocking rates were achieved by adjusting paddock size from 0.25 to 0.09 ha to accommodate three rams at the appropriate rate.

The mean initial liveweight of Yankasa rams used in each grazing period was 20 kg: the mean biomass of the three rams in all paddocks was similar. The animals were treated with an anthelmintic and dipped before grazing began and at four-week intervals thereafter. The animals were not provided with shade or supplementary feed but were given water and mineral salt block in each paddock. Rams were weighed every two weeks after a 14-hour overnight fast (without feed or water) in an enclosure outside the paddocks.

Pasture components were sampled before each grazing period and then every six weeks and at the end of the grazing period. Dry-matter yield on offer was estimated by cutting from six random 0.5 x 0.5 m quadrats in each paddock. The cutting was done at ground level with a hand sickle in the paddocks and cages used as control. The herbage samples were weighed, mixed and two fresh subsamples of about 500 g were taken. One was hand-sorted into green and dead materials; the other remained intact. These were oven dried and weighed.

Data on forage and liveweight gains were subjected to analysis of variance. Duncan's New Multiple Range Test (Steel and Torrie, 1980) was used to compare means of stocking rate and grazing days.

RESULTS

Pasture dry-matter yields are shown in Table 2. Yields of both green and dead material decreased as stocking rate increased. Yields of green material declined significantly ($P<0.05$) as the grazing period progressed, while yields of dead material increased. Stylo constituted only 11.2% of the total pasture yield at the start of grazing in 1986. In the first grazing period (1986–87) the yields of stylo at the various stocking rates were not different ($P>0.05$). The highest stylo yield was recorded in the control plot. Stylo yields declined with increase in grazing days at all stocking rates. Stylo was eliminated in the second grazing period, except in the control plot where a mean yield of less than 0.5 t/ha was recorded.

In all grazing periods, daily liveweight gain of sheep decreased significantly ($P<0.05$) as grazing progressed (Figure 1). Also, weight losses commenced earlier in each successive grazing period. Daily liveweight gain also tended to decrease with increasing stocking rate in all the grazing periods (Table 3). Using the regression $Yh = ax - bx^2$ for liveweight gain per hectare (*Yh*), where *x* is the stocking rate and *a* and *b* are constants, the calculated optimum stocking rates in the first, second and third grazing periods were 20.4, 24.9 and 21.2 sheep/ha. The corresponding liveweight productions were 155.4, 186.2 and 129.4 kg/ha.

DISCUSSION

Stylo did not persist in the mixed pasture beyond the first grazing period. Winter et al (1977), however, reported that stable pastures of *Brachiaria decumbens* and *Panicum maximum* with *S. guianensis* cv Endeavour were obtained after three years of grazing with cattle at 0.7 and 2.2 animals/ha. Stocking rate in the first grazing period did not suppress stylo yield in this trial as was observed in other trials of grass–legume pastures grazed by sheep (Curll and Davidson, 1983; Curll et al, 1985) and by cattle (Stobbs, 1970; Shaw, 1978; Eng et al, 1978).

The observed decline in stylo coverage caused by the companion Rhodes grass agrees with a report from Thailand (Gutteridge, 1985) where ungrazed stems of bamboo grass (*Arundinaria ciliata*) reduced the development of *S.*

Table 2. *Effect of stocking rates and grazing days on dry- matter yields of green and dead materials in the Rhodes grass–stylo pasture*

Pasture component	Dry-matter yield (t/ha)					
Stocking rate (sheep/ha)	*12*	*18*	*24*	*30*	*36*	*Control*
1986/87						
Green	6.96b	6.96b	6.51bc	6.27cd	5.88d	8.67a
Dead	1.27a	1.04b	1.19ab	1.08b	1.05b	0.55c
Stylo	0.56	0.57	0.65	0.50	0.64	1.00
1987/88						
Green	7.55a	7.21bc	7.27bc	6.86c	6.82c	8.81a
Dead	1.41a	1.29ab	1.20abc	1.16abc	1.00bc	0.86c
1988/89						
Green	7.30b	7.00bc	6.83c	6.60c	6.25d	8.88a
Dead	1.29a	1.25a	1.16b	1.01c	0.93c	0.82d
Grazing days	*0*	*42*	*84*	*126*	*168*	*210*
1986/87						
Green	10.3a	9.5b	8.0c	5.4d	4.4e	3.7f
Dead	0.0	0.5d	0.8c	1.6b	1.6b	1.7a
1987/88						
Green	9.5a	9.4a	7.5b	5.9c	4.8d	–
Dead	0.6c	0.8b	1.1b	1.5b	1.7a	–
1988/89						
Green	8.8a	7.8b	6.7c	5.3d	–	–
Dead	0.4d	0.9c	1.3b	1.7a	–	–

Within a row, means followed by the same letter, or no letter, do not differ significantly (P>0.05)

humilis, *S. hamata* cv Verano and *S. guianensis* cv Endeavour. Earlier, Blair Rains (1963) had observed that 24-hour stocking of stylo-based pastures in Nigeria would reduce the legume content. The legume might have performed better if its initial content in the pasture was higher.

Yields of green fodder declined as stocking rate and grazing days increased. This finding supports work by Mears and Humphreys (1974) who reported reductions in green matter of Kikuyu grass (*Pennisetum clandestinum*) as stocking rate increased. Similarly, Watson and Whiteman (1981) reported a drop in green yields of mixed pastures of *Panicum maximum* and *B. decumbens* with the legumes *Centrosema pubescens*, *Macroptilium atropurpureum* cv Siratro and *S. guianensis* cv Endeavour as stocking rate increased from 1.8 to 4.5 animals/ha.

Figure 1. *Daily liveweight changes of sheep during three grazing periods*

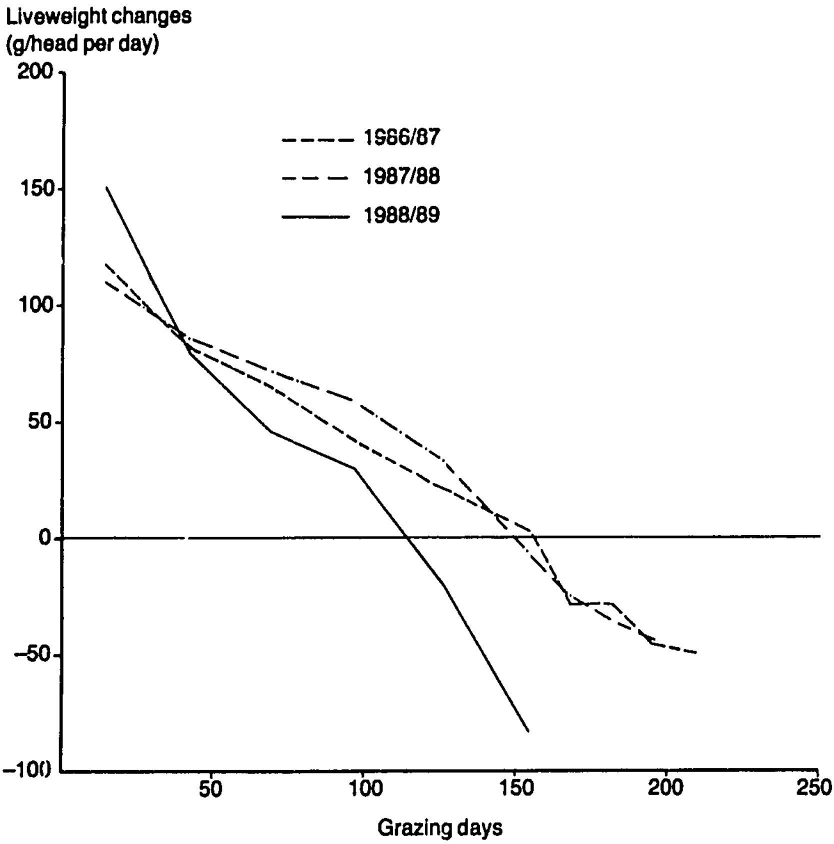

Table 3. *Effect of stocking rate on daily liveweight gain of sheep during three grazing periods*

	Daily liveweight gain (g/head)		
Stocking rate (sheep/ha)	1986/87	1987/88	1988/89
12	52	61	60
18	39	47	47
24	33	36	26
30	14	31	23
36	11	23	16

The consumption of a high percentage of the green materials and subsequent restriction of the formation of dead material (Greenwood and Arnold, 1968) and possible consumption of dead leafy materials at higher stocking rate (Mears and Humphreys, 1974) could have resulted in the lowering of the yield of dead material as stocking rate increased.

The decline in daily liveweight gain per animal as stocking rate increased appeared to have arisen from differences in the amount of green material on offer (Arnold, 1962) which followed the same pattern. As a result, sheep at the lowest stocking rate had better opportunity to select herbage higher in crude protein and lower in fibre (Weir and Torrell, 1959), hence the higher liveweight gain. In this study it was observed that some rams were very slow to gain weight and some came down with diarrhoea which could have affected the overall liveweight gain.

The general decline in liveweight gain as grazing progressed was attributed to reduced nutritive value due to advanced plant maturity (Blunt, 1978), season (Bryan and Evans, 1973; Okeagu, 1989) and thus reduction in herbage, especially leaf, on offer (Laredo and Minson, 1973). From this study it can be argued that sheep will start to lose weight at the highest and lowest stocking rates in late December and late January, respectively, when the pasture is stocked in August/September. Thus farmers should give supplementary feed or remove animals or reduce stocking rates before these dates when grazing grass pasture.

Yearling rams and/or those above 20 kg were observed to survive better than lighter animals. With respect to the time to stock the pasture, this study would suggest periods before the flowering stage is reached or at sward heights below the knee. A case of cutaneous myasis, an acute dermatitis of sheep caused by blowfly (*Chrysomia regalis*) larvae was noticed in the second grazing period, presumably because the pasture was high (over 100 cm) and dense. A less dense canopy might discourage the fly. Predators and thefts can also account for losses of animals on pasture. Adequate security and close fencing should be maintained at all times. This will also enable a regular check to be made on the flock to monitor the health of the animals and allow immediate treatment.

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EFFECTS OF ENVIRONMENT, BOTANICAL COMPOSITION AND NUTRITION ON GOAT PRODUCTION ON *ACACIA* SAVANNA IN KENYA

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ABSTRACT

Effects of botanical composition and environmental variables on dietary preference and nutrition of goats were evaluated at Kiboko, Kenya, over one dry season (June–September) and one wet season (October–November). Mature oesophageally fistulated East African goats were used in the study. Dietary behaviour of goats reflected a high degree of seasonal plasticity with regard to forage types and plant species and plant parts eaten. Graminoid forage, forb and browse herbage availability was correlated with soil moisture. Crude-protein levels in ingested diets were generally high and tended to peak in November due to increased moisture recharge at this time. *In vitro* organic matter digestibility (IVOMD) was closely related to soil moisture. High IVOMD values were observed at the beginning of the dry and wet seasons. Ingested digestible energy increased as forbs, grasses and immature browses increased in the diets in response to increased soil moisture availability.

RESUME

Effet de l'environnement, de la composition botanique des pâturages et de l'alimentation sur le comportement alimentaire des caprins dans la savane d'*Acacia *au Kenya

L'effet de la composition botanique des pâturages et des facteurs écologiques sur les préférences et le comportement alimentaires des caprins a été étudié à Kiboko (Kenya) au cours d'une saison sèche (juin–septembre) et d'une saison humide (octobre–novembre). Cette expérience a porté sur des caprins d'Afrique de l'Est munis de fistules oesophagiennes. Il ressort des résultats enregistrés que ces animaux avaient un comportement alimentaire très saisonnier, notamment en

ce qui concerne le type de fourrage, les espèces végétales et les parties des plantes qu'ils consommaient. Il existait une corrélation positive entre d'une part, les disponibilités en fourrage graminéen, en herbe et en ligneux et de l'autre, l'humidité du sol. La teneur en protéines brutes des fractions ingérées était généralement élevée et tendait vers un maximum en novembre, en raison de l'accroissement du degré hygrométrique du sol à cette époque de l'année. Il existait en outre une étroite relation entre la digestibilité in vitro *de la matière organique et l'humidité du sol. Conséquence enfin de l'accroissement de l'humidité du sol, la consommation d'herbe, de graminées et de fourrage ligneux tendre augmentait, entraînant un accroissement de la consommation d'énergie digestible des animaux.*

ETUDE DE L'INFLUENCE DE QUATRE FOURRAGES LIGNEUX SUR L'EVOLUTION PONDERALE DES OVINS DE LA RACE NAINE DE L'AFRIQUE DE L'OUEST

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RESUME

Des essais d' alimentation destinés à comparer divers régimes ont été effectués pendant 74 jours sur des ovins de la race naine de l' Afrique de l' Ouest élevés en stabulation et en cases individuelles. Leur ration était composée de graminées (*Pennisetum purpureum*) pures ou complémentées avec du fourrage ligneux (*Alchornea cordifolia*, *Flemingia macrophylla*, *Gliricidia sepium* ou *Leucaena leucocephala*). Ni le poids initial, ni le mode d' élevage n' avaient d' effet significatif sur les gains moyens quotidiens (GMQ), mais le type de fourrage ligneux avait une influence significative ($F=18,13$; $P<0,05$) sur ce paramètre. Le lot soumis à la ration exclusivement graminéenne a enregistré des pertes de poids et une mortalité élevée (60%), ce qui montre que ce régime était inadéquat pour maintenir en bon état pendant une longue période de temps des animaux élevés en stabulation. La complémentation avec *Gliricidia sepium* donnait les meilleurs résultats, avec un GMQ de 64,14 g. Les performances associées à *Leucaena leucocephala* ne reflétaient pas la valeur énergétique et azotée de ce fourrage, ses potentialités réelles ayant probablement été masquées par les effets de la mimosine, alcaloïde toxique présent dans toutes les parties de la plante. Enfin, bien qu' il s' agisse d' une légumineuse, *Flemingia macrophylla* ne semble pas particulièrement indiqué pour promouvoir la croissance pondérale chez les ovins.

ABSTRACT

Study of the effect of four fodder browses on weight changes in West African Dwarf sheep

Feeding trials were carried out on individually penned African Dwarf Forest sheep over a 74-day period. Diets consisted of Pennisetum purpureum *(grass) either alone or combined with a browse plant (*Alchornea cordifolia, Flemingia macrophylla, Gliricidia sepium *or* Leucaena leucocephala*). Weight gain was not affected by the initial weight or the type of housing, but was significantly ($F=18.13$; $P<0.05$) affected by the browse species. The group receiving* Pennisetum purpureum *alone lost weight and suffered a high mortality (60%). This shows that* Pennisetum *is not suitable for keeping confined animals in good health for long periods of time. Supplementation with* Gliricidia sepium *proved to be the best combination, with an average daily weight gain of 64.14 g. The performance of the group receiving* Leucaena leucocephala *did not reflect the energy and protein value of this forage, as its potentials may have been obscured by the presence of mimosine, a toxic alkaloid found in all parts of the plant. Although* Flemingia macrophylla *is a legume, the results showed that this species is not suitable for promoting growth in this sheep breed.*

INTRODUCTION

Dans de nombreuses régions du monde, et plus particulièrement en Afrique tropicale, le manque de ressources fourragères de bonne qualité constitue un obstacle de taille au développement de la production animale. La pénurie est encore plus marquée dans les régions à très faible pluviométrie où la seule végétation permanente est constituée d'espèces ligneuses. De nombreux auteurs (Dayton, 1931 cité par Skerman, 1982; Curasson, 1956; Boudet, 1979; Harrington et Wilson, 1980; Skerman, 1982; Guérin *et al.*, 1987; Koné, 1987) sont unanimes pour reconnaître l'importance des ligneux dans l'alimentation du bétail, principalement comme source d'azote pouvant servir de complément aux fourrages herbacés dont la qualité nutritionnelle se dégrade rapidement au cours du cycle de développement.

En ce qui concerne plus précisément le Cameroun, les données relatives aux fourrages ligneux et à leur utilisation par les ruminants restent limitées. Les seuls documents pertinents connus découlent des travaux de Piot (1966, 1969, 1970), réalisés sur le plateau de l'Adamaoua en zone soudano-guinéenne. Cet auteur fournit sur cette région une liste plus ou moins exhaustive des ligneux appétés par les bovins, ainsi que la composition chimique des principales espèces. La présente étude est destinée à identifier des essences ligneuses qui, en association avec les principales graminées spontanées ou cultivées, pourraient contribuer à promouvoir le développement de la production des petits ruminants et permettre ainsi de mieux répondre aux besoins des populations en protéines animales.

MATERIELS ET METHODES

Cette expérience a été réalisée sur 25 ovins de la race naine de l'Afrique de l'Ouest, de poids moyen égal à 15 kg. La protection sanitaire des animaux a été assurée par un déparasitage externe et interne, respectivement à base d'une solution de Tigal® et de Panacur®.

Les essais se sont déroulés dans un bâtiment de type "semi plein air" à la Station de recherches zootechniques de Nkolbisson.

Le dispositif expérimental correspond à celui du bloc aléatoire à randomisation totale à cinq répétitions.

On trouvera au tableau 1 la composition des cinq régimes alimentaires utilisés. Cinq lots de poids homogène, constitués chacun de cinq animaux, ont été constitués et affectés chacun à un régime alimentaire donné. Ce processus d'affectation, de même que l'attribution des cases individuelles au sein de chaque bloc, a été effectué au hasard.

Les divers fourrages ligneux ont été décrits par Kouonmenioc (1990).

Toutes les espèces ligneuses testées ici ont été cultivées, exception faite de *Alchornea cordifolia* qui, tout comme *Pennisetum purpureum*, a été récolté à l'état naturel.

L'expérimentation s'est déroulée en deux phases distinctes, à savoir une période préexpérimentale de 15 jours et une période expérimentale de 59 jours.

Les fourrages ont été récoltés et distribués tous les jours entre 7 heures et 8 h 30. Le taux de matière sèche de chaque type de fourrage a été déterminé. A l'issue de l'essai, un mélange constitué des échantillons moyens hebdomadaires a été analysé en vue de déterminer la composition chimique globale du fourrage considéré.

La quantité de matière sèche effectivement ingérée chaque jour a été mesurée individuellement par pesée des quantités de fourrages offertes et des refus.

En ce qui concerne les rations binaires, la distribution des deux composantes a été effectuée en fonction des différences d'appétibilité observées. Ainsi, pour certaines rations (*Pennisetum* + *Leucaena* et *Pennisetum* + *Flemingia*), il a fallu procéder à une distribution "décalée", stratégie visant à induire une consommation "forcée" de l'espèce peu appétée.

Tableau 1. *Régimes alimentaires*

Composante herbacée	Composante ligneuse
Pennisetum purpureum	*Alchornea cordifolia*
Pennisetum purpureum	*Flemingia macrophylla*
Pennisetum purpureum	*Gliricidia sepium*
Pennisetum purpureum	*Leucaena leucocephala*
Pennisetum purpureum seul	–

Les animaux dont la ration était constituée exclusivement de *Pennisetum purpureum* recevaient cette graminée *ad libitum*. Par contre, *Pennisetum* était rationné dans les rations mixtes où les fourrages ligneux étaient en revanche offerts *ad libitum*.

Les fourrages ligneux ont été distribués sous forme de rameaux feuillés alors que *Pennisetum* était présenté à l'état entier.

La distribution des ligneux sous forme de rameaux conduit à distinguer deux types de refus, à savoir le refus "brut", équivalant à la quantité totale non consommée (feuilles + tiges) et le refus "réel", constitué par la partie consommable mais non consommée du refus brut.

Les animaux disposaient en permanence d'un complément minéral (55% de poudre d'os, 40% de NaCl, 5% d'oligo-éléments). L'eau était fournie *ad libitum*. Une simple pesée a été effectuée hebdomadairement et le poids initial a été déterminé par une triple pesée marquant la fin de la phase d'accoutumance.

Les gains moyens quotidiens (GMQ) ont été soumis à une analyse de variance et l'influence d'un effet secondaire "loge" (bloc) sur les GMQ a été testée. La relation entre le poids initial individuel et le GMQ a été déterminée pour l'ensemble des cinq régimes.

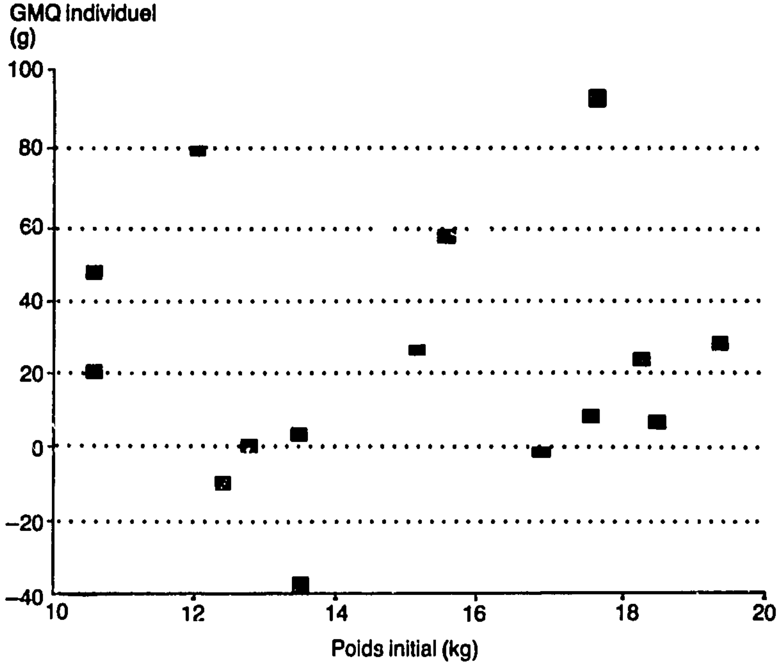
RESULTATS

Bien que l'étude ait porté sur cinq traitements, la différence statistique entre les GMQ n'a été recherchée que pour les rations mixtes. Le lot témoin dont le régime était constitué exclusivement de *Pennisetum* a été exclu de l'analyse en raison des fortes mortalités (60%) qui y avaient été enregistrées. Ces mortalités étaient presque partout précédées des mêmes symptômes, à savoir baisse de consommation, pertes importantes de poids, diarrhées légères et parfois persistantes conduisant à la mort de l'animal. Les résultats des autopsies n'ont révélé aucune anomalie dans les organes internes.

L'analyse comparative des gains de poids des animaux soumis aux régimes à base de *Alchornea cordifolia*, *Gliricidia sepium*, *Leucaena leucocephala* et *Flemingia macrophylla* n'a révélé aucune relation significative entre le poids initial et les GMQ individuels (r=0,26) (figure 1). Par ailleurs, alors que le paramètre "loge" (bloc) n'avait aucune influence significative (F=0,55; tableau 2) sur les GMQ, ceux-ci variaient significativement (F=18,12 au seuil de 5%) en fonction du type de fourrage ligneux. Enfin, la comparaison des moyennes des GMQ par le biais du test de Newman-Keuls permet de regrouper les traitements en 3 catégories, à savoir A (*Gliricidia sepium*), B (*Alchornea cordifolia*) et C (*Flemingia macrophylla* et *Leucaena leucocephala*) (voir tableau 3 et figure 2).

Les chiffres moyens hebdomadaires d'ingestion quotidienne des fourrages (g/kg $P^{0,75}$) ont permis de dresser les bilans de consommation.

Figure 1. *Relation entre poids initial et gain moyen quotidien (GMQ) individuels*



DISCUSSIONS

Régime sans complémentation

Avec la ration constituée uniquement de *Pennisetum purpureum*, les GMQ n'étaient positifs que durant les deux semaines suivant la phase d'accoutumance. On peut penser que la qualité nutritive médiocre de la graminée (tableau 4) a été compensée par de fortes consommations (113 g de MS/kg $P^{0,75}$/j).

Tableau 2. *Analyse de variance de l'effet de l'espèce ligneuse sur les GMQ des ovins*

	SCE	d.d.l.	Carrés moyens	Test F	Niveau de probabilité
Variance totale	23 301,79	18	1 294,54		
Variance facteur 1	1 874,05	3	6 251,35	18,13	0,0002
Variance blocs	755,35	4	188,84	0,55	0,7065
Variance résiduelle 1	3 792,39	11	344,76		

SCE : somme des carrés des écarts
d.d.l. : dégré de liberté

Tableau 3. *Comparaison des moyennes de GMQ des traitements (Test de Newman–Keuls au seuil de 5%)*

Nombre de moyennes	2	3	4
PPAS	25,87	31,69	35,32

Traitements	Moyennes	Groupes homogènes
Gliricidia sepium	64,07	A
Alchomea cordifolia	24,6	B
Flemingia macrophylla	– 9,14	C
Leucaena leucocephala	–11,19	C

PPAS: plus petite amplitude significative

Les pertes de poids s'amorçaient alors, puis augmentaient pour aboutir à des mortalités. Ces mauvaises performances semblaient liées à la chute importante des quantités ingérées, lesquelles passaient de 113 à 55 g de MS/kg $P^{0,75}$ du début à la fin de l'expérience.

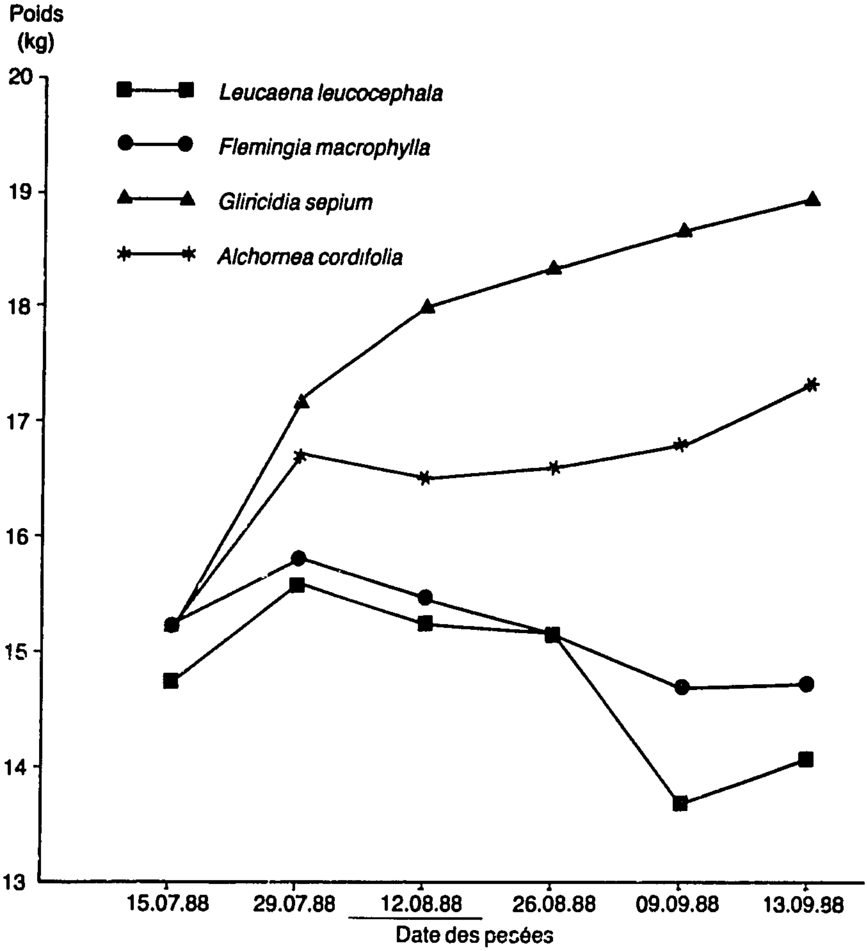
Les résultats de l'analyse de la composition chimique effectuée sur *Pennisetum purpureum* (tableau 4) confirment les conclusions de Guérin (1987) sur la valeur alimentaire des graminées tropicales. Celui-ci note que par comparaison avec les graminées tempérées, les graminées tropicales sont plus riches en constituants pariétaux et pauvres en matières azotées totales avec de surcroît de faibles taux de digestibilité de la matière organique et de la matière sèche. Ainsi, la dégradabilité enzymatique de la matière organique de *Pennisetum* est de 34,3% (tableau 4) contre 47% pour une graminée tempérée comme *Festuca pratensis*.

Soulignons enfin que la faible solubilité des matières azotées, soit 20,6% (tableau 4), est peut-être liée à la présence de tanins. Ceux- ci, surtout abondants chez les ligneux, se rencontrent parfois également en fortes quantités chez certaines espèces herbacées pérennes (McLeod, 1975).

Bien que Boudet (1975) souligne que *Pennisetum purpureum* est une graminée pauvre en énergie quel que soit son stade de croissance, un fourrage plus jeune aurait probablement donné lieu à de meilleures performances. Cependant, des cas sévères de diarrhées ont souvent été signalés chez les animaux consommant des plantes herbacées très jeunes.

Les carences alimentaires associées à ce régime alimentaire purement graminéen sont en harmonie avec les résultats d'essais préliminaires du même type réalisés auparavant sur des ovins et des caprins (Kouonmenioc, 1986). Tous les six animaux de chacun des deux lots recevant uniquement des graminées étaient morts, par opposition à ceux soumis aux rations mixtes. Cependant, compte tenu de l'origine des animaux utilisés dans ces essais ("tout venant"), et du dispositif expérimental (alimentation en groupe), on ne pouvait tirer aucune conclusion définitive de cette constatation.

Figure 2. *Evolution du poids moyen des ovins en fonction de la nature du fourrage ligneux contenu dans le régime alimentaire*



Ces résultats posent le problème du maintien des ruminants domestiques sur les "prairies" graminéennes, source de l'essentiel de l'alimentation des animaux d'élevage dans les régions tropicales. Sous une relative homogénéité physionomique liée à la prédominance d'une ou de quelques espèces graminéennes, la plupart de ces formations sont en effet caractérisées par une grande diversité de composition, fréquemment liée à l'existence d'une strate herbacée inférieure bien développée. C'est le cas des pâturages des hauts

Tableau 4. *Teneurs en constituants organiques des espèces fourragères utilisées*

Constituants	*Alchornea cordifolia*	*Flemingia macrophylla*	*Leucaena leucocephala*	*Gliricidia sepium*	*Pennisetum purpureum*
Constituants pariétaux (% de MS)					
Cellulose brute (CB)	19,01	30,86	19,00	18,03	35,50
Parois totales (NDF)	34,04	59,39	27,72	33,33	68,70
Lignocellulose (ADF)	25,58	53,04	18,76	23,61	36,10
Lignine (ADL)	7,17	29,31	8,14	8,90	3,80
Matières azotées					
Mat. azotées totales (%MS)	16,92	18,39	24,66	22,80	11,20
Mat. azot. solubles (%MAT)	7,63	18,86	21,47	36,21	20,6
Mat. azot. résiduelles de l'ADF (%MAT)	9,77	37,66		7,23	8,09
Dégradabilité enzymatique					
de la matière organique	57,29	26,54	53,18	60,66	34,30
des matières azotées	52,94	46,15	71,55	74,51	20,60

plateaux de l'ouest du Cameroun où existent en abondance, entre les touffes de l'espèce dominante *Sporobolus africanus*, de nombreuses petites légumineuses très appétées comme *Trifolium repens*, *T. baccarinii*, *T. usambarense* et capables d'assurer le complément nécessaire à l'équilibre alimentaire des animaux.

Complémentation avec *Gliricidia sepium*

Les animaux bénéficiant d'une complémentation avec *Gliricidia sepium* avaient la croissance la plus rapide avec un GMQ de 64 g, chiffre équivalant à ceux obtenus avec des aliments complémentaires composés de concentrés.

Indépendamment des qualités nutritionnelles de *Gliricidia*, les GMQ élevés enregistrés ici étaient associés à une consommation élevée de fourrages s'établissant en moyenne à 141 g de MS/kg $P^{0,75}$/j, dont 65% de *Gliricidia*. Celle-ci est supérieure, non seulement à la moyenne de 2,5 kg de MS/100 kg de poids vif, soit 79 g de MS/kg $P^{0,75}$/j (Boudet et Rivière, 1968) considérée comme normale, mais également aux chiffres rapportés par de nombreux auteurs dont Reyne et Garambois (1975), Van Eys *et al.* (1986), Koné (1987), Guérin (1987) et Richard (1987). Ces valeurs, de même d'ailleurs que les résultats de la présente étude, demeurent cependant inférieures à la consommation record de 162 g de MS/kg $P^{0,75}$/j obtenue en Libye par Le Houérou (1987) dans un essai d'alimentation en enclos effectué sur des ovins dont le régime alimentaire était composé uniquement de trois fourrages ligneux (*Atriplex nummularia, A. halimus* et *Acacia saligna*).

Notons que les chiffres de consommation les plus fréquents rapportés sur les ovins en zone tropicale se situent entre 45 et 82 g de MS/kg $P^{0,75}$/j pour des animaux pâturant librement des parcours naturels. Ces résultats dépendent bien évidemment d'un certain nombre de paramètres liés tant à la végétation qu'au comportement de l'animal, notamment la fréquence des éventuels déplacements. Pour sa part, Nebout (1978) souligne que la consommation de fourrage dépend non seulement du poids du sujet et de l'espèce animale, mais également de la quantité et de la qualité du fourrage disponible.

Ademosum *et al.* (1985) rapportent que la présence de *Gliricidia* dans une ration en augmente la consommation de matière sèche et probablement la digestibilité. Ils ont noté, au cours d'un essai effectué sur des caprins recevant *Panicum maximum ad libitum* comme aliment de base et *Gliricidia sepium* (quatre niveaux) comme aliment complémentaire, que les animaux recevant le niveau le plus élevé de complémentation ne refusaient jamais *Gliricidia* et avaient une consommation de 37,7% supérieure à celle du groupe témoin soumis au régime exclusivement graminéen.

Par ailleurs, l'utilisation de fourrage de *Gliricidia* issu indifféremment de 14 cultivars n'a donné lieu à aucune différence significative dans les quantités ingérées. Cette constatation semble en contradiction avec les observations de Glander (1979, 1981 d'après Nancy, 1987) qui mentionne une influence de la variabilité génétique de l'espèce végétale sur l'appétibilité.

Enfin l'alimentation à base de *Gliricidia* n'a eu aucune incidence pathologique ou dépressive sur les animaux.

Complémentation avec *Alchornea cordifolia*

Avec un GMQ de 25 g, la complémentation avec *Alchornea cordifolia* se classait en deuxième position. La consommation moyenne était de 120 g de MS/kg $P^{0,75}$/j et augmentait au cours de la phase d'expérimentation (rapport de 1,6).

Alchornea entrait ici pour 48% dans cette consommation contre 64,6% pour *Gliricidia*. Une aussi faible différence d'ingestion (15%) entre ces deux espèces ne peut expliquer des écarts de GMQ aussi importants (62%) entre les deux régimes. Ces différences semblent donc directement liées à la nature et à la composition chimique des deux espèces (tableau 4).

Le taux de dégradabilité de la matière azotée totale (tableau 4) d'*Alchornea cordifolia* (52,9%) est nettement inférieur à celui de *Gliricidia* (78,8%). Enfin, la probable hétérogénéité du fourrage d'*Alchornea*, du fait qu'il a été récolté à l'état naturel, est peut-être pour quelque chose dans les faibles GMQ associés à cette espèce ligneuse.

Un fourrage d'*Alchornea* à base de rameaux plus jeunes aurait peut-être permis de meilleures performances. Cela nécessiterait cependant un rabattage en vue de l'utilisation des repousses.

Complémentation avec *Flemingia macrophylla*

Le GMQ relatif à toute la période de l'expérience était négatif (–9,1 g). Les GMQ individuels étaient caractérisés par une grande variabilité au sein du lot (constance, gains et pertes de poids). Les baisses de poids étaient probablement dues aux qualités nutritionnelles médiocres de cette espèce dont la teneur en matières azotées totales (MAT) était seulement de 18% (tableau 4), valeur voisine de celle d'*Alchornea cordifolia*. Par ailleurs, les tests de dégradabilité enzymatique (pepsine–cellulase) ont révélé que moins de la moitié (42,2%) de ces MAT étaient digestibles. La consommation était en moyenne de 140,1 g de MS/kg $P^{0,75}$/j, valeur très proche de celle relative à la meilleure complémentation, c'est-à-dire avec *Gliricidia sepium*.

Sur la base de ces résultats, on peut conclure que bien qu'il s'agisse d'une légumineuse, *Flemingia macrophylla* est peu indiqué pour la production animale. De fait, Asare (1985), à l'issue d'essais pourtant très satisfaisants effectués sur diverses caractéristiques agronomiques de cette espèce ligneuse (production de biomasse foliaire), a insisté sur la nécessité, avant toute tentative de vulgarisation, de mener des études sur l'appétibilité et l'ingestion de *Flemingia* afin de tester l'influence desdites caractéristiques sur les paramètres zootechniques objectifs (production de viande, de lait).

A défaut de l'utiliser en production animale, on pourrait cependant exploiter sa forte capacité de production pour produire de la litière qui servirait à limiter le développement des adventices dans certaines cultures pérennes (plantations de café, par exemple). Etant donné qu'il s'agit d'une légumineuse, *Flemingia* pourrait en outre servir à enrichir les sols en vue de la production végétale.

Complémentation avec *Leucaena leucocephala*

Le GMQ relatif à toute la durée de l'expérience était négatif (–11,2 g).

La moyenne de consommation était de 107,9 g de MS/kg $P^{0,75}$/j. La consommation avait considérablement diminué au cours de l'expérience, passant de 144 à 72 g de MS/kg $P^{0,75}$/j au cours de la dernière semaine, soit une baisse de 50%.

Les résultats enregistrés ici sont plutôt surprenants, compte tenu du fait que les feuilles de *Leucaena* avaient la teneur en MAT la plus élevée des quatre ligneux étudiés. De plus, leur digestibilité à la pepsine, égale à 71,6% (tableau 4) était proche de celle de *Gliricidia*, espèce associée aux meilleures performances pondérales enregistrées dans le cadre de cet essai.

Ces chiffres peuvent s'expliquer par des perturbations notées chez les animaux, correspondant probablement à des symptômes d'intoxication par la mimosine, une toxine présente dans toutes les parties de la plante. La toxicité de cette substance, par accumulation dans l'organisme, a déjà été soulignée par plusieurs auteurs chez les monogastriques (Hegarty *et al.*, 1964; Hamilton *et al.*, 1968; Shiroma et Takahashi, 1976).

Chez les polygastriques cependant, il n'y a danger que lorsque *Leucaena* entre pour plus de 50% dans la ration. Divers signes cliniques étaient néanmoins apparus au cours de cette étude, y compris des émissions intenses de bave, l'incoordination des mouvements, la perte de la voix, l'alternance de pertes et de reprises d'appétit et des pertes sensibles de poids. Toutefois, bien qu'on n'ait observé aucun des phénomènes couramment cités comme signes d'une intoxication à la mimosine — alopécie (Hegarty *et al.*, 1964; Reis *et al.*, 1975) et hypertrophie thyroïdienne — il y a cependant tout lieu de soupçonner ce type d'empoisonnement.

Cette intoxication semble liée au fait que les ovins, très friands des feuilles de *Leucaena*, avaient presque complètement délaissé le *Pennisetum* et ce, malgré le décalage entre la distribution des fourrages de ces deux espèces. En effet, les animaux s'étaient semble-t-il très vite adaptés au rythme adopté, préférant jeûner toute la matinée dans l'attente de la distribution du fourrage de *Leucaena*.

Si l'on considère que, pour tous les autres régimes, la consommation d'éléments ligneux avait augmenté avec la durée de l'expérience, on peut penser que sans les phénomènes d'intoxication constatés, les performances de cette ration seraient proches de celles du meilleur régime alimentaire, c'est-à-dire celui complémenté avec du fourrage de *Gliricidia*.

Ces résultats ne doivent cependant pas conduire à remettre globalement en cause la valeur du *Leucaena leucocephala* en production animale, en particulier dans la production bovine sur laquelle ont porté la majorité des travaux à ce jour. Ainsi, au Malawi, de jeunes animaux métis Zébu x race frisonne, alimentés avec des rations composées de *Leucaena*, de son et de tiges de maïs, ont présenté des gains de poids de 1,17 kg/tête/j (Thomas et Addy, 1977). Pour sa part, Jones (1979) rapporte qu'en Indonésie et dans l'île de Timor, des bovins engraissés pendant 6 mois, uniquement avec un mélange de *Leucaena* et de stipes de bananiers, avaient enregistré des GMQ satisfaisants pendant les trois premiers mois, après quoi on assistait à un ralentissement de la croissance pondérale avec apparition de symptômes graves d'intoxication. Il en conclut que la toxicité est cumulative quand les animaux consomment du *Leucaena* pendant une longue période de temps.

Un certain nombre de recherches sont actuellement en cours sur ce sujet, notamment en Australie. Celles-ci visent entre autres soit à créer dans le tube digestif des ruminants les conditions favorables au développement de bactéries capables de dégrader la mimosine (Reed et Chater, 1986), soit à produire des souches de *Leucaena* pauvres en mimosine.

CONCLUSION

Un essai d'alimentation qui, comme celui présenté ici, est caractérisé par le suivi individuel des animaux semble constituer, par rapport aux estimations d'ingestion sur parcours, une méthode plus objective de mesure des chiffres de consommation. Même si cette approche complique sérieusement les expériences, elle devrait cependant permettre de déterminer les espèces ligneuses qui, en combinaison avec les graminées, pourraient aider à améliorer l'alimentation animale et partant à promouvoir le développement du sous-secteur de l'élevage.

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EFFET DE LA COMPLEMENTATION DE *PANICUM MAXIMUM* AVEC DES FOURRAGES LIGNEUX SUR LA CROISSANCE ET LE RENDEMENT EN CARCASSE D'OVINS DJALLONKE MALES

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RESUME

Un essai a été conduit pour déterminer la valeur nutritionnelle de fourrages ligneux dans l'alimentation d'ovins Djallonké mâles. Quatre lots de moutons ont été soumis pendant 90 jours à quatre rations composées de *Panicum maximum* pur (ration 1) ou complémenté avec *Pterocarpus erinaceus* (ration 2), *Bridelia ferruginea* (ration 3) ou du tourteau de coton (ration 4).

Le GMQ des animaux soumis au *Panicum maximum* uniquement s'établissait à 47 g. La complémentation avec *Pterocarpus* ou *Bridelia* n'entraînait aucun accroissement significatif du GMQ, les chiffres enregistrés étant respectivement de 43 et 51 g. En revanche, la complémentation avec du tourteau de coton se traduisait par une augmentation significative du GMQ (38 g) et un bilan économique positif. Enfin, les rendements carcasse n'étaient pas statistiquement différents, avec des moyennes de 51,2%, 49%, 51,9% et 52,1% pour les animaux soumis respectivement aux rations 1, 2, 3 et 4.

ABSTRACT

Effect of supplementing* Panicum maximum *with fodder browses on growth and carcass yield in male West African Dwarf sheep

A feeding trial was conducted to assess the nutritional value of browse forages for male West African Dwarf sheep. Four experimental diets consisting of Panicum maximum *alone (diet 1) or supplemented with* Pterocarpus erinaceus *(diet 2),* Bridelia ferruginea *(diet 3) or cottonseed cake (diet 4) were fed to four groups of sheep for 90 days.*

Animals receiving Panicum maximum *alone achieved an average weight gain of 47 g/day. Supplementation with* Pterocarpus *or* Bridelia *did not*

significantly improve daily weight gains, which averaged 43 and 51 g, respectively. Supplementation with cottonseed cake significantly increased the average daily weight gain to 88 g and resulted in satisfactory economical results. Carcass yield was not significantly affected by type of diet with means of 51.2, 49, 51.9 and 52.1% for animals on diet 1, 2, 3 and 4, respectively.

EFFET DE LA COMPLEMENTATION D'UNE RATION DE BASE DE QUALITE MEDIOCRE PAR *ALBIZIA ZYGIA* SUR LE COMPORTEMENT ALIMENTAIRE ET LA CROISSANCE D'OVINS DJALLONKE

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RESUME

L'intérêt de la complémentation d'une ration de base de qualité médiocre par *Albizia zygia* pour des ovins Djallonké en croissance a été testé dans un essai d'alimentation en deux phases de 90 jours chacune. Les animaux avaient été divisés en quatre lots. Au cours de la phase I, tous avaient reçu du foin de *Brachiaria ruziziensis* offert *ad libitum* et 100 g de mélasse de canne par jour. Les lots 2, 3 et 4 avaient reçu en complément respectivement 200 et 400 g de tourteau de coton et 800 g de feuilles d'*A. zygia* par jour. Au cours de la phase II, tous les animaux avaient été nourris sur pâturage artificiel avec 400 g de tourteau de coton par jour. Au cours de la phase I, les gains moyens quotidiens (GMQ) étaient de 0, 93, 113 et 31 g/j respectivement pour les lots 1, 2, 3 et 4. L'indice de consommation était de 7,4, 6,9 et 21,3 kg de MS/kg de croît pour les lots 2, 3 et 4. Au cours de la phase II, les GMQ s'établissaient à 54, 40, 45 et 63 g pour les lots 1, 2, 3 et 4 et n'étaient pas significativement différents. Sur l'ensemble des deux périodes, les GMQ étaient de 27, 67, 80 et 48 g respectivement. L'étude de carcasse effectuée à l'issue des deux phases fait ressortir un effet de croissance compensatrice sur le poids de la carcasse et le rendement carcasse. Quant à l'étude économique, elle montre que la complémentation se justifiait, même dans l'hypothèse d'un coût maximum pour *A. zygia*.

ABSTRACT

Effect of supplementing a poor quality base diet with* Albizia zygia *on feeding behaviour and growth in Djallonké sheep

The effect of Albizia zygia *as a supplement to a low quality feed was tested on growing Djallonké lambs during two feeding periods of 90 days each. The lambs* *were divided into four groups. During Phase I, a base ration of* Brachiaria ruziziensis *hay was fed* ad libitum *to all animals with 100 g/day of cane molasses. In addition, group 2, 3 and 4 were supplemented with a daily ration of, respectively, 200 and 400 g of cottonseed cake and 800 g of* Albizia zygia. *During Phase II, all animals were put on grown pasture and received 400 g of cottonseed cake daily. During Phase I, average daily weight gains were 0, 93, 113 and 31 g for groups 1, 2, 3 and 4, respectively, while feed intakes were 7.4, 6.9 and 21.3 kg dry matter/kg of weight increase for groups 2, 3 and 4, respectively. There was no significant difference in weight gains during Phase II with rates of 54, 40, 45 and 63 g/day for groups 1, 2, 3 and 4, respectively. Over both periods, the average daily gains were 27, 67, 80 and 48 g for groups 1, 2, 3 and 4, respectively. Carcass evaluation at the end of the two phases showed an effect of compensatory growth on carcass weight and yield. Feeding supplements to growing Djallonké lambs was shown to be economically justified, even at a the maximum cost of* Albizia zygia.

INTRODUCTION

En Côte d'Ivoire, les ligneux interviennent largement dans l'alimentation des troupeaux en élevage traditionnel et sont même commercialisés sur les marchés à bétail (ovins, caprins) toute l'année dans les grands centres urbains (Bodji et N'Guessan, 1989). Parmi ceux-ci, citons *Albizia zygia*, une légumineuse très appétée et disponible toute l'année sur une grande partie du territoire. L'analyse bromatologique indique que cette espèce possède une bonne valeur nutritive (0,50 UF/kg de MS et 136 g de MAD/kg de MS) (Bodji, 1989), raison pour laquelle elle a été choisie pour cet essai d'alimentation.

Celui-ci visait à:

- effectuer une étude comparative du comportement alimentaire et pondéral des ovins Djallonké recevant une ration de base de qualité médiocre (foin de *Brachiaria*) complémentée avec du fourrage d'*Albizia zygia* ou du tourteau de coton;
- étudier le phénomène de la croissance compensatrice sur les animaux soumis à différents régimes alimentaires; et
- mesurer les effets de la complémentation et de la croissance compensatrice sur le rendement carcasse.

MATERIELS ET METHODES

L'essai s'est déroulé à la station du département Elevage de l'Institut des savanes (IDESSA) à Bouaké (Côte d'Ivoire) en deux phases de 90 jours chacune.

Il a été réalisé sur un total de 44 sevrons de race Djallonké, provenant d'un même lot d'agneaux nés à la ferme de l'IDESSA du Foro Foro. Ceux-ci ont été transportés sur la station pour les besoins de l'essai et ont été répartis en quatre lots. Un animal est mort au cours de la période d'adaptation.

L'âge moyen des sevrons au début de l'essai était de 110 jours. Les poids à la naissance et les GMQ de la naissance au premier jour de l'essai étaient homogènes.

En début d'essai, divers traitements ont été administrés à titre prophylactique.

Il s'agissait d'un traitement anticoccidien, d'un traitement antibiotique et d'un traitement anthelminthique. Tous les animaux disposaient d'eau et de minéraux (pierre à lécher) à volonté.

Phase I

Les ovins sont parqués en permanence dans des loges de 13 m sur 7 sur aire bétonnée avec abri. La période d'adaptation a duré huit jours. Au cours de cette phase, chaque lot recevait sa ration expérimentale (tableau 1).

Tableau 1. *Composition des rations journalières (g/j/animal) par lot*

	Lot 1	Lot 2	Lot 3	Lot 4
Effectif initial	11	11	11	10
Foin	*ad libitum*	*ad libitum*	*ad libitum*	*ad libitum*
Mélasse (g)	100	100	100	100
Tourteau de coton (g)	-	200	400	-
Albizia zygia (feuilles) (g)	-	-	-	800

On trouvera au tableau 2 la composition chimique, les valeurs nutritives moyennes des composantes de la ration et les résultats des tests de digestibilité d'*Albizia zygia in vivo.*

Phase II

Les animaux étaient menés de jour au pâturage, lequel était constitué de cultures fourragères de *Panicum maximum* C1 ou T58, ou de *Brachiaria ruziziensis*, selon les disponibilités. Ils étaient reconduits au parc le soir, où ils recevaient 400 g de tourteau de coton.

Contrôle et détermination des données zootechniques

Le poids des animaux était contrôlé régulièrement par une triple pesée effectuée à 24 heures d'intervalle en début et en fin d'essai et tous les 15 jours au cours de l'essai.

Tableau 2. *Composition chimique et valeurs nutritives moyennes des composantes des rations*

	Foin	Mélasse	Tourteau de coton	*Albizia zygia*
MS (%)	90	73,6	91,88	35,6
Cendres	8,60	12,77	7,35	4,08
MAT	5,48	4,76	45,16	21,84
CB	37,13	–	13,40	35,45
ENA (% de MS)	–	82,20	32,47	37,50
MG	–	–	1,64	1,53
Ca	0,38	1,22	0,21	0,45
P	0.19	0,07	1,28	0,15
Mg	0,21	–	0,66	0,21
K	1,45	3,94	1,65	0,93
Si (insoluble chlorhydrique)	–	–	–	0,03
dMO (%)	53,1*	–	–	49,5*
MAD (g/kg de MS)	23*	33	370	105*
UFL (kg de MS)	0,56*	0,95	0,87	0,54*

*D'après Kouao (1988)

Les quantités d'aliments offertes et refusées étaient mesurées quotidiennement. Le taux de matière sèche était déterminé toutes les deux semaines pour les aliments offerts.

Les quantités de matière fraîche d'*Albizia zygia* offertes étaient constantes tout au long de l'essai, soit 12 kg en bottes, de manière à faire consommer environ 800 g de feuilles par animal et par jour. Les différences de consommation étaient dues aux variations du rapport feuilles/branches dans les bottes, les feuilles ayant toujours été consommées en totalité.

Une étude du rendement vrai des carcasses a été effectuée à la fin de chaque phase. 3 et 6 animaux ont été abattus par lot respectivement pour les phases I et II. Pour les deux phases, les animaux n'ont pu être tous abattus le même jour, ce qui signifie que la période de jeûne avant l'abattage n'était pas la même pour tous.

Le coût de la complémentation a été évalué. Pour les fourrages ligneux, 20 à 30 bottes ont été pesées chaque jour pendant 9 jours, sur les marchés à bestiaux de Bouaké. En tenant compte des prix pratiqués, une approche économique a pu être élaborée.

Les données rassemblées ont été soumises à une analyse de variance et les moyennes des traitements comparées à l'aide du test de Newman–Keuls.

RESULTATS

Consommation

Phase I

L'adaptation aux régimes alimentaires a été très rapide, sans aucun signe de pathologie digestive ni diminution d'appétit. Les consommations de foin de *Brachiaria ruziziensis* étaient très variables quel que soit le lot considéré (tableau 3). *Albizia zygia* était très appété. Les taux de matière sèche (MS) étant variables, les chiffres de consommation présentés au tableau 3 n'ont qu'une valeur indicative. L'ingestion moyenne d'*Albizia zygia* au cours de la première phase était de 2,0 kg de MS/100 kg de PV ou 39,1 g de MS/$P^{0,75}$.

La mélasse et le tourteau de coton étaient toujours consommés en totalité.

On trouvera au tableau 3 les chiffres de consommation moyenne par animal et par jour en MS, en UFL (unités fourragères lait) et en MAD (matières azotées digestibles).

Tableau 3. *Consommation (±écart type) de MF (foin et ligneux), MS, UF et MAD par animal et par jour*

	Lot 1	Lot 2	Lot 3	Lot 4	Seuil de signification
MF foin (g/j)	337,18±120,30	461,26±117,52	373,29±135,11	336,71±115,88	1%
MS foin (g/j)	303,47±108,3	415,14±105,77	335,96±121,60	303,04±104,29	1%
MF ligneux (g/j)	-	-	-	802,07±90,09	-
MS totale (g/j)	379±109	692±107	781±125	661±108	1%
UFL totales	0,24±0,06	0,46±0,06	0,57±0,07	0,40±0,06	1%
MAD totales (g/j)	9,38±2,60	79,95±2,50	146,16±2,85	39,23±3,95	1%
MAD/UF	39	173	256	98	-

Les indices de consommation (IC) en UFL/kg de gain de poids vif et en kilo de MS par kilo de gain de poids vif sont présentés au tableau 4. L'IC du lot 1 n'a aucune signification zootechnique étant donné que la croissance des animaux de ce lot était quasiment nulle au cours de cette période.

Phase II

La consommation au pâturage n'a pas été mesurée. Le tourteau de coton (400 g/tête/j) était consommé en totalité par tous les animaux, y compris ceux des lots 1 et 4. L'adaptation au nouveau régime alimentaire s'est faite au bout de trois jours sans le moindre accident digestif.

Tableau 4. *Indices de consommation relatifs à la phase I de l'essai*

	UFL/j	GMQ (kg)	IC kg de MS/kg de croît	IC UFL/kg de croît
Lot 1	0,24	0,00001	37 900	24 000
Lot 2	0,46	0,093	7,44	4,95
Lot 3	0,57	0,113	6,91	5,04
Lot 4	0,40	0,030	21,32	12,90

Evolution du poids

Les chiffres de gains moyens de poids vif (kg), de GMQ (g/j) et de gains moyens quotidiens par quinzaine sont présentés aux tableaux 5 et 6 pour les deux phases. Le ralentissement de la croissance entre les 135^e et 165^e jours correspond à une période où les pâturages disponibles étaient de qualité médiocre en raison d'un temps de repos insuffisant. Qui plus est, cette période a été marquée par une rupture de stock de tourteau de coton de plus de 15 jours.

Tableau 5. *Performances pondérales comparées (±écart type) des deux phases*

	Lot 1	Lot 2	Lot 3	Lot 4	Seuil de signification
Phase I					
Effectifs à la fin de la phase I	9	11	11	10	
Poids vif initial (kg)	11,87±2,08	12,67±1,95	12,05±1,83	12,75±2,54	n.s.
Poids vif final (kg)	12,37±2,30	21,03±2,59	22,19±19	15,49±2,90	P<0,001
GMQ moyen (g/j)	6±9	93±12	113±16	31±8	P<0,001
Gain moyen de PV (kg)	0,01±0,77	8,36±1,04	10,14±1,40	2,75±0,75	P<0,001
Phase II					
Effectifs à la fin de la phase II	6	8	7	7	
Poids vif initial (kg)	12,37±2,30	21,03±2,59	22,19±2,92	15,4±2,90	P<0,001
Poids vif final (kg)	17,11±2,71	24,57±2,36	26,01±3,48	21,27±3,48	P<0,001
GMQ moyen (g/j)	54±24	40±21	45±13	63±18	n.s.
Gain moyen de PV (kg)	4,82±2,16	3,60±1,90	4,06±1,16	5,70±1,66	n.s.

Tableau 6. *Gain quotidien moyen (g/j) par quinzaine au cours des deux phases*

Quinzaine	Lot 1	Lot 2	Lot 3	Lot 4
1	-27±25	122±19	138±32	10±19
2	0±28	77±22	125±31	47±14
3	-5±32	177±20	107±25	18±14
4	3±20	75±23	110±43	12±22
5	7±18	67±37	84±45	44±38
6	13±30	98±40	107±36	47±37
7	28±42	16±40	25±11	11±35
8	60±57	49±31	4±54	74±11
9	117±54	71±43	106±22	102±32
10	22±49	32±43	41±47	61±74
11	-5±34	-9±90	28±51	20±49
12	75±38	75±58	60±82	101±39

Etude des carcasses

Le rendement par rapport au poids vif n'est donné ici qu'à titre indicatif compte tenu des conditions d'abattage signalées plus haut. Cela n'affecte en rien les résultats relatifs au rendement vrai, exprimé par rapport au poids vif vide (tableau 7).

Après abattage, on a noté la présence d'un liquide clair abondant dans le péritoine chez deux animaux du lot 1, trois du lot 4 et un dans chacun des lots 2 et 3. Aucune lésion macroscopiquement visible n'a été observée sur les organes internes. Chez trois animaux des lots 1 et 4 et un animal du lot 3, on a noté la présence d'un liquide clair péritonéal ou pleural, avec des lésions localisées et anciennes de pneumonie pour deux animaux du lot 1 et celui du lot 3.

Coût de la complémentation

Prix des compléments

Il ressort d'une enquête effectuée sur le marché des petits ruminants de Bouaké que les bottes de ligneux étaient vendues à 50 FCFA l'après-midi, et les invendus conservés jusqu'au lendemain matin où, la demande étant forte, ils étaient vendus à 100 FCFA. La "fraîcheur" du produit ne semble donc pas essentielle. Au cours de la saison sèche, les prix restent les mêmes. Certains ligneux (*Albizia zygia, Pterocarpus erinaceus*), plus appétés par les ovins et caprins, étaient plus appréciés par les acheteurs mais cela ne semblait avoir aucune incidence sur les prix. Quelle que soit l'espèce botanique, le poids moyen des bottes était très

Tableau 7. *Résultats des deux premiers abattages (±écart type)*

	Lot 1	Lot 2	Lot 3	Lot 4	Seuil de signification
1^er^ abattage					
Poids vif avant abattage (kg)	11,53±0,91	20,03±1,27	21,43±4,01	14,47±1,50	P<0,001
PV vide (kg)	7,93±0,99	15,4±1,78	17,23±2,57	10,00±1,67	P<0,001
Carcasse chaude (kg)	3,93±0,46	8,03±0,81	9,50±1,45	5,03±0,93	P<0,001
Rendement carcasse (%)	34,03±1,50	40,05±1,79	44,56±2,26	34,62±3,32	P<0,001
Rendement vrai (%)	49,61±0,67	52,22±1,12	55,13±1,33	50,22±1,35	n.s.
Gras (g)	82±32	167±58	267±153	133±58	n.s.
Gras en % du poids de carcasse	2,03±0,61	2,08±0,75	3,01±2,04	2,67±1,03	n.s.
2^e^ abattage					
Poids vif avant abattage (kg)	16,95±3,27	24,63±3,13	25,51±4,07	20,43±3,52	P<0,01
PV vide (kg)	13,34±2,24	19,72±2,50	21,05±3,12	16,68±3,18	P<0,01
Carcasse chaude (kg)	6,78±1,19	10,35±1,49	11,05±1,81	8,59±1,94	P<0,01
Rendement carcasse (%)	40,19±1,60	42,00±2,04	43,33±1,82	41,72±2,65	n.s.
Rendement vrai (%)	50,82±1,32	52,48±0,93	52,39±1,23	51,28±2,76	n.s.
Gras (g)	67±28	158±46	245±104	101±45	P<0,001
Gras en % du poids de carcasse	0,89±0,38	1,53±0,39	2,18±0,83	1,13±0,36	P<0,01

variable, allant de 1,2 à 3,6 kg. Sur la base du coût de 50 FCFA par botte, le coût de la complémentation quotidienne par animal au cours de cet essai était donc de 18,4 FCFA. Il s'agit de l'hypothèse d'un coût maximum, car en élevage en milieu paysan, le prix du complément est égal à celui de la main-d'oeuvre. A raison de 640 FCFA par jour pour un ouvrier journalier, le prix de la complémentation est inférieur à 18,4 FCFA au delà de 35 animaux, en admettant qu'un ouvrier soit embauché spécialement pour ce travail.

Avec un prix départ usine du tourteau de coton de 30 FCFA/kg, le coût de la complémentation pour les lots 2 et 3 était donc de 6,2 FCFA et 12,4 FCFA par jour respectivement, transport non compris.

Coût de la complémentation par kilo de gain de poids vif

Ces résultats ne sont que des indications de l'intérêt de la complémentation par rapport au prix du kilo de poids vif (PV). Le tableau 8 donne le coût moyen pour

Tableau 8. *Coût en FCFA de la complémentation par kilo de gain de PV pour la phase I*

Lot	Gain moyen de PV (kg)	Coût de la complémenation par animal (b)	Coût par kg de gain de PV	Gain total dû au croît (a)	X = a – b
1	–	–	–	–	–
2	8,36	558	66,75	6 688	6 130
3	10,14	1 116	110,06	8 112	6 996
4	2,75	1 665	605,45	2 200	535

chaque type de complément par kilo de poids vif. Le prix moyen de vente des animaux sur pied étant de 800 FCFA par kilo de PV, la complémentation dans les conditions de l'essai est toujours intéressante même si les performances sont médiocres (lot 4), surtout si l'on sait que la croissance était nulle chez des animaux du lot témoin, qui ne bénéficiaient d'aucune complémentation.

En ce qui concerne la consommation de tourteau, on constate que le lot 3 consommait 200 g de plus, soit une dépense supplémentaire de 6,2 FCFA par jour, pour un GMQ plus élevé de 20 g soit un gain de 16 FCFA par jour. Les 200 g supplémentaires, bien valorisés par l'animal, sont donc économiquement justifiés.

Le tableau 9 donne pour chaque lot le coût moyen de l'aliment complémentaire par kilo de gain de poids vif pour la totalité de l'essai ainsi que le gain dû au croît, diminué du prix du complément (Y).

Tableau 9. *Coût en FCFA de la complémentation par kilo de gain de PV pour les deux phases*

Lot	Gain moyen de PV (kg)	Coût de la complémentation: Pour la phase I	Coût de la complémentation: Pour la phase II (b)	Coût de la complémentation: Pour les phases I et II	Coût par kg de gain de PV	Gain total dû au croît (a)	Y = a – b
1	4,82	0	1 116	1 116	231,54	3 859	2 740
2	12,07	558	1 116	1 674	138,69	9 656	7 982
3	14,33	1 116	1 116	2 232	155,76	11 464	9 232
4	8,56	1 665	1 116	2 781	324,88	6 848	4 067

Le tableau 10 donne le coût supplémentaire de l'aliment complémentaire et le gain supplémentaire par jour dû à la différence de croît entre les lots sur l'ensemble de l'essai. En ce qui concerne la phase I, la complémentation était toujours économiquement justifiée; la complémentation avec 400 g de tourteau en lieu et place de 200 g était également justifiée.

Une comparaison des tableaux 8 et 9 révèle que le gain dû au croît diminué du prix de l'aliment complémentaire obtenu grâce à la phase de croissance

Tableau 10. *Coût de la complémentation et bénéfice supplémentaire (FCFA/j) dû à la différence de croît entre les lots sur l'ensemble de l'essai*

Lot	Coût du complément	Gain supplémentaire dû à la différence de croît
1	-	-
2	3,1	32
3	6,12	46,7
4	9,25	16,8

compensatrice (Y–X) est maximum pour le lot 4, même dans l'hypothèse du coût maximum de l'aliment complémentaire au cours de la première phase.

