Small Ruminant Research and Development in Africa

Proceedings of the Second
Biennial Conference of the African
Small Ruminant Research Network
AICC, Arusha, Tanzania
7–11 December 1992

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International Livestock Centre for Africa (ILCA)
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Abstract

This volume contains papers and abstracts of the Second Biennial Conference of the African Small Ruminant Network. In addition to the keynote address, there are nine papers on Small Ruminant Production Systems, Economics and Policy, nine papers on Small Ruminant Performance and Reproduction, ten papers on Small Ruminant Health and Reproductive Wastage, eight papers on Small Ruminant Feeds and Feeding Systems and eight papers on Small Ruminant Genetic Resources and Breeding. Ten poster abstracts covering the above topics add to the volume.

Keywords

/Sheep//goats//small ruminant production systems//productivity//economics//policy//weaning practices//agropastoral//pastoral//production constraints//feeds//feed resources//feeding systems/ /digestibility//nutrition//supplementation//diet//reproduction//reproductive wastage//performance evaluation//health//peste des petits ruminants//infectious diseases//vaccines//breeds//breeding systems/ /breed improvement//Africa/

Résumé

Le présent volume rassemble les exposés et les résumés d'articles présentés à la deuxième Conférence biennale du Réseau africaine de recherche sur les petits ruminants. Outre le discours liminaire, il contient neuf communications sur les systèmes de production, l'économie et les politiques, neuf autres sur les performances et la production, dix sur la santé et les pertes en reproduction, huit sur l'alimentation et les systèmes d'alimentation et huit autres enfin sur les ressources génétiques et la sélection. A quoi il convient d'ajouter dix séries d'affiches présentées à cette conférence sur l'ensemble des sujets énuméres ci-dessus.

Mots Clés

/Ovins//caprins//systèmes de production des petits ruminants//productivité//économie//politiques/ /modes de sevrage//agropastoral//pastoral//obstacles à la production//aliments du bétail//ressources alimentaires//systèmes d'alimentation//digestibilité//nutrition//complémentation//régime alimentaire/ /reproduction//pertes en reproduction/ /évaluation des performances//santé//peste des petits ruminants/ /maladies infectieuses//vaccins//espèces//systèmes d'élevage//amélioration génétique//Afrique/

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Preface

Two of the major constraints to small ruminant development in the developing world and, in particular, Africa are limited access to information and limited opportunity for interaction among scientists working in the same area of interest.

It is against this background that the African Small Ruminant Research Network (SRNET) has made the promotion and improvement of information exchange on small ruminant research and development one of its major priorities in addition to collaborative research and training. The network has set out to achieve its goal through the organisation and sponsoring of a biennial scientific conference, amongst other channels. This provides a forum for small ruminant scientists in Africa and elsewhere, developers, policy makers and farmers to meet, exchange ideas and establish partnerships.

This proceedings reflects the oral and poster presentations at the Network's Second Biennial Conference held in Arusha, Tanzania, from 7 to 11 December 1992. Some 100 participants, representing 30 African countries, five European countries and various international and regional organisations (ILCA, OAU/IBAR, NRI, ODA and GTZ) were present. Five scientific sessions were held, at which 48 oral and 10 poster presentations were made and discussed. The sessions focused on production systems, economics and policy, performance and reproduction, health and reproductive wastage, feeds and feeding systems and genetic resources and breeding for both oral and poster presentations.

The Network is grateful to the European Economic Community (EEC) and ILCA for promoting and supporting the activities of the Network including the holding of the Second Biennial Conference and the publication of the proceedings. The Natural Resources Institute (NRI) of Great Britain and the Technical Centre for Agriculture and Rural Co-operation (CTA) are recognised for their support in the collaborative research and publication of this proceedings, respectively. A lot of thanks go to the ILCA Nairobi support office for the usual superb logistical support.

Special thanks go to the Tanzanian Government for its support in holding the conference, and in particular to the Ministry of Agriculture, Livestock Development and Cooperatives and the National Small Ruminant Research Network for co-hosting the conference. The Network also appreciates the kind willingness of Dr Ben Moshi, Principal Secretary, Ministry of Agriculture and Livestock Development, to be the guest speaker. My final thanks and gratitude go to all those who made the publication of this proceedings possible, particularly Mr Matthew Pritchard, for English editing, and the staff of the Publications Section of the International Livestock Centre for Africa (ILCA).

Constraints and prospects for small ruminant research and development in Africa

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Abstract

Small ruminants have a great potential to affect the socio-economic development of the majority of African rural communities.This paper discusses the constraints on small ruminant production and the future prospects for small ruminant production.

Contraintes et perspectives de la recherche-développement sur l'élevage des petits ruminants en Afrique

Résumé

Les petits ruminants peuvent apporter une contribution considérable au développement socio-économique de la majorité des communautés rurales de l'Afrique. Cet article examine les contraintes qui pèsent sur l'élevage de petits ruminants ainsi que les perspectives d'avenir.

Introduction

Africa has a population of 205 million sheep and 174 million goats representing approximately 17% and 31% of the world total, respectively (FAO, 1990). Within Africa, the distribution of these small ruminants varies widely, with a higher concentration found in dry areas than in humid areas. These animals serve primarily as sources of meat, but also provide milk, skins and manure. Sheep and goats produce only about 16% of the world's meat, despite their high contribution to the total world livestock population. Milk and skin production show similar figures. African small ruminants produce only 14% of the world's milk and 15% of the world's skin.

The ownership of small ruminants in Africa differs from that of cattle. Only a small percentage of the population own cattle, and rear them mainly in the arid and subhumid zones. Most people in rural areas own small ruminants.

The ownership of small ruminants is regarded as an investment. They are sold to meet compelling family financial obligations or slaughtered for consumption at home or at festivals. The size of the animals makes them ideal for families. Little capital investment in buildings or other materials is required for their upkeep, and space and maintenance requirements are low. They are suitable for family consumption in the absence of refrigeration for storage, or adequate transportation (Ademosun, 1988), and their reproductive efficiency is high. However, the animals are given little attention.

Until recently, small ruminants were not a priority in the research activities and development programmes of African governments. This has changed with the establishment of international research institutes under the Consultative Group on International Agricultural Research, particularly ILCA (International Livestock Centre for Africa). The broadening of the base of livestock research in National Agricultural Research Systems has also boosted small ruminant research, which has taken its place besides research into cattle, pig and poultry production.

The new orientation of research can be attributed to a number of factors. These include a new awareness of the potential of the small ruminant, the need for increased meat production, pressure on land, urbanisation, disease problems with other traditional livestock species and increasing feeding costs for non-ruminants.

Constraints

Health

A serious constraint on small ruminant production in Africa has been the high prevalence of diseases and parasites, particularly in the more humid areas. This causes high mortality amongst kids and lambs, diminishing the benefits of their high reproductive performance.

Preweaning mortality of up to 40% has been recorded with kids and lambs in Nigeria. However, preweaning mortality under the extensive system of management may be underestimated. Births which occur when animals are bush grazing and result in the death of the offspring usually go unnoticed. In addition, further losses are caused by abortions and stillbirths.

One of the most serious diseases of small ruminants, *peste des petits ruminants* (PPR), was first recognised as a contagious "rinderpest-like" condition in goats in Nigeria in 1930. It was first described in Côte

d'Ivoire in 1942 and later in the Benin Republic during 1944. The disease has been difficult to quantify due to the lack of precise statistical records. However, it has been stated that it is the most destructive viral disease among small ruminants (Bourdin, 1983). Goats are more susceptible to PPR than sheep and young animals are more susceptible than adult ones. The use of tissue-culture rinderpest vaccine (TCRV) is effective in the control of PPR.

Parasitism ranks high among the factors that limit the productivity of small ruminants although its effect is often underestimated. Akerejola et al (1979) have estimated that the losses from parasitic diseases in Nigeria's subhumid zone are higher than those attributable to PPR. Helminthiasis was the most prevalent condition encountered. Assoku (1980) studied the helminths of sheep and goats on the Accra plains of Ghana. He found that 80% of the sheep and 88.3% of the goats were infected. The problem of parasitism is compounded by the fact that, under the traditional system, livestock are usually reared extensively. This increases infestation and makes control measures difficult. Young animals are the most affected and parasitism could aggravate other conditions such as nutritional stress and susceptibility to disease.

About 46% of tropical Africa is infested by tsetse flies, with the highest infestation in the humid (90%) and subhumid (68%) zones. It has generally been believed that small ruminant breeds adapted to the humid zones are trypanotolerant. However, cases of trypanosomiasis have been recorded amongst indigenous breeds in these zones. In a village survey of south west Nigeria, trypanosomiasis was responsible for more of the diseases recorded than any other (ILCA, 1982). Kariuki and Jacobsen (1980) also reported trypanosomiasis in sheep in Kenya. Close attention needs to be paid to this disease as it frequently occurs among animals under stress, especially nutritional stress. Animals imported for upgrading indigenous stock are also susceptible.

External parasites cause extensive losses among small ruminants, especially in humid areas. The two most serious vectors are ticks and mites. The irritation and dermatitis that accompany mange infestation can reduce the value of the skins for sale to the leather industry and the meat with skin for consumption as food. Haemoparasites transmitted by ticks are quite common. Assoku (1979) studied the incidence of bloodborne parasites of sheep and goats in southern Ghana. He found moderate to heavy infestation of tick-borne parasites in both species. Extensively reared animals showed greater infestation than semi-intensively kept ones. Dwarf breeds were less infested than long-legged breeds, but infestation increased with age.

Other diseases that have limited the productivity of small ruminants in tropical Africa include pneumonia, coccidiosis, contagious caprine pleuropneumonia, ecthyma, caseous lymphadenitis and brucellosis. Individually, these diseases might not constitute serious problems, but combinations of them or their occurrence under marginal conditions could result in serious losses.

High standards of sanitation and good management are essential to control disease. Table 1 shows the incidence of diseases at the goat unit of the Obafemi Awolowo University in south west Nigeria. When the flock was started in mid-1981, animals were kept mainly on concrete floors spending four hours a day on pasture. A change in management practices, including slatted floors, zero-grazing and once-a-year vaccinations against PPR with TCRV reduced cases of disease. The goat population increased from 57 in 1982 to 216 in 1985.

Table 1. *Incidence of disease among the goat flock at Obafemi Awolowo University Farm, Nigeria in 1982 and 1985.*

Disease	No of cases	
	1982	1985
Helminthiasis	100	–
Scabies	80	2
Tick borne diseases	41	–
Lice	10	–
Ecthyma	12	18
PPR	8	–
Caseous lymphadenitis	10	5
Diarrhoea	9	19
Crippling	3	-
Localised inflammation	10	–
Abortions	7	14
Hoof problems	–	4
Pneumonia	–	1
Bloat	–	1
Retained placenta	–	2
Others	3	2
Total	293	68

Nutrition

Inadequate feeding is a major limiting factor to small ruminant production in tropical Africa. Fodder is of poor nutritional value for most of the year due to the rainfall pattern. In the arid and semi-arid zones, rainfall is less than 600 mm and between 600–1000 mm per year, respectively. The management system is nomadic or transhumant pastoralism. Animals have to trek great distances in search of fodder and water. The quality of available forage is low and browse species which can provide higher levels of proteins and carbohydrates are sparsely dispersed. In the humid and subhumid zones, up to six months of the year can be rainless, resulting in poor quality forages. The rapid buildup of cell-wall materials and decline in crude protein (CP) content with maturity reduces the nutritional value of the forages. Little is known about the nutritional value, distribution, palatability, seedling vigour and seasonal production of the forage species that characterise the natural grassland. This is particularly true of the arid, semi-arid and subhumid areas which contain 75% of the sheep and

80% of the goats of tropical Africa and where the rangeland is the most important source of food.

A variety of grasses and legumes have been used to improve pastures and high yields have been recorded. Under station conditions a yield of 20 tonnes of dry matter per hectare (DM/ha) has been obtained with *Pennisetum purpureum* in the humid zone of Nigeria. Under ranching conditions, with systematic clearing of woody vegetation, Jahnke (1982) reported a yield of 6 t DM/ha with *Cynodon dactylon*. Results from West Africa indicate annual DM yields of between 10–18 t/ha for *Panicum maximum* without fertiliser application. Using fertilisers, appropriate cutting regimes and by-products, molasses etc). The types and quantities available tend to be location and season specific.

The feeding quality of the rangelands in semi-arid and subhumid areas can be improved by oversowing the natural grassland with legumes. This has been successful in the subhumid zone of Nigeria (ILCA, 1984). The legume of choice has been *Stylosanthes*. The ILCA work was with cattle but could be useful for small ruminants. Crop residues also provide good alternative feeds in the dry season. Their feeding value and DM production can be improved if the crops are planted with forage legumes. With the selection of the appropriate legume, grain yield need not decrease (Table 2).

Table 2. *Grain and fodder yields of sorghum/forage legume mixtures in the subhumid zone of Nigeria.*

Crop mixture	Grain yield	Legume/crop residue	DM (kg/ha)	Total fodder	Total CP
Sorghum alone	1296	4467	–	4467	126
Sorghum + *S. hamata*	313	1685	2778 (11.4)	4463	363
Sorghum + *S. guianensis* cv Cook	388	1555	2063 (12.8)	3618	326
Sorghum + *M. atropurpureum*	356	2111	1296 (14.2)	3407	241
Sorghum + *C. pascuorum*	1019	2981	1204 (14.9)	4185	259
Sorghum + *A. vaginalis*	1092	2519	926 (10.8)	3445	168
Sorghum + *M. lathyroides*	1297	2761	1481 (16.5)	4222	316

Source: ILCA (1984).

Figures in parentheses are CP (%) of fodder crop.

S = *Stylosanthes;* M = *Macroptilium;* C = *Centrosema;* A = *Alysicarpus.*

suitable mixed improved pasture species, annual yields of up to 30 t DM/ha are possible in humid areas. However, high yields are not necessarily matched by high nutritional values. Tropical grasses are generally low in C P content. As they grow, the lignin content and other cell-wall materials build up rapidly, adversely affecting digestibility. Studies have shown that the use of a grass such as *Panicum maximum* or *Cynodon nlemfuencis* alone is not adequate to allow optimum production in sheep and goats (Ademosun et al, 1985). The use of browse and other feed sources has proved satisfactory. Browses such as *Gliricidia sepium* and *Leucaena leucocephala* have been successfully used for small ruminant production systems in alley farms (Sumberg, 1985) and intensive feed gardens (Ademosun, 1988).

Besides the use of browse, other strategies can be employed to improve the feeding of animals. During the dry season, the quality of available herbage is so low that, unless the animals have access to supplementary feeds, they lose weight. These supplementary feeds can be obtained from agro-industrial by-products such as residues of oil extracted from oil bearing seeds (groundnuts, coconut, palm kernels, cotton seed, soyabean etc), by-products of grain processing (maize, rice, wheat, sorghum, millet etc), peelings of crops (yams, cassava, potatoes, plantains etc) and industrial by-products (brewers' dried grains, fruit cannery

Breeds

Small ruminant breeds in tropical Africa are characterised by small birth weights, low milk production, slow growth rates and small mature weights. The West African Dwarf goat has been variously called the Nigerian Dwarf, Cameroun Dwarf, Forest Djallon and Fouta Djallon, which indicate its wide geographical spread. These animals weigh 20–45 kg at maturity, have short hair and attain sexual maturity at about five months. Table 3 shows the production traits of the West African Dwarf sheep and goats in south western Nigeria (Mack, 1983).

Table 3. *Production traits of village sheep and goats of the WAD breed in south west Nigeria.*

Trait	Sheep	Goat
Litter size	1.23	1.52
Parturition interval (days)	322	267
Birth weight (kg)	2.12	1.63
Preweaning liveweight % gain (g/day)	74	38
Live weight at 12 months	19.7	9.6
Survival index for lambs/kids to 90 days	0.84	0.75

Source: Mack (1983).

Ninety-nine per cent of the goats and most of the sheep in Botswana belong to indigenous breeds with high variation in conformation, colour and type (Molefe, 1986). Small East African (SEA) goats are slightly bigger than their West African counterparts. According to Mburu (1986), SEA goats are the most numerous in Kenya. Okello (1983) indicated that SEA goats weigh 25 kg at maturity and reach sexual maturity at four months when they weigh 14–16 kg. The local ecotype of the SEA goat in Burundi has recorded a litter size of 1.75 under improved management. Primiparous females have a smaller litter size of 1.3. The South African Bantu (SAB) goat is similar to the SEA. It is, however, bigger and found in the southern parts of the zone. Like the other breeds, it is a meat animal. The Landim goat in Mozambique is similar to the SEA (Rocha, 1986). Dlamini and Lebbie (1986) have stated that 99% of the goat and 81% of the sheep population in Swaziland belong to indigenous breeds.

Attempts to improve indigenous breeds by crossing them with exotic breeds have been unsuccessful due to the inability to sustain initial efforts and lack of coordination. The Black Headed Nungua sheep developed in Ghana and the Permer sheep (a cross between the Persian and Merino) in Nigeria are examples. Teeluck (1986) for Mauritius, Kassahun Awgichew and Getaneh Hailu (1986) for Ethiopia and Dlamini and Lebbie (1986) for Swaziland, have given examples of such efforts. Crossbreeding should be preceded by rigorous selection among the adapted breeds for desirable characteristics and good productivity. Meticulous performance records need to be kept and accurate livestock census data are needed. Each breed must be well defined. Using improved breeds in the production process needs to be backed up by a strong livestock extension service which, at present, does not exist in many countries.

Management

Small ruminants in tropical Africa are kept under traditional extensive systems. In the arid and subhumid zones, cattle are reared with sheep and/or goats. In the humid zone, animals generally graze freely, with access to household and kitchen wastes when available. These are supplemented with bush grazing on low quality forages or browses. In some places, animals are tethered and fed kitchen wastes supplemented with zero-grazing.

Sheep and goat management under traditional systems has the following characteristics:

(a) stock owners are usually crop farmers (mostly arable crops in the arid and subhumid zones and tree crops in the humid zone) for whom livestock keeping is of secondary importance;

(b) most households keep only a few sheep and goats, also keeping other livestock such as pigs, horses, chickens and domestic animals such as cats and dogs (Table 4);

(c) the flock structures do not reflect good breeding strategy;

(d) veterinary and livestock improvement services are minimal; and

(e) the management systems are not integrated with crop production.

These management practices are not ideal. Mortality rates (particularly amongst the young) and losses from accidents, theft and predators are high. Research innovations and extension services have little impact on the production systems, and the benefits of an integrated crop/livestock production system are lost.

Research and development

The major problems of small ruminant production in Africa can all be tackled with the appropriate research. In order to be effective, research must be targetted at the smallholder farmer. It must also be systems oriented, practical and adaptable. The most prevalent diseases in each locality should be given priority. This can substantially improve animal production, as demonstrated by ILCA in the control of PPR and mange

Table 4. *Livestock species in households in the humid and subhumid zones of Nigeria.*

Species	Eruwa (Humid)*[1]		Kamerukaje (Subhumid)**[2]		Ganawuri (Subhumid)**[3]	
	No	%	No	%	No	%
Sheep	84	10.9	1	2.6	5	12.2
Goats	521	67.8	39	100.0	38	92.7
Pigs	55	7.2	29	74.4	5	12.2
Chickens	635	82.6	33	84.4	37	90.2
Dogs	135	17.6	31	79.5	30	73.2
Cats	214	27.8	–	–	8	19.5

* Source: Sellers et al (1976).

** Source: ILCA (1985).

1 Total number of households 769.

2 Total number of households 39.

3 Total number of households 41.

in some villages in the humid zone of Nigeria (ILCA, 1984).

The nutritional problem is a serious one, particularly during the dry season. This situation will be worsened if livestock productivity and population increase. Research into providing good quality, year-round feed for the small ruminants is therefore very important. Adapted forage species can provide nutrients for small ruminants. The agronomic characteristics of these forages need to be explored in order to achieve maximum benefits from them. Fertiliser requirements, frequency of cutting, cutting height, grass/legume mixtures and other factors affect the yield and nutritional value of forages. These need to be studied. Browses occupy an important place in small ruminant feeding, particularly during the dry season. This is because most browse species are drought resistant and provide proteins, vitamins and minerals which are lacking in the herbage species in the range. The use of browse in the various locations needs to be investigated. Household and kitchen wastes and agro-industrial by-products provide valuable supplementary feed. Their feeding value and rates of incorporation need to be determined.

If further processing is needed by foodstuffs before their use, it must be simple, adaptable and adoptable. For example, the use of sodium hydroxide on straw and other poor quality roughages may not be attractive due to its cost and the hazards involved in its handling. However, the use of ash from various farm wastes may serve as an alkali source and achieve the same objective. The nutrient requirement tables of the ARC (Agricultural Research Council) and NRC (National Research Council) still serve as references for sheep and goat requirements in tropical Africa, despite the fact that various workers have established energy and protein requirements of tropical sheep and goats. There is a need to collate this information and extend it to include vitamins and minerals.

Research into the traditional husbandry system for sheep and goats is a priority. Researchers must be aware that small ruminants are usually reared with cattle in pastoral systems, flock sizes are small and farmers in agro-pastoral and village systems see rearing small ruminants as secondary to farming. Research into integrating crop and animal production is essential, especially for the areas where crop production is the farmers' primary preoccupation. In wetter areas, simple and inexpensive structures can be designed to provide shelter. This will help reduce high mortality rates amongst kids and lambs, which are partly due to their exposure to inclement weather conditions. Structures developed at Obafemi Awolowo University in Nigeria based on local materials are already being adopted by farmers to provide protection for goats.

ILCA's alley farming with the use of *Leucaena* and *Gliricidia* in the humid zone and fodder banks involving oversowing the natural grassland with legume (*Stylosanthes*) in the subhumid zone are good adaptable programmes.

The FAO (Food and Agriculture Organization of the United Nations) has shown an interest in alley farming in some West African countries. It links crop and livestock production. The legume browses provide mulch which improves soil fertility, checks erosion and shortens the fallow period. They also provide fodder for small ruminants on a cut-and-carry basis.

Management systems need to be improved in order to improve livestock performance.

The reproductive performance of small ruminants is high, therefore research into this area need not be a high priority. Selecting for desirable traits could be used to improve breeds. Cross-breeding should be kept between adapted breeds. Imported exotic breeds are usually more susceptible to diseases, parasites and the harsh tropical environment. Selection and breeding work is slow, expensive, painstaking, tedious and requires large populations. It should only be embarked upon when the resources are adequate, and must be systematic, consistent and aimed at developing breeds that will succeed under field conditions.

Institutional support for livestock development programmes is generally weak. Many African governments make minimal budgetary allocations to livestock development. Existing government agencies may need to be reorganised to operate more effectively. Routine vaccination against PPR is cheap. Control of tsetse flies and other disease vectors should have a high priority in small ruminant development programmes. The marketing of small ruminants and their products is largely unorganised and leads to exploitation of the primary producers. Lack of credit has hampered small ruminant production in many places. Organising farmers into cooperatives and establishing fattening schemes run by smallholders will enhance productivity. Conferences, workshops and seminars for sub-regional groupings will establish and enhance communication channels among interested groups.

Conclusion

Tropical Africa has a high population of small ruminants but productivity is low with low contribution to the total GDP. The ownership pattern of small ruminants is widespread and the previously neglected animals are gradually gaining a respectable place in research and development programmes. The constraints to production and strategies to enhance development are discussed.

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SESSION 1

Small Ruminant Production Systems, Economics and Policy

Socio-economic constraints to strategic sheep fattening: Evidence from the Ethiopian highlands

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Abstract

This study provides the economic analysis of on-farm strategic feed trials carried out by ILCA (International Livestock Centre for Africa) since 1985. There is the potential to increase farmers' incomes by strategic feeding to meet the increased demand created by holidays and other occasions. However, the results of the economic analysis show that current feed packages are not economically viable and do not result in profitable strategic feeding.

This study also indicates that a number of socio-economic factors need to be considered in the design of station trials. The potential benefits of including economic considerations at the beginning of on-station research are highlighted.

Obstacles socio-économiques à l'engraissement stratégique des moutons dans les hauts plateaux éthiopiens

Résumé

Cette étude présente l'analyse économique des essais d'alimentation raisonnée effectués en milieu paysan par le CIPEA (Centre international pour l'élevage en Afrique) depuis 1985. En permettant au paysan de satisfaire la demande croissante en mouton à l'époque des fêtes et à d'autres occasions, l'alimentation raisonnée des ovins apparaît comme une possibilité d'augmenter les revenus. Cependant, il ressort des résultats de l'analyse que les stratégies alimentaires utilisées ne sont pas économiquement viables et ne débouchent pas sur une spéculation économiquement intéressante. L'étude montre également qu'un certain nombre de facteurs socio-économiques doivent être examinés dès le stade de la conception des essais en station. Les avantages qui pourraient découler de la prise en considération des facteurs économiques dès le début de la recherche en station sont présentés.

Introduction

Livestock productivity in both Ethiopia and sub-Saharan Africa is low. Recent increases in livestock production have mainly been due to expansion of herds, not improvements in productivity (Jahnke, 1982). According to Jahnke (1982), many areas have rapidly increasing populations, resulting in small farm sizes and less pastureland. Intensified feed and livestock production may be one way to raise production per land and livestock unit in a sustainable fashion. Livestock also earn farmers cash, which can then be used to increase the production of their food crops (Fitzhugh et al, 1992).

African farmers often fatten a few sheep to sell during feasts and holidays when prices are relatively high. Traditionally, sheep are raised on native pastures and crop residues. Animals which are to be sold during peak demand periods may have some supplemental feeding, but this traditionally includes only surplus grains and leftover household food. Forages, grains and concentrates could be used to increase animals' weight and therefore the price they will sell for.

This study presents an economic analysis of on-farm strategic sheep feeding trials carried out by ILCA in the highlands (cool tropics) of Ethiopia since 1985. The purpose of these trials was to identify feeding strategies that could sustainably raise animal productivity and farmer incomes, particularly where pasture land is becoming scarce due to crop growing. The objectives of the economic analysis presented here are:

1. to demonstrate the returns that could be obtained from strategic fattening using different feed types, with and without veterinary care;
2. to provide nutritionists and animal production specialists who are devising strategic sheep fattening methods with information on their potential for adoption, as well as constraints.

Other fundamental research questions about on-farm research into intensified livestock production practices and the role of economic analysis in livestock technology research are also addressed. Results of two indicative trials are presented in detail.

Methodology

Data source

Production data from eight on-farm trials done by ILCA were analysed with partial budgeting to assess the financial viability of strategic sheep fattening.

The partial budgeting methodology

Partial budgeting is often used to evaluate the potential profitability of new technologies and provides a criterion for choosing between alternatives. It involves tabulating the costs and benefits of a small change in farm practice. Only income and expenses which change are considered. The farmer's objective is assumed to be the maximisation of profits. His other objectives can be accounted for in sensitivity analysis and qualifying the results (Boehlije and Eidman, 1984).

Partial budgeting measures profits (or losses) which are the net benefits or difference between gains and losses for the proposed change. Gains include added returns and reduced costs, losses include added costs and reduced returns. The method entails calculating net income (NI), i.e. the amount of money left when total variable costs (TVC) are subtracted from total returns (TR):

$$NI = TR - TVC \quad (1)$$

Total variable costs include the costs of all inputs that change due to the change in production technology. The most important criterion in deciding whether or not to adopt a new technology is the change in net income (ΔNI). This amount is the difference between the change in total returns (ΔTR) and the change in total variable costs (ΔTVC):

$$\Delta NI = \Delta TR - \Delta TVC \quad (2)$$

Assuming that capital is not a constraint, the technology with the highest ΔNI is chosen. However, new technologies normally require investment, therefore additional capital is necessary. When capital is limited, the extra (or marginal) costs should be compared with the extra (or marginal) net benefits. The marginal rate of return (MRR) measures the increase in net income (ΔNI) associated with each additional unit of expenditure (ΔTVC):

$$MRR = \Delta NI/\Delta TVC \quad (3)$$

The MRR measures the effect of additional investment in a new technology on additional net returns (CIMMYT, 1988).

The study area

Ethiopia has 490,000m^2 or about 50% of all the highland area of the cool tropics of Africa. In the central-eastern highlands of Ethiopia the indigenous sheep are Menz, which are medium-sized and fat-tailed (Epstein, 1971) and Arsi-Bale, which are thin-tailed. As in most of the Ethiopian highlands, smallholder farmers at ILCA's on-farm research sites in Debre Zeit and Inewari castrate rams and fatten them for sale as part of their normal production activities. At Debre Zeit a high proportion of farmers (80.4 %) fatten sheep for a period of 1–2 years (Lili, 1990). Sheep intended for fattening are usually purchased at local markets or taken from the flock when 1–2 years old (Lili, 1990).

The ILCA on-farm site at Hidi/Debre Zeit is located 40 kilometres south of Addis Ababa and 13 km east of Debre Zeit town. It is 1850 metres above sea level (masl). The temperature ranges from a mean minimum of 10°C to a mean maximum of 22°C. Annual average rainfall is 800 mm and is bimodal. The main rains occur between June and September (Gryseels and Anderson, 1983). Most crop production takes place during these rains. Average livestock holdings at Hidi/Debre Zeit are reported to be 6.2 sheep, 1.5 oxen, 1.9 cows, 1.7 donkeys, 0.1 mules and 1.1 horses (Asfaw et al, 1987). Debre Zeit is known for the quality of the teff that is grown there.

The ILCA on-farm site at Deneba/Inewari is located 50 kms west of Debre Berhan town, 180 kms north of Addis Ababa and is at an altitude of 2600 masl. The temperature ranges from a mean minimum of 6°C to a mean maximum of 18°C. Annual average rainfall is 880 mm and is bimodal, resulting in two crop seasons. The main rains occur between July and October and the short rains occur between February and April (de Leeuw et al, 1992). The most important crops are wheat, teff, faba bean and chickpea.

The supply of land is inelastic at both sites relative to labour, but more so at Deneba/Inewari. Average land holdings are approximately 2.5 hectares at Debre Zeit (Gryseels and Anderson, 1983), but only 1.8 ha approximately at Deneba/Ineware (McCann, 1992). Labour in both areas is normally provided by members of the farm household or neighbouring farmers.

A survey conducted in the Debre Zeit area found that 50% of the farmers considered feed shortage to be the major constraint to improved livestock production. Disease was seen as the major constraint by 46% of the farmers (Asfaw et al, 1987). Traditionally, sheep fattening is based on grazing, aftermath grazing, crop residues, and residues of local beer (tella). Some farmers also feed the animals faba beans and chickpea grain (Asfaw et al, 1987).

Trials and design

Trials at Hidi/Debre Zeit, East Shoa Region

Five fattening trials were carried out at Hidi/Debre Zeit. The first two trials took place in 1987 and 1989 for a duration of 24 and 34 weeks, respectively. The sheep were sold during the Ethiopian Christmas in January of each year.

The treatment groups in Trial 1 were as follows:

- Treatment 1: Grazing only (*ad libitum* for 8 hours; 8 g salt per head/day);

- Treatment 2: Pen-feeding (teff straw, 800 g; sesbania leaves, 375 g; salt, 8 g per head/day).
- Treatment groups for Trial 2 were as follows:
- Treatment 1: Grazing (plus 400 g teff straw per head/day due to poor pasture);
- Treatment 2: Grazing plus supplementation (200 g sesbania, 50 g noug cake and 50 g wheat bran per head/day);
- Treatment 3: Pen-feeding (700 g teff straw, 200 g sesbania leaves, 50 g noug cake and 50 g wheat bran per head/day).

As not enough sesbania was available for Trial 2, 50 g noug cake and 50 g wheat bran were substituted for 100 g sesbania in treatments 2 and 3. These treatments also included 8 g salt and 5 g bone meal per head/day. Each feed treatment group was further subdivided to test the effect of veterinary prophylaxis.

For Trial 3, 95 sheep with an average live weight of 23.6 kg were purchased in early January, 1990. 17 sheep (18%) died between January and March, 1990. The trial started with 78 sheep but 6 more (6%) died between May and June, 1990. The sheep had been vaccinated against anthrax, sheep pox and pasteurellosis. All had been drenched against internal parasites. The cause of death could not be determined, therefore the surviving sheep were used for the economic analysis. 72 sheep were sold after 135 days. The treatment groups involved were as follows:

- Treatment 1: Pen-fed (150 g teff straw, 600 g wheat bran, 400 g cotton seed per head/day);
- Treatment 2: Grazing plus supplementation (300 g cotton seed, 150 g teff straw and 300 g wheat bran per head/day);
- Treatment 3: Grazing plus supplementation (200 g (200 g cottonseed cake, 150 g teff straw and 200 g wheat bran per head/day).

Trials 4 and 5 involved two batches of sheep which were fattened for 10 weeks each in 1991. The sheep in Trial 4 were fattened during the long dry season (period 1). The sheep in Trial 5 were fattened during the wet season (period 2). 147 and 120 sheep between 20–22 kg live weight were bought from local markets for the two fattening periods respectively. After being vaccinated against pasteurellosis and sheep pox they were treated for internal and external parasites. The treatment groups in each trial were as follows:

- Treatment 1: Grazing only;
- Treatment 2: Grazing plus concentrates (300 g wheat bran, 300 g cottonseed cake per head/day);
- Treatment 3: Grazing plus supplementation with forages.