DISCUSSIONS

Consommation

Les résultats de l'analyse de variance montrent que la consommation de MS de *Brachiaria ruziziensis* variait significativement (P<0,001) en fonction du lot et de la période.

Les consommations moyennes étaient significativement différentes pour l'ensemble des lots (P<0,01). Les moyennes des lots 2 et 4 n'étaient pas significativement différentes. Il n'y avait pas de différence entre les périodes. Ces consommations étaient plus élevées, excepté pour le lot 1, que les chiffres de 3,12 à 3,73 kg de MS/100 kg de PV obtenus par Richard *et al.* (1985) au cours de plusieurs essais d'alimentation avec des ovins Djallonké dont la ration était complémentée. Berger (1979a) rapporte une consommation moyenne de 5 kg de MS/100 kg de PV dans un essai d'alimentation où du foin de *Brachiaria* était distribué en quantité limitée (350 g) avec un concentré *ad libitum* à base de mélasse, de farine de riz et de tourteau de coton. Il a obtenu, avec cette ration, un GMQ de 87 g après 90 jours d'essai.

Berger (1979a) a noté des indices de consommation (IC) de 12,4 à 23,3 kg de MS/kg de croît et de 7,4 à 12,7 UF/kg de croît. Quant à Richard *et al.* (1985), ils ont rapporté des IC de 9,5 à 11,4 kg de MS/kg de croît.

La transformation de la matière sèche s'opérait bien dans les lots 2 et 3; en revanche, les performances du lot 4 étaient médiocres, ce qui indique qu'*Albizia zygia* ne peut être considéré comme un complément intéressant pour la production de viande.

Evolution du poids

Les différences entre les taux de croissance obtenus au cours de la phase I étaient toutes significatives (P<0,001).

La croissance était pratiquement nulle chez les animaux du lot témoin, ce qui montre que cette ration doit être évitée pour les périodes critiques sur le plan alimentaire.

Les GMQ des lots 2 et 3 étaient acceptables car comparables à ceux rapportés par certains auteurs chez des moutons Djallonké recevant une complémentation après sevrage; ces chiffres allaient de 65 à 110 g/j (Charray et N'Dri, 1981; Charray, 1984; Vallerand et Branckaert, 1975; Rombaut, 1980; Bassewitz *et al.*, 1988; Richard *et al.*, 1985; Berger, 1979b).

Le GMQ du lot 4 était de 31 g, chiffre médiocre, qui correspondrait néanmoins à une croissance moyenne en milieu villageois avec une alimentation non complémentée (Rombaut cité par Vallerand, 1979). La complémentation avec *Albizia zygia* avait donc permis d'obtenir une croissance modérée chez des ovins nourris avec un aliment de qualité médiocre. *Sesbania sesban* utilisé comme complément de la paille de tef (*Eragrostis tef*) a entraîné chez des ovins un GMQ de 48 g (CIPEA, 1986). Ademosun *et al.* (1985) ont obtenu un GMQ de 35 g pour une ration de base de *Gliricidia* et de *Leucaena*. Quant à Smith et van Houtert (1987), ils ont rapporté un GMQ de 40,2 g avec des animaux qui recevaient du *Gliricidia* et du *Leucaena*.

Au cours de la phase II, les lots 2 et 3 avaient présenté les croissances les plus faibles tandis que le lot 4 présentait les meilleures performances. Cependant, il n'y avait pas de différence significative entre les lots (P>0,05). On remarque également que le lot 1 était le moins homogène avec ses variations individuelles extrêmement importantes. Il semble qu'il n'y ait pas eu de croissance compensatrice.

Sur l'ensemble des deux phases, la différence entre les lots était très significative (P<0,001) (tableau 11). Les performances du lot 1, malgré la deuxième phase, étaient demeurées très médiocres. Celles du lot 4 étaient modestes mais le gain total de poids vif était presque double de celui du lot 1.

Tableau 11. *Croissance et gain de poids vif pour les phases I et II*

	Lot 1	Lot 2	Lot 3	Lot 4	Seuil de signification
GMQ (g/j)	27±11	67±9	80±11	48±11	P<0,001
Gain total de PV (kg)	4,82±1,92	12,07±1,64	14,33±1,93	8,56±1,94	P<0,001

Etude des carcasses

Les poids vifs vides et les poids de carcasse étaient significativement différents pour les deux abattages à P<0,001 et P<0,01 respectivement. A l'issue de la phase II, il y avait une différence significative entre les lots 2 et 4 pour ces paramètres au premier abattage mais pas au deuxième. L'effet de la croissance compensatrice se retrouve donc au niveau de la production de viande.

Les rendements vrais étaient significativement différents au premier abattage (P<0,01) et seul le lot 3 avait un bon rendement (55,1%). Ginisty (1976) rapporte un rendement vrai moyen de 54% pour un poids vif moyen de 16,75 kg; Richard *et al.* (1985) donnent des rendements vrais de 53,75 à 56,6% pour des ovins de poids vif vide compris entre 25 et 30 kg. Alors que les poids vifs vides étaient toujours significativement différents (P<0,001), il n'y avait pas de différence significative entre les lots pour le deuxième abattage: la phase de croissance compensatrice influençait donc la conformation des carcasses.

Les quantités de gras (en grammes par carcasse ou en % du poids de carcasse) n'étaient pas significativement différentes au premier abattage. On peut donc penser que du point de vue nutritionnel, la phase I se caractérisait par des apports permettant au mieux une bonne croissance, suffisante toutefois pour permettre un bon engraissement. Pour le deuxième abattage en revanche, la différence entre les états d'engraissement était significative (P<0,001) (gras en % du poids de carcasse). On constate que plus le poids moyen au début de la phase II était élevé, plus la quantité de gras était importante, ce qui correspond à une augmentation des dépenses énergétiques par kilo de croît. La phase II, qui correspondait donc uniquement à une croissance compensatrice pour les lots 1 et 4, serait une phase de croissance — engraissement — ou de finition pour les lots 2 et 3.

Le poids de gras augmentait surtout à partir de 18,20 kg de poids vif vide, ce qui correspondait à un poids vif de 23 à 25 kg. C'est donc à partir de ce poids vif moyen que la transformation devenait moins efficace et que l'augmentation du poids vif nécessitait une quantité d'énergie de plus en plus importante. Pour Richard *et al.* (1985), le poids vif n'est pas lié au rendement vrai (à un poids moyen de 27,75 à 29,25 kg). Il existait ici une liaison hautement significative pour les deux abattages (r=0,803 et 0,620, respectivement pour le premier et le second abattage), ce qui signifie que l'alimentation avait un effet favorable tant sur le poids vif que sur la conformation. Le gain de poids vif était donc associé à l'augmentation du rendement de carcasse.

Coût de la complémentation

Berger (1979b) et Ettien (1983), après des essais d'alimentation de 97 et 120 jours respectivement, rapportent pour le coût de divers concentrés pour 1 kg de gain de poids vif des valeurs très variables, allant de 71 à 84 FCFA/kg pour le premier et de 69 à 130 FCFA pour le second. Alors que le coût de la complémentation par *Albizia zygia* était beaucoup plus élevé dans l'hypothèse du coût maximum, le tourteau de coton avait permis d'obtenir un coût moyen, malgré la qualité médiocre de la ration de base.

Justifiée du point de vue zootechnique, la complémentation par *Albizia zygia* durant une période critique du point de vue alimentaire l'était également sur le plan économique car elle se traduisait par une croissance compensatrice.

CONCLUSION

La complémentation avec *Albizia zygia* au cours de la phase I a permis aux animaux de conserver un état physiologique suffisamment satisfaisant pour mettre à profit une période plus favorable et enregistrer une bonne croissance compensatrice. La différence avec le lot témoin est significative sur l'ensemble des deux phases.

La complémentation avec du tourteau de coton à raison de 200 ou 400 g par jour permettait d'améliorer nettement les performances.

L'étude des carcasses effectuée à la fin de chaque phase de l'essai a fait ressortir un certain effet de la croissance compensatrice sur les poids des carcasses et surtout sur les rendements vrais.

Bien qu'*Albizia zygia* n'ait qu'une valeur nutritive moyenne, ce ligneux était très bien consommé. Le coût de la complémentation par kilo de croît montre que la complémentation est justifiée du point de vue économique, même dans le cas d'un coût maximum avec *Albizia zygia*. La complémentation avec ce ligneux a surtout permis d'atteindre le poids minimum de commercialisation de 20 kg de poids vif au cours de la phase II, ce qui n'a pas été possible avec le lot témoin.

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PERFORMANCE OF WEST AFRICAN SHORTHORN CATTLE GRAZING UNDER SHEANUT TREES IN THE GUINEA SAVANNA ZONE OF GHANA

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ABSTRACT

West African Shorthorn cattle were grazed under sheanut trees on a research station at Bole in the Guinea Savanna zone of Ghana. Animals were herded during the day and kraaled at night, according to local practice. Performance data collected so far indicate a mean calf birth weight of 14.4 kg (range 10–19.5 kg) and a mean calving interval of 429.2 days (range 314–702 days); these results compare favourably with results from similar studies in the forest belt. During the six-month rainy season, grasses growing naturally under shea trees yield about 800 kg dry matter/ha, with a nitrogen content of 1.29% of dry matter; based on this yield, the carrying capacity of the natural grassland in the rainy season is one animal per 1.4 ha.

RESUME

Performances des taurins à courtes cornes d'Afrique occidentale élevés sous l'arbre à beurre ou karité dans la zone de savane guinéenne au Ghana

Des taurins à courtes cornes d'Afrique occidentale ont été élevés sous l'arbre à beurre ou karité en station à Bole en zone de savane guinéenne au Ghana. Les animaux paissaient la journée et étaient rassemblés la nuit dans des enclos conformément à la pratique dans cette région. Les données de performance obtenues jusqu'ici indiquent que le poids moyen des veaux à la naissance était de 14,4 kg (intervalle de variation de 10 à 19,5 kg) et l'intervalle entre vêlages de 429,2 jours (intervalle de variation de 314 à 702 jours). Ces résultats étaient meilleurs que ceux obtenus dans des études analogues effectuées en région de

forêt. Au cours des six mois d'hivernage, la production de matière sèche de l'herbe naturelle poussant sous couvert de karité était de 800 kg/ha—chiffre qui, avec une teneur en protéines de 1,29% de la MS, donnait une capacité de charge d'un animal pour 1,4 ha.

INTENSIVE FODDER GARDENS FOR INCREASING FORAGE AVAILABILITY FOR SMALLHOLDER DAIRY PRODUCTION IN HAI DISTRICT, TANZANIA

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ABSTRACT

For a long time, scarcity of animal feed has been a major constraint to smallholder dairy production in Hai District in the Kilimanjaro region of Tanzania, where land shortage is a serious problem. Feed resources commonly used are grass (cut and transported from the lowlands), crop residues and agro-industrial byproducts. But the costs of transporting low quality feed from the lowlands and of treating crop residues increase the cost of milk production. Small backyard fodder plots have been used to provide additional feed, but these plots have not been managed intensively, and their yields have been low.

From September 1989, studies on intensive fodder gardens were started at four sites in Hai District; three grasses—*Pennisetum purpureum* (elephant grass), *Tripsacum laxum* (Guatemala grass) and *Setaria splendida* (setaria)—were planted alone or together with a legume, green leaf Desmodium (*Desmodium intortum*), at each site. In the first year, total annual herbage yields (fresh weight) from sole grass plots ranged from 48 to 254 t/ha; yields from grass–legume plots were usually slightly higher. These results indicate that intensive fodder gardens can increase forage quality and availability for smallholder dairy production in land shortage areas.

RESUME

Accroissement du disponible fourrager grâce aux vergers d'embouche en vue de la petite exploitation laitière dans le district de Hai en Tanzanie

Les pénuries d'aliments du bétail constituent depuis de nombreuses années un obstacle majeur au développement de la petite production laitière dans le district de Hai, dans la région du Kilimandjaro en Tanzanie. Les graminées (en *provenance des basses terres), les résidus de récolte et les sous-produits agro-industriels sont les ressources alimentaires les plus utilisées dans cette zone où le manque de terre constitue un problème extrêmement sérieux. Malheureusement, les frais de transport de ce fourrage de qualité médiocre et les frais de conditionnement des résidus de récolte grèvent lourdement la production laitière dans cette région. Faute d'un mode de gestion intensif, la production des petits vergers d'embouche mis en place autour des cases pour accroître la production d'aliments du bétail demeure faible.*

En septembre 1989, des études ont démarré sur des vergers d'embouche sur quatre sites du district de Hai. A cet effet, trois graminées, à savoir Pennisetum purpureum *(herbe à éléphant),* Tripsacum laxum *(herbe du Guatemala) et* Setaria splendida *(setaria) ont été semées en cultures pures ou en association avec* Desmodium intortum*—une légumineuse—sur chaque site. Au cours de la première année, la production totale (poids vert) de fourrage des parcelles semées uniquement de graminées allait de 48 à 254 t/ha; quant à celle des parcelles à association graminées–légumineuses, elle était généralement légèrement plus élevée. Ces résultats montrent que les vergers d'embouche peuvent permettre d'accroître la qualité et la production de fourrage à l'intention des petits producteurs de lait des régions où le manque de terre constitue un sérieux problème.*

INTRODUCTION

In recent years smallholder dairy farming in Hai District, Tanzania, has been gaining momentum, not only as a supplier of a high quality food (milk) but also as a major source of cash for farmers (Mdoe, 1985). A major constraint to this flourishing industry is shortage of animal feed; most farmers own only small farms (about 0.5 ha) around their homesteads, which they use to grow coffee, bananas and vegetables. The problem will worsen as population pressure increases and land becomes even scarcer.

Feed resources used by these farmers are grass and crop residues transported from the lowlands, vegetable residues, weeds from banana/coffee plots and sometimes agro-industrial byproducts (such as molasses). But the cost of transporting cut grass and crop residues from the lowlands increases the costs of smallholder dairy production, and because these feeds have only low nutritive value, milk yields are low (Urio, 1987). Moreover, feeding weeds from banana/coffee plots to animals can be dangerous because toxic fungicides and pesticides are sprayed on the coffee plants.

Small backyard fodder plots have been used to grow additional animal feed, but lack of intensive management has meant that the yields from these plots have been low. Urio (1987) noted that increased production from backyard fodder plots can be increased by improving agronomic practices, by including legume species in pasture plots and through better supply of pasture seeds. And recently, small-scale farmers in Hai district have been urged by livestock extension advisers to manage their homestead fodder plots intensively, in the same way as vegetable gardens, so as to improve fodder yield and quality: fodder plots that are managed intensively in this way are termed "intensive fodder gardens".

This paper presents the encouraging first-year results from an on-going study on intensive fodder gardens at four different sites in Hai District, Tanzania.

MATERIALS AND METHODS

Experimental plots were established at four research sites (Sanya juu, Mowanjamu, Kashashi and Nronga) in September 1989; plot size ranged from 20 to 48 m^2, depending on the availability of land. Three grasses—*Pennisetum purpureum* (elephant grass), *Tripsacum laxum* (Guatemala grass) and *Setaria splendida* (setaria)—were planted from the end of September to mid-October 1989, alone or together with a legume, (*Desmodium intortum* cv Greenleaf). The experimental design was a randomised complete block with two replicates. Grass spacing was 1.0 x 0.5 m; the legume was sown in rows between the grass rows, at a seed rate of 1.2 kg/ha. Manure was applied at Sanya juu (8 t/ha) and Nronga (10 t/ha) before planting. Urea was applied at Mowanjamu (70 kg N/ha) one month after planting. No manure or fertiliser was applied at Kashashi. Plots were weeded continuously during fodder establishment.

Elephant grass was harvested when it was about 1 m high, Guatemala grass and setaria at about 0.75 m. Guatemala grass and setaria were cut at 15 cm above ground level; elephant grass was cut at almost ground level so as to get strong tillers and maintain the productive lifespan of the grass. Three cuttings were made between January and June 1990, except at Sanya juu where only two cuttings were possible due to late onset of the long rains. After cutting, the grass and legume were separated and weighed to determine the fresh-weight yield.

Routine management of the experimental plots was done by farmers; planting, cutting and weighing were undertaken jointly by researchers, farmers and extension staff.

RESULTS AND DISCUSSION

Results for each site are presented in Table 1. Yields of grass or grass–legume mixture were highest from elephant grass plots and lowest from Guatemala grass plots. The legume gave the highest yield when mixed with Guatemala grass and the lowest when mixed with elephant grass. The shading effect of the elephant grass appears to hinder the growth of the legume.

With the exception of elephant grass at two sites and setaria and Guatemala grass at one site each, total herbage yield was slightly (but not significantly) higher from grass–legume mixtures than from sole grass plots. It has been shown that elephant grass is at a competitive disadvantage with *Desmodium intortum* under regular defoliation (Tiley, 1989). However, in this case the decline in yield

Table 1. *Mean yields of grass and grass/legume mixtures at four sites in Hai District, Tanzania, 1990*

Species	Mean fresh-weight yields (t/ha per year)					
	Grass alone	Grass/legume mixture: Grass	Grass/legume mixture: Legume	Grass/legume mixture: Total	% change in total herbage yield	% legume in the mixture
Kashashi						
Pennisetum purpureum	254.05	203.60	12.05	215.65	–15.10	5.59
Tripsacum laxum	85.80	81.90	26.10	108.00	25.87	24.17
Setaria splendida	98.50	140.00	25.40	165.40	67.92	15.36
Mowanjamu						
Pennisetum purpureum	132.35	116.25	7.25	123.50	– 6.69	5.87
Tripsacum laxum	72.50	63.10	21.35	84.45	16.48	25.28
Setaria splendida	93.95	102.30	9.60	111.90	19.11	8.58
Nronga						
Pennisetum purpureum	203.45	213.20	1.55	214.75	5.56	0.72
Tripsacum laxum	47.80	48.70	18.10	66.80	39.75	27.1
Setaria splendida	96.65	90.45	11.80	102.25	5.79	11.54
Senya Juu						
Pennisetum purpureum	193.60	207.80	0.50	208.25	7.57	0.24
Tripsacum laxum	81.10	56.90	9.00	65.90	–18.74	13.66
Setaria splendida	153.90	146.90	0.65	147.50	– 4.16	0.44

at the two sites did not appear to be due to competition because the percentage of legume in the mixture was low, and so the effect must have been caused by other environmental factors.

Significant yield differences were found across the four sites. Although the differences observed were partly attributed to site-specific factors, differences in the level of management might also have contributed to the observed results.

CONCLUSION

These first-year results seemed very encouraging to the farmers who learned the importance of backyard intensive fodder gardens. With intensive management, the fodder gardens could produce enough fodder to improve the feed budget and thus maintain high milk production throughout the year. The farmers also learned other advantages of grass–legume mixtures, such as conserving labour by harvesting two separate forages together, suppression of weed growth by legume between grass rows and improving forage quality. An on-going economic evaluation is looking at how the cost of milk production could be affected by these fodder gardens. Meanwhile, the technology of grass–legume mixtures, which was hitherto uncommon in the district, is spreading fast because of the apparently obvious advantage of better quality feed.

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ANIMAL PRODUCTION SYSTEMS

BASED ON

CROP RESIDUES AND LEGUMES

INTERCROP *STYLOSANTHES* EFFECTS ON MILLET YIELDS AND ANIMAL PERFORMANCE IN THE SAHEL

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ABSTRACT

The increasing interest in crop–livestock integration in sub-Saharan Africa has emphasised the beneficial uses of forage legumes in cereal-based cropping systems. Forage legume–cereal cropping systems were evaluated in 1989 and 1990 at the ICRISAT (International Crops Research Institute for the Semi-Arid Tropics) Sahelian Center along with the performance of sheep fed millet residues as a basal diet and supplemented with forage legume hay.

Intercropping *Stylosanthes fruticosa* (Retz.) Alston and *S. hamata* (L.) Taub. with millet (*Pennisetum glaucum* [L.] R. Br.) did not significantly affect grain yields during the legume establishment year. During the second year, when millet was planted into pre-established stylo, total biomass and crude-protein yields increased by 45 and 125%, respectively, yet millet grain yield decreased by more than 30%. Sheep supplemented with 500 g stylo hay per day consistently gained weight during 60–70 day pen-feeding and grazing trials.

Management strategies are needed to fully exploit the agronomic benefits and feeding value of forage legumes introduced into Sahelian mixed farming systems.

RESUME

Effet de l'introduction de* Stylosanthes *dans les systèmes agraires du Sahel sur la production de mil et les performances animales

L'intérêt croissant que suscite l'intégration de l'agriculture et de l'élevage en Afrique subsaharienne a permis de faire ressortir les avantages de l'introduction des légumineuses fourragères dans les systèmes agraires à base de céréales. Des systèmes agraires associant cultures de légumineuses et de céréales ont été évalués en 1989 et 1990 au Centre sahélien de l'ICRISAT (Institut international de recherche sur les cultures des zones tropicales semi-arides). Ces études avaient été effectuées simultanément avec des travaux visant à examiner les performances d'ovins soumis à un aliment de base composé de résidus de mil et complémenté avec du foin de légumineuses.

L'introduction de Stylosanthes fruticosa *(Retz.) Alston et de* S. hamata *(L.) Taub entre les rangées de mil (*Pennisetum glaucum*) n'avait aucun effet significatif sur la production de grains au cours de l'année d'établissement des légumineuses. Au cours de la seconde année, lorsque le mil était semé entre ces légumineuses, les productions de biomasse totale et de protéines brutes avaient augmenté de 45% et de 125% respectivement, alors que le rendement en grains du mil avait baissé de plus de 30%. Des ovins soumis pendant 60 à 70 jours à un régime d'alimentation à l'auge et de pâturage le jour complémenté par 500 g de foin de* Stylosanthes *enregistraient des gains réguliers de poids.*

Des efforts doivent être déployés pour élaborer des méthodes de gestion permettant de tirer pleinement parti des avantages agronomiques et nutritionnels de l'introduction des légumineuses fourragères dans les systèmes agraires mixtes du Sahel.

INTRODUCTION

The introduction of forage legumes in cereal-based cropping systems is a promising strategy for increasing crop and livestock productivity in sub-Saharan Africa (Gryseels and Anderson, 1983; Tothill, 1986). Forage legumes can enhance soil fertility, improve yields and nutritive value of harvested products, sustain food production and combat erosion (Mohamed-Saleem, 1985; le Houérou, 1989; Izaurralde et al, 1990; Garba and Renard, 1991). However, the beneficial effects of legumes vary according to crop species, management and environmental factors (Waghmare and Singh, 1984; Nnadi and Haque, 1988; Varvel and Peterson, 1990). Because forage legumes do not contribute directly to food security, farmers are reluctant to devote land and other resources solely to forage production. The adoption of forage crops by farmers will, therefore, depend on the demonstration of their productivity and subsequent positive impact on cereal and livestock production, The following studies were conducted to determine the effect of forage legume–cereal intercropping on yields, nutrient uptake and fodder quality, and performance of sheep fed cereal stover as a basal diet and supplemented with forage legume hay.

MATERIALS AND METHODS

The studies were conducted during 1989 and 1990 at the International Crops Research Institute for the Semi-Arid Tropic (ICRISAT) Sahelian Center (ISC), at Sadoré (latitude 13° 15′ N, longitude 2° 18′ E), Niger. The sandy soil (Siliceous Isohyperthermic Psammentic Paleustalf) of ISC is acidic (pH 5.6 in 1:1 soil:water mixture) and low in native fertility (West et al, 1984). Average annual rainfall is 560 mm; rainfall was 623 mm in 1989 and 499.5 mm in 1990.

Agronomic trials

Legumes for the intercropping trials were selected based on their previous superior performance in screening evaluations. Seed of *Stylosanthes fruticosa* (Retz.) Alston was collected locally and seed of *S. hamata* (L.) Taub. cv Verano was obtained from the International Livestock Centre for Africa (ILCA), Addis Ababa, Ethiopia. Seed of both species was multiplied at the ISC. The millet (*Pennisetum glaucum* [L.] R.Br.) cv CIVT, a recommended cultivar in the region, was used. Experimental treatments consisted of two planting strategies:

- millet and stylo sown on the same day
- millet sown into year-old pre-established stylo;

and seven cropping patterns:

- pure millet
- pure *S. fruticosa*
- millet plus *S. fruticosa* in alternate single rows
- pure *S. hamata*
- millet plus *S. hamata* in alternate single rows
- millet plus *S. fruticosa* in alternate triple rows
- millet plus *S. hamata* in alternate triple rows.

The treatments were replicated four times in a split plot design with planting date assigned to the main plot and cropping system randomly assigned to 8 x 12 m subplots. Each plot received an annual application of 13 kg P/ha as single superphosphate which was broadcast before planting and worked into ridges with an oxen-drawn plough after the first rains. Nitrogen was applied to millet at the rate of 15 kg N/ha as calcium ammonium nitrate in a single application about 30 days after emergence. Planting occurred on 30 June 1989 and 30 May 1990. Millet was sown in pockets at 1.2-m spacing on ridges 0.75 m apart, and was thinned to three plants per pocket three weeks after sowing. Stylo was sown in continuous lines and was not thinned.

To determine treatment effects on yields, the total biomass from the innermost 3 x 4 m of each subplot was hand harvested and weighed. Millet was fractionated into panicles, leaf (blade and sheath) and stem. Subsamples of millet plant parts were sun-dried to constant weight for dry-matter (DM) determination. Panicles were threshed to determine grain yield. The legumes were harvested twice, approximately 60 and 120 days after emergence. Herbage subsamples were oven-dried (75°C, 48 hours) for DM determination. Seed yields for the legumes were determined at the second harvest. All plant samples were milled to pass a 1-mm screen, acid-digested using a modification of the aluminium block digestion procedure (Gallaher et al, 1975) and nitrogen and phosphorus were determined by semi-automated colorimetry (Hambleton, 1977).

Analysis of variance using the General Linear Model procedures (SAS, 1982) was used to determine treatment effects on yields of millet grain and stover, stylo herbage and seed and fodder crude protein. A least significant difference (LSD) test (Montgomery, 1984) was used to identify possible differences in treatment means.

Sheep feeding trials

A pen-feeding and a grazing trial were conducted in 1989 and 1990 to determine liveweight changes of sheep fed millet stover as a basal diet and supplemented with cowpea (*Vigna unguiculata* [L.] Walp.) or *S. fruticosa* hay.

In the 70-day pen-feeding trial, three groups of eight intact male sheep (average liveweight 28 kg) were randomly assigned to one of three rations:

1. millet stover only (control)
2. millet stover plus 300 g cowpea hay
3. millet stover plus 500 g stylo hay.

Millet was fed *ad libitum* and legume levels were determined to provide a daily nitrogen supplement of 6 g per animal. The hays were offered individually to animals at the end of the day.

In the 60-day grazing trial, 30 intact male sheep (average liveweight 25 kg) were divided into three equal groups. All animals grazed a 3.5-ha millet field during the day and the legume hays were offered individually to animals in the evening at the same level as in the pen-feeding trial.

RESULTS AND DISCUSSION

Agronomy trials

Planting time and pattern highly influenced millet and stylo yields. During the stylo seeding year, yields were highly variable and so no significant differences in grain yields among the cropping systems were detected (Table 1). However, average millet grain yields from the alternate triple row millet/*S. hamata* treatment decreased by 78% in 1989. Millet stover yields were 10–53% less from intercrops than from sole crops. Reductions were greatest in the millet/*S.*

Table 1. *Seeding year yields of millet and* Stylosanthes *(millet and stylo sown on the same date) as affected by cropping system*

Cropping system	Millet Grain (kg/ha)	Millet Stover (kg/ha)	Stylo herbage (kg/ha)	Residue[a] Biomass (kg/ha)	Residue[a] Crude protein (%)
1989					
Pure millet	1080	2706	–	2706	4.3
Pure *S. fruticosa*	–	–	213	213	11.9
Millet/*S. fruticosa* single rows	805	2405	14	2419	5.6
Pure *S. hamata*	–	–	552	552	12.4
Millet/*S. hamata* single rows	1020	2428	22	2450	5.5
Millet/*S. fruticosa* triple rows	613	2400	327	2727	6.2
Millet/*S. hamata* triple rows	246	1276	353	1629	5.9
LSD (5%)	ns	1181	123	948	1.7
1990					
Pure millet	591	1960	–	1960	4.8
Pure *S. fruticosa*	–	–	783	783	12.2
Millet/*S. fruticosa* single rows	407	1484	202	1686	5.0
Pure *S. hamata*	–	–	126	126	12.2
Millet/*S. hamata* single rows	414	1453	51	1504	5.7
Millet/*S. fruticosa* triple rows	539	1349	395	1744	7.5
Millet/*S. hamata* triple rows	341	939	61	1000	4.1
LSD (5%)	ns	433	324	476	1.2

[a] Residue = millet stover + stylo herbage

hamata association. When millet was grown with *S. hamata* in alternate triple rows, total biomass yield decreased by 40% in 1898 and 49% in 1990. Although stylo intercropping reduced yields in some treatments, crude-protein content of intercrop total biomass was 4–56% higher than that of sole millet crop in all treatments, except in 1990 when stylo herbage yields in intercrops were very low. Yet crude protein concentration of all harvested biomass was below 7%, the minimum maintenance level for ruminants (Humphreys, 1978). This poor feeding quality was due to the low stylo yield, probably caused by intermittent drought and poor germination during the seeding year.

When millet was sown into pre-established stylo, grain yield was reduced by 26–83% relative to monocrop millet (Table 2). Total biomass, crude-protein and phosphorus contents of intercrops were, however, higher in both years than those obtained in sole millet crop. Alternate triple row planting of millet with either stylo resulted in lower millet grain yield in 1989 than alternate single row

Table 2. *Yields of millet and* Stylosanthes *(millet sown into pre-established stylo) as affected by cropping system*

Cropping system	Millet Grain (kg/ha)	Millet Stover (kg/ha)	Stylo herbage (kg/ha)	Residue[a] Biomass (kg/ha)	Residue[a] Phosphorus (%)	Residue[a] Crude protein (%)
1989						
Pure millet	642	2662	–	2662	3.4	5.7
Pure *S. fruticosa*	–	–	3075	3075	5.1	13.0
Millet/*S. fruticosa* single rows	313	1214	2032	3246	4.6	9.3
Pure *S. hamata*	–	–	1265	1265	1.7	12.2
Millet/*S. hamata* single rows	276	1006	4698	5704	8.0	10.9
Millet/*S. fruticosa* triple rows	106	618	2508	3126	5.4	11.1
Millet/*S. hamata* triple rows	139	814	4122	4936	6.8	11.2
LSD (5%)	183	798	889	931	1.1	1.7
1990						
Pure millet	832	3204	–	3204	1.5	2.9
Pure *S. fruticosa*	–	–	2889	2889	4.6	12.2
Millet/*S. fruticosa* single rows	429	2234	1518	3752	3.0	7.3
Pure *S. hamata*	–	–	3936	3936	5.3	12.8
Millet/*S. hamata* single rows	217	1286	3064	4350	4.4	9.5
Millet/*S. fruticosa* triple rows	610	1845	1154	2999	2.8	6.2
Millet/*S. hamata* triple rows	439	1308	2271	3579	3.9	8.5
LSD (5%)	112	787	429	652	1.0	1.0

[a] Residue = millet stover + stylo herbage

planting. Cropping patterns involving *S. hamata* reduced millet yields more than those involving *S. fruticosa*.

Dry-matter yields of both stylos were greatest the second year after establishment. *Stylosanthes hamata* produced significantly more herbage ($P<0.01$) and assimilated more nutrients ($P<0.01$) than *S. fruticosa*. An exception to this was lower pure *S. hamata* yields in 1989 due to plants being cut too short the previous year, resulting in poor regeneration. Higher legume yields in the second year versus the first year of establishment contributed to the increase of intercrop dry matter and crude-protein content but caused a decline of millet yields.

Sheep feeding trials

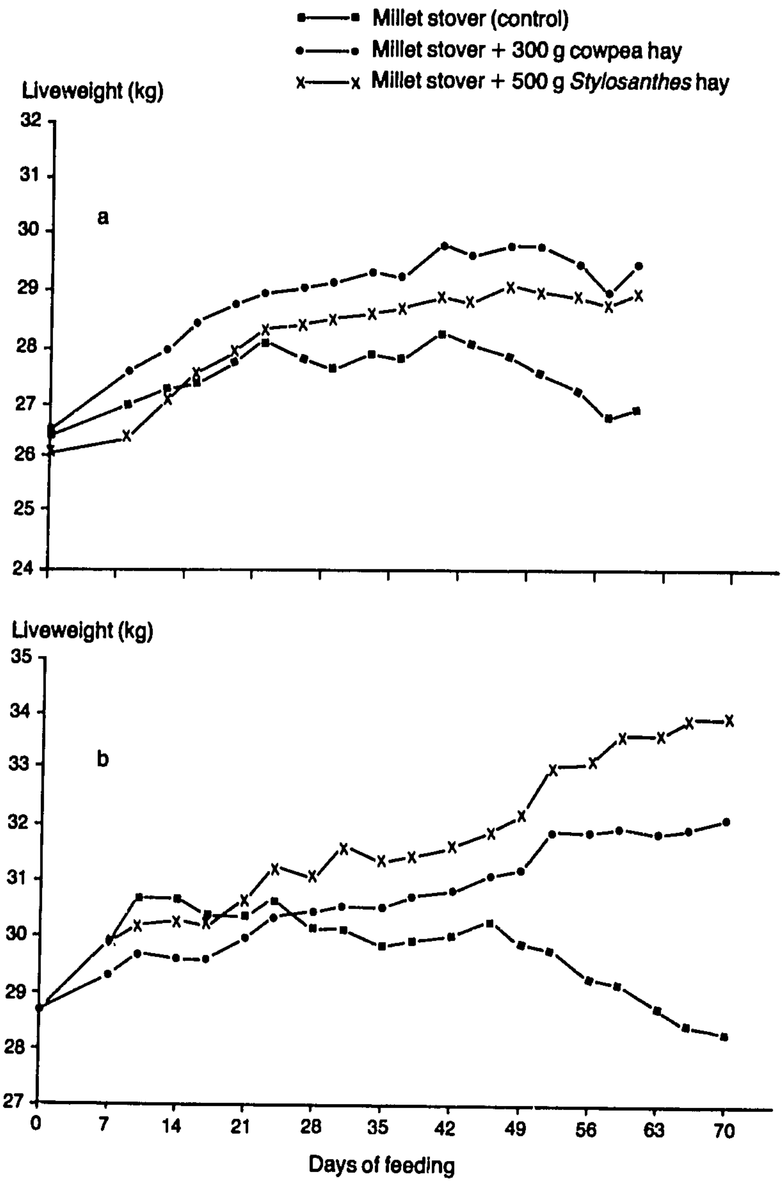
For sheep grazing millet stover, average daily liveweight gains (ADG) for the control, stylo and cowpea supplemented sheep were 78, 98 and 115 g, respectively, during the first 22 days of the trial (Figure 1a). Unsupplemented animals maintained their weight up to the 42nd day, after which they consistently lost weight. Supplemented sheep continued to gain weight up to the end of the trial. Average daily gains at the end of the trial were 12, 48 and 53 g for the unsupplemented, stylo and cowpea supplemented sheep, respectively. Weight gains of unsupplemented sheep during the first three weeks were probably due to animals grazing selectively the more nutritious portion of the biomass such as leaves, tillers and weeds. A parallel trial involving sheep grazing millet stover and browse wind breaks (ILCA, unpublished) found that crude-protein (CP) content of millet residue dropped from 50 g CP/kg DM at the start of grazing to 39 g CP/kg DM after four weeks. The reason why unsupplemented sheep began to lose weight, and weight gains of supplemented animals decreased after the first three weeks of grazing, was probably a decrease in the nutritive value of millet residues.

Pen-fed sheep consumed mostly millet leaves (blades and sheaths) and refused most stems. Supplemented animals had steady growth rate throughout the feeding period (Figure 1b). Unsupplemented sheep gained weight for a week and then maintained it up to 49 days, after which they lost weight up to the end of the 70-day trial. Resulting ADG for the entire trial were –1.8, 78 and 51 g for the control, stylo and cowpea hay supplemented sheep, respectively. That supplemented animals consistently sustained growth rate throughout the trial period was primarily due to constant nutritive value (53.1 g CP/kg DM) of feed supplied in the basal diet.

CONCLUSIONS

There appear to be distinct tradeoffs in grain and feed output when millet and stylo are intercropped. When millet was sown into year-old established stylo, grain yield decreased but total feed biomass and protein yield increased as compared with sole millet crop. The adoption of such intercropping systems will depend on the relative emphasis placed by small-scale farmers on grain versus feed production. The cut-and-carry system seemed to have an advantage over grazing but this benefit would need to be weighed against other factors such as labour input, storage, nutrient cycling, etc.

Figure 1. *Effect of supplementing cowpea or stylo hay on liveweight of sheep grazing millet ..ver (a) or fed millet stover in pens (b)*



In terms of improved feeding systems, the study showed that as little as 6 g N in the form of stylo supplemented daily to sheep fed millet residue is enough to obtain steady animal growth. The average additional 35 kg N/ha produced by intercropping *S. fruticosa* with millet could, therefore, in theory provide sufficient N supplement to 30 animals for 194 feeding days. Corresponding millet stover yields could, however, be reduced. Appropriate management strategies are therefore required to maximise the benefits of forage legume introduction into mixed crop–livestock farming systems of the Sahel.

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EFFECTS OF FEEDING HYDRATED TEFF STRAW AND PROTEIN SOURCES ON TEFF STRAW VOLUNTARY INTAKE AND GROWTH OF YOUNG HORRO SHEEP GRAZING NATIVE PASTURE DURING THE DRY SEASON

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ABSTRACT

Two experiments were carried out to investigate the effects of supplementary feeding on the dry-matter intake and growth rate of young Horro sheep grazing native pasture during the dry season. In the first experiment, there was no significant difference between the dry-matter intakes of *ad libitum* supplements of dry or wetted teff straw (117 and 139 g/day, respectively). Neither dry nor wetted teff-straw supplements significantly increased lamb growth rates in comparison with unsupplemented controls (41, 40 and 37 g/day, respectively). Lamb growth rates were, however, significantly increased by daily supplementation with 238 g dry *Leucaena* per lamb, offered alone or with dry or wetted teff straw (79, 69 and 78 g/day, respectively). In the second experiment, feed supplements comprising different proportions of maize grain, noug cake and dry *Leucaena* all significantly increased lamb growth rates above the average of 10 g/day of unsupplemented controls. Growth rates of supplemented lambs increased approximately linearly from 45 to 64 g/day as *Leucaena* gradually replaced noug cake as the source of crude protein in the supplement.

These results demonstrate that home-grown *Leucaena* supplements can improve the productivity of small ruminants during dry periods when feed supplies are limited.

RESUME

Effet d'un aliment complémentaire composé de paille de tef hydratée et des sources de protéines sur l'ingestion volontaire de paille de tef et la croissance d'agneaux Horro élevés sur pâturage naturel au cours de la saison sèche

Deux expériences ont été effectuées en vue d'évaluer l'effet d'un aliment complémentaire sur l'ingestion de matière sèche et la croissance d'agneaux

Horro élevés sur pâturage naturel au cours de la saison sèche. Dans la première expérience, aucune différence significative n'a été enregistrée entre la consommation de matière sèche d'un complément de tef offert ad libitum, *qu'il soit sous forme séchée ou hydratée, les chiffres étant de 117 et 139 g respectivement. Par ailleurs, la paille de tef, qu'elle soit séchée ou hydratée, n'entraînait aucune accélération significative de la croissance des agneaux, laquelle s'établissait à 41 et 40 g/j respectivement contre 37 g/j pour le lot témoin. En revanche, un complément de 238 g de* Leucaena *par jour et par tête offert seul ou associé à de la paille de tef séchée ou hydratée entraînait une augmentation significative des taux de la croissance, les gains de poids étant respectivement de 79, 69 et 78 g/j.*

Dans la seconde expérience, des aliments complémentaires composés de différentes combinaisons de grains de maïs, de tourteau de noug *et de fourrage de* Leucaena *séché entraînaient chez les agneaux des accroissements significatifs des taux de croissance supérieurs à la moyenne de 10 g/j enregistrée chez les témoins. Les gains de poids des agneaux augmentaient de manière linéaire de 45 à 64 g/j à mesure que le* Leucaena *remplaçait le tourteau de* noug *comme source de protéine dans l'aliment complémentaire.*

Ces résultats montrent qu'une complémentation de Leucaena, *légumineuse poussant sur place, peut permettre d'accroître la productivité des petits ruminants au cours de la saison sèche, c'est-à-dire en période de pénuries d'aliments du bétail.*

SUSTAINABLE DRY-SEASON FEEDING OF RUMINANTS IN GHANA: THE USE OF CROP RESIDUES AND LEGUMINOUS SHRUBS AS FEEDSTUFFS

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ABSTRACT

Ruminant livestock production in Ghana is based predominantly on native grassland. The nutritive value of the natural pastures varies drastically according to season: protein content is between 8 and 12% of DM at the start of the rainy season but drops to 2–4% in the four- to six-month dry season. Animal performance fluctuates widely, and there is overwhelming evidence of undernutrition and malnutrition in the animals.

About 2.3 million tonnes of cereal crop residue are produced in Ghana annually. If it is used strategically, this feed resource could save up to 186 million kg of livestock weight loss during the 120-day dry season.

Research work is underway on methods of transforming fibrous feeds into adequate feed resources for ruminants in the dry season. For example, animals fed urea-ensiled straw either maintained their liveweight or made modest positive weight gains. When supplemented with *Leucaena leucocephala* (15 to 30% of total DM intake) liveweight gains in goats fed urea-treated rice straw rose from 33 to 61 g/d over 56 days. It is suggested that feeding urea-treated low-quality roughages supplemented with leguminous browses is the key to solving dry-season feeding problems for the smallholder livestock farming system in Ghana.

RESUME

Alimentation des ruminants pendant la saison sèche au Ghana: utilisation des résidus de récolte et du fourrage des légumineuses arbustives dans les rations

L'élevage des ruminants au Ghana repose essentiellement sur la production des pâturages naturels dont la valeur nutritive varie très sensiblement en fonction de la saison. Ainsi la teneur en protéines de l'herbe naturelle varie de 8 à 12% de la

matière sèche au début de l'hivernage pour chuter à 2 à 4% au cours des quatre à six mois de saison sèche. Les performances animales fluctuent donc très largement et la sous-nutrition ainsi que la malnutrition semblent très répandues chez les animaux.

Environ 2,3 millions de tonnes de résidus de céréales sont produites chaque année au Ghana. Utilisée de manière rationnelle, cette production peut permettre d'éviter chez les animaux des pertes de poids évaluées à 186 millions de kilos de poids vif au cours des 120 jours de sécheresse.

Des travaux sont actuellement en cours sur la transformation des aliments fibreux en ressources alimentaires utilisables par les ruminants au cours de la saison sèche. Par exemple, on s'est aperçu que des ensilages de paille traitée avec de l'urée permettaient aux animaux de maintenir leur poids ou même de l'augmenter légèrement. Par ailleurs, une complémentation de Leucaena leucocephala *(15 à 30% de la quantité totale de matière sèche ingérée) entraînait un accroissement des gains de poids de 33 à 61 g/j pendant 56 jours chez des caprins nourris avec de la paille de riz traitée avec de l'urée. L'utilisation de fourrages grossiers de qualité médiocre traités avec de l'urée et complémentés avec du fourrage de légumineuses ligneuses pourrait donc permettre de résoudre le problème des pénuries alimentaires auquel sont confrontés au cours de la saison sèche les petits éleveurs au Ghana.*

COLOPHOSPERMUM MOPANE BROWSE PLANT AND SORGHUM STOVER AS FEED RESOURCES FOR RUMINANTS DURING THE DRY SEASON IN BOTSWANA

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ABSTRACT

Livestock in Botswana depend on natural rangelands for feed during both wet and dry seasons. Indigenous browse plants providing feed for livestock include leguminous types such as *Acacia nilotica* and nonleguminous types such as *Colophospermum mopane*. The mopane tree has long roots which enable it to extract moisture at great depth: because of this ability the plant breaks dormancy and produces fresh green leaves before the rainy season. During the dry season and drought years, mopane trees bear pods with seeds and these, together with the dry mopane leaves, are consumed by livestock.

Cereal stovers are used to feed livestock during the dry season in certain areas of Botswana. Because cereal stovers are low in crude protein, digestible energy and mineral content, livestock farmers grow lablab (*Lablab purpureus*), a legume fodder crop, to feed in association with crop residues in the dry season.

A dietary selection study on goats showed that the crude-protein content of the plant material browsed in May, June and July was about 11.5%, compared with about 9% in August. The average dry matter of the plant material browsed in June, July and August was 93% compared with 84% in May. Liveweights of animals dependent on browse plants during the dry season remained constant.

Differences in the apparent digestibilities of dry matter, crude protein and organic matter found in a nutrient digestibility study with goats were highly significant ($P<0.001$). There was a wide variation in the feed value of the dry mopane leaves offered to the animals.

Fresh green mopane leaves contain more polyphenolic compounds and condensed tannins than dry mopane leaves.

Average liveweight change and daily gain for steers fed sorghum stover with lablab hay were higher ($P<0.001$) than those of steers fed sorghum stover alone or with dry mopane leaves. The average cold dressed weight for Bonsmara steers fed stover with lablab hay was higher ($P<0.05$) than for Bonsmara steers fed stover alone or stover with mopane leaves. The poor performance of steers fed stover with dry mopane leaves could be due to poor condition of the plant material and/or to using steers that were not used to browsing the mopane plant.

RESUME

Utilisation de fourrage de **Colophospermum mopane** *et de paille de sorgho dans l'alimentation des ruminants au cours de la saison sèche au Botswana*

Que ce soit au cours de l'hivernage ou pendant la saison sèche, l'essentiel des aliments du bétail utilisés au Botswana proviennent des ressources pastorales naturelles. Les espèces ligneuses locales qui entrent dans l'alimentation du bétail sont, entre autres, des légumineuses (exemple: Acacia albida*) et d'autres espèces végétales comme* Colophospermum mopane. *Avec ses longues racines, ce ligneux peut aller chercher l'eau à des profondeurs insoupçonnées, ce qui lui permet d'éviter le phénomène de dormance et de produire des feuilles vertes avant le début de la saison des pluies. Au cours de la saison sèche,* Colophospermum mopane *porte des gousses avec des graines, lesquelles sont consommées par les animaux au même titre que les feuilles mortes.*

La paille de céréales entre également dans l'alimentation des animaux d'élevage dans certaines régions du Botswana. Etant donné que la paille est pauvre en protéines brutes, en énergie digestible et en matières minérales, elle est complémentée en saison sèche par du foin de Lablab purpureus, *une légumineuse cultivée sur place par les éleveurs.*

Des analyses ont révélé que le taux de protéines brutes des ligneux broutés par les caprins était d'environ 11,5% en mai, juin et juillet contre 9% en août. Quant à leur teneur en matière sèche, elle était en moyenne de 93% en juin, juillet et août contre 84% en mai. Les animaux se nourrissant de ces ligneux au cours de la saison sèche parvenaient à maintenir un poids relativement constant.

Une étude de digestibilité des éléments nutritifs effectuée sur des caprins a permis de mettre en évidence des différences hautement significatives ($P<0,001$) entre les taux de digestibilité apparente de la matière sèche, les teneurs en protéines brutes ou les taux de matière organique. Par ailleurs, d'importantes différences ont été enregistrées dans la valeur nutritive des feuilles sèches de Colophospermum mopane.

De même, les feuilles vertes contenaient plus de composés polyphénoliques et de tanins que les feuilles sèches.

Les variations et les gains moyens de poids des boeufs soumis à un régime composé de paille de sorgho complémentée avec du foin de Lablab purpureus *étaient plus élevés ($P<0,001$) que ceux des animaux recevant de la paille de* *sorgho associée ou non à du fourrage de* Colophospermum mopane. *Chez les boeufs Bonsmara, un régime composé de paille complémentée avec du foin de* Lablab purpureus *se traduisait par un poids moyen de la carcasse refroidie supérieur (P<0,05) à celui associé à un régime constitué de paille complémentée ou non avec des feuilles de* Colophospermum mopane. *Les performances médiocres liées à la complémentation avec des feuilles sèches de* Colophospermum mopane *pourraient s'expliquer par le piètre état du matériel végétal utilisé et/ou le fait que les boeufs de cette expérience n'avaient guère l'habitude du fourrage de* Colophospermum mopane.

INTRODUCTION

There are several species of indigenous trees in Botswana which provide feed for both game and livestock, especially during dry seasons and drought years. Browse plants provide the bulk of the protein, vitamins and mineral elements which are normally lacking in grasses during the dry season (le Houérou, 1980).

Colophospermum mopane trees, which have formed a distinctive vegetation in the mopane veld area, provide feed for livestock during dry seasons and drought years. Livestock browse mopane leaves when they turn reddish-brown in colour, at which time their crude-protein content averages about 11%. Fresh green mopane leaves have higher crude-protein content (almost 13%) but they are not eaten as readily by livestock as the reddish-brown leaves. Fresh mopane has low pH (4.83–5.05) and a bitter taste, which might contribute to its low acceptability by livestock (Ernst and Sekhwela, 1987). Furthermore, during the time when the mopane leaves are still green, natural grasses are abundant, and livestock prefer to graze rather than browse. Also, antinutritional factors such as tannins and polyphenolics may be present in high concentration in fresh mopane and may reduce its intake by livestock. Polyphenolic compounds and tannins in browse affect intake, digestibility and animal performance by reducing degradation of fibre and protein by rumen micro-organisms.

During the dry season *C. mopane* plants bear pods with seeds which contain 15–16% crude protein and are readily eaten by livestock. The mopane plant has long roots which enable it to extract moisture at great depths. Because of this ability, the mopane plant breaks dormancy and produces fresh green leaves before the rainy season, and therefore provides fodder for ruminants during the periods of grass shortage.

The importance of goats and cattle to Botswana's economy, and of browse plants to these animals during the dry season and drought years, justifies conducting studies to determine the nutritive value and goats' selection patterns of browse plants. Utilisation of dry mopane leaves and lablab (*Lablab purpureus*) hay as dry-season supplementary feeds for beef steers fed sorghum stover was investigated. The objectives of the studies were to:

- assess antinutritional factors in fresh and dry mopane leaves
- determine the nutritive value of goats' diets

- evaluate the effect of feeding dry mopane leaves with sorghum stover on nutrient digestibility by goats
- evaluate the performance of beef steers fed sorghum stover with mopane dry leaves or lablab hay as supplementary feeds during the dry season.

MATERIALS AND METHODS

The sorghum (*Sorghum bicolor*) stover used in the goat nutrient digestibility and steer performance studies was obtained from Sebele Agricultural Research Station fields: it was chopped through a 10-cm size screen using a forage harvester, left on the fields for two weeks to dry, and then piled together to prevent loss of nutrients through leaching. Fresh and dry mopane leaves were hand picked from Lesego Government Research Ranch in north-east Botswana. Lablab hay was grown and harvested from Sunnyside Research Station farm.

Experiment 1

A study of goat diet selection patterns was conducted at Lesego Government Ranch. The ranch covers an area of about 3990 ha, of which two 200-ha paddocks, each with a similar vegetation cover, were used for the experiment. There are several varieties of browse plants on Lesego ranch, but its vegetation is classified as mopane mixed tree and shrubland.

Four castrated male Tswana goats (average initial liveweight 62 kg), fitted with an oesophageal fistula, were used in the study. One day before sampling, animals were kraaled at 1200 hours to starve them so as to increase their intake of the browse plants during the sampling period. At 0800 hours on the day of sampling, the fistula plugs were removed and each animal was fitted with a collection bag around its neck. Sampling was done monthly for four months during the dry season (May to August). At least two samples for each goat were collected each month. Sampling time was about 30–40 minutes and this was preceded by removal of the sampled plant material from the collection bag into plastic bags kept on dry ice to prevent further changes by plant enzymes. After sampling the fistula plugs were refitted and the goats were transferred to the paddock not used for sampling. The browsed samples for each individual goat were freeze-dried, the ratio of browse plants/pods with seeds of the dried browsed plants was determined, and the dried plant material was then ground through a 1-mm screen for chemical analysis.

Experiment 2

A second study with goats was conducted to investigate nutrient digestibility. Three groups of four Tswana goats (average initial liveweight 55 kg) were randomly assigned to one of three diets:

- 540 g sorghum stover per day (diet 1)
- 407 g sorghum stover + 133 g mopane dry leaves per day (diet 2)
- 280 g sorghum stover + 260 g mopane dry leaves per day (diet 3).

The experimental regimen consisted of an *ad libitum* intake period of 18 days, followed by a five-day adjustment period to the feeding levels of the three experimental diets.

Each animal also received (at 0800 hours each day) 260 g of concentrate supplement containing 50% lablab leaves, 45% sorghum bran and 5% mineral mix (dicalcium phosphate and salt (1:2)). The chemical composition of the supplement was:

- dry matter: 94.04%
- crude protein: 13.35% of dry matter
- organic matter: 79.97% of dry matter
- ash: 20.03% of dry matter
- crude fibre: 11.23% of dry matter
- ether extract: 11.81% of dry matter
- nitrogen-free extract: 3.58% of dry matter

All animals were kept in metabolic crates during both the voluntary feed intake and nutrient digestibility periods and were weighed at the start and end of the experiment.

Weights and samples of feed offered and refused were taken daily during the last seven days of the voluntary intake and nutrient digestibility period. Urine and faeces were also collected daily from each animal during the digestibility study. Samples of feeds offered and refused and of faeces were ground through a 1-mm screen and analysed for dry matter and nitrogen by standard methodology (AOAC, 1980). Crude fibre was determined using a Fibertec System M (#1020 Hot Extrator). Ether extract was determined using the Soxtec System HT6 (#1043 Extraction Unit). Neutral and acid detergent fibre were determined on the browsed plant material using the method of Goering and Van Soest (1970). Lignin was determined using the 72% sulphuric acid procedure (Goering and Van Soest, 1970). A quantitative analysis for polyphenolic compounds and condensed tannins was done on both the fresh and dry mopane leaves using the procedure outlined by Marini-Bettolo (1980).

Experiment 3

The effect of dry mopane leaves and lablab hay as supplementary feeds for beef steers fed sorghum stover during the dry season is being evaluated in an on-going study.

Three groups of three Tswana and three Bonsmara steers (average initial liveweight 385 kg) were randomly assigned to one of three diets:

- 50% sorghum stover + 50% mopane dry leaves (diet 1)
- 70% sorghum stover + 30% lablab hay (diet 2)
- sorghum stover alone (diet 3)

All animals were also offered dicalcium phosphate and salt (1:2) *ad libitum*. The amount of feed offered to the animals was calculated based on the average body size of the animals.

Animals were dipped every two weeks to control external parasites and were weighed monthly. At the end of the experimental period (90 days) animals were sent to the Botswana Meat Commission (BMC) for slaughter and the carcasses were graded according to standard procedures.

Samples of feeds offered and refused were taken daily during the first seven days of each month for a period of 90 days. The feeds were analysed for dry matter and nitrogen by standard methods (AOAC, 1980). Neutral and acid detergent fibre were analysed using the method described by Goering and Van Soest (1970). Lignin was determined using the 72% sulphuric acid procedure (Goering and Van Soest, 1970). *In vitro* organic matter digestibility was measured using the Tilley and Terry (1963) procedure. The rumen fluid used in the *in vitro* procedure was collected from two steers fed lablab and grass hay.

RESULTS

Experiment 1

The ratio of browsed plant material and pods with seeds found in the collection bags of goats during the months of June and July was equal. The pods with seeds were mainly of *Dichrostachys cinera* (Moselesele) and small quantities of *Acacia nilotica* (Moka). Monthly chemical analyses of the browsed plant material are presented in Table 1. Average dry-matter content of goats' extrusa samples was lowest in May, while crude-protein content and *in vitro* organic matter digestibility were lowest in August.

Table 1. *Monthly chemical analysis of plant material browsed by goats at Lesego Ranch*

	Chemical composition (% DM)			
	May	June	July	August
Dry matter	84.00	93.00	93.00	93.77
Crude protein	12.00	10.98	11.49	9.07
Neutral detergent fibre	38.41	39.96	38.24	38.27
Acid detergent fibre	27.21	29.97	26.58	27.52
Lignin	12.03	12.45	11.09	11.99
Calcium	1.57	1.11	1.62	1.48
Phosphorus	0.18	0.27	0.18	0.20
In vitro organic-matter digestibility	–	–	58.25	45.23

Experiment 2

In the digestibility trial, substituting dry mopane leaves for stover increased the crude-protein content and the total digestible nutrients of diets 2 and 3 over the control diet (Table 2). The digestibilities of nutrients in goats fed diet 3 were higher (P<0.001) than those in goats fed diet 1 or 2 (Figure 1).

The concentration of condensed tannins was higher in fresh than in dry mopane leaves.

Average liveweights of the goats were 68 kg in May, 70 kg in June and July and 67 kg in August.

Table 2. *Chemical composition and total digestible nutrients of diets fed to goats in the nutrient digestibility trial*

	Chemical composition (% DM)		
Ingredients	Diet 1	Diet 2	Diet 3
Dry matter	95.02	95.07	95.07
Crude protein	6.48	8.55	10.62
Organic matter	82.87	85.25	86.78
Ash	17.13	14.75	13.22
Ether extract	9.28	14.25	14.25
Crude fibre	22.52	21.78	21.09
Neutral detergent fibre	44.59	40.67	40.82
Total digestible nutrients	43.69	66.15	67.41

Experiment 3

The chemical analysis of the diets given to the animals is presented in Table 3.

Average daily dry-matter intakes were 31.17, 49.17 and 43.80 kg for animals fed stover + mopane, stover + lablab hay and stover alone, respectively. There were differences (P<0.001) in the liveweight changes and average daily gains of the animals offered the experimental diets, and in the cold dressed carcass weights of Bonsmara steers (P<0.05) (Table 4).

Two carcasses of steers that were fed stover alone and one carcass of a steer fed stover and dry mopane leaves were condemned at BMC because of cysticercus bovis.

DISCUSSION

The lower crude-protein and higher DM content obtained in browsed plants sampled in August confirms that plant material deteriorates in quality as the dry season progresses. Subsequently, the performance of animals dependent on this

Figure 1. *Nutrient digestibility by diet*

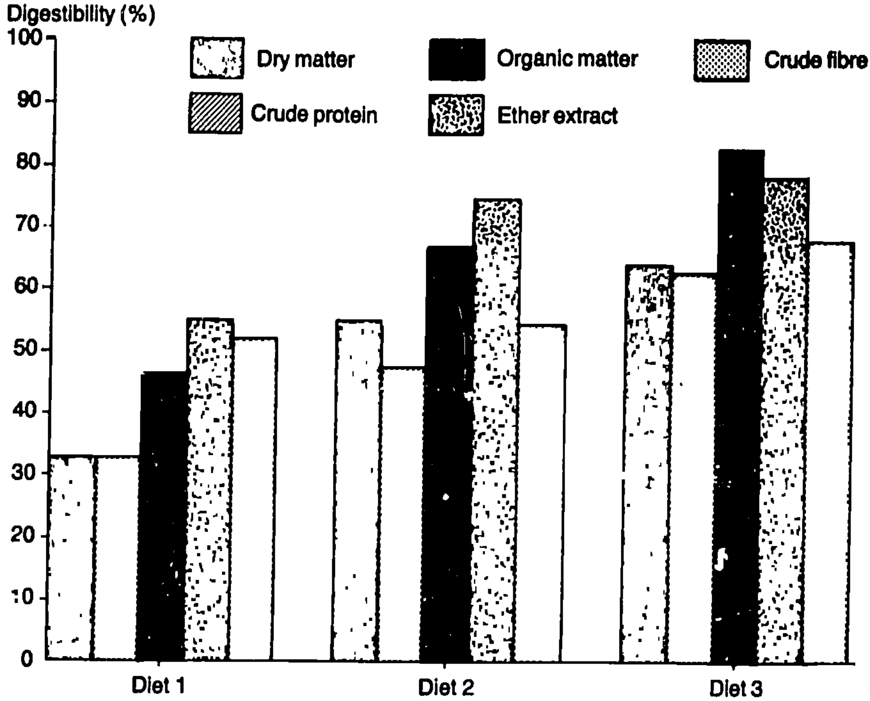

Table 3. *Ingredients and chemical composition of the diets fed to steers*

	Chemical composition (% DM)		
Ingredient	Diet 1	Diet 2	Diet 3
Dry matter	93.76	93.44	93.52
Crude protein	7.86	10.06	5.57
Neutral detergent fibre	52.16	65.54	69.90
Acid detergent fibre	33.31	41.98	41.35
Lignin	6.38	6.00	4.80
In vitro dry-matter digestibility	45.1	59.46	49.15

plant material is affected. In the tropics, animals need a diet of 7% crude protein and 45% dry matter digestibility to maintain their liveweight. Animals fed a diet with the 10–11% crude protein and 55% DMD are expected to gain weight (McDowell, 1972). In this experiment, the average liveweights of the goats remained constant in May, June and July and dropped slightly in August. The decrease in liveweight of the goats in August may be attributed to the decrease in

Table 4. *Liveweight changes, daily gains and cold dressed carcass weights of beef steers fed sorghum stover + mopane leaves, stover + lablab hay and sorghum stover alone during the dry season*

Parameters	Diet 1	Diet 2	Diet 3	SE
Initial mean liveweight (kg)	384	385	385	ns
Final mean liveweight (kg)	404	436	402	22.0
Change in liveweight (kg)	18	51	17	6.66
Average daily gain (g)	200	566.7	188.2	52.65
Cold dressed weight (kg)				
Tswana	166	168	158	ns
Bonsmara	168	191	168	

crude protein and increase in DM of the plant material eaten by the goats. The lignin content of the sampled plants during the dry season was similar and high. Previous studies comparing the digestive efficiency of goats, sheep and other ruminants have shown that goats are more efficient in digesting crude fibre (Devendra, 1986; ILCA, 1988). The greater efficiency for goats to digest fibre is associated with the intake of poor quality roughages, the feeding behaviour, concentration of cellulotic bacteria and rate of feed movement along the alimentary tract (Devendra, 1986).

Even though a significant increase in the digestibility of nutrients was found in goats fed diet 3, this increase was due mainly to the high proportion of concentrate supplement fed with the stover. There was a high degree of variation in the crude-protein, calcium and phosphorus content in the dry mopane leaves offered to the goats during the nutrient digestibility study (Table 5): this variation may be due to picking mopane leaves that may be low in feed value even though still attached to the plant. Mopane and other browse plants selected by the goats during the dietary selection study had crude-protein contents higher than the 7% suggested for liveweight maintenance (McDowell, 1972). This therefore indicates that goats are able to select nutritious plant material. However, the overall productivity of these animals dependent on browse plant during the dry season can be improved by providing them with locally available supplementary

Table 5. *Percentage crude protein, calcium and phosphorus of* Colophospermum mopane *plant offered to goats at Lesego Government Ranch during the dry season*

	Content (% DM)			
Nutrient	May	June	July	August
Crude protein	10.53	9.01	9.23	8.97
Calcium	1.74	1.42	1.45	1.40
Phosphorus	0.19	0.15	0.14	0.14

feeds such as sorghum bran, sorghum chaff and a mineral supplement. The higher concentration of condensed tannins in fresh than in dry mopane leaves suggests that these antinutritional factors have a contributory effect on the intake of fresh mopane leaves by animals. Research work on the quantitative and qualitative analysis of both the fresh and dry mopane leaves is necessary in order to make any recommendations on the efficient utilisation of the mopane plant for livestock feeding during the dry season and drought periods.

The average daily gain of 0.566 kg obtained for steers supplemented with lablab hay was due to the high intake of lablab hay and agrees with the results of McDowell (1972) that animals given a diet with 10% crude protein and 55% DMD can gain 0.5–0.6 kg per day. The high average liveweight change, daily gain and cold dressed weight obtained with steers supplemented with lablab hay was mainly due to the better performance of the Bonsmara animals; these increased their liveweight by 21% compared to 12% for Tswana steers fed the same diet. The better performance of Bonsmara cattle indicates that animals with a high genetic potential can perform better under improved management. Utilisation of cereal crop stovers with lablab hay for cattle feeding in the dry season is a new intervention which has been adopted by a number of livestock farmers in Botswana, especially dairy producers. However, appropriate technology for harvesting, conservation and utilisation of the lablab crop is needed if it is to be used efficiently as a livestock feed.