Forage supplementation varied by season. Animals in Trial 4 (dry season) received 500 g per head/day oats hay plus maize stover, cowpea hay and wheat straw. Animals in Trial 5 (wet season) received oats hay only at 500 g per head/day. Animals in all groups had unlimited access to urea and molasses block.

Trials at Deneba/Inewari, North Shoa Region

Three fattening trials were carried out in Denebe/Inewari. Trial 1 compared supplementary feeds normally grown on-farm; a high proportion of oats straw versus oats grain under zero-grazing, with and without parasite control. Zero-grazing was chosen due to the shortage of grazing land in the area. Participating farmers purchased 40. Sheep the trial started in August 1988 and lasted 36 weeks. The animals were sold during Easter 1989. Preventive health care included drenching for nematodes and trematodes, dipping against ectoparasites and vaccination against sheep pox and pasteurellosis. The treatment groups were as follows:

- Treatment 1: High proportion of oats hay (1000 g oats hay per head/day);
- Treatment 2: High proportion of oats grain (450 g oats grain and 100 g oats hay per head/day).

All sheep were fed 100 g horse beans and 50 g rough peas per day.

Trial 2 took place during 1989 and lasted only 10 weeks. Participating farmers purchased 40 sheep from the local market with a mean weight of 18.3 kg. The same experimental design as Trial 1 was followed. By the end of the experiment four sheep had died. The surviving 36 sheep were sold by the farmers at Easter.

In Trial 3, participating farmers purchased 120 sheep from surrounding markets in September 1989 and the sheep were sold during Easter 1990. Due to results from the previous two trials at Deneba/Inewari, a 30 week fattening period was chosen. Changes were also made to the feed composition and amount. A high proportion of oats grain and cottonseed cake were compared with additional feed in both diets for the last five weeks, with and without health care. Health care included drenching for nematodes and trematodes, dipping against ectoparasites and vaccination against sheep pox and pasteurellosis.

For the first 25 weeks the treatment groups were as follows:

- Treatment 1: High proportion of oats grain (400 g of oats grain, 300 g wheat straw, 250 g cottonseed cake per head/day);
- Treatment 2: High proportion of cottonseed cake: (400 g of cottonseed cake, 300 g wheat straw, 200 g oats grain per head/day).

For the last five weeks the treatments were modified as follows:

- Treatment 1: High proportion of oats grain (650 g oats grain, 300 g wheat straw, 350 g cottonseed cake per head/day);

- Treatment 2: High proportion of cottonseed cake (550 g cottonseed cake, 300 g wheat straw, 325 g oats grain per head/day).

The increased feed during the last five weeks was designed to supply an additional 73.2 and 82.4 g crude protein (CP) and 1.006 and 0.797 mcal ME for sheep in Treatments 1 and 2, respectively.

Results

Hidi/Debre Zeit

Trials 1 and 2. Sheep on Treatments 1 and 2 in Trial 1 showed similar growth performances (Gautsch, 1992) and commanded the same average sales price. The sheep on the traditional grazing regime (Treatment 1) therefore returned a higher profit margin than the sheep that were pen-fed (Treatment 2), due to the lower feed costs for Treatment 1.

The supplementation of grazing sheep in Trial 2 (Treatment 2) resulted in higher daily growth rates than Treatments 1 (control) and 3 (pen-fed), by 16 and 7 g respectively. Table 1 shows that with or without veterinary intervention, combining grazing with concentrate supplementation is potentially more profitable than either grazing without concentrates or pen-feeding of concentrates without grazing. For example, without veterinary intervention, the marginal net benefit from supplementing grazing with concentrates was 23 Ethiopian Birr (EB) per animal with a marginal rate of return of 505% compared to not feeding concentrates. Veterinary intervention did not improve weight gains, therefore the additional costs without additional benefits reduced profitability. The sheep seemed to prefer sesbania to teff straw. However, to be an economically viable feed supplement, it would have to be grown by the farmers at little or no opportunity cost.

Trial 3. Average daily weight gains and body weights for survivors were influenced by diets and initial body weights (Gautsch, 1992). Pen-fed sheep on Treatment 1 suffered severe diarrhoea that led to weight loss. This was attributed to Gossypol toxicity related to the use of cotton seed and resulted in a negative return of EB -51.85 per sheep. Treatments 2 and 3 resulted in positive net returns of about EB 2.30 and 4.70 per sheep, respectively. The marginal rates of return for both 2 and 3 were negative. The additional profits from these treatments did not justify the additional cost. Diseased sheep may have been intentionally brought to the market and therefore bought by some participating farmers. Farmers need to be encouraged to purchase sheep within their own locality, which could help reduce losses due to disease.

Trials 4 and 5. Mean daily weight gains of 33 g and 70 g were observed during the dry and wet seasons, respectively. However, final body weights within seasons did not vary by feed treatments, perhaps due to

Table 1. *Partial budget analysis for on-farm sheep fattening experiment at Hidi/Debre Zeit in the wet season, Trial 2 (1991) (Ethiopian Birr/sheep).*

	Treatment group*					
	1		2		3	
	NVT	VT	NVT	VT	NVT	VT
Revenue from sales (A)	73.50	97.34	154.11	131.26	120.48	114.48
Total variable costs (B)	44.26	71.65	101.50	90.50	90.00	87.00
Sheep purchase	28.50	29.10	29.40	28.65	29.65	28.85
Feed:						
– Teff straw	5.76	5.76	–	–	10.08	10.08
– Sesbania	–	–	6.19	6.19	6.19	6.19
– Noug cake	–	–	1.54	1.54	1.54	1.54
– Wheat bran	–	–	0.76	0.76	0.76	0.76
– Salt	–	–	0.76	0.76	0.76	0.76
– Bonemeal	–	–	0.24	0.24	0.24	0.24
Labour:						
– Sheep purchase (per diem)	1.0	1.0	1.0	1.0	1.0	1.0
– Herding	8.0	8.0	8.0	8.0	8.0	8.0
Veterinary (Ranide)	–	1.10	–	1.10	–	1.10
Transportation (sheep)	1.10	1.10	1.10	1.10	1.10	1.10
Net return (A-B)	29.24	25.69	52.61	40.76	30.48	27.48
Net return over control	–	–	23.37	15.07	1.24	1.79

*NVT = no veterinary intervention

VT = veterinary intervention

the short fattening period (70 days). During the wet season, grazing plus concentrates resulted in a 13% rise in additional income per animal over grazing alone. The marginal rate of return was 28%. However, the marginal net benefit was only EB 1.80 per head. During the dry season, grazing was the only viable option. Of the two feeding alternatives to grazing, only grazing plus concentrates appears to have more potential than grazing plus forages. Forage feeding was not found to be economically viable in either period due to the income lost by growing forage instead of food crops.

Concluding remarks — Hidi/Debre Zeit

The economic analysis indicates that grazing plus concentrates has more potential than grazing plus forages to achieve sufficient weight gains for profitable short-term strategic fattening. Forage feeding was not found to be viable due to the income lost by growing forage instead of food crops. Further testing of supplementation with sesbania is indicated, therefore it would need to be grown on-farm to be a viable feed. Prophylactic health care did not improve weight gains, but added to production costs, thus reducing profits.

In order to achieve an acceptable return, the following socio-economic factors may have to be taken into consideration when planning future trials:

- sufficient time for fattening should be allowed so animals can gain sufficient weight to make a profit;
- sheep need to be of sufficient size to achieve a profitable weight by the time of sale, and need to be purchased when prices are low and sold at times of peak demand when prices are high;
- health care measures for fattening animals over a short period may not be needed.

Deneba/Inewari

Trial 1. Sheep on Treatment 2 were significantly ($P<0.05$) heavier than sheep on Treatment 1 after 16, 24 and 36 weeks of fattening (Gautsch, 1992). The average daily weight gain of 45 g for sheep on Treatment 2 was three times higher than for sheep on Treatment 1. Health care affected growth rates and feed conversion ratio (feed intake/body weight gain) and hence feed costs per kg live weight gain. All pen-feeding treatments resulted in losses. Local market prices were high for oats straw, oats grain, horse beans and rough peas. Thus the opportunity values of oat straw as feed for cattle and for horse beans, oats grain and rough peas as feed for humans are quite high.

There was a significant difference in price for different weight categories of animals. The average sales price/kg live weight for animals on Treatment 1 was EB 2.19, while that for sheep on Treatment 2 was EB 3.09. Sheep on Treatment 2 reached a weight range where consumers were willing to pay higher prices per kg.

Trial 2. Although the effect of diet on weight was marginally positive, health care had no effect. The fattening period was not long enough for sheep to reach the weight range that attracts higher prices per kg. The low weights of the sheep when purchased (18.3 kg mean body weight) were also a contributing factor. Net returns for all treatments were negative (Gautsch, 1992).

Trial 3. Gautsch (1992) indicated that at the end of the trial, animals on both dietary treatments attained a similar mean final body weight of 32.14 kg. Table 2 presents the partial budgeting results for this trial. The average sales price per sheep was the same for both diets. Net profits for Treatment 2 without veterinary intervention were EB 24.06 per head, about EB 9 per head higher than for Treatment 1. However, with veterinary intervention, the net profits per animal for Treatment 1 were about EB 5 per head higher than Treatment 2. Cottonseed cake was cheaper than grain, but the effect on weight gain was similar.

Concluding remarks — Deneba/Inewari

At Deneba/Inewari, zero-grazing was judged to be appropriate. The high price of oats straw and grain was the major reason for negative returns. Similarly to the trials at Hidi/Debre Zeit, the 10 weeks fattening period

Table 2. *Partial budget analysis for on-farm sheep fattening experiment at Deneba/Inewari, Trial 3, 1989 (Ethiopian Birr/sheep).*

	Treatment group*			
	1		2	
	NVT	VT	NVT	VT
Revenue from sales (A)	110.03	118.36	114.20	110.00
Total variable costs (B)	94.76	95.46	90.14	92.03
– Sheep purchase	50.63	50.73	51.60	51.50
– Labour	6.03	6.03	6.03	6.03
– Feed	33.13	33.66	27.71	29.58
– Barn depreciation	1.72	1.72	1.72	1.72
– Interest rate	3.25	3.32	3.08	3.20
Net return (A-B)	15.27	22.90	24.06	17.97
Change in net return	–	+7.63	+8.79	+2.70

*NVT = no veterinary intervention

VT = veterinary intervention

proved inadequate for sheep to reach a body weight which would have attracted the premium price. Consumers are willing to pay considerably higher prices per kg live weight for sheep with high body weight. If a pre-trial socio-economic survey had been done, these factors could have been taken into account.

Conclusions and implications

Short-term strategic fattening programmes based on supplementing grazing are feasible even in areas of land shortages, provided there is some land available for grazing. Agro-industrial by-products such as oilseed cakes and brans are good potential supplements to grazing. Urea and suitable forages and forage legumes also have potential as good feed supplements. Research into integrating forage and food crops is needed (intercropping, mixed cropping, etc.) and should be part of sheep fattening research. Pulses and grains should be avoided where their prices are high because they are part of human diets. Leguminous trees such as sesbania may also have potential as a supplement, but further on-farm research is required.

Conventional wisdom states that farmers' incomes can be increased through strategic feeding using the zero-grazing pen-feeding method. However, economic analysis shows that feed packages developed for this method are not economically viable. Alternative feeds tested have not resulted in much higher profitability compared to traditional methods of strategic feeding. Oilseed cakes such as noug and cotton do not seem to have any advantage over grains that are also used as human food. Other factors such as availability of inputs and financial risk have not been taken into consideration in this partial budget analysis. Furthermore, the genetic potential of the sheep breeds to respond to better feeding may have to be studied. The low marginal returns obtained for pen-feeding indicate that alternative feeding and crop production strategies should be tested on-station before on-farm tests.

Veterinary prophylaxis does not appear to affect weight gain under strategic short-term fattening programmes. Reproduction is not a factor in fattening for sale at times of peak demand.

The results show a number of socio-economic factors that can only be addressed at the farm level. These also need to be addressed in the design of station trials. The following technical and socio-economic factors may have to be considered when planning future trials:

- the alternative economic activities of the farm household need to be considered when choosing feeds;
- the effect of times of purchase and sale on profitability;
- the factors affecting consumer preferences in animals such as desired size, and therefore price, in order to achieve maximum income;
- the food preferences of farmers and relative market prices of alternative feeds; and
- the relative land and labour requirements for crops and forage production when considering the fattening period.

This study showed that analysing socio-economic factors is critical for achieving satisfactory results. Socio-economists can play an important role in designing effective strategic sheep fattening methods and designing station and on-farm trials.

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Socio-economic aspects of goat nutrition in Swaziland

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Abstract

Goats play an important role in Swazi custom and culture. However, their performance is limited by poor nutrition, especially during the dry winter months. Improving goat nutrition could therefore enhance their productivity and utility. This study involved a survey of goat production systems and an inventory of crop by-products in the small-scale farming sector. The study found cattle to be the dominant class of livestock, followed by goats, although both contributed minimally to the cash economy. The major factor affecting goat production was identified as feed shortage during winter. Several crop residues and agro-industrial by-products were identified as potential supplements. Their suitability for animal feeding is discussed.

Caractéristiques socio-économiques de l'alimentation des caprins au Swaziland

Résumé

Une large place est faite aux caprins dans les coutumes et la culture du Swaziland. Toutefois, ces animaux ont des performances faibles en raison de l'inadéquation de leur alimentation, notamment au cours des mois secs de l'hiver. Pour que s'améliorent leur productivité et leur utilité, il faut donc améliorer leur alimentation. Dans le cadre de l'étude présentée ici, une enquête a été effectuée sur les systèmes d'élevage caprin, et les sous-produits de récolte disponibles au niveau de la petite exploitation agricole ont été inventoriés. Il ressort des résultats de cette enquête que le cheptel national est essentiellement constitué par des bovins, puis par des caprins, encore que la contribution de chacune de ces deux espèces à l'économie monétaire soit insignifiante. Le déficit fourrager d'hiver constitue le principal obstacle la production caprine. Plusieurs résidus de récolte et sous-produits agricoles susceptibles d'être utilisés comme compléments alimentaires ont été identifiés et sont examinés.

Introduction

Livestock have traditionally been an important component of the agricultural industry in Swaziland. In 1986 their production accounted for about 21% of the agricultural output, 5% of the GDP and nearly 3% of total exports (CSO, 1987). In 1990 there were 715,741 head of cattle, 416,166 goats, 20,436 sheep and 23,802 pigs (MOAC, 1991). The majority of these goats, cattle and sheep are reared under a traditional system of management characterised by overstocking, communal grazing and uncontrolled herding. This has led to poor livestock performance in the form of low calving percentage, high young mortality rates and slow growth rates. Lebbie and Manzini (1989) reported the following characteristics of the indigenous Nguni goats (averages): age at first kidding 301 ± 55; litter size 1.18 ± 0.29; weight at birth 1.9 ± 0.14 kg and a growth rate to three months of 68.2 g/day. This performance is generally poorer than those reported for indigenous goats elsewhere (Wilson, 1976; Khombe, 1985). Lebbie and Mastapha (1985) mainly attributed the sub-standard performance to poor nutrition, especially in winter when the quantity and quality of the feed from the natural rangeland are very low. An improvement in nutrition through strategic supplementation could therefore enhance the productivity of the goats.

Methodology

This study is the first phase of a research project being conducted under the African Small Ruminant Research Network on the use of crop residues and agro-industrial by-products by smallholder farmers in Swaziland. It involved a survey of goat production systems and an inventory of crop by-products, as well as the determination of their suitability for animal feeding.

A total of 121 small-scale farmers were interviewed using a semi-structured questionnaire. Farmer distribution over three ecological zones of Swaziland is presented in Table 1.

Table 1. *Frequency distribution of the farmers interviewed across zones.*

Zone	Number of farmers	Percentage
Highveld	30	24.8
Middleveld	45	37.2
Lowveld	46	38.0
Total	121	100.0

Results and discussion

The population of livestock in the homesteads surveyed is presented in Table 2.

Table 2. *The population of animals in the homesteads surveyed.*

Class of livestock	Number of animals/ homestead (x ± SE)		Number of home-steads	Percentage of home-steads
Cattle	18	11	103	85.1
Sheep	9	4	7	5.8
Goats	15	9	86	71.1
Pigs	3	1	30	24.8

SE = standard error.

Table 2 demonstrates the dominance of cattle in the rural Swazi farming system, followed by goats. Similar findings have been reported by de Vletter (1983). The commercial role of livestock at the household level is indicated in Table 3. The main source of income was from wage employment, followed by crop sales and traditional medicine. Cattle and goats contributed little to the household financially, confirming the general observation that livestock ownership in Swaziland tends to emphasise numbers rather than productive capacity and financial value. Goats are kept mainly for home consumption and to meet other socio-cultural needs. Only rarely do they contribute a useful source of cash. Nonetheless, a fairly large proportion of the rural community do keep goats (71.1%) and derive financial benefits (40.7%) from them (Tables 2 and 3).

Table 3. *Sources of income for the rural households.*

Income source	Mean income ranking*	Percent of households (N=113)
Wages	1.7	75.2
Gross sales of crops	2.0	64.6
Traditional medicine	2.0	14.2
Handicrafts	2.2	36.3
Sales of cattle	2.7	43.4
Others	2.7	23.9
Brewed beer	2.8	16.8
Sales of goats	2.9	40.7

* Highest income source scored 1 and lowest scored 5.

Farmers were asked to identify the major constraints to goat production. Their responses are shown in Table 4.

The most common problems associated with goat production were feed shortage in winter, followed by disease. However, more farmers reported winter feed problems with cattle than with goats (55.9 vs 13%). This perception may be true considering that, unlike cattle, goats are capable of browsing on shrubs and bushes which normally remain green during the winter season.

Table 4. *Factors affecting goat production.*

Factor	Mean factor ranking*	Percent of farmers (N=113)
Feed shortage in winter	1.4	83.2
Diseases	1.9	83.2
Labour shortage	2.1	82.3
Land shortage	2.2	78.8
Availability of good bucks	2.3	77.9
Accidents	2.3	81.4
Plant poisoning	2.6	77.9
Feed shortage in summer	2.6	76.1

* Ranking of problems : 1 = serious, 2 = mild, 3 = none.

Accessibility of the various feed resources to livestock during the winter season is shown in Table 5. Natural pastures, maize stover, maize cobs and browse constitute the bulk of winter feed in most homesteads. Apart from browse, the quality of these feed resources is known to be low and practical methods of improving their quality are being investigated. Identification and quality determination of the browse species are also being undertaken. Besides the feed resources shown in Table 5, some farmers were found to provide extra feed to their livestock. Some of these supplementary feeds are listed in Table 6.

Table 5. *Accessibility of livestock to various feed resources in winter.*

Feed resource	Number of homesteads (N=113)	Percentage
Natural grazing	112	98.2
Maize stover	107	94.7
Maize bran	24	22.9
Maize cobs	52	47.3
Sorghum stover	2	2.1
Bean haulms	5	5.3
Pumpkin residues	4	4.2
Sweet potato vines	1	1.1
Browse	55	56.7

Table 6. *Agro-industrial by-product and supplement utilisation by livestock.*

By-product or supplement utilised	Number of homesteads (N=110)	Percentage
Sugar- cane tops	4	3.6
Other by-products	4	3.6
Common salt	5	4.6
Rumevite mix	2	1.8
Molasses	3	2.8
Urea	2	1.8
Hay	2	1.8
None of the above	88	75.5

Table 7. *The potential of crop residues and agro-industrial by-products as feed for goats.*

	By-product			
	Maize stover	Sugar-cane tops	Pineapple waste	Citrus pulp
Where produced	rural homesteads	lowveld sugar estates	Malkerns area estates, farms	Malkerns factory
When produced	April to May	April to December	January to November	April to July
When available	April to July	April to December	January to December	April to October
Annual quantities produced (t)	154,800	38,000	24,000	3,000
Exploited commercially?	no	no	no	yes
Alternative uses	ploughed in otherwise no use	feed base with molasses	ploughed in or burnt	no use possibly silage
Problem as livestock feed	storage and social factors	removal from field and distribution	removal from field and distribution	none except transport

Source: Wickstead (1990) and Ogwang (1988).

Table 6 shows that the majority of farmers do not give their livestock any agro-industrial by-products as feed. It also shows the diversity of supplements that are available in Swaziland but which are currently under-utilised. The potential of some of these feed resources for use in goat production is summarised in Table 7.

The most critical period for grazing livestock in Swaziland is between May and September when many of the crop residues and agro-industrial by-products are available. However, the practical problems mentioned above need to be overcome and appropriate feeding strategies devised before farmers can be encouraged to use them.

Conclusion

Natural pastures, browse and maize stover are the most important component of goat diets in Swaziland. Goat owners generally invest minimally in livestock production. The animals are largely left to graze freely, with any supplementation consisting of cheap green feeds and crop residues. However, there is an immense potential for improving goat nutrition and therefore production by using crop by-products such as sugar-cane tops, pineapple waste and citrus pulp as feed supplements.

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The role of the West African Dwarf goat in the economy of the smallholder arable farmer in the subhumid zone of Nigeria

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Abstract

This study analysed 875 records of West African Dwarf (WAD) goats owned by 45 farmers and collected over 30 months. In the wet season WAD goats had access to either fodder banks or natural pasture. After crop harvest, animals roamed freely. Litter sizes were 1.67 ± 0.08 and 1.56 ± 0.06, respectively, on the two grazing systems and were affected by parity ($P<0.05$). Births accounted for 87% of all entries while multiple births accounted for about 68% of all kids. Castrates accounted for about 60% of all mature males. Between 35 and 39% of adult goats were sold for meat and offtake accounted for between 51 and 53% of all exits. Sufficient cash was generated from goat offtake to purchase farm inputs and some household items. Goats play other important roles in the socio-economy of the traditional smallholder farming system.

Place de la chèvre naine d'Afrique occidentale dans l'économie de la petite exploitation agricole dans la zone subhumide du Nigéria

Résumé

Cette étude analyse 875 relevés effectués sur des chèvres naines d'Afrique occidentale détenues par 45 exploitants, et recueillis sur une période de 30 mois. Les caprins séjournaient sur des banques fourragères ou des pâturages naturels durant la saison humide et étaient laissés en pâture libre après la récolte. La taille des portées était repectivement de 1,67 ± 0,08 et de 1,56 ± 0,06 pour ces deux systèmes de pâture et subissait l'influence de la parité ($P<0,05$). Les naissances représentaient 87% de l'ensemble des entrées. 68% des chevreaux provenaient de naissances multiples. Les animaux castrés constituaient 60% des mâles adultes. De 35 à 39% des animaux adultes étaient vendus comme animaux de boucherie. L'écoulement representait 51 à 53% des sorties et procurait le revenu monétaire nécessaire à l'achat d'intrants agricoles et de certains articles de ménage. Les caprins jouaient d'autres rôles importants dans la socio-économie du système traditionnel de la petite exploitation.

Introduction

FAO (1991) estimated the goat population of Africa in 1990 to be 171 million, out of which 22 million were found in Nigeria. A recent livestock census, however, puts the goat population in Nigeria at 34.5 million (RIM, 1991).

The keeping of goats in any community is related to the value attached to their production. Goats are mainly kept for meat (Williamson and Payne, 1978). Brinkmann and Adu (1977) estimated that goat meat accounted for about 20% of all meat eaten in Nigeria. This is probably an underestimate as goats slaughtered in rural areas are seldom recorded.

In addition, goats play an important role in the welfare of the smallholder arable farmer in Nigeria through the income generated when sold. There is global concern about alleviating poverty and improving the welfare of the rural poor. The sale of goats could improve the welfare of farmers, particularly women, most of whom own goats and who, along with children, are entrusted with the care of small ruminants.

About 85% of the smallholder farmers in the Nigerian subhumid zone keep West African Dwarf (WAD) goats (Bayer, 1986). Traditional methods of keeping goats in the wet season are tethering or free-range grazing on enclosed natural pasture. While this restriction of movement may prevent crop damage, it induces feed stress. The introduction of herbaceous legumes into enclosed fallow land is attractive to farmers because it alleviates the feed constraint in the wet season. At the same time it fixes nitrogen from the atmosphere, helping to restore or increase soil fertility for subsequent cropping. There is, however, little information on WAD goat offtake in the subhumid zone (SHZ) of Nigeria.

This paper documents a 30-month ILCA case study of goat flocks in Ganawuri, in the subhumid zone of Nigeria, to assess the contribution of goat offtake to the economy of the smallholder farmer.

Materials and methods

Site

This study was carried out at Ganawuri, Plateau State of Nigeria, located at 9°N and 8°35'E. The average annual rainfall is about 1400 mm, 95% of which falls between April and October. Cultivation density ranges from 40 to 70% (Bayer, 1986).

Animals

Flocks of goats from 45 households were tagged and recorded for 30 months to determine flock population dynamics. Flock sizes ranged from 4 to 20 animals per household and belonged to smallholder farmers. Animals were weighed every two weeks using hanging spring scales. They were vaccinated annually against *peste des petits ruminants* (PPR) and routinely treated for ecto- and endoparasites. Birth weights, birth type and birth dates were recorded. When this study began in August 1989, 18 farmers with 158 goats were included. Eight had access to a communal fodder bank and 10 relied on natural pasture for wet-season grazing. In 1990 there were 40 farmers. Seventeen used fodder banks, 23 used natural pasture, and they had 324 animals. At the beginning of August 1991 there were 45 farmers, 19 using fodder banks while 23 used natural pasture. They had 157 does, 15 bucks, 66 castrates, 57 young males and 100 young females, making a total of 395 animals. There was a concomitant increase in the number of fodder banks from one in 1989 to 9 and 11 in 1990 and 1991, respectively. Where farmers shared fodder banks, their animals were treated as single flocks for analysis.

Housing and feeding

Goats were housed at night in small mud huts with thatched or metal roofs. In the dry season, animals were allowed to graze freely from natural pasture (NP), which included grasses and browses. In the wet season they were tethered on natural pasture or were allowed to graze freely on enclosed natural pasture. In addition, some flocks grazed freely from small plots or mini fodder banks (FB) of about 0.1 ha of herbaceous legume. After crop harvest, they roamed freely and grazed crop residues or were fed household wastes. At the beginning of the next cropping season they were again confined. The period of greatest feed stress was usually August to October.

Pasture establishment

Stylosanthes pasture was established according to the method of Otsyina et al (1987). The seed rate used was 12 kg/ha, and 150 kg of single superphosphate (SSP)/ha was applied. Early-season grazing was used to control grass growth. Pasture was top-dressed annually with 100 kg SSP/ha.

Data analysis

A total of 875 entries were made over the 30-month period. The animals were divided into two groups based on the differing wet-season feed regimes. These were either enclosed herbaceous legume or natural pasture, which included enclosure or tethering. Frequencies of exits from and entries to flocks and the reason for these occurrences were analysed in relation to wet season grazing system and sex of the animal. General linear models (SAS, 1987) were used to analyse litter size, using parity, birth type and sex as fixed effects.

Economic analysis

In order to apportion monetary value to offtake, the weight of animals sold or slaughtered for meat and the average weight of a weaner were calculated. The cost in Nigerian Naira (₦) of fertiliser was taken as ₦ 1/kg and labour as ₦ 4/man-hour for 16 hr. The cost of establishing a small FB was taken as ₦ 80.

Results

Births accounted for 86.7% of the entries, with purchase and transfers accounting for the rest. Females accounted for 56.7% of all entries. Of the pioneer stock, 68% were females and about 13% were breeding males (Table 1). Castrates accounted for 60% of the pioneer mature males.

Table 1. *Frequency distribution of entries of West African Dwarf goats to flocks in Ganawuri by wet-season grazing system and sex over a 30-month period.*

	Grazing system					
	Fodder bank			Natural pasture		
Parameter	Cast.	Male	Female	Cast.	Male	Female
Pioneer	21	19	83	37	22	127
Purchase	1	1	4	2	3	15
Transfer	5	3	14	4	3	15
Gift	1	0	1	0	0	3
Birth	2	92	108	2	126	161
Total	30	115	210	45	154	321

Cast. = castrate.

Table 2 shows the distribution of exits of WAD goats under the two wet-season grazing systems. Between 35 and 39% of all mature goats were sold for meat. The NP and FB wet-season grazing systems gave overall percentage offtakes of 51 and 53%, respectively. Overall percentage offtake was defined as per cent sold for meat + transfer + slaughtered for ill health. Deaths of kids up to one year of age accounted for between 12.8 and 14.5% of all exits.

Table 2. *Frequency distribution of exits from flocks and reproductive performance of West African Dwarf goats under two wet-season grazing systems.*

Parameter	Grazing system			
	Fodder bank		Natural pasture	
	No.	%	No.	%
Adult				
Sold for meat	70	39.1	94	35.1
Transfer	16	8.9	32	11.9
Slaughtered for ill health	9	5.0	11	4.1
Unknown	3	1.7	1	0.4
Gift	14	7.8	31	11.6
Died accident/sickness	7	3.9	11	4.1
Kids				
Died within 1 year	23	12.8	39	14.5
Abortion or still birth	10	5.6	8	3.0
Transferred	9	5.0	13	4.8
Slaughtered	9	5.0	10	3.7
Sold	3	1.7	9	3.4
Lost or stolen	3	1.7	9	3.4
Accidental death	3	1.7	–	–
Reproduction				
Does	43		73	
Parturitions	80		126	
Parturitions/doe	1.86		1.73	
Litter size	1.67		1.56	

Legume supplementation significantly ($P<0.05$) reduced weight losses in non-pregnant does on FB when compared with those on NP between August and October. Viability of kids of up to one year of age lay between 86 and 89%. Table 3 shows that litter size was significantly ($P<0.001$) affected by parity, with first kidders having smaller litters. Average litter sizes were 1.67 ± 0.08 and 1.56 ± 0.06 on the FB and NP feeding regimes, respectively. Multiple births accounted for about 68% of all kids in the study. Does that remained in the system throughout the period showed improved productivity on the fodder bank feeding system (1.86 vs 1.73 parturitions/doe). Grazing of fodder banks is thus beneficial in this cropping system.

The average weight of animals sold or slaughtered for meat was 22 kg. A goat currently sells for about ₦ 10 per kg liveweight (US$ 1= ₦ 18.5). The average weight of a weaner at 150 days of age is 8 kg (unpublished data). This would give an average value of ₦ 220 per adult goat and ₦ 80 for each weaner when sold.

Figures based on numbers of animals sold, given in Table 2, show that sales of adults (sold for meat, transferred out or slaughtered because of ill health) from the two grazing systems amounted to ₦ 51,040 (232 x ₦ 220). Kid sales amounted to ₦ 960 (12x ₦ 80). This sum was generated by 45 farmers over two years, which comes to ₦ 580/ household per year. Actual sales from 13 households, each owning nine animals or more, gave an income of ₦ 633/household per annum.

Table 3. *Least squares means of litter sizes of WAD goats in Ganawuri in the SHZ of Nigeria.*

Effect	Level	Parturition	Mean ± SE
Treatment	FB	121	1.67 ± 0.082
	NP	171	1.56 ± 0.064
Year	1989	24	1.64 ± 118
	1990	115	1.59 ± 0.069
	1991	154	1.61 ± 0.053
Parity			***
	1	79	$1.31^{a} \pm 0.075$
	2	45	$1.65^{b} \pm 0.009$
	3	68	$1.67^{b} \pm 0.073$
	4	61	$1.74^{bc} \pm 0.079$
	≥5	40	$1.70^{bc} \pm 0.102$
Season			
	Dec–Feb	40	1.67 ± 0.097
	Mar–May	86	1.62 ± 0.074
	Jul –Aug	80	1.6 ± 0.083
	Sep–Nov	77	1.56 ± 0.076

FB = Fodder bank; NP = Natural pasture.

Means with different superscripts within each column are significantly different ($P<0.05$).

Discussion and conclusions

The overall size of a WAD goat flock at any time is a function of entries and exits. Offtake was mainly to secure cash to purchase household needs such as food and farm inputs. In addition, goats could be slaughtered for meat. Bayer (1986), using a small data set, reported offtake at 23.4%. This was made up of all transfers out, sales and slaughters. This study showed the offtake of mature animals to account for between 51 and 53% of exits.

Births accounted for approximately 87% of all entries. This suggests that flocks are able to maintain their numbers through birth replacements, partly due to the tendency of WAD goats to produce multiple births. Of particular interest is the appreciable number of animals given out as gifts (10% of exits) in contrast to entries (0.9%). This suggests that the greater portion of animals received as gifts were not added to the flocks but were eaten or sold.

Pioneer flocks showed a preponderance of castrates over bucks. This suggests that the castrates were used as the "savings account" which could be drawn upon at short notice to meet family needs. Goats which were sold or slaughtered for meat also included those that were needed for ceremonies such as weddings or communal feasts (Bayer, 1986). These ceremonies are part of the social system and help to sustain the

smallholder farming system. Most goat sales were completed just before the cropping season. This allowed farmers to reduce the labour requirement for tethering during a period when labour was required for cultivating their crops.

The low mortality rate contrasts with the higher mortality of 40 to 50% reported in the humid zone (Reynolds et al, 1988). This may in part be due to the small veterinary package provided in this study which improved flock survival.

Litter size and survival rate were improved among goats on the fodder bank. The slight increase in litter sizes and birth rate provides evidence of improved reproductive efficiency for goats on the fodder bank grazing regime. These figures also support incorporating herbaceous legumes into this cropping system.

The observed ratio of intact males to does of 1:10 in this study and 1:16 in another study in the same zone (Bayer, 1986) indicates that more breeding males than necessary are kept within these flocks. However, the total absence of breeding males in some flocks is a cause for concern. The tethering of all animals in the day during the wet season means that no breeding will occur in flocks that do not keep breeding males.

With money realised from the sale of a goat a smallholder farmer can purchase about 200 kg of fertiliser for use during the cropping season. The average farmer in Ganawuri cultivates about 2–3 ha. The fertiliser requirement could, therefore, be met by selling three goats. In addition, manure could be collected from goathouses and used as fertiliser. The fertiliser and labour costs required for establishing an FB could be further reduced by undersowing a cereal crop with stylo a year before the land is left fallow (Tarawali et al, 1987).

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Some socio-economic factors that affect decisions on small ruminant production by small-scale farmers — A case study of west Laikipia

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Abstract

One of the main problems of small-scale farming in the arid and semi-arid lands (ASAL) of west Laikipia is that of low household incomes. A major contributor to net farm income in this area is income from livestock production. Previous studies show that small ruminants have many advantages over the large ruminants (Mburu, 1988; Ngategize, 1989; Andargachew Kebede, 1990). The objective of this study was to identify some of the socio-economic factors that affect decisions on small ruminant production enterprises and recommend ways of increasing income from them.

A sample of 65 small-scale farmers was selected from two of the subdivided ranches in the ASA lands of west Laikipia. We found that the age of the respondents and the ownership of small ruminants were not correlated. Respondents identified pneumonia and Contagious Caprine Pleuropneumonia (CCPP) as major constraints on small ruminant production, but not insufficient grazing. However, we observed that parts of the study area had only fair to poor grass cover. Lastly, we found a negative correlation between the presence of off-farm income and income from small ruminant production, but none between contact with livestock extension personnel and the number of respondents reporting small ruminant mortality as a major constraint.

Facteurs socio-économiques intervenant dans les décisions prises par les petits exploitants de West Laikipia concernant l'élevage des petits ruminants — étude de cas

Résumé

La faiblesse des revenus des ménages constitue l'un des principaux problèmes qui touche la petite exploitation agricole dans les terres arides et semi-arides de West Laikipia. Dans cette région, les revenus de l'élevage représentent une part importante du revenu agricole net. Des études antérieures ont montré que les petits ruminants offraient de nombreux avantages par rapport aux gros bétail. La présente étude visait à identifier certains des facteurs socio-économiques qui déterminent les décisions prises en matière d'élevage ovin et caprin et à recommander les moyens à mettre en oeuvre pour augmenter les revenus qu'on peut en dégager.

Un échantillon de 65 petits exploitants a été sélectionné dans deux des ranches subdivisés situés dans les terres arides et semi-arides de West Laikipia. Il n'y avait pas de corrélation entre l'âge des enquêtés et la détention de petits ruminants. D'après les exploitants interrogés, les principaux obstacles à l'élevage de petits ruminants sont la pneumonie et la péripneumonie contagieuse des caprins, et non pas l'absence de pâturage. Il a pourtant été constaté qu'à certains endroits de la zone d'étude le couvert herbeux était de médiocre qualité. Par ailleurs, il y avait une corrélation négative entre la disponibilité d'un revenu non agricole et les revenus de l'élevage de petits ruminants, et il n'y avait pas de corrélation entre l'accès à des services de vulgarisation de l'élevage et le nombre d'enquêtés pour lesquels la mortalité des agneaux constituait un important facteur limitant.

Introduction

It is estimated that 82% of the population in Kenya live in rural areas, mainly as small-scale farmers. In Laikipia, 91% of the population live in rural areas (GOK, 1991). From this, it can be deduced that the majority of the population in the district are small-scale farmers. This is confirmed by the fact that by 1987, land buying companies in the district had bought 74% of the former European ranches and subdivided 63% of them (GOK, 1987). In the study area, nearly two-thirds (2/3) of the small-scale farms have been settled (Table 1). This makes small-scale farming in the district significant. It is for this reason that the Laikipia Research Programme (LRP) has orientated its research towards this type of farming. Most of the LRP research is focused on small-scale farming in the ASA lands which make up 80% of the district.

Table 1. *Information on the human settlement in the study area.*

	Frequency	Per cent
Number of settled farms	605	61
Number of unsettled farms	390	39
Total number of farms	995	100

These small-scale farmers face many challenges in generating household incomes. One way of helping them is to increase the income they receive from small ruminant production. This study therefore focuses on some of the socio-economic factors that affect decisions on small ruminant production in west Laikipia. Some of these factors are more economic than sociological, while others are more sociological than economic. It is difficult to separate the two, but this study focuses primarily on the sociological factors. A discussion of all socio-economic factors can be found in Mucuthi (1992).

Materials and methods

In 1990 there were 28 former European ranches and five government settlement schemes in west Laikipia that were in various stages of settlement and/or subdivision. In eight, subdivision was completed and therefore maps were available. For sampling convenience, we selected two ranches from this group. Each selected ranch was subdivided into four equal subclusters and one subcluster was chosen from each ranch as the starting point. The farms or sampling units were not sampled randomly within the subclusters but systematically from a randomly selected corner of the subcluster.

Using this method, 65 respondents who were defined as small-scale farmers were interviewed. They represented 9% of the potential respondents in each ranch. Herd size (50 small ruminants and 10 cattle) instead of land size was used to classify small-scale farmers, though recognising that land size is the standard measure of farm classification. Herd size was used because Kohler (1987) found that in west Laikipia most small-scale farmers owned no more than 50 head of small ruminants and eight head of cattle. No prior appointments were made for visits, but efforts were made to interview the husband or the wife, or in default, the *de facto* head of the farm. Otherwise, the enumerator moved to the next farm. Each respondent was asked general questions relating to small ruminant production. They were also asked specific questions relating to the factors that affected decisions on small ruminant production.

The Farming Systems Research (FSR) approach was used in determining the factors considered to affect decisions on small ruminant production. This approach was used because, among other attributes, it is characterised by the "bottom-up" rather than the traditional "top-down" approach to farmers' problems. It also recognises the need to have research tailored to a specific area, in this case the small-scale farming area of west Laikipia. When using the FSR approach, there is a time-lag in the recognition of the problem and finding the relevant solution. Therefore, the approach is inherently expensive. Nonetheless, it is consistent with the development strategies of the Kenya District Focus For Rural Development as it builds on, rather than destroys, the farmers' development techniques. This study considered the age of the respondent, farm size, frequency of contact with livestock extension personnel, type and amount of income accruing from off-farm income and constraints to small ruminant production.

Results and discussion

Age of respondents

Only in 20% of the cases was the male head of the household involved in herding. Most of the herding was done either by the wives (35%), children (25%), or hired labour (20%).

Neither ownership nor herd size of small ruminants was associated with age of respondent ($P>0.05$). Age may not be a crucial factor in the adoption or non-adoption of projects on small ruminant production.

Farm sizes and small ruminant production

In the study area, the mean farm size was 5.3 ha, with most of the respondents owning between 3.7 and 7.2 ha (Table 2). Thirty-six per cent of the land was used for crop land while 4% was used as homesteads (Table 3); the rest of the land (60%) was available for grazing.

Grazing land size, however, tends to be determined by the area reserved for crop production rather than vice versa. This explains why land size *per se* was neither significantly correlated with the herd size nor with the presence or absence of the small ruminant enterprises ($P<0.05$). It also confirms our earlier assumption that land size can be a deceptive criterion for identifying small-scale farmers for livestock-related studies and projects, especially where the farmers are employing extensive methods of livestock production. It was observed that when small-scale farmers had extra income to invest, they preferred to invest in livestock rather than in crop production (Mucuthi, 1992).

Table 2. *Land ownership by farm sizes.*

Farm in hectares	Percentage of respondents
Under 1.8	3
1.8–3.6	9
3.7–4.8	40
4.9–7.2	37
Over 7.2	11
Mean 5.3	100

Table 3. *Mean land sizes for various land uses in the study area.*

Type of land use	Land size (ha)	Per cent of total
Mean grazing land	3.2	60
Mean crop land	1.9	36
Mean size of homestead	0.2	4
Mean land holding	5.3	100

Availability of grazing for livestock

Most respondents (84%) utilised their own farms and the unoccupied farms for grazing. They kept as many animals as they were able to, because there were no grazing restrictions. The stocking rate, which was calculated by dividing the number of ha of the available grazing land by the Tropical Livestock Unit (TLU=250 kg) was 2.8 ha per TLU. This was less than the carrying capacity recommended to graziers of 3–5 ha per TLU (Pratt and Gwynne, 1977).

When the stocking rate was calculated with the assumption that only one's own farm was available for grazing, the stocking rate was even lower at 1.4 ha/TLU. Without feed supplementation, the available grazing land in the study area could support only one cow or 10 small ruminants per respondent. Unfortunately, only 27% of the respondents gave any form of supplementary feed (maize stover and crop residue) to small ruminants. Available fodder was fed mainly to cattle.

Effect of small-scale farmers' off-farm occupations on small ruminant production

Respondents engaged in off-farm occupations because food crop yields in the ASA lands are unreliable. Even in good years, maize crop yields (a maximum of 20 bags of 90 kg) are not enough to guarantee the respondents sufficient food and income for one year.

When off-farm work was the main occupation, the head of the household was engaged in permanent off-farm work. However, we could not rule out the fact that respondents engaged in farming to supplement off-farm income. We found that 60% of the respondents depended solely on net farm income while 40% were also engaged in off-farm work.

The proportion of respondents dependent on net farm income was higher than that reported by Kohler (1987). He found that in central Laikipia, only 33% of the respondents depended on net farm income. The lower dependence on off-farm work in the study area compared to central Laikipia was because the respondents in west Laikipia were farther away from the main employment areas.

Of the 43 respondents, 38 with positive household income had small ruminants; only data from these respondents were used in the test of difference of means.

A comparative analysis of the levels of income from small ruminant production for respondents with off-farm income and those without, did not indicate any significant difference ($P>0.05$) in the mean small ruminant herd sizes. Therefore, any significant difference in mean incomes from small ruminant production was from the number of small ruminants sold by the respondents.

Table 4 shows that the mean income from small ruminant production for respondents without off-farm income was significantly higher ($P<0.05$) than for those with off-farm income. Though the sample sizes were small (19 respondents) and the standard deviations high, large variations across observations do occur in cross-section studies (Pindyck, 1981).

Table 4. *Comparison of differences of mean income from small ruminant production, for respondents with and without off-farm income.*

	Without off-farm income	With off-farm income
Mean income (Kenyan shilling)	1326[a]	523[b]
Standard deviation	1344	942
Sample size	19	19

Values within the same row with different superscripts are significantly different ($P<0.05$).

The high mean income from small ruminant production for respondents without off-farm income indicates the significant contribution of small ruminants to net farm income. Indeed, small-scale farmers in the ASA lands considered small ruminant production and off-farm income as the most important sources of household income for development as well as daily expenses. Small ruminant production contributed 50 and 54% to income used for daily and development expenses, respectively (Mucuthi, 1992).

Effect of livestock extension services on small ruminant production

The five Ministry of Livestock Development extension personnel were either livestock production personnel (LPP), who advised the respondents on animal husbandry, or veterinary personnel (VP), who were in charge of livestock treatment. While the LPP were expected to visit farmers on a regular basis, the VP were expected to stay at predetermined places where farmers could reach them. However, advisory and treatment work was sometimes done by the same people.

Table 5 shows the number of visits by the LPP as reported by the 50 respondents who had small ruminants. Of the respondents, 74% were never visited at all while 20% were visited whenever the need arose. For the VP (Table 6), the majority of the respondents were visited whenever the need arose and the rest were never visited.

Table 5. *Reported visits by the livestock production personnel.*

Response	Frequency	Per cent
Never visited	37	74
Whenever need arises	10	20
Fortnightly	2	4
Weekly	1	2
Respondents interviewed	50	100

Table 6. *Reported visits of the veterinary personnel.*

Response	Frequency	Per cent
Whenever need arises	39	78
Never visited	11	22
Respondents interviewed	50	100

It appears that the problem of infrequent visits by the LPP was not due to lack of personnel, but due to the disproportionate time given by the extension personnel to the treatment service. Where the same extension personnel are expected to perform both advisory and treatment work, it is obvious that the advisory work will be compromised because the personnel cannot visit farms and wait for the farmers' visits at the same time.

Visits by Ministry of Livestock Development extension personnel are expected to have an impact on the small-scale farmers' management practices. It is expected that through contact with extension personnel, small-scale farmers will improve livestock husbandry practices. Thus it was surprising to find no correlation between the frequency of visits by the LPP or the VP and the small ruminant mortality rate.

Constraints to small ruminant production

Respondents were asked to indicate the most important constraints on small ruminant production and to prioritise them. They indicated that mortality through disease (53%) and lack of enough water for livestock (21%) were the most important constraints. This confirms what had been reported in other studies, that diseases are among the most important constraints to small ruminant production (GOK, 1990; Herren, 1990; Mucuthi, 1992).

The LPP and the VP are supposed to advise small-scale farmers on the best animal husbandry practices. It was expected that more frequent visits by these personnel would lower the significance of diseases as a constraint. However, an insignificant correlation ($P<0.05$) was found between the frequency of their visits (both LPP and VP) and the number of respondents who reported that diseases were the major constraint. This is because most respondents were satisfied with the veterinary treatment but not the small ruminant production advisory services.

Insufficient grazing was not seen as a major constraint by the respondents. Nevertheless it was apparent, especially in the unoccupied farms. In assessing the availability of grazing, grass cover was determined by the amount of bare soil observed by the enumerator at the time of the interview. Less than 10% of bare soil cover was considered to be good grass cover, 11–30% was medium and 31–50% was bad. It was estimated that 59% of the occupied farms had good grass cover, 30% had medium grass cover and 11% had bad grass cover. The unoccupied farms had medium soil cover or worse.

To achieve the optimum carrying capacity, one needs to do any or all of these things. First, livestock numbers must be reduced. However, where grazing is communal, as in the study area, this method has been unpopular. Second, livestock feed can be improved and increased. Although this is easier to achieve than the first option, lack of enough grazing for small ruminants was not seen as a significant constraint by the respondents. Feed availability could be increased by planting fodder trees like *Leucaena* and *Sesbania* along the fences and on terraces. Third, the productivity per animal can be enhanced through upgrading and improving management. This is the easiest of the three options to implement. It is not expensive and would be agreeable to the respondents.

Conclusion

a) In west Laikipia the age of the respondent did not affect participation in small ruminant production enterprises.

b) Land size was not correlated with small ruminant herd size or the ownership of small ruminants. Land size can therefore be a deceptive criterion in classifying small-scale farmers for livestock-related studies and projects.

c) There is a significant contribution ($P<0.05$) of income from small ruminant production to net farm income for respondents without off-farm income.

d) Respondents were satisfied with the services of the VP but not with those of the LPP.

e) Grazing land was determined by the area reserved for crop production but not vice versa. Respondents also perceived capital, rather than land, as the limiting factor in livestock production.

Recommendations

a) For livestock-related studies and projects, land size should not be used as a criterion for classifying small-scale farmers.

b) Action needs to be taken to improve the optimum livestock carrying capacity of the study area.

c) The question of poor extension services for small ruminant producers needs to be addressed. Some options would be to separate the roles of the personnel and/or charge a fee for their services.

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Priority setting for small ruminant research

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Abstract

The limited resources available to national agriculture research and extension systems in Africa will allow only top priority areas to be funded. Priority identification must take into account farmers' objectives and those of national planners. A farming systems approach is essential to determine farmers' objectives and constraints and to identify appropriate solutions. Such information is an essential prerequisite in the formulation of research programmes, which must be backed up by a thorough review of the literature. Small ruminants may or may not be a national priority.

Définir les axes prioritaires de recherche sur les petits ruminants

Résumé

L'insuffisance des ressources dont ils disposent oblige les services nationaux de recherche et de vulgarisation agricoles en Afrique de ne financer que les domaines revêtant une priorité absolue. Pour identifier ces priorités, les objectifs des petits exploitants et des planificateurs nationaux doivent être pris en considération. L'adoption d'une approche systèmes agraires est essentielle si l'on veut déterminer les objectifs des paysans et les contraintes auxquelles ils se heurtent, et identifier des solutions appropriées. Ce type d'information est un préalable indispensable à la formulation de programmes de recherche, qui devront être appuyés par une étude bibliographique approfondie. Les petits ruminants peuvent ou non figurer parmi les priorités nationales.

Introduction

Africa is experiencing political and economic changes, and national research and extension organisations must adapt to survive in the face of these changes. Across sub-Saharan Africa (SSA) the level of funding from governments for agricultural research has fallen below the level needed for active and productive use of trained manpower. While the present level of funding is a reflection of the economic realities for the Governments of SSA, it also accounts for the limited progress that has been made in African agriculture. Donors, be they national or international are more than ever before concerned about impact. Technology developed from agricultural research has not always been adopted in SSA over the past 20 years. Promises of technological breakthroughs and of adoptable packages have not been kept. Scepticism on the part of paymasters must be overcome, realistic objectives set and adoptable technology produced if financial support is to be sustained, let alone increased. Sustainability as an issue has been accepted as an objective for biological research, but less attention has been paid to the sustainablity of the research institutions and the accompanying infrastructural support required for research and extension.

Populations in SSA are expected to expand threefold by 2025 from the present level of 500 million. Over the same period, urbanisation is expected to rise from 31 to 57% of the population (Winrock International, 1992). Urban consumers tend to require more processed foods, high value cereals, livestock products and vegetables. To meet this demand agricultural production must increase and become more market oriented to supply urban areas. Market forces can stimulate production, as seen in the variations in cereal sales in Zimbabwe in response to changes in the level of guaranteed prices, but market forces alone will not be enough. More land will be cropped to supply the requirements of higher populations, but uncultivated productive land is already limited. Unit area productivity must therefore increase. Storage, processing and transport must become more efficient. Research, in collaboration with producers and advisory services, has a critical role to play in these developments.

Nations must decide on their priorities and ensure that they are providing enough funds for essential research. Donor-driven research programmes are affected by the availability of funds. They may not conform to national priorities, and may divert the limited number of trained personnel away from more important work. In most countries in SSA, very few activities can be funded solely from national resources. External funds should therefore be directed towards supporting the priority research areas. Only after those areas have been adequately covered should other work be considered. If and when external support declines, high priority areas will be less affected because core funding will already have been assured from the national exchequer. This is

a risk-avoidance strategy against variations in donor countries' economic and political climates, similar to that adopted by farmers in minimising annual differences in the biophysical climate. However, this strategy will be effective only if focussed on the highest priorities.

The ratio between staffing and operational costs is 9:1 in many countries. This ratio is unsustainable and must therefore be narrowed. A ratio nearer 3:2 would produce sufficient operational funding to allow useful research to continue. When operational funds are in short supply staff still receive salaries, but cannot carry out any useful function. Unpalatable though it may seem, closing research stations and reducing staff levels to allow those remaining to operate effectively is essential, given that additional funding is unlikely (Eicher, 1989).

Priority setting: the key issue

Agricultural research has largely focussed on biological problems, and there is a shortage of economists and social scientists in NARS (National Agricultural Research Systems). However, policy and socio-economic considerations must be considered in order to increase the probability of developing adoptable technology. Technology must be appropriate to the prevailing policies and economic conditions of the country, or to those expected when the research matures. A valid research objective would be to model the effect of alternative policies on agricultural production, so that policy makers can make informed choices. It follows that adaptive research, which must include on-farm studies in collaboration with development/extension agencies and farmers, must try to anticipate the national environment at the time when the research comes to fruition. While it can be argued that "on-the-shelf" technologies and production systems are a valid output from research, they may not fit the present or projected economic and political environment. They may therefore be a luxury when current needs are so pressing.

The overall research agenda

A research organisation must decide where to focus its work and how to allocate resources between commodities, species and research areas, including policy to fulfill its mandate. It must decide how important small ruminants are, and where and for which section of society research could have the most impact. Numbers of animals, distribution and values of production are required to quantify importance. The first stage in deciding on the allocation of resources is to consider the following elements: the estimated value of production, adjusted by modifying factors to allow for national research objectives; the probability of research success; efficiency in the use of research resources; and distribution of impact.

Table 1 shows the value of production of the most important commodities in sub-Saharan Africa. Sheep and goat meat is the least important livestock item, after milk and beef.

Table 2 shows the output of meat and milk from ruminants in the regions of SSA. Of the small ruminants mutton is more important in East Africa, while goat meat predominates in West Africa. From the limited data available, small ruminant milk appears more important in East Africa than in West Africa, but much of the production is consumed by young stock.

Table 1. *Gross value of annual production of the twenty most important commodities in SSA, 1983–85 (US$ million).*

Fuel (non-coniferous)	12489
Banana/plantain	8518
Sawlogs (non-coniferous)	4844
Sweet potato	4406
Cassava	4377
Coffee	4008
Milk	2894
Yam	2624
Other industrial wood	2361
Beef/buffalo meat	2548
Cocoa	2361
Maize	2064
Charcoal	1721
Sheep/goat meat	1648
Groundnut	1425
Cotton	1342
Sorghum	1648
Millet	1147
Rice	1092
Inland fish	1044

A summary of methods for priority setting has been presented by Norton and Pardy (1987), and Contant and Bottomley (1988). Checklists and scoring systems are the most practical methods for setting priorities in agricultural research. However, there are practical difficulties in attempting to rank programmes dealing with aspects of the natural resource base (e.g. soil fertility) alongside those dealing with commodities (e.g. small ruminant meat). Benefits from commodity research programmes can be expressed directly in monetary terms. Benefits from research on factors such as soil can only be estimated from assumptions regarding increased productivity over a range of commodities.

Table 2. *Output ('000 mt) of meat and milk in the regions of SSA, 1987.*

	Meat			Milk		
	Beef	Sheep	Goat	Cow	Sheep*	Goat*
West Africa	587	135	240	1057	139	288
Central Africa	216	17	30	308	3	21
East Africa	860	265	199	4858	1052	1414
Southern Africa	349	10	26	630	NA	12

*Data not available from some countries in each region.

ISNAR (International Service for National Agricultural Research) have assisted NARS in a number of countries to prioritise their research programmes. These countries include the Dominican Republic, Ecuador, Uruguay, Peru, Gambia, Zimbabwe and Kenya (Cessay et al, 1989; Norton and Pardy, 1987; Norton, 1991).

Choosing priorities

There are so many scientifically valid research activities that some formal way is required to identify policies for technological and socio-economic research that will have real impact. Selected research activities should stimulate action by policy makers or development and extension colleagues, and be capable of adoption by farmers.

Identifying problems worthy of research can be started by researchers or by farmers. An example of the first route is goal-oriented programme planning (GOPPing). GOPPing is a component of the ISNAR approach to long-term programme design as described by Collion and Kissi (1991). It was used by ILCA, assisted by national scientists, when it produced its long-term strategy document (ILCA, 1987). A multi-disciplinary group, including representatives from different research, development and extension groups participate in the exercise. Farmers are usually not included because it is assumed that the group already knows the problems that limit on-farm production, and hence can identify research routes to improve output.

The second approach involves researchers meeting farmers and extension staff to identify problems and propose solutions (Chambers et al, 1989). Farmers are the key players in this approach as they know the problems and will have to work with any proposed solutions.

However, merely identifying a problem says nothing about its importance in relation to other problems or constraints. As indicated earlier, problems are many but funds are limited, therefore priorities must be set. Priorities across agro-ecological zones need to be considered, as these will affect the balance of work between regions. If a weighting method is used, issues of efficiency, equity and security need to be considered. Criteria are required to measure the contribution of each of these issues toward the fulfillment of the goals of the institution. Efficiency criteria should include: importance of the problem; adoption rate; probability of research success; environmental impact; research costs; comparative advantage; and compatability with national goals. Equity criteria will cover: farm scale; producer/consumer benefits; gender; and agro-ecological zones. Security issues would include production stability and food security.

Consideration must also be given to whether research leads to an increase in the use of abundant resources and a saving of scarce resources, and also the number and severity of research problems. Other areas are non-duplication with transferable research from outside, and the current emphases in the research programme. The process is consultative and iterative. The criteria and rankings are produced in discussions with policy makers, researchers, development/extension workers and producers.

The priorities of other countries in the region and of IARCs (International Agricultural Research Centres) such as ILCA, and their compatibility with the priorities of the NARS should also be considered. If, for example, we consider that priority should be given to improving the nutritional value of crop residues, we would need to collaborate with crop breeding institutions and ensure that their priorities reflected our concerns. There is a vast quantity of published information on most subjects, therefore any research process must start with a literature search. All involved in research planning should be aware of the results of past research and development projects, so that we build on success and avoid repeating the same mistakes. Researchers in Africa often have only limited access to adequate library facilities and are unaware of published and ongoing work inside their own country, let alone outside. The ILCA library provides a literature search service for livestock researchers.

Most research activities undertaken by NARS in SSA will be applied or adaptive in nature, as that is where their comparative advantage lies. Traditionally, researchers have set the agenda, but, given the lack of adoptable output, we need to explore other ways of planning research to ensure applicable results. Output from applied and adaptive research that cannot be adopted by farmers is valueless. Strategic research that

is not based on problems identified on-farm and which does not have a target group of farmers in mind as beneficiaries should not be started. Sumberg and Okali (1989) go so far as to propose that adoption by farmers is sufficient validation of a technology, even if we are unable to identify or quantify the effects of the technology.

Principles to follow

All applied and adaptive research must have a strong on-farm base. For the humid and subhumid zones this means that the low priority given to small ruminants by farmers must be taken into account. In mixed crop/livestock farming systems where crops are the more important, small ruminant research will be only one component of multidisciplinary on-farm studies. Monodisciplinary small ruminant research on-station can be justified only when the need has arisen from on-farm observations and the results can be taken back for application on-farm. This is particularly relevant to universities where suitable component work for student projects can be identified from on-farm studies.

As small ruminants are of secondary importance to small-scale mixed farmers, they will only become prominent if justified by market demand and price. Projects in which small ruminant production is the central aspect have little chance of success if imposed on farmers unless their objectives have been incorporated into the design. With small farmers, risk avoidance usually takes precedence over increased production.

Little progress has been made in humid or subhumid Africa by research or development projects for increasing small ruminant meat production on small-scale farms. In general, the disease risks associated with raising youngstock are too high to attract farmers. Youngstock mortality rates of 40% are common. Thus for increased productivity the first priority should be to reduce the death rate. Unfortunately, small farmers do not have ready access to veterinary services and governments cannot afford the cost of expanding the service. Improved management, including better health through improved feeding, can reduce susceptibility to disease and improve survival (Reynolds and Adediran, 1988; Reynolds and Ekwuruke, 1988). The integration of small ruminants into alley farming is one such improved management option (Kang and Reynolds, 1989; Kang et al, 1990).

Market importance can be illustrated by comparing two dairy goat schemes, both started about 10 years ago in East Africa, based on crossbred exotic–indigenous animals. In Burundi around 10,000 crossbreds have been accepted by farmers and the milk produced is purchased by a factory for processing into cheese, which is then sold to urban consumers (Rey, personal communication). Regular income from the sale of milk is the key factor encouraging adoption. In Western Kenya a much smaller number of animals have been distributed to farms, but only 10% of the does are milked. All the milk is used for household consumption (Mbabu et al, 1991). The main attraction of the crossbred animals to Kenyan farmers is reported to be their large body frame. At both locations surplus male kids are purchased by the project. Time will tell which of the two approaches will be sustainable when external funding ceases, but so far the market-led scheme in Burundi has had more impact. The scheme in Kenya provides no clear-cut economic advantage to farmers that would encourage their continued interest when external project funding ends and staff are withdrawn.

Research into improved feeding must be linked to a strong market demand for the animal product, and its profitability demonstrated by *ex-ante* economic analysis. Research into forage production has only produced adoptable technology when linked to milk production. Specialised short-term fattening schemes, designed to produce animals for festival peaks, may be viable when the feed sources are crop residues or agro-industrial by-products. The economic viability of meat production based on planted pasture is poor, as shown by Doppler (1980) for beef cattle in Togo.

Over most of Africa, small ruminants are kept as free roaming scavengers. Many flocks in the humid zone of West Africa have no adult male, relying on those in other flocks in the village. The more active males will sire the most offspring, from which replacement sires will be drawn. At village level there is therefore the danger of inbreeding. In addition the most rapidly growing males are sold or slaughtered first, so the few males that reach breeding status have been selected for slow growth (Reynolds and Adediran, 1993). The selection, distribution and use of superior sires may be a valid research and development objective. However, maintaining improved genes in village herds will require infrastructural support superior to that which present governmental organisations have been able to maintain. Farmer demand for improved breeding stock will be generated if there is a market demand for the eventual product, as shown by smallholder dairy schemes with cattle in Kenya (Walshe et al, 1991).

Much of the day to day management of small ruminant herds is in the hands of women, even when the flock owner is male. Research is needed to determine the flexibility that women have to alter flock management, use different feedstuffs and to market animals at different times or in different ways. Will the woman benefit directly as a result of the changes, or will the benefits accrue to the owner? The contribution to household income from small ruminants is less than 5% of farm income, and probably half that figure for household income. However, their role as an investment for savings may account for the wide ownership pattern (ILCA, 1979). Improved animal productivity is equivalent to a higher rate of interest on the savings account.

Small-scale farming is a high risk business, and with few capital reserves to fall back on in bad years farmers minimise risks by undertaking a wide range of

activities. Lack of appreciation of this aspect of the strategy of small farmers is one reason why the traditional biological research approach has failed. Increasingly, farmers are looking to off-farm activities and involvement in the monetary economy as risk avoidance strategies, in addition to or in place of established farming practices (Downing, 1989). In much of Africa small farm households derive over half of their income from off-farm sources such as remittances (von Braun and Pandya-Lorch, 1991). The positive side of this picture is that the extended family can generate funds off-farm for investment in farming. The negative side is that the more innovative members of the household move away from the farm unless the returns from farming appear attractive in comparison to employment prospects in urban areas.

It is important that all small ruminant researchers, biological, social and economic, combine to provide data and analyses to policy makers so that the consequences of alternative courses of action can be predicted. Modelling is the way this objective can be achieved. Piecemeal research will not provide the depth and breadth needed for modellers to construct and test their models. Research and development groups must cooperate within and across both national and research borders to prevent unnecessary duplication of effort.

Conclusion

In the past, livestock research has been ineffective in producing technologies that can be adopted by small-scale farmers. NARS have insufficient resources to stretch further than top priority areas. In any one country these may or may not include small ruminants. A top-down allocation of resources for small ruminant research is not effective; appropriate research can only be identified in consultation with farmers, developers and extensionists.

For humid and subhumid zones integrating sheep and goats more closely into the farming system should be a long-term objective, taking into account the emphasis placed by small-scale farmers on risk avoidance. Market demand for the product and the economics of production should be important considerations in determining the priority of biological research. Another key factor is clarifying who will implement the technology at farm level, and who will reap the benefits.

The need for multidisciplinary work at farm level is overwhelming, but the costs of such work can be high. Cooperation between research, development/extension and farmers, within and across national borders will be necessary to achieve the conditions for success. Networking can help to build these links.

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Overcoming the constraints of dry matter intake on dual-purpose goat production by feeding defoliated maize leaves

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Abstract

Feeding trials were conducted at Maseno, Kenya, based on defoliated maize leaves from three plots measuring 0.25 ha each. On average, each plot produced 359 kg (SE 40 kg) dry matter of defoliated leaves as forage. Defoliation, which commenced at the tasselling stage at the rate of one leaf per week per maize plant, did not affect the grain yield. The defoliated maize leaf forage had 12% crude protein and *in vivo* dry matter digestibility of 60%.

In maize-growing areas where there are no pastures or land for growing fodder, it is recommended that feeding and management of goats should be strategically matched with maize production. Lactation period should coincide with the availability of maize leaves, while yearlings should take full advantage of a maize leaf diet which gives better performance than a grass mixture diet.