It is generally accepted that tree forage improves livestock performance when fed in combination with cereal residues (Agishi, 1988). However, in this experiment, dry mopane leaves were poorly accepted compared with lablab hay. The poor acceptance of the dry mopane leaves could have been due to poor condition of the plant material and/or to using steers that were not used to browsing the mopane plant. More research work is being planned with the mopane plant and with other browse plants that provide fodder for livestock during the dry season and drought years when there is no grass available for livestock feeding.

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THE USE OF *LEUCAENA LEUCOCEPHALA* SUPPLEMENTATION TO IMPROVE THE UTILISATION OF MAIZE STOVER BY SHEEP

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ABSTRACT

Experiments were conducted to investigate the effect of *Leucaena leucocephala* supplementation on the intake and rumen degradation of maize stover (Staha variety) by sheep. A feed intake study on four levels of *Leucaena* supplementation (0, 3, 6 and 9 g dry matter/kg liveweight per day) in a 4 x 4 Latin square design was undertaken. Dry-matter degradation of maize stover and rumen ammonia concentration were measured using two fistulated sheep fed the four diets.

Total dry-matter intake of the supplemented diets was significantly ($P<0.05$) higher than that of the unsupplemented diet. Daily dry-matter intake of maize stover alone increased from 32.8 g/kg for the unsupplemented diet to 36.2 g/kg for the diet containing the lowest level of *Leucaena* supplementation. Higher levels of *Leucaena* supplementation led to a decrease in the amount of maize stover consumed.

Leucaena supplementation significantly ($P<0.05$) increased the rumen degradation of maize stover at 48 hours of incubation compared to unsupplemented maize stover.

Ammonia concentration in the rumen increased significantly ($P<0.05$) with increase in the level of *Leucaena* supplementation up to 6 g/kg per day. Higher levels of *Leucaena* in the diet did not result in further increase in rumen ammonia concentration. There was no change in the rumen pH for the different levels of *Leucaena* supplementation.

The results indicate that intake and rumen degradation of maize stover in sheep could be improved by supplementing the animals with up to 6 g DM/kg liveweight per day of *Leucaena* hay. Higher levels of supplementation appear to lead to substitution effects.

RESUME

***Amélioration de l'utilisation de la paille de maïs par les ovins grâce à une complémentation de* Leucaena leucocephala**

Des expériences ont été menées sur des ovins pour déterminer l'effet d'une complémentation de Leucaena leucocephala *sur la consommation et la dégradation de la paille de maïs (variété Staha) dans le rumen. L'ingestion a été étudiée avec quatre niveaux de complémentation de* Leucaena *(0, 3, 6 et 9 g de matière sèche par kilo de poids vif et par jour) sur le modèle d'un carré latin d'ordre 4. La dégradation de la matière sèche de la paille de maïs et la concentration de l'ammoniac dans le rumen ont été mesurés sur deux ovins fistulés alimentés avec les quatre rations.*

L'ingestion totale de matière sèche était significativement plus élevée (P<0,05) avec la complémentation. En ce qui concerne la paille du seul maïs, la consommation journalière de matière sèche avait augmenté de 32,8 g/kg/j pour la ration non complémentée à 36,2 g/kg/j pour la ration complémentée contenant le niveau le plus faible de Leucaena. *Des niveaux plus élevés de complémentation entraînaient une baisse de la consommation de paille de maïs.*

Par rapport à la ration non complémentée, l'apport de Leucaena *entraînait un accroissement significatif (P<0,05) de la dégradation de la paille dans le rumen après 48 heures d'incubation. La concentration d'ammoniac dans le rumen augmentait significativement (P<0,05) avec l'accroissement du niveau de* Leucaena *dans la ration et ce, jusqu'à 6 g/kg/j. Au-delà, l'augmentation du niveau de complémentation n'entraînait plus aucun accroissement de la concentration d'ammoniac dans le rumen. Le pH du rumen était indépendant du niveau de complémentation de la ration.*

Ces résultats montrent que l'on peut accroître la consommation de paille de maïs et sa dégradation dans le rumen des ovins en les soumettant à une ration complémentée avec jusqu'à 6 g de matière sèche de foin de Leucaena *par kilo de poids vif par jour. Des niveaux plus élevés entraînent des phénomènes de substitution.*

INTRODUCTION

Intake of straws and stover by ruminants is usually too low to maintain body weight: tough texture, poor digestibility and nutrient deficiency all contribute to the low level of consumption (El-Naga, 1989). These roughages are low in readily available energy, carbohydrates and nitrogen, which reduces the efficiency with which they are utilised by animals. Chemical treatment of straws using sodium hydroxide (Urio, 1977; Kategile, 1979) or urea (Kiangi 1981; Raymond, 1989) can improve both their digestibility and intake, but is not always practical under farmer conditions. Thus alternative strategies to improve straw utilisation have been sought.

Leguminous forages such as *Leucaena leucocephala* have been used to improve dry-matter intake and digestibility of pasture hay by sheep (Bamualim et al, 1984). Because of the increased interest in the use of *Leucaena* spp as protein supplements for ruminants, the present study investigated the effect of various levels of *Leucaena leucocephala* supplementation on the intake and rumen degradation of maize stover by sheep.

MATERIALS AND METHODS

Experimental animals and feeds

Six Blackhead Persian sheep were used in the experiment. Four sheep, weighing about 28 kg, were used for intake studies in a 4 x 4 Latin square. The other two, weighing 33 kg and 41 kg, were fistulated and used for degradation studies.

Maize stover was obtained from harvested maize fields and chopped into 3–5 cm lengths. *Leucaena leucocephala* hay was obtained by cutting and wilting leafy branches of the plant and threshing the branches to separate the leaflets (the hay) from the twigs.

Intake studies

For the intake studies, the animals were confined in individual metabolic cages and offered a known quantity of maize stover *ad libitum* twice a day at 0900 and 1600 hours. Each animal also received 200 g of maize bran and vitamin/mineral mixture, alone or together with one of three levels of *Leucaena* hay supplement (3, 6 and 9 g dry matter/kg liveweight per day), at the morning feeding. Each diet combination was fed to each animal for 14 days, a seven-day preliminary period and a seven-day data collection period.

Degradability of maize stover

Degradation of maize stover was investigated for each diet combination using the nylon-bag technique (Ørskov et al, 1980).

Maize stover was ground to pass through a 2.5-mm screen and 2-g samples were weighed into 20 labelled nylon bags of known weight. For each ration, 10 bags were put into the rumen of each sheep and removed, two at a time, after 6, 12, 24, 48 and 72 hours of incubation. The removed bags were washed under running tap water until the water was clear and the residues were dried in an oven at 60°C for 48 hours, cooled in a desiccator and weighed. Dry-matter degradability was calculated using the formula

$$\%DMD = \frac{\text{weight of DM incubated} - \text{weight of dry residue}}{\text{weight of DM incubated}} \times 100$$

Rumen ammonia and pH

For rumen ammonia and pH determination, rumen liquor was obtained from the fistulated animals during the data collection period for each level of *Leucaena* supplementation. The liquor was collected at 0600, 1000, 1400 and 1800 hours, strained through cheese-cloth and centrifuged at 3000 rpm for 15 minutes, and 20-ml samples were taken for immediate pH determination.

For ammonia determination, 25-ml samples of the centrifuged rumen liquor were treated with two drops of concentrated sulphuric acid and frozen to await analysis. For the analysis, 5 ml of rumen liquor were mixed with 10 ml of 5% sodium tetraborate solution. Two drops of mixed indicator were added and the mixture was distilled using the kjeltec system. The distillate was collected in a flask containing 25 ml of 20% boric acid, and titrated with 0.1213N HCl. Ammonia concentration was calculated by

$$\%\,Ammonia\text{-}N = \frac{14.01 \times (titre - blank) \times norm\ of\ HCl}{mls\ of\ sample \times 10}$$

$$\%\,Ammonia = Ammonia\text{-}N \times 1.21$$

% Ammonia was then converted into mg ammonia/litre.

Statistical analysis

Two-way analysis of variance for a Latin square design was used for intake studies data, and one-way analysis of variance was used for other parameters, according to Snedecor and Cochran (1980). The significance of the results was tested using F test and LSD.

RESULTS

Dry-matter intakes (DMI) of the total ration roughage (maize stover plus *Leucaena*) and of maize stover alone are shown in Table 1.

Total DMI was significantly ($P<0.05$) increased by *Leucaena* supplementation. Total DMI of ration B was significantly lower ($P<0.05$) than that of ration D, but there was no significant difference between the DMI of rations B and C or rations C and D.

Dry-matter intake of maize stover alone increased when the diet was supplemented with 3 g *Leucaena* DM/kg liveweight per day, but further increase in the level *Leucaena* supplementation led to a decline in the amount of maize stover consumed.

Dry-matter (DM) and organic-matter (OM) degradabilities of maize stover in the rumen of sheep fed the different rations are shown in Table 2. *Leucaena* supplementation increased DM and OM degradability of maize stover at all incubation times. The greatest increase was observed at the supplementation level of 3 g *Leucaena* DM/kg liveweight per day. Statistical analysis of the DM

Table 1. *Dry-matter intake of total roughage (maize stover and* Leucaena *supplement) and maize stover alone for the four rations*

	Daily intake (g DM/kg liveweight)			
	Total roughage		Maize stover	
Ration	Mean	SE	Mean	SE
A	32.8	1.29	32.8	1.29
B	39.2	1.29	36.2	0.29
C	41.4	0.67	35.7	0.83
D	42.8	1.29	33.8	1.29

Ration A = unsupplemented
Ration B = supplemented with 3 g *Leucaena* DM/kg liveweight per day
Ration C = supplemented with 6 g *Leucaena* DM/kg liveweight per day
Ration D = supplemented with 9 g *Leucaena* DM/kg liveweight per day

and OM degradabilities at 48 hours of incubation revealed that ration A had significantly ($P<0.05$) lower DM and OM degradability than the supplemented rations. Ration B had lower ($P<0.05$) DM and OM degradabilities than ration D, but the differences between rations B and C or rations C and D were not significant ($P>0.05$).

Table 2. *Dry-matter and organic-matter degradabilities of maize stover at different incubation times*

	Degradability (%) at various incubation times						
					48 hours		
Ration	0 hours	6 hours	12 hours	24 hours	Mean	SE	72 hours
Dry-matter degradability							
A	7.25	7.73	9.65	12.99	14.84	0.01	29.94
B	7.25	11.05	15.95	23.68	33.79	1.46	44.44
C	7.25	13.38	19.11	28.62	35.02	0.48	52.59
D	7.25	8.13	16.63	27.20	37.60	0.30	51.59
Organic-matter degradability							
A	3.96	4.42	6.40	10.65	12.12	0.89	29.38
B	3.96	7.48	12.59	20.75	31.74	1.26	41.60
C	3.96	9.90	15.73	25.55	32.71	0.37	51.19
D	3.96	6.61	13.10	24.15	35.76	0.40	49.58

Ration A = unsupplemented
Ration B = supplemented with 3 g *Leucaena* DM/kg liveweight per day
Ration C = supplemented with 6 g *Leucaena* DM/kg liveweight per day
Ration D = supplemented with 9 g *Leucaena* DM/kg liveweight per day

Rumen ammonia concentrations in sheep fed the four rations are shown in Table 3. Inclusion of *Leucaena* in the maize-stover-based diet significantly (P<0.05) increased the rumen ammonia concentration. The concentration in sheep fed ration B was significantly (P<0.05) lower than those in sheep fed rations C and D, which were not different (P>0.05) from each other.

Rumen ammonia concentration increased immediately after feeding, and then decreased (Figure 1).

Rumen pH was not affected (P>0.05) by ration (Table 3).

DISCUSSION

The high dry-matter intake of rations supplemented with *Leucaena* indicates that *Leucaena* is a good supplement to low quality roughages such as maize stover. This improvement in intake with *Leucaena* supplementation is in agreement with results reported by Bamualim et al (1984). However, Dixon et al (1981) cautioned that an increase in total dry-matter intake could be due to consumption of the supplement *per se* rather than the roughage.

The fact that the highest dry-matter intake of maize stover was obtained at a supplementation level of 3 g *Leucaena* DM/kg liveweight per day may indicate that it is this optimum level of supplementation for poor quality roughages. Further increase in the level of *Leucaena* supplementation led to a substitution effect whereby the intake of maize stover was reduced. Increase in the intake of maize stover with *Leucaena* supplementation could be due to the increase in the concentration of rumen ammonia and dry-matter degradability of maize stover.

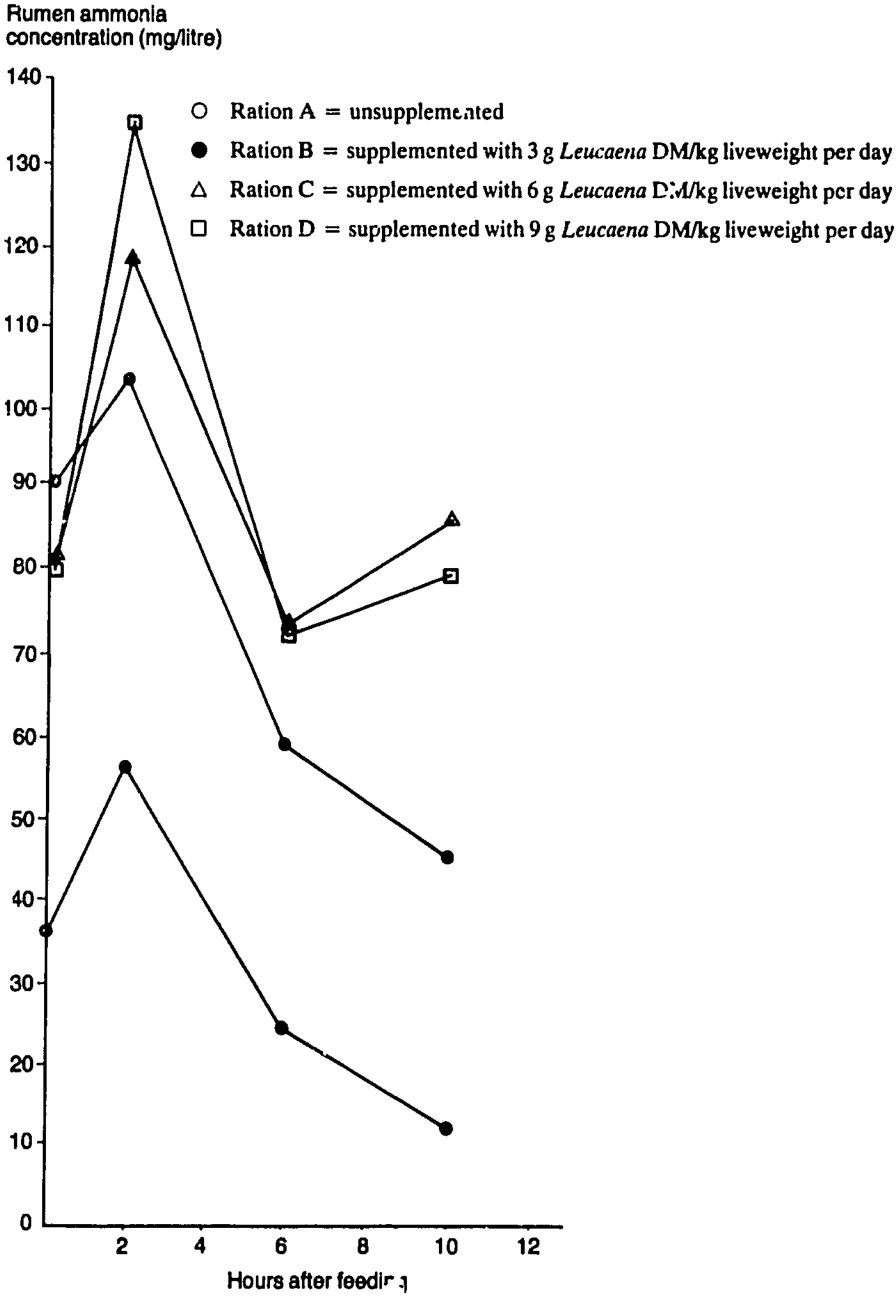
The improvement in the rumen degradation of maize stover dry matter and organic matter with *Leucaena* supplementation indicates a possible improvement in microbial growth. This is supported by the observed increase in rumen ammonia concentration.

Table 3. *Rumen ammonia concentration and rumen pH for the four rations*

	Rumen ammonia concentration (mg/litre)		Rumen pH	
Ration	Mean	SE	Mean	SE
A	32.0	4.83	6.83	0.07
B	74.8	6.21	7.10	0.65
C	91.3	6.71	6.61	0.03
D	90.1	6.16	6.9	0.07

Ration A = unsupplemented
Ration B = supplemented with 3 g *Leucaena* DM/kg liveweight per day
Ration C = supplemented with 6 g *Leucaena* DM/kg liveweight per day
Ration D = supplemented with 9 g *Leucaena* DM/kg liveweight per day

Figure 1. *Rumen ammonia concentration before and after feeding the four rations*



Rumen ammonia concentration is an indicator of nitrogen available for microbial protein synthesis. In this study, rumen ammonia concentration increased from 32 mg/litre for the unsupplemented diet to about 90 mg/litre for higher levels of *Leucaena* supplementation. FAO (1986) reported that, for efficient rumen function, ammonia concentration in the rumen should be between 50 and 90 mg/litre. With the unsupplemented maize stover diet, the rumen ammonia concentration was below the critical level, and this corresponds with the low dry-matter intake and dry-matter and organic-matter degradabilities for that ration.

CONCLUSIONS AND RECOMMENDATIONS

Dry-matter intake, rumen degradation and rumen ammonia concentration all showed improvement when the maize stover diet was supplemented with *Leucaena leucocephala*. This means that the efficiency of utilisation of maize stover is improved by *Leucaena* inclusion. However, the improvement declined at higher levels of *Leucaena* supplementation. It is therefore recommended to supplement maize stover with *Leucaena* at a level not exceeding 6 g DM/kg liveweight per day.

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BROWSE SPECIES AND SUPPLEMENTS USED FOR FEEDING SMALL RUMINANTS IN OGUN STATE, NIGERIA

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ABSTRACT

A questionnaire survey was conducted to determine the browse species and supplementary feeds used for sheep and goat production in Ogun State, south-west Nigeria. Results indicate that farmers sustain their sheep and goats on browse plants supplemented by farm and household wastes. The predominant browses are *Spondias mombin*, *Gliricidia sepium*, *Ficus* sp and *Marantochloa leucantha*; the main supplements are cassava, cocoyam and yam peels, maize residues and millet; and grasses include *Panicum maximum* and *Cynodon* sp. The supplements fill the animal feed availability gap during dry months. Farmers spend variable amounts on supplements and little effort is made to establish pastures. Alley farming and intensive feed gardens are not common in this area. Free ranging and cut-and-carry systems are predominantly practised.

RESUME

Les ligneux fourragers et les aliments complémentaires dans l'alimentation des petits ruminants dans l'Etat d'Ogun (Nigéria)

Une étude a été effectuée à partir d'un questionnaire en vue de déterminer les espèces ligneuses fourragères et les compléments alimentaires utilisés dans l'élevage des ovins et des caprins dans l'Etat d'Ogun, dans le sud-ouest du Nigéria. Il ressort des résultats enregistrés que les paysans nourrissaient leurs animaux avec des ligneux, des sous-produits agricoles et des ordures ménagères. Les espèces ligneuses les plus utilisées étaient Spondias mombin, Gliricidia sepium, Ficus *sp et* Marantochloa leucantha*; les principaux sous-produits* *agricoles étaient les pelures de manioc, de taro et d'igname ainsi que les résidus des cultures de maïs et de mil. Certaines graminées entraient en outre dans l'alimentation de ces animaux, notamment* Panicum maximum *et* Cynodon *sp. Utilisés pour combler les déficits de saison sèche, les aliments complémentaires occasionnaient des dépenses variables. Les pâturages artificiels, les cultures en couloirs et les vergers d'embouche étaient rares dans cette région. En revanche, la divagation et l'alimentation à l'auge étaient extrêmement fréquentes.*

INTRODUCTION

Browse forms an important part of goat diets in the tropics (Devendra and Burns, 1983), especially in rural areas where goat meat is a major source of protein. Livestock feeds and feeding have always been production constraints in sub-Saharan Africa; inadequate feeding can lead to reproductive wastage, low birth weights, high infant mortality, etc (Sumberg, 1985: Reynolds, 1986).

Rural small ruminants roam around freely and eat a variety of grasses, legumes and kitchen wastes. However, during the dry season, green forages are less nutritive, particularly grasses which are lignified (le Houérou, 1983). The feed problem is further magnified by the handling of small-ruminant production as a minor enterprise with few or no inputs. With the pressure on land for crop production, there is need now, more than ever before, to look in depth into the feeds and feeding of small ruminants.

The nutritive values of browse plants to livestock have been studied (Jones, 1979; Onwuka, et al, 1989). This study was concerned mainly with identifying browse species and supplements fed to sheep and goats in south-west Nigeria.

MATERIALS AND METHODS

Three hundred questionnaires were administered by trained enumerators to small-ruminant owners in five Local Government Areas (Remo, Obafemi-Owode, Egbado North, Ifo and Ijebu-Ode) of Ogun State, south-west Nigeria, during the wet and dry seasons of 1990. The five areas were randomly selected to represent the socio-political and ecological zones of the state.

The questionnaires covered such topics as the types of feeds used, sources, times of feeding, reasons for using specific forages, the commonest browses and supplements in use, and awareness by the farmers of intensive feed garden/alley farming technology. To minimise errors, the same trained enumerators were used in all five Local Government Areas. They could all communicate in the local language of these areas.

In most cases the interviewee was the household head. Some of the forages used by the respondents to feed their stock were collected for identification.

RESULTS AND DISCUSSION

A total of 290 questionnaires weie recovered.

Small-ruminant owners in the study area show a clear preference for goats; 74% of the households surveyed owned goats (average flock size 5.1), but only 13% owned sheep (average flock size 1.9).

Most of the respondents were crop farmers and traders (Table 1) who use family labour to take care (if any) of their livestock. There are no large commercial goat and sheep enterprises in the areas surveyed.

Table 1. *Predominant occupations of survey respondents in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of respondents by occupation				
Occupation	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Farming	50.0	95.2	76.7	70.4	92.0
Trading	31.0	4.8	14.0	16.6	1.6
Civil servants	3.4	–	4.7	7.0	4.8
Retired civil servants	5.2	–	2.3	2.8	–
Tradesmen	3.4	–	2.3	3.2	1.6
Unemployed	1.7	–	–	–	–
Others	5.3	–	–	–	–

Small ruminants are generally left to roam freely and fend for themselves on whatever forage or other feed they can find. However, household wastes (cassava, yam and cocoyam peels) are given to stock as supplements (Table 2); they are offered in the mornings, or as they become available. Cut forages are de-emphasised during the dry season when green material is in short supply.

Table 3 shows the commonest browse species and supplements used in small-ruminant production in the study area. Some of these browses and supplements have high nutritive value and can support animal production (Oyenuga, 1978; Fomunyam and Meffeja, 1987; Onwuka et al, 1989). Their use could, however, be limited by some antinutritional components (Onwuka, 1991).

The supplements come mainly from the stock owners' farms. Farmers also buy some supplements (Table 4) from either local markets or neighbours, but generally small-ruminant owners invest minimally in animal feed (Table 5). None of the respondents in this study claimed that they used compounded diets.

Most sheep and goat keepers give specific forages to their stock believing that they induce rapid growth rates; some use them for medicinal purposes and a few use some forages to prevent their animals being attacked by evil spirits (Table 6). Table 7 shows that browse are generally fed to ruminants because they are readily available and palatable.

Table 2. *Sources of animal feeds by season in five Local Government Areas in Ogun State, Nigeria, 1990*

	Sources of feed (%) by season									
	Remo		Obafemi-Owode		Egbado North		Ifo		Ijebu-Ode	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Animals fending for self	37.7	39.5	51.6	8.1	25.9	34.5	25.0	50.0	50.8	50.4
Improved pasture	17.8	13.2	1.6	1.6	25.9	29.3	–	–	–	–
Household waste	35.6	40.7	45.2	38.7	34.5	25.9	75.0	–	45.8	38.2
Cut forages	8.9	6.6	1.6	51.6	13.7	10.3	–	50.0	3.4	11.4

Table 3. *Commonest browses/grasses and supplements in use in five Local Government Areas in Ogun State, Nigeria, 1990*

	% of total diet				
Feed	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Browse/grass					
Grass/pasture	14.6	29.9	5.9	15.0	36.4
Musa cv paradisciaca	1.2	–	–	1.0	–
Cymbopogon cutrilis	3.7	–	–	–	–
Gliricidia sepium	–	–	3.5	–	1.1
Marantochloa leucantha	–	2.0	–	–	–
Spondias mombin	–	–	1.2	2.0	–
Ficus sp	–	–	2.0	3.0	–
"Ewe akoko"	–	–	1.2	2.0	–
Leucaena leucocephala	–	–	1.2	–	–
Supplements					
Cassava peels	58.5	53.7	34.5	40.0	34.1
Yam peels	4.9	7.2	9.4	5.0	–
Cocoyam peels	1.2	7.2	–	7.0	12.5
Millet	–	–	15.3	–	–
Maize waste	15.9	–	25.8	25.0	15.9

The forages usually preferred by stockmen are *Eupatorium odoratum*, giant star grass, elephant grass, lemon grass, cassava leaves, Guinea grass, bamboo leaves, *Ficus sp*, *Centrosema pubescens*, *Spondias mombin*, *Aegeratum conizoides*, *Cida acuta*, *Talinum triangulaire*.

Table 4. *Types of feedstuffs bought by sheep and goats farmers in five Local Government Areas in Ogun State, Nigeria, 1990*

	% of purchased feeds				
Feedstuff	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Cassava peels	59.2	64.6	37.5	55.4	11.8
Maize chaff	13.6	26.2	25.0	20.5	35.5
Yam peels	–	–	6.3	6.0	–
Millet	–	1.5	18.7	8.6	–
Dried brewers' grain	–	–	3.1	–	2.7
Cocoyam peels	–	4.6	–	9.5	14.7
Rice waste	–	–	–	–	35.3
Lemon grass	13.6	3.1	–	–	–
Cassava leaves	13.6	–	9.4	–	–

Table 5. *Attitudes of sheep and goat keepers to the purchase of feeds in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of respondents				
	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Farmers that buy feed	31.0	33.9	27.9	36.3	30.2
Farmers that do not buy feed	65.5	59.7	65.1	57.6	68.2
Farmers indifferent to purchase of feed	3.5	6.4	7.0	6.1	1.6

Table 6. *Reasons for use of specific forages in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of farmers giving reason				
Reason	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Rapid growth of animals	88.9	81.3	68.9	83.4	95.0
Medicinal	11.1	12.5	28.9	10.0	5.0
Fetish beliefs	–	6.2	2.2	6.0	–

Although stock owners are willing to feed forage to their stock, they are not willing to propagate the crops to ensure availability (except in Ijebu-Ode; Table 8). The major constraints are availability of land and capital (Table 9). The land

Table 7. *Reasons for feeding forage to sheep and goats in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of farmers giving reason				
Reason	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Readily available	51.8	–	40.7	50.0	31.2
Palatable	13.8	1.6	50.0	50.0	–
The only species farmers know	10.3	62.9	1.9	–	6.3
Cheap	'3.8	12.9	5.5	–	62.5
Recommended by others	10.3	–	1.9	–	–

Table 8. *Attitude of farmers to growing forage in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of respondents				
	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Willing to plant	34.5	17.7	35.7	34.8	71.4
Not willint to plant	51.7	45.2	40.5	60.0	27.0
Undecided	13.8	37.1	23.8	5.2	1.6

Table 9. *Major problems associated with fodder production in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of farmers citing problems				
Problem	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Land	64.0	35.3	25.6	28.4	20.6
Credit	10.3	47.1	41.9	30.4	66.7
Labour	10.3	–	18.6	–	–
Seed availability	5.1	17.6	4.6	38.0	11.1
Others	10.3	–	9.3	3.2	1.6

issue is worsened by the land-use policy in the country. These are usually subsistence farmers who invest minimally in their enterprises and will not welcome any extra investment in feed/forage propagation, except, of course, for crops that can also be used as food.

The survey found few farmers who were aware of alley farming or intensive feed gardens (Table 10). However, many farmers indicated an interest in these technologies when the possibilities of augmenting animal feed supply were explained to them (Table 11). The interest in alley farming may be partly explained by the perceived human food benefits of this technology.

Table 10. *Awareness of intensive feed garden and alley farming technologies by sheep and goat farmers in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of respondents				
	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Unaware	98.3	100	86.1	90.0	81.7
Aware	1.7	–	13.9	10.0	18.3

Table 11. *Willingness to establish alley farms/intensive feed gardens in five Local Government Areas in Ogun State, Nigeria, 1990*

	Percentage of respondents				
	Remo	Obafemi-Owode	Egbado North	Ifo	Ijebu-Ode
Willing to establish intensive feed gardens	50.0	–	40	40	27.0
Willing to establish alley farms	13.8	6.5	22.2	29.1	65.1
Undecided	36.2	93.5	37.8	30.9	7.9

When they were shown a detailed analysis of the benefits of investing in livestock feed, up to 85% of the small-ruminant farmers interviewed were willing to invest up to Naira 500 (about US$ 63) a year to purchase feed supplements. Some, however, were ready to stake up to US$ 380, provided they could be guaranteed a return from such investments. Granted that nutrition is just one of the small-ruminant production constraints in sub-Saharan Africa, with a good nutritional base, other factors could be kept to the barest minimum.

CONCLUSION

Browse plants supplemented with some agricultural byproducts form an essential component of goat and sheep diets in Ogun State, south-west Nigeria. Small-ruminants owners invest minimally in livestock production and so have to resort to cheap green feeds and supplements while allowing the animals to fend for themselves. Browses are fed to small ruminants when they are readily available and because farmers believe browses initiate rapid weight gains in their animals. However, most small-ruminant owners do not cultivate forage because land and planting materials are scarce, and they are reluctant to invest in non-food-crop production. A lot of extension work still needs to be done to interest rural farmers in forage-producing technologies, such technologies could provide important feed resources, especially during the dry period when available grasses are low in feed quality.

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BODY WEIGHT RESPONSE OF WEST AFRICAN DWARF GOATS FED *GLIRICIDIA SEPIUM, PANICUM MAXIMUM* AND CASSAVA (*MANIHOT*) PEELS

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ABSTRACT

Six diets, 100% *Gliricidia sepium* (T1), 100% *Panicum maximum* (T2), 100% cassava peels (T3), 35% *G. sepium* plus 35% *P. maximum* plus 30% cassava pee.. (T4), 70% *G. sepium* plus 30% cassava peels (T5) and 70% *P. maximum* plus 30% cassava peels (T6) were fed to 24 intact male West African Dwarf goats in a completely randomised experiment. Four bucks were randomly assigned to each dietary treatment for 90 days. Treatment T3 was discontinued after 28 days and results for this treatment are not presented.

Goats on T4 consumed the most dry matter (DM) and organic matter (OM) (P<0.05); those on T2 consumed most acid detergent fibre (ADF) and neutral detergent fibre (NDF); and those on T1 consumed the highest amount of nitrogen (N). Least N consumption was by goats on T2 and T6. Goats on T1 digested DM and OM least (P<0.05); those on T2 digested ADF most (P<0.05); N and NDF were best digested (P<0.05) by goats on T5. Goats on diet T4 achieved the highest liveweight gains (P<0.05).

Supplementing equal proportions of *G. sepium* and *P. maximum* with 30% (w/w) cassava peels appeared most beneficial to goats.

RESUME

Performances pondérales de chèvres naines d'Afrique occidentale soumises à des rations composées de* Gliricidia sepium, *de* Panicum maximum *et de pelures de manioc (*Manihot*)

Six rations constituées de 100% de Gliricidia sepium *(T1); 100% de* Panicum maximum *(T2); 100% de pelures de manioc (T3); 35% de* G. sepium *plus 35% de* P. maximum *plus 30% de pelures de manioc (T4); 70% de* G. sepium *plus 30% de pelures de manioc (T5); et 70% de* P. maximum *plus 30% de pelures de* *manioc (T_6) ont été servies chacune pendant 90 jours à quatre boucs entiers de la race naine d'Afrique occidentale. Cette expérience a été conçue sur le modèle des blocs aléatoires complets et les animaux ont été assignés au hasard à l'un ou l'autre de ces traitements. Les résultats enregistrés pour le traitement T_3 n'ont pas été présentés car celui-ci avait été interrompu au bout de 28 jours d'essai.*

La consommation de matière sèche (MS) et de matière organique était maximum pour la ration T_4. Celle de lignocellulose et de fibres NDF était la plus élevée pour la ration T_2, tandis que celle d'azote était maximum pour la ration T_1. Quant au niveau minimum de consommation d'azote, il avait été enregistré pour les rations T_2 et T_6. Le taux de digestibilité de la matière sèche et celui de la matière organique étaient minimums ($P<0,05$) pour la ration T_1; celui de la lignocellulose était maximum ($P<0,05$) pour la ration T_2 tandis que ceux de l'azote et de la fibre NDF étaient maximum pour la ration T_5 ($P<0,05$). Enfin, les gains de poids les plus élevés étaient associés à la ration T_4 ($P<0,05$).

La combinaison alliant G. sepium *et* P. maximum *en proportions égales avec en poids 30% de pelures de manioc semble être la plus indiquée pour les caprins.*

INTRODUCTION

West African Dwarf goats are among the few important trypanotolerant livestock species of humid Nigeria. Matthewman (1979) reported an average of four goats per household in humid Nigeria but larger numbers are kept in the savannah parts of the country. Nigeria has an estimated 26 million goats.

Inadequate nutrition has been recognised as the major constraint to livestock, especially goat, production in Nigeria (Olubajo and Oyenuga, 1974).

The use of *Gliricidia sepium* as livestock feed has received attention in Nigeria only recently (Mba et al, 1982; Onwuka, 1983; Ademosun et al, 1985). The chemical composition of *G. sepium* has been variously reported as 7.4–34.5% dry matter (DM) ("as-fed basis"), 81.9–92.3% organic matter (OM), 3.1–4.2% nitrogen (N), 30.8% neutral detergent fibre (NDF), 18.5–44.4% acid detergent fibre (ADF) and 12.7–32.5% crude fibre (CF) (Chadhokar, 1982; Ifut, 1987).

Panicum maximum is highly palatable to ruminant animals and has 23.5–29.9% DM at harvest (Olubajo, 1977; Aken'ova and Mohamed-Saleem 1982; Ifut, 1987). Nitrogen content in *Panicum maximum* ranges from 0.8 to 2.0% DM and CF from 29.5 to 42.2% DM (Akinyemi and Onayinka 1982; Ifut, 1987).

In parts of Nigeria where *Manihot* (cassava) is grown, the average annual yield of tubers is 21.1 t/ha. Since peels constitute about 20% of the tuber, large quantities of cassava peels could be available to feed ruminants, especially goats. Currently, however, cassava peels are largely under-exploited as livestock feed.

Cassava peels have been found to contain 86.5–94.5% DM, 89.0–93.9% OM, 10.0–31.8% CF and 0.7–1.0% N (Oyenuga, 1968; Adegbola, 1980; Carew, 1982; Onwuka, 1983; Ifut, 1987). Sun-dried cassava peels have been reported to contain 14.2–116.9 mg HCN/kg, depending on variety. Sun-drying has been reported to reduce HCN content by 89.4–94.0% rendering the peels innocuous (Maner and Gomez, 1973; Tewe et al, 1976).

Average *G. sepium* DM intake of goats has been reported as 66.7 $g/kg^{0.75}$ per day (Ademosun et al, 1988) and 21.3 $g/kg^{0.75}$ per day (Carew, 1983; Onwuka, 1983; Ademosun et al 1985). Mba et al (1982) also noted DM intake values of *G. sepium* by kids ranging from 54.8 to 71.3 $g/kg^{0.75}$ per day.

Growing West African Dwarf goats fed *Panicum* achieved daily DM intakes ranging from 54.9 $g/kg^{0.75}$ for young, well fertilised grass to 43.1 $g/kg^{0.75}$ for standing hay (Ademosun et al, 1988).

Reported liveweight gains by growing West African Dwarf goats on a sole *Gliricidia* diet were 17.5–20.0 g/day (Onwuka, 1983) 27.0 g/day (Mba et al, 1982) and 23.3 g/day (Ademosun et al, 1988).

This paper reports work on intake and body weight response by goats fed *Gliricidia* and cassava peels, *Panicum* and cassava peels and *Gliricidia* plus *Panicum* plus cassava peels.

MATERIALS AND METHODS

Twenty-four growing, parasite-free, intact West African Dwarf bucks aged six to nine months and weighing an average of 6 kg (range 5–10 kg), obtained from the University of Ibadan Teaching and Research Farm, were used for this experiment. The bucks were housed for 90 days in previously sanitised individual metabolism cages and offered liberal, but known, quantities of the experimental diets daily for a 21-day preliminary period to adapt the animals to the diets and cage environment. Fresh water and salt lick were available *ad libitum* in the cages.

Fresh *G. sepium* branches (about 1.2 m long and 1.5 cm thick) with leaves and branchlets and fresh *P. maximum*, chopped to about 2 cm length, were obtained daily from IITA, Ibadan, during the wet season (April–July). Cassava peels from low-HCN TMS 30572 and TMS 1425 varieties were obtained fresh from local cassava grating plants in and around the University of Ibadan campus. The peels were sun-dried for three to four days.

Diets fed to the goats were:

- 100% *G. sepium* (T1)
- 100% *P. maximum* (T2)
- 100% dried cassava peels (T3)
- 35% (w/w) each of *G. sepium* and *P. maximum* plus 30% cassava peels (T4)
- 70% *G. sepium* plus 30% cassava peels (T5)
- 70% *P. maximum* plus 30% cassava peels (T6).

Treatment T3 was discontinued after 28 days because the animals were losing weight and were in danger of dying.

The amount of each diet offered to each experimental animal ensured at least a 5% left-over. Residues were collected after a 24-hour feeding, weighed and the voluntary intake determined.

Samples of the diets offered and rejected were taken daily during the 90-day period. Subsamples of each were taken for DM and chemical determination according to standard methods (AOAC, 1975; Van Soest and Robertson, 1980).

Total faeces and total urine were collected in the mornings before feeding and watering during days 22–28 and 84–90 of the experiment. The faeces were weighed fresh and 10% aliquots of each day's collection for each animal were taken, dried at 60°C for 48 hours in a forced draught air oven and bulked. A subsample of faeces from each animal was dried in a similar oven at 100–105°C for 48 hours for DM determination. The two seven-day faecal samples for each experimental animal were thoroughly mixed and milled to pass through a 0.6-mm sieve and put in sealed polythene bags until analysed.

The urine was collected in a plastic bucket placed under each cage; 75 ml of 25% sulphuric acid was added to the bucket daily to curtail volatilisation of ammonia from the urine. The total output of urine per animal was measured and 10% aliquots were saved in stoppered, numbered plastic bottles and stored at –5°C. At the end of each seven-day collection period the sample collections were bulked for each animal and subsamples were taken for analysis.

The animals were weighed once a week in the morning before feeding and watering. Liveweight change was estimated as the difference between the initial and final body weights of the animals during the experiment.

The data obtained were subjected to analysis of variance and correlation analyses. Differences between treatment means were determined by Duncan's multiple range test using the Genstat V computer program, release 4.04B (1984, Lawes Agricultural Trust, Rothamsted Experimental Station, UK).

RESULTS AND DISCUSSION

No results are presented for treatment T3. This treatment was discontinued after only 28 days, because the animals were losing weight dramatically. HCN toxicity could not have been implicated in this liveweight loss because sun-dried, low-HCN varieties of cassava were used, but it is clear that a diet of sole cassava peels is not a suitable feed for goats.

The chemical compositions of the other five experimental diets are shown in Table 1. Chemical components of *G. sepium*, *P. maximum* and cassava peels compare favourably with values reported in literature (Oyenuga, 1968; Olubajo, 1977; Adegbola, 1980; Aken'ova and Mohamed-Saleem, 1982; Carew, 1983; Chadhokar and Sivasupiramaniam, 1983; Onwuka, 1983; Ifut, 1987).

Dry-matter and nutrient intakes and digestibilities by West African Dwarf goats are summarised in Table 2.

The highest DM and OM intakes were from diet T4 probably because this combination was more palatable than the other diets.

Table 1. *Chemical composition of the diets fed to West African Dwarf goats (means of six determinations)*

	DM (%)		% of DM			
Diet	As fed	Residual	OM	ADF	NDF	N
T1	31.0	87.3	91.3	28.3	41.5	3.8
T2	24.7	88.9	87.7	40.2	65.5	1.7
T4	45.4	87.9	89.4	31.1	47.7	2.2
T5	47.7	87.3	90.7	27.0	39.3	2.9
T6	43.2	88.4	88.1	35.3	56.1	1.5

Diet T1 = 100% *Gliricidia sepium*
Diet T2 = 100% *Panicum maximum*
Diet T4= 35% *G. sepium* + 35% *P. maximum* + 30% cassava peels
Diet T5= 70% *G. sepium* + 30% cassava peels
Diet T6= 70% *P. maximum* + 30% cassava peels

Table 2. *Dry-matter and nutrient intakes, digestibility coefficients and body weight changes of West African Dwarf goats*

Parameter	Diet T1	Diet T2	Diet T4	Diet T5	Diet T6	SE
Intake (g/kg$^{0.75}$ per day)						
Dry matter (DM)	46.3	63.5	86.4	76.0	73.8	8.7
Organic matter (OM)	43.0	55.1	77.3	67.5	64.6	7.8
Acid detergent fibre (ADF)	18.7	27.5	20.8	20.5	26.9	3.9
Neutral detergent fibre (NDF)	27.7	44.4	36.2	36.9	41.1	5.6
Nitrogen (N)	1.8	1.1	1.5	1.5	1.1	0.3
Digestibility coefficients (%)						
DM	54.2	58.8	71.9	74.3	65.2	4.1
OM	56.8	61.1	73.1	76.6	67.5	4.0
ADF	42.9	60.1	36.1	46.2	58.4	3.6
NDF	46.2	54.5	57.4	67.7	62.6	4.7
N	56.3	27.1	41.0	57.3	56.7	7.2
Body weight change (g/day)	51.0	25.7	66.3	54.2	41.5	0.3

Diet T1 = 100% *Gliricidia sepium*
Diet T2 = 100% *Panicum maximum*
Diet T4 = 35% *G. sepium* + 35% *P. maximum* + 30% cassava peels
Diet T5 = 70% *G. sepium* + 30% cassava peels
Diet T6 = 70% *P. maximum* + 30% cassava peels

The highest intake of NDF and ADF was by goats on T2. ADF intake from T6 was significantly (P<0.05) the highest among the composite diets. However, there were no differences (P>0.05) in NDF intake among the composite diets.

Dry matter of T5 was digested best by goats, probably due to a better balance of nutrients resulting from the simultaneous feeding of N-rich *Gliricidia* (70%) and soluble carbohydrate-rich (30%) peels. DM digestibility of T6 was superior (P<0.05) to that of T2.

The N of T5 was digested most, which suggests that a favourable energy:N balance resulted from the diet. However, the N digestibility of T5 was not different (P>0.05) from that T1 or T6.

Supplementating either *Gliricidia* or *Panicum* with 30% cassava peels did not seem to improve (P>0.05) ADF digestibility. However, the composite diets contained NDF which was distinctly superior (P<0.05) in digestibility to that contained in T1. The highest NDFD of T5 might have been due to a better balance of nutrients, particularly N from *Gliricidia* and soluble carbohydrates from the peels.

The highest average daily body weight gain was by goats on T4, probably because this diet provided the best balance of nutrients for growth. Goats gained more weight when *Gliricidia* or *Panicum* was supplemented with 30% cassava peels than when each was fed alone.

CONCLUSION

Cassava peel, as a supplement to a leguminous and/or grass feed, is potentially beneficial to goats as a source of readily available carbohydrates. The most beneficial diet appeared to be equal proportions of *G. sepium* and *P. maximum* supplemented with 30% (w/w) cassava peels.

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THE FEEDING VALUE OF CROP RESIDUES FROM SORGHUM, PEARL AND FINGER MILLET CULTIVARS

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ABSTRACT

Two experiments were conducted to evaluate the value of sorghum and millet residues as feeds for indigenous sheep. In the first, wethers received a daily diet of 100 g cottonseed meal plus hay (control) or one of the following stovers *ad libitum*: sorghum (white, SVI; or red, DC75); pearl millet (white, SDMV 89004; or red NCD2); finger millet (white, SDFM 63; or red, 25C). Nitrogen (N) and neutral detergent fibre (NDF) concentrations differed between species but not variety. Finger millet stover contained most N and least NDF, was most readily eaten (P<0.05) and resulted in the highest N retention and the lowest NDF digestibility. In the second experiment wethers received one of the following diets: hay plus 100 g/day cottonseed meal (control); threshed heads of white (SVI) or red (DC75) sorghum, with or without 100 g/day cottonseed meal; or threshed heads of red finger millet (25C). Finger millet heads contained most N and least NDF and were most readily eaten and digested (P<0.05). The addition of cottonseed meal was beneficial and SVI was more digested than DC75.

RESUME

Valeur nutritive de résidus de cultivars de sorgho, de mil perlé et d'éleusine

Deux expériences ont été effectuées en vue d'évaluer les résidus de sorgho, de mil perlé et d'éleusine dans l'alimentation des ovins. Dans la première étude, les animaux avaient été soumis à une ration composée de 100 g de tourteau de coton par jour et de foin (témoin) ou de paille d'une des céréales suivantes offerte ad libitum*: sorgho (blanc, SVI; ou rouge, DC75); mil perlé (blanc, SDMV 89004; ou rouge NCD2); éleusine (blanche, SDFM 63; ou rouge, 25C). Les concentrations en azote et en parois cellulaires étaient différentes entre espèces mais non entre variétés. Avec la teneur en azote la plus élevée et la concentration en parois cellulaires la plus faible, l'éleusine était plus volontiers consommée (P<0,05) et donnait lieu à une rétention d'azote maximum et une* *digestibilité minimum des parois cellulaires. Dans la seconde expérience, les animaux étaient soumis à l'une des rations suivantes: foin plus 100 g de tourteau de coton par jour (témoin); épis égrenés de sorgho blanc (SVI) ou rouge (DC75) seuls ou avec 100 g de tourteau de coton par jour; ou épis égrenés d'éleusine (25C). Les épis d'éleusine avaient la teneur la plus élevée en azote et la plus faible en parois cellulaires, et étaient plus consommés et plus facilement digérés (P<0,05). L'addition de tourteau de coton était bénéfique pour les animaux et le cultivar du sorgho SVI était plus facilement digéré que le DC75.*

INTRODUCTION

The constraints to livestock production from feeding large quantities of fibrous byproducts are known (Sundstol and Owen, 1984), as are interventions which can ameliorate them. However, much of the information has been derived from temperate crops and in circumstances where inputs, such as chemicals and protein supplements, are available and affordable. In much of Africa maize, sorghum and millet are the major cereal crops and there is little scope to purchase inputs for livestock production. In some areas of Zimbabwe up to 50% of dry-season feeding can come from crop residues.

In Zimbabwe maize is the preferred staple but because of low rainfall and short grazing seasons in natural ecological regions IV and V (Johnson, 1987) sorghums and millets are recommended by researchers and extension staff. Total crop-residue production in 1989/90 from the three major cereals, based on preliminary estimated forecasts of grain yield (Kossila, 1988; CSO, 1990), amounted to more than 5.5 million tonnes. Methods for improving the utilisation of maize stover have been reported (Manyuchi et al, 1990). Work is now in progress to evaluate sorghum and millet residues as livestock feeds.

MATERIALS AND METHODS

Two experiments were conducted to measure intake, digestibility and nitrogen retention (NR) of sorghum and pearl and finger millet residues.

In one experiment, 35 indigenous wethers (average initial liveweight 34 kg; age about 18 months) were allocated at random to one of seven treatment groups (five animals each):

- hay (control)
- white sorghum stover (SVI)
- red sorghum stover (DC75)
- white pearl millet stover (SDMV 89004)
- red pearl millet stover (NCD2)
- white finger millet stover (SDFM 63)
- red finger millet stover (25C).

All animals in this trial also received 100 g cottonseed meal (CSM) per day.

The second experiment used 30 of the wethers from the first experiment, after they had grazed on veld for one month: their average initial liveweight was 31 kg. They were allocated at random to six treatments (five animals each):

- hay plus 100 g CSM/day (control)
- threshed heads of white sorghum (SVI) with or without 100 g CSM/day
- threshed heads of red sorghum (DC75) with or without 100 g CSM/day
- threshed heads of red finger millet (25C), alone.

Cereal heads were threshed using a mechanical thresher. Residues were milled using a 25-mm screen and offered to sheep *ad libitum* at 0800 and 1400 hours daily. Sheep were individually penned; water was always available. Intake was measured after 21 days acclimatisation, after which 80% of *ad libitum* intake was fed prior to measuring digestibility and nitrogen retention. A seven-day period was allowed for adjustment to the digestibility crates. Faeces and urine were weighed daily, subsampled and stored at –20°C to await analysis.

RESULTS

Experiment 1

Neutral detergent fibre (NDF) and nitrogen (N) contents of the stovers were different between species (Table 1) but not between varieties within species. Finger millet contained most N and least NDF. The hay used contained less N and more NDF than the residues. Intake was highest ($P<0.05$) with finger millet and lowest with hay and SDMV pearl millet (Table 2): differences between pearl millet varieties may have been due to traces of mould in SDMV. Dry-matter (DM) and organic-matter (OM) digestibilities were lowest for hay ($P<0.05$), and NDF digestibility was lowest in the finger millets ($P<0.05$). (The differences in digestibility between sorghum varieties were probably due to a higher concentration of phenolics in DC75.) Nitrogen retention was greatest with finger millet, especially 25C, and least with hay ($P<0.05$).

Experiment 2

The threshed stover heads contained about 70 g grain/kg DM. Finger millet heads contained most N and least NDF (Table 1). Heads of red sorghum contained more N than those of white sorghum. Intake was highest with finger millet heads and lowest with hay ($P<0.01$). CSM increased ($P<0.05$) intake of the sorghum heads, especially DC75 (Table 3). DM and OM digestibilities were greatest with finger millet and DC75 plus CSM and least with hay ($P<0.05$). Intake and digestibility of both sorghums were enhanced by CSM; SVI was more digestible than DC75. Digestibility of NDF was greatest with SVI plus CSM and hay and least with DC75 alone and finger millet ($P<0.05$). Nitrogen retention was increased by CSM and finger millet ($P<0.05$).

Table 1. *Chemical composition of stovers and threshed heads*

Roughage	Dry matter (g/kg)	Chemical composition (g/kg DM)		
		Nitrogen	Neutral detergent fibre	Organic matter
Hay	941	6.1	861	940
Stovers				
Sorghum				
SVI	938	8.6	762	935
DC 75	932	8.8	765	923
Pearl millet				
SDMV 89004	935	10.2	784	902
NCD 2	938	10.4	777	901
Finger millet				
SDFM 63	918	15.5	605	901
25 C	925	17.0	637	906
Threshed heads				
Sorghum				
SVI	917	8.5	710	946
DC 75	918	14.2	776	949
Finger millet				
25 C	888	18.9	434	929

DISCUSSION

The results confirm earlier reports (Smith and Balch, 1984) that low protein and high fibre reduce the nutritional value of cereal residues. Intakes of the residues used here were much higher than those reported in lambs receiving maize stover supplemented with urea (Manyuchi et al, 1990) or CSM (Smith et al, 1990), probably reflecting the relatively low N content of maize stover.

Quantities of threshed heads available are minimal compared to stover. The retained grain in the heads (about 70 g/kg DM) would have contributed to their acceptability as feed. The finger millet heads could probably be effectively used as a supplement to dry-season grazing or stover diets.

In another study, the grains removed from sorghum (SVI) and pearl millet (SDMV) stovers were compared as replacements for maize grain in high-energy finishing diets for steers (Nengomasha et al, in press). The results indicate that these two varieties can replace maize grain in fattening diets.

The study of sorghums and millets is continuing with emphasis on the effects of agronomic and handling techniques on stover yield and quality.

Table 2. *Voluntary intake, digestibility and N retention in sheep fed sorghum and pearl and finger millet stovers*

	Intake		Digestibility (g/kg DM)			N retention	
Roughage	g/day	$g/kg^{0.75}$	Dry matter	Organic matter	Neutral detergent fibre	g/day	g/kg N intake
Hay	690	49.4	456	483	554	1.78	213
Sorghum							
SVI	874	61.1	548	559	583	4.03	352
DC 75	900	62.9	502	521	565	3.69	316
Pearl millet							
SDMV 89004	684	48.8	498	504	544	4.70	429
NCD 2	957	66.8	510	528	570	3.65	292
Finger millet							
SDFM 63	1054	75.8	523	539	459	6.76	375
25 C	1017	72.1	517	540	482	9.23	482
SE	40.6	3.1	0.66	0.65	0.96	0.46	

Table 3. *Voluntary intake, digestibility and N retention in sheep fed sorghum and finger millet threshed heads*

	Intake		Digestibility (g/kg DM)			N retention	
Roughage	g/day	$g/kg^{0.75}$	Dry matter	Organic matter	Neutral detergent fibre	g/day	g/kg N intake
Hay	708	57.4	492	521	481	3.54	378
Sorghum							
SVI	1090	87.5	493	505	444	2.34	312
SVI + CSM	1262	101.2	563	585	528	5.63	392
DC 75	888	69.8	446	443	403	2.91	282
CD 75 + CSM	1141	89.3	513	531	443	7.20	341
Finger millet							
25 C	1409	110.3	570	589	413	9.27	428
SE	81.1	5.62	1.39	5.46	0.98	0.47	

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NON-CONVENTIONAL FEED SOURCES AS SUPPLEMENTS TO BEEF HEIFERS FED LOW QUALITY HAY

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ABSTRACT

During the dry season in the savannah region of Nigeria, low quality hay constitutes an important source of energy for ruminants, especially cattle. Because of its high fibre and low protein contents, the hay is poorly digested and intake is consequently limited.

Grazing cattle, especially those managed under nomadic conditions, commonly lose body weight during this time unless they are provided with some form of protein supplement. Cottonseed and groundnut cakes are the traditional supplements but their use is limited by several factors, one of which is that most of the oilseed cakes produced find their way into compound feed for monogastric animals and so are now too expensive for use in cattle feed supplements. For this reason, other non-conventional sources of protein supplement need to be explored. Fertiliser grade urea with or without molasses and bloodmeal with or without bonemeal, used as supplements, improve digestibility and reduce weight loss in beef heifers fed low quality hay during the dry season.

RESUME

Utilisation de sources non conventionnelles d'aliments pour la complémentation des rations de génisses de race de boucherie recevant du foin de qualité médiocre

Au cours de la saison sèche, le foin de qualité médiocre constitue une importante source d'énergie pour les ruminants, et notamment les bovins, dans la savane au

Nigéria. Etant donné que ce foin est riche en cellulose et pauvre en protéines, sa digestibilité demeure faible et sa consommation est en conséquence limitée.

Les bovins élevés sur pâturage, et notamment par les éleveurs nomades, perdent généralement du poids pendant la sécheresse, à moins d'avoir accès à une complémentation protéique. Les tourteaux de coton et d'arachide constituent les sources traditionnelles de complémentation les plus fréquemment rencontrées dans cette région. Malheureusement, leur utilisation est limitée par un certain nombre de facteurs, notamment le fait que la plupart d'entre eux entrent également dans les aliments composés des monogastriques et sont en conséquence trop chers pour être incorporés dans les rations des bovins. Il faut donc rechercher d'autres sources de compléments pour cette catégorie d'animaux. Cette étude a permis d'établir que l'addition ou non de mélasse à l'urée utilisée dans la production d'engrais et la farine de sang additionnée ou non de farine d'os permettaient d'accroître la digestibilité et de réduire les pertes de poids des génisses de race de boucherie recevant du foin de qualité médiocre au cours de la saison sèche.

USE OF WHOLE SUNFLOWER SEEDS AND UREA AS SUPPLEMENTS TO CROP-RESIDUE-BASED DIETS FOR GOATS

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ABSTRACT

The potential use of diets based on maize stover and groundnut hay with either urea or sunflower seed as a supplement was investigated using indigenous Small East African goats. Four female goats fitted with permanent rumen cannulae were randomly assigned to a 2 x 2 change-over design to determine dry-matter loss using the nylon-bag technique. The sunflower-supplemented diet contained more readily degradable fraction than the urea-supplemented diet (11.45 *vs* 4.64%) but had a lower dry-matter degradation (45.08 *vs* 56.02%). In another trial, 33 female goats were balanced for weight and assigned to two groups and given one of the two diets for 16 weeks. Intake and liveweight changes were not different between the two diets. Both diets were adequate to maintain weight.

RESUME

Utilisation de graines entières de tournesol et d'urée comme compléments de rations à base de résidus de récolte chez les caprins

Des rations à base de paille de maïs et de fourrage d'arachide complémentés avec de l'urée ou des graines de tournesol ont été évaluées sur des petites chèvres d'Afrique de l'Est. Quatre femelles dans le rumen desquelles avaient été en permanence fixées des canules ont été réparties au hasard selon un modèle croisé en vue de déterminer les pertes de matière sèche par la méthode des sachets en nylon. Il ressort des résultats enregistrés que la fraction facilement dégradable était plus importante avec les graines de tournesol qu'avec l'urée (11,45% contre 4,64%). Par ailleurs, le taux de la dégradation de la matière *sèche était plus faible avec le premier (45,08%) qu'avec le second type de complément (56,02%). Dans un autre essai, 33 chèvres avaient été divisées en deux groupes de poids homogène soumis chacun à l'une ou l'autre de ces deux rations pendant 16 semaines. Ces deux régimes alimentaires permettaient en outre aux animaux de maintenir leur poids et n'étaient différents ni en ce qui concerne la consommation, ni en ce qui concerne les variations de poids des animaux.*

INTRODUCTION

Nutrition is the main constraint to goat production in Zimbabwe (Manyuchi and Sibanda, 1989) and stocking rates may be as high as 15 times the recommended levels. As pressure on land continues to increase with the increasing population (3.6% per year), especially in the crop–livestock areas, overgrazing in the wet season does not allow sufficient weight carry-over for the dry season, leading to weight loss and general low productivity. Results from the University of Zimbabwe (Nyamangara and Ndlovu, 1991) show that goats lose weight even in the wet season, especially when continuous rain restricts grazing time.

One possible solution is to provide supplementary feed. The resources available in communal areas are mainly crop residues (maize and sorghum stover and groundnut tops). Cereal stovers have high fibre and low nitrogen contents and thus low degradabilities in the rumen, and so are generally low in nutritive value. Groundnut hay has higher nutritive value and has been found to improve utilisation of stovers (Ndlovu and Hove, 1989). However, low nitrogen diets supplemented with legume still need a source of readily fermentable nitrogen to ensure adequate concentration of ammonia in the rumen (Preston, 1986). Urea used as a feed supplement, even in small amounts, can increase fermentable nitrogen. There may also be a need to supply animals with "by-pass" energy in the form of lipids. Most farmers in the communal areas grow some sunflowers. Sunflower seed contains about 20% crude protein and 40% oil and its use in crop-residue-based diets could be beneficial.

The aim of this study was to characterise diets based on crop residues supplemented with small amounts of urea or sunflower seed.

MATERIALS AND METHODS

Animals and diets

The experimental animals were indigenous female Small East African goats.

Two experimental diets, based on maize stover and groundnut hay, were investigated; one (diet A) contained urea as a supplement, the other (diet B) sunflower seed (Table 1).

Table 1. *As-fed composition and chemical analysis of diets*

	Diet A	Diet B
As-fed composition (%)		
Groundnut hay	28.2	25.9
Maize stover	65.9	60.2
Urea	1.9	-
Sunflower seed	-	10.3
Ground limestone	1.2	1.1
Salt	2.6	2.4
Vitamin/mineral mix	0.2	0.2
Chemical analysis (g/kg DM)		
Dry matter	95.78	95.89
Crude protein	7.17	8.45
Neutral detergent fibre	73.05	69.35
Acid detergent fibre	52.72	48.49
Ash	1.09	8.33
Fat	1.31	3.49

Dry-matter degradability

Dry-matter degradabilities of the diets were determined using four female goats fitted with rumen cannulae and randomly assigned to a 2 x 2 change-over design. Feed samples were milled to pass through either a 3-mm or a 1-mm screen to assess the effect of particle size on degradability. Nylon bags (195 x 90 mm; pore size, 38 μm) containing 3 g of feed were incubated in the rumen of each goat. Bags were withdrawn at 3, 6, 9, 12, 24, 48 and 72 hours, washed under running tap water and dried at 60°C to constant weight. Dry matter was analysed at each sampling time. Degradability was described using a derivation of the equation described by Ørskov and McDonald (1979):

Amount degraded in time t = $a + be^{-ct}$

where:

a = readily degradable fraction (%)

b = extent of degradation (%)

c = rate of degradation

t = time (hours)

Intake and growth of goats

A total of 33 young indigenous female goats were stratified according to weight and then randomly assigned to two groups. Goats with a liveweight less than

15.5 kg at the start of the trial were classified as light, the others as heavy. The goats were housed in individual pens with concrete floors and received either diet A or diet B for 16 weeks. Feed intake was recorded daily. Liveweight changes were recorded fortnightly.

RESULTS

Dry-matter degradability

Results of the dry-matter degradability studies are shown in Table 2.

Diet B had a significantly (P<0.001) higher readily degradable fraction than diet A. Screen size had an effect on degradability of diet B, but not of diet A. There were significant diet and screen interactions (P<0.05). Within the 1-mm screen size, diet B had higher (P<0.05) readily degradable values than diet A. There were no such differences with between samples milled through the 3-mm screen.

Diet A had a higher extent of degradation than diet B (P<0.001). Within diet A, samples milled through a 1-mm screen had a higher extent of degradation (P<0.05) than those milled through a 3-mm screen. Diet B was not affected by screen size. Within both screens diet A had a higher extent of degradation (P<0.05) than diet B.

Rate of degradation was similar for both diets and was not affected by screen size.

Table 2. *Dry-matter degradability values of crop-residue-based diets supplemented with either urea (diet A) or sunflower seed (diet B); feed samples milled through 1-mm or 3-mm screen*

	Degradability value (%)	
	1-mm screen	3-mm screen
Readily degradable fraction (%)[a]		
Diet A	3.42	5.85
Diet B	14.37	8.54
Extent of degradation (%)[a]		
Diet A	58.97	53.08
Diet B	46.06	44.10
Rate of degradation[a]		
Diet A	0.041	0.045
Diet B	0.044	0.051

[a] In the equation (amount degraded in time $t = a + be^{-ct}$), a = readily degradable fraction; b = extent of degradation; c = rate of degradation; t = time

Table 3. *Effect of diet and weight category of goats on liveweight change, feed intake and efficiency of production for goats fed crop-residue-based diets supplemented with either urea (diet A) or sunflower seed (diet B)*

	Total liveweight change (kg)	Total intake (kg)	Feed efficiency (liveweight gain/feed intake)
Diet A	0.70	49.6	0.014
Diet B	0.66	50.7	0.013
SE	0.35	1.21	0.007
Light goats	0.84	48.3	0.017
Heavy goats	0.52	52.1	0.010
SE	0.35	1.21	0.007

Animal responses

Feed intake and growth responses of the animals fed the experimental diets are shown in Table 3. There were no differences in liveweight changes within diet groups or weight categories. There were no differences in daily intake between diets but, as expected, heavier animals consumed more than light animals ($P<0.01$). Feed efficiency did not differ within diet or weight groups.

DISCUSSION

Dry matter degradabilities

The inclusion of sunflower seed in diet B was meant to increase both energy and protein content of the diet. This was, however, not achieved as the diets were similar in terms of chemical composition. Adding a source of oil to diets based on maize stover is supposed to alter the glucogenic ratio in volatile fatty acids in favour of propionate (Preston and Leng, 1987) thus leading to higher gains of goats on such diets. However, the maximum recommended level of oil inclusion is 5%, as higher values tend to depress intake and reduce microbial activity (Jenkins and Palmquist, 1984). Adding 12% unprocessed sunflower seeds supplied 3.5% oil inclusion. As this was less than the maximum recommended level, the lack of response by the goats was probably due to poor degradation of the unprocessed sunflower seed. Sunflower seed has a thick seed coat which might be resistant to degradation by rumen bacteria. It is also possible that the fat in the sunflower seed reduced hydrophility of feed particle surfaces and prevented further microbial adhesion and digestion (Lindberg, 1985).