Utilisation de feuilles de maïs dans l'alimentation de chèvres à aptitudes mixtes afin de supprimer les facteurs limitant la consommation de matière sèche

Résumé

Des essais d'alimentation ont été conduits à Maseno (Kenya) avec des feuilles de plants de maïs provenant de trois parcelles de 0,25 ha. Chaque parcelle produisait en moyenne 359 kg (± 40 kg) de matière sèche sous forme de feuilles utilisées comme fourrage. La défoliation des plants de maïs, commencée au stade de la formation des aigrettes à raison d'une feuille par semaine et par plant, n'a pas eu d'effet sur le rendement en grains. Les feuilles de maïs servant de fourrage présentaient une teneur en protéines brutes de 12% et une digestibilité in vivo *de la matière sèche de 60%.*

Dans les régions productrices de maïs où l'on manque de pâturages et de terres se prêtant à la production de fourrages, il est recommandé d'aligner stratégiquement l'alimentation et la conduite des caprins sur la production de maïs et de synchroniser la période de lactation et l'époque où les feuilles de maïs sont disponibles. Par ailleurs, les chevreaux de 1 an devraient pouvoir bénéficier d'un régime à base de feuilles de maïs, ce type de ration permettant des performances supérieures à celles obtenues avec un régime à base d'un mélange d'herbe

Introduction

Kenya's population is expected to increase by more than 50% by the end of the century. This forecast has serious implications for livestock production in densely populated areas with small farms as is the case in western Kenya. In these areas human and livestock populations are inversely correlated. As the human population increases, more land is needed for food crop production. This is acquired from livestock's share of land resources. As land previously reserved for livestock is taken, stocking pressure increases. This results in logistical destocking and poor performance syndrome caused primarily by low intake of dry matter. A sustainable solution to this problem could be the integration of livestock with crop production. For this reason research for dual-purpose goats (DPG) in western Kenya focuses on integration of the sub-systems.

Materials and methods

Three plots of a quarter hectare each were demarcated from a plot of two hectares planted with maize hybrid seed no. 621. The number of maize plants at knee height on each plot was counted. Plot 1 had 7875 maize plants, Plot 2 had 7536 and Plot 3 had 9278, giving a total of 24,689 and an average of 8230 plants per plot. Randomly, Plot 1 was allocated to two lactating does, Plot 3 to three yearlings and Plot 2 was the control. Defoliation began 79 days after planting. Grain yield was determined by harvesting every fifth maize plant on a transect running longitudinally on each plot. Nine yearlings and two does were used, all crossbreeds (F1) of Toggenburg with East African Goat. The yearlings, with an average live weight of 21.2 kg (± 0.2 kg), were

Table 1 *Maize grain and defoliated leaves production per quarter hectare.*

Parameter	Plot 1 (Does)	Plot 2 (Control)	Plot 3 (Yearlings)	Overall mean	SD
Number of plants	7875	7536	9278	8230	924
Number of leaves	110250	105504	129892	115215	12930
Leaf dry matter (kg)	344	329	405	359	40
Grain yield (kg)	1362	1263	1387	1337	66
Grain yield/plant (g)	173	168	149	163	13

SD = standard deviation.

allocated randomly in groups of three to three feeding treatments of grass mixture, maize leaves and concentrates (dairy meal). Their adaptation period to the feeding trial was determined by the yearlings' live weight trend. The adaptation period was five weeks, which was the time the yearlings took to regain their initial live weight, following a weight loss on introduction to the experiment. The experimental period was determined by the availability of green maize leaves and lasted eight weeks. Yearlings and does were treated against helminthiasis before the experiment started. All the goats were placed in metabolic cages to determine dry matter intake (DMI) and *in vivo* dry matter digestibility (IVDMD). The animals were fed three times a day at 0900 h, 1300 h and 1600 h.

Kjeldahl, and Tilley and Terry (1963) chemical analyses were conducted. Energy calculations were based on coefficients and formulas of MAFF (1975) and NRC (1981). SYSTAT (Wilkinson, 1990) was used for data analysis.

available than the goats could eat. Plot 1, which catered for two does, produced 344 kg dry matter of green maize forage, while the total dry matter intake (DMI) over the trial period of 90 days was 333 kg. Plot 3 produced 405 kg dry matter, while the total DMI of the three yearlings was 213 kg. The yearlings' plot produced sufficient forage either to cater for two more yearlings over the same duration, or to extend the three yearlings' feeding duration from 90 to 171 days.

Stripping maize leaves was an easier task than cutting mixed grass because, unlike cutting grass mixture, it is a focused activity and requires no implements.

Table 2 shows that the crude protein (CP) content of maize leaves was above the threshold known to limit DMI. Maize leaves had better *in vitro* dry matter digestibility (DMD) than grass leaves. As expected the concentrate diet had a higher CP content and DMD than maize leaves and grass mixture.

Table 2. *Chemical composition of the diets (%).*

Parameter	Grass mixture		Maize leaves		Concentrate	
	Mean ± SD		Mean ± SD		Mean ± SD	
Dry matter	31^a	3.2	34^a	3.6	94^b	0.9
Crude protein	12^a	0.8	12^a	0.8	18^b	1.0
In vitro DMD	57^a	2.1	64^b	1.8	78^c	1.9
In vivo DMD	61^a	6.4	60^a	4.5	68^b	2.9

abc = means in the same row having different superscripts differ significantly ($P \leq 0.05$).
SD = standard deviation.

Results and discussion

The grain yield was affected by plant population, but not by defoliation (Table 1). Plot 3 had the highest population and the highest total grain yield, but the grain yield per plant was the lowest. The mean grain yield of 5349 kg per hectare or 59 bags of 90 kg each is above the western Kenya average of 29 bags/ha (Ministry of Agriculture, 1987). Stripping the maize leaves allows for easy under sowing in the maize fields. Similar results from maize defoliation have been reported elsewhere. During defoliation there were more green leaves

There was an inverse correlation between the age of the maize and the quality of the defoliated leaves. CP dropped from 14 to 10% ($r = -0.91$) while DMD dropped from 66 to 56% ($r = -0.74$). Concentrate quality remained constant, while variations in the grass mixture were kept minimal by selective cutting.

The success of fodder production is ultimately judged by livestock response. Table 3 shows that yearlings responded positively to a diet of maize leaf. Kayongo-Male and Abate (1982) reported growth responses of 95 and 98 g/day for sheep fed on maize leaves, higher than that found in this study. Sheep

performance was better than that achieved by goats with concentrates. The difference between the species was probably due to ease of adaptation to a new feed rather than conversion efficiency. Sheep are more adaptable to a new feed than goats.

Bulkiness is known to fill the gut resulting in lowered dry matter and energy intake. Contrary to this known phenomenon, yearlings fed the grass mixture and maize leaves diets (Table 3) consumed more dry matter on body weight basis (3.5%) than yearlings fed the concentrate diet (3.1%). Notwithstanding their relatively lower intake of dry matter, yearlings fed the concentrate diet utilized their feed more efficiently and grew better than yearlings fed the grass mixture and maize leaves diets. The yearlings on the grass mixture were the least efficient in feed utilization and growth. The lower protein:energy ratios of the grass mixture and maize leaves diets may have been largely responsible for the lower response of yearlings fed these diets.

Table 3. *Performance of DPG yearlings fed grass mixture, defoliated maize leaves and concentrates.*

Parameter	Grass mixture	Maize leaves	Concentrates
As-fed (kg/day)	3.0	3.5	1.5
DMI (g/day)	764	788	723
DMI (% body wt.)	3.5	3.5	3.1
Average daily gain (g/day)	27	45	89
Protein: energy ratio	8	8	12
Feed conversion	28	18	8

The two lactating does in the trial were in their third and sixth months of lactation. They were previously on a high plane of nutrition made up of a grass mixture as the basal diet, and *Leucaena leucocephala* and concentrates as supplementary feeds. For the nine months' lactation on a high plane of nutrition, the does produced an average milk yield of 1.7 kg per day/doe. When the does switched to defoliated maize leaves, the average milk yield dropped to 0.9 kg per day/doe for a six months' lactation. The drop in yield was partially due to the normal decline in milk production with advancing lactation, but also due to the insufficiency of maize leaves for sustaining milk production. The average DMI for maize leaves was 1.3 ± 0.3 kg per day/doe. Based on an *in vivo* DMD of 62%, this supplied 10.9 MJ (ME)/day per doe. This energy supply fell short of the daily energy requirement of a doe by 1.3 MJ ME. An attempt by the does to meet this energy deficit may have resulted in the observed average loss of 3.75 kg or 9% of body weight/doe during the 90 days' lactation period. Maize leaves can promote milk production, but in order to minimise mobilisation of body reserves, keeping the does' milk production at 0.7 kg/day is recommended.

For western Kenya and other areas with two maize seasons per year, DPG production can be integrated with maize production for the latter to provide forage (Table 4). Except for the 0.1 ha plot size, defoliated maize leaves' potential production is in excess of a year's demand for a 40 kg doe producing 0.7 kg milk per day. Excess forage can therefore be stored, used for raising more DPGs or both. The nutritive value of defoliated leaves is high for three months per season. With two growing seasons there are six months of high quality forage per year. Excess leaves could be sold and the proceeds used to purchase farm inputs or to meet personal needs.

Conclusion

Kenyans grow maize year in year out because it is a preferred food crop. As long as maize maintains this role, its production must be capitalised on for the enhancement of sustainable agriculture. The importance of integrating maize production with other crops and livestock production cannot be over emphasised. Also the benefits derived from under sowing in defoliated maize plots need to be assessed. An under sown crop in a plot of defoliated maize plants has more access to sunlight, and hence the opportunity for higher photosynthetic output.

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Table 4. *Production of defoliated maize leaves per plot size and DPG feeding days.*

Maize plot size (ha)	Defoliated leaves production potential (number)	Dry matter yield	Potential feeding days for a 40 kg doe producing 0.7 kg milk per day	
			per season	per year
1.0	460 860	1437	1105	2210
0.5	230 430	719	553	1106
0.25	11 525	359	276	552
0.1	46 086	144	111	222

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Goat development in Masvingo province, Zimbabwe: the farmers' perspective

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Abstract

A great deal of goat research has been conducted in Zimbabwe since the 1980's. There is, however, a need to link research to the farmers' needs and objectives. This paper focuses on the farmers' perspective with regard to goat development in Masvingo province.

Le développement de l'élevage caprin dans la province de Masvingo, au Zimbabwe: le point de vue des paysans

Résumé

Les recherches sur les caprins effectuées au Zimbabwe depuis les années 80 sont légion. Il reste cependant que des liens doivent être établis entre la recherche d'une part et les besoins et les objectifs des paysans d'autre part. Cet article présente le point de vue des éleveurs sur le développement de l'élevage caprin dans la province du Masvingo.

Introduction

Ngategize (1989) stresses the fact that, when making recommendations for interventions in small ruminant production, farmer goals and objectives have to be given serious consideration. What is the farmer trying to maximise or minimise in his production activities? Is it profitable to the farmer to adopt such innovations and interventions? Are they going to compete with existing farm or non-farm enterprises?

A social and financial cost-benefit analysis is necessary before implementing innovations. For example, apparent production constraints such as high mortality, long birth intervals and slow growth rate may not be as critical to the farmer as animal production scientists think. This explains why some technologically sound interventions and innovations may not be adopted in certain socio-economic and ecological circumstances. A multidisciplinary approach is necessary to understand fully the farmer's goals, objectives and his environment, and also to minimize disciplinary biases.

With this in mind, this study focused on current goat management practices and socio-economic aspects of goat production within the communal areas of Gutu and Zaka Districts of Masvingo Province. The survey was carried out in Natural Regions 3, 4 and 5, both in and out of grazing schemes. The objectives were: analysing production systems and constraints; assessing socio-economic effects and constraints; and analysing marketing trends, constraints and opportunities.

Information from farmers could indicate points of intervention for technological innovations and help in designing appropriate goat development strategies.

Methodology

Informal and formal surveys were conducted at the same time. A sample size of 120 respondents per district was taken.

Summary of survey findings

The goat enterprise in communal areas has more opportunities than constraints. 27% of respondents had no problems at all with their goat enterprises. Common problems are given below.

Production constraints

Herding

The selective nature of feeding behaviour and their small size make goats difficult to herd even within grazing schemes that use fences. Goats move fast in a given grazing area or paddock, they jump over fences into rested paddocks or they stray into fields during the growing season. Fencing that can restrain cattle cannot necessarily restrain goats. This means that there must always be a person looking after them. During the cropping season this presents a labour constraint. Evidence of labour constraint can be seen in the restriction of goats to pens up to mid-afternoon during summer.

Kid mortality

Kid mortality was high at 33% compared to 18% at research stations. About 55 and 30% of this mortality was due to diseases and predation respectively. 30% of respondents had no disease problems, but 50% reported some problems. The commonest diseases mentioned by farmers included heartwater (a tick borne disease),

pneumonia (caused by exposure to cold, wind and rain), foot rot (caused by muddy conditions in goat houses) and worms and infestation.

Housing and kraaling

15% of respondents had poor goat houses, which limited production. Such houses had no protection against wind, cold or rain, and muddy conditions prevailed during the rainy season. Lack of knowledge and financial resources were cited as causes for such poor goat houses. Housing improvement is required, especially in flooring.

Lack of knowledge

Extension staff and farmers have received no training in goat production, which is a serious constraint to production. Most of the production constraints mentioned above are attributed to lack of knowledge and poor managerial skills.

Socio-economic constraints

Goat marketing system

The viability of a goat enterprise depends not only on technical and biological efficiency, but also on a well organised marketing system.

At present, goat markets are characterised by poorly managed and unrealistic carcass grading and pricing systems, inadequate promotion of goat meat and an inadequate and inefficient transport system. These problems will have to be corrected if goat production is to be improved.

Attitudes to goats

The farmer regards cattle as being more important than goats. In the case of limited resources, cattle always take priority, putting goats at a disadvantage. This is not to say that goats are unimportant to the farmer, but the multipurpose uses of cattle *vis-à-vis* goats produce a bias in favour of cattle.

Opportunities for goat production in the districts

The environment

Masvingo Province lies in the semi-arid region of Zimbabwe and is basically a livestock area. The two districts surveyed lie in the low rainfall areas of the country where browsable species are abundant.

Socio-economic advantages

Leaving aside the investment needs and risks of goat rearing compared with cattle, the socio-economic advantages of goat production include: high profitability and fast turnover due to earlier maturity and shorter generation interval; suitable meat quantities for rural families; easy salability (unlike cattle which are regarded as capital); and a highly popular and acceptable meat among different peoples and religions.

Managerial advantages

Apart from herding problems, goats are not difficult animals to manage. Very few respondents reported management problems. Family labour can adequately manage goats except during the growing season when labour demands are high.

Biological advantages

These include: versatility and ability to adapt to various ecological environments; high resistance to disease and dehydration; and complementarity of goats with cattle, resulting in efficient resource utilization as goats use those resources which cattle do not.

The proposed strategy for goat development

From the survey findings a goat development strategy for Masvingo Province can be proposed. The major feature of the strategy is the proposal that the different facets of goat development work should be integrated through research, extension training, production and marketing techniques.

If any of these areas is overlooked in the overall goat development strategy, problems can be expected even before a project begins. Each element in the proposed strategy will be looked at in turn.

Research

With on-station research information as the guideline, more on-farm adaptive research is necessary. On-farm adaptive research is essential because it assesses the interrelationships between cattle and goats within the context of the communal farming system. Such research should take into account the limited grazing resources available; the prevailing land tenure system; and the financial status and management systems in the communal set-up. Specific areas for adaptive research include: determining goat and cattle populations in relation to available grazing resources; determining differences between vegetation types; analysing vegetation composition in different natural regions or areas to assess the availability of palatable species for goats; and determining the extent to which goats control bush in the grazing system of a communal area.

Palatable browse species for goats are location-specific, and research on them cannot be done on-station as findings will be limited to that locality. Carrying capacities and stocking rates are also location-specific. Variations occur even within one natural region due to climatic, soil and topographic factors. Research institutions should give guidelines for the assessment of carrying capacity, stocking rates and available browse for goats in conjunction with on-farm adaptive research.

Extension/Training

Devendra (1982) observed that the goat has for a long time been considered a veld degrader and neglected in both research and extension institutions. This bias against goats, coupled with the low priority goats are given and other negative attitudes, has resulted in goat development being allocated limited financial resources. Agricultural institutions have concentrated their training on beef and dairy development. Such attitudes should change and more personnel should be trained specifically in goat management at both higher and lower levels. The training of extension staff is a sure way to have communal area farmers realise and exploit the potential of goat production. Extension staff should be trained at the worker, officer and specialist levels. Once staff are trained, dissemination of information to farmers should be the next step. Farmer training programmes, the provision of reading material and demonstration units for goat management practices can all be used to educate the farmers.

Goat production

Goat production should move from an extensive (low production level) system to a semi-intensive (higher production level) system, but at costs which are within the reach of farmers. This part of the strategy should incorporate improved nutrition, better kid management and housing, reduced disease, reduced predation and better breed selection from within existing local stocks.

Marketing

The viability of goat production depends not only on technical and biological efficiency, but also on market factors (Mutetwe, 1987). The goat market is a neglected area and limits goat development in communal areas. Blackie (1982) suggests that an effective marketing system for goats (and sheep) would likely increase communal area meat production and peasant incomes and improve veld (range) conditions more than would a substantial rise in the price of beef.

The marketing policy should therefore be to improve prices, improve transport facilities for live goats from communal areas and design goat meat promotion and advertising techniques.

Conclusions

Farmers in different localities have different needs and objectives relating to goat production. Within the two districts surveyed there are variations in the environment, in the availability of grazing area resources and in browse species. Herd sizes vary from 8–10 head and goats are kept mainly for home consumption. Such variations mean that it is difficult to make blanket recommendations about goats. This also highlights the need for baseline surveys before implementing goat projects in communal areas. The important thing is that any goat development strategy designed should address the farmers' needs and problems directly.

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Goat production in a mixed cattle–goat system: Effect of stocking and substitution rate on redsoil thornveld stability

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Summary

The effects on animal performance and vegetation changes of cattle and goats grazing together at five different stocking rates in a continuous grazing system are being studied at Matopos Research Station. In the long term, the trial is expected to provide information on the impact of climatic cycles. Preliminary results for the first three years are presented. Year effect was significant (P<0.01). The lightest stocking rate (3.3 ha/LU) for both goats and cattle had higher (P<0.01) performance levels compared with other treatments. There was no effect of treatments on density and basal cover of herbaceous plants.

Elevage caprin en système mixte bovin-caprin: effet des taux de charge et de substitution sur la stabilité des formations à épineux sur sol rouge

Résumé

Les effets sur les performances zootechniques et sur l'évolution de la végétation de la mise au parcours de bovins avec des caprins à raison de cinq taux de charge différents ont été étudiés à la station de recherche de Matopos (Zimbabwe). A long terme, l'essai devrait fournir des informations sur l'impact des cycles climatiques. Les premiers résultats des trois premières années sont présentés. L'effet de l'année était significatif (P<0,01). Le niveau de performance obtenu avec le taux de charge le plus faible (3,3 ha/UBT) pour les caprins et les bovins était significativement supérieur (P<0,01) à celui obtenu avec les autres traitements. Les traitements n'avaient pas d'effet sur la densité et la surface terrière pastorale des herbacées.

Introduction

Many grazing areas of Southern Africa are badly degraded or are in the process of becoming unproductive because of the encroachment of dense bush. Donaldson (1979) reported that it is usually impractical or uneconomical to thin or remove the woody components. It has been suggested that the full production potential of bushveld areas can be realized by integrating goats into cattle farming systems (Aucamp, 1976).

Mixed species grazing has received little research attention, despite the fact that most communal and small-scale commercial farmers in Zimbabwe graze cattle and goats together. Goats seem to survive droughts better than cattle. This has led to the belief that goats degrade rangelands more than cattle. However, it is argued that stocking rate is the most important variable that affects rangeland condition rather than animal species per se (Gambiza and Sikosana, 1989). A multidisciplinary study on the interaction of goats and cattle grazing on redsoil thornveld was started in 1989. The objectives were to study the effects on rangelands of different goat and cattle stocking and substitution rates and the productivity of goats in a mixed goat and cattle system.

A continuous grazing system was used. Preliminary results on the standing biomass of herbaceous plants and animal performance for the three seasons are presented.

Materials and methods

The study is being conducted at the Matopos Research Station in the south west of Zimbabwe. The site is at an altitude of 1340 m with a mean annual rainfall of 600 mm which falls between October and April. Marked fluctuation in rainfall brings about corresponding fluctuations in herbage production from year to year. October is the hottest month (mean maximum of 29.4°C) and June the coolest (mean maximum of 20.9°). The land is characterised by clay soil (red and black), thorny acacia species and other shrubs in the browse layer, while the field layer is composed of perennial grasses with occasional annuals. A brief description of the area and its dominant vegetation has been documented (Ward et al, 1979).

Initially the site was subjected to a uniform grazing regime prior to the introduction of treatments. Ten paddocks of 20 hectares each were grazed continuously at a medium stocking rate of 2.8 ha per livestock unit (LU = 500 kg liveweight). In June 1989 the planned

stocking regimes were applied (Table 1). Goats were substituted for cattle on the basis of metabolic liveweight. The conversions to LUs assume 1.67:1 for cattle and 10:1 for goats. Additivity is then assumed for the treatments although this is likely to give high estimates of the true rates and is to be the subject of study in the trial. A total of 60 steers were used in the trial. They were maintained in two age groups, weaners and long weaners in equal proportions. The long weaners were slaughtered each year at the age of two and a half years and replaced by weaners. Monthly weights were recorded, and carcasses were assessed as described by Moyo (1991). Slaughter data is used to assess cattle productivity from each treatment.

Table 1. *Cattle and goat numbers and stocking density in a mixed species stocking rate trial on redsoil thornveld.*

Treatment	Cattle	Goat	Ha/LU*	LU/20ha
1. Light – cattle	8	12	3.3	6.0
2. Heavy – cattle	8	36	2.1	8.1
3. Light – goat	4	36	3.3	6.0
4. Heavy – goat	4	60	2.4	8.1
5. Medium: cattle – goat	6	36	2.8	7.2

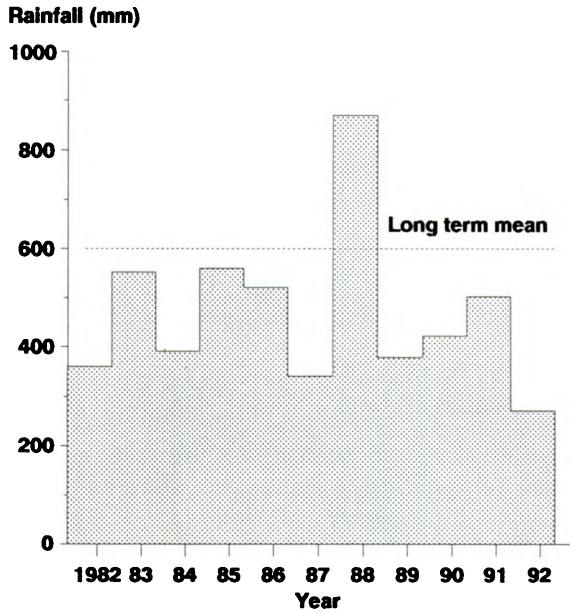
LU = 500 kg liveweight. The animal species contributing the higher proportion of livestock units has been quoted.

A total of 360 indigenous (Matabele goat) breeding does of stratified age groups were used. All goats were mated in May and June to kid once a year during the start of the wet season (October and November). The offspring from the goats were weaned at an average age of five months and details of birth, deaths and weaning were recorded. Reproductive performance of the does was assessed.

Herbaceous and woody plant dynamics (species composition, basal cover, density of above-ground grass biomass) and soil variables were measured in permanent plots.

The annual rainfall at the experimental site for the duration of the trial is shown in Figure 1. Superimposed on Figure 1 is the long term mean rainfall at the site.

Figure 1. *Annual rainfall at the site of the cattle – goat mixed grazing system.*



Statistical analysis

Data were analysed by the analysis of variance (ANOVA) using a General Linear Model (SAS, 1982) fitting replication, treatments and their interactions.

Animals that became sick or died in the course of the experiment were replaced with animals of similar weights. This was done to maintain the prescribed stocking pressure. Data from these animals and their replacements were not included in this preliminary analysis.

Results

Livestock data for different stocking rates are presented in Table 2 (production traits of goats), Table 3 (steer productivity), Figure 2 (total weaner production from goats, kg per 20 ha) and Figure 3 (the overall doe productivity).

Goat performance under the lightest stocking rate was higher ($P<0.01$) than other treatments. Figure 2

Table 2. *Production traits of goats in a mixed cattle and goat grazing system (1989/90 to 1991/92).*

	1	2	3	4	5	SE
Stocking rate (ha/LU)	3.3	2.4	3.3	2.4	2.8	
No. of goats:steers	12:8	36:8	36:4	60:4	36:6	
Total no. of does kidded	51	136	119	157	136	
Prolificacy[1]	1.6	1.4	1.4	1.3	1.4	0.05
Kid birth weight (kg)	2.0	1.8	1.9	1.8	1.8	0.14
Kid weaning weight (kg)	15.9	13.5	13.6	20.8	13.0	0.30
Pre-weaning gain (kg) of kids	13.0	11.0	11.0	8.6	10.7	0.37
Kidding %[2]	127.2	97.5	95.0	71.9	104.9	5.31

[1]Prolificacy (litter size)= number of kids born/number of does kidding

[2]Kidding % = number of kids born/number of does mated X100

Table 3. *Weight gain and carcass characteristics of steers in a mixed cattle and goat grazing system (1989/90 to 91/92).*

Treatment	1	2	3	4	5	SE
Stocking rate (ha/LU)	3.3	2.4	3.3	2.4	2.8	
No. of goats:steers	12:8	36:8	36:4	60:4	36:6	
Total no. of cattle slaughtered	16	16	8	8	12	
Initial weight at 8 months of age (kg)	191	192	197	197	189	4.14
Weight gain per head (kg)	111	115	126	122	109	7.19
Cold carcass weight (kg)	117	115	126	120	112	3.29
Carcass length (cm)	118	117	118	118	115	1.26
Eye muscle area (cm^3)	38.4	40.6	43.9	40.5	37.2	1.8

Figure 2. *Total weaner production from goats (kg per 20 ha) in a cattle – goat mixed grazing system.*

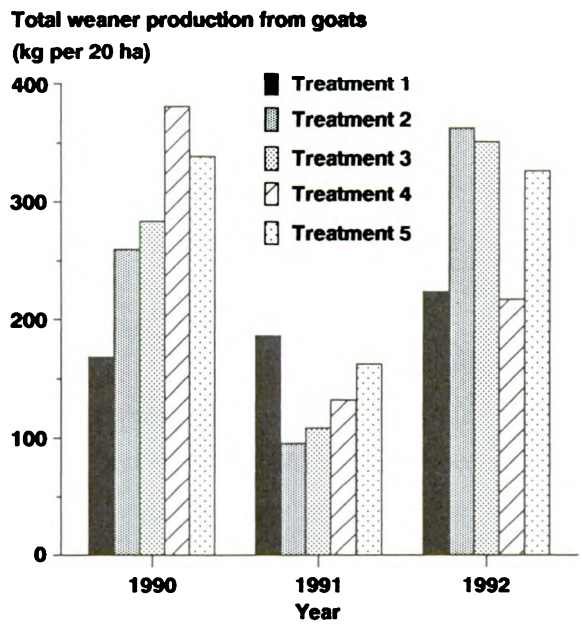
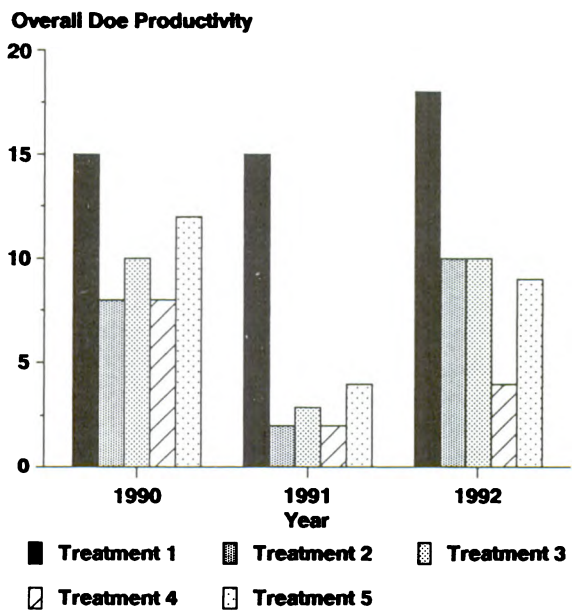


Figure 3. *Overall doe productivity (number of kids weaned X Average weaning weight of kids/Number of does mated.*



shows that weaner production from goats increased when total and goat stocking rate was low ($P<0.01$). Other treatments resulted in inconsistent productivity over the three years. This is also the trend in the overall doe productivity (Figure 3).

It is evident that the annual liveweight production of steers (Table 3) was largely dependent on total biomass (Table 4). Steers in treatment 3 had the highest ($P<0.05$) weight gains over the three years.

Discussion and conclusion

Stocking rate is now widely accepted as the major factor associated with livestock output. If productivity is to be maintained, the stocking rate has to be appropriate to the output goal and adjusted to the carrying capacity of the ecosystem. This should also reduce abuse of grazing land, essential in semi-arid areas.

Results from this study suggest that the productivity of indigenous goats, when managed correctly in conjunction with grazers (cattle), is potentially acceptable. This agrees with Aucamp et al (1984). A prerequisite for implementing an integrated system is determining an appropriate mix of cattle and goats in order to utilise efficiently both the herbaceous and woody vegetation. Discussion of mixed grazing at this stage of the trial is restricted due to lack of adequate information. More research is needed to explain the biological processes involved (Nolan, 1979; Shuster, 1986).

These results show that livestock productivity varied across treatments. This could be due to seasonal variations and differences in forage availability during the study, as well as stocking rate.

Livestock equivalents for cattle and goats need further investigation. These may have to vary from region to region depending on the species composition of the grazing areas. Sound animal and veld management practices, together with the correct ratios of cattle and goats, are essential for success.

Table 4. *Grass basal cover (%) and peak biomass (tonnes dry matter per ha) in a mixed cattle and goat grazing system.*

Treatment		1	2	3	4	5
Stocking rate (ha/LU)		3.3	2.4	3.3	2.4	2.8
No. of goats:steers		12:8	36:8	36:4	60:4	36:6
Basal cover	(1990)	2.9	3.5	4.0	3.4	3.3
	(1991)	2.9	3.5	4.4	3.0	3.4
	(1992)	2.2	1.8	3.0	1.6	1.6
Biomass	(1990)	1.2	1.3	1.6	1.3	1.3
	(1991)	0.6	0.5	0.9	0.5	0.6
	(1992)	0.12	0.16	0.08	0.01	0.01

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SESSION 2

Small Ruminant Performance and Reproduction

Evaluation de l'activité sexuelle pendant la saison de baisse de fertilité chez la chèvre de race D'man

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Résumé

Une baisse de la fertilité a été observée chez la chèvre D'man pendant les mois de février, mars et avril. Les activités ovarienne et oestrale entre mars et juin de 20 chèvres adultes de race D'man ont été étudiées, la première par détection biquotidienne (8 heures et 17 heures) des chaleurs et la seconde par observation directe des ovaires (endoscopie) 4 à 10 jours après la manifestation du comportement oestral. L'incidence des ovulations silencieuses a été estimée par la mesure du taux de progestérone plasmatique.

La proportion des chèvres en chaleur était de 70%, 45%, 55% et 90% pour les mois de mars, avril, mai et juin respectivement; celle des chèvres ayant ovulé était respectivement de 85%, 60%, 65% et 95%. La proportion des cycles courts (39%) et l'incidence des ovulations silencieuses (15 à 25%) étaient relativement élevées. La baisse de la fertilité de la chèvre D'man au printemps est donc principalement due à une baisse simultanée de l'activité ovarienne et de l'extériorisation des chaleurs.

Evaluation of breeding activity in D'man goats during lower fertility period

Abstract

A decline in fertility was observed in D'man goats in the months of February, March and April. Ovarian and oestrus activity of 20 adult D'man goats was observed during March and June, the first by oestrus detection twice daily (8 am and 5 pm) and the latter by direct observation of the ovaries (endoscopy) 4 to 10 days after the first signs of oestrus behaviour. Silent oestrus was estimated by measuring plasma progesterone rate.

Seventy per cent, 45%, 55% and 90% of the goats were in heat in March, April, May and June, respectively, while ovulation was observed in 85%, 60%, 65% and 95% goats, respectively. The proportion of short cycles (39%) and the incidence of silent oestrus (15 to 25%) were relatively high. The decline of fertility in D'man goats during spring is therefore mainly due to simultaneous decline of ovarian activity and oestrus expression.

Introduction

Au Maroc, l'élevage caprin représente une activité agricole très importante, surtout dans les régions les plus défavorisées telles que les montagnes et les parcours dégradés. En 1987, le cheptel caprin national était estimé à 5,8 millions de têtes (MARA, 1990). La quasi-totalité est élevée en système agropastoral ou pastoral extensif, à l'exception de la chèvre laitière de race D'man, dont l'effectif est estimé à 20 000 têtes, soit 0,34% de l'effectif total. Cette race est élevée en système très intensif et en troupeaux de petite taille de 2 à 17 têtes dans les oasis de la vallée du Draa (Hachi, 1990). L'analyse des données de mise-bas enregistrées pendant sept années à la station de Tinzouline (centre de la vallée du Draa) (Ezzahiri et Benlakhal, 1989) et chez les éleveurs (Hachi, 1990) a montré que les chevrottages s'étalent sur toute l'année. Toutefois, une faible incidence des naissances (7%) a été observée en été (juillet, août et septembre), ce qui correspond à des saillies de printemps (février, mars et avril). L'objectif de cette étude est d'évaluer les activités ovarienne et oestrale entre les mois de mars et de mai chez la chèvre D'man élevée en station en dehors de son berceau de race.

Matériel et méthodes

Cette étude a été réalisée à la ferme d'application de l'Institut agronomique et vétérinaire Hassan II, située à la périphérie du périmètre irrigué du Tadla. Cette région à climat méditerranéen de type aride et sous influence continentale est caractérisée par des hivers froids et peu pluvieux et des étés chauds et secs.

Les animaux

Le troupeau expérimental était constitué d'animaux achetés dans la vallée du Draa en février 1988. Après une période d'adaptation de deux ans, 20 chèvres adultes âgées de 2 à 7 ans ont été utilisées. Les animaux étaient maintenus en stabulation libre et

recevaient une alimentation à base de foin de luzerne et de concentrés (orge grain et pulpe sèche de betterave). L'ensemble du troupeau caprin a été traité contre les parasites internes avant le démarrage de l'étude.

Etude de l'activité oestrale

L'activité oestrale a été évaluée par une détection minutieuse des chaleurs suivant une exposition biquotidienne (8 heures et 17 heures) d'une demi-heure des femelles à un mâle vasectomisé. Une femelle était considérée en chaleurs quand elle devenait réceptive au bouc, s'immobilisait et acceptait le chevauchement.

Etude de l'activité ovarienne

On a procédé à l'observation directe des ovaires 4 à 10 jours après la manifestation du comportement des chaleurs, afin de confirmer l'ovulation et d'en déduire le taux. L'incidence des ovulations silencieuses a été estimée à partir de la progestérone plasmatique dosée à l'aide d'un kit commercial (Diagnostic Laboratory, Los Angeles, Californie, E.-U.) dans des échantillons de sang prélevés à 5 jours d'intervalle. La limite de sensibilité du dosage était de 0,06 ng/ml et les coefficients de variation intra- et interdosage étaient respectivement de 6,0% et 8,2%. Une ovulation était confirmée quand le taux de progestérone plasmatique était inférieur ou égal à 1 ng/ml.

Résultats

Activité oestrale

Les résultats obtenus montrent que la saison influe sur l'activité oestrale de la chèvre D'man maintenue dans des conditions expérimentales en dehors de son berceau de race. En effet, l'expression de l'oestrus, 70% au mois de mars, était minimum (45%) au mois d'avril. Des signes de chaleurs apparaissaient chez 55% des animaux à partir du mois de mai, et chez 92% des animaux au mois de juin. La durée du cycle oestral, définie comme l'intervalle de temps entre deux oestrus consécutifs, variait de 5 à 27 jours. La distribution des cycles en fonction de leur durée fait ressortir deux types de cycle: l'un à 10 et l'autre à 20 jours. Le premier correspond aux cycles courts dont la durée moyenne est de 10,5 ± 3,45 jours (5 à 16 jours); le second correspond aux cycles longs d'une durée moyenne de 20,96 ± 2,24 jours (17 à 26 jours).

Activité ovarienne

L'activité ovarienne suit les mêmes variations que l'activité oestrale. La proportion des chèvres ayant ovulé était de 85% au mois de mars et de 60% au mois d'avril. A partir du mois de mai, la proportion des chèvres à ovaires actifs s'élevait à 65% pour atteindre 95% au mois de juin. Par ailleurs, la proportion des chèvres qui présentaient une activité ovarienne était toujours supérieure à celle des sujets qui manifestaient des signes des chaleurs. Cette caractéristique témoigne de l'existence d'ovulations non accompagnées de chaleurs. L'incidence des ovulations silencieuses était très élevée aux mois de mars (17,6%), d'avril (25%) et de mai (15,4%), alors qu'elle était faible au mois de juin (4,2%). Par ailleurs, sur l'ensemble des animaux, 12 femelles sur 20 (soit 60%) avaient une activité ovarienne continue pendant toute la période de l'étude et 25% présentaient un arrêt momentané ou continu de cette activité de mars à mai. Le nombre maximum d'ovulations enregistré dans les conditions de cette étude était de 2. Le taux moyen d'ovulations doubles (46,5%) était légèrement inférieur à celui des ovulations simples (53,5%). Le taux moyen d'ovulation ne variait pas en fonction du mois ($P>0,05$).

Discussion

Au cours de cette étude, il a été observé une baisse de l'activité oestrale et ovarienne chez des chèvres D'man maintenues vides dans des conditions expérimentales en dehors de leur berceau de race entre mars et juin. Ainsi, sur l'ensemble de la période d'étude, 70% des femelles ont ovulé au moins une fois par mois mais 55% seulement ont manifesté un comportement oestral à ce rythme. Cela correspond à un taux moyen de 21,4% des ovulations non accompagnées de signes de chaleurs. Dans une étude antérieure, Hachi (1990) rapporte des taux d'ovulations de 8,3 à 87% pour une saison similaire. Ces écarts pourraient en partie s'expliquer par les conditions environnementales telles que le niveau alimentaire ou les variations interannuelles. Au demeurant, l'une des raisons à l'origine du faible taux de chevrottage observé chez la chèvre D'man en été est la diminution de l'activité sexuelle au printemps (Ezzahiri et Benlakhal, 1989; Hachi, 1990).

Il ressort également de cette étude que certaines ovulations ne sont pas accompagnées de signes de chaleurs. La fréquence de ce type d'ovulations diminuait au fur et à mesure qu'approchait la saison sexuelle des races dites saisonnées. Par ailleurs, les ovulations silencieuses constituent un phénomène physiologique normal au début de la saison sexuelle chez les chèvres alpine (Thibier *et al.*, 1981) et nubienne (Camp *et al.*, 1982). Chez la brebis, elles sont généralement associées à la reprise de l'activité sexuelle post-partum (Chami, 1981; Khaldi, 1984; Boukhliq, 1986; Lahlou-Kassi *et al.*, 1989) ou saisonnière (Lahlou-Kassi et Marie, 1985) et à la période de passage de la vie prépubertaire à la vie postpubertaire (Foster et Ryan, 1979; Derquaoui, 1992).

La durée moyenne du cycle oestral est de 10,5 ± 3,45 jours pour les cycles courts et de 20,96 ± 2,84 jours pour les cycles normaux chez la chèvre D'man. Cette durée est comparable aux valeurs rapportées pour un certain nombre de races caprines tropicales et revues par Garcia et Gall (1981). Il semblerait que l'incidence

relativement élevée des cycles courts soit une caractéristique de l'espèce caprine. En effet, 86%, 32% et 11% des cycles sont courts respectivement chez la chèvre nubienne (Camp *et al.*, 1982), créole (Chemineau et Thimonier, 1986) et chez la chèvre locale du Vénézuela (Carlos et Madrid-Burry, 1982. L'origine et l'étiologie des cycles courts des petits ruminants ne sont pas complètement élucidées, mais il semble que les corps jaunes des cycles courts soient de mauvaise qualité et que leur durée de vie secrétoire soit limitée (Chemineau et Thimonier, 1986) et fortement influencée par le niveau alimentaire (Oldham et Martin, 1979).

Conclusion

La baisse du taux de chevrottage observée chez la chèvre D'man en été est principalement due aux baisses simultanées de l'activité ovarienne et de l'extériorisation des chaleurs pendant le printemps, la mortalité embryonnaire demeurant à priori faible. Par ailleurs, 60% des femelles présentaient des signes d'une activité sexuelle continue. Du fait que la chèvre D'man soit élevée en troupeaux de petite taille et dans des conditions très intensives, la sélection, à travers les générations, a probablement résulté en une perte de la saisonnalité de la reproduction chez certains individus de la population.

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Etude du cycle oestral chez la brebis Djallonké

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Résumé

Le cycle oestral de brebis Djallonké allaitantes et de brebis non allaitantes a été étudié pendant une période d'un an. Les chaleurs ont été détectées par exposition à des béliers et par examen des frottis vaginaux.

La plupart des cycles oestraux déterminés par détection des chaleurs avaient une durée de seize à dix-neuf jours et se répartissaient sur toute l'année. Les chaleurs silencieuses étaient plus fréquentes en saison pluvieuse qu'en saison sèche.

Au cours du cycle oestral, les variations des proportions des cellules et des polynucléaires de l'épithélium vaginal étaient maximum au cours du dioestrus. L'examen de l'aspect des frottis vaginaux a permis de déterminer la phase du cycle oestral.

The oestrus cycle of the West African Dwarf sheep

Abstract

The oestrus cycle of lactating and non-lactating West African Dwarf ewes was monitored over a period of one year. Oestrus was detected by exposure to rams and vaginal smears examination.

The length of most oestral cycles determined by oestrus detection ranged from 16 to 19 days and were spread over the whole year. Silent oestrus were more frequent in the rainy season.

During the oestrus cycle, variability of the proportion of cells and polynuclears of the vaginal epithelium reached a maximum at dioestrus. The stage of the oestral cycle was determined by examining the appearance of the vaginal smears.

1. Introduction

Le cycle oestral chez la brebis est défini comme l'intervalle de temps qui sépare deux oestrus (Berger et Ginisty, 1980). Les données dont on dispose actuellement sur ce paramètre sont essentiellement basées sur des observations (Fall et coll., 1983; Vallerand et Branckaert, 1975) ou sur des techniques plus fiables telles que les dosages d'hormones (Yenikoye, 1984; Thibier, 1976). Très onéreuses, ces dernières ne sont pas toujours accessibles aux petites institutions de recherche. Compte tenu de l'importance de la durée du cycle oestral dans les efforts visant à améliorer et à accroître la production de la brebis, il s'avère nécessaire de recourir à d'autres techniques fiables mais plus abordables.

Qui plus est, selon Doney et Gunn (1981) et Haresing (1984), la persistance de plusieurs parasites gastro-intestinaux et la restriction alimentaire pendant la période de croissance, caractéristiques des systèmes extensifs d'élevage dans les régions humides de l'Afrique de l'Ouest, peuvent avoir un effet inhibiteur permanent sur les capacités de reproduction.

Le présent article est consacré à l'étude de la durée du cycle oestral par détection des chaleurs et examen des frottis vaginaux chez la brebis Djallonké au Bénin.

2. Matériel et méthode

Le troupeau étudié dans le cadre de ces travaux est gardé dans une ferme de l'Université nationale du Bénin à Abomey-Calavi, localité située à une vingtaine de km de Cotonou (Bénin). Les animaux, des moutons de race Djallonké, correspondent à la sous-race décrite par Rombaut et Van Vlandaeren (1976) pour le sud de la Côte d'Ivoire.

L'étude du cycle oestral a porté sur 4 brebis non allaitantes et 12 brebis allaitantes âgées de 18 à 32 mois et pesant 17 à 23 kg, et sur 4 agnelles âgées de 6 à 16 mois dont les poids variaient entre 10 et 16 kg.

Au début de l'expérience, les animaux ont été vaccinés contre la peste des petits ruminants et le tétanos, et vermifugés (helminthes et coccïdies). Des traitements prophylactiques contre les parasites externes (tiques et gales) ont été réalisés plus fréquemment. Toutes les brebis étaient alimentées sur pâturage naturel et recevaient en outre des compléments de sous-produits agro-industriels.

Au cours des travaux, les animaux étaient pesés, et des frottis vaginaux étaient prélevés une fois par semaine. Des observations journalières (matin, midi, soir) du comportement sexuel des brebis en présence d'un bélier muni d'un tablier ont été effectuées. Les frottis vaginaux avaient été colorés par la technique de Papanicolaou (1942). Ces expériences ont été réalisées au cours de la saison des pluies (mai–juillet) et des deux saisons sèches (février–avril et août–octobre) de la même année.

3. Résultats

3.1 Durée du cycle oestral estimée par la détection des chaleurs

Les 90 cycles détectés sur les 112 cycles observés se répartissaient en 57 cycles chez les brebis non allaitantes contre 33 cycles chez les brebis allaitantes.

L'intervalle entre deux oestrus était de 17,98 ± 0,66 jours avec des extrêmes allant de 6 à 28 jours; les cycles se déroulaient sans interruption pendant toute l'année.

Le test de chi-carré n'a pas fait apparaître d'effet significatif de l'état physiologique, de l'âge et des saisons sur la durée des cycles oestraux (P>0,05) (tableaux 1 et 2).

La comparaison des durées des cycles oestraux par le test t de Student a révélé que les valeurs moyennes des durées du cycle oestral ne variaient pas d'une saison à l'autre (P>0,3) (tableau 1). Cependant, les écarts entre les valeurs extrêmes de durée de cycle étaient plus importants en saison sèche (P<0,01) qu'en saison des pluies. Aussi la comparaison des variances de ces moyennes par le test F a-t-il révélé des différences significatives (P<0,001) dans les fluctuations des valeurs autour des moyennes selon la saison et l'âge.

La courbe de répartition de la fréquence des durées des cycles était normale. Ces fréquences, comprises en majorité entre 16 et 19 juin (figure 1), étaient un peu plus étalées chez les brebis âgées de plus de 20 mois.

Chez l'ensemble des brebis allaitantes, et quel que soit leur âge, la durée moyenne des cycles oestraux était de 17,75 ± 0,88 jours, une valeur comparable à celle de la durée (18,12 ± 0,92 jours) des cycles des brebis non allaitantes. Par ailleurs, les chaleurs silencieuses étaient moins fréquentes chez les brebis allaitantes (11%) que chez les brebis non allaitantes (26%) et plus fré-quentes en saison pluvieuse (53%) qu'en saison sèche (11%).

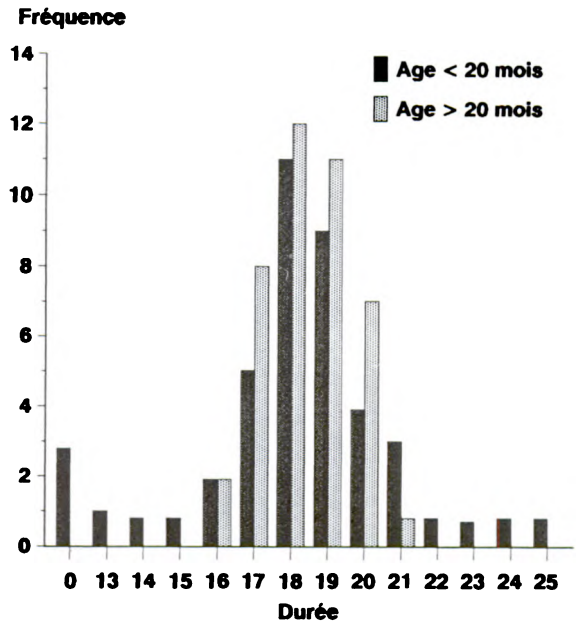
Tableau 1. *Effet de la saison sur la durée du cycle oestral chez des brebis Djallonké*

		Nombre de cycles détectés	Durée moyenne (écart type) (jours)	Extrêmes	Taux de chaleurs silencieuses (%)
Saison sèche	Ensemble	78	18,22	6–28	11
	des brebis	50	0,73		
	Brebis	50	18,22	6–28	20
	cyclées		1,00		
	Brebis	28	17,9	6–20	0
	allaitantes		1,2		
Saison des pluies	Ensemble	12	17,92	14–24	53
	des brebis		1,38		
	Brebis	7	18,43	14–24	58
	cyclées		2,11		
	Brebis	5	17,2	16–19	43
	allaitantes		1,14		

Tableau 2. *Effet de l'âge sur la durée du cycle oestral chez des brebis Djallonké*

Age		Nombre de cycles (écart type)	Durée moyenne (jours)	Extrêmes	Taux de chaleurs silencieuses (%)
Plus de 20 mois	Ensemble	46	17,91	6–28	18
	des brebis		1,1		
	Brebis	29	18,41	6–28	20
	cyclées		1,5		
	Brebis	27	17,1	6–20	11
	allaitantes		1,5		
Moins de 20 mois	Ensemble	44	18,07	15–20	22
	des brebis		0,66		
	Brebis	7	18,82	16–20	26
	cyclées		0,97		
	Brebis	5	18,5	15–20	12
	allaitantes		0,69		

Figure 1. *Répartition des fréquences de durée de cycle oestral selon l'âge*



3.2 Modification des frottis vaginaux au cours du cycle oestral

3.2.1 Aspect des frottis au cours du cycle

L'examen de l'aspect des frottis a permis de faire les observations suivantes:

Phase 1

Le jour de l'apparition des chaleurs, les cellules étaient nombreuses (parabasales ou intermédiaires) et isolées les unes des autres. Les cellules intermédiaires (vertes ou violettes) étaient de grande taille et aussi nombreuses que les cellules superficielles (rose pâle). Les polynucléaires étaient plus ou moins abondants (figure 2A).

Phase 2

72 heures après le début des chaleurs, le frottis contenait beaucoup de grandes cellules superficielles; certaines étaient étalées, d'autres (25-50%) kératinisées ou plicaturées. Les polynucléaires étaient beaucoup moins abondants qu'au premier jour de l'oestrus (figure 2B).

Phase 3

Au cours des trois jours suivants, l'éosinophilie augmentait (figure 2C) et la quasi-totalité des spasmes colorés étaient cornifiés. La kératinisation était bien visible et le nombre de polynucléaires avait augmenté.

Phase 4

Comme l'indique la figure 2D, les cellules parabasales et intermédiaires basophiles ont réapparu. Pendant environ cinq jours, le frottis était riche en cellules parabasales et polynucléaires (en surabondance). On notait la présence de cellules superficielles de type squame colorées en vert et regroupées en amas avec les autres types cellulaires.

Au cours des trois jours suivants, le frottis présentait (figure 2E) les cellules colorées en vert ou violet isolées les unes des autres avec des contours réguliers. La différenciation des cellules à ce stade n'était pas toujours aisée.

Phase 5

Pendant les deux ou trois jours précédant l'oestrus visible, le frottis présentait les mêmes images cytologiques, mais était beaucoup plus pauvre en cellules (figure 2F).

3.2.2 Pourcentages des cellules de l'épithélium vaginal

Les cellules superficielles étaient plus ou moins nombreuses (40 %) à l'apparition des premiers signes de chaleur. Ce taux atteignait rapidement 50 à 60% deux à cinq jours plus tard, pour chuter 24 heures après l'obtention du pic (figure 3).

Les pourcentages les plus faibles de cellules superficielles (10–20%) s'observaient lors de la deuxième moitié du cycle et peu avant l'oestrus suivant.

Il y avait une forte corrélation ($r = +0,83$; P0,001) entre l'indice karyopcnotique (IK) et le pourcentage de cellules superficielles.

La durée du cycle (19,67 ± 1,33 jours) déterminée à partir de la cytologie vaginale semblait plus longue que celle (17,958 ± 0,66 jours) déterminée par la détection des chaleurs ($P<0,01$).

4. Discussion

Selon Vallerand et Brankaert (1975), le cycle oestral chez la brebis Djallonké dure de 16 à 17 jours. Berger (1979) estime la moyenne à 17,4 jours avec des extrêmes allant de 16 à 19 jours. Les valeurs moyennes observées ici correspondent à celles indiquées par ces auteurs. En effet, dans 71% des cas, elles se situaient dans l'intervalle de 16 à 19 jours.

Les fluctuations de la durée du cycle oestral chez la brebis âgée de plus de 20 mois peuvent être attribuées à l'âge de l'animal d'une part et à la fréquence des mises-bas d'autre part. En effet, ces femelles étaient saillies tôt (première mise-bas à 16 mois) et avaient un rythme de deux agnelages par an pendant environ trois ans, ce qui a entraîné une fatigue physiologique. A celle-ci s'ajoute l'insuffisance alimentaire à laquelle étaient exposées les brebis avant le début des expériences, la restriction alimentaire pendant la période de croissance ayant un effet dépressif sur les capacités de reproduction des animaux.

Les écarts entre les valeurs extrêmes de la durée du cycle oestral étaient plus importants en saison sèche qu'en saison des pluies. Au cours de cette saison là, les conditions plutôt défavorables d'élevage (manque d'eau

Figure 2 A.

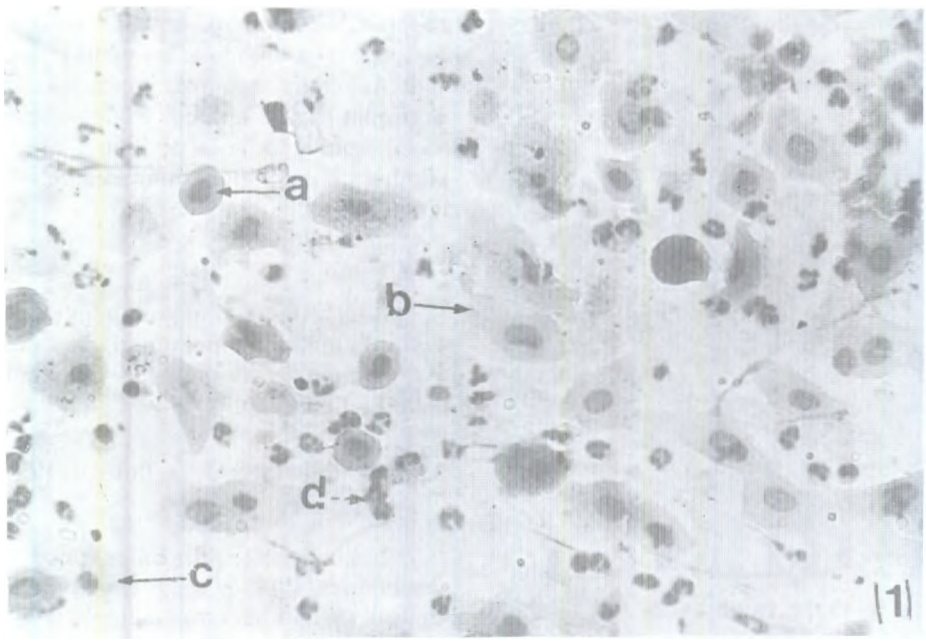
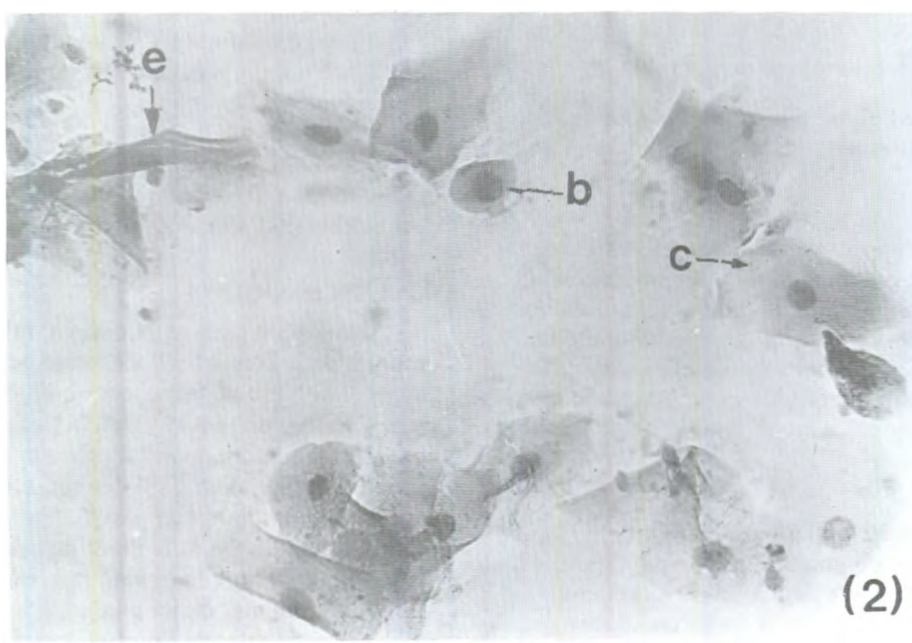


Figure 2B.



et d'herbe fraîche) ont pu perturber la biologie des reproductrices. Yenikoye (1984) a montré qu'entre décembre et avril (saison sèche relativement fraîche), la durée des cycles était de 31 jours, avec des ovulations silencieuses.

La fréquence élevée des chaleurs silencieuses en saison des pluies pourrait s'expliquer par la variation de l'éclairement : bien que faible dans les pays tropicaux, celle-ci diffère néanmoins d'une saison sèche à l'autre. Il est établi que l'activité des gonades induite par la lumière se fait par l'intermédiaire de l'hypophyse via l'hypothalamus. Ce complexe hypotalamo-hypophysaire contrôle l'apparition de l'oestrus. Thimonier et Mauleon (1969) ont confirmé que la diminution des taux de gonadotrophines pendant les jours courts et à faible ensoleillement pouvait bloquer ou diminuer les activités ovariennes chez la brebis, entraînant des anoestrus vrais ou des chaleurs silencieuses.

Dans les pays tropicaux à climat humide, le degré hygrométrique varie entre la saison sèche et la saison

Figure 2C.

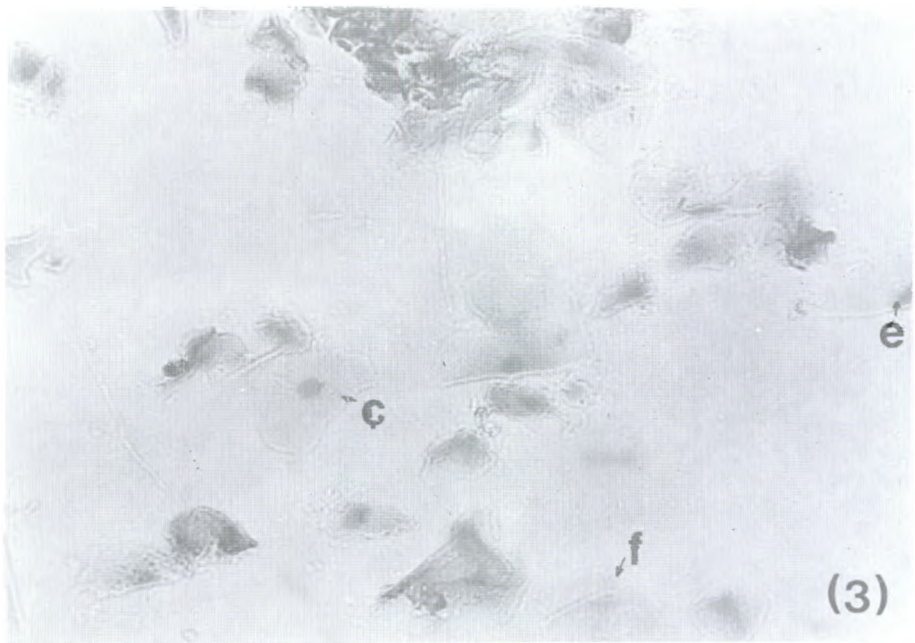
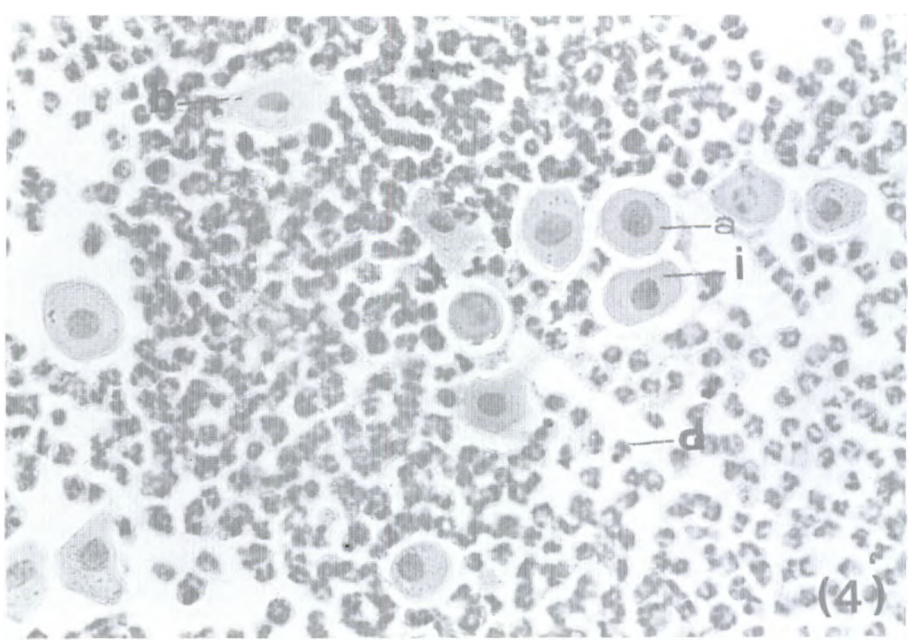


Figure 2D.



humide. L'humidité au sol en saison des pluies peut également influencer indirectement la physiologie de la brebis.

Chez les brebis allaitantes, le nombre de chaleurs silencieuses diminue considérablement après la reprise de l'activité sexuelle. L'anoestrus post-partum étant un repos sexuel, la brusque décharge des facteurs de libération de l'hypothalamus augmenterait l'activité oestrale et rendrait les brebis plus aptes à l'acceptation du bélier.

L'étude de la transformation périodique de l'épithélium vaginal en fonction du cycle oestral a fait apparaître des modifications assez diffuses mais néanmoins sensibles.

Comme dans tout cycle oestral, les cellules superficielles sont sensibles aux oestrogènes, ce qui se traduit par une éosinophilie intense de ces cellules, tandis que l'abondance des polynucléaires correspond souvent à la mise en place d'une phase lutéale. La disparition partielle des polynucléaires s'explique par le

Figure 2E.

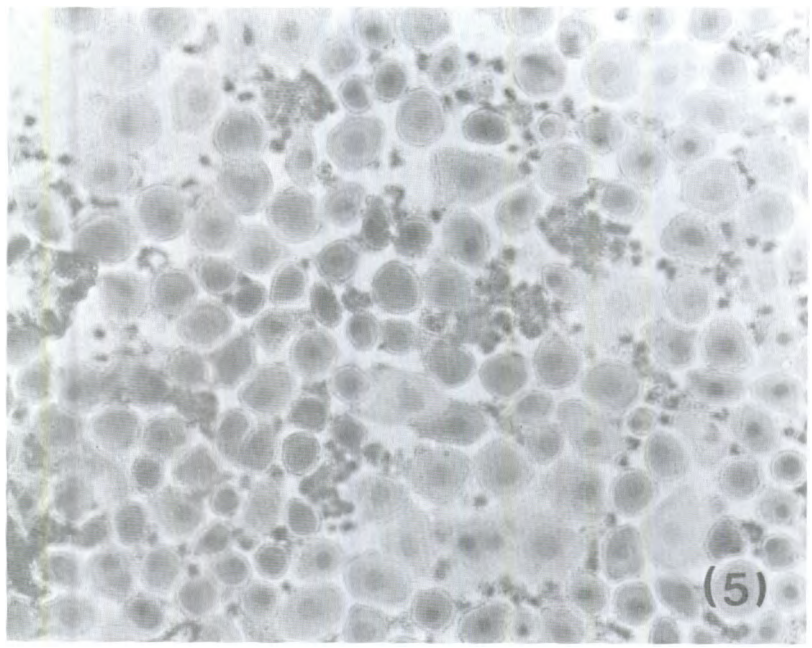
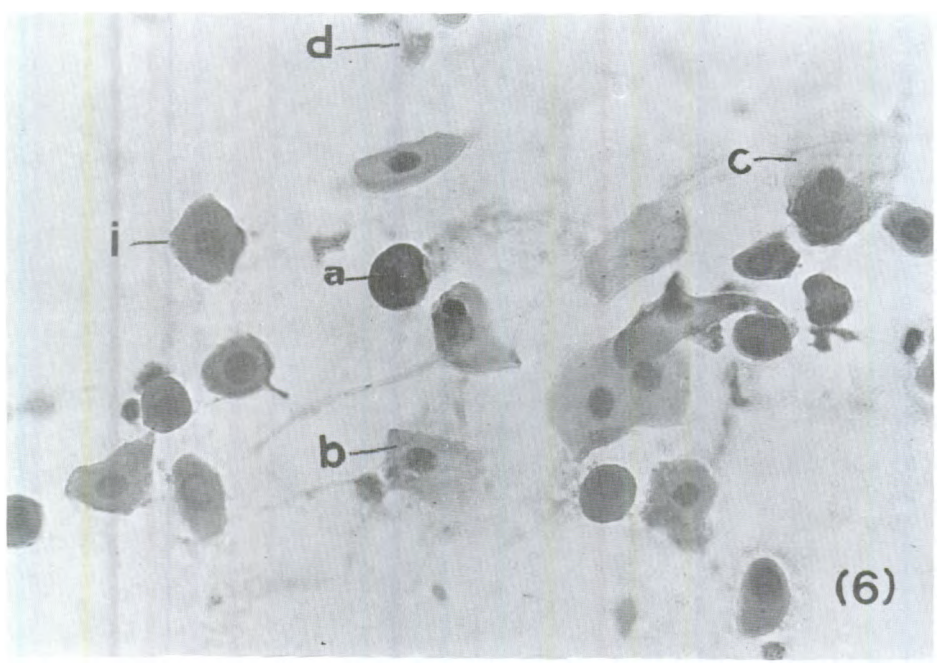


Figure 2F.



faible taux de progestérone au moment du pic des cellules superficielles.

Sur la base de ces données et des signes cytologiques (indices d'éosinophilie, indice karyopcnotique et indice des polynucléaires), on peut déduire que les quatre phases observées correspondent aux quatre phases du cycle oestral définies par Galet (1980), à savoir la phase 1 ou proestrus (durée 4–5 jours), la phase 2 c'est-à-dire oestrus et le postoestrus (72 heures), la phase 3 ou métoestrus (durée 8 jours) et la phase 4 ou dioestrus (durée 3–4 jours).