According to Preston (1986), if extent of degradation of roughage after 48 hours is less than 40–50%, then it is not worth feeding. Degradability of both diets A and B had exceeded 40% by 48 hours; these diets thus appear to be promising feeds.

Effect of screen size

Milling samples through a 3-mm screen decreased the readily degradable fraction in diet B and the extent of degradation in diet A compared with the 1-mm screen. Decreasing screen (feed particle) size increases the surface area exposed to microbial activity and hence results in higher degradation values (Ørskov, 1975). However, in other instances screen size had no effect. Lindberg (1984) postulated that lack of effect due to particle size could be due to reduced inflow of rumen liquor and microbes into the nylon bags. Other workers (van Keuren and Heinemann, 1962) also found no significant effects due to screen size. Differences in dry-matter disappearance due to screen size may be noticeable at short incubation times, but prolonged incubation reduces the magnitude of differences in digestibility (McLeod and Minson, 1969).

Animal responses

Goats on both diet A and B managed to maintain weight throughout the 16-week experimental period. The results obtained are in contrast to work done by Prasad and Mandebvu (Makoholi Research Station, Masvingo, Zimbabwe) who reported weight loses (–14 and –11 g/d) when groundnut and siratro hay, respectively, were fed with maize stover. However, Banda and Ayoade (1986) reported that groundnut haulms significantly improved liveweight gains in goats fed maize bran.

CONCLUSIONS

Although neither diet could support goat production, both were adequate to meet the maintenance requirements, and this is a positive step in improving goat productivity in critical periods (hot wet and cold dry seasons) when the goats lose weight.

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VELD HAY AS FEED FOR MATEBELE GOATS DURING THE LAST TRIMESTER OF PREGNANCY

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ABSTRACT

Under natural husbandry conditions, kid birth weights and growth rates are lowest in the dry season when feed is scarce and of very low quality. The experiment investigated the potential of veld hay supplemented with lucerne hay as feed for pregnant goats. The digestibility and metabolisable energy (ME) content of the forages were estimated from the dry-matter (DM) disappearance, which was measured by the rumen-bag technique. Forty-five multiparous Matebele goats (mean liveweight 35.1 kg) in the 14th week of gestation were fed at one of three levels: low (L: 0.26 MJ ME/kg $LW^{0.75}$), medium (M: 1.5 x L) and high (H: 2 x L, with veld hay offered *ad libitum*). Maize grain (13.2 MJ ME/kg DM), lucerne hay (7.2 MJ ME/kg DM) and veld hay (5.52 MJ ME/kg DM) were fed at 20, 24 and 56%, respectively, of the total metabolisable energy per treatment. The goats were weighed and body-condition scored (scale 1--10) weekly during pregnancy and within eight hours of parturition.

Results for 42 goats that gave birth to single living kids are presented. Mean ME intakes during pregnancy were 10.23, 5.91 and 4.08 MJ/day (SE=0.261) for H, M and L groups, respectively. Between week 15 and kidding, changes in net liveweight were +4.8, +0.9 and –1.5 kg (SE=0.86), and changes in body condition were –0.4, –1.6 and –1.3 (SE=0.27), for the goats on H, M and L treatments, respectively. Kid birth weights were 3.18, 2.92 and 2.89 kg (SE=0.154). These birth weights were higher than normally realised in the dry season under natural rearing conditions. It is concluded that Matebele goats can eat sufficient quantities of veld hay to meet energy requirements during pregnancy.

RESUME

Alimentation de chèvres Matebele avec du fourrage de veld au cours des trois derniers mois de gestation

Dans les conditions normales d'élevage, le poids des chevreaux à la naissance et leur vitesse de croissance tombent au plus bas au cours de la saison sèche, au moment où les aliments du bétail sont rares et de très mauvaise qualité. Cette expérience examine l'effet de l'alimentation de chèvres en gestation avec du fourrage de veld complémenté avec du foin de luzerne. La digestibilité des fourrages et leur teneur en énergie métabolisable (EM) ont été estimées à partir du taux de dégradation de la matière sèche, mesuré par la technique des sacs en nylon introduits dans le rumen. Quarante cinq chèvres Matebele pesant en moyenne 35,1 kg et qui se trouvaient dans leur 14^e semaine de gestation ont été divisées en trois groupes. Chaque lot a été soumis à l'un ou l'autre de trois régimes alimentaires caractérisés par leur teneur en énergie, laquelle était faible (F: 0,26 MJ EM/kg $PV^{0,75}$), moyenne (M: 1,5 x F) ou élevée (E: 2 x F avec du fourrage de veld ad libitum*). Le maïs grain (13,2 MJ EM/kg MS), le foin de luzerne (7,2 MJ EM/kg MS) et le foin de veld (5,52 MJ EM/kg MS) constituaient respectivement 20, 24 et 56% de l'énergie métabolisable contenue dans chaque ration. Les chèvres étaient pesées et leur état d'engraissement enregistré une fois par semaine au cours de la gestation puis dans les huit heures précédant la parturition.*

Les résultats présentés ici portent sur les 42 chèvres qui avaient donné naissance à un seul chevreau vivant au cours de cette expérience. L'ingestion moyenne d'EM pendant la gestation était de 10,23; 5,91 et 4,08 MJ/j (erreur type=0,261) pour les lots soumis respectivement aux niveaux faible, moyen et élevé d'énergie. De la 15^e semaine de gestation à la parturition, les variations de poids vif net étaient respectivement de +4,8; +0,9 et –1,5 kg (erreur type=0,86) avec des variations correspondantes de l'état d'engraissement égales à –0,4; –1,6 et –1,3 (erreur type=0,27). Les poids à la naissance des chevreaux étaient de 3,18; 2,92 et 2,89 kg (erreur type=0,154) respectivement pour les niveaux faible, moyen et élevé d'énergie. Ces valeurs étaient supérieures aux chiffres habituellement enregistrés en saison sèche dans les conditions normales d'élevage. Les chèvres Matebele en gestation peuvent par conséquent consommer suffisamment de foin de veld pour couvrir leurs besoins en énergie.

INTRODUCTION

Goats play a vital role in the livelihood of smallholder farmers in Zimbabwe. Over 70% of the national goat population are found on communal lands within agro-ecological zones IV and V (Vincent and Hack, 1960). As these areas are generally unsuitable for cropping, livestock rearing on natural vegetation is the major agricultural enterprise.

The natural vegetation of these semi-arid areas of Zimbabwe (commonly referred to as sweetveld (Rattray, 1957)) consists mostly of palatable annual grasses which goats willingly graze in the rainy season when they are nutritious (high protein content) and abundant (Nyamangara, 1990). However, during the dry season the grasses are very mature and of low palatability. Moreover, the trees and bushes on which the goats rely for browse shed their leaves. Elliot and Fokkema (1961) showed that the dry-matter intake of range livestock in Zimbabwe during the dry season is unlikely to exceed 1.5%, and may be as low as 1.2%, of body weight. This energy and protein deficiency causes weight loss in all livestock, but the effects are particularly severe in goats. Seventy per cent of the indigenous Matebele goats in the communal areas kid in the dry season; consequently, kid birth weights and growth rates are low (<2 kg and 40 g/day) and kid survival rates below 65% are not uncommon (Ndlovu and Royer, 1988).

Adequate nutrition of goats during pregnancy and lactation can improve kid birth weights and survival rates (Sibanda, 1990). Veld hay, harvested during the rainy season, is a potential low cost feed resource for the dry season, but the responses of pregnant goats to diets based on veld hay are not known. The study reported here examined the effects of three levels of feeding on doe liveweight and body-condition score changes and kid birth weights.

MATERIALS AND METHODS

Location

The experiments were conducted at the former Thuli Breeding Station, Guyu, situated within agro-ecological zone V in Matebeleland Province, south-west Zimbabwe. Total rainfall during the study year (1989) was 362 mm. Mean maximum and minimum temperatures were 28 and 13°C, respectively.

Experimental diet

The experimental diets consisted of maize grain, lucerne hay and veld hay, providing 20, 24 and 56%, respectively, of the total metabolisable energy. Three levels of feeding were investigated: the low level treatment (L) allowed 0.26 MJ ME/kg $LW^{0.75}$; the medium level treatment (M) was calculated as 1.5 x L; and the high level treatment (H) was calculated as 2 x L for the purposes of establishing the allowance of maize grain and lucerne, while veld hay was given *ad libitum* at 1.4 times the previous day's intake.

Feedstuffs

Lucerne hay and veld hay were obtained from Aiselby Municipality Farm, Bulawayo, which is in the same agro-ecological zone as Guyu. The lucerne was

Table 1. *Chemical composition of maize grain, lucerne hay and veld hay*

Feed	Dry matter (g/kg)	Chemical composition (g/kg DM)		
		Ash	Crude protein	Neutral detergent fibre
Maize grain	90.0	1.6	8.2	–
Lucerne hay	90.1	9.5	18.1	53.8
Veld hay	91.2	10.8	12.8	72.6

harvested at the early flowering stage, left to wilt overnight, baled and then heat-dried in a barn. The veld hay was made from natural annual grasses growing on cleared rangelands during the rainy season. The grass was baled and then dried in the same manner as the lucerne.

The dry-matter, ash, crude-protein and neutral detergent fibre contents of the feedstuffs were determined and are shown in Table 1.

The rumen degradabilities of the lucerne hay and the veld hay were established using the nylon-bag technique (Mehrez and Ørskov, 1977). Four individually-penned, non-pregnant multiparous indigenous Matebele does fitted with permanent rumen cannulae (40 mm diameter) were used in a 2 x 2 cross-over design that investigated the degradability of the two feedstuffs when the does were fed at the low and medium feeding levels. The goats were offered the diets for three weeks before any measurements were made. Water and a salt–mineral lick were freely available at all times.

Representative samples of the two hays were ground through a 3-mm screen using a laboratory hammer mill. Nylon bags containing 4 g of the sample were suspended in the rumen for 3, 12, 24, 36, 48, 60 and 72 hours. After withdrawal, the bags were hand washed in cold water for 30 minutes. A further feed sample was used to determine the amount of soluble material by soaking in water before washing. All the bags were then dried at 60°C to constant weight.

The rumen degradability of the feeds was calculated from the percentage dry-matter loss from the incubated samples, as described by the mathematical model $p = a + b(1 - e^{-ct})$ (Ørskov and McDonald, 1979), where p is the percentage dry-matter loss at time t, $(a + b)$ defines the maximum potential degradability (the asymptote) and c is the rate constant of b.

Feeding trial

Forty-five multiparous Matebele goats that had been synchronised for oestrus using progesterone-impregnated sponges, mated after oestrus and diagnosed pregnant by consistently high plasma progesterone concentrations, were individually penned and randomly allocated to one of the three feeding levels from week 14 of gestation. Maize grain and lucerne hay were offered at the same time (0800 hours) and veld hay for the M and L groups was offered in two portions (at approximately 1000 and 1500 hours). Refused forage was collected and a representative sample analysed for crude-protein and neutral detergent fibre contents. Water and a salt–mineral lick were always available.

Does were weighed and body-condition scored (Honhold et al, 1989) at weekly intervals. Kids were weighed within eight hours of birth.

Statistical analysis

Data were analysed by the method of least squares analysis of variance using general linear model procedures (SAS, 1986). Post-kidding weights and body-condition scores were adjusted using the initial weights and scores as covariates

RESULTS

Rumen degradation of lucerne hay and veld hay

The degradability characteristics of the forages are shown in Table 2. Feeding level had no effect on any of the parameters. The lucerne hay contained more soluble material and was degraded at a more rapid rate than the veld hay.

Table 2. *Dry-matter degradability constants of lucerne hay and veld hay at low and high feeding levels*

		Degradability constants		
Feed	Feeding level	a	b	c
Lucerne hay	Low	24.43	40.58	0.0926
Lucerne hay	High	24.05	40.12	0.0901
Veld hay	Low	14.52	56.65	0.0392
Veld hay	High	14.90	54.24	0.0423

From the equation $p = a + b(1 - e^{-ct})$
where:
p = dry-matter loss (%)
a = readily degradable fraction (%)
b = potentially degradable fraction (%)
c = rate of degradation of the b fraction
t = time (hours)

The effective degradability of organic matter (*P*) was calculated as from the equation $P = a + \{bc/(c + k_1)\}$, where k_1 is the passage rate of digesta from the rumen. As k_1 was not determined in this experiment, *P* was calculated for a range of k_1 values, as shown in Table 3. The mean *P* values were then used to provide an estimate of the ME values of the two forages, assuming that *P* is equivalent to organic matter digested (OMD%). The OMD% was converted to

Table 3. *Derivation of metabolisable energy values for lucerne hay and veld hay from potential organic matter degradability parameters*

Feed	Rumen turnover rate (k_1)	OMD%[a]	DOMD%[b]	ME (MJ/kg DM)[c]	Mean ME (MJ/kg DM)
Lucerne hay	0.03	56.64	51.26	7.69	
	0.04	52.31	47.34	7.10	7.20
	0.05	50.33	45.55	6.83	
Veld hay	0.025	43.86	39.13	5.87	
	0.03	41.69	37.20	5.58	5.52
	0.04	38.17	34.05	5.11	

[a] OMD% is effective OM degradability = a + {bc/(c + k_1)}
[b] DOMD% = OMD% (100 – ash%)/100 (MAFF, 1984: equation 55)
[c] ME = 0.15 DOMD% (MAFF, 1984: equation 58)

digestible organic matter in the dry matter (DOMD%) using the equation DOMD% = OMD% (100 – ash%)/100 (MAFF, 1984: equation 55). ME was then calculated as ME = 0.15 DOMD% (MAFF, 1984: equation 58). The ME values of lucerne hay and veld hay are shown in Table 3.

Feeding trial

Two does gave birth to twins and a third was pseudo-pregnant. The other 42 does gave birth to single, living kids; results from these does (14 per treatment) are shown in Tables 4 and 5.

The mean crude-protein and neutral detergent fibre contents of the refused veld hay from the H treatment were 125 and 756 g/kg DM, respectively, compared to 128 and 726 g/kg DM for the offered material. Therefore there was little evidence of selective feeding. The H treatment does were able to consume 36 g DM/kg liveweight on average over the period of the experiment (Table 4).

Table 5 shows the liveweight changes and body-condition scores of the does, and the birth weights of the kids. Both M and H treatment does showed a net gain in liveweight over the course of gestation, while the L treatment does lost a small amount of weight. Only H treatment does maintained their body condition. There were no significant treatment effects upon kid birth weight. Although there was a trend for birth weight to decline with energy intake, the differences were small compared to the very large differences in energy intake.

DISCUSSION

The ME values estimated for both hays are lower than the values found by Topps and Oliver (1966). The differences could be attributed to many factors, including

Table 4. *Least-squares mean feed intakes of goats during late gestation*

	High feeding level	Medium feeding level	Low feeding level	SE
Number of animals	14	14	14	
Daily dry-matter intake				
Maize grain (g/head)	180	107	74	3.9
Lucerne hay (g/head)	370	220	150	7.4
Veld hay (g/head)	930	520	360	34.4
Total (g/kg)	36	24	16	0.82
Daily ME intake				
MJ/head	10.23	5.91	4.08	0.261
MJ/kg $LW^{0.75}$	0.58	0.37	0.26	0.011

Table 5. *Least-squares mean doe liveweights and body condition scores and kid birth weights*

	High feeding level	Medium feeding level	Low feeding level	SE
Number of animals	14	14	14	
Liveweight (kg)				
Week 15	36.4	33.1	35.6	1.45
Post-kidding	39.8	36.0	33.6	0.92
Net change	4.8	0.9	–1.5	0.86
Body-condition score[a]				
Week 15	5.6	5.4	5.4	0.27
Post-kidding	5.2	3.9	4.2	0.27
Net change	–0.4[b]	–1.6	–1.3	0.27
Kid birth weight (kg)	3.18	2.92	2.89	0.154

[a]On a scale of 1 (severely emaciated) to 10 (over-fat)
[b]Not significantly different from zero

the degree of maturity of the forages at cutting and the methods of preservation, as well as the methodologies of establishing the energy values.

Despite the poor digestibility values of the forages, the goats were able to achieve high levels of intake. The intakes achieved by the H treatment does were well in excess of the 3% of liveweight considered by Devendra and Burns (1983) to be the maximum achievable. These high intakes were achieved without recourse to selection, a characteristic of goats offered poor quality forages (Wahed et al, 1990). The lack of selection could be a reflection of the very poor quality of the veld hay.

The net liveweight gains of H and M treatment does indicate the adequacy of nutrient supply for maintenance and production on these treatments. Does on the L treatment utilised body tissue to support the demands of the foetus, so this treatment had little effect on birth weight. The mean birth weights on all three treatments were greater than those reported by Tawonezvi and Ward (1987) for single kids from Matebele goats under a semi-intensive system on-station.

CONCLUSIONS

Veld hay, even of poor digestibility, supplied as a major part of the diet, can be eaten in sufficient quantities to support the energy needs of Matebele goats in late pregnancy.

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FITTING FORAGE LEGUMES INTO THE CROPPING SYSTEMS OF SEMI-ARID TANZANIA

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ABSTRACT

Forage legumes were grown as intercrops with maize, sorghum and bullrush millet, and maize was planted in alleys of *Leucaena*, for two growing season (1988/89 and 1989/90) at Mpwapwa, Tanzania. The objective was to determine the best entry points of these legumes into the crop–livestock systems of semi-arid Tanzania.

Cereal grain yields were not significantly depressed by the presence of forages, pointing to the possibility of introducing forages to the cereal-cropping systems existing in semi-arid Tanzania, through such methods as intercropping and alley cropping.

RESUME

Introduction de légumineuses fourragères dans les systèmes agraires de la zone semi-aride en Tanzanie

Des essais ont été effectués en vue de déterminer la meilleure manière d'introduire des légumineuses dans les systèmes agraires mixtes de la zone semi-aride de la Tanzanie. Dans le cadre de ces travaux, des légumineuses fourragères ont été intercalées entre des cultures de maïs, de sorgho et de mil chandelle et du maïs a été semé entre des haies de Leucaena *pendant deux saisons de croissance (1988/89 et 1989/90) à Mpwapwa (Tanzanie).*

Il ressort des résultats enregistrés que la présence de plantes fourragères n'entraînait aucune baisse significative de la production de céréales, ce qui signifie que l'on peut introduire ces espèces végétales dans les systèmes à base de céréales de la zone semi-aride de la Tanzanie en utilisant la technique des cultures intercalaires ou en couloirs.

INTRODUCTION

It is common practice, in semi-arid Tanzania, for grazing lands to be taken for crop growing and so for livestock production to be pushed out to poorer, less productive lands, where rainfall is unreliable. In these areas, sound land-use practices, aimed at economically using the land resources at a sustainable level, need to be developed and employed. One such practice is to produce more good quality forage feed within the existing crop–livestock systems.

Forage legumes have played an important role in raising the productivity of farming in temperate areas, a role which has yet to be clearly demonstrated for the tropics. The primary role of the legumes is fixation of atmospheric nitrogen; this leads to improved soil fertility, enhanced forage and mulching quality (Tothill, 1986), and also to a supply of high quality feed for ruminants. In Tanzania, semi-arid areas are characterised by small-scale mixed crop–livestock farming systems. In such systems, forage legumes could be integrated into both the crop and the livestock components. In the crop phase, legumes can reduce the rate of decline of soil fertility, or even enhance crop yields, and can also reduce the length of the fallow period. In the pastoral phase, legumes contribute to better quality and use of crop residues and of natural forages on fallow land (Kusekwa, 1990).

This paper discusses the testing of best-bet legumes for semi-arid Tanzania under two cropping systems with a view to determining their possible entry points into the crop–livestock farming systems in the area.

MATERIALS AND METHODS

The work was carried out at the Livestock Production Research Institute, Mpwapwa, Tanzania (6° 20′ S; 36° 3[illegible]′ E; altitude 1100 m). Annual rainfall here is 700 mm, with 90% of the rain falling during December–April. Maximum and minimum temperatures are 27.5 and 15.5°C, respectively.

The cereals used in the study were varieties of maize, sorghum and millet commonly grown in the area. The maize and sorghum varieties used were early maturing (80 days): the millet (a local variety) took about 100 days to mature.

The legumes used were best-bet forage legumes: *Stylosanthes hamata* (Verano stylo): *S. scabra* (Seca stylo); *Lablab purpureus* (Rongai and Red); *Macroptilium atropurpureum* (Siratro). *Neonotonia wightii* (Tinaroo glycine) and *Leucaena leucocephala* (Peru).

Intercropping trial

The six forage legumes were grown as intercrops with the three cereal crops commonly grown in central Tanzania, during the 1988/89 growing season. The cereals and legumes were planted 30 cm apart, in rows 90 cm apart. The split plot design was used, with the cereals making up the main plots and the legumes the subplots; the control was cereal with no legume. In anticipation of severe competition for nutrients by the intercrops, phosphorus and nitrogen fertilisers were applied as recommended for the area, 40 kg P/ha as triple superphosphate (46% P_2O_5) and 42 kg N/ha as calcium ammonium nitrate (26% N). Nitrogen was split-applied at active vegetative growth and then at the pre-ear-emergence stages of the cereals.

During the 1989/90 growing season, two legumes were dropped from the study: Rongai lablab because of severe smothering effects on the cereals; and Seca stylo because of its poor survival, caused by termite damage. The established legumes were slashed to ground level before the cereals were sod-seeded at the usual spacing of 30 x 90 cm.

Alley-cropping trial

For the alley-cropping study, an area was selected from a previously established 5-ha *Leucaena* field, in which rows of *Leucaena* were spaced 3, 4, 5 and 6 m apart; maize was sown in the alleys at 30 x 90 cm spacing. The rows of *Leucaena* were cut back to stubble heights of 25, 50 and 75 cm, making the study a four alleys x three cutting heights combination of treatments. Maize was fertilised with phosphorus and nitrogen in the first year of the study (1988/89), but in the subsequent year (1989/90) fertiliser N was withdrawn as fertility build-up was anticipated from the effects of mulching. During the 1989/90 growing season, interface competition was also investigated by looking at yields of grain and stover in relation to distances of the maize rows from the *Leucaena* rows.

Statistical analysis

Statistical analysis was performed with Instat (PC version, June 1987: Statistical Service Centre, University of Reading, UK).

RESULTS AND DISCUSSION

Intercropping trial

In 1988/89, grain and stover yields of the different cereals were significantly ($P<0.05$) different (Table 1). However, the type of cereal did not significantly effect legume dry-matter (DM) production, which was about 3 t/ha in each case. Millet and sorghum yielded higher ($P<0.05$) total forage (stover + legume herbage) than maize. The trends in yield of cereal grain and stover and legume forage during the 1989/90 growing season were similar to those in the 1988/98 growing season.

Table 1. *Effects of intercropping forage legumes with cereals on grain-stover and legume-herbage yields, 1988/89 and 1989/90 growing seasons*

	Yield (t/ha)			
Cereal	Cereal grain (air dried)	Cereal stover (DM)	Legume herbage (DM)	Total forage (stover + legume) (DM)
1988/89 growing season				
Maize	5.6	3.9	3.2	7.1
Sorghum	2.0	5.0	3.4	8.4
Millet	3.7	5.7	3.2	8.9
Mean	3.77	4.87	3.27	8.07
LSD (5%)	0.69	0.64	ns	1.33
1989/90 growing season				
Maize	4.5	3.4	3.5	6.9
Sorghum	3.1	5.5	2.9	8.4
Millet	3.9	6.0	2.9	8.9
Mean	3.83	4.97	3.10	8.07
LSD (5%)	0.59	0.79	0.46	1.41

The grain yield did not seem to be depressed by the presence of intercrops as the yields were high compared with the area averages which, according to the Mpwapwa District Agricultural Officer, are 3.0 t/ha for maize, 1.5 t/ha for sorghum and 2.5 t/ha for millet. This result points to the possibility of introducing forages to the cereal cropping systems of the area, especially dual-purpose legumes such as lablab. Traditionally, agropastoralists in this area usually intercrop cereals with grain legumes. This could be realised if and when farmers can be shown that overall productivity of the land is increased when forage from stover and legume is put to proper use such as maintaining a productive animal.

Table 2 shows the effects of forage legumes on grain and stover yields and legume herbage production when intercropped with cereals. Rongai lablab appeared to depress grain yield of the cereals the most, probably as a result of smothering effects of the lablab on any companion plants, while Siratro and Verano and Seca stylo seemed to enhance grain yield, which indicated that there was some soil fertility build-up in plots under these legumes. In general, the more DM produced by the legume the more the depressing effect on grain yield.

It is evident that the inclusion of forage legumes in cereal plots led to increased quantity and quality of the total forage (stover + legume herbage) produced. Stovers alone had an average crude protein (CP) content of 2.4% while legumes averaged 13.9% CP. Such an improvement in the quantity and quality of the feed resource is seen as the key to improved nutrition of the

Table 2. *Effects of forage legumes on grain, stover and legume-herbage yields when intercropped with cereals, 1988/89 and 1989/90 growing seasons*

Cereal	Yield (t/ha)			
	Cereal grain (air dried)	Cereal stover (DM)	Legume herbage (DM)	Total forage (stover + legume) (DM)
1988/89 growing season				
No legume	3.7	5.1	–	5.1
Verano stylo	4.2	5.8	1.0	6.8
Lablab (red)	3.4	5.1	2.1	7.2
Lablab (Rongai)	2.8	4.3	9.8	14.1
Siratro	4.2	5.8	4.7	10.5
Tinaroo glycine	3.7	5.2	1.1	6.3
Seca stylo	4.1	5.6	1.0	6.6
Mean	3.73	5.14	3.28	8.09
LSD (5%)	0.25	ns	0.93	0.78
1989/90 growing season				
No legume	3.6	5.3	–	5.3
Verano stylo	4.2	5.3	1.7	7.0
Lablab (red)	3.4	5.0	3.0	8.0
Siratro	4.3	5.0	4.9	9.9
Tinaroo glycine	3.5	4.8	3.3	8.1
Mean	3.80	5.10	3.10	7.66
LSD (5%)	0.23	ns	0.52	0.91

ruminant livestock during the extended dry season of six to seven months in semi-arid central Tanzania.

Further work is needed on some aspects of soil fertility build-up and animal feeding in order to determine the extent of improvement in productivity when forage legumes are introduced into the crop–livestock farming systems of semi-arid Tanzania.

Alley-cropping trial

Table 3 shows the effects of the width of *Leucaena* alleys on maize grain and stover yields and *Leucaena* leaf-meal production. Grain yield tended to increase with increase in alley width, but the increases were not significant. During the 1989/90 growing season grain and stover yields were lower than in the previous year. The lower yields could be attributed to withdrawal of fertiliser nitrogen.

Table 3. *Effects of width of alleys of* Leucaena *on maize grain and stover yields and* Leucaena *leaf-meal production, 1988/89 and 1989/90 growing seasons*

	Yield (t/ha)					
	Maize grain (air dried)		Maize stover (DM)		Leucaena leaf meal (DM)	
Alley width (m)	1988/89	1989/90	1988/89	1989/90	1988/89	1989/90
Control	4.3	2.71	6.8	4.00	–	–
3	2.8	2.53	4.7	3.48	3.0	3.60
4	2.7	2.41	5.0	2.10	2.5	3.20
5	3.0	2.65	5.5	3.28	2.3	3.00
6	4.0	2.52	6.9	2.99	2.1	3.10
SE	0.55	0.30	0.62	0.34	0.37	0.39

Increases in *Leucaena* stubble height tended to progressively decrease maize grain and stover yields (Table 4), but the effects were not significant. The effects of distance of maize rows from *Leucaena* alleys were not clear (Table 5).

Table 4. *Effects of stubble height of* Leucaena *rows on maize grain and stover yields, 1989/90*

	Yield (t/ha)	
Leucaena stubble height (cm)	Maize grain (air dried)	Maize stover (DM)
Control	2.71	4.00
25	2.66	3.06
50	2.48	3.10
75	2.44	3.39
SE	0.26	0.30

Table 5. *Effects of distance of maize rows from* Leucaena *on maize grain and stover yields, 1989/90*

	Yield (t/ha)	
Distance from Leucaena rows (cm)	Maize grain (air dried)	Maize stover (DM)
Control	2.71	4.00
90	2.49	3.16
180	2.56	3.21
SE	0.22	0.24

These results indicate that it is feasible to introduce *Leucaena* into the cropping system, using the alley-cropping approach. The additional production (forage) from the *Leucaena* rows could serve to supply mulch and supplement forage feed, particularly during the dry season.

CONCLUSIONS

Results from these two cropping studies, intercropping and alley cropping, show that including legumes in the cropping systems in semi-arid central Tanzania can increase the productivity of these systems. Grain as well as fodder for mulch and livestock feed are produced with negligible or no adverse effects on grain yield. It would be even more useful if dual-purpose legumes, such as lablab, were used. Screening for more suitable multipurpose legumes is required to cater for fitting legumes into the cropping systems. The total produce would then include grain from both cereals and legumes, forage, stover and nitrogen from N-fixation.

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EFFECT OF GRAZING HOURS AND CONCENTRATE SUPPLEMENTATION ON MILK YIELD OF CROSSBRED COWS UNDER HIGHLAND CONDITIONS IN ARSI REGION, ETHIOPIA

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ABSTRACT

A comparative study was undertaken on the effect of grazing time on milk yield and general performance of lactating dairy cows. Two groups of 20 crossbred cows were used; they were grazed on natural pasture over one calendar year (1983–84). Cows in group I were allowed day-round grazing (less milking hours), with a little supplementation only during the dry season. Cows in group II were grazed in the traditional way, with about seven hours of grazing a day, and were fed hay (1.86 kg DM/day per cow) and concentrate (0.5 kg/litre milk yield).

Average daily herbage intake for cows in group I was 1.2 and 2.6 kg DM/100 kg liveweight during dry and wet season, respectively. Corresponding figures for cows in group II were 0.9 and 1.2 kg. Mean milk yield during the year differed ($P<0.05$) between the two groups at 1261 and 1762 litres/cow for groups I and II, respectively. The difference, however, varied with season, being high in the dry season and falling to zero during wet season when pastures were lush and green.

RESUME

Effet du temps de pâturage et d'une complémentation de concentrés sur la production de lait de vaches métisses dans les hauts plateaux de la région d'Arsi (Ethiopie)

Une étude comparative a été effectuée sur l'effet du temps de pâturage sur la production de lait et les performances de vaches laitières en lactation. Deux groupes composés chacun de 20 vaches métisses avaient été élevés sur prairie naturelle pendant un an (1983–1984). Les animaux du groupe I avaient accès au

pâturage toute la journée (à l'exception des périodes de traite) et recevaient en outre un peu d'aliment complémentaire au cours de la saison sèche. Quant à ceux du groupe II, ils étaient gérés selon la méthode traditionnelle de pâturage, avec par jour environ sept heures de présence effective sur les parcours, et recevaient en plus du foin (1,86 kg de matière sèche par tête) et des concentrés (0,5 kg/litre de lait produit).

La consommation des animaux du groupe I était en moyenne de 1,2 et 2,6 kg de matière sèche par 100 kg de poids vif respectivement au cours de la saison sèche et de l'hivernage. Les chiffres correspondants étaient de 0,9 et 1,2 kg pour les animaux du groupe II. La production moyenne annuelle de lait des deux groupes était différente ($P<0,05$) et s'établissait à 1261 litres par vache pour le groupe I contre 1762 litres pour le groupe II. Cependant, cette différence dépendait de la saison; élevée en saison sèche, elle diminuait puis s'annulait au cours de l'hivernage, c'est-à-dire au moment où l'herbe était abondante et verte.

USE OF THE NYLON-BAG TECHNIQUE IN DETERMINING THE COMPLEMENTARITY OF FEEDSTUFFS FOR DAIRY CATTLE RATIONS

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ABSTRACT

Degradation of various feedstuffs (protein sources, energy concentrates and roughages) eaten by dairy cattle in the high potential areas of Kenya was studied by incubating samples in nylon bags in the rumens of steers. For each feedstuff, degradation characteristics were estimated from a hand-drawn degradation curve.

Average dry-matter solubility was about 25.3, 18.0 and 24.8% for protein feeds, energy concentrates and roughages, respectively. Maize germ flakes had the highest degradable fraction (65.0%) and fish meal the lowest (38.5%). Degradation rate constants averaged 0.05% per hour for protein feeds, 0.06% per hour for energy concentrates and 0.03% per hour for roughages.

The use of degradation characteristics in evaluating livestock feedstuffs and in formulating ration combinations for dairy cattle is discussed. The nylon-bag technique is a useful tool for improving tropical animal production systems because it is reliable, cheap and easy to perform.

RESUME

Etude comparée de la dégradabilité de divers aliments du bétail par la technique d'incubation des sacs en nylon dans le rumen

Le rythme de dégradation de différents aliments (sources de protéines, aliments énergétiques et fourrages grossiers) consommés par les bovins de race laitière dans les zones à forte potentialité du Kenya a été étudié par incubation de sacs en nylon dans le rumen des animaux. Une courbe a été tracée pour chaque aliment en vue de déterminer ses paramètres de dégradabilité.

Il ressort des résultats enregistrés que la solubilité moyenne de la matière sèche était d'environ 25,3; 18,0; et 24,8% respectivement pour les sources de protéines, les aliments énergétiques et les fourrages grossiers. Les taux de dégradation variaient de la valeur maximum de 65,0% pour la farine de germe de maïs au chiffre minimum de 38,5% pour la farine de poisson. Quant à la constante horaire de dégradation, elle s'élevait à 0,05%; 0,06%; et 0,03% respectivement pour les sources de protéines, les aliments énergétiques et les fourrages grossiers.

L'évaluation des aliments du bétail et la formulation des rations à partir des études de dégradabilité ont été discutées. La technique du sac en nylon constitue un instrument utile d'amélioration des systèmes d'élevage dans les régions tropicales dans la mesure où elle est fiable, peu chère et d'utilisation facile.

INTRODUCTION

As a tool for studying rumen digestion, the artificial-bag technique is not new (see, for example, Quin et al, 1938; Fina et al, 1958). In recent years the nylon-bag technique has become more widely used, and it is now being recommended as a means for evaluating tropical livestock feeds. However, little work has been done on the practical application of the technique to the evaluation of feeding systems. This study aimed to use degradation characteristics as a means of formulating ration combinations for dairy cattle.

MATERIALS AND METHODS

Samples of various feedstuffs, used for feeding dairy cattle on small-scale farms in different parts of Kenya, were studied. The feedstuffs included byproducts of the food industry, pasture forage, crop residues and non-conventional feeds. Samples were degraded in nylon bags in the rumens of three crossbred steers (average weight 590 kg) fitted with permanent cannulae. The daily diet of the animals comprised Napier grass and concentrate.

Feedstuffs for analysis were oven-dried at 70°C and then ground to pass through a 2-mm screen. Samples (2–5 g) were measured into nylon bags (approximately 14 x 8 cm) which were securely tied with a knot at the end of a 24-cm long string. The bag strings were permanently tied in groups of 20 to a main string about 60 cm long, and the whole assembly was inserted into the ventral sac of the rumen of one of the steers. All samples were incubated in duplicate per steer and replicated in the three steers. Withdrawal of the bags was timed to give incubation times of 1, 6, 12, 18, 24 and 36 hours for protein feeds and energy concentrates and 1, 12, 24, 36, 48 and 72 hours for forages. Zero-hour incubation was obtained by extrapolation of the degradation curve to the *y*-axis. Retrieved bags were washed under running water until the water was clear. Dry-matter degradation was determined from dry-matter determinations on original and degraded samples.

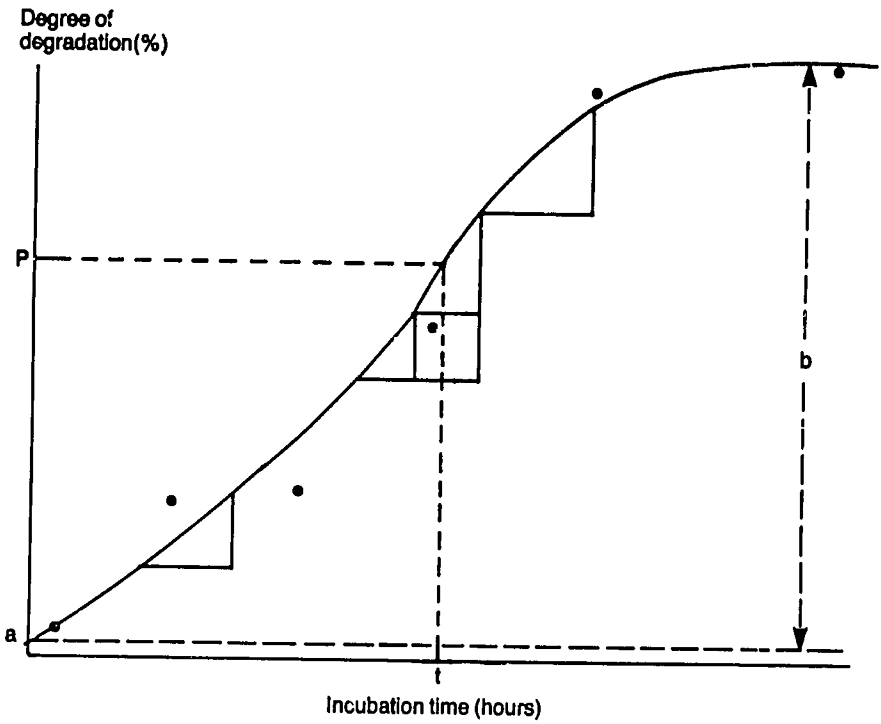
For each feedstuff, degree of dry-matter degradation was plotted against incubation time and the curve drawn by hand (Figure 1). The values of *a* (% solubility) and *b* (potentially degradable fraction) were determined from the graph. The steepest section of the curve (where the change *dy/dt* was most rapid, indicating maximum rate of dry-matter degradation) was identified and the percentage degradation (*p*) and incubation time (*t*) corresponding to the mid-point of this section were read off; this enabled the degradation rate constant (*c*) to be calculated from the following exponential equation (Ørskov et al, 1980):

$$p = a + b(1 - e^{-ct})$$

where:

p = dry-matter degradation (%)
a = dry-matter solubility (%)
b = potentially degradable fraction (%)
t = time of maximum rate of dry-matter degradation (hours)
c = degradation rate constant

Figure 1. *Hand-drawn curve for estimating % degradation* (p) *at time* t



The constants estimated from the hand-drawn curve were compared to those derived using a computer program.

RESULTS AND DISCUSSION

The contents of major nutrients in the feeds (Table 1) were within the published range (Said, 1971; Abate, 1980; Kamande, 1988) except that the level of insoluble material in the fish meal was very high, probably because of a high proportion of scale and contamination in the sample analysed.

The degradation characteristics (Table 2) are generally comparable to those obtained for similar feeds by other authors (Ørskov et al, 1980; Kamande, 1988). Previous studies used sinkers of sand or water (Kamande, 1988) or nylon tubes, or weights to position bags in the rumen (Ørskov et al, 1980), but the present study indicates that reliable, accurate, results can be cbtained without these aids. There is, however, some variation in estimates of solubility. For example, compared with the values found in this study, Kamande (1988) reported a higher solubility value for wheat bran and a lower solubility for lucerne. This may suggest that solubility is unreliable as an indicator of feeding value.

Table 1. *Dry-matter, ash, crude-protein and fibre contents of feedstuffs*

		Content (% DM)			
Feed	DM (%)	Ash	Crude protein	Crude fibre	Neutral detergent fibre
Protein sources					
Fish meal	96.4	15.6	35.0	nd	nd
Soybeans	90.9	4.9	40.8	9.1	nd
Cottonseed cake	97.3	5.9	31.1	20.7	nd
Sunflowerseed cake	96.5	5.7	33.6	28.8	nd
Lucerne, flowering	91.8	10.4	22.7	nd	77.8
Energy concentrates					
Maize germ flakes	87.8	6.0	16.5	11.4	nd
Wheat bran	91.2	7.9	17.2	13.4	nd
Cornflakes waste	91.4	2.7	8.1	9.3	nd
Green banana fruit	92.5	6.1	5.0	6.4	nd
Roughages					
Bean stalks and pods	90.7	8.7	6.3	nd	70.8
Coffee pulp	89.9	10.7	13.6	nd	51.5
Hay (mixed species)	92.0	8.7	8.8	nd	76.6
Kikuyu grass	93.5	12.6	19.0	nd	64.8

nd = value not determined

Table 2. *Degradation characteristics of feedstuffs obtained from a hand-drawn curve and by computer*

Feed	a		b		c	
	Hand	Computer	Hand	Computer	Hand	Computer
Protein sources						
Fish meal	15.3	13.9	38.5	43.1	0.054	0.066
Soybeans	34.9	34.8	62.6	66 5	0.053	0.078
Cottonseed cake	21.8	14.6	45.6	47.8	0.057	0.220
Sunflowerseed cake	22.5	21.7	41.4	46.3	0.054	0.069
Lucerne, flowering	32.1	30.3	47.6	48.0	0.050	0.074
Energy concentrates						
Maize germ flakes	10.2	11.9	65.0	61.8	0.047	0.086
Wheat bran	14.4	12.7	55.2	56.6	0.072	0.128
Cornflakes waste	28.8	30.3	51.4	56.5	0.063	0.067
Green banana fruit	18.4	17.5	53.6	169.4	0.044	0.012
Roughages						
Bean stalks and pods	15.0	12.6	45.9	52.7	0.033	0.041
Coffee pulp	42.8	41.3	48.4	54.9	0.035	0.037
Hay (mixed species)	16.4	15.3	41.8	48.2	0.029	0.033
Kikuyu grass	25.2	22.9	55.3	62.2	0.037	0.043

$p = a + b(1-e^{-ct})$
where:
p = dry-matter degradation (%)
a = dry-matter solubility (%)
b = potentially degradable fraction (%)
t = time of maximum rate of dry-matter degradation (hours)
c = degradation rate constant

Degradation characteristics derived by computer are also given in Table 2. There was a high correlation (r = 0.97) between the solubility estimates obtained by the two methods, indicating that both methods are equally applicable for determining this parameter. However, there was little or poor agreement between the methods in the estimation of *b* (r = 0.32) and *c* (r = 0.60); on average the *b* and *c* values were higher than those obtained from the hand-drawn curve. It is therefore difficult to judge the reliability of either method, but comparison of results from this study with those reported in the literature suggests that the estimates made from the hand-drawn curve are more accurate.

All the protein sources showed similar rates of degradation. However, this similarity can be misleading. The relatively low total degradability (potentially degradable fraction) of the fish meal implies that this feed could be a source of undegradable protein and therefore would be useful for cows that are high producers of milk. In contrast soybean was so highly degraded that more of its protein would be exposed to hydrolysis, and so diets based on this feedstuff would need to be supplemented by a source of rumen degradable energy, such as cornflakes waste or possibly wheat bran (but not coffee pulp which, despite a high total degradability, has a low degradation rate).

The low solubility of the bean stalks and pods and hay is in agreement with similar values demonstrated for Kenyan pasture grasses and fodder legumes (Kamande 1988) and low quality range forage (Rutagwenda, 1989). More recently Abate (1990) has shown that maize forage harvested and ensiled at different stages of growth differed in solubility and degradability. Fibrous materials are less soluble because of the dominance of structural over soluble carbohydrates in the cell wall. Also, Van Soest (1982) has demonstrated that degree of lignification has a negative effect on cell wall digestion in forages. The low solubility of fish meal, compared with cottonseed and sunflowerseed cakes, may be a result of the composition of the meal or of contamination with indigestible matter. Low and slow degradability, as found in the hay, can limit voluntary intake of feed. It is hence desirable that roughages such as hay or crop residues be combined with highly soluble feedstuffs; such a combination would stimulate a more active rumen microbial population which would degrade the fibre faster and hence increase digesta passage rate and DM intake.

CONCLUSIONS

Knowledge of dry-matter degradation characteristics of feedstuffs can be used as a basis for formulating ration combinations for dairy cattle in tropical animal production systems. The nylon-bag technique offers a cheap, reliable and easy to perform method of obtaining this information; analysis can be done by hand without the need for expensive computer equipment and software. However, assessment of protein degradability of feedstuffs is also desirable, to ensure that protein requirements are met.

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CROP RESIDUES AND AGRO-INDUSTRIAL BYPRODUCTS IN ZAMBIA: AVAILABILITY, UTILISATION AND POTENTIAL VALUE IN RUMINANT NUTRITION

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ABSTRACT

Large quantities of crop residues and agro-industrial byproducts are produced each year in Zambia. The potential value of these materials in animal nutrition is well known, but little information has been published on their actual utilisation as livestock feed or on their availability to smallholder farmers in the country. Where they are available, most of them are used haphazardly because farmers lack storage facilities and knowledge of how to use them effectively in animal diets. Efforts currently being made to help smallholders solve their animal feed problems are focusing on improving methods of harvesting, handling and processing crop residues and byproducts, and on incorporating them into year-round feed budgets. Improved feeding methods could lead to substantial increases in Zambia's livestock population.

RESUME

Les résidus de récolte et les sous-produits agro-industriels en Zambie: production, utilisation et valeur potentielle pour l'alimentation des ruminants

De grandes quantités de résidus de récolte et de sous-produits agro-industriels sont produits chaque année en Zambie. Alors que leur valeur potentielle en tant qu'aliment du bétail est bien documentée, on ne peut en revanche pas en dire autant de leur utilisation réelle et de leur relative disponibilité au niveau des *petits paysans. Ceux-ci les utilisent au petit bonheur, faute de matériel de conservation et d'une méthode rationnelle d'introduction de ces produits dans l'alimentation du bétail. Aussi les efforts déployés actuellement en Zambie pour aider les petits éleveurs à mieux nourrir leurs animaux visent-ils en priorité, non seulement à améliorer leurs méthodes de récolte et de traitement des résidus de récolte et des sous-produits agro-industriels, mais également à les amener à prévoir dans leurs budgets les dépenses annuelles d'achat de ces produits. L'amélioration des méthodes d'alimentation du bétail devrait permettre d'accroître de manière substantielle les effectifs des animaux d'élevage dans le pays.*

INTRODUCTION

Zambia's ruminant livestock population currently comprises about 2.4 million cattle, more than 600 000 goats and more than 50 000 sheep. Malnutrition is the major constraint on animal production, especially during the seven-month dry period when grazing ruminants lose weight dramatically. However, Zambia produces sufficient feed resources, in the form of crop residues and agro-industrial byproducts, to make it potentially capable of supporting a much larger animal population. The problem is that these resources may not be readily available to smallholder farmers, or are not being used as effectively as they could be. This paper discusses the availability, utilisation and potential value in ruminant nutrition of agro-industrial byproducts and crop residues in Zambia.

CROP RESIDUES AND AGRO-INDUSTRIAL BYPRODUCTS IN ZAMBIA

Production

Zambia produces a wide variety of cereals and other food crops (Table 1). After these crops have been harvested and processed, various residues and byproducts remain—for example, stovers, straws, husks, cobs and brans from cereal crops; and shells, heads, pulp, peels and tops from other crops.

No accurate data have been published on the quantities of crop residues and agro-industrial byproducts produced in Zambia. However, based on government crop production statistics, and using appropriate crop:residue ratios (Munthali and Dzowela, 1987), it is estimated that more than 3.25 million tonnes of crop residues and byproducts could be available each year (Tables 2 and 3).

Value in livestock nutrition

Basic chemical composition and nutritive value data available for most of the crop residues and agro-industrial byproducts produced in Zambia (Chimwano,

Table 1. *Provincial distribution of crops in Zambia*

Province	Crops
Central	Maize, sweet potato, soybean, groundnut, cotton, watermelon, sunflower, wheat, tobacco
Copperbelt	Maize, sunflower, soybean, beans, groundnut, wheat, oilseeds
Eastern	Maize, soybean, sunflower, orange, sweet potato, cassava, cotton, groundnut, pigeon pea, sorghum
Luapula	Cassava, rice, maize, sunflower, sweet potato, millet, beans, banana, groundnut, oilseeds
Lusaka	Maize, soybean, sunflower, sorghum, tobacco, sweet potato, pigeon pea, rice, cotton, wheat, watermelon, orange
Northern	Rice, maize, cassava, sunflower, millet, sweet potatoe, banana, cotton, beans, soybean, coffee
Northwestern	Maize, pineapple, sweet potato, soybean, sunflower, millet, orange, cassava, faba bean, sorghum, coffee, groundnut, rice
Southern	Maize, soybean, sunflower, tobacco, sugarcane, cotton, banana, millet, oranges
Western	Maize, sorghum, rice, millet, groundnut, faba bean, cassava

Table 2. *Annual production of crop residues*

	Annual production (thousands of tonnes)							
Province	Maize stover	Sorghum stover	Millet stover	Rice straw	Wheat straw	Groundnut straw	Soy/ sweetbean straw	Sunflower heads
Central	586.7	11	1.4	-	1.8	1.4	2.4	8.1
Copperbelt	72.7	18	-	0.1	1.5	0.7	0.8	0.1
Eastern	641.5	9	0.5	1.4	-	9.1	1.0	7.5
Luapula	22.9	0.5	0.1	0.7	-	0.4	0.4	0.1
Lusaka	119.5	6	-	-	5.9	0.4	5.2	1.6
Northern	182.5	0.5	8	5.2	-	1.6	4.6	0.1
Northwestern	20.5	7.2	1.2	0.8	-	0.3	4.7	0.1
Southern	536.0	20.1	0.5	-	1.8	3.8	3.7	7.6
Western	40.8	17.1	11.7	3	-	0.4	-	-
Total	2223.1	90.0	23.4	11.2	11.0	18.1	22.8	25.2

Based on government crop production statistics and stover to grain ratios of 2:1 for maize, sorghum and millet; and straw to grain ratios of 1:1 for rice, wheat, groundnut and soybean (Munthali and Dzowela, 1987)

1990) show clearly that they could satisfy the nutritional requirements of ruminant livestock.

Table 3. *Annual production of agro-industrial byproducts*

	Annual production (thousands of tonnes)					
Province	Maize bran	Rice bran	Wheat bran	Soybean cake	Cottonseed cake	Sunflower cake
Central	94.6	–	0.3	1.2	77.4	2.5
Copperbelt	11.7	0.1	0.4	0.3	0.8	–
Eastern	103.5	0.1	–	0.2	50.7	2.3
Luapula	3.7	0.7	–	–	0.2	–
Lusaka	19.3	–	1.4	2.4	29.1	0.5
Northern	29.4	0.5	–	0.2	0.4	–
Northwestern	3.3	0.1	–	0.1	0.1	–
Southern	86.5	–	0.5	1.8	233.3	2.3
Western	6.6	0.3	–	–	2.1	–
Total	358.6	1.8	2.5	6.2	484.1	7.6

Based on government crop production statistics and grain to bran/cake ratios of 3.1:1 for maize; 10:1 for rice; 4:1 for wheat; 2:1 for groundnut; and 3.3:1 for cottonseed (Munthali and Dzowela, 1987)

Many of these materials have been studied in detail. For example, orange pulp and peels, byproducts of the citrus industry, are known to be good sources of energy for cattle, small ruminants and even monogastrics (Ammerman et al, 1963; Devendra, 1973). Peels, hulls and pulp of other crops, such as cassava, groundnut, sunflower, soybean, potato, pineapple, banana and watermelon, have also been shown to be of value in livestock nutrition (Ting and Deszyck, 1961; Bhattacharya and Harb, 1973; Devendra, 1973; Cantner, 1987; Balock et al, 1988). Malt screening, brewers' grains and Chibuku (local brew) wastes, tonnes of which are produced annually by Zambia's two breweries (at Lusaka and Ndola), are high in protein and of medium energy, and their value in livestock nutrition is well documented (Adebowale and Ademosun, 1981; Ugye et al, 1988; Aregheore et al, 1990). The use of molasses as a carbohydrate and an energy source has been extensively studied (Reyley, 1961; Shindende, 1990). And milling byproducts such as bran, wheatlings and screenings are important byproducts which, along with oilseed cakes from soybean, groundnut, cotton and sunflower, could form important raw materials in the production of livestock feed in Zambia.

UTILISATION OF CROP RESIDUES AND AGRO-INDUSTRIAL BYPRODUCTS

Little information is available on the extent to which smallholder farmers in Zambia use crop residues and agro-industrial byproducts as livestock feed. It is very likely, however, that these resources are under-utilised. Even when they are utilised, farmers may not be able to incorporate them effectively into their year-round livestock feeding programmes because they lack suitable storage facilities and technical knowhow on treatment and processing methods and on formulating feed rations.

The few crop residues known to be used for livestock nutrition in Zambia are brans, stovers and straws of wheat, maize, sorghum and millet. But these are not used in the most efficient manner; smallholder farmers usually feed them to their stock *in situ* during harvest seasons.

Most of the valuable agro-industrial byproducts produced in Zambia are not used for livestock production at all, and are simply wasted. The problem is mainly one of availability; food manufacturing and processing industries are generally located in urban centres along the railway lines, and so their byproducts are not readily available to smallholder farmers in the rural areas of the country.

IMPROVING LIVESTOCK PRODUCTION IN ZAMBIA

Ruminant livestock production in Zambia could be increased substantially if more efficient feeding methods could be introduced. Adequate feed resources are potentially available, and so the challenge before animal nutritionists is how to improve their utilisation and hence help smallholder farmers solve their feed problems. Current research is focusing on:

- improving methods of harvesting, handling and storing crop residues so as to reduce wastage
- developing treatment methods that could increase the availability of nutrients
- introducing supplementation techniques to correct nutrient deficiencies
- determining seasonal availability and nutritional values of residues and byproducts with a view to formulating adequate year- round feeding systems

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EFFECT OF LEGUME CROP RESIDUES AND CONCENTRATE SUPPLEMENTATION ON VOLUNTARY INTAKE AND PERFORMANCE OF KIRDI SHEEP FED A BASAL DIET OF RICE STRAW

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ABSTRACT

Twenty young Kirdi rams of the West African Dwarf sheep, averaging 22 kg liveweight and 15 months of age, were randomly assigned to four feeding groups and subjected to an eight-week feeding trial, to determine the effect of different protein supplements on voluntary intake of rice straw and on performance. Control group animals were fed a daily basal diet of *ad libitum* rice straw and 250 g of rice bran. Other groups were fed the basal diet supplemented with 300 g of groundnut haulms, 45 g of cottonseed cake or 210 g of chopped cowpea vines. Liveweight changes of the supplemented groups did not differ significantly but there was a difference ($P<0.05$) in liveweight gain between the supplemented groups and the control group. There were highly significant ($P<0.01$) differences between the groups in the intake of rice straw; cottonseed cake increased intake while the crop residues reduced intake. Variations in height at withers, heart girth and scapulo-ischial length showed no significant differences between treatments. Cottonseed cake was the most effective supplement, in terms of both liveweight gain and intake of rice straw. However, because crop residues are readily available to farmers, it is worthwhile paying some attention to them.

RESUME

Effet de la complémentation de la paille de riz avec des résidus de culture de légumineuse et des concentrés sur l'ingestion volontaire d'ovins Kirdi

Un essai d'alimentation d'une durée de huit semaines a été effectué pour déterminer l'effet de divers compléments protéiques sur les performances et *l'ingestion volontaire de paille de riz chez des ovins. 20 jeunes béliers Kirdi de race Djallonké, pesant en moyenne 22 kg et âgés d'environ 15 mois ont été divisés au hasard en quatre groupes soumis chacun à un régime alimentaire donné. Tous les animaux recevaient de la paille de riz* ad libitum *comme aliment de base; ceux du lot témoin recevaient en outre 250 g de son de riz par jour et par tête, alors que ceux des trois autres lots recevaient soit 300 g de fanes d'arachide, soit 45 g de tourteau de coton, soit 210 g de fourrage de niébé broyé. Les variations de poids des animaux recevant une complémentation n'étaient pas significativement différentes de celles du lot témoin mais leurs gains de poids vif étaient significativement (P<0,05) différents. L'ingestion de paille de riz variait significativement (P<0,01) selon la ration: elle était élevée avec le tourteau de coton et faible avec les résidus de récolte. En revanche, les variations des mensurations linéaires (hauteur au garrot, périmètre thoracique et longueur scapulo-ischiale) n'étaient pas significativement différentes. Bien que le tourteau de coton donne les meilleurs résultats en ce qui concerne les gains de poids et l'ingestion de paille, on ne saurait cependant déconseiller l'utilisation des résidus de récolte, étant donné que les paysans peuvent se les procurer facilement.*

INTRODUCTION

Thousands of tonnes of rice straw are destroyed every year in the Far North Province of Cameroon. This is a waste of resources: even with a crude-protein content of only 4% (Nour, 1986; Udo and El-Harith, 1985) and an organic-matter digestibility of between 40 and 50% (Pearce, 1984; Zainur et al, 1984), rice straw could be a major feed for ruminants if properly supplemented. Intake of rice straw is limited to less than 2% of body weight (Jackson, 1978) because of the slow rate at which it is fermented in the rumen, but it can still be a major source of energy for ruminants in an area like the Far North Province where pasture and grain production is hampered by a long (eight-month) dry season.

Chemical, physical or microbial methods of treating straws to improve their low energy and protein content (Hartley, 1981; Kiangi et al, 1981; Saadullah et al, 1981; Wongsrikeao and Wanapat, 1984; Mason and Owen, 1986) are of little economic relevance to small-scale farmers. However, it is at this level that the problem of weight loss by animals during the dry season is most critical. There is thus a great need to prevent weight loss by the use of simple techniques applicable to farmers and involving readily available agro-industrial byproducts and crop residues. Supplementation of poor quality roughages, including cereal crop residues, with legumes has been shown to increase their digestibility (Devendra, 1982) or intake (Mosi and Butterworth, 1985) or both (Minson and Milford, 1967; Lane, 1982; Moran et al, 1983; McMeniman et al, 1988).

This study investigated the effects of different protein supplements on the intake of rice (*Oryza sativa*) straw, on the efficiency of nutrient utilisation and on the performance of Kirdi rams.

MATERIALS AND METHODS

Animals

Twenty Kirdi yearling male lambs (average age 15 months; average liveweight 22 kg) were randomly assigned to four treatment groups of five animals each. The animals were kept in a roofed half-walled shed with a concrete floor. They were treated against worms and ectoparasites and fed polyvitamins dissolved in water.

Feeds and feeding

A two-week adaptation period on a daily diet of *ad libitum* rice straw and 250 g rice bran per animal was followed by an eight-week experimental period, during which the groups were allocated to one of four diets:

- basal diet (control): rice straw (*ad libitum*, 125% ot daily intake) plus 250 g rice bran per animal per day
- diet 1: basal diet plus 300 g groundnut haulms per animal per day
- diet 2: basal diet plus 45 g cottonseed cake per animal per day
- diet 3: basal diet plus 210 g chopped cowpea vines per animal per day

The experimental period was divided into four periods of two weeks each to examine the effect of time of feeding on voluntary intake and performance.

Table 1 shows the nutrient composition of the ration ingredients. The rations were formulated to be approximately isonitrogenous. Diets 1 and 3, unlike diet 2, were isocaloric. The protein supplements were offered each morning before the basal diet. Water and a 50:50 common salt/bonemeal mineral supplement were offered *ad libitum*. The feed ingredients and refusals were weighed each morning.

Table 1. *Nutrient composition of ration ingredients*

Ingredients	Dry matter (%)	Energy[a] (UF/kg DM)	Digestible crude protein (% DM)	Calcium (% DM)	Phosphorus (% DM)
Rice straw	95	0.42	0	0.19	0.08
Rice bran	94	0.85	0.9	0.16	1.74
Cottonseed cake (Alibet)	95	0.84	38.3	0.24	1.24
Groundnut haulms	94	0.43	5.8	1.41	0.21
Cowpea vines	94	0.60	9.2	0.64	0.29

[a] UF = unité fourragère = 1883 calories

Dry-matter content was determined on-station. Other analyses were carried out by the nutrition laboratory of the Institut d'élevage et de médecine vétérinaire des pays tropicaux (IEMVT) in France

Animals were weighed every two weeks during the experimental period. Height at withers, heart girth and scapulo-ischial length were measured at the beginning, middle and end of the experiment.

Statistical analysis

Liveweight changes, average daily gains and feed intake were subjected to analysis of variance (Steel and Torrie, 1980). The treatment means were compared using Duncan's new multiple range and Student's test (Ott, 1977).

RESULTS

All animals remained in good health throughout the experimental period.

The voluntary intake of rice straw varied highly significantly between feeding groups and with time of measurement (Table 2). Rice straw intake increased highly significantly (P<0.01) in animals supplemented with cottonseed cake but decreased highly significantly in animals supplemented with the legume crop residues (Table 3).

The liveweight changes of the supplemented animals did not differ significantly from each other (Table 2) although they were highly significantly affected by the time of measurement. Average daily gain tended to be affected by the type of protein supplementation (Table 2). This tendency may reflect the

Table 2. *Least-squares analysis of variance of mean squares of rice straw intake, liveweight change and average daily gain*

Source of variation	df	Mean square	Significance level
Rice straw intake			
Treatments (T)	3	7.123	P<0.01
Supplementation period (P)	3	0.432	P<0.01
T x P	9	0.206	P<0.05
Residual	192	0.060	
Liveweight change			
Treatments (T)	3	0.897	ns
Supplementation period (P)	3	9.162	P<0.01
T x P	9	0.410	ns
Residual	64	0.449	
Average daily gain			
Treatments	3	1144.58	P<0.1
Residual	16	467.60	

Table 3. *Efficiency of feed utilisation and cost of ration for Kirdi sheep by treatment group*

Parameters	Basal diet	Diet 1	Diet 2	Diet 3
Dry matter intake				
Rice straw (g/animal per day)	502	380	552	446
Total (g/animal per day)	736	896	829	877
Total (g/kg liveweight$^{0.75}$)	77.1	93.8	86.8	86.2
Energy intake (UF/animal per day)[a]	0.41	0.48	0.47	0.51
Digestible crude protein intake (g/animal per day)	20.8	37.2	37.2	39.0
Protein:energy ratio (g/UF)[a]	50.7	77.5	79.2	76.5
Feed utilisation efficiency (kg DM consumed/kg liveweight gain)	36.8	18.3	15.9	17.8
Cost of daily ration/animal (FCFA)	13.4	19.2	15.6	17.8
Cost per kg liveweight gain/day (FCFA)	670.0	392.6	291.5	361.1

[a] UF = unité fourragère = 1883 calories
Basal diet = ad libitum rice straw plus rice bran (250 g/animal per day)
Diet 1 = basal diet plus groundnut haulms (300 g/animal per day)
Diet 2 = basal diet plus cottonseed cake (45 g/animal per day)
Diet 3 = basal diet plus chopped cowpea vines (210 g/animal per day)

short duration (eight weeks) of the experiment. However, the objective of the study was to maintain the weight of the animals during the period of scarcity which, evidently, was achieved. The average daily gain of the supplemented groups exceeded ($P<0.05$) that of the control group.

Cottonseed cake was the most effective protein supplement in terms of both intake and weight gain (Tables 3 and 4). In the supplemented groups, the quantity of protein offered was similar, suggesting that the intake of rice straw was influenced by the source of protein supplement. The high protein:energy ratios (Table 3) are explained by the poor quality of rice straw which was the major source of energy in the diets. Height at withers, heart girth and scapulo-ischial length did not differ significantly with the treatments (Table 4) although there was a general increase in the supplemented groups. Within the same treatment group, variations in heart girth and scapulo-ischial length were greater than the variation in height at withers.