Les résultats relatifs aux frottis sont conformes aux descriptions cytologiques faites par Sanger et coll. (1958) et Thibault (1971) pour la brebis.

Chez la brebis, il semblerait que les premiers signes de chaleur, qui durent de 24 à 72 heures, apparaissent avec le début du proestrus, c'est-à-dire au moment de la réapparition des oestrogènes consécutive à la croissance folliculaire. L'oestrus proprement dit s'étale sur une période de 72 heures au cours de laquelle a lieu l'ovulation. Celle-ci se produit dès la fin des signes apparents de chaleurs.

Figure 3. *Variations des pourcentages moyens des cellules superficielles (CS) (les traits verticaux indiquent l'erreur standard de la moyenne; le jour D est celui du début des chaleurs).*

Robinson et Moore (1956) cités par Mauleon (1972) signalent que les polynucléaires sont peu nombreux les jours qui suivent l'oestrus mais restent présents pendant tout le cycle chez la brebis.

Conclusion

Les valeurs moyennes de la durée du cycle oestral déterminées par la détection des chaleurs au cours de nos travaux correspondent à celles indiquées par la bibliographie.

Malgré quelques différences en ce qui concerne les modifications de l'épithélium, les résultats observés sur les frottis vaginaux étaient cohérents et conformes à ceux enregistrés par d'autres chercheurs avec des dosages hormonaux. De fait, il suffit d'un seul frottis pour savoir si la brebis se trouve en période pré- ou post ovulatoire. Des travaux supplémentaires sont néanmoins nécessaires pour déterminer le degré de fiabilité de cette méthode, notamment en période ovulatoire.

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Puberty and early mating performance in subtropical fat-tailed sheep and their crosses

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Abstract

In a crossbreeding trial of both Ossimi (O) and Awassi (A) with the highly prolific Chios (C) subtropical fat-tailed sheep, crossbred ewe lambs exhibited their first oestrus at a significantly ($P<0.05$) younger age than the purebred parents. They also had a higher ($P<0.05$) conception rate at yearling. C ewe lambs exhibited their first oestrus at the youngest age (230 days) and had the highest conception rate at one year of age. Season of lambing had little effect on age at puberty of either purebred or crossbred ewe lambs.

Crossbred ram lambs performed better in pubertal age than purebred parents. Semen quality at first ejaculation had poor quality, while it was good at 80% semen motility score.

Puberté et premières performances de reproduction chez des moutons à queue grasse des régions subtropicales et chez les produits de leur croisement

Résumé

Dans des essais de croisement entre des moutons de race Ossimi (O) et Awassi (A) avec des moutons à queue grasse très prolifiques de race Chios (C), les agnelles métisses avaient leurs premiers oestrus à un âge significativement moins avancé ($P<0,05$) que leurs parents de race pure, et un taux de conception à l'âge de 1 an également plus élevé. Les agnelles Chios affichaient l'âge au premier oestrus le plus précoce et le taux de conception à l'âge de 1 an le plus élevé. La saison d'agnelage avait très peu d'effet sur l'âge à la puberté des agnelles de race pure ou croisées.

Les performances à la puberté des agneaux mâles croisés étaient supérieures à celles de leurs parents de race pure. Le premier éjaculat était de qualité médiocre mais présentait une bonne note sur le plan de la motricité du sperme (80%).

Introduction

The Mediterranean subtropical Chios (C) sheep are known for their high prolificacy, early sexual maturity and good milk production. Their usefulness for improving sheep production in the subtropics where prolific temperate breeds performed poorly as purebreds has been reported (Aboul-Ela and Aboul-Naga, 1987). A crossbreeding programme was carried out by the Ministry of Agriculture in Egypt between the imported C sheep from Cyprus and both Ossimi (O) and Awassi (A) sheep. Production performance of these breeds and their crosses has been described by Mousa (1991). The present study reports on the puberty and early mating performance of the crosses and compares it with that of their purebred parents.

Materials and methods

An experiment was conducted at Mallawi Research Farm, Ministry of Agriculture, Upper Egypt between January and September 1987. O and A ewes were mated to C rams to produce the F_1 CO and CA lambs together with their parental groups. Lambs were kept with their dams up to weaning at eight weeks of age. There was a gradual introduction of pelleted concentrate mixture plus Berseem hay into their diets. From December till May, the flock grazed on Egyptian clover (*Trifolium alexandrinum*). In the summer the flock grazed on crop residues and green fodder when available. Grazing was supplemented with pelleted concentrate mixture.

Puberty performance was studied in both ewe and ram lambs born in the lambing season of May/June 1987 and in ewe lambs born in January/February 1988, starting from four months of age. Behaviourial oestrus was detected by active rams twice daily at 800 and 1600 hours. The first incidence of heat symptoms was recorded and the lambs were weighed. Conception rate among yearlings was tested by putting a fertile ram with each group of ewe lambs for a period of 35 days.

The ram lamb's ability to ejaculate in an artificial vagina was considered as a puberty criterion. The date of first ejaculation was recorded and the lambs were weighed. Semen samples from the ram lambs in each breed group were used to evaluate the physical

properties of semen at first ejaculation. Semen motility was examined weekly until it reached a score of 80% of the age of the ram lambs' and other physical properties of the semen were also recorded.

Results

Ewe lambs

Puberty performance

The breed of the ewe lambs had a highly significant effect on age and weight at puberty (P<0.01). O ewe lambs reached puberty at younger ages and heavier weights (P<0.05) than A ewes (Table 1). C ewe lambs, however, reached puberty at a younger age than both O and A ewe lambs (P<0.01). CO ewe lambs exhibited their first oestrus significantly earlier than the O ewes (P<0.01), but at a similar weight. The CA ewe lambs reached puberty significantly younger than A ewes (P<0.01) and at slightly heavier weights.

Single and triplet ewes lambed at a slightly older age than twins, but the differences were not statistically significant (Table 1).

Ewe lambs born in May/June reached puberty a few days later than those born in January/February, and were slightly heavier (Table 1).

Yearling fertility

Conception rate was highest amongst yearlings, lowest amongst A, and O yearlings were intermediate (Table 2). C ewe lambs had a better performance than either O or A ewe lambs (P<0.01). The crossbred yearling ewes had significantly (P<0.05) higher conception rates than O and A, but lower conception rates than their parent (C). The difference between C and CO crosses was not statistically significant.

Table 2. *Conception rate and body weight of yearling ewe lambs in the breed groups.*

Breed group	No. of ewe lambs	Conception rate %	Body weight	
			x (kg)	± SE
Ossimi (O)	28	57.1[b]	37.5	1.6
Awassi (A)	25	44.0[c]	34.7	1.7
Chios (C)	27	74.1[a]	38.2	1.4
CO	26	65.4[a]	39.2	1.6
CA	32	59.3[b]	37.4	1.5

Values within the same column with different superscripts differ significantly (P<0.05).

Ram lambs

First ejaculation

The two CO and CA crossbred ram lambs performed their first ejaculation at a slightly older age and heavier weight than their A and O parents (P<0.05). They showed better performances in pubertal weight and age than C ram lambs (Table 3). C ram lambs reached their first ejaculation at the oldest age and lightest weight of all the groups studied, possibly due to slow growth rates.

Table 1. *Mean age in days and body weight in kg at first oestrus for ewe lambs in the breed groups.*

Classification	No.	Age		Body weight	
		Cons. (day)	± SE	Cons. (kg)	± SE
Overall means	138	275.3	17.2	32.0	1.3
Breed groups					
Ossimi (O)	28	12.9	0.4[d]	1.3	0.0
Awassi (A)	25	40.2	2.0[b]	1.4	0.2
Chios (C)	27	-45.0	3.8[a]	-1.8	0.7
CO	26	-7.8	1.3[c]	1.2	0.1
CA	32	-0.0	0.1[d]	1.0	0.0
Type of birth					
Singles	117	5.1	12.3[a]	1.1	0.9
Twins	19	-10.8	1.2[b]	-1.0	0.1
Triplets	2	-5.8	19.8[a]	-0.0	1.4
Seasons					
May–June	75	19.4	1.9	1.0	0.1
Jan–Feb	63	-6.6	2.4	-1.0	0.2

Values within the same column with different superscripts differ significantly (P<0.05).

Variations in pubertal age within each group were high, except for C ram lambs.

Table 3. *Age and body weight of ram lambs at first ejaculation.*

Breed group	No.	Age at puberty		Weight at puberty	
		(day)	± SD	mean (kg)	± SE
Ossimi (O)	14	296.8	35.4[a1]	41.1	6.6[a]
Awassi (A)	14	284.6	48.5[a]	38.7	5.9[a]
Chios (C)	17	334.9	45.3[b]	35.4	1.9[b]
CO	15	318.5	39.7[ab]	51.7	5.3[d]
CA	16	286.9	24.4[a]	44.7	5.5[d]

Estimates followed by the same letter in any column do not differ significantly (P>0.05).

Semen physical properties

Table 4 shows the analysis of semen samples from first ejaculation at puberty. C rams showed the lowest motility score while CA rams had the highest. The other breeds had intermediate scores. Most of the other properties followed the same trend as the motility scores. Both CO and CA crossbreeds had high values for semen volume, percentage of live sperm and total number of sperms per ejaculation. C ram lambs had the poorest semen quality.

Performance at 80% semen motility

As the age of the ram advanced, semen motility increased to 80%. The crossbred ram lambs reached 80% semen motility at a younger age than purebred parents (Table 5 and Figure 1) and were also heavier. Most of the semen samples were creamy or whole milk in appearance. The pH values at first ejaculation were high, and gradually declined in alkalinity. Differences in percentage of dead sperms between breeds were not significant. Variations in the percentage of abnormal spermatozoa were generally insignificant, except for CA ram lambs (P>0.05). Sperm cell concentration per ejaculation was high in C, CA and CO ram lambs (Table 5), probably due to their high semen volumes.

Discussion and conclusions

Most subtropical breeds reach puberty late (Osman, 1985), possibly due to low growth rates (Aboul-Ela and Chemineau, 1989). However, C ewe lambs attain their puberty at about 225 days (Fox et al, 1971), which agrees with the present study. The results of this study show that crossbreeds between C and O and C and A reached puberty earlier than purebred O and A sheep. Similar reports have showed that heterosis may contribute to earlier sexual development (Land, 1978; McMillan and McDonald, 1983; Lahlou-Kassi and Marie, 1985). However, season of birth seems to have less influence

Table 4. *Physical properties of semen at first ejaculation.*

Breed group	No.	Volume (ml)	Motility %	pH (%)	Dead sperm	Abnormality %	Sperm Con. x 10^6/mm^3
Ossimi (O)	5	0.6	50[a]	7.5[a]	28.0[a]	11.6[a]	2.0
Awassi (A)	5	0.8[b]	50[a]	7.3[a]	34.0[a]	12.8[a]	1.5
Chios (C)	5	0.8[b]	45[a]	7.5[a]	24.0[a]	9.8[a]	1.3
CO	5	0.8[ab]	50[a]	7.2[a]	25.0[a]	8.0[a]	1.9
CA	5	0.9[b]	55[a]	6.9[a]	21.0[a]	7.5[a]	1.9

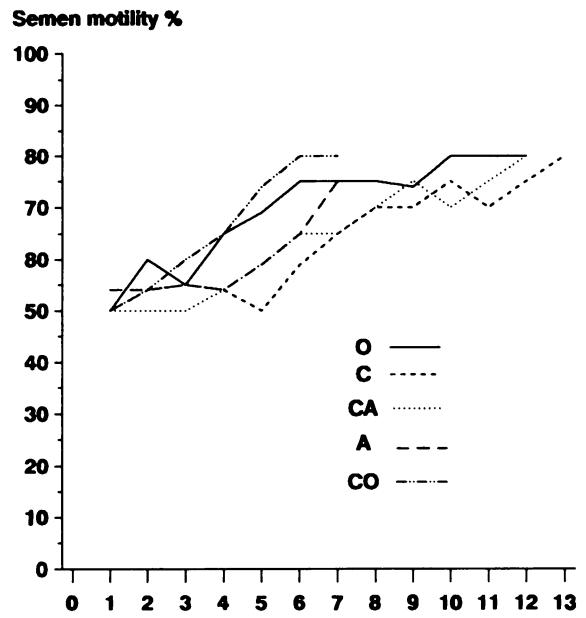
ab = Estimates followed by the same letter in any column do not differ significantly (P>0.05).

Table 5. *Semen physical properties, age and body weight at 80% semen motility score.*

Breed group	No.	Volume (ml)	pH	Dead sperm %	Abnormality %	Sperm Con. x10^6/mm^3	Sperm Con. x10^9/ejac	Age		Body weight	
								x(day)	± SE	x(day)	± SE
Ossimi (O)	5	1.5[a1]	6.8[a]	16.6[a]	7.4[a]	3.2	4.6[a]	414.2	19.2[a1]	51.4	4.2[a]
Awassi (A)	5	1.2[a]	6.8[a]	17.2[a]	6.8[a]	3.5	4.2[a]	401.7	19.6[a]	45.8	4.3[a]
Chios (C)	5	2.0[a]	6.7[a]	18.8[a]	6.2[a]	2.7	5.3[b]	425.6	18.7[a]	48.8	4.1[a]
CO	5	1.9[a]	6.7[a]	14.6[a]	6.4[a]	2.5	4.8[b]	393.3	20.2[b]	55.9	4.6[a]
CA	5	2.0[a]	6.8[a]	13.5[a]	4.3[b]	2.7	5.3[b]	398.6	20.5[ab]	51.1	4.5[a]
Overall mean		1.7[a]	6.8[a]	16.4	6.2	2.9	4.8				

ab = Estimates followed by the same letter in any column do not differ significantly (P>0.05).

Figure 1. *Semen motility changes from puberty up to score of 80% for different breed groups.*



on age at puberty of subtropical breeds, compared to its effect on their body weight. Results obtained by Younis et al (1978) support these findings.

Early breeding of subtropical sheep can result in lower conception and twinning rates and higher lamb losses (Younis et al, 1978; Aboul-Naga et al, 1987). This showed that C, CO and CA yearling ewes had better early breeding performances than the O and A yearling ewes (Table 2). C sheep are expected to infuse the advantage of early breeding to their crosses.

The two crossbred ram lambs reached puberty at younger ages and heavier weights than C ram lambs. C ram lambs seem to be adversely affected by the environment in Upper Egypt, resulting in slower growth rates than those reported in their home country (Lysandrides, 1981). The evidence does not show crossbreeds having better semen properties at puberty. However, by the time the sperm had reached 80% motility, ejaculation volumes in the two crossbreeds and C ram lambs were significantly higher ($P<0.05$) than in both O and A ram lambs. These differences may be due to the variation in testicular size (Mann, 1964). This study shows that crossbreeding with the highly fertile Chios subtropical breed can considerably improve the early breeding performances.

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Preweaning performance of Yankasa sheep under semi-intensive management

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Summary

Preweaning growth traits and weaning rate of Yankasa sheep under a semi-intensive management system with twice-yearly lambings were studied for nine years at Shika, in the subhumid zone of Nigeria.

Least squares means (± SE) for birth weight (BW), 90-day weaning weight (WW), average daily gain to weaning (ADG) and weaning rate (WR) were 2.51 ± 0.01 kg, 10.87 ± 0.08 kg, 91.86 ± 0.91 g/day and 77.8 ± 1.0%, respectively. BW, WW and ADG were significantly (P<0.001) affected by dam parity and the lamb's litter size, sex, month and year of birth. WR was significantly (P<0.01) affected by parity, litter size, month and year of birth but not by sex of lamb (P>0.05). Preweaning growth performance was generally better in the wet seasons than in the dry seasons while the reverse was true for weaning rate.

Performances présevrage du mouton Yankasa élevé en système semi-intensif

Résumé

Les paramètres de croissance présevrage et les taux de sevrage du mouton Yankasa élevé selon un mode semi-intensif, avec deux agnelages par an, ont été étudiés sur une période de neuf ans à Shika, dans la zone subhumide du Nigéria.

Les moyennes des moindres carrés (± erreur type) du poids à la naissance, du poids au sevrage à 90 jours, du gain moyen quotidien (GMQ) jusqu'au sevrage et du taux de sevrage étaient respectivement de 2,51 ± 0,01 kg, 10,87 ± 0,08 kg, 91,86 ± 0,91 g/jour et 77,8 ± 1,0%. La parité de la mère, la taille de la portée, le sexe des jeunes, et le mois et l'année de naissance avaient un effet significatif (P<0,001) sur les poids à la naissance et au sevrage et sur le GMQ. A l'exception du sexe des agneaux (P>0,05), ces mêmes paramètres avaient aussi un effet significatif (P<0,01) sur le taux de sevrage. Les performances de croissance avant le sevrage étaient généralement meilleures en saison des pluies alors que l'inverse était vrai pour le taux de sevrage.

Introduction

The preweaning traits of sheep which influence flock productivity include birth weight, weaning weight, average daily gain to weaning and weaning rate. These traits are in turn influenced by genetic and environmental factors. For a given breed, influencing environmental factors may include dam parity and type of birth and sex, month and year of birth of young (Terrill, 1966).

The Yankasa sheep is the most numerous breed of sheep in Nigeria and also has the widest distribution, being found throughout the subhumid and semi-arid zones (FDLPCS, 1991). It is estimated to constitute about 60% of the national sheep population of 22.1 million (Osinowo, 1992). Preweaning traits have been studied in Yankasa sheep (Adu et al, 1979; Adu and Buvanendran, 1982; Taiwo and Buvanendran, 1985; Hassan, 1987). However, these earlier studies were carried out with smaller data sets of less than four hundred records.

This study re-examined preweaning traits of Yankasa sheep under semi-intensive management at Shika in the subhumid zone of Nigeria, using a much larger data set collected over a nine-year period.

Materials and methods

The Yankasa sheep flock from which the data were obtained was located at the National Animal Production Research Institute (NAPRI), Ahmadu Bello University, Shika, Nigeria, latitude 11°12'N, longitude 7°33'E and 610 metres above sea level (masl). The climate is subhumid and the vegetation zone is Northern Guinea Savanna. Mean annual rainfall and temperature recorded at Samaru, 10 km from Shika, were 1107 mm and 24.4°C, respectively. The seasonal distribution of rainfall is approximately 0.1% in the late dry season (January – March), 25.8% in the early wet season (April – June), 69.6% in the late wet season (July – September) and 4.5% in the early dry season (October – December). Fodder is generally scarce and of low quality in the late dry and early wet seasons. It is in abundant supply and of relatively good quality in the late wet and early dry seasons.

The origin and management of the Yankasa sheep flock studied have been previously described (Osinowo, 1982; Osinowo and Ekpe, 1985). In 1987, the flock was enlarged from 100 to 300 ewes by additional purchases from livestock markets in the same North Western region of Nigeria. The sheep were managed under a semi-intensive system. This involved grazing on improved and sown pastures for 6 – 8 hours daily, with 0.3 – 0.5 kg/day of a 15–20% crude protein concentrate supplement throughout the year, depending on the animal's physiological status (pregnant, nursing or dry). The animals were housed in well ventilated pens overnight. The ewes were routinely bred to lamb twice a year under an accelerated lambing programme. The lambs were weaned at about 90 days of age.

Data on birth weight (BW), weaning weight (WW) and weaning rate (WR) were collected over nine years, from 1983 to 1991. Preweaning average daily gain (ADG) was calculated for each lamb after age-correction of WW to 90-day weight. Factors included in the study were parity of dam (1 – 6) and lamb litter size (single vs twin), sex (male vs female), month of birth

Table 1. *Effects of some production and environmental parameters on the preweaning performance of Yankasa sheep.*

TRAITS		Birth weight (BW) (kg)		Weaning weight (WW) (kg)		Average daily gain to weaning (ADG) (g/d)		Weaning rate	
LSM ± SEM		2.507 ± 0.011		10.874 ± 0.084		91.861 ± 0.911		0.779± 0.010	
No. of observations		2020		1203		1203		1576	
				Least-squares constants					
Variable		No.		No.		No.		No.	
Parity	1	589	-0.179	320	-1.194	320	-11.159	440	-0.045
	2	461	-0.048	260	-0.529	260	-5.253	359	-0.002
	3	369	0.042	247	0.077	247	1.012	307	0.053
	4	237	0.033	157	0.565	157	5.918	185	0.074
	5	155	-0.002	103	0.363	103	4.174	119	0.097
	6	87	0.124	56	0.012	56	-1.506	73	-0.018
	7	59	0.050	26	-0.254	26	-4.716	39	-0.083
	8	38	0.005	19	0.437	19	4.759	29	-0.010
	9	30	-0.025	15	0.523	15	6.771	29	-0.066
Litter size									
	Single	1385	0.207	889	1.160	889	10.618	1120	0.066
	Twin	635	-0.207	314	-1.160	314	-10.618	456	-0.066
Sex	Male	1004	0.058	604	0.523	604	5.199	781	0.007
	Female	1016	-0.058	599	-0.523	599	-5.199	795	-0.007
Month	Jan	218	-0.032	154	-0.970	154	-10.812	190	0.026
	Feb	123	-0.249	100	-1.743	100	-16.445	110	0.033
	Mar	200	-0.304	145	-0.236	145	0.068	176	0.007
	Apr	161	-0.089	103	0.165	103	2.538	132	0.017
	May	234	-0.032	123	0.947	123	11.404	170	0.079
	Jun	215	0.111	78	-0.285	78	-5.398	149	-0.132
	Jul	192	0.260	97	1.197	97	10.934	130	-0.025
	Aug	146	0.150	70	0.997	70	9.308	130	-0.114
	Sep	99	0.138	66	0.934	66	8.731	86	-0.035
	Oct	100	0.014	68	0.048	68	0.277	81	-0.033
	Nov	129	0.070	86	-0.655	86	-6.715	96	0.159
	Dec	203	-0.037	113	-0.393	113	-3.890	163	0.180
Year	1983	86	-0.077	41	-0.160	41	-1.490	48	0.132
	1984	197	-0.078	158	0.228	158	3.587	167	0.123
	1985	201	0.068	154	-0.024	154	-0.096	176	0.143
	1986	128	0.087	95	-0.440	95	-5.622	104	0.088
	1987	210	-0.072	86	1.440	86	15.809	108	-0.034
	1988	453	-0.064	236	-1.139	236	-12.355	376	-0.166
	1989	249	-0.173	138	-0.656	138	-6.088	196	-0.125
	1990	308	-0.062	167	-0.403	167	-3.295	231	-0.078
	1991	188	0.371	128	1.154	128	9.550	170	-0.083

Table 2. *Comparison of estimates of preweaning and weaning performance of Yankasa sheep by different investigators.*

Trait	No. of observations	Mean ± SE	Investigators
Birth weight (kg)	214	2.80 ± 0.19	Adu et al (1979)
	43	2.54	Adu and Buvanendran (1982)
	357	2.51 ± 0.03	Hassan (1987)
	2020	2.51 ± 0.01	Current study
Weaning weight (kg)	32	9.14.	Adu and Buvanendran (1982)
	298	10.90 ± 0.19	Hassan (1987)
	1203	10.87 ± 0.08	Current study
Preweaning ADG (g/day)	214?	107.8	Adu et al (1979)
	32	75.8	Adu and Buvanendran (1982)
	1203	91.86 ± 0.91	Current study
Weaning rate (%)	43	76	Adu and Buvanendran (1982)
	362	85	Taiwo and Buvanendran (1983)
	1576	77.9 ± 1.0	Current study

(January – December) and year of birth (1983 – 1991) of the lambs. After editing, 2020 BW, 1203 WW, 1203 ADG and 1576 WR records were included in the analyses.

Environmental effects on the preweaning traits were examined by least squares analyses (SYSTAT, 1989) according to the linear model :

$$Yijklmn = u + Pi + Lj + Sk + Ml + Ym + Eijklmn$$

where Yijklmn was the preweaning trait (BW, WW, ADG or WR) of an individual lamb, u was the overall mean, Pi was the fixed effect of the ith parity, Lj that of the jth litter size, Sk that of the kth sex, Ml that of the lth month of birth, Ym that of the mth year of birth and Eijklmn was the random error term associated with each record.

Results and discussion

Birth weight

The least squares mean for BW (Table 1) agreed closely with earlier reports (Adu and Buvanendran, 1982; Hassan, 1987) but is lower than the estimate by Adu et al (1979), as shown in Table 2.

The effects of dam parity and litter size, sex, month and year of birth of lambs on BW were all highly significant ($P<0.001$). BW tended to increase with parity, with the highest BW occurring at the 6th parity. As expected, singles and male lambs weighed more at birth than their twins and female counterparts. BW was higher in June–November than in Dec–May. BW followed the seasonal fluctuation in forage availability. Yearly variations in BW did not follow any particular pattern except for a consistent improvement over the last three years of the study.

Weaning weight (Table 1)

The 90-day WW for Yankasa sheep in this study agreed closely with that reported by Hassan (1987) (Table 2) but both are higher than the earlier estimate by Adu and Buvanendran (1982). The effects of parity, litter size, sex, month and year of birth were highly significant ($P<0.001$).

WW increased consistently from first to fifth parity, and both singles and male lambs had a higher WW than twins and female lambs. WW of lambs born between November and March and also in June were below average, with lambs born in July having the highest WW. This pattern reflects the seasonal availability of forage, except for June. The low WW of lambs born in June could be due to a high disease incidence during this month; June also had the highest preweaning mortality rate. This observation needs closer clinical investigation to determine the cause. Yearly variations followed no particular pattern except for the consistent improvement in WW in the last four years of the study.

Preweaning ADG (Table 1)

The preweaning ADG obtained in this study is intermediate between values reported by Adu et al (1979) and Adu and Buvanendran (1982). The effects of parity, litter size, sex, month and year of birth on ADG were highly significant ($P< 0.001$). ADG improved consistently from first to fourth parity. Singles and male lambs had a higher ADG than twins and female lambs. Below average ADG were obtained in June and between November and February. Yearly variations in ADG followed no pattern except for a consistent increase over the last four years of the study.

Weaning rate (Table 1)

The WR obtained in the present study compares favourably with that of Adu and Buvanendran (1985) but is lower than the figure reported by Taiwo and Buvanendran (1985) (Table 2). WR was significantly affected by litter size, month and year of birth (all $P<0.001$) and parity ($P<0.01$), but not by sex ($P>0.05$). WR increased consistently from first to fifth parity, with higher parities giving below average values. Single lambs had a higher WR than twin lambs. Lower WR values were obtained for lambs born between November and May. There is a close parallel between WR and rainfall pattern; lambs survive better if born in the dry rather than the wet months.

Conclusion

This study shows that there may be no advantage in keeping Yankasa breeding ewes under semi-intensive management beyond the sixth parity in terms of preweaning traits, especially WR which consistently fell below average in the latter group. However, the high parities had a relatively low number of observations and therefore need further study when larger data sets become available. The reasons for the peculiarly bad growth and weaning rate performances of lambs born in June also need further investigation. Seasonal effects on preweaning traits show that growth traits were better for lambs born in the wet seasons rather than the dry seasons, while the reverse was true of the weaning rate.

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Studies on factors affecting reproductive performance and mortality rates of Small East African goats and their crosses

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Abstract

This study compares genetic and non-genetic factors affecting the reproductive performance and mortality rates of Kamorai x Small East African (SEA), Boer x SEA and SEA goats using records kept at the Department of Animal Science and Production, Sokoine University of Agriculture, Tanzania, between 1972 and 1989.

Age at first kidding and kidding interval ranged from 638 to 984 days and 293 to 419 days, respectively. Age at first kidding was significantly ($P<0.001$) influenced by period of kidding. Period of kidding and season of previous kidding affected kidding interval significantly ($P<0.01$ and $P<0.05$, respectively).

Overall average mortality rate was 40.6% and 25.7% for preweaning and postweaning periods, respectively. Animals with birth weights of less than 1.5 kg had the highest preweaning mortality rate (57.9%). The lowest preweaning mortality rate occurred in animals with a birth weight of greater than 2.6 kg (29.8%). Twins exhibited a higher preweaning mortality rate than singles (48.3% vs 38.5%). Preweaning mortality was lower in period 1 (1972–1974) than in later years.

Non-genetic factors, especially period and season of kidding, were the main sources of variation in reproductive performance and mortality rate. Crossing SEA goats with Kamorai and Boer showed little improvement in these factors. Poor feeding management and disease control probably prevented the crosses from expressing their genetic potential.

Etude des facteurs influant sur les performances de reproduction et la mortalité de la petite chèvre d'Afrique de l'Est et de ses produits de croisement

Résumé

Les données enregistrées entre 1972 et 1989 au Département de science et de production animales de l'Université agricole de Sokoine (Tanzanie) ont été utilisées pour comparer les facteurs génétiques et les facteurs non génétiques qui agissent sur les performances de reproduction et les taux de mortalité des caprins Kamorai x petite chèvre d'Afrique de l'Est, Boer x petite chèvre d'Afrique de l'Est, et petite chèvre d'Afrique de l'Est.

L'âge au premier vêlage était compris entre 638 et 984 jours, et l'intervalle de vêlage entre 293 et 419 jours. La période de mise-bas avait un effet significatif ($P<0,01$) sur l'âge au premier vêlage. La période et la saison des mises-bas précédentes avaient un effet significatif (respectivement $P<0,01$ et $P<0,05$) sur l'intervalle de mise-bas.

La mortalité générale moyenne était de 40,6% avant le sevrage, et de 25,7% après le sevrage. Les animaux pesant moins de 1,5 kg à la naissance présentaient le taux de mortalité présevrage le plus élevé (57,9%) et ceux pesant plus de 2,6 kg, le taux de mortalité présevrage le plus bas (29,8%). La mortalité présevrage des chevreaux issus de naissances gémellaires était supérieure (48,3%) à celle des agneaux nés simples (38,5%). La mortalité présevrage au cours de la période 1 (1972–1974) était inférieure à celle enregistrée les années suivantes.

Les facteurs non génétiques, en particulier la période et la saison de mise-bas, constituaient les principales sources de variation des performances de reproduction et de la mortalité. Le croisement de la petite chèvre de l'Afrique de l'Est avec des animaux de race Kamorai et Boer n'a pas apporté d'améliorations en ce qui concerne ces facteurs. La piètre conduite de l'alimentation et de la prophylaxie sanitaire a probablement empêché les sujets de croisement d'extérioriser leur potentiel génétique.

Introduction

Poor reproductive efficiency of tropical goats compared with temperate breeds has been documented in the literature (Wilson, 1989). However, tropical goats are able to adapt and reproduce under harsh environmental conditions (Kiwuwa, 1992) and have good fitness traits (Olayiwole and Adu, 1989; Kiwuwa, 1992). Rearing exotic goats under tropical conditions has disadvantages of high mortality and poor adaptation (Olayiwole and

Adu, 1989; Kiwuwa, 1992). Tropical goats could be genetically improved by selecting for growth, reproduction and survivability. This has not been seriously undertaken because the process is time-consuming and expensive (Mchau, 1979). Good selection is also impossible in flocks with inadequate or non-existent records, as is the case in many developing countries (Olayiwole and Adu, 1989). Wilson (1989) and Kiwuwa (1992) suggest that selection should improve reproduction and growth while conserving the characteristics that adapt tropical goats to their environment. On the other hand it has been well documented (Kyomo, 1978; Mchau, 1979; Senyatso, 1986) that crossbreeding tropical goats with exotic 'improver' breeds could increase meat and milk production. This advantage has led to the introduction of crossbreeding programmes in Tanzania.

Data on the reproductive traits and mortality rates of the exotic Boer and indigenous Tanzanian goats and their crosses were collected at the Sokoine University of Agriculture between 1972 and 1989. Prior to this study the data had not been systematically analysed. The purpose of this study was to analyse the performance of the cross-bred goats before their large-scale spread to the villages.

Materials and methods

Animals and management

The genetic groups involved in this study were the Small East African (SEA), Boer x SEA and Kamorai x SEA goats. The SEA goats were the dam line. This breed has been characterised by Mason and Maule (1960). The sire lines were the Boer and Kamorai, which have been characterised by Mason (1981). The goats were regularly provided concentrates between 1972 and 1974. Thereafter the regular provision of concentrates was hampered by their scarcity.

Data collection and analyses

Data on reproductive traits were extracted from record cards for individual animals. Records on mortality rates were collected from liveweight records and yearly inventory books.

Reproductive traits studied were age at first kidding (AFK) and kidding interval (KI). For AFK the effects of genetic group, birth type of the first-kidding doe, season of birth and period of birth were studied. For KI the effects of genetic group, parity, season of previous kidding and period of kidding were studied.

AFK and KI were analysed using the GLM procedure in SAS (1988). The model used for the analysis of AFK was:

$$Y_{ijklm} = \mu + B_i + T_j + M_k + R_l + e_{ijklm},$$

where:

Y = Age at first kidding (days)

i = genetic group (1–3)

j = type of birth (1 or 2)

k = season of birth (1–4)

l = period of birth (1–4)

m =doe

μ = overall mean

B = the effect of genetic group

S = the effect of type of birth

M = the effect of season of birth

R = the effect of period of birth

e = the error term

The model used for analysing KI was:

$$Y_{ijklm} = \mu + B_i + P_j + M_k + R_l + e_{ijklm}$$

where:

Y = kidding interval (days)

m =doe

i = genetic group (1–3)

j = parity (1–3)

k = season of previous birth (1–4)

l = period of birth (1–4)

μ = overall mean

B = effect of genetic group

P = effect of parity

M = effect of season of previous birth

R = effect of period of birth

e = error term

Seasons were grouped by weather pattern: season 1, February to April (late rains); season 2, May to July (cool dry season); season 3, August to October (hot dry season) and season 4, November to January (dry season). As there were only a small number of observations across the years, the data were divided into periods in order to assess effects over time: period 1 (1972–1974); period 2 (1975–1977); period 3 (1978–1980) and period 4 (>1981).

Mortality rates (MR) were determined for three periods: birth to weaning (16 weeks); 16 to 52 weeks of age; and birth to 52 weeks age. MR for each period was determined as the proportion of all kids born in period that have died.

Mortality rates were calculated by genetic group, sex, birth type, season of birth, period of birth and birth weight. These factors had further subclasses: genetic group (Kamorai x SEA, Boer x SEA and SEA); sex (male and female); birth type (singles and twins); and birth weight (1 to 1.5, 1.6 to 2.0, 2.1 to 2.5, 2.6 to 3.0 and 3.1 to 3.5 kg). Season and period of birth were classified in the same way as for reproductive traits.

The effects of the above factors on mortality rates were analysed using the chi-square test (X^2) in a 2 x C contingency table (Snedecor and Cochran, 1989).

Results

Age at first kidding

The overall mean age at first kidding during the whole period of the study was 810.78 days (SE = 172.73) (Table 1). Of the factors studied, only period of birth significantly (P<0.001) affected age at first kidding. Figures given in Table 1 show that does kidded at younger ages in periods 1 and 4 than in other periods. Although age at first kidding was not significantly affected (P>0.05) by birth type, female kids born as twins were on average 50.88 days older at first kidding than those born as singles.

Table 1. *Least squares means and standard errors (days) for age at first kidding.*

Effect	Age at first kidding (days)		
	n	Mean	SE
Overall mean	291	810.78	172.73
Genetic group			
Kamorai x SEA	50	828.05	28.00
Boer x SEA	61	806.34	26.31
SEA	180	790.44	18.47
Birth type			
Single	210	782.83	15.83
Twins	81	833.71	27.11
Season of birth			
1	49	833.36	28.63
2	75	832.99	25.33
3	88	798.08	23.34
4	79	768.67	24.15
Period of kidding			
1	90	762.54[b]	16.70
2	75	883.0[a]	27.08
3	78	860.20[a]	26.47
4	48	728.26[b]	37.45

SE = Standard error.

ab = means within a column that have different superscripts are significantly different (P<0.03).

Kidding interval

Season of previous kidding and period of kidding had significant (P<0.05 and P<0.01, respectively) effects on the intervals between successive kiddings (Table 2). Does that kidded in season 1 had shorter subsequent kidding intervals than those kidding in other seasons. Does that kidded in period 4 had shorter subsequent kidding intervals than does that kidded in other periods. The differences in kidding intervals due to period of kidding were not significant (P>0.05) among periods 1, 2 and 3.

Table 2. *Least squares means and standard errors (days) for kidding interval.*

Effect	Kidding interval (days)		
	n	Mean	SE
Overall mean	336	355.89	63.3
Genetic group			
Kamorai x SEA	59	350.09	8.9
Boer x SEA	68	355.86	8.0
SEA	209	350.77	5.67
Parity			
1	163	349.41	5.75
2	91	352.68	7.76
3	82	354.63	8.27
Season of previous kidding			
1	44	331.31[a]	10.16
2	79	359.69[b]	7.78
3	85	362.08[b]	8.16
4	128	355.88[b]	6.54
Period of kidding			
1	32	369.75[a]	12.66
2	166	365.83[a]	6.02
3	69	342.92[a]	8.12
4	69	325.45[b]	8.33

SE = standard error.

ab = means within the same column that have different superscripts are significantly different (P<0.05).

Mortality

The chi-square test indicated that differences in mortality rates among genetic groups were not significant (P>0.05). The Boer x SEA group had the highest mortality rates, SEA had the lowest and the Kamorai x SEA was intermediate (Table 3).

There was a significant influence (P<0.05) of birth type on the mortality rate of kids from birth to one year of age (Table 3). There was no significant difference (P>0.05) in mortality rate between singles and twins from 0 to 16 and 16 to 52 weeks of age. However, there was a tendency for the mortality rate to be higher for twins than for singles in all age groups (Table 3). Season of birth had a significant effect (P<0.05) on the mortality rate of kids from birth to 16 weeks and birth to one year. Kids born in season 1 had the highest mortality rate, followed by those born in season 2. Sex had no effect on mortality rate (P>0.05).

Birth weight had a significant effect on the mortality rate of kids from 0 to 16 weeks (P<0.01) and from 0 to 52 weeks of age (P<0.05). Mortality rate decreased with increasing birth weight (Table 3).

Preweaning mortality rate in kids was also significantly (P<0.05) affected by period of birth of the kids. Mortality rates were highest for kids born in period 4 and were lowest in kids born in period 1 (Table 3).

Table 3. *Mortality rate of goat kids in different age groups by genetic group, sex, birth type, period of birth, season of birth and birth weight.*

	Birth to weaning			Weaning to 1 year		Birth to 1 year	
Factor	Born	Died (%)	At risk	Died (%)	Born	Died	%
Genetic group							
SEA	345	138 (40.0)	207	51 (24.6)	345	189	54.8
Boer x SEA	30	14 (46.7)	16	6 (37.5)	30	20	66.6
Kamorai x SEA	24	10 (41.7)	4	4 (28.6)	24	14	58.3
Total	399	162 (40.6)	237	61 (25.7)	399	223	55.9
Sex							
Males	212	87 (41.0)	125	32 (25.6)	212	119	56.1
Females	187	75 (40.1)	112	29 (25.7)	187	104	55.6
Birth type							
Single	312	120 (38.5)	192	45 (24.4)	312	165	52.9[b]
Twins	87	42 (48.3)	45	16 (29.9)	87	58	66.7[a]
Period of birth							
1 1972–74	15	4 (26.7)	11	3 (27.3)	15	7	46.6
2 1975–77	81	25 (30.9)	56	12 (21.4)	81	37	45.7
3 1978–80	135	54 (40.0)	81	20 (24.7)	135	74	54.8
4 1981–	168	79 (47.0)	89	26 (29.2)	168	105	62.5
Season of birth							
1 Nov – Jan	108	51 (47.2)	57	18 (31.6)	108	69	63.9
2 Feb – April	131	62 (47.3)	69	17 (24.6)	131	79	60.3
3 May – July	78	28 (35.9)	50	11 (22.0)	78	39	50.0
4 Aug – Oct	82	21 (25.6)	61	15 (24.6)	82	36	43.9
Birthweight (kg)							
1.0–1.5	57	33 (57.9)	24	7 (29.2)	57	40	70.2
1.6–2.0	116	56 (48.3)	60	16 (26.6)	116	72	62.2
2.1–2.5	96	34 (35.4)	62	17 (27.4)	96	51	53.1
2.6–3.0	94	28 (29.8)	66	15 (22.7)	94	43	45.7
3.1–3.5	36	11 (30.5)	25	6 (24.0)	36	17	47.2

ab = means within the same column that have different superscripts are significantly different.

Discussion

Age at first kidding

The average age at first kidding was 810.78 days (SE=172.73). This value is close to those reported by Kyomo (1978) and Wilson and Murayi (1988), which range from 600 to 780 days for on-station studies. The values reported in this study are higher than those reported in studies of the traditional sector of sub-Saharan Africa, which range from 301 to 431 days (Wilson, 1988; Lebbie and Manzini, 1989). This is because, in this study, goats were mated for the first time at 72 weeks of age. It is also possible that feeding and general husbandry practices were substandard under station conditions, contributing to the greater age at first kidding in this study.

SEA goats tended to be younger than Kamorai x SEA and Boer x SEA at first kidding. Younger ages at first kidding for tropical goats compared with crosses have also been reported in the literature. Raja and Mukundan (1974) showed that purebred Malabari goats were younger at first kidding than were Jamunapari x Malabari goats. Wilson and Murayi (1988) also found that SEA goats were younger at first kidding than were Anglonubian x SEA goats. However, Devendra and Burns (1970) reported little variation in age at first kidding between Indian native and crossbred goats, and Kyomo (1978) found no difference between SEA and Kamorai x SEA goats.

Does born single tended to kid at a younger age than twins, which agrees with other findings (Wilson and Murayi, 1988; Wilson et al, 1989). Female twins were probably delayed in reaching puberty due to a lower-than-average growth rate (Wilson and Murayi, 1988; Wilson et al, 1989). For twins and singles to kid at the same age, twins may need supplements to their diet to encourage growth. This is especially true for twins from dams with low milk yields. Period of birth influenced age at first kidding, also reported by Wilson

and Murayi (1988) and Wilson et al (1989). The effect of period of birth on age at first kidding was mainly a reflection of changed management practices (Wilson and Murayi, 1988), which was probably true for this study.

Kidding Interval

The overall mean kidding interval (Table 2) was close to values reported in studies carried out on experimental and multiplication stations in the tropics (Wilson and Murayi, 1988; Wilson et al, 1989). It is, however, longer than values found in the traditional sector, which ranged from 238 to 265 days (Wilson and Durkin, 1988; Lebbie and Manzini, 1989). The longer kidding intervals recorded on stations is the result of a controlled breeding policy imposed to achieve the best breeding season. Normally there is no imposition of seasonal breeding in the traditional sector and animals of all ages and sex run together day and night. In this study, although there was no well-defined seasonal breeding policy, mating was taking place only at night (between 1800 and 0800 hours), resulting in less exposure of the does for mating than in the traditional sector.

This study shows that the season of previous birth and period of birth were the only main sources of variation contributing to differences in kidding intervals. Does that had their previous kid in season 1 (late rains) showed shorter kidding intervals than does that gave birth in other seasons. This confirms the findings of Wilson and Murayi (1988), who reported shorter kidding intervals for dams that had their previous kid during the rainy season. Wilson and Durkin (1988) also reported a similar seasonal effect. This is possibly related to the availability of feed from pasture, which may have influenced ovulation rate and fertility.

The effect of period (year) of kidding on kidding interval has also been demonstrated by Adeoye (1985), Wilson and Durkin (1988) and Wilson and Murayi (1988). In this study the variation might have been associated with inconsistent management on the station.

Mortality

The effect of genetic group on mortality rate was small and non-significant. However, Boer x SEA tended to show higher mortality rates (Table 3). This is in agreement with other findings (Mchau, 1979; Senyatso, 1986). This may be due to the poor adaptation of Boer goats to harsh environmental conditions and increased susceptibility to disease. Similar conclusions have been drawn for crosses between Boer and indigenous tropical goats by Mchau (1979) and Senyatso (1986). In this study the major causes of mortality were not fully recorded. Nonetheless, from the limited records available, pneumonia seems to have been a major cause of death in kids.

Mortality was high in the preweaning period (Table 3). Similar results were reported by Kyomo (1978), Mchau (1979) and Sarmah et al (1981). Younger animals seem less able to withstand attack by both physical and biological agents due to their lack of immunity. This makes them more susceptible to enteric and respiratory infections (Ndamukong, 1985). Losses in the preweaning period can be minimised by providing proper shelter, prophylaxis and better nutrition.

This study showed that twins were more likely to die than were singles. This agrees with observations made by Sarmah et al (1981) and Wilson and Murayi (1988). Twins tended to have lower birth weights. Curtis (1969) concluded that animals with low birth weights had lower energy reserves and were therefore less able to withstand harsh environments; also if the dam has a poor milk yield, she may be unable to provide adequate nutrition for twins, thus increasing their susceptibility to disease.

Kids born during the wet season had a higher mortality rate than those born in the dry season. Similar trends have been reported elsewhere (Mazumdar et al, 1980; Sarmah et al, 1981; Chawla et al, 1982; Wilson, 1988). The higher mortality rate in the rainy season was associated with high rainfall and high relative humidity (Mazumdar et al, 1980), both of which are known to promote disease and parasitic infection.

The birth weight of the kid had an influence on pre- and post-weaning mortality rates. This confirms earlier findings in tropical goats (Mazumdar et al, 1980; Singh et al, 1990). Mazumdar et al (1980) reported mortality rates of 100% for kids weighing 1.0 to 1.5 kg and 32.2% for kids weighing from 2.0 to 2.5 kg. This study shows a lower mortality rate for kids weighing 1.0 to 1.5 kg than Mazumdar et al (1980) (Table 3).

The effect of period of birth on viability of kids agrees with results published by Chawla et al (1982) and Wilson and Murayi (1988). Table 3 shows that kids born between 1972 and 1974 had lower pre-weaning and post-weaning mortality rates than those born in other periods. During this period disease prevention and feed provision were good. Thereafter, inconsistent management contributed to higher mortality rates. The standard of flock hygiene and disease monitoring needs improvement in order to lower mortality rates.

Conclusion

Crosses were expected to perform better in reproductive traits and survivability of kids compared to SEA goats but did not. This may be due to poor adaptation of the crosses and poor nutrition and disease control from 1975 to 1989.

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Reproductive traits and disease incidence characteristics of Dorper, Dorper x Masai and Masai ewes raised under semi-arid conditions in Kenya

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Abstract

Reproductive and disease incidence characteristics of Dorper (D), F_1 Dorper x Masai (DM) and Masai (M) ewes were compared under semi-arid conditions in Kenya.

Percentage of lambs born alive were 87.1, 90.1 and 98.2 for D, DM and M ewes respectively. Gestation lengths were 149.1, 148.2 and 146.7 days respectively; birth weights were 3.1, 3.5 and 2.7 kg; ages at first service were 12.2, 11.8 and 12 months and weights at first service were 30, 32.2 and 26.2 kg respectively. Significant differences between breed groups were observed in reproductive traits and disease frequencies. The DM ewes were younger and heavier at first service than the parental breeds (D and M). The differences between breed groups kept under the same environmental conditions indicate that disease susceptibility has a genetic basis.

Caractéristiques de la reproduction et de l'incidence des maladies chez les brebis de race Dorper, Dorper x Massaï et Massaï élevées en milieu semi-aride au Kenya

Résumé

Les caractéristiques de la reproduction et de l'incidence des maladies chez des brebis Dorper (D), F_1 Dorper x Massaï (DM) et Massaï élevées en milieu semi-aride au Kenya ont été comparées. Les pourcentages d'agneaux nés vivants étaient respectivement de 87,1, 90,1 et 98,2 pour les brebis D, DM et M. Les durées respectives de gestation étaient de 149,1, 148,2 et 146,7 jours et les poids à la naissance de 3,1, 3,5 et 2,7 kg. L'âge à la première saillie était respectivement de 12,2, 11,8 et 12 mois et les poids à la première saillie de 30, 32,2 et 26,2 kg. On observe des différences significatives entre les types génétiques pour ce qui concerne les caractéristiques de la reproduction et la fréquence des maladies. Les brebis DM étaient plus jeunes et plus lourdes à la première saillie que les races parentales (D et M). Les différences entre types génétiques maintenus dans des conditions environnementales identiques montrent que la prédisposition aux maladies repose sur une base génétique.

Introduction

Hair sheep form a major component of the livestock sector of agriculture in Kenya. Of a total of approximately 7 million sheep in Kenya (De Boer, 1981) about 95% are hair sheep (Odenya, 1984) which produce an estimated 15 to 20% of the country's red meat (Allonby, 1975). The predominant indigenous hair sheep breeds are Masai and Blackhead Persian. However, Dorper has emerged as the most important sire breed for use in crossbreeding for mutton production in the semi-arid areas of Kenya. The indigenous hair breeds have not been adequately evaluated against Dorper under similar conditions to ascertain genetic differences between them. It is only after genetic evaluation of individual, maternal and paternal traits that appropriate breeding plans can be formulated to optimise production in a given environment.

Reproductive traits and disease incidence within and between breeds are important traits that are taken into account in selecting sheep for meat production and culling. De Boer (1981) reported that the reproductive rate of hair sheep in semi-arid areas is low. Allonby (1975) reported prevalence of disease in hair sheep breeds in the same environment. Low reproductive rates and a higher disease incidence would ensure a low selection differential resulting in reduced genetic gains.

The objective of the research reported here was to examine flock records and determine reproductive traits (percentage of lambs born alive; gestation length; birth weight; age and weight at first service), disease incidence and reasons for culling in Dorper (D), Dorper x Masai (DM) and Masai (D) breed groups.

Materials and methods

Animals and traits

Reproductive parameters were determined for 330 D, 260 F_1 DM and 100 M ewes between 1982 and 1984. Parameters included percentage of lambs born alive in a lambing season, gestation length (days), birth weight

of lamb (kg) as a trait of the dam, age of ewe at first service (months) and weight of ewe at first service (kg). Data on the number of animals treated or diagnosed for dystocia, mastitis, foot-rot, pneumonia, haemonchosis and other undefined problems and diseases were collected from 3110 ewes (860 D, 1200 DM and 1050 M) between 1974 and 1984. Similarly, the reasons for culling were determined from 428 ewes (200 D, 150 DM and 78 M) from 1979 through to 1984. The reasons for culling were the same as those for disease incidence, plus low milk yield.

The animals were located at Ol'Magogo farm in Naivasha, Kenya at the UNDP/FAO (United Nations Development Programme/Food and Agriculture Organization of the United Nations) Sheep and Goat Development Project.

Animals management

All the animals were managed in the same flock. They were maintained on natural pastures that consisted primarily of Naivasha star-grass. Once a month the animals were supplied with mineral supplements. Water was supplied freely. The animals were mated in December (after the short rains) to lamb in April–May (after the long rains). Flocks of purebred D and M were maintained. Some of the D breed sires were used for crossbreeding M ewes to obtain F_1 DM animals. All animals were eartagged at birth.

Analysis of data

The data were analysed with a one-way (breed group) analysis of variance. Pairwise comparisons of means for reproductive traits were done using Duncan's multiple range test (Steel and Torrie, 1960). The Friedman test (Steel and Torrie, 1960) was used to find significant differences between breed groups for disease incidence.

Results and discussion

Reproductive parameters

Results of reproductive parameters for D, DM and M breed groups are shown in Table 1. M ewes had the highest percentage of lambs born alive, followed by DM and then D. The increased reproductive performance of the crossbred ewes relative to that of D ewes is probably due to the increased oestrons and gonadal activities coupled with improved uterine and peri- and post-natal conditions for foetal and lamb survival. One important determinant of the number of lambs born is ovulation rate. Ovulation rate, however, shows little or no heterosis (Nitter, 1978). The little heterosis observed in this study in the crossbreds could be due to this reason. Another possible reason for the low heterosis shown in the crossbreds could be that there was little genetic variance in the ovulation rate of their purebred parents. Also, lack of heterosis may have been possible if both parental breeds (D and M) had been well adapted to the prevailing environmental conditions.

Table 1. *Reproductive parameters for Dorper, F_1 Dorper x Masai, Masai breed groups.*

Parameters	Dorper (N=330)	F_1 Dorpers X Masai (N=260)	Masai (N=100)
% Lambs born alive	87.1^a	90.1^b	98.2^c
Gestation length (days)	149.2^a	148.1^a	146.7^b
Birth weight (kg)	3.1^a	3.5^b	2.7^c
Age at first service (months)	12.2^a	11.8^a	12^a
Weight at first service (kg)	30^b	32.2^b	26.2^a

Means with different superscripts within the same row are statistically different, $P<0.05$.

Studies by Dickerson and Laster (1975) and Jakubec (1977) showed that heterosis may contribute to earlier sexual development in sheep. Their observations were confirmed in this study (Table 1), although the differences were not significant ($P>0.05$).

M ewes had the shortest gestation length of the three breed groups (Table 1). Studies by Ricordeau (1981) have shown that larger animals have longer gestation length than smaller ones. In this study, M ewes were significantly ($P<0.05$) lighter than DM and D ewes at first service (Table 1). This may have accounted for the shorter gestation length in the M ewes.

Disease incidence

Table 2 shows the number and frequency of different diseases by breed group. The DM breed group had the highest incidence of dystocia while M had the lowest. The DM breed group also had the highest birth weight while M had the lowest (Table 1). Breed groups with higher incidence of dystocia also tended to have longer gestation lengths (Tables 1 and 2). This concurs with results by Philipsson (1976) who reported that gestation length is positively correlated with dystocia. The results therefore suggest a possible positive phenotypic correlation between dystocia, birth weight and gestation length.

The D breed group had the highest incidence of foot-rot, pneumonia and haemonchosis (Table 2). The M breed group had the lowest incidence of all specified diseases but also recorded the highest incidence of unspecified diseases (Table 2).

Differences in the frequency of diseases between breed groups kept under the same environmental conditions indicate that disease susceptibility has a genetic basis.

Reasons for culling

Table 3 shows the frequency distribution (%) of reasons for culling among ewes of the three breed groups. D

Table 2. *Number (No.) and frequency (%) per breed group of different diseases in ewes.*

Diseases	Dorper		F_1 Dorper x Masai		Masai	
	No.	%	No.	%	No.	%
Dystocia	86	10.0^b	145	12.1^b	21	2.0^a
Udder (mastitis)	172	20.0^b	286	23.8^c	66	6.3^a
Feet (foot-rot)	185	21.5^c	153	12.8^b	56	5.3^a
Respiratory (pneumonia)	133	15.5^c	155	12.9^a	126	12.0^a
Digestive (haemonchosis)	176	20.5^c	180	15.0^b	107	10.2^a
Others	108	12.6^a	281	23.4^b	674	64.2^c
Total	860	100	1200	100	1050	100

Friedman test: Significant differences between breed groups, $P<0.05$.

ewes were culled most frequently for udder problems and low milk yield, while the M breed group had the lowest culling rate in all categories of known reasons for culling.

Table 3. *Frequency distribution (%) within breed groups for reasons for culling ewes.*

Reasons for culling	Dorper	F_1 Dorper x Masai	Masai
Dystocia problems	12^c	10^b	4^a
Udder problems	40^c	30^b	4^a
Feet problems	9^b	8^b	5^a
Respiratory problems	7^b	5^{ab}	4^a
Low milk yield	23^c	20^b	10^a
Unknown problems	9^a	27^b	73^c
Total	100	100	100

Means with different superscripts within the same row are different ($P<0.05$).

Implications and conclusion

The difference in reproductive traits, the known culling reasons and the known disease frequencies in Dorper, Dorper-Masai and Masai breed groups may have a genetic basis, probably due to differences in adaptation to their environment. In disease epidemic areas it may be cost-effective to rear Masai rather than Dorper sheep as Masai seem to be the most appropriate breed for farmers in semi-arid areas, followed by F_1 Dorper-Masai crosses.

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Impact de la prophylaxie sanitaire sur la productivité des petits ruminants dans la zone semi-aride du Mali

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Résumé

L'effet de la prophylaxie sanitaire sur les performances de croissance et de reproduction en milieu paysan a été étudié sur 500 ovins et 700 caprins appartenant à 34 unités de production réparties entre 8 villages du Cercle de Banamba (Mali). Les animaux ont été répartis en trois lots: un lot témoin; un lot d'animaux vaccinés contre la pasteurellose, le charbon bactéridien et la peste des petits ruminants; et un lot d'animaux vaccinés contre les trois maladies précitées et déparasités aux anthelminthiques (Thibenzol, Panacur, Exhelm et Bolumisole ND).

Il ressort des résultats obtenus que l'infestation est beaucoup plus importante chez les adultes que chez les jeunes. En juillet, la moyenne de l'OPG (oeufs par gramme de fèces) des ovins était de 146,25 chez les adultes et de 108,75 chez les jeunes. Chez les caprins elle était respectivement de 24,07 et de 10,32. Après le déparasitage, l'OPG avait baissé dans le lot déparasité (26,05) mais restait élevé dans les lots non déparasités (X = 168,18). La différence entre les moyennes des OPG des lots déparasité et non déparasités était significative. Les meilleurs gains pondéraux étaient réalisés par les animaux déparasités au Panacur et à l'Exhelm.

La moyenne des GMQ des animaux traités au Panacur était la plus élevée tant chez les ovins que chez les caprins, tandis que celle du lot témoin était supérieure en certains cas à la moyenne obtenue pour les autres traitements. Toutefois, l'analyse n'avait pu être effectuée que sur 68 chèvres et 43 ovins, en raison des nombreuses sorties et de la gestation.

Le taux de naissance était de 108% et 116% respectivement chez les ovins des lots non déparasités et déparasité, et de 126% et 140% chez les caprins. Les taux d'avortement chez les ovins étaient de 2,9 et 3,2% dans les lots non déparasités et déparasité, et de 6,25 et 20% chez les caprins.

Impact of disease control on small ruminant productivity in the semi-arid zone of Mali

Abstract

A study was conducted to determine the effect of disease control on on-farm growth and reproductive performance of 500 sheep and 700 goats belonging to 34 production units distributed among eight villages around Banamba in Mali. The animals were divided in three groups: a control group, a group of animals vaccinated against pasteurellosis, anthrax and PPR (peste des petits ruminants), and a group of animals vaccinated against these three diseases and treated with anthelmintics (Thibenzol, Panacur, Exhelm and Bolumisole ND).

Results show that infestation was much higher in adults. In July, average EPG (eggs/g in faeces) was 146.25 and 108.75 in adult and young sheep, respectively, and 24.07 and 10.32, respectively in goats. After anthelmintic treatment, EPG declined in the treated group but remained high in the two untreated groups (X=168.18). Average EPG of treated and untreated groups differed significantly. Animals treated with Panacur and Exhelm showed the highest weight gains. Mean daily weight gain was highest in animals treated with Panacur, both in sheep and goats and in some cases was higher in the control group than the mean obtained from other treatments. However, only 68 goats and 43 sheep were included in the analysis, due to numerous disposals and pregnancy.

Birth rate was 108% and 116%, respectively, for sheep in the untreated and treated groups, and 126% and 140% for goats. Abortion rate in sheep was 2.9% and 3.2% in untreated and treated groups, and 6.25 and 20% in goats.

The performance of the Small East African goats and their Saanen crosses in Malawi

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Abstract

The performance of randomly selected Malawian local goats and their Saanen crosses was compared. The average litter size at kidding was 1.35 and 1.52, respectively. Birth weights, 12-week weights and weaning weights at 17 weeks were respectively 2.2 kg (SE= 0.12 kg), 8.2 kg (SE=0.41 kg) and 10.7 kg (SE = 0.62 kg) for the local goats and 2.31 kg (SE=0.40 kg), 11.4 kg (SE = 1.59 kg) and 19.2 kg (SE = 2.39 kg) for the Saanen crosses (P<0.001). The growth rate up to weaning was 71 g (SE = 4.8 g/day) and 139 g (SE=18.5 g/day) for the local goats and their Saanen crosses respectively (P<0.01). Saanen crosses produced more milk (83 kg, SE 4 kg) during a 12–week period (P<0.001) than the local does (37 kg, SE 5 kg).

The results indicate that crossing Small East African goats with Saanens would improve not only milk production, but also the growth rate of their kids, contributing to improved meat production.

Performances de la petite chèvre d'Afrique de l'Est et des produits de son croisement avec la Saanen au Malawi

Résumé

Les performances de chèvres locales du Malawi choisies au hasard ont été comparées à celles des produits de leur croisement avec la Saanen. La taille moyenne des portées de ces deux types génétiques était respectivement de 1,35 et de 1,52; les poids à la naissance et à 12 semaines et le poids au sevrage à 17 semaines étaient de 2,2 kg (± 0,12 kg), 8,2 kg (± 0,41 kg) et 10,7 kg (± 0,62 kg) respectivement chez les chèvres locales, et de 2,31 kg (± 0,40 kg), 11,4 kg (± 1,59 kg) et 19,2 kg (± 2,39 kg) respectivement chez les croisés Saanen (P<0,001). La croissance jusqu'au sevrage des chèvres locales était de 71 kg (± 4,8 g/jour), celle des croisés Saanen de 139 kg (± 18,5 g/jour) (P<0,01). Sur une période de 12 semaines, la production laitière des croisées Saanen était supérieure (83 kg ± 4 kg) à celle des chèvres locales (37 kg ± 5 kg) (P<0,001).

Ces résultats montrent que le croisement de la petite chèvre d'Afrique de l'Est avec les Saanen permet d'accroître la production laitière et la croissance des métis et partant, la production de viande.

Introduction

The rural people of Malawi depend on the zebu cow for their milk supply. Malawi has one million cattle. Of the eight million people, 89% live in rural areas. The population of people is increasing at a rate of 3.7% per year, but that of cattle is decreasing (NSO, 1988). With a rural population density of 85 people/km^2 (NSO, 1988) and per capita land availability of 0.97ha (Munthali, 1987), the prospects for meeting the rising demand for milk from the zebu alone do not seem promising.

Some 28% of the rural community keep goats (NSSA, 1981/82). Thus there are considerable opportunities for milk production from goats.

The performance of the Small East African (SEA) goat of Malawi has been extensively investigated (Karua, 1989; Kasowanjete et al, 1987). Results on milk yield indicate that the Malawi goat is a poor yielder (Mwenifumbo and Phoya, 1982; Mchiela, 1989; Banda, 1989; Banda, 1992). Crossbreeding may be a more rapid way of improving their milk yield. The choice of the most efficient breed/genotype requires estimates of the relative performance of the genotypes. The objective of this study was to evaluate the milk production and reproduction performance of local goats and their Saanen crosses. Crossbreeding with Saanen dairy goats was started in 1988. This paper reports the results of the study.

Material and methods

The SEA goat indigenous to Malawi (local) and Saanen x local halfbreds were randomly mated to either local or Saanen bucks. The four kid genotypes produced were pure local, 1/4 Saanen, 1/2 Saanen and 3/4 Saanen and were compared for birth weight. The 1/4 and 3/4 Saanen genotypes were not included in the comparisons for daily weight gains due to their small numbers. The dams were compared for milk yields and litter size.

Both the dams and kids were fed indoors on stargrass (*cynodon nlemfriensis*) and Napier grass (*pannisetum purpureum*) for the first month after parturition. Thereafter they were herded on natural pasture with the rest of the flock. Supplementary feeding comprising 30% Leucaena (*leucaena leucocephala*) was given at 1 kg/goat during milking times. The kids were supplemented with the same concentrates at 1/2 kg per kid/day until weaning. The animals were milked once daily in the morning. Kids were left with their dams during grazing hours but separated in the evening and weaned at 12 weeks of age.

Data collected included: birth weight; sex of kid; weekly bodyweight gains; litter sizes; dam postpartum weight; and milk yields. The milk yield was multiplied by two, assuming equal intake by the kids. The data was analysed using Harvey's (1977) Least Square analysis and the Statistical Package for Social Sciences (SPSS) programmes available at Bunda College.

Results

Birth weight

Birth weight was examined in four genotypes. Results show that the birth weight increased (P<0.001) with the level of crossing with Saanen (Table 1).

Table 1. *Least square means for birth weight of kids (kg).*

Source of evaluation	No. of observations	Mean	SE
Pure local	120	2.025^{a}	0.146
1/4 Saanen	7	2.285^{b}	0.191
1/2 bred Saanen	128	2.406^{c}	0.044
3/4 Saanen	15	2.733^{d}	0.130

Means bearing different superscripts differ significantly (P<0.05).

Dam parturition weight

Parturition weight was affected by breed and season of kidding (Table 2). Saanen crosses had a higher (P<0.01) parturition weight than the local dams and dams kidding in the dry season had significantly higher (P<0.05) parturition weights. Year of parturition did not affect the dam parturition weight.

Litter size

Results indicate that the breed of dam, season of birth, or year of birth did not affect litter size. Saanen crosses had slightly higher litter sizes. Dams kidding in the dry season also had higher litter sizes, but the differences were not statistically significant (Table 3).

Milk yields

Results show that the total weekly milk yield was affected by breed and year (Table 4). The Saanen crossed dams produced significantly more milk (P<0.001). There were significant differences in milk yield in 1988, 1989 and 1990 (P<0.01). Season did not influence milk yield. Although lactation stage did not significantly affect total weekly milk yields, indications were that peak yield was reached in the fifth week of lactation.

Table 5 shows the total milk yield in 12 weeks. The overall milk yield was 69.6 ± 5.70 Kg. The total milk yield in 12 weeks was affected by breed; Saanen crosses produced more milk than the locals (P<0.001). Neither the season of kidding nor the year of kidding affected milk yields.

Growth rate to weaning

Table 6 shows the daily weight growth of the kids. Saanen crosses grew faster (P<0.01) than pure local, and growth was higher in the dry season (P<0.05) than in the rainy season for both genotypes. Daily weight gains were higher in 1988 than in the subsequent years.

Weaning weight also followed the same pattern with Saanen crosses having a higher weaning weight than the local. Those weaned in the dry season and in 1988 also had higher weaning weights (P<0.01). Male kids were heavier (P<0.05) than female kids.