DISCUSSION

The dry-matter intakes of rice straw observed for sheep fed the different diets were comparable to the values of 0.3–0.5 kg/animal per day reported by other authors (Zainur et al, 1984; Boonloom and Potikanond, 1984) under similar experimental conditions. They were, however, lower than values reported for chemically treated straws: chemical treatment of straws increases their

Table 4. *Weight gain and linear measurements of Kirdi sheep by treatment group*

Zootechnical parameters	Basal diet	Diet 1	Diet 2	Diet 3	SD
Number of animals	5	5	5	5	
Average initial weight (kg)	22.26	22.58	22.54	24.04	
Average final weight (kg)	23.38	25.32	25.46	26.80	
Average daily weight gain (g/day)	20.00	48.93	52.14	49.29	9.67
Average change in height at withers (cm)	1.33	1.00	1.80	1.70	0.30
Average change in heart girth (cm)	2.30	3.10	3.50	2.00	0.40
Average change in scapulo-ischial length (cm)	2.60	3.10	3.00	2.50	0.50

Basal diet = ad libitum rice straw plus rice bran (250 g/animal per day)
Diet 1 = basal diet plus groundnut haulms (300 g/animal per day)
Diet 2 = basal diet plus cottonseed cake (45 g/animal per day)
Diet 3 = basal diet plus chopped cowpea vines (210 g/animal per day)

digestibility and intake (Ibrahim, 1984). Rice straw, like any other crop residue, has a high crude-fibre content of 40% (Suriyajantratong and Wilaipon, 1984) and low levels of protein, soluble carbohydrates and minerals. It has also been reported that the ash fraction of rice straw contains mostly silica which not only has no nutritional value for animals but also depresses the digestibility of other nutrients (Clawson and Garett, 1970). It is thus likely that the high fibre and ash contents of rice straw are the major factors limiting its utilisation by ruminants. Intake and digestibility of rice straw are consequently too low to sustain animal maintenance, let alone support animal production. Supplementation with energy and/or protein should thus increase the efficiency of utilisation of rice straw.

Supplementation with groundnut haulms, cowpea vines and cottonseed cake produced positive effects on growth rate. However, intake of the basal diet decreased when supplemented with legume crop residues. An ideal supplement should maintain or increase the intake of the basal diet rather than substitute for it, a phenomenon often seen with animals fed legumes (Moran et al, 1983) or legume crop residues (Mosi and Butterworth, 1983). Supplementation with legume crop residues contributes fermentable energy to the rumen in the form of available cellulose and hemicellulose which stimulate fibre digestion (Silva and Ørskov, 1985). It is possible that offering such material prior to the daily feeding of rice straw may induce a greater degree of colonisation of rice straw by rumen bacteria and by rumen fungi, which have been implicated in the breakdown of fibre (Bauchop, 1981). Ørskov and Dolberg (1984) stated that if animals feeding on untreated straws or poor quality roughages are supplemented with substrates which increase the fermentation rate of cellulose, the rumen environment becomes similar to that of animals receiving ammonia-treated straws. This may explain why Nolan and Stachiw (1979) found an increase in the intake of wheat straw by sheep when 50 g of lucerne chaff was added to their ration.

The improvement of the rumen environment when animals are fed untreated straws or poor quality roughages with certain supplements is very important in areas where chemical treatment of these poor roughages is not possible. The supplement should be an easily digestible byproduct containing cellulose and/or hemicellulose (Ørskov and Dolberg, 1984), such as green grass, azolla, water hyazinth, legumes or citrus pulps. The higher intake of rice straw by sheep supplemented with cottonseed cake is explained by the fact that cottonseed cake not only provided the essential nutrients to maintain optimal rumen activity but was also more rapidly degraded in the rumen. Groundnut haulms and cowpea vines, although contributing the essential nutrients, took much longer to break down, hence the lower intakes of the basal diet. Ingested fibre material must be broken down by rumination, microbial fermentation or both to produce particles which are small enough to pass through the reticulo-omasal orifice (Blaxter et al, 1956; Crampton, 1957; Campling and Balch, 1961; Campling et al, 1962). Cottonseed cake turned out to be the most efficient supplement, probably because animals fed this supplement had more than twice the quantity of energy received by the other treatment groups. This is attributed to the higher intake of rice straw by this group (Table 3). The cottonseed cake supplemented diet was the cheapest (Table 4). However, as groundnut haulms and cowpea vines are more readily available to farmers, it is worth paying particular attention to them.

CONCLUSIONS

The use of low quality roughages in ruminant diets is limited, at least in part, by the insufficient intakes of these roughages to ensure satisfactory animal performance. It has been suggested that the intake of these roughages is limited mainly by their low digestibilities. This study shows that giving small quantities (up to 30% of total DM intake) of a legume crop residue will substantially increase the total DM intake and improve the digestibility of rice straw above that which can be obtained by use of non-protein-nitrogen supplements. Judicious amounts of legume crop residues, which are generally available in abundance during the harvest season, could be fed in combination with rice straw and rice bran to small ruminants in the hot dry season to ensure minimal weight loss, mortality and weakness due to malnutrition.

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THE POTENTIAL OF RUSSIAN COMFREY (*SYMPHYTUM OFFICINALE*) AS AN ANIMAL FEEDSTUFF IN UGANDA

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ABSTRACT

A trial was established at the Makerere University farm, Kabanyolo, Uganda, to study the growth characteristics, dry-matter yield and nutrient composition of Russian comfrey (*Symphytum officinale*) to assess its potential for livestock feeding in Uganda.

Dry-matter (DM) yields increased from about 2 t/ha at eight weeks of growth to 3 t/ha at 12 weeks of growth. Yields of 2–3 t DM/ha were sustained during four, five and six weeks of regrowth. Crude-protein (CP) production increased steadily from 344 kg/ha at eight weeks to 517 kg/ha at 12 weeks of growth. However, CP content remained constant at about 16% at all cuttings. This is comparable to CP values of good to medium quality forage legumes, but is higher than observed in most pasture grasses. Both macro- and micro-mineral contents of the plants were higher at all cuttings than normally observed in most Ugandan fodder plants. Amino acid analyses indicated that the protein quality of comfrey is comparable to that of good quality alfalfa leaf meal, but higher than that of *Amaranthus* leaf meal.

Russian comfrey thus has potential as a complement to forage legumes, grasses and crop residues for sustainable animal production in Uganda.

RESUME

Evaluation de la consoude voyageuse* (Symphytum officinale) *en vue de l'alimentation du bétail en Ouganda

Un essai a été réalisé à la ferme expérimentale de l'Université Makerere à Kabanyolo (Ouganda) pour étudier la croissance, la production de matière sèche et la teneur en éléments nutritifs de la consoude voyageuse (Symphytum officinale) *en vue de son introduction dans l'alimentation du bétail en Ouganda.*

La production de matière sèche, qui était d'environ 2 t/ha à 8 semaines, passait à 3 t/ha à 12 semaines puis allait de 2 à 3 t/ha après 4, 5 et 6 semaines de repousse. Quant à la production de protéines brutes, elle augmentait régulièrement de 344 kg/ha à 8 semaines à 517 kg/ha à 12 semaines. Toutefois, la teneur en protéines brutes demeurait constante, s'établissant toujours autour de 16%. Ce taux est comparable à ceux enregistrés pour les légumineuses fourragères de bonne qualité ou de qualité moyenne, mais supérieur à ceux rapportés pour la plupart des parcours de graminées. En ce qui concerne les analyses minérales macroscopiques et microscopiques, les chiffres enregistrés étaient plus élevés que les valeurs correspondantes rapportées sur la plupart des plantes fourragères rencontrées en Ouganda. Enfin, une analyse des acides aminés a montré que du point de vue qualitatif, les protéines de la consoude voyageuse étaient comparables à celles des feuilles de la luzerne mais supérieures à celles des feuilles de l'amarante.

La consoude voyageuse peut donc être utilisée comme complément des légumineuses fourragères, des graminées et des résidus de récolte en vue d'une production soutenue des animaux d'élevage en Ouganda.

INTRODUCTION

The majority of ruminant animals in Uganda depend wholly on grazing unimproved natural pastures. These pastures are dominated by coarse and stemmy grasses with low dry-matter yield and nutritive value. Hence animal production is limited from such pastures. Very little attention has been given to the development of suitable forage species and/or establishment of pastures capable of sustaining high levels of animal productivity.

Cultivated comfrey (*Symphytum officinale*), often referred to as Russian or Quaker comfrey, was introduced in Uganda in the 1950s. It is a perennial herb with the arrangement of stems and leaves similar to that of the tobacco plant. The root system of a well-established comfrey plant is fleshy and extensive. The plant is semi-sterile and is propagated vegetatively mainly through root cuttings and root offsets.

Once comfrey plants are well established, plenty of vegetative material can be harvested by cutting several times during the year; the plants regenerate quickly because of the large food reserves in the roots. Comfrey could become a major source of fresh herbage for most of the year in Uganda where there is plenty of sunshine and rainfall. Comfrey is also the only known land plant that extracts vitamin B_{12} from the soil (Odwongo et al, 1987). It also contains alantoin which is used by herbalists for treating digestive disorders. However, comfrey contains at least eight pyrrolizidine alkaloids which cause acute necrosis of liver and lungs in cattle and horses (Culvenor et al, 1980). Administration of comfrey pyrrolizidine alkaloids to rats resulted in mortality and liver damage (Culvenor et al, 1980).

Because little is known in Uganda about the agronomy and nutritive value of comfrey, a study was carried out to study its growth characteristics and nutrient composition.

MATERIALS AND METHODS

The study was conducted at Makerere University Research Institute, Kabanyolo, 19 km north of Kampala (0° 28′ N, 32° 37′ E; altitude 1200 m). The upland soils of Kabanyolo are classified as ferralitic soils. The area has a moist tropical climate with mean maximum temperatures varying from 28.5°C in January to 26.0°C in July and minimum temperatures ranging from 17.4°C in April to 15.9°C in July. Mean annual rainfall is about 1300 mm, with peaks in April and November and two periods of low rainfall in January and July when the monthly mean drops to 60 mm.

Russian comfrey was planted as offsets with 8 cm of cut root buried into the ground at a spacing of 1 x 1 m in a 0.2-ha plot. Weeding was carried out every three weeks after planting.

Comfrey was harvested at weekly intervals from eight to 12 weeks after planting. (Harvesting was stopped at 12 weeks of growth because the plants had become very coarse. They were also heavily infested with blight caused by *Cladosporium* sp, indicating that bacterial blight is potentially a major disease of comfrey in Uganda.) Regrowth materials were harvested after four, five and six weeks of regrowth. For each harvest, 12 plants were randomly selected from each quarter of the field, cut about 2.5 cm above ground, weighed and subsampled. The subsamples were dried to constant weight in an air-draught oven at 65°C and then ground through a 1-mm sieve for chemical analysis (AOAC, 1980). Amino acid profiles were determined by high performance liquid chromatography (Waters/Millipore). Minerals were assayed by atomic absorption spectrophotometry.

RESULTS AND DISCUSSION

Dry-matter (DM) and crude-protein (CP) yields of the comfrey plants are shown in Table 1. These DM yields are lower than that obtained from a comfrey field planted at a spacing of 0.9 x 0.9 m in Kenya—a total of about 40 t/ha from 12 monthly harvests, equivalent to a monthly yield of 3.4 t/ha (Anon, 1960). The differences in the yields may be due to variations in spacing, soil fertility, stage of plant establishment and plant variety. Most of these factors remain to be defined for comfrey production in Uganda.

There was a steady increase in CP yield during both growth and regrowth (Table 1), but CP content stayed constant at about 16%. This is comparable to CP values of good to medium quality forage legumes but higher than for most pasture grasses (Soneji et al, 1971; Sabiiti and Mugerwa, 1990).

Table 1. *Russian comfrey dry-matter and crude-protein yields and contents during cutting trials*

	Dry matter		Crude protein	
Cutting time	Yield (t/ha)	Content (%)	Yield (kg/ha)	Content (%DM)
Weeks of growth				
8	2.11	13.74	343.93	16.30
9	2.48	13.27	409.94	16.53
10	2.60	12.89	440.70	16.95
11	3.64	14.96	591.86	16.26
12	3.34	14.44	516.70	15.47
Weeks of regrowth				
4	2.06	12.87	339.49	16.48
5	2.88	12.38	419.04	14.55
6	2.58	12.48	408.67	15.84

During all harvests, the comfrey plants had higher contents of both macro- and micro-minerals (Table 2) than are usually observed in many fodder crops (Kabaija and Smith, 1988). Similar results have been reported from studies in Britain and New Zealand (Anon, 1960). The potassium content is very high, which may indicate that comfrey plants have a high requirement for potash fertiliser. However, Hart (1972) attributed the high potassium content of comfrey plants to soil clinging to the hairy leaves during harvest. It was not possible to estimate the contribution of such contamination to the values observed in the present study.

Table 2. *Mineral content of Russian comfrey during cutting trials*

	Content (%DM)						
Cutting time	Calcium	Phosphorus	Potassium	Magnesium	Iron	Copper	Sulphur
Weeks of growth							
8	1.94	0.51	8.07	0.41	0.27	0.0019	0.26
9	1.90	0.44	7.11	0.45	0.45	0.0021	0.23
10	1.95	0.45	6.47	0.42	0.42	0.0017	0.23
11	1.86	0.45	7.03	0.45	0.45	0.0016	0.22
12	1.56	0.41	6.11	0.38	0.38	0.0016	0.21
Weeks of regrowth							
4	1.80	0.48	7.00	0.39	0.39	0.0018	0.22
5	1.90	0.43	7.40	0.40	0.39	0.0018	0.22
6	2.24	0.45	6.90	0.55	0.55	0.0012	0.22

Table 3. *Amino acid profiles of Russian comfrey during cutting trials*[a]

	Content (%DM)							
	Weeks of growth				Weeks of regrowth			
Amino acid	8	9	10	12	4	5	6	Mean
Alanine	1.30	1.22	1.44	1.21	1.16	0.85	0.84	1.15
Arginine	1.13	0.99	0.95	0.90	0.94	0.64	0.57	0.87
Asparagine	1.95	1.95	-	1.85	1.94	1.59	1.74	1.84
Glutamine	2.09	1.86	1.92	2.17	2.38	1.95	2.26	2.09
Glycine	1.17	1.13	1.15	1.03	1.10	0.84	0.50	0.99
Histidine	-	-	-	0.30	0.28	0.23	0.23	0.26
Isoleucine	-	-	-	-	0.86	0.88	0.60	0.78
Leucine	-	-	-	0.86	1.38	1.12	0.98	1.09
Lysine	-	-	-	-	0.63	-	0.54	0.59
Proline	0.99	0.95	1.00	0.90	1.01	0.87	0.89	0.94
Phenylalanine	-	-	-	-	0.96	0.74	0.65	0.79
Serine	0.85	0.80	0.82	0.75	0.79	0.65	0.59	0.75
Threonine	0.95	0.92	0.90	0.75	0.84	0.65	0.57	0.80
Tyrosine	-	-	-	0.58	0.66	0.63	0.50	0.59
Valine	1.33	1.23	1.26	1.07	1.10	0.83	0.79	1.09

[a] Assays for methionine and tryptophan are not available

Amino acid profiles of comfrey are shown in Table 3. Amino acid content tends to decrease as the plants mature. A comparison of essential amino acid profiles (Table 4) indicates that the protein quality of comfrey is comparable to that of good quality alfalfa but higher than that of *Amaranthus* leaf meal. These observations need to be confirmed through direct animal studies.

CONCLUSIONS

The results of this study suggest that comfrey could provide average monthly yields of 2 t DM/ha, containing over 300 kg high quality crude protein and high levels of minerals. It would therefore be worthwhile investing in comfrey production for livestock feeding because these yields are higher than those of most forage legumes and grasses available in Uganda.

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Table 4. *Comparison of essential amino acid profile of egg protein (standard protein) with those of leaf meals of Russian comfrey,* Amaranthus hybridus *and alfalfa*[a]

Amino acid	Amino acids as % crude protein				% deficiency compared with egg protein		
	Egg protein	*Amaranthus* (29% CP)	Alfalfa (23% CP)	Comfrey (16% CP)	*Amaranthus*	Alfalfa	Comfrey
Arginine	6.60	5.86	5.65	5.44	11.2	14.4	17.6
Histidine	2.40	1.45	1.74	1.63	39.6	27.5	32.1
Isoleucine	6.60	2.79	4.35	4.88	57.7	34.1	26.1
Leucine	8.80	5.45	6.52	6.81	38.1	25.9	22.6
Lysine	6.60	4.03	4.78	3.69	38.9	27.6	44.1
Phenylalanine	5.80	3.69	4.35	4.94	36.4	25.0	14.8
Threonine	5.00	3.82	3.48	5.00	23.6	30.4	0.0
Valine	7.40	3.52	4.78	6.81	52.4	35.4	8.0

[a] Assays for methionine and tryptophane of comfrey are not available

Sources: Amino acid profiles: egg protein and alfalfa leaf meal, NRC (1982); Amaranthus leaf meal, Olaboro (1975)

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COMPLEMENTATION DE L'ALIMENTATION DES RUMINANTS DOMESTIQUES AVEC DE LA PAILLE ENRICHIE AVEC DE L'UREE A 4%

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RESUME

Deux expériences ont été menées au Mali en vue d'évaluer l'effet de la paille enrichie avec de l'urée sur la production des ruminants.

Dans la première expérience, 30 boeufs de labour de race Zébu maure, peul et Méré ont été divisés en trois lots élevés pendant 63 jours sur pâturage (lot témoin), avec complément de paille enrichie (lot 2) ou de paille additionnée d'aliment bétail Huicoma (ABH) (lot 3). La consommation de complément du lot 2 (2,28±0,28 kg/tête/j) était supérieure à celle du lot 3 (1,86±0,45 kg/tête/j). Il n'y avait pas de différence significative entre les gains moyens quotidiens des lots 2 (38,3 g) et 3 (53,9 g). Quant au lot témoin, il perdait en moyenne 148 g/j.

Dans la deuxième expérience, des ovins de race Djallonké métis et Bali Bali et des caprins de race Djallonké âgés de 24 à 48 mois ont été élevés sur pâturage avec divers compléments alimentaires. Les variations de poids ont été enregistrées chez ces deux espèces animales tandis que la production de lait a été analysée chez les seuls caprins. Une étude économique a montré que la technique de production de paille enrichie utilisée était à la portée des petits éleveurs.

ABSTRACT

Supplementation of ruminant diets with 4% urea-enriched straw

Two experiments were carried out to evaluate the effect of urea-enriched straw on ruminant production.

In the first experiment, 30 Maure, Fulani and Méré Zebu work oxen were divided into three groups and kept for 63 days on pasture (control) with two types of supplements—enriched straw (Group 2) or straw with Huicoma Animal Feed (ABH) (Group 3). Group 2 consumed more supplement (2.28±0.28 kg/animal per day) than Group 3 (1.86±0.45 kg/animal per day). There was no

significant difference between the average daily weight gains of animals in Group 2 (38.3 g) and Group 3 (53.9 g). The control animals lost weight.

In the second trial, West African Dwarf cross and Bali Bali sheep and West African Dwarf goats aged between 24 and 48 months were kept on pasture with different feed supplements. Weight changes were recorded in both species while milk production data were recorded only for goats. An economic analysis showed that the enriched straw production technique used was within the reach of smallholders.

EFFECT OF ADDITION OF CONCENTRATES TO SUDAN GRASS (*SORGHUM SUDANENSE*) IN THE PRE-CALVING PERIOD ON PERFORMANCE OF HOLSTEIN–FRIESIAN HEIFERS IN SUDAN

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ABSTRACT

Holstein–Friesian heifers were used to study the effect of nutrition in late pregnancy on early lactation performance. Before calving heifers were fed 10 kg Sudan grass (*Sorghum sudanense*) per head per day, supplemented with 6 kg concentrate supplement for 43 days (treatment 1); 6 kg concentrate for 60 days (treatment 2); or 8 kg concentrate for 60 days (treatment 3). During the early lactation period all the animals were fed 10 kg Sudan grass per day plus concentrate *ad libitum*.

Average daily liveweight gains during the steaming-up period were not different (P>0.05) among treatments. The level of concentrate feeding affected (P<0.05) calf birth weight; calves born to heifers on treatments 2 and 3 were 7 and 8% heavier, respectively, than those born to heifers on treatment 1. No differences (P>0.05) were observed among the treatment groups in average daily gain after calving or in milk fat percentage. However, heifers on treatment 3 produced more milk than those on treatment 1.

RESUME

Performances post-partum de génisses croisées Holstein x race frisonne alimentées avant le vêlage avec du fourrage de sorgho fourrager (*Sorghum sudanense*) complémenté avec des concentrés

L'effet du régime alimentaire vers la fin de la parturition a été étudié sur les performances de lactation post-partum de génisses métisses Holstein x race frisonne. Avant le vêlage, le régime alimentaire des animaux était composé de 10 *kg de fourrage par jour complémenté soit avec 6 kg de concentrés par jour et par animal pendant 43 jours (traitement 1) ou 60 jours (traitement 2) soit avec 8 kg de concentrés pendant 60 jours (traitement 3). Au début de la lactation, le régime alimentaire était constitué de 10 kg de sorgho fourrager par jour complémenté avec des concentrés* ad libitum.

Les traitements n'avaient aucun effet significatif (P>0,05) sur les gains moyens quotidiens enregistrés avant la parturition. En revanche, ils avaient une influence significative (P<0,05) sur le poids des veaux à la naissance: ceux nés de femelles préalablement soumises aux traitements 2 et 3 pesaient respectivement 7 et 8% de plus que ceux dont la mère avait été soumise au traitement 1. Par ailleurs, le type de ration n'avait d'effet ni sur les gains moyens quotidiens post-partum, ni sur le taux butyreux du lait produit. Toutefois, la production de lait des animaux préalablement soumis au traitement 3 était supérieure à celle des autres génisses.

INTRODUCTION

Many tropical and subtropical countries are importing exotic breeds of dairy cattle or up-grading local types in an attempt to meet the local demand for milk and milk products. However, imported animals rarely achieve the levels of production that they show in their original habitats. Nutrition seems to be the major factor limiting the productive and reproductive performance of such animals.

Management practices in the tropics normally emphasise nutrition of milking cows and neglect, to some extent, nutrition of heifers and dry cows. Therefore, the aim of this work was to study the effects of feeding period and level of concentrate supplements in late pregnancy on post-calving performance of Holstein–Friesian heifers.

MATERIALS AND METHODS

The study used 18 in-calf heifers (liveweight 320–420 kg: average 359 kg) born in Sudan to Holstein–Friesian cows imported as in-calf heifers in October 1984. Because the experimental animals were selected randomly from a large herd which was housed and managed as one group, they were given one week to adapt to the experimental handling. They were then blocked, according to liveweight, into three groups, of six animals each. All animals were fed a daily ration of 10 kg Sudan grass (*Sorghum sudanense*) and, in addition, the groups were randomly assigned to three dietary treatments:

- Group 1: 6 kg concentrates/head per day for 43 days pre-calving
- Group 2: 6 kg concentrates/head per day for 60 days pre-calving
- Group 3: 8 kg concentrates/head per day for 60 days pre-calving

All the animals were housed and fed individually.

The forage was offered in one meal at 1300 hours and concentrates were offered in two meals at 0800 and 1700 hours; the compositions of the feed ingredients are shown in Table ..

After calving all animals were group fed 10 kg Sudan grass per head per day plus concentrates *ad libitum.*

Animals were machine-milked every 12 hours, at 0400 and 1600 hours; milk yield was recorded at each milking. Milk samples were collected once a week and tested for butter-fat content by the Gerber method.

Liveweight changes during the pre- and post-calving periods were assessed by weighing each animal once a week at 0700 hours, before the morning meal.

Calves were weighed immediately after calving. After calving, mastitis was kept at a minimum level by strict sanitary control (including good hygiene and teat dipping), and all calvers were tested for mastitis by rapid mastitis test at monthly intervals. Ticks were controlled by spraying with Gamatox.

Data were subjected to analysis of variance applicable to a randomised omplete-block design (Steel and Torrie, 1980).

RESULTS

Animals in group 3 achieved higher liveweight gains than animals in the other two groups (Table 2), but the differences were not significant (P>0.05).

Calves born to heifers on treatment 2 (mean weight 34.6 kg) and 3 (34.8 kg) were heavier (P<0.05) than those born to heifers on treatment 1 (32.3 kg).

Table 1. *Composition and analysis of feed ingredients used in the feeding trial*

	Composition (%)		
Ingredient	Pre-calving concentrate	Post-calving concentrate	Sudan grass
Sorghum grain (dura)	40	35	
Cottonseed cake	30	35	
Wheat bran	28	28	
Salt (NaCl)	1	1	
Limestone	1	1	
Chemical composition[a]			
Dry matter	93.6	94.1	45.0
Ash	5.8	5.9	12.3
Crude protein	13.7	15.8	6.7
Crude fibre	12.8	11.5	50.5
Ether extract	3.8	5.1	1.2
Nitrogen-free extract	57.5	55.8	29.3

[a] Determined according to AOAC (1980)

Liveweight at calving did not differ (P>0.05) among the treatment groups (Table 3). There were also no significant differences in average daily gain and final body weight at the end of the early lactation period.

Milk yields and fat percentage in early lactation are shown in Table 4. Heifers in group 1 clearly produced more milk than those in group 1, but butter-fat percentage did not differ (P>0.05) among treatments.

DISCUSSION

Heifers on treatments 2 and 3 appeared to be superior to heifers on treatment 1 in final body weight and liveweight gain before calving, but the differences were not significant. The apparent comparative rapid increase in the rate of weight

Table 2. *Effect of pre-calving nutrition on performance of heifers in the pre-calving period*

Treatment group	Steaming-up period (days)	Average body weight (kg)		Average daily gain (kg)
		Initial	Final	
1	43	358.0	411.2	1.2
2	60	359.0	438.6	1.3
3	60	359.0	451.5	1.5
SE		14.1	15.4	0.3

Table 3. *Effect of pre-calving nutrition on performance of heifers in the early lactation period*

Treatment group	Early lactation (days)	Liveweight at calving (kg)	Final body weight (kg)	Average daily gain (kg)
1	98	355.3	455.0	1.0
2	98	388.3	464.5	0.8
3	98	396.0	473.7	0.8
SE		14.1	16.1	0.1

Table 4. *Effect of pre-calving nutrition on milk yield and fat content in the early lactation period*

Treatment group	Milking period (days)	Milk yield (kg)		Fat content (%)
		Total	Daily average	
1	91	980.2	10.7	3.9
2	91	1030.1	11.3	4.1
3	91	1329.2	14.6	3.9
SE		127.6	1.4	0.2

gain as calving approached, for heifers on treatments 2 and 3 compared with those on treatment 1, was probably due to availability of nutrients which catered for both dam and foetus growth. This agrees with previous work (Greenhalgh and Gardner, 1958) which showed that the increased weight of heifers in the later stages of pregnancy, as a result of an increase in concentrate feeding, was related to the increase in weight of mother and foetus and its membranes at this time.

The observed improvement in milk yield of heifers on treatment 3 compared with that of those on treatments 1 and 2 indicates that supplementation with high levels of concentrates before calving tends to cause heifers to exhibit their potentials in milk production. This is in line with previous studies (Keys et al, 1984; Nocek et al, 1986) which showed that feeding cows and heifers at high levels before calving resulted in better body condition at calving and better production performance after calving. This may be attributed mainly to availability of enough nutrients during the later stages of gestation, which would enable the dam to meet the increased nutrient requirements of lactation.

Milk fat contents were not significantly different ($P>0.05$) among treatments. Gardner (1969) also showed that milk fat percentages were not influenced by prepartum plane of nutrition.

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CAGED-LAYER WASTE AS A NITROGEN SOURCE IN CROP-RESIDUE UTILISATION

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ABSTRACT

Poultry litter has a crude-protein content of about 22–25% and has been successfully used as a component of ruminant feeds. However, poultry waste is a potential carrier of pathogenic microorganisms and must be treated to reduce the risk of transmitting diseases. This study assessed the effect of sun-drying, ensiling, deep-stacking and fumigating with formaldehyde gas on the nutritional value of caged-layer waste (CLW). Deep-stacking resulted in a higher ($P<0.01$) ash content and undesirable odour, but also in a higher ($P<0.01$) dry-matter degradability (DMD) than the other treatment methods. Duration of sun-drying or deep-stacking or the number of times the CLW was fumigated did not affect ($P>0.05$) DMD in the rumen. However, ensiling CLW for 42 days resulted in a higher ($P<0.01$) DMD than ensiling for 21 days and also reduced odour.

In another study, CLW was ensiled in 21-litre plastic silos for 21 or 42 days, at 0, 20 or 40% (DM basis) rate of inclusion with crop residues having low crude-protein levels (maize stover, maize cobs or wheat straw). Fermentation (as indicated by pH) approached optimum ($P<0.01$) at 40% rate of CLW inclusion and 42 days of ensiling. Crude-protein, ash and *in vitro* dry-matter digestibility increased with level of CLW in the silage mixtures but NDF decreased ($P<0.01$). Ensiling fibrous crop residues with caged-layer waste could provide a means of more efficiently utilising caged-layer wastes and crop residues as livestock feed.

RESUME

Utilisation des déjections de pondeuses élevées en batteries comme source de complément protéique des résidus de récolte

Avec une teneur en protéines brutes d'environ 22 à 25%, la litière de volaille est incorporée avec succès dans l'alimentation des ruminants. Cependant, étant *donné qu'elles peuvent transmettre des microbes, les déjections des volailles doivent être traitées pour réduire les risques de maladies. Une étude a été effectuée en vue d'évaluer l'effet du séchage solaire, de l'ensilage, de l'empilage et de la fumigation au formol sur la valeur nutritive des déjections de volailles. Par rapport aux autres méthodes, l'empilage, qui s'accompagnait d'odeurs désagréables, se traduisait par une plus forte teneur en matières minérales et un taux de dégradation de la matière sèche plus élevé (P<0,01). Ni la durée du séchage à l'air et de l'empilage, ni le nombre de fumigations n'avaient d'effet (P>0,05) sur la digestibilité de la matière sèche dans le rumen. Cependant, un ensilage de 42 jours permettait de réduire les mauvaises odeurs et se traduisait en outre par une digestibilité de la matière sèche plus élevée (P<0,01) qu'un ensilage de 21 jours.*

Dans une autre étude effectuée immédiatement après, des déjections de pondeuses en batteries ont été ensilées pendant 21 ou 42 jours dans des silos en plastique (environ 21 litres). Elles avaient été incorporées à 0, 20 ou 40% (sur la base de la matière sèche) dans des résidus de récolte pauvres en protéines brutes (paille de maïs, épis égrenés de maïs ou paille de blé). La fermentation (mesurée par le pH) était maximum (P<0,01) au taux de 40% et avec l'ensilage de 42 jours. Enfin, la teneur en protéines brutes, le taux de matières minérales et la digestibilité in vitro *de la matière sèche augmentaient alors que la teneur en parois cellulaires diminuaient (P<0,01) avec la proportion de déjections. L'ensilage des résidus de récolte riches en cellulose avec des déjections de pondeuses en batteries peut donc permettre d'utiliser l'un et l'autre produits de manière plus rationnelle.*

INTRODUCTION

In Kenya, crop farming produces a wide range of crop residues, mainly maize cobs, maize, sorghum and millet stovers and wheat, barley and rice straws. Other important crop residues are produced by the sugar industry and from horticultural crops. An estimated 7.2 million tonnes of highly lignified arable farm products are produced annually (Said and Wanyoike, 1987). However, it is difficult to assess the amounts of crop residues fed to livestock as there are great variations with season and individual farm requirements.

Most available crop residues have low protein and high fibre contents, factors that lead to their poor utilisation by livestock (Said and Wanyoike, 1987). Utilisation of the energy component of such materials by ruminants is highly dependent on the efficiency of fermentative activity in the rumen (Mehrez et al, 1977) which depends, in turn, on adequate supplies of nitrogen in the rumen. Positive responses on intake and liveweight gain have been recorded when a nitrogen source has been included in a diet based on crop residues (Alayu, 1987). In Kenya, most studies on crop residues have been on evaluating chemical treatment methods such as the use of alkali and/or urea to improve utilisation (Kevelenge et al, 1983; Alayu, 1987; Said and Wanyoike, 1987). However, the applicability of results from such work has been limited by the high cost of chemicals and by farmers' lack of knowledge. The need has thus arisen to find alternative, more practical, ways to improve the nutritive value of crop residues.

Caged-layer waste (CLW) is reported to contain between 22.3 and 25% crude protein (Kayongo and Muinga, 1985; Nambi, 1987). Between 40 and 50% is true protein and the rest non-protein nitrogen (Nambi, 1987). However, feeding unprocessed CLW can pose potential health hazards, both to the livestock consuming the feed and to people eating products (meat and milk) from such animals (Shah and Müller, 1983). Ensiling is an inexpensive biological method of processing poultry litter for incorporation into rations (Caswell et al, 1977; Shah and Müller, 1983). It has also been reported that ensiling broiler litter with corn forage or wheat straw improved the nutritional value of the crop residues compared to ensiling the crop residues by themselves (Caswell et al, 1977; Daniels et al, 1983). This study therefore examined the effect of processing methods on the composition and degradability of CLW. The effect of ensiling CLW (as a nitrogen source) with crop residues on the chemical composition and degradability of the silage was also investigated.

MATERIALS AND METHODS

Experiment 1. Processing methods

Caged-layer waste was collected from laying Shavers chickens, aged 50 weeks and housed in battery cages. A polythene sheet was spread below the cages and the droppings, which included excreta, feathers, broken eggs and spilled feed, were collected after three days. The waste was processed by one of four methods, all applicable at farm level in Kenya:

Sun-drying. Caged-layer waste was spread on polythene sheets in 1–2-cm thick layers and raked thoroughly twice a day. Drying lasted four or eight days at an average temperature of 25.74°C and radiation intensity of 20.37 MJ.

Ensiling. Caged-layer waste was packed into plastic silos with a capacity of 0.021 m^3 (21 litres) and left for either 21 or 42 days. Samples were taken at ensiling and after opening the silos.

Deep-stacking. Deep-stacking was achieved by heaping approximately 1000 kg of caged-layer waste on a concrete floor under direct sunshine. The stack was then covered with a polythene sheet and sampled after 21 or 42 days by taking composite samples from the entire stack.

Fumigation. Caged-layer waste was spread on perforated trays in layers 0.5–1 cm thick and sun-dried for two days. The trays were then placed in an air-tight metal chamber with a capacity of 0.81 m^3. The chamber was fumigated using a 1:2 mixture of potassium permanganate and 40% formalin in a glass jar: the amount of formalin used was 1.85 ml per chamber. Fumigation was carried out four or eight times: the CLW was turned by hand after each fumigation.

All samples were dried in an oven at 60°C for 48 hours, ground in a Wiley mill fitted with a 2-mm screen and stored in air-tight bottles.

In sacco dry-matter degradability studies were carried out using five fistulated Somali Blackhead wether sheep (15–18 months old; average weight 32.4 kg.) The sheep were fed Rhodes grass (*Chloris gayana*) hay and supplemented with a commercial concentrate at a rate of 0.3 kg/animal per day. The animals were dewormed with *Valbazen* 10% (Kenya Swizz Chemical Company, Nairobi, Kenya) at a rate of 1 ml per 10 kg body weight one week before the start of the study.

Samples (5 g) of each feed were weighed into nylon bags (15 x 7 cm: pore size of 35 µm). The bags were attached to nylon cords and incubated inside the rumens of the sheep for 6, 12, 24, 48 or 72 hours. After incubation the bags were removed, washed thoroughly with tap water, dried at 70°C in an oven for 24 hours and weighed to calculate dry-matter losses (Ørskov and McDonald, 1979). The experimental layout was a 4 x 2 x 5 factorial arrangement in a completely randomised design, with four treatment methods at two levels each and five durations of incubation in the rumen. Unprocessed CLW was used as the control giving a total of nine test feeds.

Experiment 2. Effect of ensiling crop residues with graded levels of caged-layer waste

Maize stover and cobs and wheat straw were cut into 2.5–5-cm lengths; water was added at a ratio of 1:1 to increase moisture content. Freshly collected caged-layer waste was mixed with the crop residues at a rate of 20 or 40% (dry-matter basis): no CLW was added to the control materials. Molasses was added to all ensilages at a rate of 5%. The ensilage materials were thoroughly mixed by hand and packed in 21-litre plastic silos in triplicate. The silos were opened after 21 or 42 days. The top 2.5 cm of the silage from each silo was discarded. The silages were observed for colour, odour and any mould growth.

Proximate composition of crop residues, molasses, CLW and silages before and after fermentation was determined using standard AOAC (1984) procedures. Detergent fibres were analysed by the methods of Van Soest (1963) and Van Soest and Wine (1967). *In vitro* dry-matter and organic-matter digestibilities of the crop residues, CLW and silages were determined by the methods of Tilley and Terry (1963). Water extracts of the silages were prepared by homogenising 25 g of wet silage with 100 ml distilled water in a blender for two minutes. The homogenate was filtered through four layers of cheese cloth and its pH measured.

The rest of the silages were dried at 60°C for 48 hours, milled through a 2-mm sieve and stored in air-tight jars. Samples (5 g) of each milled silage were weighed into nylon bags and incubated for 12, 24, 36, 48 or 72 hours in the rumens of the same sheep used in Experiment 1. A completely randomised design with a factorial arrangement of 3 x 3 x 3 x 5 (three crop residues, at three levels of CLW, three durations of ensiling and five incubation times) was used.

Calculations

In both experiments, degradability was estimated using the model developed by Ørskov and McDonald (1979):

$$p = a + b(1 - e^{-ct})$$

where:
p = actual degradation after time t
a = readily degradable fraction (%)
b = potential degradable fraction (%)
c = rate constant for the degradation of b
t = incubation time (hours).

The constants *a*, *b*, and *c* were derived using EUREKA, an iterative computer programme (Borland International Inc). The data obtained were subjected to analysis of variance using Harvey's Least-Squares analysis. The differences between treatment means were tested with orthogonal contrasts.

RESULTS AND DISCUSSION

Experiment 1

Chemical composition of unprocessed and processed CLW

The proximate compositions of unprocessed, sun-dried, ensiled, deep-stacked and fumigated CLW are shown in Table 1. Dry-matter (DM) content increased with increasing duration of sun-drying and deep-stacking as has also been reported by Fiano et al (1984) when CLW was sun-dried for 30 days. Fumigated CLW also had a higher DM content than fresh CLW. However, ensiling did not change the DM content of CLW. Crude-protein (CP) content had declined sharply after sun-drying for four days, but thereafter the decrease was negligible; this result is also in agreement with the study by Fiano et al (1984). The loss in CP was attributed to the breakdown of uric acid (Caswell et al, 1975) which constitutes 40 to 50% of total nitrogen in CLW (Nambi, 1987). Direct sunlight could have caused volatisation of the uric acid (Fiano et al, 1984); Caswell et al (1975) showed that dry-heat processing of broiler litter lowered the uric acid nitrogen as well as ammonia nitrogen. Other treatment methods did not affect the CP values significantly.

Deep-stacking increased the ash content of CLW suggesting that CLW underwent a composting process in which the organic matter might have been converted into soluble materials (Müller, 1982). This increase in ash content might reduce the digestible energy of CLW and hence its nutritional value (Müller, 1982). The other methods had no effect on ash content of CLW; this result is in agreement with observations by Fiano et al (1984) from air-drying, autoclaving and oven-drying of CLW.

Table 1. *Chemical composition of unprocessed and processed caged-layer waste*

Processing method	Proximate component (%)		
	Dry matter	Ash	Crude protein
Unprocessed	31.02	20.50	21.80
Sun-drying			
4 days	81.44	21.57	13.13
8 days	90.12	20.22	12.76
Ensiling			
21 days	28.88	23.92	17.29
42 days	29.41	23.80	18.72
Deep-stacking			
21 days	54.17	33.56	16.38
42 days	78.10	35.45	17.20
Fumigation			
4 times	77.32	21.04	17.97
8 times	76.52	20.98	16.55

Degradation characteristics of unprocessed and processed CLW

Dry-matter degradabilities (DMD) of unprocessed and processed CLW are shown in Tables 2 and 3. Deep-stacked CLW had a higher DMD ($P<0.01$) than CLW processed by the other methods, whose DMD were similar ($P>0.05$). However, the deep-stacked CLW had an offensive odour. DMD increased ($P<0.01$) with incubation time for all methods of processing, as has also been reported by Alayu (1987).

Sun-drying for four or eight days, deep-stacking for 21 or 42 days or fumigation four or eight times did not affect DMD of CLW within method ($P>0.05$). However, ensiling for 42 days gave superior ($P<0.01$) DMD than ensiling for 21 days. This result agrees the finding of Daniels et al (1983) who reported that ensiling broiler litter for 42 days gave better quality silage.

Experiment 2

Chemical composition of crop residues ensiled with CLW

Table 4 shows the chemical composition of the crop residues and molasses used for ensiling with CLW. All the three crop residues had low crude-protein and high crude-fibre and detergent fibre contents, in total agreement with reports by Kevelenge et al (1983), Alayu (1987) and Tuah and Ørskov (1989). After

Table 2. *Least-squares means of the effect of method, level within method and time on dry-matter degradability of unprocessed or processed caged-layer waste*

Independent variable	Dry-matter digestibility (%)
Processing methods	
Unprocessed	41.99
Sun-drying	41.67
Ensiling	43.85
Deep-stacking	53.42
Fumigation	43.63
SE	0.60
Level within method	
Sun-drying	
4 days	41.22
8 days	42.13
Ensiling	
21 days	40.85
42 days	46.86
Deep-stacking	
21 days	53.46
42 days	53.37
Fumigation	
4 times	44.41
8 times	42.85
SE	0.85
Duration of incubation	
6 hours	27.69
12 hours	33.67
24 hours	45.27
48 hours	54.98
72 hours	62.96
SE	0.64

ensiling, all silages that had CLW as an additive had a pleasant aroma, a gold-brown colour and no mould growth. However, the control silages only had a weak characteristic silage smell. Similar observations have been made on poultry litter ensiled alone or with barley straw, a mixture of weeds and grapefruit peels (Hadjipanayotou, 1982).

Table 3. *Fitted dry-matter degradation constants for unprocessed and processed caged-layer waste incubated in nylon bags in the rumen of sheep*

Method of processing	Degradation constants[a] a	b	c
Unprocessed	20.4	49.9	0.021
Sun-drying			
4 days	20.9	51.9	0.019
8 days	13.6	51.3	0.034
Ensiling			
21 days	15.6	43.8	0.036
42 days	22.1	66.5	0.017
Deep-stacking			
21 days	24.5	53.0	0.026
42 days	29.4	45.3	0.030
Fumigation			
4 times	18.9	57.6	0.022
8 times	19.2	39.3	0.040

[a]From the model $p = a + b(1 - e^{-ct})$
p = actual degradation after time t
a = readily degradable fraction (%)
b = potential degradable fraction (%)
c = rate constant for the degradation of b
t = incubation time (hours)

The pH values were not affected (P>0.05) by type of crop residue (Table 5). However, maize stover and wheat straw silages had higher CP and ash and lower neutral detergent fibre (NDF) (P<0.01) than silage based on maize cobs. These changes could be attributed to the inclusion of CLW in the mixtures. As the level of CLW was increased from 0 to 40% there was a significant increase in pH, CP, ash and *in vitro* dry-matter digestibility (IVDMD) of the resultant silage whereas NDF values decreased. Similar findings have been reported by Daniels et al (1983) and Hadjipanayotou (1984). Ensiling for either 21 or 42 days had no effect on ash and NDF content of the silages (P>0.05) but significantly decreased pH (P<0.01) suggesting that desirable fermentation had taken place (Daniels et al, 1983).

Degradability of crop residues silages

Wheat straw silage had a higher degradability (P<0.01) value than maize stover and maize cob silages (Table 6), probably because of higher readily soluble cell contents (Tuah and Ørskov, 1989). Tables 6 and 7 show that increasing the level

Table 4. *Chemical composition of maize stover, maize cobs, wheat straw, caged-layer waste and molasses used in Experiment 2*

Component	Maize stover (%)	Wheat straw (%)	Maize cobs (%)	Caged-layer waste (%)	Molasses (%)
Dry matter	94.30	94.30	91.76	30.65	67.74
Crude protein	4.60	3.64	4.20	22.5	3.40
Ash	3.20	2.32	4.68	20.36	8.32
Crude fibre	45.70	47.86	48.61	6.69	0
Neutral detergent fibre	85.25	84.28	91.84	57.65	–
Acid detergent fibre	58.0	58.79	44.84	22.80	–
Lignin	8.40	7.33	14.96	6.12	–
Cellulose	49.60	51.46	29.88	16.68	–
Hemicellulose	26.75	25.49	47.0	34.85	–
Cell content	14.75	15.72	8.16	42.35	–
In vitro digestibility					
Dry matter	30.32	29.84	43.58	74.31	*
Organic matter	29.32	32.19	42.70	74.40	*

* Not assessed

Table 5. *Least-squares means for chemical composition and* in vitro *digestibility of crop residues ensiled with caged-layer waste*

Independent variable	pH	Crude protein (%)	Ash (%)	*In vitro* dry-matter digestibility (%)	Neutral detergent fibre (%)
Crop residues					
Maize stover	4.36	9.31	10.89	60.79	69.67
Wheat straw	4.09	9.11	10.09	57.41	67.12
Maize cobs	4.39	7.62	6.76	59.89	77.08
Level of caged-layer waste					
0%	4.39	5.39	6.34	53.57	80.07
20%	4.72	9.03	9.51	60.93	70.40
40%	4.93	11.63	12.71	63.60	63.40
Duration of ensiling					
0 days	5.32	7.67	9.40	60.37	72.10
21 days	4.57	9.39	9.55	58.65	70.67
42 days	4.16	8.99	9.61	59.09	71.11
SE	0.03	0.13	0.24	0.33	0.43

Table 6. *Least-squares means for dry-matter degradablity of crop residues ensiled with caged-layer waste*

Independent variable	Dry-matter degradability (%)
Crop residue	
Maize stover	39.16
Maize cobs	37.75
Wheat straw	41.03
SE	0.42
Level of caged-layer waste	
0%	32.08
20%	39.83
40%	45.99
SE	0.42
Duration of ensiling	
0 days	38.16
21 days	39.05
42 days	40.69
SE	0.42
Incubation time in the rumen	
12 hours	22.09
24 hours	26.72
36 hours	35.65
48 hours	50.03
72 hours	57.59
SE	0.60

of CLW in the ensilage significantly ($P<0.01$) increased the degradability, probably because of increased nitrogen content (Alayu, 1987). There was an increase ($P<0.01$) in degradability when the duration of ensiling was increased from 21 to 42 days suggesting that a longer period was desirable to facilitate microbial activity on the ensiled crop residues (Daniels et al, 1983). Alayu (1987) reported that extending treatment time for wheat straw from 14 to 28 days improved the DM degradability. The increase in degradability of the silages with longer duration of ensiling could be attributed to the increased degradability of CLW observed in Experiment 1 when CLW was ensiled for up to 42 days. The longer the silages were incubated in the rumen the higher was the degradability, in agreement with earlier studies on wheat straw treated with urea (Alayu, 1987).

Table 7. *Fitted dry-matter degradation constants for crop residues ensiled with caged-layer waste*

Crop residue	Duration of ensiling (days)	Level of CLW (%)	Degradation constants[a]		
			a	b	c
Maize stover	0	0	7.9	55.7	0.011
		20	13.1	78.3	0.011
		40	19.8	78.8	0.014
	21	0	13.9	62.8	0.010
		20	16.3	64.1	0.014
		40	19.4	67.1	0.017
	42	0	10.9	86.1	0.010
		20	15.6	72.9	0.023
		40	21.3	66.4	0.030
Maize cobs	0	0	11.1	45.9	0.009
		20	16.0	59.5	0.011
		40	18.5	62.8	0.013
	21	0	12.2	48.5	0.011
		20	12.5	58.5	0.017
		40	19.3	64.9	0.021
	42	0	13.5	53.9	0.011
		20	13.4	52.4	0.018
		40	14.5	69.6	0.024
Wheat straw	0	0	12.5	52.9	0.013
		20	15.6	67.2	0.013
		40	15.9	76.2	0.020
	21	0	13.3	55.9	0.013
		20	14.1	52.7	0.018
		40	16.4	75.2	0.019
	42	0	10.2	64.0	0.013
		20	17.5	71.3	0.019
		40	17.9	72.0	0.023

[a]From the model $p = a + b(1 - e^{-ct})$
p = actual degradation after time t
a = readily degradable fraction (%)
b = potential degradable fraction (%)
c = rate constant for the degradation of b
t = incubation time (hours)

CONCLUSIONS

The study showed that processing CLW by deep-stacking gave best results with respect to DM degradability. However, the steep increase in the ash content was indicative of composting, which might reduce the nutrient utilisation of deep-stacked CLW. Therefore, ensiling for 42 days would be preferred for odour control of the processed product. Ensiling crop residues with CLW as the additive at an inclusion rate of 40% and ensiling for 42 days was considered to be beneficial in improving the nutritional value of the crop residues. Investigations into the performance of growing sheep fed such silage are underway at the University of Nairobi.

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EFFECTS OF UREA TREATMENT OF MAIZE STOVER AND SUPPLEMENTATION WITH MAIZE BRAN OR UREA–MOLASSES BLOCK ON THE PERFORMANCE OF GROWING STEERS AND HEIFERS

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ABSTRACT

Maize stover is an important feed resource in Malawi, but it is poorly utilised. Simple methods of processing and/or treating the stover to optimise its utilisation by stall-fed cattle are being sought. An experiment was conducted at the Chitedze Agricultural Research Station during October to mid-December 1990 to assess the effects of water or urea treatment of maize stover and supplementation with urea–molasses blocks or different levels of maize bran on the growth of yearling steers and heifers.

Animals fed water-treated stover without supplementation lost weight and had the lowest crude-protein intake, indicating that this diet was deficient in nitrogen. Urea treatment increased the crude-protein content of maize stover four-fold compared with untreated stover. Water or urea treatment of maize stover did not affect stover dry-matter or total dry-matter intake. Supplementing urea-treated stover with high levels of maize bran significantly ($P<0.01$) increased liveweight gains.

RESUME

Performances de bouvillons et de génisses en croissance alimentés avec de la paille de maïs traitée avec de l'urée et complémentée avec du son de maïs ou un concentré de mélasse–urée

Bien qu'elle constitue l'une des principales sources d'aliments du bétail rencontrées au Malawi, la paille de maïs est peu utilisée dans ce pays. Les efforts déployés actuellement visent entre autres, à mettre au point des méthodes simples de transformation et/ou de traitement de ces résidus de récolte afin d'en optimiser l'utilisation dans l'alimentation des bovins à l'étable. A cet effet, un *essai a été effectué d'octobre à la mi-décembre 1990 à la station de recherche de Chitedze en vue de déterminer l'effet, sur la croissance de bouvillons et de génisses âgés de 1 an, d'un régine alimentaire composé de paille de maïs traitée avec de l'eau ou de l'urée et complémentée avec un concentré mélasse–urée ou différents niveaux de son maïs.*

Les animaux recevant uniquement de la paille traitée avec de l'eau perdaient de poids et consommaient moins de protéines brutes que ceus soumis aux autres régines alimentaires, ce qui signifie que cette ration présentait une carence en azote. Le traitement avec de l'urée permettait de quadrupler la teneur en protéines brutes de la paille. Par ailleurs, le traitement avec de l'eau ou de l'urée n'avait aucun effet sur l'ingestion de paille brute ou de matière sèche totale. Enfin, la paille traitée avec de l'urée et complémentée avec des niveaux élevés de son de maïs entraînait un accroissement significatif ($P<0,01$) des gains de poids vif.

INTRODUCTION

Maize stover is the largest animal feed resource in Malawi following crop harvests. Although it is widely acknowledged to be a useful feed, it is not utilised efficiently; it is grazed *in situ* and so is subjected to trampling, soiling, termite damage and fires. As a result, less than 50% of the available stover is actually consumed by livestock.

Acute cattle feed shortages occur at the peak of the dry season (September through November). The animals hardest hit are the stall-fed dairy cows and their followers or fattening steers which, by regulation, are not supposed to graze freely in order to avoid diseases and indiscriminate mating. For this group of animals, improvements in the utilisation of maize stover and other crop residues are essential in order to maintain productivity. In addition to proper storage of maize stover, attempts are being made to integrate forage legumes in maize crops and to find simple methods of processing and/or treating the stover to optimise its utilisation by stall-fed cattle. Urea was chosen for treating maize stover because, apart from its ability to increase the nitrogen content of the treated stover, it is being vigorously promoted as a fertiliser, and hence is readily available in the country, and farmers can handle it safely.

An experiment was conducted at the Chitedze Agricultural Research Station, Malawi, during October to mid-December 1990 to assess the effects of water or urea treatment of maize stover and supplementation with maize bran or urea–molasses block on the growth of yearling steers and heifers. Specifically, the objectives were to compare water-treated maize stover with urea-treated maize stover, water-treated maize stover with and without urea–molasses block supplementation, and urea-treated maize stover supplemented with three levels of maize bran.

MATERIALS AND METHODS

Animals

The experimental animals were 40 yearling crossbred (Friesian x Malawi zebu) cattle (22 steers and 18 heifers) that had been previously grazed as a group on Rhodes grass (*Chloris gayana*) standing hay, maize stover and unimproved dambo grasses. All animals were dewormed with Thibenzole at the start of the experiment. They were then randomly allocated to five feeding treatment groups (eight animals each), taking into account sex and initial liveweight differences.

Feeds

The animals were fed maize stover (treated with water or urea), groundnut tops, Rhodes grass hay, maize bran, urea–molasses blocks and a mineral mixture.

Maize stover from the station was collected and chopped, using a forage harvester, into pieces up to 14 cm long. The stover was ensiled in circular pits, 1.5 m in diameter and 2.0 m deep, with a seepage pit at the bottom. Weighed batches of chopped stover were placed in the pit and sprayed (using a garden watering can) with either plain water or a urea solution at the rate of 1.5 litres of water/solution to 1 kg of stover. (Previous work (Munthali et al, 1990) had shown that spraying at the rate of 1 litre of water to 1 kg of stover DM resulted in inadequate wetting of the stover and hence poor chemical reaction.) The amount of urea used was calculated to give a treatment of 4 g urea to 100 g stover (ie, 4% urea-treated stover). The stover was mixed and trampled by two to three people to compress it. More batches of stover were then added and treated until the pit was filled. Finally, the pit was covered with polythene sheets and a thick (about 45 cm) layer of soil.

Groundnut tops were also collected at the station and either baled or kept loose in stooks under a barn. Hay was made from fully mature Rhodes grass, baled and kept in a barn. Maize bran was purchased either from families in and around the station or from Grain and Milling Company as a hominy chop (maize germ meal).

Urea–molasses blocks were manufactured using fertiliser grade urea (45% nitrogen) and type C cane molasses. The characteristics of the molasses and the compositions of the urea–molasses block and of the mineral mixture (also included in the urea–molasses blocks), are given in Table 1.

Feeding

Animals were fed in pairs at 0800 and 1400 hours.

During the first 10 days, animals were fed hay *ad libitum* and maize bran (1.0 kg/animal per day). Thereafter, all animals were fed the experimental

Table 1. *Characteristics of type C cane molasses and compositions of urea–molasses–mineral block and mineral mixture*

Molasses[a]		Molasses–urea–mineral block		Mineral mixture	
	Value (% DM)	Component	Content (g/kg)	Component	Content (g/kg)
Dry solids	78.8	Molasses	370	Meat and bone meal	600
Brix	77.4	Urea	100	Common salt	350
Sucrose	32.8	Maize bran	300	Magnesium sulphate	35
Polarisation	30.0	Salt	50	Copper sulphate	6
Total invert	50–56	Cement	130	Zinc oxide	8.5
Ash	13.7	Mineral mixture	50	Cobalt sulphate	0.2
Purity	38.8			Potassium iodide	0.3

[a]*Source*: Sugar Corporation of Malawi (SUCOMA), Personal communication, 1991

diet—a daily allowance of 1 kg groundnut tops, 0.5 kg hay and 0.05 kg mineral mixture plus one of the following treatment diets:

- Diet 1: *ad libitum* water-treated maize stover plus 1.0 kg maize bran
- Diet 2: *ad libitum* water-treated maize stover plus 1.0 kg maize bran plus urea–molasses block for three hours
- Diet 3: *ad libitum* 4% urea-treated maize stover plus 1.0 kg maize bran
- Diet 4: *ad libitum* 4% urea-treated maize stover plus 2.0 kg maize bran
- Diet 5: *ad libitum* 4% urea-treated maize stover plus 3.0 kg maize bran

The experimental diets were first fed for a 22-day acclimatisation period, during which time the animals on diet 2 were exposed to the urea–molasses block for only one hour daily. The experimental period was 56 days, ending at the onset of the rainy season.

Data collection

Quantities of feed offered and refused were recorded daily. Feed intake was calculated from daily intakes on four consecutive days weekly. Urea–molasses block intake per animal was calculated from the total number of blocks consumed by each treatment group during the 56-day experimental period.

Initial and final liveweights were calculated as a mean of three consecutive daily weights taken after depriving animals of water for approximately 16 hours.

RESULTS AND DISCUSSION

The chemical compositions of the feeds are shown in Table 2.

Table 2. *Chemical compositions of feeds*

Feed material	Dry matter (%)	Crude protein (% DM)
Maize stover		
Untreated	91.7	2.8
Water-treated	43.3	3.5
4% urea-treated	35.9	14.4
Maize bran (madeya)	90.1	9.6
Groundnut tops	90.6	7.8
Rhodes grass hay	91.8	5.6

The chemical compositions of groundnut tops, hay and maize bran were similar to those commonly found in samples collected on the station. However, crude-protein (CP) content of untreated stover was lower than that previously reported by Munthali (1987). The stover used in the present experiment was collected late in the dry season and exposure to varying climatic conditions may have led to nitrogen degradation (Berger et al, 1979).

Urea treatment increased the CP of the maize stover more than four-fold. Similar increases in CP content of forages following urea treatment have been reported elsewhere (Jackson, 1978; Klopfenstein, 1978; Sundstol et al, 1978; Kiangi, 1981). Therefore, urea treatment is a practical method of increasing the nitrogen content of low quality roughages.

The observed differences in dry-matter (DM) content of the water- and urea-treated maize stover may be attributed to sampling errors.

The performance of growing steers and heifers is shown in Table 3.

Crude-protein intake increased when animals were fed 4% urea-treated maize stover. It declined as the amount of maize bran fed increased from 1.0 to 3.0 kg/animal per day because stover intake declined with increased feeding of maize bran. The decline in CP consumption was due to the substitution of high N urea-treated maize stover by maize bran. The intake of the urea–molasses block was calculated to be 200.8 g/animal per day, giving a nitrogen consumption from the block of approximately 90 g/animal per day. The anticipated intake of the block was 300 g/animal per day, so the limited exposure time (three hours) of the animals to the block probably lowered its intake.

Total DM intake did not vary greatly, and all animals appeared to have satisfactory DM intakes of 3% or more of their body weights. Urea treatment of maize stover did not increase DM intake compared with water treatment of the stover. However, Smith et al (1989) reported significant increases in DM intake of urea-treated maize stover compared with dry tresh maize stover, indicating that water treatment followed by ensiling has a similar effect in increasing DM intake to urea treatment followed by ensiling.

Table 3. *Performance of growing steers fed maize stover diets*[a]

	Diet 1	Diet 2	Diet 3	Diet 4	Diet 5
Crude-protein content in diet (% dry matter)[b]	5.7	5.7[c]	13.2	12.3	11.7
Stover dry-matter intake					
kg/animal per day	3.56	3.71	4.46	3.46	2.99
% of body weight	1.86	1.98	2.29	1.76	1.55
Total dry-matter intake					
kg/animal per day	5.80	5.95	6.70	6.58	6.99
% of body weight	3.02	3.17	3.44	3.36	3.63
Mean liveweight at start of experimental period (kg)	187.1	197.1	201.0	222.7	229.2
Daily gain during 56-day experimental period (g)					
Mean	-83.0	170.6	116.1	483.0	649.8
SE	70.0	65.3	96.3	51.9	85.8

[a] Diets were:
Diet 1: *ad libitum* water-treated maize stover + 1 kg maize bran + 1 kg groundnut tops + 500 g hay + 50 g mineral mixture
Diet 2: *ad libitum* water-treated maize stover + 1 kg maize bran + 1 kg groundnut tops + 500 g hay + 50 g mineral mixture + urea–molasses block
Diet 3: *ad libitum* 4% urea-treated maize stover + 1 kg maize bran + 1 kg groundnut tops + 500 g hay + 50 g mineral mixture
Diet 4: *ad libitum* 4% urea-treated maize stover + 2 kg maize bran + 1 kg groundnut tops + 500 g hay + 50 g mineral mixture
Diet 5: *ad libitum* 4% urea-treated maize stover + 3 kg maize bran + 1 kg groundnut tops + 500 g hay + 50 g mineral mixture
[b] Crude-protein content in maize stover was determined using fresh samples
[c] Urea N from urea–molasses block not included, but intake of nitrogen was 90 g/animal per day

The highest liveweight gain ($P<0.01$) was achieved by animals on diet 5, the treatment with the highest level of maize bran supplementation. Animals fed unsupplemented water-treated stover (diet 1) lost weight; these animals showed the lowest crude-protein intake, indicating that diet 1 was deficient in nitrogen. Supplementation of the water-treated stover with urea–molasses block (diet 2) or treatment of the stover with urea (diet 3) was enough to support maintenance and slight liveweight gains of the animals, further showing that nitrogen could have been the limiting nutrient in diet 1. The improvement in liveweight gain by animals on diets 4 and 5 could be attributed to the increased intake of energy and an accompanying improvement in the utilisation of non-protein nitrogen in the 4% urea-treated maize stover. Early work by Pearson and Smith (1943), Arias et al (1951) and Belasco (1956) showed that starch induced better utilisation of non-protein nitrogen than any other carbohydrate source, and the maize bran used in the present study is rich in starch.

CONCLUSIONS

Treatment of maize stover with water followed by ensiling gave comparable DM intakes to that obtained when the stover was treated with 4% urea and ensiled, although animals fed unsupplemented water-treated stover lost weight. Supplementing water-treated stover with urea–molasses block, or treating the stover with urea, was sufficient to support maintenance plus small liveweight gains in cattle. Supplementing urea-treated stover with a suitable source of energy (such as starch, as in maize bran) promoted high liveweight gains.

The experiment has demonstrated that an adequate supply of nitrogen is essential to maintain cattle fed basal diets of maize stover, and that farmers could supplement their animals with energy to promote faster liveweight gains, even when the sole diet is treated maize stover.

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EFFECTS OF UNDEGRADABLE PROTEIN SUPPLEMENTS ON THE PERFORMANCE OF WEANER STEERS FED VELD HAY SPRAYED WITH UREA

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ABSTRACT

The effects of different sources of undegradable protein supplements (cottonseed, soybean, meat and bone and blood meals) on the performance of Hereford x Africander weaner steers (205 kg liveweight) offered veld hay sprayed with 1% urea were investigated. Supplementation with undegradable protein increased dry-matter intake of veld hay offered *ad libitum* by 18% (P<0.05) and reduced loss of live- and carcass weight in steers offered sub-maintenance quantities of veld hay, but had little effect on rumen pH and ammonia concentration, or degradation of veld hay in the rumen. The results confirm the beneficial effects of supplementing low quality roughages with a supply of undegradable protein, but suggest that the undegradable protein from the four supplements studied was of equal value.

RESUME

Effet des sources de protéines non dégradables sur les performances de veaux sevrés recevant du foin traité par pulvérisation avec de l'urée

L'effet de diverses sources de protéines non dégradables (graines de coton, de soja, farine de viande et d'os et farine de sang) sur les performances de veaux sevrés de race croisée Hereford x Africander pesant en moyenne 205 kg de poids vif et recevant du foin de veld traité par pulvérisation avec de l'urée à 1% a été étudié. La complémentation entraînait une augmentation de 18% (P<0,05) de l'ingestion de matière sèche de veld offerte ad libitum. *Elle freinait en outre la baisse du poids vif et du poids de la carcasse même lorsque les quantités de veld* *offertes étaient inférieures aux niveaux nécessaires à l'entretien. Cependant, la complémentation n'avait qu'un effet limité sur le pH et la concentration en ammoniac du rumen ainsi que sur la dégradation du foin de veld dans le rumen. Ces résultats confirment les avantages de la complémentation de fourrages de qualité médiocre avec des sources de protéines non dégradables. Ils permettent de conclure par ailleurs que les quatre sources de protéines évaluées ici sont de valeur comparable.*

INTRODUCTION

The poor performance of ruminants fed low quality roughages is mainly due to a deficiency of nitrogen which results in low intake and digestibility of dry matter (Topps, 1972). Protein and non-protein nitrogen supplements may be used to correct this deficiency (Topps, 1972; Siebert and Hunter, 1982).

One of the problems of supplementing low quality roughages with a single daily meal of urea is that the urea is rapidly degraded into ammonia in the rumen (Falvey, 1982). This results in non-synchronised release of ammonia and energy, leading to poor utilisation of urea for microbial protein synthesis and substrate fermentation (Satter and Slyter, 1974). This problem may be overcome by using slow-release forms of non-protein nitrogen (Ferero et al, 1980) but these alternatives are generally more expensive than urea.

Spraying urea onto poor quality roughages just before feeding has been suggested as a way of ensuring uniform release of ammonia to rumen microbes (Hennessy, 1984). Urea supplementation at the rate of 1% seems adequate for roughages containing 3–4% crude protein (Verma and Jackson, 1984). However, the optimum level of urea is likely to vary with the type of roughage.

Further improvements in animal performance may be expected when roughages fed with urea are supplemented with a source of dietary undegradable protein (UDP) (Kempton et al, 1979; Smith et al, 1980; Mullins et al, 1984). The magnitude of the response at equal levels of UDP may depend on the quality of the protein (Petersen and Clanton, 1981).

A study was carried out to determine the effects of different UDP supplements on the performance of weaner steers fed veld hay sprayed with 1% urea. A combined supplement containing iso-nitrogenous levels of cottonseed, soybean and meat and bone meals was also tested in order to determine if these proteins were complementary.

MATERIALS AND METHODS

Animals and housing

Twelve rumen-cannulated Hereford x Africander steers (average weight 535 kg) were used to measure the degradation patterns of veld hay. The cannulae (Pigot

Maskew (Pvt) Ltd, Bulawayo, Zimbabwe) were made of rubber with an internal diameter of 8 cm. In addition, 84 Hereford x Africander weaner steers (average weight 205 kg) were used to measure intake of veld hay and growth response to protein supplementation.

The steers were housed in individual pens with concrete floors, asbestos roofing and sides made of wooden rails. Each pen had a permanent food trough at one end and a water trough at the other. No bedding was provided.

Experimental design, protein supplements and basal diet

The 84 weaner steers were stratified by weight and randomly allocated to two groups of six animals and six groups of 12 animals. One group of six animals was used to determine the initial carcass weight, to provide the baseline for the growth performance assessment. The animals were fasted for 24 hours and weighed. They were then slaughtered and their carcasses were weighed. Initial carcass weight was estimated from the regression equation

$$ICW = 10.36 + 0.4521SLW \quad (RSD = 3.266; R^2 = 0.906)$$

where:

ICW = initial carcass weight (kg)

ISLW = initial starved liveweight (kg)

The other group of six animals, and five of the groups of 12 animals, were used in the feeding trial. The treatments were:

1. Basal diet of milled veld hay sprayed and mixed with 1% urea just before feeding (control, six animals)
2. Basal diet plus cottonseed meal supplement (12 animals)
3. Basal diet plus soybean meal supplement (12 animals)
4. Basal diet plus meat and bone meal supplement (12 animals)
5. Basal diet plus bood meal supplement (12 animals)
6. Basal diet plus a combined supplement of cottonseed, soybean and meat and bone meals (12 animals)

The remaining group of 12 animals was used to measure intake of veld hay for the six treatments.

The basal diet was prepared by dissolving urea in warm water and spraying it onto milled (25-mm screen) veld hay just before feeding. Five litres of a 20% urea solution were sprayed onto 100 kg of hay to give a 1% level of application. A mechanical mixer fitted with a horizontal auger was used to prepare the feed, to ensure that the hay and urea were well mixed. Half of the urea solution was sprayed onto the hay in the mixer, using a watering can fitted with a rose on the spout, and the mixer was run for 10 minutes. The remainder of the solution was then added and the mixing repeated.

The composition of the protein supplements (Table 1) was based on effective degradabilities determined in an earlier experiment (Sibanda, 1989).

Table 1. *Composition of protein supplements offered to weaner steers fed 1%-urea-treated veld hay*

Ingredient	Composition of treatment diets supplemented with				
	Cottonseed meal	Soybean meal	Meat and bone meal	Blood meal	Combined supplements[a]
As-fed composition of supplements (g/kg)					
White maize grain	780	783	815	815	815
Cottonseed meal	143	–	–	–	29
Soybean meal	–	207	–	–	120
Meat and bone meal	–	–	104	–	14
Blood meal	–	–	–	30	–
Urea	14.7	–	16	26	7.6
Gypsum (calcium sulphate)	12	–	12	12	11.7
Salt (sodium chloride)	25.1	5	26.5	58.5	1.4
Monocalcium phosphate	25.2	5	26.5	58.5	1.3
Calculated chemical composition					
Dry matter (g/kg)	900	905	900	900	935
Rumen degradable protein (g/kg DM)	131	125	126	131	124
Undegradable protein (g/kg DM)	49	53	56	51	50
Total crude protein (g/kg DM)	180	178	182	182	174
Metabolisable energy (MJ/kg)	12.8	12.8	12.8	12.8	12.8

[a] Cottonseed, soybean and meat and bone meals

Determination of degradation patterns of veld hay

The 12 rumen-cannulated steers were used in an incomplete (6 x 2) Latin Square design with two periods of 24 days each and two animals per treatment; the treatments were the six diets used in the feeding trial. The steers were offered veld hay sprayed with 1% urea once daily at the rate of 36 g DM/kg$^{0.75}$. Animals on treatments 2 to 6 were also fed 300 g/day of the protein supplement split into two equal parts and fed at 0800 and 1400 hours. Water was freely available. After 21 days on each feeding regime the degradation patterns of veld hay were measured using the nylon-bag technique (Mehrez and Ørskov, 1977; Ørskov and McDonald, 1979). Six bags containing veld hay samples (2.5-mm screen) were incubated in the rumen and one bag at a time was withdrawn after 12, 24, 36, 48, 60 and 72 hours. The constants of the degradation curve ($p = a + b(1 - e^{-ct})$) were determined according to Mehrez and Ørskov (1977).

Rumen liquor samples were taken after all the bags had been withdrawn, two hours after offering the morning supplement. The contents of the rumen were mixed by hand before a 200 ml sample was taken with a beaker. The rumen liquor was strained through four layers of cheesecloth.

Measurement of intake of veld hay

The 12 steers allocated to the intake measurement group were paired in such a way that animals with weights as similar as possible were placed in one cell. Intake of veld hay was measured for each of the treatments in an incomplete (6 x 3) Latin Square design with three four-week periods.

The animals were fed individually for a preliminary period of three weeks, followed by a period of seven days when intake was measured. Veld hay sprayed with 1% urea was offered *ad libitum* (15% more hay than the previous day's intake) on a daily basis, with the previous day's refusals being weighed, recorded and removed before fresh hay was offered. The protein supplements were offered in two equal meals of 150 g at 0800 and 1400 hours. Water was freely available.

Performance of weaner steers fed veld hay and protein supplements

The feeding trial lasted 90 days. The animals were housed in individual pens and fed the basal diet (veld hay (sprayed with 1% urea) at the rate of 36 g DM/kg$^{0.75}$) once a day in the morning. The protein supplements were offered in two equal meals at 0800 and 1400 hours at the rate of 300 g/head per day. The animals were weighed weekly and the allowance of veld hay adjusted if necessary. Water was freely available. After 90 days the animals were fasted for 24 hours and weighed. They were then slaughtered and their carcasses were weighed.

Laboratory analyses

The dry-matter content of veld hay and protein supplements was determined by drying in a forced draught oven at 100°C for 24 hours. Nitrogen was determined by a macro-Kjeldahl technique.

The pH of the rumen liquor was measured within 10 minutes of sampling. For rumen ammonia determination, a mixture of 50 ml rumen liquor, 200 ml water and 100 ml 50% NaOH was distilled and the distillate collected over 2% boric acid. Released ammonium ion was titrated against 0.1 M HCl using screened methyl red indicator.

Statistical analysis

Analyses of variance for the degradation curve constants of veld hay and the protein meals and intake of veld hay were done with the MINITAB statistical package. Analyses of variance of live- and carcass weights, with initial starved liveweight as a covariate, were carried out using the GENSTAT programme. In all cases differences between treatments were determined by Student's t-test.

RESULTS

Degradation of veld hay

The crude-protein content of the veld hay before and after spraying with 1% urea was 49 and 73 g/kg DM, respectively. Veld hay degradation constants, rumen pH and ammonia concentrations did not differ (P>0.05) between any of the treatment groups (Table 2).

Hay dry-matter intake

Intake of veld hay dry matter by steers fed the basal diet *ad libitum* is shown in Table 3. Steers fed the protein supplements ate 18% (P<0.05) more hay than the steers fed no supplement. However, differences among the supplemented groups were not significant (P>0.05).

Table 2. *Degradation constants for veld hay dry matter and rumen pH and ammonia concentration in steers fed 1%-urea-treated veld hay (36 g DM/kg$^{0.75}$ per day) with or without protein supplements*

Treatment	Degradation constants for veld hay[a] a	b	c	Rumen pH[b]	Rumen ammonia (mg/litre)[b]
1. Basal diet (C): milled veld hay treated with 1% urea	10.3	75.4	0.016	7.2	309
2. (C) + cottonseed meal	11.1	71.8	0.011	7.1	339
3. (C) + soybean meal	7.0	72.7	0.025	7.4	301
4. (C) + meat and bone meal	10.3	76.4	0.010	7.1	336
5. (C) + bood meal	7.0	63.7	0.015	7.1	293
6. (C) + combined supplement[c]	8.4	60.2	0.012	7.2	306
SE	2.65	15.80	0.0083	0.16	62.0

[a] From the equation $p = a + b(1-e^{-ct})$
where:
p = dry-matter loss (%)
a = readily degradable fraction (%)
b = potentially degradable fraction (%)
c = rate of degradation of the b fraction
t = time (hours)
[b] Rumen liquor samples were taken 2 hours after offering the morning supplement
[c] Cottonseed, soybean and meat and bone meals

Table 3. *Intake of veld hay dry matter by weaner steers fed 1%-urea-treated veld hay* ad libitum *with or without protein supplements*

Treatment	Intake of veld hay dry matter ($g/kg^{0.75}$ per day)
1. Basal diet (C): milled veld hay treated with 1% urea	52.1
2. (C) + cottonseed meal	62.5
3. (C) + soybean meal	61.1
4. (C) + meat and bone meal	65.4
5. (C) + bood meal	61.5
6. (C) + combined supplement[a]	66.1
SE	2.87

[a] Cottonseed, soybean and meat and bone meals

Live- and carcass weight changes of steers on restricted hay intake

The live- and carcass weight changes of steers fed restricted amounts of veld hay sprayed with urea (36 g $DM/kg^{0.75}$) and offered different protein supplements are shown in Table 4.

All steers lost live- and carcass weight. Steers fed the combined supplement lost 8.8 kg more ($P<0.05$) liveweight than the steers offered other supplements, but this was not significantly different to the performance of the control steers. The steers in the other supplemented groups lost similar amounts of liveweight but only the steers fed cottonseed meal performed better ($P<0.05$) than the control steers.

Table 4. *Live- and carcass weight changes of weaner steers fed 1%-urea-treated veld hay (36 g $DM/kg^{0.75}$ per day) with or without protein supplements*

Treatment	Starved liveweight (kg)			Carcass weight (kg)		
	Initial	Final	Change	Initial	Final	Change
1. Basal diet (C): milled veld hay treated with 1% urea	190.8	151.5	–39.3	98.9	72.5	–26.4
2. (C) + cottonseed meal	196.2	162.7	–33.5	98.9	79.9	–19.0
3. (C) + soybean meal	195.8	161.7	–34.1	98.9	80.6	–18.3
4. (C) + meat and bone meal	195.4	160.0	–35.4	98.9	80.8	–18.1
5. (C) + bood meal	195.4	160.4	–35.0	98.9	78.9	–20.0
6. (C) + combined supplement[a]	199.2	155.9	–43.3	98.9	77.4	–21.4
SE	6.60	2.53	2.53	0.01	1.41	1.40

[a] Cottonseed, soybean and meat and bone meals

The steers in the control group lost 7 kg more (P<0.05) carcass weight than the steers fed supplements. Among the supplemented steers the only significant (P<0.05) difference was between the steers fed the combined supplement and those fed soybean and meat and bone meal supplements.

DISCUSSION

Protein source had no significant effect (P>0.05) on the extent and rate of degradation of veld hay in the rumen of steers on the different treatments. This indicates that the rumen environments in the steers on the different treatments were similar. The rumen pH and ammonia concentrations confirm this view. Preston and Leng (1987) have recommended rumen ammonia concentrations of at least 150 mg/litre for roughages of similar quality to the hay used in this experiment. The concentrations recorded in this experiment were more than double this recommended figure. However, only one sample was taken, and sampling could have coincided with peak concentrations.

The absence of a significant effect of protein supplementation on the degradation of veld hay suggests that the basal diet supplied adequate nutrients for the rumen microbes and that the supply of pre-formed amino acids, peptides and carbon chains from protein nitrogen sources provided no added advantage.

Other studies (Kellaway and Leibholz, 1983; Sriskandarajah and Kellaway, 1984; Ndlovu, 1985) have found that when rumen ammonia concentrations are adequate the response to rumen degradable protein from protein nitrogen sources is negligible. Thus, while acknowledging diurnal variation and the fact that spot samples were used, it may be inferred that the ammonia concentrations found in this experiment were adequate for both maximum microbial protein production and optimum degradation of veld hay.

Although there was no increase in the rate or extent of degradation of veld hay with protein supplements, there was a significant (P<0.05) increase in intake of veld hay dry matter. Kempton et al (1979) obtained similar results. Since the degradation of veld hay was similar in all treatments, it may be inferred that the increase in veld hay intake was not due to an improvement in the rumen environment of the supplemented animals compared to the control ones.

Supplementation with protein, in addition to urea sprayed on the veld hay, resulted in a significant (P<0.05) reduction in live- and carcass weight losses in weaner steers offered sub-maintenance amounts of veld hay. This suggests that the effects of protein supplementation were achieved not only through an increase in roughage intake, but also through an improvement in nutrient supply. This agrees with the findings of Smith et al (1978) and Ortigues (1987) who offered fish meal to growing dairy heifers and steers fed restricted amounts of fibre-rich diets, although their animals were fed in excess of maintenance requirements.

However, the reduction in live- and carcass weight losses with protein supplemented treatments compared to the control may be partly explained by an increase in energy intake. Assuming a metabolisable energy (ME) content of 6.72 MJ/kg DM for veld hay (Topps and Oliver, 1978), an intake of 36 g of veld hay DM/kg$^{0.75}$ would be equivalent to about 0.242 MJ ME/kg$^{0.75}$. Taking a steer of about 178 kg liveweight (mean of the initial and final weights), the 300 g/day of supplement translates to 5.2 g/kg$^{0.75}$, equivalent to 0.079 MJ ME/kg$^{0.75}$. This level of supplementation is equivalent to an increase of about 33% in ME intake. The average improvement in carcass weight change with supplementation was about 27%.

While the contribution of ME intake in reducing live- and carcass weight losses of the supplemented steers is acknowledged, it is possible that part of the response was due to UDP (undegradable protein) supply. Several studies (Smith, 1978; Lindsay and Loxton, 1981; Fattet et al, 1984; Ortigues, 1987) have shown the beneficial effects of UDP supplementation compared to energy at equal ME intakes. Smith (1978) used multiple regression analysis to show that for diets with high roughage and low protein content (85 g CP/kg DM), as used in this experiment, ME and UDP intake accounted for about 10 and 25%, respectively, of the total variation in liveweight gains of growing dairy heifers and steers.

The metabolisability (ME/GE) of the diet used in the current experiment was estimated to be about 0.42. This would give a k_m value of 65% (ARC, 1980). Therefore the contribution of increased energy intake to the reduction in carcass weight loss in this experiment would be about 79% of the total response to supplementation. The remainder would be due to UDP supply.

The reason for including the combined protein supplement was to determine if the individual protein sources would complement each other and result in improved performance. There was no evidence of this for either veld hay intake or live- or carcass weight changes of steers. In fact, there was a slight negative response to the combined supplement compared to the individual protein sources.

The lack of difference in the degradation and intake of veld hay and, possibly, in the performance of weaner steers fed restricted quantities of veld hay and offered different protein supplements, supports the observations by Oldham (1981) and Ørskov (1982) that there is little likelihood of improving animal performance by manipulating the quality of protein supply to the animal. This is because the amino acid composition of digesta passing into the duodenum was found to vary little under different feeding conditions (Oldham, 1981).

CONCLUSIONS

This study confirms the positive effects of UDP supplementation, in addition to adequate rumen degradable protein, on the performance of growing steers offered restricted quantities of low-protein roughages. The feeding of protein supplements led to an increase in intake of low-protein veld hay irrespective of protein source. However, the source of UDP had no effect on either intake or the performance of steers, suggesting that the UDP from the four proteins was of equal value.

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EFFECTS OF SUPPLEMENTING A LOW QUALITY FORAGE WITH CONCENTRATES ON PERFORMANCE AND SEXUAL DEVELOPMENT OF DAIRY HEIFERS

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ABSTRACT

A feeding trial was conducted with crossbred dairy heifers to examine the effects on animal performance and sexual development of supplementing green *Sorghum bicolor* with low or high levels of concentrate. Supplementation had highly significant (P<0.01) effects on average daily gain, feed conversion efficiency and heart girth of experimental animals. Animals supplemented with the high level of concentrate reached puberty significantly (P<0.05) younger and at heavier liveweight than those on the low level of concentrate. Heifers fed forage only did not reach puberty during the experimental period.

RESUME

Performances et développement sexuel de génisses de race laitière alimentées avec un fourrage de qualité médiocre complémenté avec des concentrés

Un essai d'alimentation a été effectué sur des génisses métisses de race laitière pour examiner l'effet, sur leurs performances et leur développement sexuel, de la complémentation de fourrage vert de Sorghum bicolor *avec deux niveaux de concentrés. La complémentation avait un effet hautement significatif (P<0,01) sur les gains moyens quotidiens, le taux de conversion des aliments et le périmètre thoracique des animaux. Les génisses recevant le niveau élevé de concentrés avaient atteint la puberté à un âge significativement (P<0,05) inférieur et à un poids vif supérieur à celui des sujets soumis au faible niveau de concentré. Enfin, aucune des génisses recevant uniquement du fourrage n'avait atteint la puberté au cours de la période expérimentale.*

INTRODUCTION

Sorghum bicolor is a popular ruminant feed in Sudan. However, because its digestible crude-protein content is low, animals fed only this forage do not perform well. Supplementing forage-based diets with concentrates can improve rumen fermentation, fibre digestibility and forage intake (Church and Santos, 1981; Lee et al, 1985; McCollum and Galyean, 1985). El-Tayeb and Gaber (1987) demonstrated that supplementing a combination of forages with concentrates improves performance and reproductive traits of Sudanese crossbred dairy heifers. However, during much of the year only one forage may be available. Therefore, the objective of this research was to examine the performance and sexual development of dairy heifers fed a low-quality forage (*Sorghum bicolor*) supplemented with a concentrate mixture.

MATERIAL AND METHODS

Eighteen crossbred (Butana x Friesian) dairy heifers (average liveweight approximately 100 kg) were used in this trial; they were selected at random from a large herd which was housed and treated as one group. The animals were allowed a seven-day adaptation period after which they were stratified according to liveweights into three similar groups, of six animals each, which were then randomly assigned to one to the following treatments:

- forage only (diet A)
- forage plus 1 kg concentrate mixture (diet B)
- forage plus 2 kg concentrate mixture (diet C).

Heifers were penned and fed in pairs.

The concentrate mixture comprised 35% sorghum grain, 35% sunflower cake, 27% wheat bran, 2% limestone flour and 1% common salt.

For the first 130 days of the trial *Sorghum bicolor* was the only forage offered to the experimental animals. For the next 45 days sorghum was in short supply and the heifers were fed a mixture of groundnut hulls, alfalfa and sorghum. Sorghum then became freely available again and was offered to the heifers until they reached puberty.

The chemical analysis of the feed ingredients is shown in Table 1.

The concentrate was offered to the heifers once a day at 0800 hours throughout the experimental period. The heifers ate all the concentrate offered. Clean water was available throughout the experimental period in all pens.

The daily allowance of the forage was offered in one meal at 1000 hours, the amount offered being adjusted daily until the refusals were about 10% of the amount offered. Forage refusals were collected the following morning and the weight recorded. The daily feed intake was then calculated by subtracting the refusals from the amounts offered.

The heifers were weighed, and their heart girths measured, every two weeks at 0700 hours before the morning meal. Average daily gain of the heifers was

Table 1. *Chemical composition of ingredients of treatment diets*

	Composition (% DM)			
	Concentrate mixture	*Sorghum bicolor*	Groundnut hulls	Alfalfa
Dry matter (DM)	98.4	94.3	97.0	93.6
Ash	6.2	8.2	6.5	10.6
Crude protein (CP)	20.8	4.1	5.8	16.8
Crude fibre (CF)	33.4	39.3	66.5	28.0
Ether extract (EE)	6.3	1.8	2.7	2.1
Nitrogen-free extract (NFE)	31.5	45.0	18.4	36.1
ME, MJ/kg DM	10.52	9.31	7.43	9.12

Chemical compositions were determined by methods described by AOAC (1980)
Metabolisable energy (ME) values were obtained using the following equation (Ellis, 1980):
ME (MJ/kg DM) = 0.012CP + 0.031EE + 0.005CF + 0.014NFE

calculated by dividing the average biweekly liveweight gain by 14. Feed conversion ratio (kg feed/kg weight gain) was also computed.

Sexual maturity was detected by the first presence of progesterone in the peripheral blood of the heifers. Jugular venous blood (5 ml) was obtained from each heifer once a week during the experimental period, by direct venipuncture using 22G needles. Serum progesterone was assayed by direct solid-phase radioimmunoassay.

Data were subjected to analysis of variance applicable to the randomised complete-block design (Steel and Torrie, 1980). Differences among treatment means were determined by least significant differences (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

There were no significant differences (P>0.05) in dry-matter intake across treatments (Table 2). This finding agrees with that of Tayler and Wilkison (1972), but contradicts other studies which indicated that roughage intakes were depressed by increasing the level of concentrate supplementation (McCullough, 1970; Leaver, 1973).

As expected, metabolisable energy and crude-protein intakes increased (P<0.01) as the level of concentrate supplement was increased (Table 2).

There were highly significant (P<0.01) differences in the final liveweights, average daily gains and feed conversion ratios of heifers in the three treatment groups (Table 3). The weight improvement in heifers fed concentrates was expected, as the concentrate would provide nutrients which may be lacking or deficient in the forage. Previous studies (Tayler and Wilkison, 1972; Leaver, 1973; El-Tayeb and Gaber, 1987) also found that liveweight gain increased as

Table 2. *Effect of concentrate supplements on feed intake of dairy heifers over 130 days*

	Diet A	Diet B	Diet C
Dry-matter intake (kg)			
Sorghum bicolor	3.33	3.17	3.02
Concentrate	–	0.98	1.96
Total	3.33	4.15	4.98
Daily dry-matter intake (% of liveweight)	2.52	2.59	2.55
Daily ME intake (MJ)	31.00a	39.83b	48.73c
Daily crude-protein intake (kg)	0.14a	0.33b	0.52c

Means in the same row followed by a different letter differ significantly (P<0.01)

Table 3. *Effect of concentrate supplements on liveweight gain and feed efficiency of dairy heifers over 130 days*

	Diet A	Diet B	Diet C
Initial liveweight (kg)	100.0	99.8	100.2
Final liveweight (kg)	119.8a	160.8b	195.7c
Average daily gain (kg)	0.15a	0.47b	0.74c
Feed conversion ratio (kg feed/kg weight gain)	19 8a	8.9b	6.8c

Means in the same row followed by a different letter differ significantly (P<0.01)

the rate of concentrate supplementation increased. The feed conversion ratios found in the present study were higher than those observed by El-Tayeb and Gaber (1987); this discrepancy may be due to the roughage used, which directly affects the dry-matter intake and hence feed conversion ratio.

The relationship between liveweight and heart girth is shown in Table 4. The greater (P<0.01) increase in heart girth was achieved by animals on the high level of supplementation. Shioya et al (1975) and Takla (1988) also found that concentrate supplementation had a highly significant effect on heart girth.

Serum progesterone was not detected in heifers in group A (the unsupplemented heifers), or in two heifers in group B. Serum progesterone concentrations of the remaining heifers are shown in Table 5. These data are in line with those reported by Donaldson el al (1970) who found that the plasma progesterone concentrations of heifers ranged from 0.3 to 3.9 ng/ml when the first sample was obtained.

Ovary surface examination by rectal palpation showed that high concentrations of progesterone were accompanied by the presence of corpus luteum. This agrees with previous work by Rakha et al (1970).

Table 4. *Effect of concentrate supplements on body conformation of dairy heifers*

	Diet A	Diet B	Diet C
Initial			
Liveweight (kg)	100.0	99.8	100.2
Heart girth (cm)	112	112	111
Correlation coefficient	0.99	0.99	0.97
Final			
Liveweight (kg)	119.8a	160.8b	195.7c
Heart girth (cm)	136a	187b	219c
Correlation coefficient	0.98	0.98	0.97

Means in the same row followed by a different letter differ significantly (P<0.01)

Table 5. *Serum progesterone concentration of dairy heifers*[a]

	Serum progesterone concentration (ng/ml) for individual heifers									
	Diet B				Diet C					
1st Ds	0.77	2.78	0.94	2.21	0.89	2.21	3.35	1.08	0.87	0.94
2nd Ds	1.89	0.40	3.92	0.48	1.75	0.48	0.54	1.98	1.53	3.40
3rd Ds	3.21	0.98	0.44	0.64	3.45	0.64	ND	3.47	2.20	ND
4th Ds	0.42	3.12	0.82	1.74	ND	1.74	ND	0.67	0.60	0.91
5th Ds	0.69	ND	1.68	3.27	0.98	3.27	0.69	1.20	0.93	1.63

[a] All heifers in group A, and two heifers in group B, did not reach puberty
Ds = Detectable sample
ND = Non-detectable

Some heifers showed visible signs of oestrus before progesterone was detected in their peripheral blood.

Heifers fed the high level of concentrate reached puberty (first onset of oestrus) at a significantly (P<0.05) younger age (20.5 months) and heavier liveweight (248 kg) than heifers fed the low level of concentrate (23.9 months and 231 kg, respectively). Generally, these findings agree with those of previous studies (Rakha et al, 1970; Short and Bellows, 1971; Little and Kay, 1979; Stewart et al, 1980; El-Tayeb and Gaber, 1987) which showed that the improved nutrition affected the onset of puberty in cattle.

The relationship between age and liveweight at puberty (r=0.33) was positive, but not significant (P>0.05), indicating that animals reached puberty at a given liveweight rather than at a given age.

CONCLUSIONS

This work demonstrates that supplementing poor quality forage improves the performance and reproductive traits of crossbred dairy heifers. More research is needed to examine the influence of different types of supplement and combinations of forages, and to determine the optimum level of supplementation.

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INTEGRATED FEED RESOURCE USE ON FARM

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PROSPECTS FOR INTEGRATING FOOD AND FEED PRODUCTION IN WELAYITA SODO, ETHIOPIA

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ABSTRACT

Welayita Sodo is a densely populated and intensively cultivated mid-altitude area of Ethiopia. Smallholder mixed farming is the dominant mode of production. The crop and livestock subsystems are closely interdependent: livestock contribute to the cropping system in the form of draught power, manure and sources of cash for purchase of crop production inputs, while crop residues provide livestock feed, especially during the dry season.

Because of the high population density, land holdings per household are small. Inadequate feed supply is the main constraint to livestock production. In order to optimise overall productivity there is a need to integrate food and feed production. Introducing forage legumes seems an acceptable approach: forage legumes will improve soil fertility, crop yields and herbage quality, and make the system more sustainable. Hedgerows of multipurpose fodder trees, productive backyard forages and undersowing or interplanting improved forages with food or plantation crops will probably be the most successful forage development strategies in this area. Research should look at temporal interactions between forage supply and form of feeding and nutrient demand by animals to exploit opportunities for marketing animals and their products.

RESUME

Perspectives de l'intégration des cultures vivrières et de la production des aliments du bétail à Wolayita Sodo (Ethiopie)

Wolayita Sodo est une région d'altitude moyenne, densément peuplée, où l'agriculture constitue une activité extrêmement répandue dominée par le *système de la petite exploitation mixte. L'élevage y est étroitement associé à l'agriculture: d'une part, le bétail fournit l'énergie de traction et le fumier et assure des revenus monétaires servant à l'achat des intrants agricoles; de l'autre, les résidus de récolte entrent dans l'alimentation des animaux, notamment au cours de la saison sèche.*

Compte tenu de la forte densité de population de cette région, les ménages doivent se contenter de petits lopins de terres. Par ailleurs, les pénuries d'aliments du bétail constituent ici le principal obstacle au développement de l'élevage. Pour optimiser la productivité de l'ensemble du système, il convient de promouvoir l'intégration de la production des cultures vivrières et des aliments du bétail. L'introduction de légumineuses fourragères dans ces systèmes de la petite exploitation mixte semble constituer une stratégie viable. En effet, celles-ci permettront, non seulement d'améliorer la fertilité des sols, les rendements des cultures et la qualité du couvert herbacé, mais également de promouvoir la durabilité du système. La mise en place de haies de ligneux fourragers à usages multiples et de vergers d'embouche ainsi que l'introduction d'espèces fourragères améliorées sous culture ou entre les rangées de plantes vivrières ou pérennes constituent sans doute certaines des meilleures stratégies possibles dans cette région. Enfin, il convient, pour promouvoir la commercialisation du bétail et des productions animales, d'effectuer une étude approfondie des interactions à long terme, entre d'une part les disponibilités fourragères et de l'autre, le mode d'alimentation et les besoins en éléments nutritifs des animaux.

INTRODUCTION

A diagnostic survey was carried out in 1988 to assess the feed resources and the animal production situation in Welayita Sodo, Ethiopia. Data were collected by interviewing 102 heads of households in the study area. In addition to the formal survey, supplementary information was collected from the Ministry of Agriculture. The information reported in this paper is partly based on this survey.

Welayita Sodo is located at 6° 49′ N latitude and 39° 47′ E longitude, about 400 km south-west of Addis Ababa at an altitude of about 1900 m. The area has moderately drained, acidic red soils (nitosols). The average monthly temperature in the area ranges between 11.9°C (August) and 26.2°C (January) with a mean annual temperature of 18.9°C. Rainfall averages 1100 mm a year and is bimodal, with the short rains from February or March until April and the long rains from June until September or October. The area is representative of medium altitude, medium rainfall, acid soil areas of western Ethiopia, Kenya, Tanzania, Uganda, Rwanda, Burundi and Cameroon.

The population density at Welayita Sodo is 250 inhabitants per km^2, similar to that of other densely populated areas in Ethiopia. Land holdings are very small, the average per household being 0.96 ha. More than 65% of the total holding is cultivated, of which 68% is under food crops. Cash crops occupy 32% while cultivated forages occupy only 0.04% of the cultivated land.

The cropping system of the area is very intensive. Major food crops include, in order of importance, maize, sweet potato, enset (false banana), teff (*Eragrostis tef*), haricot bean, taro, sorghum, Irish potato, yam and cassava. Coffee is the major cash crop. Intercropping is a common practice. Some farmers use chemical fertiliser, mainly diammonium phosphate, on food crops such as teff and maize.

About 93% of the farmers are engaged in livestock production in addition to cropping. The average livestock holding per household is 3.60 cattle, 0.74 sheep, 0.25 goats, 0.13 donkeys, 0.02 mules, 0.02 horses and 2.09 poultry. The predominant breed of cattle is the local zebu.

Animal manure is applied on garden crops; livestock also provide draught power for important farm operations. Crop residues are mainly used as dry-season feed for livestock. It seems that there is a strong positive interaction between crop and livestock production. This paper, therefore, attempts to assess this complementarity and the prospects for further integration of food and feed production in Welayita Sodo.

PREVAILING FEED RESOURCES IN WELAYITA SODO

Type and nutritional quality of available feed resources

Natural pasture is the main source of feed for most of the year, but because of population pressure grazing land is limited to about 0.23 ha/household. Some 65% of the respondents do not have access to common grazing land and so have to depend on their small individual holdings. About 50% of the farmers buy-in additional grass from outside their farm.

Quantitatively, therefore, stubble grazing and crop residues also serve as important sources of feed. Cereal crop residues (straws and stovers) are mostly stacked and fed to livestock during the dry season when the quantity and quality of available fodder from natural pasture declines drastically.

The use of concentrate feeds is very minimal or nonexistent. However, malted barley and boiled maize are occasionally fed to lactating cows to stimulate milk production. Agro-industrial byproducts such as meat and bone meal, oilseed cakes and flour mill byproducts are not available in the area.

Two mineral-rich soils, locally known as *Bole* and *Megadua* are used as mineral supplements for ruminants and equines, respectively.

Farmers also lop the leaves and branches of various trees and shrubs and feed them to their animals during the dry season. They also collect herbaceous wild plants, mostly legumes, as feed for lactating cows. Specimens of these plants were collected and identified at ILCA. They include *Acacia* spp, *Albizia* spp, *Buddleja polystachya*, *Clausena anisata*, *Combretum* spp, *Cordia abyssinica*, *Dodonaea viscosa*, *Dracaena steudneri*, *Ehretia cymosa*, *Erythrina brucei*, *Flacovirtia indica*, *Grewia* spp, *Ipomoea* spp, *Neonotonia wightii*, *Olea* *africana, Rubia cordifolia, Schrebera alata, Triumfetta rhomboidea, Vernonia amygdalina, Zornia glochidiata* and *Zornia setosa*. Enset and cassava leaves and sweet potato vines are also fed to animals during the dry season.

The chemical composition and *in vitro* dry-matter (DM) digestibility of some of these feeds were determined. Crude-protein (CP) content ranged from 3.38% (sweet potato tuber) to 24.19% (cassava tops). Neutral detergent fibre (NDF) content ranged from 31.28% (*Dracaena steudneri*) to 62.20% (sorghum leaves). Acid detergent fibre (ADF) content varied between 6.73% (sweet potato tuber) and 56.85% (*Cordia abyssinica*). Lignin content ranged from 1.35% (sweet potato tuber) to 27.86% (*Cordia abyssinica*). The ADF-ash content, which is indicative of the silica content, ranged from 0% in some of the feeds to 17.13% in *Combretum* sp. *In vitro* DM digestibility varied between 32.90 and 82.17% and was negatively correlated with ADF (r=–0.71) and lignin (r=–0.60) contents. About 74% of the feeds commonly used had *in vitro* DM digestibility values greater than 50%.

All the feeds analysed, with the exceptions of sweet potato tuber, *Schrebera alata* and sorghum leaves, had relatively high CP content—above the 7.5% considered necessary for optimum rumen function. Thus, most of them could be useful supplements to diets based on crop residues and poor quality natural pastures, which have low protein content.

Most of the feeds analysed contained adequate amounts of all the required minerals, with the exception of phosphorus and sodium. *Bole* and *Megadua* soils are rich in sodium, and could be used as sources of the mineral, but are low in phosphorus. Moreover, the high calcium content in the various feeds and mineral soils could aggravate the wide Ca:P ratio and precipitate the problem of phosphorus deficiency. Attempts should be made to correct the phosphorus levels of these feeds when they are used as dry-season supplements to diets based on crop residues and dry pastures.

Availability of feed resources in Welayita district

Estimated quantities of feed resources

The total quantities of feed obtainable from crop residues in 1982/83 and 1983/84 are shown in Table 1; there was drought in in Welayita Sodo in 1983/84. Assuming 10% wastage, the quantity potentially available for actual animal consumption was estimated as almost 166 000 and 107 000 t of DM in 1982/83 and 1983/84, respectively. Among the many types of crop residue, maize stover and enset are quantitatively the most important, followed by teff, sorghum, haricot bean and sweet potato.

In addition, natural sources provide more than 475 000 t of feed dry matter per year, about 73% of which is obtained from grazing and browsing of natural pasture (Table 2).

Table 1. *Estimated quantities of feed dry matter obtainable from different crop residues in Welayita district in 1982/83 and 1983/84 production years*

Crop	Crop production (t)		Conversion factor	Crop residue production (t DM)	
	1982/83	1983/84		1982/83	1983/84
Teff	10 810	9 934	1.5	16 215	14 901
Barley	804	343	1.5	1 206	515
Wheat	241	331	1.5	362	497
Maize	37 973	31 122	2.0	75 946	62 244
Sorghum	3 699	1 628	2.5	9 248	4 070
Horse bean	1 025	306	1.2	1 230	367
Chick pea	66	122	1.2	79	146
Haricot bean	4 156	2 791	1.2	4 987	3 349
Field pea	135	66	1.2	162	79
Potato	512	391	0.3	154	117
Sweet potato	8 027	9 366	0.3	2 408	2 810
Yam	458	592	0.3	137	178
Cassava	1 025	365	1.0	1 025	365
Coffee	2 302	1 931	0.4	921	772
Lentil	17	-	1.2	20	-
Enset[a]	na	na	na	65 200	22 872
Banana[a]	na	na	na	4 880	5 272
Total				184 180	118 554

[a] Crop production data not available. Crop residue production based on area planted (8150 and 2859 ha of enset, and 610 and 659 ha of banana, in 1982/83 and 1983/84, respectively: MOA, 1984) and crop residue yields of 8.0 t/ha per year for both crops (FAO, 1987)

Sources: Crop production data from MOA (1984). Conversion factors from FAO (1987)

Availability of feed dry matter relative to livestock population of the district

The livestock population of Welayita district is estimated at 468 288 tropical livestock units (TLU) (MOA, 1984; Jahnke, 1982). The availability of feed DM was calculated to be 1.37 and 1.24 t DM/TLU per year (equivalent to 3.75 and 3.41 kg DM/TLU per day for the 1982/83 and 1983/84 production years, respectively. The maintenance requirement is estimated at 4.6 kg DM/TLU per day (Kearl, 1982), so the available feed supply satisfied only about 78% of the livestock feed requirement of the area. However, the animals are reared intensively; they are kept in the yards within the household and younger animals or smallstock are kept inside the family's house. Hence, the animals have very

Table 2. *Feed dry matter obtainable from different land use types in Welayita district*

Land use type	Area (ha)	DM yield (t/ha per year)	Annual DM production (t)
Natural pasture	172 602	2.0	345 204
Aftermath	53 410	0.5	26 705
Fallow land	9 261	1.8	16 670
Forest	12 771	0.7	8 940
Woodland, bushland and shrubland	65 016	1.2	78 019
Total			475 538

Source: FAO (1987)

limited exposure to inclement weather and this minimises their maintenance requirement. The animals also have constant access to household wastes, which gives them a decided advantage with reduced movement resulting in minimum energy loss. This, among other factors, is reflected in near acceptable animal performance in spite of the estimated inadequate feed supply. On the other hand, the methods used in estimating the quantities of feeds available may not have been accurate and therefore there is a need to re-examine them.

LIVESTOCK PRODUCTIVITY IN WELAYITA SODO

The productivity of the ruminant livestock in the area is summarised in Table 3 In general, livestock productivity is low for all classes of animals. The relatively late age at maturity and the extended parturition intervals reflect an environment in which animals are subjected to long periods of nutritional stress. However, the estimated milk yield of cattle (about 500 kg/lactation, excluding milk consumed by the calf) can be considered acceptable for unimproved local zebu cows and this could be attributed to the practice of hand-feeding with various herbaceous and tree plants collected from the surroundings as well as with household wastes.

Mortality rates could not be calculated from the data collected. However, farmers reporting mortality of young animals cited drought and nutritional stress as the main causes of death.

MAJOR CONSTRAINTS TO LIVESTOCK PRODUCTION

Shortage of grazing land and inadequate feed supply are the major problems facing livestock producers in the area. Most of the crop residues are used as livestock feed, but their supply is seasonal and they are used in the traditional way, without any pretreatment and/or strategic supplementation. The cultivation of fodder crops is limited due, among other reasons, to shortage of land. The

Table 3. *Productivity data for ruminant livestock in Welayita Sodo, based on interview data from 102 households*

Performance parameters	Cattle		Sheep		Goats	
	Mean	SD	Mean	SD	Mean	SD
Weaning age (months)	9.8	2.9	4.8	1.8	5.3	1.0
Age at sexual maturity (months)	52.3	10.2	11.4	4.6	11.0	6.6
Age at first parturition (months)	65.0	10.2	18.4	7.1	16.9	6.7
Parturition interval (months)	26.2	6.6	12.9	4.3	11.1	2.3
Daily milk yield (litres/head)						
Maximum	2.4	0.9	–		–	
Minimum	1.0	0.5	–		–	
Mean	1.6	0.6	–		–	
Lactation length (months)	10.3	2.8	–		–	

integration of food and fodder crops in Welayita Sodo is nil to minimal due to inadequate research data and extension services and the lack of economic incentives to the farmers. Generally, available feed resources are not sufficient for optimum animal production. Lack of adequate financial resources and the absence of institutionalised credit services for investment in livestock production are other constraints identified in the survey.

PROSPECTS FOR INTEGRATING FOOD AND FEED PRODUCTION

The traditional complementarity of food and feeds in Welayita Sodo

Acute shortage of land and inadequate feed supply constrain animal output in Welayita Sodo but the farmers in the area are amenable to supplementary feeding of their animals. Where cash availability limits investment in livestock enterprises, as is the case in Welayita Sodo, the incorporation of forage legume production with the crop subsystem may be an acceptable approach.

Leguminous forages can contribute to better utilisation of cereal crop residues. Legumes are rich in protein and other nutrients such as minerals and vitamins. Some forage legumes such as *Desmodium intortum*, *Macrotyloma axillare* and *Stylosanthes guianensis* were shown in initial agronomic screening trials to be suitable and productive; the trials were conducted by the International Livestock Centre for Africa (ILCA), in collaboration with the Ministry of Agriculture, in mid-altitude areas of Welayita Sodo and in the Rift Valley region of Ethiopia. Some of the forage legumes were further evaluated in feeding and digestibility trials and were found to be useful supplements to crop-residue-based diets (Table 4).

Table 4. *Voluntary feed intake, nitrogen retention and body weight gain of lambs fed a basal diet of maize stover supplemented with different levels of legume hays*

Supplement g/head per day	Dry matter intake (g/kg$^{0.75}$ per day)			Nitrogen retention (g/day)	Liveweight gain (g/day)
	Maize stover	Legume hay	Total		
Desmodium intortum					
250	28.9a	26.8c	55.7b	–0.19	7.3b
350	26.9b	35.0b	61.9a	1.51	24.9a
450	17.0c	44.7a	61.7a	1.41	30.9a
Stylosanthes guianensis					
250	33.4a	26.0c	59.4b	0.82	15.0b
350	22.2b	36.6b	58.8b	1.61	13.9b
450	20.3c	44.4a	64.7a	1.37	30.3a

Within legume species, values in the same column followed by the same or no letter do not differ significantly (P>0.05)

Leguminous fodders also make a very important contribution to the crop subsystem. In systems with minimum fertiliser inputs legumes enhance crop yields by reducing the rate of decline of soil fertility. Nitrogen fixed by the legumes will be available to food or plantation crops grown by the smallholders during concurrent and/or subsequent seasons. For example, the planting of *Desmodium intortum* cv Greenleaf under coffee increased coffee berry yields by up to 19% on peasant holdings in Welayita Sodo (Lazier, 1987). Similarly, Haque (1990) found that intercropping maize with *Macrotyloma axillare* produced significantly more total dry matter than sole maize plots, although the intercropped plots yielded less than half as much grain as maize in pure stand. From this finding, it was concluded that the production of large amounts of high quality feed during the dry season by *Macrotyloma axillare* may be sufficient to offset the loss in maize grain yield for farmers with mixed crop–livestock farms and encourage them to adopt cereal–legume intercropping (Haque, 1990). But this tentative assumption needs to be tested in the field against farmers' responses/reactions to low grain yields *vis-à-vis* potential animal productivity and marketing in Welayita Sodo. Alley cropping with leguminous multipurpose trees such as *Sesbania sesban, Leucaena leucocephala* and *Gliricidia* spp offers alternatives to intercropped forage legumes.

Stratification of livestock production

The adoption of forage legume technologies would also assist in stratification of livestock production. During the dry season there is an acute shortage of feed in the lower altitude rangelands (mainly inhabited by pastoralists), resulting in substantial body weight loss and/or, during severe droughts, even death of the animals. These losses could be partially averted by selling some meat animals (steers and small ruminants) to highland farmers for fattening, but this exercise would only be feasible if adequate feed can be made available in the highlands, through improved forage production and if there are suitable marketing facilities.

In general, stratification of animal production is an advantageous strategy for both the lowland pastoralists and the mixed crop–livestock farmers of the highlands. Studies on animal health and on marketing are needed to assess the sustainability of this intervention For the pastoralists, this strategy will:

- reduce feed problems for animals domiciled in the rangelands
- protect the rangelands from the likely slow land degradation by adjusting stocking rates through increased offtake
- generate some cash income

And the highland mixed farmers will benefit from:

- increases in income, general welfare and cash input for crop production
- enhanced soil fertility in the cropping areas from animal manure and from the forage legumes

Temporal interaction between forage supply and demand

If farmers are to adopt a sustainable integrated crop–livestock production system there is a need to develop packages that will fit forage production and conservation with the nutrient demand curves by the animals to exploit market opportunities for livestock and livestock products. Researchers need to work in a more problem-oriented and integrated approach to overcome the isolation of disciplines like nutrition, forage agronomy and socio-economics. Research should be extension-oriented, addressing the needs of the smallholder in Welayita Sodo.

The four "I"s

Irrespective of the locality or the scale of operation, successful integration of food and feed production subsystems will depend on:

- institutional factors resulting from government agricultural policy
- infrastructure that is conducive to agriculture production and marketing, nationally, regionally or internationally
- inputs to the production systems—credit and financial facilities
- incentives, interrelated to agricultural policy, infrastructure and ease with which inputs are available.

In most cases farmers' incentives to increasing agricultural productivity are spontaneous and self-triggered. Lamentably the natural wisdom of the peasantry in rationalising the practicabilities of these issues, as they affect their well-being, is often assumed not to exist, underplayed or neglected by policy makers, research workers and even by extension services. We might be excused, sometimes, for assuming that, as researchers, we have better tools to evaluate sustainability issues and other long-term interests of the farmers we are supposed to help. That should not blind us to the fact that they, the farmers, also know what are their priorities, in the short and medium term.

CONCLUSIONS

Our success in increasing agricultural production within the multiplicity of existing subsystems in sub-Saharan Africa depends upon our ability to recognise and appreciate the interrelationships of the four "I"s outlined. There is a need to develop these infrastructures at the rural level and especially, in these days of gender issues, to lessen the load of women in feeding their families. For Welayita Sodo, forage production technology will be more acceptable if it fits into the existing production system, based on the available marketing infrastructure and financial inputs. Forages should be integrated with cropping systems rather than displace crops. Other forages could be produced from fence lines and hedges or in a backyard forage bank. We advocate that research should be devoted to the temporal interaction between forage supply and nutrient demand curves as they relate to a possible exploitation of market opportunities of animals and their products in Welayita Sodo.

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A NUTRITIONAL AND ECONOMIC EVALUATION OF ANIMAL FEED SELF-SUFFICIENCY IN CAMEROON THROUGH INTEGRATION OF FORAGE/CROP AND LIVESTOCK PRODUCTION

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ABSTRACT

Inadequate feeding of livestock is a major problem in tropical Africa. Although much is known about the nutritional and economic value of crop byproducts as animal feed, little information is available on the regional distribution of these byproducts, on their extraction rates or on levels of self-sufficiency. In Cameroon, large quantities of cereal, tuber and root crops are produced annually and byproducts from these crops could be used as animal feed.

This paper provides a quantitative analysis of crop byproducts available in Cameroon. Various extraction rates are estimated and related to the numbers of livestock and their nutritional requirements to determine the level of self-sufficiency in crop byproducts as animal feed. Results indicate that nutrients from crop byproducts are currently in short supply and that the byproducts are underexploited for feeding animals. Integration of crop and animal production would be a way of alleviating animal feed problems.

RESUME

Etude nutritionnelle et économique sur l'autosuffisance en aliments du bétail au Cameroun grâce à une production fourragère/végétale et animale intégrée

Les pénuries d'aliments du bétail constituent un problème sérieux en Afrique tropicale. Alors que l'on connaît relativement bien la valeur nutritionnelle et économique des sous-produits agricoles utilisés dans l'alimentation des animaux d'élevage, on ne peut en revanche en dire autant de leur répartition géographique, des taux d'exploitation des plantes ou de la part des besoins qu'ils permettent effectivement de couvrir. Au Cameroun, on produit chaque année d'importantes quantités de céréales, de racines et de tubercules, cultures

dont les sous-produits pourraient entrer dans l'alimentation des animaux d'élevage.

Cette étude présente des données chiffrées sur ces sous-produits agricoles. Les taux d'exploitation des diverses cultures ont été estimés puis utilisés, compte tenu des effectifs animaux et de leurs besoins nutritionnels, pour déterminer la part des besoins en aliments du bétail que ces sous-produits pourraient permettre de couvrir. Les résultats révèlent que ces sous-produits ne fournissent pas suffisamment d'éléments nutritifs aux animaux et sont en outre sous-utilisés dans l'alimentation animale. Une production végétale et animale intégrée pourrait permettre d'améliorer l'alimentation des animaux d'élevage au Cameroun.

FEED PRODUCTION AND UTILISATION BY DUAL-PURPOSE GOATS IN SMALLHOLDER PRODUCTION SYSTEMS OF WESTERN KENYA

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ABSTRACT

The yields and quality of pastures, fodder grasses and food-crop-related sources of feeds in western Kenya are reviewed.

Yields of up to 5.8, 40, 1 and 14.1 t DM/ha for pastures and fodder grasses (per year) and maize thinnings and sweet potato vines (per season), respectively, are reported. Deficiencies in phosphorus and sodium in pastures in the region are reported. The potentials and limitations of the feed resources in the region with respect to the feed needs of dual-purpose goats are discussed.

RESUME

Production et utilisation des aliments du bétail par la chèvre à double fin en petit élevage dans l'ouest du Kenya

La production et la qualité des herbages des parcours, des graminées fourragères et des sous-produits des cultures vivrières rencontrés dans l'ouest du Kenya ont été analysées dans cette étude.

Des rendements pouvant aller jusqu'à 5,8; 40; 1; et 14,1 t/ha ont été enregistrés respectivement pour les herbages des parcours et les graminées fourragères (par an), les produits du démariage du maïs et les tiges de patate douce (par saison). Les carences des parcours de cette région en phosphore et en sodium ont été décrites et les potentialités ainsi que les limites des ressources alimentaires disponibles sur place ont été examinées.

INTRODUCTION

Over the past 10 years the Small Ruminant Collaborative Research Support Program (SR–CRSP) has been undertaking multidisciplinary farming systems research in the intensive farming regions of western Kenya, with a view to developing an entire production technology package for dual-purpose (meat and milk) goats. The research has been concentrated mainly in selected sites (clusters) within Kakamega and Siaya districts.

Kakamega district, at an altitude of 1400–1850 m, is considered to be a zone of high agricultural potential (Pratt et al, 1966); it has high annual average rainfall of 1200–2100 mm, distributed bimodally, and lush vegetation. According to Jaetzold and Schmidt (1982), however, 85% of the district is covered with infertile Acrisols except for a small fertile area of Nitosols around Kakamega town.

Siaya district, on the other hand, is considered to be a zone of medium agricultural potential (Pratt et al, 1966). Rainfall is bimodal but lower than in Kakamega district and second season rains are less reliable. Annual average rainfall is about 1140 mm, ranging from 800 mm at the shores of Lake Victoria to 2000 mm near the border with Kakamega. The altitude ranges from 1140 to 1500 m. Soils here are generally of low fertility; they range from black cotton soils along the lake shores to red friable loams in the north-east of the district. According to Jaetzold and Schmidt (1982) the dominant soils in the district are mainly soils developed on basic igneous rocks and occur on lower level uplands. They include Luvisols, Nitosols and Ferralsols, the later being limited in fertility and water-holding capacity.

One of the major concerns of the SR–CRSP has been to study the crop and forage production systems currently used by smallholders in the region and to develop and test interventions to improve feed production without adversely affecting food-crop production. This paper highlights some of the research findings. It also examines the practical implications of these results with respect to the utilisation of these feeds by the dual-purpose goats being introduced in the region by SR–CRSP.

MATERIALS AND METHODS

Study sites (clusters) were chosen in Kakamega and Siaya districts to represent two agro-ecological zones. The sample sites used were drawn from a much larger national sample frame which had been designed earlier by Kenya's Central Bureau of Statistics of the then Ministry of Finance and Economic Planning for use in the first phase of its Integrated Rural Surveys.

After the selection of the study sites and identification of households within each site, a baseline survey was undertaken to provide information on such aspects as household composition, land-use patterns, livestock numbers and types and other capital resources. Monitoring surveys then followed routinely at

28-day intervals to assess the seasonal changes in farming activities, quantity and quality of feeds, and condition of the animals (Sands, 1983). Samples of the major feeds consumed by livestock were taken at intervals over a year and their quality determined by laboratory analyses. After the surveys, several experiments were carried out, both on-station and on-farm, to develop feed production technologies which can be integrated into the existing cropping systems of the region (SR-CRSP, 1981–90a, b). Technology packages (Techpaks) have been developed and are being tested on the farms. The adoption patterns of the individual components of the Techpaks are being monitored.

RESULTS AND DISCUSSION

The major sources of feed for livestock in the smallholder farming systems of the two districts in western Kenya are mainly unimproved, uncultivated communal grazing areas, roadsides, homesteads, school compounds, planted fodder grasses and food-crop-related sources.

Natural grazing

The natural pastures in the region consist mostly of grasses of the genera *Cynodon, Hyparrhenia, Digitaria, Pennisetum, Loudetia, Sporobolus* and *Cymbopogon*.

There are scanty data on the potential productivity of these pastures. Goldson (1977), however, reported a mean annual yield for 18 pastures in six small farms in the region to be 4747 kg DM/ha. Basing their estimates on Goldson's results for botanical composition and annual rainfall, Sands et al (1982), working in the same region, gave specific DM yield figures for Kakamega and Siaya farms as 5757 and 3752 kg/ha per year, respectively. Of these annual totals, the long rains contribute 3838 and 2502 kg/ha per season for Kakamega and Siaya while the short rains contribute 1919 and 1250 kg/ha per season, respectively. Table 1 shows some estimates of on-farm grazing DM yields by farm size classes based on the seasonally available grazing areas. It can be seen from the foregoing that the greatest problem is lack of precise information on the productivity of the available grazing areas which still contribute over 50% of the feed resources of livestock in the region. This information would be useful in designing feeding programmes for the livestock in a situation where the opportunity cost of growing feeds would be too high and labour is constraining.

The species composition of the pastures varies with district, microclimate and season. Table 2 gives a summary of the quality parameters for some of the dominant species across the two districts. The crude-protein (CP) values for *C. dactylon*, *P. purpureum* and roadside mix compare favourably with values reported for grasses by other workers, especially for early stages of growth

Table 1. *Annual production of fodder and digestible energy from grazing areas*

Farm size (ha)	Short rains (1980)		Long rains (1981)	
	Dry-matter yield (kg/farm)	Digestible-energy yield (MCal/farm)	Dry-matter yield (kg/farm)	Digestible-energy yield (MCal/farm)
< 0.5	295	761	516	1338
0.5–1.0	576	1489	716	1828
1.0–1.5	1257	3245	1202	3002
1.5–2.0	1336	3501	1786	4610
> 2.0	2384	6150	1989	5043

Source: Sands et al (1982)

(French, 1943; Thairu and Tessema, 1987). The CP value for *C. afronardus* is, however, more characteristic of late stage of growth or dry season. Most of the areas in Siaya district are, unfortunately, dominated by this grass which is also deficient in calcium, phosphorus, magnesium and zinc. It is also low in digestibility and digestible-energy content as well as in dry-matter intake, and these conditions persist throughout the year (Sands et al, 1982).

The macro- and microelement levels of pastures are equally important and their importance in livestock production has been adequately documented by Underwood (1966) for temperate regions. The mineral levels in pastures in western Kenya have been reported by Sands et al (1982), Musalia et al (1989) and Mbwiria et al (1984). Table 3 gives a summary of the results. It is apparent from the data reported by Sands et al (1982) and Musalia et al (1989) that the sampling method used has a real effect on the results obtained in mineral analysis for samples taken from the same study area. Whereas Sands et al (1982) collected samples of individual grass species at intervals over a year and pooled these per species for analysis, Musalia et al (1989) collected representative samples of forage materials consumed by goats on a monthly basis for a period of five months covering both the wet and dry seasons. The latter workers reported generally higher levels of minerals. For example, for the macroelements, it is only phosphorus and potassium (in *C. dactylon* and *C. afronardus*) levels which were higher in the data of Sands et al (1982) than in those of Musalia et al (1989). For the microelements, it is only copper levels in the data of Sands et al (1982) that were close to those of Musalia et al (1989), the rest being very low. Again Musalia et al (1989) indicated higher mineral levels for lower altitudes than for higher altitudes. Since Musalia et al (1989) were mimicking grazing goats when taking their samples their results are probably closer to the practical situation. This is because a grazing animal is usually able to select a diet of higher quality than that of the average pasture.

It is, nevertheless, clear from both studies that Mg is adequate in the area irrespective of sampling method. The same is true of Fe which is exceptionally

Table 2. *Mean quality parameters for some of the dominant grass species in western Kenya*

Quality parameters	*C. dactylon* Mean	*C. dactylon* SD	*C. afronardus* Mean	*C. afronardus* SD	*P. purpureum* Mean	*P. purpureum* SD	Roadside mix Mean	Roadside mix SD
Crude protein	21.25	1.00	6.56	2.17	10.06	2.96	18.73	5.52
Neutral detergent fibre (NDF)	64.56	4.03	74.36	1.35	65.92	3.72	69.39	6.86
Acid detergent fibre (ADF)	31.55	1.24	44.90	2.34	38.25	3.54	33.59	4.08
Hemicellulose	33.21	2.87	29.46	1.50	27.67	1.68	35.80	3.72
Cellulose	27.33	1.38	38.13	1.70	34.28	2.84	29.25	3.35
Lignin (L)	4.02	0.38	6.78	0.86	3.97	1.09	4.34	0.89
L/ADF	0.13	0.01	0.15	0.01	0.10	0.02	0.13	0.02
Silica	2.32	0.56	3.31	0.45	4.40	0.61	2.67	0.52
In vitro cell-wall digestibility	69.79	4.42	45.46	11.48	64.81	5.47	69.42	5.36
In vitro organic-matter digestibility	79.02	2.80	55.87	9.57	72.66	4.85	76.23	5.17
Predicted cell-wall digestibility	59.97	3.83	54.49	2.83	67.94	5.49	60.02	4.18
Predicted organic-matter digestibility	78.69	3.00	69.26	2.61	86.05	6.30	75.89	5.88
Predicted digestible energy (MCal/kg DM)	3.14	0.11	2.12	0.39	2.90	0.19	3.06	0.21
Predicted dry-matter intake (g/kg $BW^{0.75}$)	61.43	5.92	43.30	3.57	59.50	5.73	52.35	11.20

Predictions based on summative equations of Goering and Van Soest (1970)
Source: Sands et al (1982)

high and Na which is low. It is apparent from this that it is difficult to rely on experimental data for establishing mineral supplementation regimes for grazing livestock and more so for those that browse as well.

It is known that concentrations of mineral elements in forages are generally dependent upon the interactions of edaphic, biotic and climatic factors (McDowell, 1976). Specific regional differences in soil characteristics such as differences in geological formations, drainage and pH, account for most of the naturally occurring mineral deficiencies in livestock (Hartmans, 1970; Mitchell et al, 1957; Latteur, 1962; Pfander, 1971;). Some differences are species-specific, some plants being able to accumulate higher levels of particular mineral elements than others growing on the same soil (Beeson, 1961). Stage of maturity

Table 3. *Macro- and microelement levels in pastures in western Kenya*

	g/kg DM					mg/kg DM			
Sample analysed	Ca	P	Mg	K	Na	Fe	Zn	Cu	Mn
C. afronardus	1.56	2.2	0.9	16.3	0.012	75	19	2	12
P. purpureum	2.12	3.5	1.4	54.8	0.038	51	18	5	80
Roadside mix[a]	4.72	3.3	1.9	3.8	0.122	202	49	9	77
Tethering sites[b]									
Grass	3.60	1.6	1.8	5.1	0.20	222	28	7	118
Browse	6.30	1.3	2.1	3.4	0.19	317	33	13	111
28 genera of grasses	3.70	2.8	3.1	28.0	0.60	480	34.9	29.4	165
Expected range	0.40 to 60	0.2 to 7.1	0.3 to 10	–	0.01 to 21.2	–	1.0 to 120	1.1 to 100	9 to 2400
Critical level (goats)	3.60	2.7	0.9	–	0.9	15	45	7	45

[a] Roadside mix is mainly *Digitaria scalarum* and *Cynodon dactylon*
[b] Data for tethering sites are means of four study sites (Maseno, Masumbi, Hamisi and Kaimosi)
Sources: Sands et al (1982); Musalia et al (1989); Kayongo Male and Thomas (1975); Minson (1977; 1982)

of pastures also affects levels of mineral contents with elements such as P, K, Mg, Na, Cl, Cu, Co, Zn and Mo declining as the plant matures (Underwood, 1966). Pasture management and yield also affect plant mineral composition through, for instance, grazing pressures which will determine the predominant species of forage in an area and consequently affect mineral composition.

Mineral requirements, on the other hand, are highly dependent on the level of productivity (ARC, 1965; NRC, 1970) and breeds (Phillips, 1956; Correa, 1957; Wiener and Field, 1969). For example, under improved management practices where levels of milk production and growth rates are highly improved, mineral nutrition becomes a crucial part of the management strategy. It is, however, difficult to pinpoint specific mineral requirements since exact needs depend on the chemical form in which the mineral is available and interrelationships which exist between them, such as occur with Ca and P. Although estimates of requirements are useful, they can only provide guidelines and cannot be a replacement for the critical diagnostic test—a positive response to correction of a suspected deficiency.

In summary, pastures in western Kenya are generally low in P and Na and these deficiencies are more elaborate in some grass species than in others. Phosphorus levels in *Cymbopogon*, for example, are inadequate to support milk production and acceptable fertility levels. The grass species is also low in Mg, Zn, and Na. The excessive levels of Fe can have adverse effects by increasing the likelihood of Cu deficiency developing. It has been shown that a relatively minor increase in dietary iron to almost 1 g/kg for cattle rapidly reduced liver plasma copper to concentrations indicative of deficiency (Humphries et al, 1981).

Fodder grasses

Fodder grasses are mainly important as cut-and-carry sources of feed. The most widely grown fodder grass in Kenya is Napier grass (*Pennisetum purpureum*) and its derivatives such as bana grass (*P. purpureum* x *P. typhoides*) which is the one mostly recommended for dairy enterprises. Productivity of bana grass varies from one area to another and depends on whether or not fertiliser or manure is applied. Yields of up to 10 t DM/ha after eight months of growth have been reported (KARI, 1985). This represents on average a daily growth rate of about 180 kg/ha.

In western Kenya, Mathuva et al (1985) reported a DM yield of 3.4 t/ha for a first cutting height of 1.3 m with a crude-protein level of 13.3% when fertiliser (NPK 20–20–60) was applied at the rate of 100 kg N/ha. The cumulative yield for a year (three cuts) was 40 t DM/ha.

The quality of Napier grass at utilisation stage is often high. Sidahmed et al (1984) reported an average *in vitro* apparent dry-matter digestibility of 76.2% for western Kenya. Research on the use of the Napiers in small ruminant production systems is still scarce. However, studies by van Eys et al (1986) have shown that goats fed only Napier grass of 6–8 weeks regrowth with a 12% CP content had an average daily weight loss of 1 g/day compared to a weight gain of 21 g/day for goats fed Napier supplemented with *Gliricidia maculata*, *Leucaena leucocephala* or *Sesbania grandiflora*. Thus, although CP requirements of ruminants for moderate levels of production are met at dietary DM concentrations of 11–12% (ARC, 1980), this study showed that productivity of goats fed Napier grass containing otherwise adequate levels of CP may still be limited by the inefficient utilisation of nitrogen. This is again demonstrated in a study by Yates and Panggabean (1988), in which goats were offered either a basal diet of Napier grass *ad libitum* with no supplement or Napier grass supplemented with either an energy- and protein-containing concentrate or fresh chopped *Leucaena* leaves and small twigs, both supplements being offered at levels of 25, 50 or 75% or *ad libitum*. The objective of this study was to look at the effects of increasing amounts of supplements on feed intake and performance. Those animals which were on 100% Napier grass lost weight at the rate of 19 g/day whereas there were positive responses in liveweight change with increased intakes of concentrates and *Leucaena*, with maximum liveweight gains of 76 and 43 g/day for *ad libitum* concentrate and *Leucaena*, respectively. It was shown that to maintain liveweights, approximately 180 and 220 g/day of concentrate and *Leucaena*, respectively, were required in addition to the basal diet. The efficiency of protein utilisation can thus be increased by supplementation with tree legumes.

Food-crop-related sources

Fresh feeds

The major food crops in western Kenya include maize (*Zea mays*), beans (*Phaseolus vulgaris*), sweet potatoes (*Ipomoea batatas*), sorghum (*Sorghum vulgare*) and cassava (*Manihot utillisima*). The distribution of these crops in the region follows the agro-ecological zones, with cassava and sorghum being mostly predominant in the lower altitude zones of Siaya district.

The interactions between the food crops and animal production systems are stronger in Kakamega than in Siaya district. This is so because, with a population density estimated at over 800 persons/km^2, Kakamega district has very little land left for grazing. Maize, which is the major cereal crop in the district, is also a major source of feed for livestock. It can generate feeds through thinning and leaf-stripping just before the crop is ready for harvesting of ears. Usually a farmer would plant more than one seed per hill as a security against germination losses. The extra seedlings are eventually thinned out at weeding and are a useful source of feed, particularly for smallstock. Depending on the original plant population, between 350 and 1000 kg DM/ha can be generated with a mean crude-protein content and *in vitro* dry-matter digestibility of 21 and 59%, respectively. Additional feed can be generated in this way just after silking stage from those plants that will have arborted.

Leaf-stripping can begin 90 days after planting with the removal of one leaf per plant per week, starting with the bottom leaves. Four leaves, including the flag leaf and the leaves subtending the cobs, should be left on each plant. This procedure can give about 800 kg DM/ha if done for up to nine weeks. Table 4 shows some estimates of quality reported for fresh and dry (hay) leaf-strippings. It has been shown that fresh maize leaves contain sufficient protein, macro-elements and energy to support lamb gains at about 100 g/day with an intake of 770 g/day and food conversion efficiency of 8–10 (Kayongo-Male and Abate, 1982).

Sorghum can also provide thinnings and strippings, although early stripping should be avoided as it can have a negative effect on grain yield. The advantage with sorghum is that after harvesting the heads the crop can be ratooned and the regrowth used as feed. However, all sorghums (grain or forage types) contain at least trace amounts of cyanogenic glucoside. When an animal feeds on the plant the glucoside is broken down by a glucosidase enzyme and hydrogen cyanide is released; the enzyme is present both in the plant tissue and in the rumen liquor. The hydrogen cyanide released is rapidly absorbed into the bloodstream where it combines with haemoglobin to form cyanohaemoglobin which does not take up oxygen. The poisoned animal then dies from respiratory paralysis. To reduce the chances of poisoning, it is better to avoid grazing wilted or very young plants, and grazing very hungry animals.

Table 4. *Quality estimates of fresh and dry (hay) maize leaf strippings*

Quality parameters	Content (% DM)	
	Fresh leaves	Dry hay
Crude protein	12.8	9.5
Acid detergent fibre	41.8	47.5
Lignin	6.5	6.3
In vitro dry-matter digestibility	55.7	50.5
Calcium	0.60	-
Phosphorus	0.25	-

Source: Adapted from Kayongo-Male and Abate (1982)

The other major food crop in the region with potential for feed is the sweet potato which is traditionally grown to provide tubers for human consumption. Several cultivars occur in the region, often planted together in mixtures, and they differ in their potential for tuber and vine production. Karachi (1982) evaluated 31 local cultivars for their tuber yields and protein contents of both tubers and vines after nine months of growth. He observed significant differences in tuber protein content, mean tuber numbers per square metre, mean tuber weight and tuber yields. There were also significant differences in dry-matter content of the vines. On the basis of these observed differences he classified the cultivars into vine, tuber, and multipurpose types (Table 5). Similar studies have been done at Maseno using cultivars collected within a 15 km radius around the Maseno research station (Onim et al, 1985). Large differences in tuber and vine yields were again observed, the best tuber-yielding cultivar giving 20.9 t/ha of fresh tuber (equivalent to 6.81 t DM/ha) with a crude protein content of 8% after three months of growth. The poorest tuber yielder gave the highest vine yield of 14.1 t DM/ha in eight months, indicating a negative relationship ($r=-0.36$) between vine DM yield and tuber fresh-weight yield. The mean vine yield of 8.5 t DM/ha in eight months is much higher than the range of 4.0–5.6 t DM/ha per harvest reported by Ruiz et al (1980). The performance of sweet potatoes in western Kenya is thus very good and the observed large and significant variations ($P<0.01$) among the forage parameters and tuber yields indicate a potential for improvement through selection. In terms of forage production a high vine:tuber ratio would be the ideal choice. However, under smallholder conditions where tubers are equally in high demand, a compromise between tuber and vine yield is a better option and this is where the multipurpose types become most appropriate.

Nutritional studies at Maseno using crosses of Toggenburg on East African goats have shown differences in dry-matter intakes of sweet potato vines according to the physiological status of the animals, with the lowest intakes being recorded in dry does (2.5–2.8% body weight) followed by kids of six months of age (3.9–4.8% body weight) and then lactating does (6.1–6.8% body

Table 5. *Classification of sweet potatoes on the basis of tuber and vine yield*

Purpose	Cultivar	Tuber:vine ratio	Vine:tuber ratio	Total dry-matter yield (t/ha)
Tuber	Muibai	0.5	1.9	17.7
	3011	0.5	2.0	17.4
	3009	0.8	2.0	21.3
	Giganda (E)	1.0	1.0	16.2
Multipurpose	Nyaliech	0.3	3.5	28.6
	Opiemo	0.4	2.5	29.6
	Nyakonde	0.6	1.7	23.9
	Mania	0.6	1.7	21.0
Vines	Namunjuna	0.2	6.4	21.0
	Calorine lea	0.2	4.6	21.9
	Musinyamu	0.3	3.7	24.0
	Toilo	0.3	3.5	20.8

Source: Karachi (1982)

weight) (Brown and Nderito, 1982). These differences would be expected, although the high value recorded for the lactating does is more characteristic of temperate dairy breeds. Values of up to 5–7% of body weight have been cited as suitable for dairy goats in a temperate environment (Mackenzie, 1967). Devendra (1967) reported a value of 1.6% as the maintenance level for Kambing Katjang goats (meat) in Malaysia. When the same goats were placed on three different planes of nutrition above maintenance, the value rose to 2.2, 2.6 and 2.7% for each level, respectively.

Dry-matter intake (DMI) as a percentage of body weight thus rises from that of meat goats through the dual-purpose types to the highest levels being achieved in the dairy types. Indeed, for meat and fibre production, goats seldom exceed DMI above 3% of body weight. Again, although the DMI for dairy breeds are higher they vary depending on breed–environment interaction. Typical values are about 3.3% for indigenous goats in the tropics, 3.6% for exotic breeds introduced in the tropics and 5.0% for goats in temperate regions. The relatively lower intakes for tropical dairy breeds and also for exotic breeds imported into the topics are attributable to a combination of body size and high ambient temperatures which tend to depress appetite.

The very high DMI values for lactating does reported under experimental conditions in Maseno are surprising for a feed with high water content (86%) given that a high level of water in feed has been reported to be one of the main causes of low DMI in the region (Semenye et al, 1989). Indeed in all the intake studies undertaken in Maseno so far the DMI for vines have been the highest

(Brown and Nderito, 1982; Said et al, 1985). The one advantage with the high levels of water in vines is that a goat on the diet does not require free water unless it is a lactating doe producing over 2.5 kg of milk per day (Brown et al, 1983). However, when offered to a lactating doe as a sole diet it can only support suboptimal levels of production. It is more appropriate for growing goat kids that can be weaned on it much earlier (three weeks postparturm) after achieving almost three times their birth weight. Early weaning has the advantage of releasing milk for the farm family.

The quality of the vines is high with a CP of over 20% and a digestibility of about 70%, which compares well with dry-matter digestibility values reported by other workers (Ffoulkes et al, 1978; Ruiz et al, 1980).

Crop residues

Maize stover is by far the most abundant cereal crop residue in Kenya with an estimated annual availability of up to 5 million tonnes, accounting for over 70% of the total annual production of the lignified arable farm byproducts (Said et al, 1982). Its use in livestock feeding is, however, mostly limited to small-scale farms. In western Kenya, Sands et al (1982) reported that stover yields were about 150% of the grain yield; this estimate was based on field measurements in which grain accounted for 37–49% of maize plant DM at harvest. Table 6 shows estimates of these yields according to farm classes. In more recent studies, Onim et al (1986) estimated stover yields for different maize cultivars, both local and commercial, under experimental conditions in Maseno. Under these conditions, in which the local cultivars had been selected specifically for double cobs and all trial plots received fertiliser, stover and grain yields were much higher than those obtained from farmers' fields and in this case the ratio of crop residue to grain of 2:1 proposed by Owen (1976) would not be applicable (Table 7).

Table 6. *Estimated stover yield in western Kenya according to farm size classes*

Farm size (ha)	Maize stover yield (kg/farm)	
	Short rains (1980)	Long rains (1981)
< 0.5	99	348
0.5–1.0	168	736
1.0–1.5	149	1043
1.5–2.0	273	1648
> 2.0	279	1893
Siaya	162	584
Kakamega	192	1221

Source: Sands et al (1982)

Table 7. *Long-rains grain and stover yields of different maize cultivars planted under experimental conditions at Maseno*

Maize cultivar	Grain yield (kg/ha)	Stover DM yield (kg/ha)
Kaimosi Double Cobber	6 494	7 269
Hamisi Double Cobber	7 136	6 778
Nyahera Double Cobber	5 691	7 177
Masumbi Double Cobber	5 803	5 765
H614	7 395	10 233
H511	4 926	6 224
H622	5 901	6 603
Mean	5 861	7 150
Mean grain to stover ratio	1:1.2	

The value of maize stovers as livestock feed is, as with other crop residues, limited by their low digestibilities and crude-protein and mineral contents. Their nutritive value can be improved either by treatment methods that increase the availability of nutrients by breaking down the lignocellulose constituents, or through supplementation methods that add deficient nutrients or correct nutrient imbalances. It has been shown that treatment of roughages with anhydrous or aqueous ammonia or with urea can increase digestibility, intake and liveweight gain in ruminants (Jackson, 1978; Sundstol et al, 1978).

However, the effect of ammoniation is influenced to a certain extent by type of roughage and quality before treatment (Sundstol et al, 1978). Generally, materials of lower digestibility respond better to treatment than those of higher initial value. In some cases ammoniation has been reported to decrease N digestibility of roughages (for example, Oji et al, 1977). Recent work in Kenya, Tanzania and Bangladesh has shown that *Magadi* soda (a natural alkali salt deposit) is effective in improving digestibility and intake of straws (Musimba, 1980; Kategile et al, 1981; Saadullah et al, 1981).

In studies with male castrated sheep, Butterworth and Mosi (1986) reported that estimated intakes of metabolisable energy (ME) for crop residues fed alone were not sufficient for maintenance of a 20 kg male castrated sheep. However, when levels of *Trifolium tembense* hay supplement were increased successively, there was an increase in average ME intake sufficient to support modest levels of production. There were also significant increases in nitrogen retention, particularly for maize stover, oat straw and wheat straw diets.

Thus legumes appear to be a viable option and one that would be more cost effective under smallholder conditions. Moreover, the conventional energy and protein feeds such as grains and oilseed cakes are neither readily available nor affordable to the small-scale farmer.

Multipurpose tree legumes

Tree legumes are currently gaining prominence in sub-Saharan Africa due to their many uses and the fact that they can easily be integrated into existing cropping systems. With the increasing demand for agricultural land in western Kenya, many of the indigenous tree legumes are being phased out as more land is cleared for cropping. Some of the introduced legume species such as *Leucaena* are slow to establish and vulnerable to wild ruminant browsers at the seedling stage. There are therefore just a few trees scattered within the homesteads and these play a negligible role as sources of feed. One of the indigenous species which grows readily in the area is *Sesbania sesban*. It is seen in many farms left standing between crops; farmers believe, and rightly so, that it improves the yield of the companion crops. This is understandable taking into consideration the fact that it is a profusely nodulating legume. However, little information is currently available on the response of *Sesbania* to cutting management for forage generation and work is currently being undertaken in SR–CRSP to establish this.

Major limitations to the utilisation of available feeds by dual-purpose goats

The areas available for natural grazing are rapidly diminishing due to the increasing human population and the attendant increase in demand for cropping land. Even in Siaya district, where communal grazing areas have been relatively abundant, the effect of population increase is beginning to show. Moreover, the land demarcation policy has meant that those areas that were initially used communally are now under strict individual ownership. The few areas that are still left available are dominated by poor grasses of the genus *Cymbopogon*. These grasses cannot maintain adequate levels of fertility and productivity. The levels of dry-matter intake recorded in the district with grazing goats is very low (1.6% of body weight) with consequent deficits in energy intakes and thus poor growth (Karimi et al, 1985). In Kakamega district the available grazing areas are seriously overgrazed with the consequence that the actual amount of herbage on offer at any particular time is lower than the estimated potential productivity. This has a severe effect on dry-matter intake.

The Napier grasses, particularly bana grass, form an important source of cut-and-carry forage in the region. However, the plots under these are often very small and most of them are on embankments of erosion-control cut-off drains and terraces. Moreover, they are rarely given manure or fertiliser and being very demanding crops they cannot do well under poor soil conditions. The small plots are often over-harvested and in many cases they are established under eucalyptus trees where the shade affects productivity. It is difficult to convince farmers to clear the trees since these are important sources of income. Introduction of shade-tolerant grasses may be a solution. There is also an inefficient utilisation of the Napier grass due to wastage at feeding time. Many farmers simply throw the harvested grass on the ground and goats, being fastidious feeders, will not eat any contaminated forage. SR–CRSP scientists are making a concerted effort to encourage farmers to hang the feeds, and this is currently picking up well.

Food crops still remain a very important source of feeds in mixed farming systems in the region. However, these can only provide maintenance diets in the form of leaf strippings, thinnings, stovers and sweet potato vines. It is therefore necessary to integrate tree legumes into the cropping systems to provide a source of supplement to the crop-related feeds. There is an urgent need to develop cropping systems that would incorporate both food crops and tree legumes in a self-sustaining manner and with optimal productivity under smallholder conditions. The SR–CRSP is already experimenting with a model of such a farm.

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ECONOMIC IMPLICATIONS OF FORAGE INNOVATIONS ON SMALLHOLDER FARMS IN WESTERN KENYA

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ABSTRACT

In response to a declining forage base, the Small Ruminant Collaborative Research Support Program (SR-CRSP) has developed a number of low cost forages and forage preservation techniques for the dual-purpose goat technology currently on trial on smallholder farms in western Kenya. Representative whole farm linear programming models incorporating a number of the new forages were constructed for three farm sizes in Hamisi Division. Food and cash crops, existing forages and zebu cattle were also included in the models. Results showed a high degree of complementarity between crop and liverstock production. Livestock stocking rates increased considerably with the smallest farm realising the largest net income gains from the new technologies.

RESUME

Incidences économiques des innovations en matière de technologies fourragères introduites dans les petites exploitations de l'ouest du Kenya

Face à la dégradation de la base de ressources fourragères, le Programme d'appui à la recherche concertée sur les petits ruminants (SR–CRSP) a mis au point un certain nombre d'espèces fourragères et de techniques de conservation des fourrages bon marché destinées à l'élevage des caprins à double fin. Celles-ci sont actuellement évaluées dans de petites exploitations de la région d'Hamisi dans l'ouest du Kenya. A cet effet, des modèles de programmation linéaire tenant compte de toutes les activités agricoles, des caractéristiques de certaines nouvelles variétés fourragères et de la taille des exploitations ont été *élaborés. Les autres paramètres pris en compte dans ces modèles sont les caractéristiques des cultures vivrières et des cultures marchandes ainsi que celles des espèces fourragères traditionnelles et de l'élevage bovin. Les analyses effectuées font ressortir une forte complémentarité entre la production végétale et l'élevage. Ces innovations technologiques permettaient d'augmenter considérablement les taux de charge des petites exploitations et partant, de maximiser les bénéfices nets des petits exploitants.*

INTRODUCTION

Much of African development research has focused on crop farming to the neglect of the livestock sector (Senga, 1976). However, small ruminants (sheep and goats) play a significant support role in small farming systems of the world (Winrock International, 1983). In Kenya, for example, about 43% (6.5 million) of the country's small ruminants are reared on small farms Between 1969 and 1978, the goat population increased by 4.8% annually, and the offtake rate rose from 17 to 31% (Schulter, 1984). With increasing prices of other meat sources, such as beef, sheep and poultry, demand for goats will probably continue to rise.

The agricultural sector is expected to continue to play a key role in the Kenyan economy, especially in employment creation. According to World Bank (1989) statistics the growth rate of the agricultural sector has steadily declined from 4.9% in 1965–80 to 2.8% in 1980–86. Several solutions are being explored to revitalise Kenya's agricultural development and growth. Currently research resources are being channelled to the lower strata of livestock farmers who in many cases still employ traditional production practices.

For the past 10 years the Kenya Small Ruminant Collaborative Research Support Program (SR–CRSP) has been working on development of the dual-purpose (milk and meat) goat and supporting technologies in smallholder farms of western Kenya, using a farming systems research approach. With increasing populations and the resultant pressure on land, the dual-purpose goat is an appropriate livestock technology alternative to the zebu cattle which are usually reared on these farms. The dual-purpose goat is low risk and requires fewer capital inputs and smaller land area per unit, and yet under good management conditions produces higher milk yields per unit of required inputs. The overall objective of this study is to assess the economic impact of the dual-purpose goat and new forage technologies as a means of improving smallholder family incomes, and human nutrition, in Hamisi Division of western Kenya. The specific objectives are to:

- determine the magnitude of economic returns from the dual-purpose goat and forage technologies developed by the SR–CRSP in western Kenya
- determine the level of integration of the new forage technologies in these smallholdings
- determine economic and nutrition constraints to adoption of the dual-purpose goat.

MATERIALS AND METHODS

Study area

The study is being carried out in Hamisi Division, in the western highlands of Kenya in Kakamega District. The area is classified as a high potential agricultural zone. Annual rainfall is 1200–2100 mm, with a bimodal distribution—the long rains season runs from March to June, and the short rains fall between September and November. The soils are humic nitrosols with moderate to high fertility (Hart et al, 1984). Hamisi Division is one of the most densely populated regions of Kenya with about 615 persons/km^2.

The farming system in Hamisi is a sedentary mixed crop–livestock system, with two cropping seasons. The primary food crops are maize intercropped with beans. Secondary food crops include sweet potato, cassava, banana and a variety of green vegetables. Tea and coffee are the major cash crops. All household keep some livestock. SR–CRSP (1986–87) surveys indicate mean livestock numbers per farm of 2.10, 0.20 and 0.20 Tropical Livestock Units (TLU: 1 TLU = 250 kg liveweight) for zebu cattle, sheep and indigenous goats. But because more than 40% of participant farmers own 1 ha of land or less, these stocking rates are considered high (Semenye, 1990; Jaetzold and Schmidt, 1982); given existing natural unimproved grazing pastures, Jaetzold and Schmidt (1982) recommend a stocking rate of 0.6 ha/TLU. It is clear that available land is being overgrazed.

Sources of livestock feed

Livestock feeds are derived from off-farm grazing and crop residues such as maize stover, maize thinnings, banana peelings and sweet potato vines. The importance and availability of any specific feed varies by season and off-farm grazing is perhaps the most important source, followed by crop residues. Heavy reliance on off-farm grazing is supported by the long grazing hours reported by Conelly et al (1987).

Table 1 shows the mean cultivable and grazing land, labour and capital endowments for small, medium and large farms in the study area. Project data indicate no significant difference in labour availability per household so the same figure was used for all farms. There is a negligible variability in mean own capital per household. The small area of on-farm fallow land available for grazing on the small and medium farms is the land around the homestead which is not in direct competition with food crop production. On large farms a greater area can be left fallow for grazing. Livestock nutrition budgets constructed by Hart et al (1984) estimate an average of 0.40 ha of off-farm grazing per household for the sample of farmers in Hamisi. Detailed descriptions of the farming system and resource endowments for the study area have been reported elsewhere (Sands, 1983; Nyaribo, 1989; Nyaribo and Young, 1991).

Table 1. *Resource constraints by farm size, Hamisi Division, western Kenya*

Farm size	Land (ha)		Labour adult equivalent (days)	Own capital (KSh)
	Cultivable	Grazing[a]		
Small	0.59	0.50	1461	3051
Medium	1.19	0.60	1461	3151
Large	2.01	1.39	1461	3737

[a] Refers to the sum of on- and off-farm grazing land available. On-farm fallow grazing land is 0.10 ha for the small and medium farms and 0.89 ha for the large farm

KSh 23 = $US 1.00 in 1990

Baseline surveys in the early phase of the SR–CRSP project identified lack of adequate quality feeds as one of the constraints to dual-purpose goat production (Sands, 1983). Seasonal fluctuations in the forage supply are such that in certain months there is excess feed which is wasted if it is not stored. In response to the shortage of livestock feed, SR–CRSP has introduced several forage interventions and forage storage technologies (Hart et al, 1984; Onim et al, 1985).

Study methodology

Linear programming was used to test the economic feasibility of dual-purpose goat and forage production and storage technologies. Representative farm linear programming models were constructed for three farm sizes for the Hamisi study site. The linear programming model maximises gross margin, net of human consumption, from the farm's production activities subject to fixed resource constraints. Gross margin is defined as total revenue minus total variable costs. The model solves for the following decision variables:

1. How many hectares to plant to food, cash and forage crops
2. The desired inventory of cattle and dual-purpose goats
3. How many animals to sell during the year
4. How much food to produce, how much to sell and how much to keep for home consumption
5. How much cash to borrow to augment cash balances.

The main constraints are:

1. Maximum cultivable and grazing land available
2. Maximum family labour available
3. Maximum hired labour available
4. Minimum family subsistence requirements
5. Minimum livestock nutrient requirements
6. Maximum available working capital for input and food purchases.

The time unit is one calendar year. The year is divided into four time periods to allow for the transfer of products and resources. The seasonal disaggregation of the livestock component is crucial because of the seasonal changes in the quality and quantity of forages. Also, most farming activities are performed at specific times during the year which leads to distinct seasonal patterns in resource use and supply (Hazel and Norton, 1986).

The livestock component generates demand for feed on a quarterly basis which in turn determines the optimal stocking rate. This permits isolating livestock nutrient needs that may be at risk in certain periods of the year. Dry matter and crude protein supplied by the different sources are balanced with the demands for livestock feeding. The requirements are specified by livestock category and by period.

Livestock production activities

There are two dual-purpose goat breeding activities. The unit of measure is a doe–kid unit. Nutrient requirements for the doe–kid units are the sum of those for the lactating doe, the kid and a yearling replacement doe. The first doe kids in April and the second in November. Weaner kids from the dual-purpose goat production activities are available at five months of age. Nutritional requirements are withdrawn each period the animal remains on the farm. Kid rearing activities produce animals which are transferred to kid sale activities. Weaner kid nutrient requirements are drawn only up to 14 months. To allow for flexibility in sale of kids within the year, sale dates are not predetermined. Accordingly four kid sale activities, one corresponding to each quarter, are specified in the model. The breeding stock replacement activity allows for yearling females to be kept for breeding stock replacement. The labour and nutrient requirements are included in the doe breeding activity.

One cattle production activity is specified. Zebu cattle produce milk for home consumption as well as for sale. They also produce calves and culls for sale. The milk sale activities allow for sales of milk from both dual-purpose goats and cows in all periods.

The model includes three livestock feeding categories; April kidding dual-purpose goat feeding, November kidding dual-purpose goat feeding, and cattle feeding. Livestock derive their feed from eight sources: maize stover, fresh pigeon peas, Sudan grass, off-farm and on-farm fallow grazing, fence row forage, pigeon pea hay, Sudan grass hay and mixed grass hay. In the model this results in 78 seasonal feeding activities. The model determines the optimal mix of feed consumed subject to dry-matter and crude-protein requirements. It also determines quantities of feed to be transferred to feed-deficit months.

Other production activities of the model include intercropped maize and beans, sorghum, vegetables and bananas. Along with maize stover, grass hay and on- and off-farm grazing, the new forages intercropped with food crops are Sudan grass and pigeon peas. Cash crops considered are tea and coffee.

Data sources

The data used in this study came from surveys conducted by SR–CRSP scientists (SR–CRSP, 1986–87, 1987; Hart et al, 1984). SR–CRSP work covers smallholder farmers in two agro-ecological zones and conducts on-farm trials in six villages with a total of 150 participating farmers. In this study modelling results from the Hamisi village with 23 farmers are reported.

MODELLING RESULTS

The different model runs are classified by type of technology and farm size. The technologies were introduced sequentially to the traditional (base) farm. Thus:

- TI denotes traditional technology, referred to as the base model
- TII denotes the base model with the dual-purpose goat and no new forages
- TIII denotes the addition to TII of new forages without forage storage technology
- TIV denotes the full technology package which includes forage storage.

Up to 42% of the SR–CRSP participant farmers own 1 ha of land or less. It was thus important to evaluate the impact of these technologies on various farm sizes. Accordingly the sample was stratified into three farm sizes and the means of the land, labour, and capital endowments for each farm size category (see Table 1) were used in the linear programming models.

Table 2 summarises the impact of the new technologies on stocking rates and on farm income by farm size. As anticipated, the new technologies have had the greatest impact on the smallest farms, where the full technology package (TIV) increased stocking rates by 767% and farm income by 497%, compared with the base model. Results for the medium and large farms showed similar trends, but at much lower levels; for example, farm income increased by only 22% on medium farms, and by a mere 8% on large farms, with the full package.

Table 2. *Impact of dual-purpose goats and new forages on stocking rates and farm income by farm size*

	Small farm (0.69 ha)		Medium-size farm (1.39 ha)		Large farm (3 ha)	
Technology	Stocking rate (TLU)[a]	Income (KSh)	Stocking rate (TLU)[a]	Income (KSh)	Stocking rate (TLU)[a]	Income (KSh)
TI	0.49	1509	0.49	9738	1.22	13792
TII	0.73	1600	0.70	9813	1.22	13792
TIII	3.87	6946	2.73	11554	2.41	14773
TIV	4.25	9003	3.35	11906	2.95	14949

[a] TLU = Tropical Livestock Unit (1 TLU = 250 kg)

KSh 23 = $US 1.00 in 1990

Figure 1 shows the shares of sales from livestock products (milk and meat) and crop sales on small and size farms. (Relative magnitudes for the large farm follow the trend of the medium farm. Thus conclusions regarding the medium farm are also relevant to the large farm.) As each element of the dual-purpose goat and forage technology package was added to the base model the share of crop sales declined while that of livestock product sales increased. This reversal of the contribution of livestock and crop sales to total farm sales can be explained by the fact that farm-gate prices for meat and milk are higher than that for maize grain, the major competing commodity. The results indicate that while crop–livestock associations are biologically complementary, economically they can be competitive because of the relative crop/livestock output price ratios.

Complementarity of crop–livestock production

The complementarity of crop–livestock production systems on smallholder farms is determined by the degree of dependence of each enterprise on the other. In western Kenya crop residues play an important role in providing forages for livestock on the farms. This is clearly illustrated in Figure 2, which shows the share of each forage type in total feed consumed on the small and medium farms under the full technology package (TIV). On the large farm the new forage and hay storage technologies contributed 37 and 15%, respectively, or 52% of the total feed consumed, while maize stover and grazing each contributed 24% of total. These results demonstrate that maize, which is the most important food crop, is highly complementary with production of dual-purpose goats.

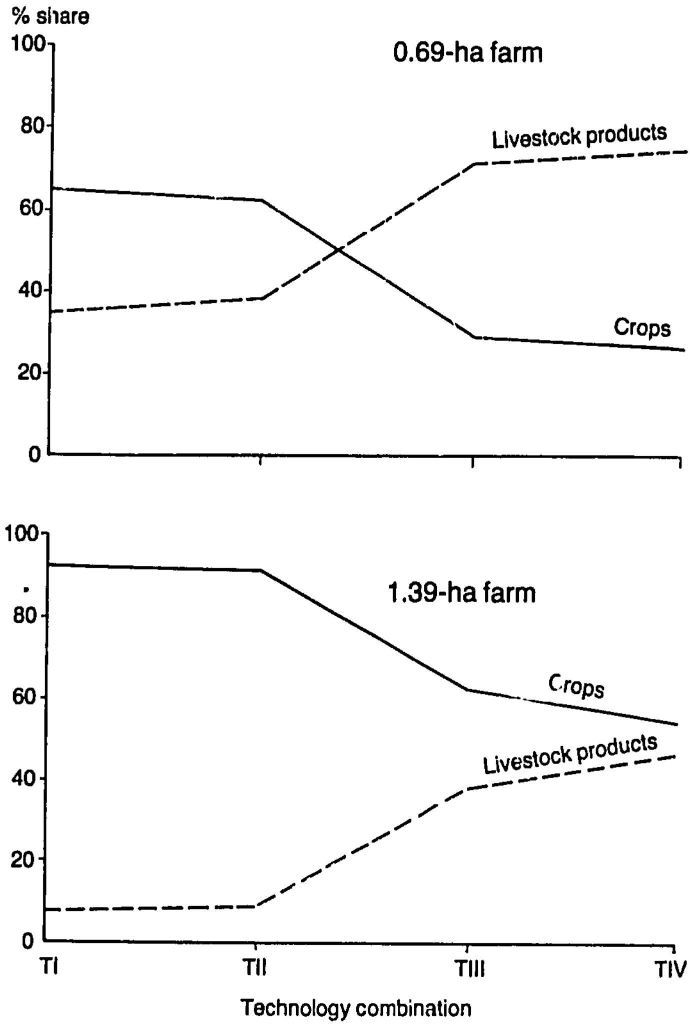
Constraints to livestock production

Four major constraints to livestock production were identified (Table 3). Digestible energy was constraining for all farm sizes under all technology alternatives. This finding is consistent with the study by Blackburn et al (1986) in the same area. Grazing land and cultivable land were also constraining for all farm sizes with the small farm realising the largest shadow price on cultivable land. Capital was constraining for the medium and large farms. This points to the need for credit support for smallholder farms.

CONCLUSIONS

Adoption of the new forage and forage storage technologies significantly increased stocking rates and farm incomes on smallholder farms in western Kenya. While all farm sizes benefited from the new technologies the smallest farm size realised the largest net income benefits from adoption of the new technologies. For all farm sizes maximum benefits were realised by adopting the new forages plus the forage storage technology, that is, the full technology

Figure 1. *Shares of livestock products and crops in farm sales*



package specified as TIV. Due to limited land endowment for the smallest farm, economic competitiveness between livestock and crop production occurred at lower farm incomes, and lower technology levels (between TII and TIII) than it did on the medium and large farms. Digestible energy, cultivable land and grazing land were identified as constraining resources for all farm sizes. Capital, on the other hand, was constraining for the medium and large farms. For the

Figure 2. *Share of various forages in total forage consumption*

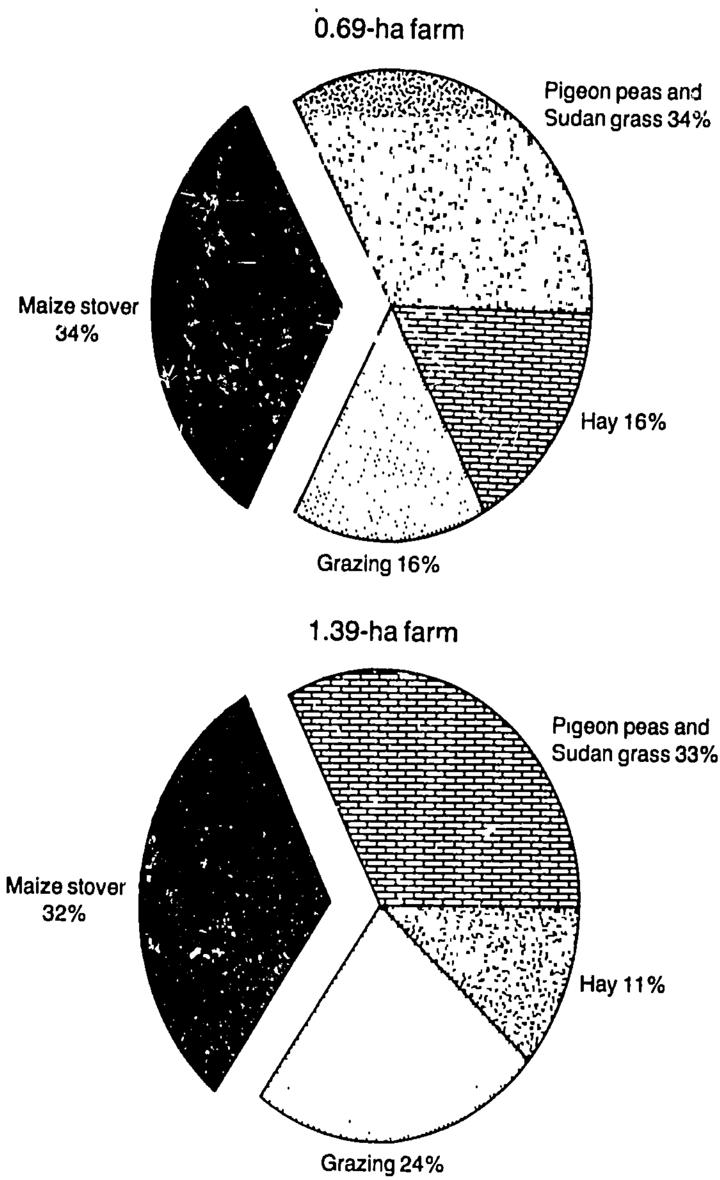


Table 3. *Economic results of selected variables by technology combination and farm size, Hamisi Division, western Kenya*

Farm size	Total livestock units (TLU)[a]	Quantity DM (kg)		Farm income (KSh)	Dual values			
		Fresh	Stored		Nutrient[b] (KSh/kg)	Grazing land (KSh/ha)	Cultivated land (KSh/ha)	Operating capital (KSh/KSh)
I								
Small	0.49	1690	na	1 509	0.77	1358	7 475	0.00
Medium	0.49	1705	na	9 738	0.77	1358	7 519	0.00
Large	1.22	4220	na	13 792	0.30	294	2 045	3.90
II								
Small	0.73	2049	na	1 600	0.85	1509	7 475	0.00
Medium	0.70	1660	na	9 813	0.65	1153	6 169	0.96
Large	1.22	4220	na	13 792	0.30	294	2 045	3.90
III								
Small	3.87	9952	na	6 946	0.85	6349	11 946	0.00
Medium	2.73	8367	na	11 554	0.16	877	857	4.75
Large	2.41	7111	na	14 773	0.09	183	117	5.28
IV								
Small	4.25	6161	1918	9 003	0.32	2346	14 816	0.00
Medium	3.35	9051	1164	11 906	0.07/0.67	217	469	5.11
Large	2.95	7730	1391	14 949	0.08	161	3	5.36

[a] TLU = Tropical Livestock Unit (1 TLU = 250 kg)
[b] Digestible energy was the constraining nutrient for all farm sizes under all technology alternatives. Crude protein was also constraining for the medium farm under TIV

KSh 23 = $US 1.00 in 1990

smallest farms, land constraints imply the need for further research in output-increasing technologies per unit of land. This will require the use of improved management and husbandry practices and the use of high yielding maize varieties as well as high milk and meat yielding dual-purpose-goat genotypes.

Considering the significant share of maize stover and grazing in total feed consumption, these traditional sources of feed will continue to play a key role in the diets of dual-purpose goats and other livestock. Livestock and crop production were shown to be highly integrated and technically complementary. This no doubt contributes to the sustainability of smallholder farms. However, complementarity of livestock–crop production is tempered by economic competitiveness due to farm-gate livestock/crop price ratios. Given the price responsiveness of farmers the balance of farm activities will continue to shift to livestock production the higher the output price ratios.

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EFFET DE LA COMPLEMENTATION ALIMENTAIRE SUR LA PRODUCTION LAITIERE ET LA CROISSANCE DES BOVINS A MADAGASCAR

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RESUME

Après avoir passé en revue les ressources alimentaires disponibles pour l'élevage à Madagascar, cette étude présente quatre expériences menées pour évaluer l'effet de diverses complémentations sur la production laitière et la croissance de diverses races de bovins.

Dans la première expérience, des vaches laitières issues de croisements race Frisonne x Zébu, réparties en lots et élevées sur pâturage artificiel de saison sèche de *Stylosanthes guianensis*, ont bénéficié de trois niveaux différents d'une complementation de concentrés. Il ressort des résultats enregistrés que celle-ci n'avait aucun effet significatif sur la production laitière.

Dans la deuxième expérience, des vaches métisses race Frisonne x Zébu élevées sur pâturage naturel de saison sèche recevaient une complémentation de tourteau de coton et de paille traitée ou non avec de l'urée. La paille traitée à l'urée entraînait une augmentation significative de la production laitière et un gain moyen quotidien pouvant aller jusqu'à 119 g. Quant à la paille brute, elle entraînait des pertes de poids pouvant aller jusqu'à 286 g/j.

Dans la troisième expérience, des génisses croisées Renitelo x Zébu ont été élevées pendant 42 jours sur pâturage de saison sèche, avec une complémentation de divers niveaux de feuilles de *Leucaena leucocephala* et de paille de riz traitée ou non. Le gain de poids des animaux soumis à la ration complémentée était significativement supérieur à celui des témoins. Le niveau de complémentation et la nature de la paille n'avaient pas d'effet significatif sur le gain moyen de poids.

Dans la quatrième expérience, des zébus adultes ont été élevés sur pâturage naturel de saison sèche avec ou sans une complémentation de graines de coton. Il ressort des résultats enregistrés que les gains de poids augmentaient linéairement en fonction de la quantité de graines de coton consommée. Les animaux élevés uniquement sur pâturage naturel perdaient du poids.

ABSTRACT

Effect of feed supplementation on cattle milk production and growth in Madagascar

After an overview of feed resources available for livestock production in Madagascar, this study reports on four trials carried out to assess the effect of various supplements on milk production and growth in various cattle breeds.

In the first trial, Friesian x zebu dairy cows divided into groups and kept on sown dry-season Stylosanthes guianensis *pasture were fed three levels of a concentrate supplement. Supplementation had no significant effect on milk production.*

In the second trial, Friesian x zebu cows kept on a natural dry-season pasture were fed a concentrate of cottonseed cake and straw with or without urea enrichment. The enriched straw significantly increased milk production and resulted in an average weight gain of up to 119 g/day. Straw alone resulted in weight losses of up to 286 g/day.

In the third experiment, Renitelo x zebu heifers were kept for 42 days on a dry-season pasture with a supplement of various levels of Leucaena leucocephala *leaves and rice straw with or without urea treatment. Supplemented animals gained significantly more weight than unsupplemented ones. Supplementation level and type of straw had no significant effect on average weight gain.*

In the fourth trial, adult zebu cattle were kept on a natural dry-season pasture with or without a cottonseed cake supplement. There was a linear increase in weight gains as cottonseed cake consumption increased. Unsupplemented animals lost weight.

IMPROVING MILK PRODUCTION IN SMALL-SCALE DAIRY FARMS IN BOTSWANA: INCORPORATING LEGUME FODDER IN THE FARMING SYSTEMS

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ABSTRACT

A research project was established to investigate the problems of milk production by small-scale cattle owners in Botswana. The major constraint identified was lack of adequate feed (quantity and quality), particularly during the dry season. The research emphasis was therefore to integrate fodder crops such as lablab (*Lablab purpureus*) into the farming systems and establish a practical feeding programme based on planted fodders and harvested crop byproducts. Participating farmers planted 1 ha with lablab, with or without single superphosphate fertiliser. On-station trials were established to study the effects of fertiliser application, the optimal stage of harvest and appropriate methods for harvesting, drying and storage.

Feeding packages developed by the project were tested on-farm. A comparative feeding trial was conducted involving Simmental–Tswana crossbreds and Tswana milking cows fed sorghum stover supplemented with different levels of lablab and sorghum bran as protein supplements.

During the four years of the trial (1985–1989), average lablab dry-matter yields from farmers' fields were 1.14, 0.70, 2.82 and 0.87 t/ha. Fertiliser application did not affect (P>0.05) lablab yields on either farmers' or research plots, and there were no differences (P>0.05) in yields between farmers' fields and the research plots. Lablab contained more crude protein than sorghum stover (16.4 *vs* 6.4%). The lactation yield of the crossbred cows was more than twice that of Tswana cows (3.8 *vs* 1.5 kg/day).

Although the major traditional crops in the project area are sorghum and millet intercropped with cowpea and watermelon, the project has succeeded in convincing farmers to allocate one 1 ha of land for lablab production and fodder production has become a component of the cropping system.

RESUME

Amélioration de la production des petites exploitations laitières au Botswana: introduction des légumineuses fourragères dans les systèmes agraires

*Un projet de recherche a été lancé pour étudier les problèmes rencontrés dans le domaine de la production laitière par les petits éleveurs de bovins au Botswana. D'après les résultats de ces travaux, les pénuries et la qualité médiocre des aliments, notamment au cours de la saison sèche, constituent certains des obstacles les plus sérieux au développement de la petite exploitation laitière dans le pays. Fort de ces conclusions, il a été décidé de mettre l'accent sur des travaux destinés non seulement à intégrer des plantes fourragères comme la luzerne (*Lablab purpureus*) dans les systèmes agraires en place mais également à élaborer un système adapté d'alimentation basé sur la culture de plantes fourragères et les sous-produits agricoles. Les paysans participant à ces travaux ont semé 1 ha de luzerne avec ou sans application de superphosphate simple. Des essais en station ont en outre été conduits en vue d'étudier l'effet de l'engrais et de déterminer le stade optimal de récolte ainsi que les meilleures méthodes de coupe, de séchage et de conservation.*

Des paquets alimentaires élaborés dans le cadre de ce projet ont été expérimentés en milieu réel. Un essai d'alimentation comparatif a été réalisé sur des vaches métisses Simmental x Tswana et des Tswana, avec une ration composée de paille de sorgho complémentée avec différents niveaux de luzerne et de son de sorgho comme sources de compléments protéiques.

Pour les quatre ans qu'a duré cette étude (1985–1989), la production moyenne de matière sèche de la luzerne au niveau des paysans s'établissait à 1,14; 0,70; 2,82; et 0,87 t/ha. L'application d'engrais n'avait aucun effet (P>0,05) sur la production de la luzerne, ni au niveau des paysans ou du projet ni entre les parcelles des paysans et celles du projet. La teneur de la luzerne en protéines brutes (16,4%) était supérieure à celle de la paille de sorgho (6,4%). Enfin, les vaches métisses produisaient plus de deux fois plus de lait (3,8 kg/j) que les Tswana (1,5 kg/j).

Bien que les principales cultures traditionnelles de la zone d'étude soient le sorgho et le mil, entre lesquelles étaient généralement intercalés le niébé et la pastèque, le projet a réussi à convaincre les paysans de réserver 1 ha de terre à la culture de luzerne, faisant désormais de la production fourragère une composante à part entière du système agraire.

INTRODUCTION

Increasing milk production by peri-urban small-scale farmers in Botswana has been the major objective of the Ministry of Agriculture during the current six-year National Development Plan (1985–91). The Animal Production Research Unit (APRU), Department of Agricultural Research, established a project to investigate the problems of milk production by small-scale cattle owners. This project is jointly funded by the Government of Botswana and the International Development Research Centre (IDRC), Canada.

The major constraint identified was lack of adequate feed (quantity and quality) to sustain milk producuon, particularly during the dry season. Large quantities of crop residues are produced and can be harvested for dry-season feeding of lactating and in-calf cows (Mosienyane, 1983; Mosimanyana and Kiflewahid, 1987). However, crop residues are of low quality and cannot satisfy the nutritional requirements of these cows. Therefore, the research emphasis has been to incorporate fodder crops into the farming system and establish a practical feeding programme based on planted fodder and crop residues.

Agronomic trials to examine various varieties of fodder legumes and pasture grasses were conducted at a number of locations between 1977 and 1980 (APRU, 1980). The results indicated that from among several annual legumes screened for drought resistance, ease of management, grazing potential and dry-matter yield, lablab (*Lablab purpureus*) was the most productive and the most easily established in the communal areas of Botswana (APRU, 1979). It has soil requirements similar to those of cowpea, and better disease and insect resistance, and can be grazed, ensiled or conserved as hay (Humphreys, 1978). In addition to these qualities and its high nutrient content, it is useful in terms of improving soil fertility in crop rotation in small-scale farm conditions (APRU, 1979).

The specific of objectives of the work described here were to determine:

- productivity and nutritive value of lablab
- optimal methods for conservation
- the potential for including a fodder legume such as lablab into the small-scale mixed farming systems.

MATERIALS AND METHODS

Fodder legume production and conservation

Beginning in 1985, the project introduced lablab to the participating farmers. Each farmer was given 20 kg of lablab seed and 100 kg of single superphosphate fertiliser (10.5% P) to plant 1 ha of land; the fertiliser was applied to half of each hectare. Three 1-ha plots were also planted at Sebele Agricultural Research Station. Superphosphate was applied at the rate of 0, 100 or 250 kg/ha on each plot. An additional 27 ha of land were planted to study the optimal stage of harvest and appropriate methods for harvesting, drying and storage, and for on-station feeding trials

Lablab yield was measured using 2-m radius circular subplots from three random locations in each of the farmers' plots and the research plots. After measuring yield, the plants were harvested, sun-dried and stored for dry-season feeding. After harvest the total quantities of lablab, crop stovers and post-harvest residues stored by each farmer were estimated.

Feeding trial

A dry-season on-farm feeding trial was carried out to determine the voluntary feed intake and performance of Simmental–Tswana crossbred and Tswana lactating cows fed sorghum stover supplemented with various levels of lablab hay and sorghum bran. The objective was to formulate a nutritionally optimal diet for lactating cows based on low quality but widely available sorghum stover and farm-produced lablab hay or sorghum bran. The four treatment diets (see Table 1) were formulated to satisfy the daily nutrient requirements for maintenance and milk production of lactating dairy cows such as those used in this trial (NRC, 1978; Crampton and Harris, 1969).

Table 1. *Experimental diets*

	Composition (%, dry-matter basis)			Nutrient content (%)	
Treatment	Sorghum stover	Lablab hay	Sorghum bran	Crude protein	Total digestible nutrients
Diet 1	60	40	–	10.5	56.3
Diet 2	60	30	10	10.0	58.8
Diet 3	60	20	20	9.5	61.0
Diet 4	60	10	30	9.3	64.1

In diet 1 lablab was mixed with the stover by hand at the time of feeding; in the other three diets, the sorghum bran was fed separately in split oil-drums. The animals were provided with *ad libitum* bonemeal–salt (1:1 w/w ratio) and vitamins A, D and E. The treatments were randomly allocated to each of 40 farmers. Voluntary feed intake was determined in all treatment groups by measuring the daily refusals over a period of seven days and for a maximum of six lactating cows per farm. Statistical analysis using the t-test (Snedecor and Cochran, 1967) was conducted on the performance data obtained from the lactating cows that completed the trial.

Nutritive value

Three replicate samples of lablab, sorghum stover and sorghum bran were submitted for laboratory chemical analysis.

Samples of fresh whole plants and plant parts were air-dried (60°C) and then ground in a Wiley mill (1-mm screen). The dried and ground samples were stored in air-tight bottles and later analysed for organic matter, crude protein, crude fibre, ash and mineral components according to methods approved by AOAC (1975) and *in vitro* dry and organic matter digestibility according to Tilley and Terry (1963) procedures.

Dairy cattle performance

Each farmer was provided with two calibrated 10-litre plastic milk buckets for recording milk yield. Milk records were collected and summarised by project staff at the end of each month.

RESULTS AND DISCUSSION

Fodder legume production and conservation

Average dry-matter yields (t/ha) of lablab by farmers and on the research plots in 1985/86 and 1986/87 are shown on Table 2. Fertiliser application had no effect (P>0.05) on average dry-matter yields on farmers' plots or on research plots, and there were no significant differences (P>0.05) in dry-matter yield between farmers' fields and the research plots. The results from the two seasons were not greatly different. Low dry-matter yields and lack of fertiliser response could be due to lower than average rainfall in both seasons.

Table 3 shows the total quantities of lablab dry matter harvested and conserved by the project farmers during the four years of the project. The higher lablab dry-matter yields in 1987/88 than in the other three years were attributed to higher rainfall in the project area (651 mm) in that year. The decrease in the total quantity of lablab hay harvested by farmers in 1988/89 season, even though the rainfall was higher than normal, was due to the improved grazing conditions caused by reasonable rainfall.

Table 2. *Average dry-matter yield of lablab hay from project farms and research plots as influenced by fertiliser application rate*

Year	Rainfall (mm)	Dry-matter yield (t/ha) at fertiliser application rate of		
		0 kg/ha	100 kg/ha	250 kg/ha
Farmers' plots				
1985/86	328	1.23	1.44	–
1986/87	380	1.37	1.49	–
Research plots				
1985/86		1.41	1.56	1.70
1986/87		1.47	1.54	1.79

Table 3. *Lablab dry-matter yields from farmers' fields*

Year	Mean rainfall (mm)	No of farmers	Average dry-matter yield (t)	Total dry-matter yield (t)
1985/86	328	12	1.14	13.1
1986/87	380	30	0.70	21.0
1987/88	651	40	2.82	112.8
1988/89	565	40	0.87	34.8

The major constraint observed during harvesting and conservation was the time required to dry the stems. Lablab leaves dry and shatter within three days but it takes up to six weeks for the stems to dry completely. Various methods of drying and storage using tripods, stooking on the ground and combing three rows into one row were tried at Sebele Research Station. Method of drying had no effect on drying time but the crop was baled more efficiently from stooks and tripods with minimum dry-matter loss due to leaf shattering, mould or termite damage. In 1987/88 lablab was dried in rows and baled six weeks after harvest.

Feeding trial (dry season)

There were no differences ($P>0.05$) in the average daily dry-matter, crude-protein and energy (TDN) intakes by lactating cows fed the four diets (Table 4).

Table 4. *Average voluntary intake of nutrients by lactating cows*

	Voluntary intake (kg/day)					
Diet	DM	DM/100 kg liveweight	CP	CP/100 kg liveweight	TDN	TDN/100 kg liveweight
Diet 1	9.43	2.46	0.99	0.26	5.33	1.39
Diet 2	8.77	2.43	0.88	0.24	5.16	1.42
Diet 3	8.93	2.50	0.85	0.24	5.45	1.52
Diet 4	8.22	2.24	0.76	0.21	5.27	1.48

Diet 1: 60% sorghum stover and 40% lablab hay
Diet 2: 60% sorghum stover, 30% lablab hay and 10% sorghum bran
Diet 3: 60% sorghum stover, 20% lablab hay and 20% sorghum bran
Diet 4: 60% sorghum stover, 10% lablab hay and 30% sorghum bran

Nutritive value

The nutrient composition and *in vitro* digestibility valves for lablab, sorghum stover and sorghum bran are shown in Table 5. Lablab contained more crude

Table 5. *Average nutrient composition of diet components*

Feed	Composition (% of dry matter)						*In vitro* digestibilities (%)	
	Organic matter	Crude protein	Crude fibre	Ash	Ca	P	DM	OM
Lablab hay	90.8	16.4	27.7	9.2	1.68	0.13	59.9	57.1
Sorghum stover	91.6	6.4	32.5	8.4	0.38	0.10	54.8	49.8
Sorghum bran	97.3	11.5	3.2	2.7	0.38	0.31	54.4	47.2

protein and had higher dry-matter and organic-matter digestibilities and calcium to phosphorus ratios than sorghum stover. The higher digestibility coefficients are attributed to the higher crude-protein and lower crude-fibre content in lablab than in sorghum stover. The calcium to phosphorus ratios were within acceptable limits reported for cattle (NRC 1978). Due to high crude-protein and mineral contents observed in lablab plants, dry-season diets for lactating and in-calf cows were based on sorghum stover supplemented with lablab hay.

Dairy cattle performance

Comparative basic data on dairy cattle performance on-farm are given in Table 6. Average lactation lengths for Simmental–Tswana cows were longer ($P<0.05$) than for Tswana cows in 1985/86, 1986/87 and 1988/89 but similar in 1987/88. Average daily milk yields per cow were similar within breed but different between breeds. On average, milk yield per day per cow for both breeds tended to increase with increasing seasonal rainfall; however, the reason for the low yield in the high rainfall year 1987/88 is not clear.

On average under similar feeding and management systems, Simmental x Tswana cows produced twice as much milk as Tswana cows. These results are comparable with those obtained in on-station trials (APRU 1988).

CONCLUSIONS

The predominant crops in the traditional cropping system of the project area are sorghum, maize and millet intercropped with cowpea and watermelon. The dairy project has succeeded in convincing participating farmers to allocate one hectare of land for lablab fodder production. Fodder production has become a component of the cropping system.

The dry-season feeding strategy using high protein *Lablab purpureus* legume fodder, planted and harvested by farmers and fed in association with crop byproducts and post-harvest residues, has been a significant intervention in the small dairy farms.

Table 6. *Milk production of Simmental x Tswana and Tswana cows*

Item	1985/86	1986/87	1987/88	1988/89
No of farmers	12	30	40	40
No of cows per farmer				
Simmental x Tswana	10	15	24	20
Tswana	24	74	140	111
Lactation length (days)				
Simmental x Tswana	273	285	303	262
Tswana	223	202	296	181
Milk yield/cow (kg)				
Per lactation				
Simmental x Tswana	760	890	818	988
Tswana	338	319	474	420
Per day				
Simmental x Tswana	2.8	3.1	2.7	3.8
Tswana	1.5	1.6	1.6	2.3
Rainfall (mm)	328	380	651	565

Fertiliser applications on farm plots as well as on station plots did not show any significant effect ($P>0.05$) on lablab dry-matter yield. Lack of response may be attributed to low seasonal rainfall and distribution.

Chemical analysis showed that lablab contained 2.5 times more crude protein than sorghum stover (16.4 *vs* 6.4%). The use of lablab as a protein supplement in crop stover based diets is the practical approach for the dry-season feeding of lactating and in-calf cows.

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SMALL-RUMINANT FEEDING SYSTEMS FOR SMALL-SCALE FARMERS IN HUMID WEST AFRICA

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ABSTRACT

Although not fully integrated into the crop-farming systems which constitute the major agricultural activity in humid West Africa, small ruminants play important economic, cultural and social roles. Of particular interest is their use as a means of storing wealth in times of agricultural plenty, to provide cash reserves for emergencies and to guarantee a degree of food security in times of crop failure. If small ruminants are to continue to play these roles, in addition to improving the protein nutrition of the population, constraints on productivity must be alleviated. One of the major constraints is inadequate and fluctuating feed supply. It is suggested that this results from poor feed management and utilisation, rather than from absolute shortages.

The major feed resources available are natural pastures, browses and crop residues and byproducts. The availability and quality of these resources vary, but evidence is presented to show that when they are properly selected and combined according to their nutritional characteristics, adequate and productive diets could be provided all year round, for sustainable small-ruminant production and productivity. A number of proven feed combinations targeted towards particular seasons and ecosystems are suggested. Future research activities required to identify additional feeding systems are highlighted.

RESUME

Systèmes d'alimentation destinés aux petits producteurs d'ovins et de caprins dans la zone humide d'Afrique de l'Ouest

Bien qu'ils ne soient pas encore pleinement intégrés dans la production végétale, la principale activité agricole de l'Afrique de l'Ouest, les petits ruminants occupent une place économique et socio-culturelle importante dans cette région. Plus particulièrement, ils constituent en période d'abondance, une forme *d'accumulation des richesses. Celles-ci procurent des recettes monétaires permettant de faire face aux situations d'urgence et d'éviter le pire en cas de mauvaises récoltes. Cela dit, seul un accroissement durable de la productivité de ces animaux leur permettra de continuer à remplir ces fonctions tout en contribuant à améliorer l'alimentation protéique des populations. Les principaux obstacles à l'amélioration de cette productivité sont l'insuffisance et les fluctuations des ressources alimentaires du bétail. Ces problèmes semblent dus, non pas à des pénuries réelles, mais à une mauvaise gestion alliée à une mauvaise utilisation des ressources alimentaires disponibles.*

Celles-ci sont constituées de foin de pâturages naturels, de fourrages ligneux, de résidus de récoltes et de sous-produits agricoles de diverses qualités produits en quantités variables. Cette étude montre que des choix rationnels et des combinaisons tenant dûment compte des caractéristiques nutritionnelles de ces divers aliments pourraient permettre d'offrir aux petits ruminants, d'un bout à l'autre de l'année, des rations propres à assurer chez ces animaux une productivité et une production soutenues. Un certain nombre de combinaisons satisfaisantes ont été proposées selon les saisons et les écosystèmes. Enfin, des axes de recherches futures ont été suggérés en vue de l'identification d'autres systèmes d'alimentation appropriés.

INTRODUCTION

Humid West Africa is made up of two distinct belts—the lowland, coastal rain forest and, to the north, the derived savannah belt. Together, they cover a total land area of 707 000 km^2, stretching from the lower third of Nigeria to Guinea. According to Jahnke (1982), annual rainfall in this zone is well over 1500 mm, and the crop growing season could be 270 days or more. The coastal lowland forest area contains cultivated farm land and bush fallow which, together with natural clearings, are often invaded by coarse grasses (*Pennisetum* spp). These grasses are sparse or absent under the forest trees that are abundant in this belt but sparse in the savannah belt, where regular fires have reduced tree cover to low trees, shrubs and bushes. Fallow areas in the savannah are also covered by coarse grasses, predominantly *Hyparrhenia* spp (Atta-Krah and Reynolds, 1989).

Small ruminants are the dominant livestock species in the zone, with an estimated population of about 14 million (Table 1). The dominant breed of both sheep and goats is the West African Dwarf. These animals are raised exclusively for meat, serve as cash reserves for emergencies and guarantee a degree of food security in times of crop failure. They therefore play an important social and cultural role for the households and communities that keep them. Small-ruminant flock sizes in these communities are small, about two to six animals per household, with goats out-numbering sheep. But large numbers of households keep small ruminants: figures reported in the literature range from a low of 23 to a high of 70% of rural households. A large proportion of these animals are owned and managed by women.

Table 1. *Small ruminant and human agricultural populations in humid West Africa*

	Populations (thousands)				Ratios	
Country	Goats	Sheep	Total small ruminants	Agricultural humans	Goats:sheep	Small ruminants per agricultural human
Côte d'Ivoire	816	874	1 690	1 555	0.93	1.08
Ghana	1200	990	2 190	4 347	1.21	0.50
Guinea	79	86	165	1 104	0.92	0.15
Liberia	190	190	380	1 268	1.00	0.30
Nigeria	5621	3476	9 097	11 955	1.62	0.76
Sierra Leone	59	20	79	1 601	2.95	0.05
Togo	45	33	78	233	1.36	0.33
Total	8010	5669	13 679	22 063	1.41[a]	0.62[a]

[a] Means

Source: Jahnke (1982)

PRODUCTION SYSTEMS

Small-ruminant production is just one of several farm activities undertaken in humid West Africa. Household food needs are met from cereals (maize, sorghum), root crops (cassava, yam, sweet potato) and food legumes (cowpeas) which are grown in a bush fallow rotation. Cash needs are met by income from cultivation of tree crops (cocoa, oil palm, rubber) and fruits (pawpaw, orange, plantain and banana). Small ruminants and other livestock are rarely integrated with crop production, and account for a small portion of household expenditures, but nevertheless make an important contribution to the total economy. This lack of crop–livestock integration means that crop residues and byproducts are not systematically and strategically used for livestock feeding, and the potential of animal waste to improve soil fertility and conservation is not fully exploited.

Perhaps the most common small-scale small-ruminant production system is that described as the traditional system—a low-input extensive or subsistence system, based on free grazing of roadside and bush forages complemented with kitchen wastes (peels of tubers and fruits, cereal brans) and crop residues (cereal stovers). Another common system of production is the intensive cut-and-carry feeding of tethered or confined animals, found in densely populated areas where almost all available land is devoted to cultivation, such as Eastern Nigeria and Benin Republic. In such densely populated areas, small ruminants are tethered or confined to protect crops and are therefore hand-fed, albeit with the same feed resources as in the free-roaming system.

Although the two systems are reasonably efficient in terms of the objectives and resources of the small-scale farmer (von Kaufman and Francis, 1989), there is room for improvement if major constraints facing the producers can be alleviated. Identified constraints include a high incidence of disease and pests, inadequate and fluctuating feed supply, poor husbandry and a lack of effective extension services (Ademosun, 1988; Atta-Krah and Reynolds, 1989; von Kaufman and Francis, 1989). This paper mainly addresses the problem of inadequate and fluctuating feed supply, particularly highlighting ways of alleviating this constraint through a judicious exploitation of the potential complementarity of the available feed resources.

AVAILABLE FEED RESOURCES

Feed resources available to smallholder production systems are natural pastures, browses, crop residues and kitchen wastes.

Natural pastures

Natural pastures grow on uncultivated land to which animals have access for grazing. They are found along roadsides and on fallow lands in the coastal forest belt of humid West Africa. They assume more important proportions in the open derived savannah. According to Atta-Krah and Reynolds (1989), natural pastures consist of a mixture of grasses such as *Imperata cylindrica*, *Andropogon gayanus*, *Pennisetum* spp and *Hyparrhenia* spp. These grasses grow rapidly during the wet season, becoming fibrous and coarse, and are undergrazed because of the large amounts that become rapidly available. Their quality declines further during the dry season when they become standing hay and are subject to overgrazing.

A review of published nutrient contents of these grasses shows that during the period of rapid growth (wet season) they contain, on average, about 25% dry matter, made up of 10% crude protein, 6% ash and a fibre content of 32% crude fibre or 43% acid detergent fibre (ADF). As the dry season advances and conditions become harsh, their nutritional quality declines to the extent that crude protein could fall to as low as 2%. Ash values decline to about 3–4% as a result of translocation to the root system, while fibre content increases in response to the process of lignification, sometimes to up to 50% crude fibre or 60% ADF.

In other words, these grasses cannot meet the nutrient requirements of small ruminants for most the year. Even during the rains they can only satisfy maintenance requirements. *In vitro* and *in vivo* studies carried out to evaluate these grasses have confirmed this conclusion.

In a recent study in which rumen degradability in sheep, goats and cattle was used as a screening technique to evaluate the potential nutritive value of various feed resources, Smith et al (1989) concluded, on the basis of 48-hour dry-matter degradability in sheep and goats, that because of high cell wall

Table 2. *Intake and utilisation of tropical grasses by goats*

Feed	Dry matter ($g/kg^{0.75}$) Offered	Dry matter ($g/kg^{0.75}$) Consumed	Digestibility (%)	Digestible dry-matter intake ($g/kg^{0.75}$)[a]
Panicum maximum (well fertilised, 6 weeks old)	75	54.9	75.8	41.6
P. maximum (hay)	77	43	45	19.4
Cynodon nlemfuensis (hay)	87.5	40.6	43.2	17.5
C. nlemfuensis (hay)	131.5	39.9	46.6	18.6

[a] NRC (1981) maintenance requirement for goats is 27 g digestible organic matter intake/$kg^{0.75}$ per day, ie, about 30 g digestible dry matter intake/$kg^{0.75}$ per day, assuming 10% ash

Source: Ademosun et al (1988)

contents during the dry season, the quality of grass forages such as *Pennisetum* and *Andropogon* spp may be too low to sustain the animals. Supplementation with browse or crop residues was recommended.

Data from Ademosun et al (1988), summarised in Table 2, confirm the suggestion that unless well fertilised, and harvested young, tropical grasses alone cannot supply small ruminants with the nutrients required for a reasonable production level. The production of high quality forages requires inputs and management know-how not yet available to the small-ruminant producers within the farming system described above. Other readily available feed resources must therefore be used to complement the forages. Fodder trees and shrubs (browses) can apparently fulfil this role.

Browses

Browses, in the form of fodder trees and shrubs, form an integral part of farming systems in humid West Africa (Atta-Krah et al, 1986). As their establishment and management require little effort, labour, time, technical know-how or resources, it should be easy to promote and intensify their use as animal feed. The multi-purpose nature of browses as fuel wood, shade, food (fruits), poles, etc, as well as their potential to improve soil fertility and conservation, are added incentives.

In terms of utilisation as animal feed, browses currently play an important, albeit non-strategic, role, as animals under confinement often receive one type or another of browse, from fallow lands or around homesteads. Efficient utilisation in a complementary way with grass forages and crop residues is what needs to be worked out through research, in order to exploit their potential nutritive value.

Data in the literature demonstrate the potential complementarity between browses and grass forages. The nutrient contents of some common browses, shown in Table 3, indicate that, on average, browses contain more crude protein and organic matter, but less fibre, than tropical grasses, and should, therefore, increase nutrient supply to the animal when combined with the poorer quality forage. Rumen degradability studies by Smith et al (1989) and others (Minor and Hovell, 1979; Kabaija, 1985) show that many browses degrade fairly well and rapidly (Table 3), supplying much needed soluble carbohydrates and fermentable nitrogen to the rumen, thus enhancing forage breakdown. Many of these browses contain high levels of essential elements such as calcium, sodium and sulphur, as well as critical microelements such as iron and zinc (Kabaija and Smith, 1989; Devendra, 1990), which have been shown to be deficient or borderline for productive purposes in many tropical grasses (Olubajo, 1974; Kabaija and Smith, 1987). Moreover, most of the browses remain green all year round and, if properly managed, continue to provide substantial amounts of foliage even during the dry season. Browses, therefore, complement grasses both quantitatively and qualitatively. Several feeding and growth trials have confirmed the potential of browses to enhance forage utilisation and improve performance.

In long-term studies designed to evaluate the effects of browse supplementation on the productivity of sheep (Reynolds and Adediran, 1987) and goats (Reynolds, 1989), pregnant ewes and does maintained on a basal diet of *Panicum maximum* were supplemented with graded levels of a 1:1 (w/w) mixture of *Gliricidia sepium* and *Leucaena leucocephala* over two reproductive cycles. Browse supplementation increased growth rate to weaning of both kids and lambs by 45%. When the effect of direct supplementation to the kids and lambs was examined, browse supplementation doubled growth rate from birth to six months in both species. It was also observed that browse supplementation increased overall daily dry-matter intake by the dams during the final two

Table 3. *Nutrient contents and rumen degradabilities of some common browses*

Browse	Dry matter (%)	% Dry matter: Crude protein	% Dry matter: Acid detergent fibre	% Dry matter: Crude fibre	% Dry matter: Ash	Dry-matter digestibility (%)	Half life (hours): Dry matter	Half life (hours): Nitrogen
Bamboo leaves	27.3	21.0	47.9	28.2	11.0	36.6	–	–
Cassava leaves	23.8	23.0	29.8	17.4	3.5	84.3	13.1	20.5
Gliricidia leaves	23.5	28.4	29.4	20.7	9.7	75.7	12.0	7.9
Leucaena leaves	24.0	30.0	33.8	31.7	8.8	70.0	23.2	21.2

Sources: Minor and Hovell (1979); Kabaija (1985); Ademosun et al (1988); Smith et al (1989) months of pregnancy and four months of lactation. A productivity index calculated as weight of offspring weaned/dam per year increased by 0.64 kg in goats, and 1.41 kg in sheep.

Recently, Ademosun et al (1988) reported that in a series of feeding trials with goats, results from preliminary experiments suggested that tropical grasses alone could not provide stall-fed goats with the nutrients required for reasonable production levels. Therefore, in subsequent trials they evaluated the effect of supplementing these grasses with two common browses, *Gliricidia* and *Leucaena*. The results, summarised in Table 4, demonstrate the potentials of these browses to improve the utilisation of poor quality forages. Follow-up studies were designed to investigate the potential of these browses as sole feeds, a feeding system that could be particularly valuable during the dry season when there is an acute shortage of conventional forages. Table 5 summarises some of the results obtained.

All of these studies suggest that the use of browses, such as *Gliricidia* and *Leucaena*, either as supplements to tropical forages or as sole feeds, is a viable feeding system in humid West Africa. The spectre of dihydroxypyridone (DHP) toxicity in the case of *Leucaena* should not be a deterrent, as evidence exists that rations containing up to 50% by weight of *Leucaena* constitute no hazards to sheep and goats (Ademosun, et al 1988).

Crops residues and kitchen wastes

As indicated above, an important component of the farming system in humid West Africa is the cultivation of various crops—food crops (maize, sorghum,

Table 4. *Complementarity of tropical forages and browses*

	Intake (g/kg$^{0.75}$ per day)	
Feed combination	Dry matter	Digestible dry matter
Panicum maximum hay *ad libitum*	43.1	19.4
Panicum maximum hay *ad libitum* plus		
10 g *Gliricidia*/kg$^{0.75}$	51.1	23.5
20 g *Gliricidia*/kg$^{0.75}$	58.7	30.0
30 g *Gliricidia*/kg$^{0.75}$	69.1	37.9
Panicum maximum hay *ad libitum*	48.3	22.9
Panicum maximum hay *ad libitum* plus		
10 g *Leucaena*/kg$^{0.75}$	50.8	20.2
20 g *Leucaena*/kg$^{0.75}$	66.1	34.4
30 g *Leucaena*/kg$^{0.75}$	68.4	32.6

Source: Adapted from Ademosun et al (1988)

Table 5. Leucaena *and* Gliricidia *as sole feed for goats*

Feed combination	Proportion consumed (%, dry-matter basis)	Intake ($g/kg^{0.75}$ per day) Total dry matter	Digestible dry matter	Growth rate (g/day)	% of optimum growth rate
Panicum maximum (hay)	100	43.1	19.5		
Gliricidia sepium	100	66.7	37.9	23.3	39
Gliricidia sepium plus *Leucaena leucocephala*	65 35	70.9	42.3	36.0	60
Gliricidia sepium plus *Leucaena leucocephala* plus Cassava	36 31 33	70.1	49.6	43.5	73
Panicum maximum plus Concentrate	20 80	77	55	60	100

Source: Adapted from Ademosun et al (1988)

cassava, plantain) or tree crops (cocoa, oil palm, rubber). Many of these crops undergo primary processing, either at the homesteads or farmsteads, thus producing a substantial amount of crop residues. Unlike browses, which tend to have medium to high nutritional values and hence complement poor quality forages, the nutritional value of crop residues could vary from high to low levels, similar to those of poor quality forages.

Many crop residues are low in protein, are highly fibrous and, therefore, low in fermentable carbohydrates. Such feeds fail to maintain an efficient rumen ecosystem for their own degradation and/or that of equally poor forages. Theoretically, but also from practical observations, it has been suggested that the characteristics of a maintenance diet for adult ruminants are a crude-protein level of 6–7%, a dry-matter intake of about 1.7% of body weight and a dry-matter digestibility of 50–55% (Devendra, 1985). Table 6 shows that many crop residues rarely meet these requirements. Such residues may require upgrading by chemical, physical or biological treatments to improve their value and usefulness. Such treatments may, however, not be economically suitable for small-scale small-ruminant production systems in humid West Africa.

Whereas crop residues (cereal straws, stovers) may not be suitable as supplements to poor quality forages, they could be used as basal feeds, supplemented with better quality feed materials such as browses. Evidence exists

Table 6. *Voluntary dry matter intake and digestibility of selected crop residues*

Crop residue	Crude protein (%)	Intake as % of body weight		Dry-matter digestibility (%)		Sources
		Sheep	Goats	Sheep	Goats	
Maize stover	4.0	–	0.7	–	53	1
Sorghum stover	4.0	–	2.0	–	57	1
Rice straw	4.2	1.4	1.9	47	48	2
Cocoa pods	5.0	–	–	20	–	3

Sources: 1. Alhassan et al (1984); 2. McManus et al (1972); 3. Smith and Adegbola (1982)

Table 7. *Performance of goats fed on crop residues supplemented with browses*

Basal diet[a]	Dry-matter intake ($g/kg^{0.75}$ per day)	Growth rate (g/day)
Corn stover	78.5	56.3
Sorghum stover	74.8	55.0
Sugar-cane tops	67.3	50.0

[a] All three diets supplemented with groundnut haulms, cassava tops and *Leucaena* leaves

Source: Soedomo-Reksohadiprodjo (1985)

in the literature (Table 7) that a feeding system consisting of fibrous crop residues supplemented with browses is a viable one.

Other crop residues could, nevertheless, be used as supplements in feeding systems based on poor quality forages, because of their fairly high nutritive values. Such residues as roots and tuber peels, cereal brans and grain legume brans supply a fairly high amount of much needed soluble carbohydrate and fermentable nitrogen to the rumen. The potential feeding value of this category of crop residues is demonstrated in Table 8.

Table 8. *The value of sun-dried peels as supplements to poor quality tropical forage for sheep*

Diet[a]	Dry-matter intake (kg/day)	Weight gains (g/day)	Dry-matter digestibility (%)
70% *Pennisetum purpureum*	0.87	45.2	50.7
35% *Pennisetum purpureum* plus 35% Cassava peels	1.36	106.7	79.0
70% Cassava peels	1.06	227.1	88.1

[a] All diets supplemented with cottonseed cake

Source: Fomunyam and Meffeja (1987)

In other words, in order to maximise the feed value of crop residues in humid West Africa, researchers need to investigate this nutritive-value-based dichotomy, and classify these materials into potential supplements to forages or browses, and potential basal feeds that require supplementation with browses. Table 9 shows such a classification for some crop residues available in the forest belt of humid West Africa. The classification based on crude-protein and fibre (ADF or NDF) contents and *in-situ* degradability will facilitate the formulation of feeding systems that maximise the use of available feed resources.

Table 9. *Nutritional role of common crop residues in humid West Africa*

	% DM			
Crop residue classification	Crude fibre	Acid detergent fibre	Crude protein	*In situ* degradability (% DM)
Basal feeds				
Rice straw	20–45	45–55	2–9	30–34
Cocoa pods	20–45	55–59	2–8	38–40
Sugar-cane tops	28–34	43	5–8	10–20
Sorghum stovers	31–35	45–50	3–6	25–30
Corn stovers	28–46	46–50	2–8	50–65
Supplements				
Cassava peels	10–22	15–18	3–7	70–75
Yam peels	5–8	10–12	5–8	75–80
Sweet potato peels	–	15–18	6–10	80–90
Cowpea husk	40–45	38–40	6–10	70–75
Maize bran	–	8–10	15–20	75–80

RECOMMENDATIONS

From the foregoing, it is clear, that a number of feasible feeding strategies exist. In order to exploit available resources, the choice must be guided by season, number of animals to be fed, available resources and ecological zone. The suggested systems shown in Table 10 have been guided by these factors as well as by research results discussed above.

The list of suggested feeding systems in Table 10 is by no means exhaustive, and many more could be added as a result of current and future research results. Some of the pressing future research needs which have high potential pay-offs include:

- characterisation through nutritional studies of the role of various crop residues and kitchen wastes as supplements or basal feeds within particular feeding systems

Table 10. *Suggested feeding systems for small ruminants in humid West Africa*

Feeding system	Target belt	Target season
Forage based		
Forage plus browse	Forest, Savannah	Wet
Forage plus browse plus crop residues	Forest, Savannah	Wet
Forage plus highly fermentable crop residues	Forest, Savannah	Wet
Browse based		
Browse alone	Forest, Savannah	Dry
Browse plus fermentable crop residues	Forest, Savannah	Dry
Crop-residue based		
Fibrous crop residues plus browse	Forest, Savannah	Dry
Fibrous plus fermentable crop residues	Forest, Savannah	Dry
Novel systems		
Under-tree crop grazing plus supplement	Forest	Wet
Alley farm foliage plus crop residue	Forest	Dry
Fodder banks	Savannah	Dry

- nutritional evaluation of local browse species. The advantages of promising local species over introduced species such as *Leucaena*, in terms of farmer adoption, are obvious
- integration of small ruminants into the alley farming concept, particularly working out the proportion of foliage to be recycled directly as mulch, or indirectly through animal faeces, in order to ensure sustainability
- development of small-scale producer-targeted technology for making forage silages. Such technology would involve no more machinery than a hand-run chopper and no additives other than forages, crop residues or browses rich in fermentable carbohydrates and nitrogen
- integration of small ruminants into tree-crop production
- adaptation of the fodder bank concept to small-ruminant production.

CONCLUSIONS

Efforts to alleviate current constraints of inadequate and fluctuating feed supply to small ruminants in humid West Africa should be directed primarily toward a proper knowledge of the nutritional characteristics of various feed resources available in order to fully exploit the natural complementarity that exists between them. Current feed management and utilisation practices also need to be examined critically, in order to identify those that maximally exploit the nutritional potential of the feed resources.

For example, farmers keeping small ruminants in the forest belt of humid West Africa feed crop residues and kitchen wastes such as cassava peels, maize bran and cowpea husks to their animals first thing in the morning, before turning the them out to graze fibrous grasses all day. Results of rumen degradability studies suggest that this system should be the other way round, with the rapidly degraded peels, brans and husks fed late in the afternoon and at night, to better synchronise the release of the energy and nitrogen they contain with those of the less rapidly degraded grasses. This thesis needs to be verified on-farm.

The abundant, lush and nutritive roadside and fallow land grasses during the rains are currently underutilised. This resource needs to be preserved as silage for dry-season feeding. The challenge to researchers is to develop an ensiling technology harmonious with the resources of the small-scale producers.

Feed constraints currently limiting small ruminant production and productivity in humid West Africa are, to a large extent, due to a non-strategic utilisation and combination of available feed resources, to develop production feeding systems, rather than absolute quantitative and qualitative shortages.

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SOCIO-ECONOMIC AND POLICY ASPECTS OF USING CROP RESIDUES AND AGRO-INDUSTRIAL BYPRODUCTS AS ALTERNATIVE LIVESTOCK FEED RESOURCES IN NIGERIA

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ABSTRACT

Nigeria has an immense capability to produce many different types of crop residues and agro-industrial byproducts which could be used to improve livestock nutrition. However, for various socio-cultural and policy reasons, farmers are not making use of these resources at present.

A model feeding trial demonstrates the profitability of the use of non-conventional feed resources, and suggestions are made for policy interventions in areas of preservation and treatment, transportation, extension and research.

RESUME

Aspects socio-économiques et stratégiques de l'utilisation des résidus de récolte et des sous-produits agro-industriels dans l'alimentation des animaux d'élevage au Nigéria

Compte tenu de ses énormes potentialités en la matière, le Nigéria pourrait produire un grand nombre de résidus de récolte et de sous-produits agro-industriels propres à servir d'aliments du bétail. Malheureusement, les paysans ne s'intéressent guère aujourd'hui à ces ressources et ce, pour diverses raisons y compris des raisons d'ordre socio-économique et stratégique.

Un régime alimentaire modèle expérimenté dans le cadre de cette étude a cependant permis de mettre en évidence les avantages économiques de l'utilisation de ces ressources alimentaires non conventionnelles. Enfin, des interventions stratégiques appropriées ont été recommandées en vue de promouvoir la conservation, le traitement, le transport et la vulgarisation des résidus de récolte et des sous-produits agro-industriels ainsi que la recherche dans ce domaine.

INTRODUCTION

Large quantities of crop residues, produced on private and government farms in Nigeria, are wasted year after year. Some are left to rot in the fields, which may improve soil fertility, but most are burned. Similarly, most agro-industrial concerns in the country dispose of their valuable byproducts in non-beneficial ways. Although there is much evidence that livestock fed crop residues and agro-industrial byproducts can achieve substantial weight gains (eg, Ward, 1978; O'Donovan, 1979), a recent survey in Benue State, Nigeria, (Ayoade and Ayoola, 1991) shows that, on average, more than 60% of livestock farmers are not aware of the value of crop residues in animal nutrition.

Recently there has been a growing policy recognition of the role of non-conventional feed resources in livestock development. Following the acute shortage of foreign exchange for importing concentrates in the structural adjustment period, the government has set up a task force to investigate and advise on the prospects and possibilities of using the alternative livestock feed resources available in the country. This paper examines some aspects of the use of crop residues and agro-industrial byproducts in livestock production.

AVAILABILITY AND UTILISATION

A general knowledge of the availability and utilisation of crop residues and agro-industrial byproducts in the various agro-ecological zones of Nigeria is important for assessing the potential of these resources.

The agricultural economy of the southern part of Nigeria is largely based on tree crops; ruminant production is a secondary activity, mainly because of the tsetse fly menace. The forest is principally exploited for wood, rubber and palm oil; secondary crops include cocoa, coffee, citrus, banana and plantain. Towards the north, more land is available for arable farming. Swampy rice thrives in the delta areas, particularly in River and southern Bendel States, while yam, cassava, cereals and legumes are abundant in the rest of the southern zone, including Anambra, Imo, Ondo and the southern part of Oyo State. Thus the crop residues available in this zone are immense quantities of cocoa pods and cassava and yam peels as well as enough cereal straws and legume haulms to sustain the local livestock population during the dry season.

The savannah middle belt (covering northern Oyo, Kwara, Benue, Niger, Plateau, and the southern fringes of Kaduna and Gongola States) operates an active grains economy. Arable farming thrives with crops like soybean, maize, upland and fadama rice, sugarcane, sorghum, yam and millet. These are usually cultivated in homesteads together with livestock—mainly goats and poultry, although sheep and cattle are also kept. Cattle rearing generally involves Fulani agropastoralists who move progressively southwards into this zone in the dry season. Sedentary and semi-settled Fulanis can also be found interspersed in the zone with small farms around their houses, integrated with cattle, sheep, goats and poultry (Nuru, 1989). Thus the savannah middle belt produces large amounts of rice straw, maize stover, millet/sorghum stover, soybean straw and yam peels as the main residues from cropping activities.

The ecology of the far north, in Kano, Sokoto, Kaduna, Katsina and Borno States, supports valuable crops such as cotton, wheat, groundnut, millet, sorghum and cowpea. The area is somewhat arid, but there is a vast expanse of land for arable cropping without the need to fell trees. This zone has great potential to supply large quantities of groundnut haulms, wheat stover, cowpea haulms and millet/sorghum stover. It also sustains a large population of ruminant animals; transhumance of cattle Fulanis is prominent in addition to homestead rearing of ruminants and poultry.

Nigeria has numerous small-, medium- and large-scale agro-industrial concerns, and hence an immense capability to supply agro-industrial waste materials to agriculture. For example, the brewing industry serves as an important source of brewers' wastes for feeding livestock.

Although crop residues are widely available throughout the country, their use as livestock feeds is limited to the northern zone. On the other hand, the use of industrial byproducts is only popular in the south, among pig owners who obtain brewers' waste direct from nearby breweries. Treatment of these products to enhance nutrient intake and availability is not common in the country as a whole, although recently some attempts to introduce this technology have been made by the National Livestock Development Project and Agricultural Development Projects.

SOCIO-CULTURAL DIMENSIONS

Table 1 shows a profile of livestock farmers in Benue State (Ayoade and Ayoola, 1991). Most livestock owners are of an age when their physical and mental abilities limit their involvement in business activities; older people cannot invest in crop residue sourcing, preservation and treatment on their own, without the help of their children, but children are often away in urban centres, at school or working. So most crop residues are left in the fields after the harvest. In addition, the level of literacy is too low to facilitate efforts of extension agents to introduce crop residues and byproducts into the farmers' animal nutrition practices; most farmers have had no schooling. Also, many small farmers keep livestock for reasons other than cash income, for example, for ceremonies or simply as a hobby. Such farmers may be unwilling to spend money on acquiring, preserving and treating crop residues or byproducts.

Ayoade and Ayoola (1991) also found that livestock production at the household level is mainly the work of women. But according to other surveys in Benue State (Akpaiyo, 1991; Unaji, 1991), women's production capabilities are greatly limited by socio-cultural factors. For example: sheep and pig rearing is believed to reduce women's fertility and cause human infant mortality; ownership of cattle by women is forbidden by the gods, who could punish

Table 1. *Selected features of livestock producers in Benue State, Nigeria, 1989*

		Frequency (%)
Age (n=72)	<20	0.3
	21–40	36
	41–60	52
	>60	12
Literacy level (n=740)	No schooling	78
	Adult education	2
	Primary school	14
	Secondary school	5
	Post-secondary school	1
Objectives (n=81)	Money	51
	Money and ceremonies	37
	Ceremonies	5
	Hobby	8

Source: Ayoade and Ayoola (1991)

defaulters; and certain animals are associated with witchcraft. As a result, livestock production is generally low, and so there is only limited demand for crop residues and agro-industrial byproducts in farm activities.

The last socio-cultural factor to be considered is the transhumance of Fulani agropastoralists. At the onset of the dry season these people move south in search of greener vegetation, and thus use grasses and harvested cereal straws *in situ* to feed their animals. Preservation of crop residues is not a priority for them because they move north again when the rains start.

Extension efforts to develop the use of crop residues and agro-industrial byproducts in livestock production need to take into account these socio-cultural factors. For example, taboos associated livestock keeping need to be overcome; agropastoralists could be encouraged to settle; the profitability of crop-residue use in animal production could be demonstrated, especially to farmers who keep animals only for ceremonial or hobby reasons. Such efforts may increase the numbers of ruminants kept by household which, in turn, may enhance the use of crop residues and industrial byproducts for their nutrition.

ECONOMIC AND POLICY CONSIDERATIONS

Profitability assessment

In order to demonstrate the profitability of enhanced livestock nutrition, a feeding trial was conducted at Makurdi. Two-year old Bunaji and Gudali feeder cattle, weighing 200 kg, were fed crop residues supplemented with agro-industrial byproducts (cottonseed cake (CSC), brewers' dried grains (BDG) and molasses) for 120 days. Health precautions taken during the fattening period included deworming, tick bathing and vaccinations according to standard recommendations.

During the first two weeks in the stall, each animal was given 3 kg crop residue, 1 kg BDG, 1 kg CSC and 1 kg molasses daily. After two weeks, each animal was given 5 kg crop residue, 2 kg BDG, 1.5 kg CSC and 2 kg molasses daily. The animals were fed twice a day, half the daily allowance being given at each meal. The supplements were well mixed before administration, and clean water and salt licks were available *ad libitum*.

A daily weight gain of 0.67 kg was achieved. Details of costs and returns on live and slaughtered animal bases are summarised below.

Liveweight basis

		Naira
Income from sale of two finished feeders at Naira 10/kg liveweight (finished weight = 280 kg)		5600
Less variable costs:		
2 feeder cattle at Naira 1000 each	2000	
480 kg BDG at Naira 0.75/kg	360	
360 kg CSC at Naira 0.80/kg	288	
240 kg molasses at Naira 1.5/kg	360	
1200 kg crop residue at Naira 0.20/kg	240	
5 Salt licks at Naira 30 each	150	
Medication at Naira 50/animal	100	3498
Gross margin		**2102**

Slaughtered basis

		Naira
Income from slaughtering and processing of two finished feeders:		
Lean meat (2 x 100 kg) at Naira 20/kg	4000	
Bone meat (2 x 15 kg) at Naira 15/kg	450	
Offals (2 x 10 kg) at Naira 15/kg	300	
Tails (2) at Naira 60 each	120	
Skins (2) at Naira 150 each	300	
Heads (2) at Naira 100 each	200	
Shanks (2 x 4) at Naira 30 each	240	5610
Less variable costs		3498
Less processing/slaughter cost (Naira 50/animal)		100
Gross margin		**2012**

The cattle fattening enterprise is profitable on both liveweight and slaughtered bases and so farmers adopting the use of residues and byproducts would be assured of substantial returns to labour and management. Proper management practices such as cooperative sourcing of animals, crop residues, byproducts and medication, would lead to even higher gross margins.

It appears that economic reasons alone cannot explain the observed limited uses of these feed materials in the livestock industry. The possibility exists, therefore, for livestock extension services to make an impact in this regard among the livestock farming population.

Inhibitory policy environment

The national agricultural policy has provisions for encouraging livestock farmers to "practise various forms of fodder conservation techniques" and to "ensure the proper utilisation of all agro-industrial byproducts and crop residues which are found to be suitable for livestock feeding". However, few practical efforts have been made to apply these policy intentions (FMAWRRD 1988).

There are three observable features of the livestock policy environment that inhibit the use of crop residues and industrial byproducts in Nigeria. First, agro-industries are generally not located in the same areas as the main livestock population. Therefore byproducts which accumulate in the industrial areas cannot be distributed to livestock owners at the time, and in the form and quantities, desired, without incurring excessive transport costs. For example, the Savannah Sugar Company at Numan and the Nigeria Sugar Company at Bacita are located far from areas of livestock concentration such as Kaduna, Kano and Sokoto States, and there are no railway links for easy haulage. Furthermore, the distribution of breweries is skewed toward the south of the country whereas the greatest population of ruminant livestock is located in the north. This constraint could be overcome by the development and use of suitable means of treatment, preservation and transport of the byproducts.

Second, little or no effort has been made to demonstrate to farmers the advantages of using crop residues and agro-industrial byproducts in livestock production. This is a part of the observed laxity of livestock extension in general. The Nigerian agricultural extension system is largely biased towards crop production, and so what is needed is a complementary extension effort in the area of livestock production to enhance understanding of sourcing, handling and utilising crop residues in animal nutrition, particularly under the prevalent mixed farming systems in the country. The current proposal for unifying agricultural extension systems should pay attention to this area. This new effort should incorporate the use of proven extension methods, such as demonstrations, training, visits and adaptive research activities.

Third, the tempo of research on crop residues and byproducts appears low in the country. Research needs to be conducted on such issues as nutrient quality of available residues and byproducts, treatment methods and feeding trials. The economics of crop residue and byproduct utilisation also requires intensive analytical investigations to formulate least-cost rations for animal nutrition. There are plenty of opportunities for a concerted research effort to raise and utilise the potential of these materials.

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COMPARING COSTS ASSOCIATED WITH THE UTILISATION OF CROP RESIDUES AND PLANTED PASTURES IN SMALLHOLDER PRODUCTION SYSTEMS IN THE HIGHLANDS OF HAI DISTRICT, TANZANIA

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ABSTRACT

This paper discusses the costs associated with the utilisation of crop residues and planted pastures as major animal feed resources in smallholder production systems in the highlands of Hai District, Tanzania. The quantitative effects of changes in transportation costs and prices of concentrate supplements on the profitability of using crop residues and planted pastures are illustrated using linear programming models. The costs associated with the use of planted pastures are lower than those associated with the use of crop residues obtained from maize and bean farms in the lowland zone, especially in the long term. And the difference becomes greater as transportation costs and prices of concentrate supplements increase.

RESUME

Comparaison des coûts associés à l'utilisation des résidus de récolte et des cultures fourragères dans les systèmes de la petite exploitation dans le district de Hai en Tanzanie

Cet article est consacré à une analyse des coûts associés à l'utilisation des sous-produits agricoles et des cultures fourragères en tant que principales sources d'aliments du bétail dans les systèmes du petit élevage des hauts plateaux du district de Hai en Tanzanie. Des modèles de programmation linéaire ont servi à illustrer les effets quantitatifs des variations des frais de transport et des coûts des concentrés sur la rentabilité des résidus de récolte et des cultures fourragères. Dans les plaines, les coûts associés aux cultures fourragères sont inférieurs à ceux relatifs aux résidus des cultures de maïs et de haricot notamment à long terme. Cette différence se creusait avec l'accroissement des frais de transport et du prix des concentrés utilisés comme compléments.

INTRODUCTION

Smallholder production systems based on crop growing combined with stall-fed crossbred dairy cows have been successfully developed in the highlands of Hai District, Tanzania. Increased population pressure has resulted in progressively smaller agricultural holdings and grazing land has been taken for perennial crops, especially coffee and banana. Lack of grazing land has induced most smallholder farmers to resort to using crop residues from the lowland zone and established pastures from the highlands as major animal feeds. The most common crop residues are maize stover and bean straw. Planted pastures include elephant grass (*Pennisetum purpureum*), setaria (*Setaria anceps*), Guatemala grass (*Tripsacum laxum*) and *Desmodium* spp.

Various projects have been initiated to improve feed resources for small farmers in Hai District. For example, the Integrated Dairy Development Programme, financed by FAO (Food and Agriculture Organization of the United Nations), was started in 1985. One of its objectives was to improve feeding of dairy cattle by helping smallholder farmers to grow improved pastures on their own land, and by improving the nutritional value of crop residues. Another project, the Dairy Feeding Systems project, financed by the International Development Research Centre of Canada, was started in 1984. Phase I of this project, carried out between 1984 and 1987, concerned developing feeding packages based on maize stover, bean straw and molasses–urea, and these feeding packages have been adopted by many smallholder farmers in the highlands (Mdoe and Mlay, 1990). While continuing with the activities of phase I, phase II of the project has put more emphasis on developing planted pastures in smallholder farmers' plots in the highlands.

There are problems associated with both categories of feed resources that the above projects are attempting to improve. Crop residues must be transported from maize and bean farms in the lowland zone to the homesteads in the highland zone. Furthermore, crop residues have low nutritive value, and so must be supplemented with high levels of concentrates. Establishment of pastures, on the other hand, is constrained by scarcity of land; most of the land is already under coffee/banana. However, if the costs of establishing pastures are compared with those of using crop residues from the lowland zone, it might be less costly, in the long term, for the farmer to use some land for pasture establishment rather than depend on crop residues.

Feed accounts for a large proportion of the total cost of dairy production, so the profitability of smallholder milk production can be increased if farmers could use low-cost feed resources that provide the required nutrients.

This paper discusses the costs associated with utilising crop residues from the lowlands and planted pastures in the highlands in Hai District. It then assesses the impact of changes in transport costs and prices of concentrate supplements on the profitability of using these feed resources, based on results of linear programming models developed by Mdoe (1985).

COSTS CONSIDERED

Beinerlein (1986) categorises costs into explicit and implicit costs. Explicit costs are cash costs incurred when inputs are purchased for production and these costs are directly determined as the money outlay required to obtain inputs. Implicit costs are costs which do not involve direct payment; they include unpaid family labour, depreciation and opportunity cost of resources.

Implicit costs are difficult to quantify (Osburn and Kenneth, 1982). Even so, they must be considered in estimating costs of production; if they are not, such estimates tend to be understated. Implicit costs considered in this paper are the opportunity costs of resources; opportunity cost is expressed as the return a resource can earn when put to its best alternative use.

COSTS ASSOCIATED WITH UTILISATION OF CROP RESIDUES

Major costs incurred by smallholders in using crop residues as animal feed in the highlands of Hai District include transport costs, upgrading costs and the opportunity cost of removing crop residues from farms in the lowlands.

Transport costs

Crop residues have to be transported from maize and bean farms in the lowlands to the highlands where animals are stall-fed. The bulkiness of the crop residues and lack of transport constrain the utilisation of crop residues. Modes of transporting the crop residues include carrying them on the head, bicycles and vehicles, especially pick-ups. Because hiring pick-ups is a common practice in the area, rising fuel prices and/or shortages of vehicles and spare parts will lead to increasingly high costs of transporting crop residues.

Baling crop residues to reduce their bulk and hence increase the quantity that can be transported could be a way of reducing transport costs. Baling is expensive for individual smallholder farmers, because of the equipment required and the need to bale large quantities to achieve economies of scale. Baling could, however, be carried out on a cooperative basis. Several large-scale farms in Kilimanjaro and Arusha already bale maize stover and bean straw and sell the bales to smallholder farmers.

Costs of upgrading crop residues

Crop residues are characteristically low in protein and high in fibre and lignin. As a result, digestibility is slow, rate of passage is low and voluntary intake is limited. Intake and digestibility of the crop residues could be improved by chopping, chemical treatment or supplementation with concentrates or molasses/urea (Kategile et al, 1981; Kiflewahid et al, 1983; Wanapat and Devendra, 1985).

There has been great variation in the extent to which these methods have been practised by smallholder farmers in the highlands of Hai District. The major limiting factor to the adoption of a particular method is the cost involved.

Chopping

Many smallholder farmers in the highlands of Hai District chop stover in order to reduce bulk, increase consumption and reduce wastage. The major drawback is availability and cost of choppers to individual smallholder farmers.

Chemical treatment

FAO started trials on chemical treatment of maize stover in Hai District in 1987. These trials were followed by a small-scale residue treatment campaign in 1988. However, this practice has not been adopted by smallholder farmers, mainly because of lack of availability and high cost of chemicals.

Supplementation with concentrates

The commonest concentrate supplements used in Hai District are cottonseed cake, wheat bran/pollard and maize bran. Smallholder farmers usually buy concentrates from cooperative societies in their villages. The cooperative societies procure and transport the concentrates from the Tanzania Farmers Association, the Kilimanjaro Native Cooperative Union and/or private traders in Moshi and Arusha. This arrangement is very beneficial and popular with smallholder farmers, but it sometimes fails, especially when concentrates are in short supply and the farmers have to buy them from other sources.

Shortage of concentrate supplements is a serious problem, not only in Hai District but throughout Tanzania. And shortages lead to frequent price rises. For example, the price of cottonseed cake increased by more than 400% between 1984 and 1990. For this reason concentrates are mainly used as a stimulant for milk let-down rather than as supplements to increase intake of crop residues.

Supplementation with molasses/urea

A simple plant for mixing molasses and urea has been constructed, with FAO assistance, at a sugar factory 20 km south of Moshi municipality and about 45–60 km from villages in the highlands of Hai District. The molasses/urea mixture is normally transported to storage tanks built at various cooperative societies which are supply centres to the smallholder farmers. Because of high transport costs, the cost of using molasses/urea as a supplement to enhance intake of crop residues is also high, and is likely to increase even more with the frequent rises in the price of fuel.

Opportunity cost of crop residues

There is competition between the utilisation of crop residues as a dairy cattle feed and their utilisation to maintain soil fertility in the lowland zone. Most of the crop residues are taken away from farms in the lowland zone and fed to dairy cattle in the highland zone. The cow dung is never recycled back to the farms in the lowland zone; instead it is used for coffee/banana production in the highland zone. Therefore farmers in the lowland zone have to use commercial fertilisers to maintain soil fertility in their farms.

The opportunity cost of using crop residues as feed for dairy cows is the value foregone by not using them to maintain soil fertility.

COSTS ASSOCIATED WITH PLANTED PASTURES

Explicit costs associated with planted pasture are seed, labour and fertiliser or manure costs.

Seed costs

Most smallholder farmers in the highland zone have Guatemala grass, setaria and elephant grass near their homesteads and so can obtain planting materials for these grasses from their own plots or from neighbours at no cost. Forage legumes are not widespread but *Desmodium* cuttings are available free of charge in most villages in the highlands. *Desmodium* seeds are, however, difficult to obtain. The Dairy Feeding Systems project has established seed production plots at two sites in Hai District but the *Desmodium* seed output from these plots is not yet enough to satisfy demand. The small amount of seed that is produced is currently distributed to small farmers free of charge, but it might be necessary in future to charge a small fee in order to sustain the seed production and distribution.

Labour costs

Labour for cultivation, planting, weeding, fertilisation, irrigation and cutting and carrying harvested pasture to cattle sheds is normally provided from within the family, but hired labour is also used to supplement family labour. Labour charges for pasture production depend on the type of work performed, and are higher for cultivation and weeding operations. In general, however, hired labour is available at relatively low cost.

Fertiliser/manure costs

Manure produced by dairy cows and other types of livestock is widely used in the highland zone, not only for pasture production but also for coffee/banana production. Use of commercial fertilisers is recommended where soil nutrient deficiencies cannot be corrected by manure application (Msumali, 1990). Smallholder farmers obtain manure from their own farms or from neighbours, mainly free of charge.

The costs involved in using manure for pasture production are the costs of collecting manure from cattle sheds, carrying it to pasture plots and spreading it on the plots. If family labour is used the farmer does not incur any explicit costs for these operations; explicit costs are incurred only if the farmer hires labour.

Opportunity cost of pasture land

Because land is a very scarce resource in the highlands of Hai District, planted pastures compete for land with coffee and banana production. The opportunity cost involved in using the scarce land for pasture production rather than producing coffee/bananas is therefore the value of the coffee and bananas given up by using the land for establishing pasture.

QUANTITATIVE ANALYSIS OF COSTS ASSOCIATED WITH THE FEED RESOURCES

Multiperiod linear programming results from a study conducted by Mdoe (1985) illustrate the impact of changes in transport costs and prices of concentrate supplements on the profitability of using crop residues and planted pastures as major feed resources.

Mdoe (1985) developed two 20-year period linear programming models—one representing a crop-residue feed-management system and the other a pasture feed-management system—to compare the profitability of using these resources as major feeds for dairy cattle in the Kilimanjaro highlands. The general mathematical form of the model is:

$$Maximise\ Z = \sum_{k=1}^{p} \sum_{j=1}^{n} C_{jk}\ (1+r)^{-t}\ X_{jk}$$

Subject to:

$$\sum_{k=1}^{p} \sum_{i=1}^{m} \sum_{j=1}^{n} a_{ijk}\, X_{jk} \lesseqgtr b_{ik}$$

and

$$X_{ik} \geq 0,\ X_{2k} \geq 0,\ \ldots\ X_{jk} \geq 0$$

where:

Z = present value of the net returns
n = number of activities in the kth period of the model
t = time in years
p = number of periods in the model
r = discount rate
$\bar{m}$ = number of resources used
b = level of resource constraints
c_{jk} = revenue or cost per unit of the jth activity in the kth period
$(1+r)^{-t}$ = present value discount factor at r discount rate for year t

The basic model for each feed management system represented a farmer keeping crossbred cows. Improved or exotic breeds were modelled by altering productivity coefficients in the basic models.

The profits determined in each model were defined as the cumulative net present value (NPV) of net returns over a 20-year planning horizon. The results of the basic models indicate that the use of planted pastures was more profitable than the use of crop residues as major feeds for dairy cows (Table 1). When transport costs were increased by 40% above the 1984 average prices, NPV fell by 12.3% in the crop-residue system but by only 4.7% in the pasture system (Table 1).

The extent to which NPV for each system was affected by increases in prices of concentrate feeds was also assessed. When the price of concentrate feed was increased by 30% above the 1984 average prices, NPV declined by 5% for the pasture system and by 28% for the crop-residue system.

Table 1. *Net present value for pasture and crop residue systems with and without increase in transport costs*

	Net present value (TSh)	
	Pasture system	Crop system
Without increase in transport cost	76 655	74 704
With 40% increase in transport cost	73 07[illegible]	65 527

Source: Mdoe (1985)

CONCLUSIONS

The costs associated with the use of crop residues are higher than those associated with the use of planted pastures as major dairy feeds in the highlands of Hai District. They are also affected more by increasing transport costs and prices of concentrate supplements, because crop residues must be transported from the lowland zone to the highland zone whereas pastures are established near the homesteads, and because crop residues require relatively large amounts of concentrate supplements to improve their nutritive value as compared to planted pastures. In the short term, initial pasture establishment costs may make pasture production more costly than the utilisation of crop residues. In the long term, however, utilisation of planted pastures becomes less costly than utilisation of crop residues, especially with the ever-increasing fuel prices. Smallholder farmers with limited land to establish adequate pastures should feed crop residues supplemented with forage legumes to increase their returns through higher intake and more efficient digestion.

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MANAGEMENT OF THE WEST AFRICAN DWARF GOAT IN THE HUMID TROPICS: A SOCIO-ECONOMIC APPRAISAL OF FEEDING REGIMES

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Ile–Ife, Nigeria

ABSTRACT

A management package for dwarf goat production developed on-station at Ile–Ife, Nigeria, is now being tested on-farm at the village level. Among other issues, the project is investigating the zootechnical and socio-economic implications of changing from a traditional feeding regime based on roadside grass and household kitchen byproducts (cassava, yam and banana peelings, maize bran) to a diet of good quality browse (*Gliricidia sepium* and *Leucaena leucocephala*) and grass (*Panicum maximum*). While highlighting the favourable effects of a browse-based diet on animal performance, this paper draws attention to some socio-economic implications of adopting such a feeding regime. It is argued that factors to consider include the prevailing farming systems in each locality and the investments required, in terms of land and labour, for goat production in relation to competing enterprises.

RESUME

Gestion de la chèvre naine d'Afrique occidentale en région tropicale humide: évaluation socio-économique des régimes alimentaires

*Un paquet technolgique élaboré en station à Ile Ife sur la gestion de la chèvre naine d'Afrique occidentale est actuellement en cours d'expérimentation en milieu réel. Entre autres questions, les travaux effectués étudient les conséquences zootechniques et socio- économiques du passage du mode d'alimentation traditionnel basé sur la divagation et les ordures ménagères (pelures de manioc et d'igname, son de maïs) à un régime alimentaire constitué de fourrages ligneux de qualité (*Gliricidia sepium *et* Leucaena leucocephala*) et de graminées (*Panicum maximum*). Après avoir souligné les avantages d'un régime à base de ligneux quant aux performances des animaux, cette étude* *souligne certaines des conséquences socio-économiques de l'adoption d'un tel système. Il est proposé, avant d'introduire un tel système, non seulement d'examiner de près un certain nombre de paramètres, y compris le type de système en place, mais également de comparer les investissements en terre et en main-d'oeuvre nécessaires pour l'élevage caprin aux autres exigences eventuelles d'autres activités concurrentielles.*

INTRODUCTION

Goats are an important and preferred source of meat in the humid tropics and particularly in southern Nigeria. To individual owners, goat rearing is also an important source of income. In a 1977 study of two villages in the humid tropical zone of southern Nigeria, Matthewman (1977) indicated that 91% of farmers interviewed gave cash income as the main reason for keeping animals. Okali and Sumberg (1985) also indicated that small ruminants are one of a limited number of sources of income large enough to be used for capital investment.

Given the importance of the goat to the socio-economic milieu of the rural population, a study of goat production management and feeding patterns in the humid tropics deserves attention. This paper examines some socio-economic considerations with respect to feed provision to West African Dwarf goats maintained under the extensive (traditional) and intensive (modern) management systems. The paper draws largely on the experience gathered from the West African Dwarf Goat (WADG) Research Project at Ile–Ife, Nigeria.

BACKGROUND INFORMATION ON THE WADG PROJECT

The joint Nigerian/Dutch research project "Management of the West African Dwarf Goat in the Humid Tropics" began in August 1981 with on-station research at Obafemi Awolowo University, Nigeria. Adopting an interdisciplinary approach (animal science, plant science, agricultural economics and extension), the project came up with a management package for dwarf goat production. The package has elements in common with alley farming developed by the International Institute for Tropical Agriculture (IITA) and with the goat improvement programme of the International Livestock Centre for Africa (ILCA), but differs from both by incorporating health and disease control with nutrition and management of the goats. The elements of the Ile–Ife package are:

Health: Animal vaccination against Peste de Petits Ruminants and quarterly dipping or washing with lindane solution against ectoparasites (mites, lice).

Nutrition: Based on roadside grass (*Panicum maximum*), browse products (*Gliricidia sepium* and *Leucaena leucocephala*) and industrial byproducts (brewers' dried grains) for critical periods.

Management: Housing in bamboo huts with slatted floors. Twice daily feeding of adults and growers on a group basis, with suckling kids supplemented in a creep feed area. Semi-controlled breeding, with bucks being rotated daily between pens with breedable females.

At present, the components of this package are being tested on-farm (Moll, 1989). The on-farm programme focuses on three broad topics:

- the actual performance of the various goat-keeping subsystems under village conditions
- the possibilities various types of households have for the potential incorporation of any of the goat-keeping subsystems
- the actual acceptance of the various goat-keeping subsystems in the villages

One subsystem relates to goat feeding regimes (nutrition subsystem) which is the issue that is of particular interest to the present paper. In the next section, two feeding regimes are identified and their essential characteristics discussed.

FEEDING REGIMES

Traditionally, goats in south-west Nigeria are free-roaming in an extensive management system. In this system, forage crops are not grown to support the animals and the animals' manure is not returned for cultivation of food crop plots. Thus, the animals appear to be poorly integrated in the prevailing farming system. Moll (1989) laments the non-use of manure from goats and argues that if manure from goats is used properly, it can complement the production of valuable crops like vegetables and fruits.

Under the extensive management system, goats scavenge all day to feed themselves; at best, they are offered feed supplements such as kitchen refuse, dried cassava, cassava/yam/banana peelings, bean husks and maize chaff. The only major investment is in acquiring new stock, and returns from this system are low.

Drawing on a study undertaken by ILCA in 1983 (Mack, 1983) and on-station data obtained from the Obafemi Awolowo University, Huijsman (1987) remarks that there is a substantial increase in reproductive performance of dwarf goats when the animals are kept under the high intensity model. The productivity (liveweight production per doe) more than doubles from 10.9 kg liveweight/doe per year in the low intensity (extensive) model to 24.2 kg in the high intensity (intensive) model.

Huijsman (1987) indicates that "this increase is due to a higher average litter size at birth, higher survival rates of weaners and growers and a substantial increase in liveweight of growers at 12 months" (see Table 1).

The other feeding regimes that have been advocated, therefore, are the intensive types which include the cut-and-carry method. In this procedure, leguminous trees planted in alley farms or intensive feed gardens provide a high-protein diet to small ruminants. Devised by IITA, alley farming involves growing arable crops in alleys between cultivated hedgerows of leguminous shrubs such as *Leucaena leucocephala* or *Gliricidia sepium* in a system that allows hedgerow foliage to be removed and fed to livestock without adverse effects on crop yields.

Table 1. *Reproductive performance data of dwarf goats in humid south-west Nigeria*

Performance indices	Low intensity model	High intensity model
Average litter size (kids/litter)	1.50	1.74
Parturition interval (days)	259	267
Annual reproductive rate (kids/doe per year)	2.1	2.4
Survival rate to weaning (%)	67	75
Survival rate 3-12 months (%)	77	95
Effective kidding rate (kids surviving to 12 months)	1.09	1.69
Liveweight at 12 months (kg)	10.0	14.3
Productivity (liveweight production per doe per year) (kg)	10.9	24.3

Source: Huijsman (1987)

The grazed fallow system, on the other hand, was conceived by ILCA and consists of a rotation of blocks of alleys with three to five years of alley cropping followed by two to three years of grazing, representing a high degree of integration of crop and livestock production. Both of these devices demand considerable management skills to ensure success.

At Ile–Ife, a modified form (probably requiring less managerial capabilities) involves the establishment of intensive feed gardens consisting solely of a mixture of *Leucaena leucocephala* and *Gliricidia sepium* close to the homestead. Planting close to the homestead reduces the time needed to carry the browse to the animals, but requires considerable labour, not only to tend the gardens but also to ensure that adequate quantities of browse are continually supplied (physically carried) to the goats in confinement. Given this requirement, the system has to be viewed within the context of the resource base and resource utilisation in particular farming systems.

GOAT-KEEPING IN THE IFE/EDE FARMING SYSTEMS FRAMEWORK

A farming systems approach should be followed when appraising the acceptability potentials of an intensive goat feeding regime. The approach should centre on the role of animal husbandry with regard to the availability and use of resources, while paying special attention to those components of the farming system that are either competing with or complementary to rearing the animals. This section examines the availability and utilisation of land and labour required for goat-keeping in the Ife/Ede zone of south-west Nigeria.

The case study is the group of six WADG on-farm research villages, three each in Ife South and Ede Local Government Areas. In five of the villages (Awo, Ikotun and Ojo in Ede and Toro and Akeredolu in Ife South), goats are allowed to roam freely. In a sixth (newly selected) village, Ogbagba in Ife South, the movement of goats is restricted under a local regulation because of the damage done to standing crops and other agricultural products. Farmers who have to confine their goats now contend with the issues of land and labour availability and use.

Availability and use of land

At present, availability of land does not seem to be a constraint to farming. During interviews conducted in 1989, farmers in all villages except Toro and Ojo said they had surplus land (see Alofe et al, 1989). In fact, at Akeredolu, the government was able to acquire vast areas of land to start a big project, the school-leavers farming scheme under the National Directorate of Employment. But although land is generally available, its acquisition, especially in the Ede area, still follows the traditional rules whereby land transactions require approval from the village chief.

In terms of use, the traditional shifting cultivation practice, involving essentially the growing of food crops, is gradually being replaced by a more permanent system of cultivation involving kola, cocoa and oil palm trees. Such a change is being facilitated with the adoption of the government-sponsored Structural Adjustment Programme (since 1986) with its export crop orientations. With the development of favourable prices for export crop products, the tendency is for farmers to devote more cultivable land to cocoa and other export crops, with feed gardens being a poor competitor.

The location of a feed garden also matters. Usually, it is advantageous that the feed garden be located as close as possible to the goat paddock near the homestead. Field investigations reveal that plots close to the homestead are planted tc food crops by farmers whose ability to travel far into the fields is now limited due to old age. Thus feed gardens may have to compete with food crops.

Availability and use of labour

Availability of labour is diminishing in the villages as able-bodied youths leave to seek city employment and are only partly replaced by migrant labourers and settlers from the Middle-Belt. To produce food for family living, village women now spend more and more time on the farm in addition to their traditional tasks of processing and trading in food products. The question then arises: Can the women who traditionally keep goats under the extensive system still cope with the higher labour requirements of an intensive goat-keeping system?

In the study areas, hired labour is used at peak periods of land preparation, weeding and harvesting. Furthermore, exchange labour (farmers assisting each other in turn) is used in particular places. Hired/exchange labour is used extensively on food crop and export crop farm operations especially during the months of April to July.

Respondents mentioned that during the slack months they engage in other occupations; for men these include palm-wine tapping, bricklaying and blacksmithing, and for women, processing of oil palm, rice and beans into various products. For all villages, except Akoredolu, many families also have members working off the farm, outside their villages. Thus, feeding the goats from feed gardens has to compete for labour with food crop production in peak periods and with secondary occupations all the year round.

CONCLUSIONS

Under conditions of scarce family labour resources, the incremental return to an additional labour investment provides an important indicator of the economic attractiveness of such an investment. The incremental returns per labour hour for moving from the extensive feeding regime must be higher than the average wage rate prevailing in the locality. Alternatively, intermediate regimes of feeding the goats must be found which involve minimal land and labour investments.

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RESEARCH PRIORITIES FOR THE DEVELOPMENT OF APPROPRIATE FEEDING SYSTEMS FOR DAIRY PRODUCTION IN SUB-SAHARAN AFRICA

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ABSTRACT

Inadequate feed supplies remain a major constraint to sustainable cattle production in general, and milk production in particular, in smallholder production systems throughout sub-Saharan Africa. In the emerging peri-urban dairy production systems in West and central Africa. for example, poor development of feed resources has invariably resulted in milk production being sustained at comparatively high feed costs, thus reducing the competitiveness of locally produced milk.

Given the opportunities for generating increased quantities of crop residues from many of the crop production projects assisted by international agencies (eg, World Bank, Global 2000), there is an urgent need to identify research priorities in the development of feeding systems appropriate to the different smallholder production systems. Such feeding systems will have to incorporate a new approach to cattle management, involving cultivation of specialised fodder crops and harvesting and conservation of crop residues for milk production.

RESUME

Priorités en matière de recherche sur l'élaboration de systèmes d'alimentation adaptés à la production laitière en Afrique subsaharienne

L'insuffisance des ressources alimentaires demeure un obstacle majeur au développement de la production bovine en général et laitière en particulier dans les systèmes du petit élevage en Afrique subsaharienne. Dans les systèmes péri-urbains de production laitière apparus récemment en Afrique occidentale et centrale par exemple, les pénuries alimentaires renchérissent invariablement le coût des aliments du bétail, diminuant ainsi la compétitivité du sous-secteur de la production laitière locale. Etant donné qu'un bon nombre de projets de production végétale soutenus par des institutions internationales (ex.: Banque

mondiale, Global 2000, etc.) peuvent permettre à l'heure actuelle d'accroître la production de résidus de récolte, il importe de définir sans délai les priorités de recherche en ce qui concerne l'élaboration de méthodes d'alimentation adaptées aux différents systèmes de la petite exploitation laitière. Cela suppose une approche nouvelle du problème de la gestion du cheptel bovin, la culture de plantes fourragères appropriées ainsi que la collecte et la conservation de résidus de récolte en vue de la production laitière.

INTRODUCTION

Dairy supplies in most countries of sub-Saharan Africa are based on both domestic production and imports, since domestic production has always been inadequate in relation to demand (von Massow, 1989; Senait Seyoum, 1988).

Given the large ruminant population of sub-Saharan Africa and the fact that the region covers an estimated 129 million hectares of arable land and 70.24% (556.9 million hectares) of Africa's permanent pastures (Table 1), there should be no cause for deficits in milk supplies. However, the estimated 164.2 million cattle, 147.8 million goats and 127.2 million sheep in the region produced only an estimated 11.98 million tons milk, providing an average 25.1 kg milk/person per year for the region's 477.7 million people (FAO, 1989).

Table 1. *Human and livestock populations, land-use patterns and milk production in sub-Saharan Africa*

	In sub-Saharan Africa	% of total Africa
Population (thousands)		
Humans	477 661	75.99
Cattle	164 169	88.36
Sheep	127 241	63.39
Goats	147 757	87.18
Land area (thousands of hectares)		
Total	2 034 141	68.63
Arable land	129 054	76.84
Permanent crops	14 140	75.55
Permanent pastures	556 963	70.24
Milk production (thousands of tonnes)		
Cow milk	9 079	65.85
Goat milk	1 718	83.76
Sheep milk	1 188	78.62

Source: FAO (1989)

The economic depression in many sub-Saharan African countries, brought about by the external debt burden, has severely curtailed the availability of foreign exchange to sustain dairy imports. The overall effect has been a worsening of the dairy supply situation at a time when the need for more food to feed the region's ever-growing population has become very acute. Indeed, the inadequacy of dairy supplies has been aggravated by a combination of drought and other adverse climatic factors and an unstable political situation in some countries. When viewed against the possible outcome of the on-going "Uruguay Round of Talks" on world trade and the rationalisation of agricultural subsidies in Europe and North America, the prospects for cheap dairy imports to supplement domestic production in sub-Saharan Africa look increasingly gloomy.

These developments present challenging opportunities for increasing domestic dairy production through a more efficient use of the resources in the existing production systems. Research support from the commodity and strategic collaborative research networks would be required to generate producer-implementable technology packages for sustainable increases in domestic dairy production throughout the region.

EXISTING PRODUCTION SYSTEMS

Domestic dairy production in sub-Saharan African countries is based largely on cattle. In 1989, for example, cattle milk accounted for 75.8% of the estimated 11.98 million tons of milk produced in the region (Table 1).

Dairy production is carried out under a variety of production systems which can be classified into two broad groups, traditional systems and improved systems, the major characteristics of which have been summarised by Olaloku et al (1990).

The traditional systems include the pastoralist, subsistence and agropastoralist systems, all of which together account for well over 90% of the dairy ruminant population in sub-Saharan Africa. Dairy production from each system reflects varying degrees of adaptation to the major constraints to sustainable production in their environment, such as seasonal variations in feed and water resources, animal health and social interactions within the overall farming system (ILCA, 1979; Synge, 1981; Jahnke, 1982; Waters-Bayer, 1988). Jahnke (1982) described production in mixed farming areas with the tradition of communal tenure of the grazing resources. Where cropping is the mainstay of subsistence and income, stubbles become important as a grazing resource.

Dairy production under the improved systems represents adaptations of the intensive, high input/output market-oriented production systems of the developed dairy industries in Europe and North America. The improved production systems include:

- intensive crop–livestock smallholder systems
- semi-intensive medium and large scale systems
- peri-urban dairying.

In general, production is low under the traditional systems and much higher under the improved systems. These differences in productivity have generally been ascribed to:

- use of improved genotypes (crossbreds, grade and pure bred exotic dairy breeds)
- investments in forage and other feed resources to ensure adequate nutrition year-round
- animal health care, with conscious efforts to reduce reproductive wastage, calf mortality and morbidity.

FEED RESOURCES

Apart from differences in productivity arising from the quality of the animal genotypes under the different production systems, the most important constraint to sustainable dairy production in sub-Sahran Africa is feed and nutrition.

The availability of feed, both in quantity and quality, varies greatly in the different production systems. Although feed availability depends to some extent on climatic conditions, particularly rainfall and the length of the growing season, in most cases the feed situation becomes critical during the dry season. At this time, the low quality of natural pastures and the inefficient use of crop residues result in inadequate feeding of stock with adverse implications on reproductive efficiency and milk production, especially among crossbred and grade cattle as feed nutrients become inadequate to support their potential yield levels.

Feed resource inventory

A wide variety of feed resources abound from sub-Saharan Africa's estimated 129 million hectares of arable land and 556.9 million hecrares of permanent pastures. These include:

Crop residues, especially cereal straws and stover from sorghum, maize, millet, rice, wheat, oats and barley, accruing from arable crop farming both in the smallholder units and in the large-scale accelerated food production projects sponsored by various international development agencies in recent years. These products are usable to various degrees to support production, depending on the crop variety, tannin content, stage of harvest, length of storage, leaf:stem ratio, soil fertility and fertiliser application, as well as the effects of agronomic practices such as irrigation. For example, Kernan et al (1979) reported that straw from irrigated wheat had a 41% *in vitro* digestibility compared to 34% for non-irrigated wheat straw. Most cereal straws are, however, low in nitrogen content and require considerable strategic utilisation to be effective feeds.

Agro-industrial byproducts, ranging from products with high-nutrient content such as wheat offals and middlings, brewers' grains, etc, to low nutrient and fibrous products such as sugarcane bagasse, rice hulls and cocoa husks.

Pasture forage and herbaceous legumes, consisting of the more popular planted grasses such as Napier grass (*Pennisetum purpureum*), Rhodes grass (*Chloris gayana*), legume forages such as *Stylosanthes* and different varieties of alfalfa (*Medicago sativa*). Recently multipurpose trees such as *Sesbania* and *Leucaena* species have been developed as useful sources of nitrogen in the diet.

Utilising feed resources for milk production

Fibrous crop residues can, at best, only support low levels of milk production because of their low and slow rate of digestibility, low propionate fermentation in the rumen, and almost negligible content of fermentable nitrogen. However, these feeds represent a significant proportion of the feed resources available to the majority of smallholder producers in sub-Saharan Africa. Therefore, greater attention would have to be given to their improved and more efficient utilisation for dairy production.

Improvements can be achieved through treatment with ammonia, such as ensiling with urea. Khan and Davis (1981) and Perdok et al (1982) have demonstrated the value of ammoniated rice straw, with average increases of 53% in milk production from zebu and buffalo cows. The increased intake of the treated straw is brought about a reduction from 14 to 9% in the average proportion of the total diet represented by concentrates. There will, however, be a need to establish acceptable regimes for feeding lactating ruminants.

Green forage can be used as a supplement for milk production. Perdok et al (1982) showed that supplementing a diet of untreated straw with *Gliricidia sepium* at approximately 15% of the dietary dry-matter intake increased milk yield by 22%.

EXAMPLES FROM EXISTING PRODUCTION SITUATIONS

Although there is potential for increasing domestic milk production in sub-Saharan Africa, poor feed resource development and utilisation could lead to lower competitiveness of locally produced milk. This is the trend emerging from the peri-urban dairy production systems operating in some countries of the region, particularly in the subhumid zones of West and central Africa.

Peri-urban dairy production

The depressed economic situation, coupled with the increasing costs of dairy imports against the background of inadequate foreign exchange and the availability of a good market in urban areas, has led to the development of dairy production in urban and peri-urban areas of many countries in sub-Saharan Africa. This system of dairy production has assumed increasing importance in the past decade, as more and more milking herds are established within a 50 km radius of major cities and towns. Indeed, national and international development agencies now see peri-urban dairy production as an important mechanism for catalysing organised dairy production and providing employment opportunities.

Factors in favour of intensifying dairy production in urban and peri-urban areas include the proximity of production sites to centres of high fresh milk demand, which leads to reductions in costs associated with collection, refrigeration and transport of fresh milk from production sites to points of final sale. On the input side, urban and peri-urban producers have ready access to feed supplements, agro-industrial byproducts, veterinary supplies and, sometimes, factory-gate prices. However, arguments against peri-urban dairy production include:

- unavailability or restricted availability of low-cost feed sources such as natural pastures and crop residues
- inadequate land for forage cultivation
- high costs of purchased feed inputs
- high labour costs for herding and feeding.

Feeding for peri-urban dairy production in Mali

Preliminary results of a recent ILCA study on three dairy production systems in peri-urban Bamako, in the subhumid zone of Mali, showed that purchased feeds represented between 34 and 73% of the total variable costs of milk production. In the traditional production system in which purchased feed supplements were fed exclusively in the dry season, supplements represented the major source of expenditure. The preliminary economic analysis also showed that the high costs of purchased feeds resulted in milk production being sustained at comparatively higher costs than the reconstituted imported dairy products (Table 2).

Prospects for increasing peri-urban dairy production

There is a high demand for fresh milk in and around Bamako, so opportunities exist for increasing production to meet this demand as well as to generate more producer income. But these aspirations can only be achieved if cheaper sources of feed can be developed. The cottonseed-cake-based supplement, containing about 27% crude protein, costs FCFA 80/kg at farm level. Research into the development of feeding packages for milk production, incorporating forage legumes, crop residues and agro-industrial byproducts, may identify cheaper alternative feeds for peri-urban dairy production in the Bamako area.

The research support required for sustainable dairy production in sub-Saharan Africa would therefore require an analysis of the existing production systems, followed by the design, evaluation and implementation of appropriate interventions, to increase productivity and generate additional income for the producer.

Table 2. *Production, cost structure and profits from milk production per cow in three different production systems in the Bamako area, Mali, July to October 1989*

Item	Per cow		
		Peri-urban	
	Traditional system	Communal system	Private system
Physical data			
Milk production (litres/day)	1.02	2.24	2.28
Concentrate (kg/day)	0.80	1.55	3.00
Milk yield/kg concentrate fed (litres/day)	1.30	1.44	0.95
Profit (loss) (FCFA)			
Revenue from milk	129	476	602
Variable costs			
Cost of supplementation	68	124	240
Veterinary costs	8	17	175
Hired labour costs	5	30	300
Total	81	171	715
Profit (loss)	48	305	(113)

This scenario has been amply demonstrated in some of the dairy production projects supported by the International Development Research Centre (IDRC) in Botswana, Burundi and Malawi (Olaloku et al, 1990). In each case, the research priority focused on the development of feeding strategies based on the available feed resources (cereal crop residues) supplemented with a forage legume, *Lablab purpureus*, as the protein source.

In designing research to solve the feed problems of producers, the farming systems research approach should not be ignored. The first step must be to characterise existing production systems in order to identify the calving calendar, calf mortality, milk offtake and reproductive activity in relation to available feed resources. Such knowledge then becomes useful in the development of appropriate feeding strategies for increased milk offtake and producer incomes according to requirements at different seasons of the year.

Given a good knowledge of the foregoing, research can then be designed to address such issues as:

- quantification and nutritional evaluation of available feed resources, especially the seasonally available forages, to provide information for their optimal exploitation for increased milk production
- development of feeding and management packages for milking cows, calves and replacement stock, based on existing feed resources, to ensure reductions in mortality and to achieve good growth rates, early maturity and calving at an earlier age

- development of management systems for range and pasture improvement, as well as methods for the production and conservation of herbage for dry-season feeding
- development of simple diets from available feed resources for maximising production under particular local conditions.

Finally, in the design of research for feed production and utilisation for sustainable dairy production, provision must be made for the on-farm packages for year-round milk production levels with existing stock and available feeds and feed combinations.

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APPENDIX

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