Table 2. *Least square means for parturition weight of dam (kg).*

Main factor	Sub-class	No. of observations	Mean	SE
Breed	local	23	27.64^{a}	1.57
	Saanen x local	10	37.7^{b}	3.67
Season	rainy	15	29.6^{a}	1.81
	dry	18	35.7^{b}	3.10
Year	1988	10	32.3	3.21
	1989	10	35.5	2.73
	1990	13	30.27	2.60
Regression	litter size			
	linear		3.35	2.90
	lactation no.			
	linear		3.70	1.26

Means bearing different superscripts differ significantly (P<0.05).

Table 3. *Least square means for litter size.*

Source of variation	Sub-Class	No. of observations	Mean	SE
Breed	local	23	1.35	0.10
	Saanen	10	1.52	0.23
Season	rainy	15	1.38	0.12
	dry	18	1.48	0.19
Year	1988	10	1.42	0.20
	1989	10	1.61	0.15
	1990	13	1.27	0.15
Lactation	1	14	1.21	0.13
	2	8	1.78	0.17
	3	9	1.50	0.14
	4	2	1.24	0.27

Table 4. *Least square estimates of total weekly milk yields (kg/wk).*

Source of variation	Sub-class	No. of observations	Mean	SE
Breed	local	276	3.08[a]	0.14
	Saanen x local	120	8.50[b]	0.33
Season	rainy	180	5.65	0.17
	dry	216	5.94	0.28
Year	1988	120	6.88[a]	0.29
	1989	120	4.74[c]	0.25
	1990	156	5.97[b]	0.24
Lactation week	1	33	4.80	0.35
	2	33	5.47	0.35
	3	33	5.41	0.35
	4	33	5.97	0.35
	5	33	6.35	0.35
	6	33	6.11	0.35
	7	33	5.67	0.35
	8	33	6.06	0.35
	9	33	6.08	0.35
	10	33	5.94	0.35
	11	33	5.69	0.35
	12	33	5.96	0.35
Regression	litter size		0.26	0.26
	lactation no.		0.48	0.11

Means bearing different superscripts differ significantly (P<0.05).

Table 5. *Least square means for total milk yield in 12 weeks (kg).*

Source of variation	Sub-class	No. of observations	Mean	SE
Breed	local	23	37.1[a]	4.79
	Saanen	10	102.0[b]	11.21
Season	rainy	15	67.7	5.52
	dry	18	71.4	9.47
Year	1988	10	80.3	9.79
	1989	10	56.8	8.32
	1990	13	71.5	7.93
Regression	Sibsta linear		3.2	8.85
	lactation no. linear		5.70	3.85

Means bearing different superscripts differ significantly (P<0.05).

Table 6. *Least square means for daily weight gains (g).*

Source of variation	Sub-class	No. of observations	Mean	SE
Breed	local	19	70.78[a]	4.81
	Saanen x local	8	139.22[b]	18.49
	dry	14	115.82[b]	10.78
Year	1988	11	132.45[c]	14.88
	1989	12	85.07[a]	8.70
	1990	4	97.48[b]	16.73
Regression	weaning weight		10.53	10.88
	lactation no.		-5.16	5.54

Means bearing different superscripts differ significantly (P<0.05).

Discussion and conclusion

Kids born to both Saanen crosses and local goats grew at similar rates. Results indicate that Saanen crosses are superior to locals in terms of milk yields and kid birth weight. Survival rate was the same for both Saanen and the locals. The higher daily weight gain of the Saanen crosses indicates that they can be used for meat as well as milk production.

The higher birth weights of kids sired by Saanen bucks reported in this study confirms the findings of Karua and Banda (1992). Litter sizes were similar irrespective of the breed, season and year of birth, showing an equally high reproductive capacity in both genotypes.

Results show that crossbred goats produced 275% more milk than did the locals. Similar results have been obtained in India using the Saanen to improve milk production in native goats (Sahni and Chawla, 1982). These authors obtained increases of between 65 and 130%. They suggest that the improvement in milk production is greater when the native breed has a lower potential milk production than the well established dairy breeds. The current results are encouraging, showing that Saanen sires could be used on Malawi local goats to improve milk production.

The results also indicate that the goats perform better in the dry season than in the rainy season. Similar results were reported by Karua (1989) among village goats. Tethering was given as the major reason for loss of condition. The likely reason for difference in performance could be a higher worm burden with the onset of rains (Eldestein, 1988; Senganimalunje, 1992; Banda, 1992).

The better performance seen in 1988 could be management or environment related. Production is likely to fall when there is drought or too much rain, both of which reduce grazing periods and intakes. Unless the animals' feed supply is supplemented, productivity is likely to be affected.

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The productivity of Small East African sheep and goats in Malawi

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Abstract

The total and additional biological productivity of local (LL) and Boer (BB) goats and their crosses (BL) and of the local (LL) and Dorper (DD) sheep and their crosses (DL) were estimated over two kidding seasons at the Lifidzi Goat Breeding Centre, Salima, Central Malawi.

The average 12-weeks milk production was 79.0 (± 2.0 kg) in goats and 54.5 (± 1.3 kg) in sheep. The difference was significant (P<0.001). The yields of LL (73.7± 2.5 kg) and BB (78.3 ± 3.8 kg) were similar, but lower (P<0.001) than those of BL does (85.1 ± 2.3 kg). LL, DL and DD ewes produced 41.4 ± 1.8, 53.5 ± 1.6 and 68.7 ± 2.1 kg milk respectively and the differences among these genotypes were significant (P<0.001).

The average daily gain (ADG) from birth to 17 weeks of age was 87.0 (± 3.5 g) for kids and 128.9 (± 2.8 g) for lambs. Milk conversion was 15.6 and 11.9 kg milk/kg liveweight gain in kids and lambs, respectively. The average mortality was 18.9 and 5.3% in kids and lambs respectively.

The total apparent biological productivity indices represented by indices I, II and III were, respectively, 16.6, 0.47 and 1.15 kg for goats. For sheep, the corresponding values were 24.9, 0.80 and 1.89 kg. Additional apparent biological productivity represented by indices IV, V and VI were 7.08, 0.204 and 0.495 kg respectively for goats and 6.13, 0.197 and 0.464 kg for sheep. These results suggest that although the two species differ in milk production, the difference in production is not substantial.

Productivité des moutons et des chèvres de l'Afrique de l'Est au Malawi

Résumé

Les productivités biologiques totale et complémentaire de chèvres de races locale (LL) et Boer (BB) et des produits de leur croisement (BL), ainsi que de moutons locaux (LL) et Dorper (DD) et des produits de leur croisement (DL) ont été déterminées sur deux saisons de mise-bas au Centre d'élevage caprin de Lifidzi à Salima (centre du Malawi).

La production de lait sur une période de 12 semaines était en moyenne de 79,0 kg (± 2,0 kg) chez la chèvre et de 54,5 kg (±1,3 kg) chez la brebis. La différence était significative (P<0,001). Les chèvres LL et BB produisaient du lait en quantités à peu près égales (73,7 ± 2,5 kg et 78,3 ± 3,8 kg respectivement) mais inférieures aux quantités produites par les mères BL (85,1 ± 2,3 kg). Les brebis LL, DL et DD produisaient respectivement 41,4 ± 1,8, 53,5 ± 1,6 et 68,7 ± 2,1 kg de lait et les différences entre génotypes étaient significatives (P<0,001).

Le gain moyen quotidien de la naissance à l'âge de 17 semaines était de 87,0 (± 3,5 g) chez les chevreaux et de 128,9 (± 2,8 g) chez les agneaux. Les taux de conversion étaient respectivement de 15,6 et 11,9 kg de lait/kg de poids vif. La mortalité des chevreaux était en moyenne de 18,9%, celle des agneaux de 5,3%.

Les indices I, II et III, qui représentent la productivité biologique apparente totale, étaient respectivement de 16,6, 0,47 et 1,15 kg pour les chèvres et de 24,9, 0,80 et 1,89 kg pour les moutons. Les indices IV, V et VI, qui représentent la productivité biologique apparente complémentaire, étaient respectivement de 7,08, 0,204 et 0,495 kg pour les chèvres et de 6,13, 0,197 et 0, 464 kg pour les moutons. Il découle de ces résultats que les deux espèces diffèrent sur le plan de la production de lait mais que cette différence n'est pas importante.

Introduction

From 20–60% of the variation in weaning weight of kids and lambs in the tropics and sub-tropics is accounted for by the variation in the amount of milk produced by the dams or the amount suckled by lambs and kids (Peart, 1982). Genotypes differ in this ability. Mortality prior to weaning, lambing/kidding interval, weight and milk production of the dams are major factors influencing the productivity of sheep and goats. These individual variables can be combined into indices termed either total apparent biological productivity or additional apparent biological productivity. These indices can then be used to compare the reproductive efficiency in species and/or populations which differ in mature size.

In Malawi, there is little information on the productivity of sheep and goats. The objectives of this study were to evaluate the present and potential milk production capacity of sheep and goats in Malawi and calculate and compare their apparent biological productivity.

Materials and methods

The study was carried out at the Lifidzi Goat Breeding Centre near Salima in Central Malawi at an altitude of 600 metres above sea level.

Data were collected from 11 local (LL), four Boer (BB) and 10 crossbred (BL) does and from 12 local (LL), 15 Dorper (DD) and 17 crossbred (DL) ewes in the dry season. Almost 80% of the experimental animals were used again in the subsequent rainy season. Milk yield was estimated by the suckling, handmilking and oxytocin + handmilking techniques on three different days in each of the 12 weeks after parturition. The oxytocin dose was 10 i.u. (1 ml) per animal. All these factors were arranged in a 2 x 3 x 2 x 3 factorial design.

For the dry season trials, does and ewes were mated to bucks and rams of their own genotype between December 1987 and February 1988. Milking commenced in May 1988. For the rainy season trials, the same animals were mated to a Boer buck and Dorper ram between September and October 1988. Milking started in January 1989. All animals grazed natural pastures. During milking only, animals on the trial received a concentrate mixture composed of 91% maize bran, 8% dried leucaena leaves and 1% common salt (NaCl) at a rate of 300 g per animal/day. The concentrate mixture contained 12.7% crude protein and 19.7 MJ gross energy (GE) or about 13 MJ metabolisable energy (ME)/kg dry matter (DM).

The milk yield of each animal was measured every week for the 12 weeks of lactation. On test days, kids were separated from their dams for two four-hour periods. For the suckling method, the young were weighed before and after suckling. The difference in weight was taken as the milk production during the separation period. For the hand-milking technique, animals were milked out at 1100 and 1500 h. The daily milk yield for both methods was calculated by summing up the two four-hourly yields and multiplying the results by three. The oxytocin technique (oxytocin + hand-milking) was done by milking the animals after injection of 10 i.u. of oxytocin at 1100 h. The amount of milk obtained during this single separation period was multiplied by six to obtain daily milk production.

Liveweights of the kids and lambs were taken at birth and at weekly intervals until weaning at 17 weeks. Records of litter sizes at birth and at weaning, mortalities of kids and lambs, kidding/lambing interval and dam weights were kept and used in the calculation of the biological productivity indices of the dams. The indices in the two species were calculated in two ways as indicated below:

Method 1

Index I = Weight of weaned lamb or kid produced per dam per year (kg)

= litter weight at 120 days (weaning age) X 365/subsequent lambing or kidding interval

Index II = Weight of lamb or kid/liveweight of dam per year (kg)

= Index I/dam post-partum weight (kg)

Index III = Weight of lamb or kid produced/dam metabolic weight per year (kg)

= Index I/dam post-partum weight$^{0.75}$

Method 2

Index IV = Additional lamb or kid weight produced/dam per year (kg)

= Milk yield X milk conversion rate X litter size

Index V = Additional lamb or kid weight produced/kg liveweight of the dam

= Index IV/dam post-partum weight (kg)

Index VI = Additional lamb or kid weight produced/dam's metabolic weight (kg)

= Index IV/dam post-partum weight$^{0.75}$

Dependent variables were milk yields, liveweights and ADG of kids and lambs. Fixed least-squares models described by Harvey (1977) for use on data with unequal subclass numbers were used for analysing the milk yields of dams and the liveweights and ADG of kids and lambs. No statistical analysis was conducted on the productivity indices calculated.

Results and discussion

Milk yield

The total milk production of goats was 45% higher than that of sheep (Table 1). Based on mean liveweight, goats produced 26.0 g milk/day per kg body weight or 63.0 g/day per kg$^{0.75}$. Sheep produced only 19.0 g milk/day per kg body weight or 45.0 g milk/day per kg$^{0.75}$. Economides (1986) compared Damascus goats and Chios sheep kept under the same feeding and management practices and obtained 11–42% more milk from goats than from sheep. Previous reviews and reports have compared goats, sheep and other ruminants for milk production. It has been concluded that goats produce more milk for the following reasons: better feed utilisation efficiency; higher lactation persistency; mammary tissue comprising a greater proportion of the body weight; and a more pronounced milk ejection reflex (Devendra, 1975; Morand-Fehr and Sauvant,

Table 1. *Least squares means (kg), standard errors (se) and t-values for total milk yields of sheep and goats.*

Main effect	Sheep			Goats			t-value
Sub class	No. obs.	Mean	± se	No. obs.	Mean	± se	Sheep vs Goats
Overall	250	54.5	1.30	163	79.0	2.00	-12.24***
Genotype							
Local	84	41.1[a]	1.80	65	73.7[a]	2.50	-10.48***
Crosses	102	53.5[b]	1.60	76	85.1[b]	2.30	-11.28***
Exotic	64	68.7[c]	2.10	22	78.3a	3.80	-2.21**

abc = means within variable groups bearing different superscripts differ significantly (P<0.05).

*** P< 0.001; ** P<0.05. No. obs. = number of observations.

1978; Devendra, 1980; Devendra, 1981; Economides, 1986; Jenness, 1986; Zometa et al, 1987).

In this study, the higher initial milk yield (56.8%) and higher persistency (6.3%) in goats may have led to higher milk production than sheep. Although not measured, the size of the udders of goats in relation to their body weight as explained by Jenness (1986) may also have contributed to this difference. The absence of total feed intake data limits a discussion on the efficiency of milk production with respect to nutrition. This implies that there is a need to conduct more research in order to ascertain whether the differences could also have been partly due to feed utilisation efficiency.

The milk yields of sheep and goats used in this study are much lower than those recorded for these species in temperate, Indian and Mediterranean areas for recognised dairy, meat and general-purpose breeds. The concentration of constituents in their milk is, however, higher than that for the temperate breeds, but comparable to that for other tropical/subtropical breeds as a consequence of lower milk yield (Devendra and Burns, 1983; Gatenby, 1986).

From local to exotic sheep, there was a linear increase in milk yield while from local to exotic goats, there was a quadratic response with Boer x local crossbreds producing the highest yields, indicating 12% heterosis. Indications are that crossbreeding improves milk production in the local small ruminant species.

Weight gains and milk conversion rates

A summary of the liveweights, liveweight gains and milk conversion efficiency of kids and lambs is shown in Table 2. It is quite clear that lambs weighed more and grew faster than kids, irrespective of the stage of growth. This has been demonstrated previously (Economides, 1986; Wilson, 1986). Consequently, kids required 15.6 litres of milk for each additional kg of weight gained while lambs required only 12.0 litres.

Economides (1986) further observed that lambs consumed more solid feed and started doing so at an earlier age than kids. It is not clear whether the differences observed in the present study are due to differences in solid food intake, as no data were collected on this aspect. Generally, the results suggest that it would be more efficient to rear lambs than kids

Table 2. *Live weights and liveweight gains of lambs and kids from birth to six months of age (two months post-weaning) and their pre-weaning milk conversion efficiency.*

	Lambs (L)		Kids (K)		t-value
	Mean	± se	Mean	± se	Lambs vs Kids
No. of observations	236		152		
Birth weight (kg)	3.19	0.05	2.77	0.08	4.45***
12-week weight (kg)	14.07	0.25	10.07	0.32	9.85***
17 week weight (kg)	18.52	0.32	12.99	0.41	10.63***
Gain (g/day)					
Birth–12 weeks	129.4	2.8	87.9	3.2	9.76***
12–17 weeks	128.5	3.5	87.0	3.6	8.27***
Overall	128.9	2.8	87.0	3.5	9.35***
Milk conversion (kg gain/litre milk)					
1–12 weeks	0.084	0.008	0.064	0.011	1.47 ns
Weeks 1–4	0.098	0.008	0.049	0.012	1.66 **
Weeks 5–8	0.076	0.009	0.068	0.014	0.30 ns
Weeks 9–12	0.058	0.012	0.059	0.012	0.06 ns

*** P<0.001; ns = not significant; ** P<0.05.

Table 3. *The apparent total biological productivity of sheep and goats.*

Parameters	Goats	Sheep	Goat vs. Sheep (%)
Offspring weaning weight (kg)	12.99	18.52	-30.0
Litter size at weaning	1.05	0.98	7.1
Total weaning weight (kg)	12.41	18.15	-31.6
Kidding/lambing interval (days)	275.6	266.5	3.4
Dam weight (kg)	34.7	31.1	11.6
Dam weight ($kg^{0.75}$)	14.3	13.2	8.4
Productivity indices (kg)			
Index I	16.4	24.9	-34.2
Index II	0.47	0.80	-51.2
Index III	1.15	1.89	-39.2

for meat production, especially during the first four weeks. However, valid conclusions can only be reached when other factors, e.g. solid feed intake, costs of treatments, mortality and reproduction are considered.

Dam productivity

The measurements of biological productivity as total weight of offspring at weaning per female per year (Index I), per kg dam weight per year (Index II) and per kg dam weight$^{0.75}$ per year (Index II) in both sheep and goats are given in Table 3. Productivity was highest in LL does and lowest in BB does, with that in BL does being closer to that of LL does.

The LL ewes outperformed the DL and DD ewes, with the last showing the lowest performance. The ewes were superior to does overall.

A summary of the additional apparent productivity of the two species based on milk production and milk conversion efficiency by the offspring as well as weight of the dams is presented in Table 4.

The additional productivity per female was higher in goats than in sheep. The difference was largely due to the milk yield level of the does and the larger litter size per annum (Table 4). When the metabolic body weight of the dam was considered, the difference between the two species narrowed. This was due to the lower weight of the sheep.

Thus, although the two species differ in milk production and annual litter size, the difference in overall production is not very great.

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Table 4. *The apparent additional biological productivity of sheep and goats based on milk conversion.*

Parameters	Sheep	±	se	Goats	±	se	Goats vs Sheep (%)
No. of observations	236			152			
Milk yield (kg)	54.5		1.3	79.0		0.2	45.0
Milk conversion rate (lambs & kids)	0.084		0.008	0.064		0.011	-23.8
Dam weight (kg)	31.1		0.2	34.7		0.3	11.6
Dam weight ($kg^{0.75}$)	13.2			14.3			8.3
Litter per annum	1.34					1.40	4.5
Productivity indices (kg)							
per female	6.13					7.08	15.5
per kg dam weight	0.197					0.204	3.6
per kg dam weight $^{0.75}$	0.464					0.495	6.7

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SESSION 3

Small Ruminant Health and Reproductive Wastage

Trypanosomiasis induced reproductive wastage in West African Dwarf sheep

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Abstract

This study reports the results of investigations on the effects of Trypanosoma vivax infection in pregnant and lactating West African Dwarf ewes on digestible organic matter intake (DOMI), live weight changes, milk yield pattern, lamb birth weight and growth rate. During pregnancy and lactation, DOMI was lower (P<0.05) in infected ewes. Rate of weight gain did not differ between infected and control animals before 14 weeks post-breeding (eight weeks post-infection). Infected ewes had low maternal weights and poor body condition at parturition, which were associated with low (P<0.01) lamb birth weights and survival. Abortion rate was 15% in the infected ewes with a lamb mortality rate of up to 85%. Lambs born by infected dams had lower weaning weights compared with lambs from control ewes.

In lactating dams, neither milk yield nor composition was affected by infection during the first half of lactation. However, during late lactation infected ewes produced less (P<0.05) milk and lost more weight compared to uninfected lactating ewes. Growth rates of lambs nursed by control and infected dams did not differ in the pre-weaning period.The findings suggest that Trypanosoma vivax infection was responsible for the observed abortions, ewe mortality, reduced ewe live weight gain and lamb birth and weaning weight in pregnant ewes. It is also concluded that infection of early lactating dams did not affect lamb performance, milk yield and composition although significant differences were encountered in milk yield during late lactation.

Pertes en reproduction dues à la trypanosomiase chez le mouton Djallonké

Résumé

Cet article présente les résultats d'une étude sur les effets de l'infection à Trypanosoma vivax sur l'ingestion de matière organique digestible, l'évolution pondérale, le rendement laitier, et le poids à la naissance et les taux de croissance des agneaux chez des brebis Djallonké gestantes ou allaitantes. Au cours de la gestation et de la lactation, la quantité de matière organique digestible ingérée était inférieure (P<0,05) chez les brebis infectées. Il n'y avait pas de différence entre l'accroissement pondéral des animaux infectés et non infectés pendant quatorze semaines après l'agnelage (huit semaines après l'infection). A la parturition, les brebis infectées affichaient un poids et un état corporel médiocres, associés à de faibles (P<0,01) poids à la naissance et à de faibles taux de survie des agneaux. Le taux d'avortement était de 15% chez les brebis infectées, avec un taux de mortalité des agneaux pouvant atteindre 85%. Le poids au sevrage des agneaux nés de mères infectées était inférieur à celui des agneaux nés des brebis témoins.

Pendant la première phase de la lactation, l'infection n'influait ni sur le rendement laitier ni sur la composition du lait. En fin de lactation toutefois, les brebis infectées produisaient moins (P<0,05) de lait et perdaient plus de poids que les brebis allaitantes non infectées. Au cours de la période présevrage, le taux de croissance des agneaux allaités par les brebis témoins était le même que celui des agneaux allaités par les brebis infectées. Il ressort des résultats que l'infection à Trypanosoma vivax était la cause des avortements observés, de la mortalité des brebis, du faible gain de poids des brebis gravides et du faible poids des agneaux à la naissance et au sevrage. Les auteurs constatent également que les performances des agneaux, la production laitière et la composition du lait n'étaient pas affectées par l'infection des mères au début de la lactation, encore que des différences significatives de production laitière soient apparues en fin de lactation.

Introduction

The role of abortion and perinatal losses in causing heavy losses in animal production has been discussed by Sellers and Leech (1955). Regrettably, studies on trypanosomiasis as a cause of reproductive losses in the West African Dwarf (WAD) sheep have been rare. In a livestock improvement scheme, an interruption of the reproductive process can result in death of offspring, loss of a reproductive season for the dam and a reduction of profit to the producer. Most of the studies with trypanosomiasis in the perinatal period were undertaken

with cattle and very little information is available on the incidence of trypanosome-induced reproductive wastage in West African Dwarf sheep and goats.

The subject of perinatal losses and trypanosome-induced reproductive disorders is well reviewed by Gunn (1983) and Ikede et al (1988). Owen (1976) reported that the main difference in lamb growth in the first half of lactation is due to differences in the dam milk yield. This view was also expressed in the studies of Reynolds and Ekwuruke (1988), Robinson et al (1969), Peart (1967) and Adu et al (1974).

The present study was aimed at investigating the effect of trypanosomiasis on pregnant and lactating WAD ewes. Factors investigated were pre- and post-natal ewe weight changes, lamb birth weight and lamb performance following *T. vivax* infection at two stages of pregnancy. The effect of the infection on milk yield and composition following infection post-partum was also studied.

Materials and methods

The experiment was conducted at the International Livestock Centre for Africa (ILCA) Humid Zone station in Ibadan, Nigeria.

All experimental animals were screened for *T. vivax* antibodies pre-infection (Katende et al, 1987) and for trypanosomes (Murray et al, 1983) at the start of the experiment and were confirmed to have no previous history of trypanosomiasis.

The pathogen used was *T. vivax* prepared from the Kaban strain isolated in 1984 from an ox in Kaban village, Plateau State of Nigeria. Each inoculated ewe was infected artificially by intravenous needle challenge using 4 X 10^6 trypanosomes in heparinised medium. Infection was confirmed by thin/thick blood smears and by the phase contrast buffy coat technique (Murray et al, 1983).

All dams were given therapeutic doses of Berenil (Diminazine aceturate 3.5 mg/kg body weight) at the end of their respective studies, when abortion occurred, or when packed cell volume (PCV) was less than 12% for two consecutive weeks.

Measurements

Blood samples were taken twice weekly to estimate PCV and parasitaemia. The mean value of the determinations was taken to be the animals' average PCV for that week. Rectal temperature (RT) was measured daily in all experimental animals between 0800h and 0900h before feeding. Intake of digestible organic matter was measured during the eighth week of gestation (Experiment I) and during the third and ninth weeks post partum (Experiment 2).

All dams were weighed once a week before feeding through the gestation and lactation period. All lambs were weighed within 24 hours of birth and live weights were monitored weekly thereafter. Lambs were weaned 12 weeks after birth. Lamb performance was measured by the estimated pre-weaning live weight gain. Survival rate of the lambs was calculated as a ratio of weaned lambs to lambs born.

Housing and management

All experimental ewes were individually penned in two separate, well ventilated, and naturally illuminated housing units. The infected ewes were kept in a fly-screened housing unit while the uninfected ewes were housed in an open barn. Routine station health management was performed as described by Reynolds and Ekwuruke (1988).

Experiment 1

This experiment used 38 West African Dwarf ewes aged 24–36 months. The sheep were randomly allotted into infected (n = 20) and control (n = 18) groups. The ewes of the infected group were subdivided into groups 1A (infected, mid pregnancy; n=10) and 1B (infected, late pregnancy; n=10). The uninfected control ewes were divided into groups 1C (control, restricted diet; n= 8) and 1D (control, *ad libitum* diet; n=10). Animals in groups 1A and 1B were inoculated in the seventh and 15th week post-breeding to simulate infection during mid and late pregnancy respectively.

All animals were offered a basal diet of 4 kg *Panicum maximum* except for group 1C which received 2 kg *Panicum maximum* from weeks 7–21 of pregnancy. Browse supplement of 550 g/day of *Gliricidia sepium* and *Leucaena leucocephala* as well as 50 g/day dried cassava peels were also offered to all animals. The feed compositions are presented in Table 1. After parturition, all animals were offered similar rations *ad lib*. Drinking water and mineral licks were offered *ad lib* throughout the experiments.

Table 1. *Mean composition (g/100g) of feed offered on dry matter basis.*

Feed stuff	Dry matter	Crude nitrogen	Ash
Panicum maximum	17.42	1.70	14.91
Dried cassava peels	70.37	0.734	11.59
Gliricidia sepium	31.94	3.69	9.88
Leucaena leucocephala	30.67	3.68	9.21

Experiment 2

This experiment used twenty WAD ewes in their second and third parity (age 24–36 months), born and raised on station. Experimental animals were all oestrus-synchronised using 2 ml analogue of prostaglandin F2-alpha to facilitate synchronised parturition. All animals received identical veterinary treatment before and during gestation.

Experimental animals were randomly allocated into three groups shortly after parturition: infected (n=10); control and fed restricted diet (n=5); and control fed *ad lib* (n=5). These constituted groups 2A, 2B and 2C respectively. Infected animals were inoculated one week post-partum and treated at the end of the trial with Berenil.

Animals in groups 2A and 2C were offered 3 kg/day of *Gliricidia sepium*, 1.5 kg/day of *Leucaena leucocephala* and 50 g/day dried cassava peels on as fed basis. Group 2B ewes received 50% of the ration offered groups 2A and 2C. Composition of feed offered is presented in Table 1. All animals had free access to drinking water and mineral licks.

Data were collected for 12 weeks after parturition. From the seventh day of lactation the milk yield of each ewe was estimated weekly for 11 successive weeks. Milk production over 24 hours was measured in each ewe using the oxytocin method (Coombe et al, 1960; Owen, 1957).

Metabolism study

Three sets of feed intake trials (one in Experiment 1 and two in Experiment 2) were conducted. Each metabolism study lasted for three weeks, the first two being an adaptation period. In the pregnant ewes, a feed intake trial was conducted during the eighth week of pregnancy using five ewes each from groups 1A, 1C and 1D.

During Experiment 2, all animals were used in the metabolism studies conducted at two phases of lactation — early and late.

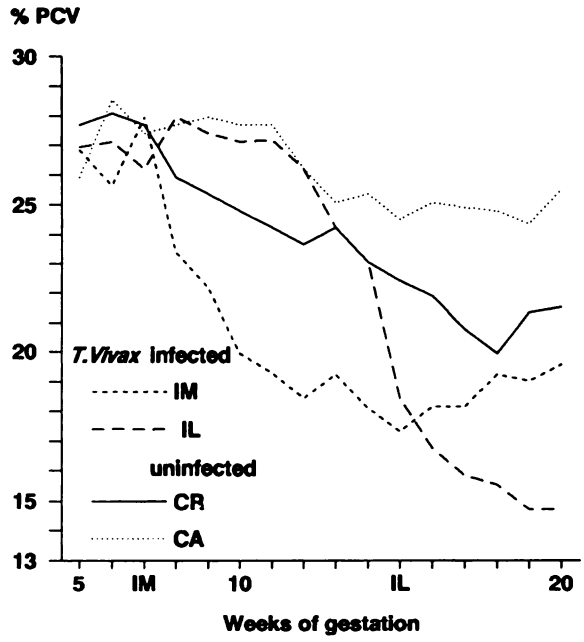
Chemical analysis

Milk samples were analysed for fat by the Gerber method (BSI, 1955). Crude nitrogen, ash and total milk solids were determined by the methods of AOAC (1975) while non-fat solids were determined by difference.

Statistical analysis

Data in treatment groups are summarised as mean ± standard error (SE). Liveweight data collected in Experiment 1 were analysed in four periods, early pregnancy, mid pregnancy, late pregnancy and 10 weeks post natal. Linear regression models of weight on gestation period and of weight on time during the first 10 weeks post partum were fitted for each animal. The estimated regression coefficients representing the rate of live weight change for each ewe were further analysed using analysis of co-variance for comparing the different treatment groups during pregnancy and post-natal phases. Corrections were made for weight at breeding and for the number of lambs born and nursed as co-variates. Milk yield and lamb performance data were analysed on an individual animal basis from the seventh day of lactation. Milk yield and dam and lamb weight gains were analysed in three lactation periods, early (1–6 weeks), late (7–12 weeks) and entire (1–12 weeks).

Figure 1. *Group average packed cell volume in* T. Vivax *infected and uninfected pregnant West African dwarf ewes.*



Results

Experiment 1

Effect of *T. vivax* on pregnant WAD sheep.

Packed cell volume declined rapidly following infection (Figure 1) with PCV in infected ewes dropping by 40% from pre-infection values. All infected dams remained febrile throughout the experiment. Mean (± SD) rectal temperature was 40.4±0.95°C compared with 38.6 ± 0.39°C in the controls.

Six of the experimental animals did not carry their pregnancy to term and were excluded from the live-weight studies. Three ewes (two from group 1A and one from group 1B) aborted while one each from groups 1A and 1B died from the infection. One ewe (group 1A) was removed from the experiment due to anaemia. All control ewes carried their pregnancy to term.

Feed intake and digestibility during pregnancy

Mean values of intake and digestibility data are presented in Table 2. While dry matter intake (DMI), digestible organic matter intake (DOMI) and nitrogen intake (NI) were lower ($P<0.05$) in infected ewes (Group 1A) compared to control ewes fed *ad lib* (Group 1D), there were no significant differences measured between groups 1A and 1C in all parameters. The digestibility coefficients did not differ between groups.

Table 2. *Mean intake and digestibility performance of WADS during mid-pregnancy under different dietary treatments.*

Variables	Groups 1A	1C	1D	SE
n	5	5	5	–
DMI	50.7[a]	51.2[a]	62.4[b]	1.75
OMI	44.4[a]	44.5[a]	54.5[b]	1.50
DOMI	26.83[a]	25.8[a]	32.7[b]	1.02
NI	0.75[a]	0.83[b]	0.85[b]	0.04
DMD	62.5[a]	60.8[a]	62.6[a]	1.02
OMD	60.3[a]	58.1[a]	60.1[a]	1.06

Means within rows with different superscripts are different from each other (P<0.05).

DMI = Dry matter intake. DOMI = Digestive organic matter intake.

OMD = Organic matter digestibility. OMI = Organic matter intake.

NI= Nitrogen intake. DMD = Dry matter digestibility.

Liveweight changes

Table 3 shows the rates of liveweight changes. In the early pregnancy phase, all groups' estimated rates of liveweight gains did not differ. Group 1A ewes lost weight post-inoculation during mid-pregnancy. The differences between the treatment groups, however, were not statistically significant. During the late pregnancy period, infected and restrictedly-fed ewes lost weight (P<0.05) compared to the controls fed *ad lib.* In the post-natal phase, all ewes lost weight until lambs were weaned.

Table 3. *Rate of liveweight changes (g/day) of* T. vivax *infected and control pregnant WAD ewes.*

Group	Early pregnancy	Mid pregnancy	Late pregnancy	10 weeks post natal
1A	37.1[a]	15.7[a]	-27.1[a]	-38.6[b]
1B	37.1[a]	32.9[a]	-21.4[a]	-25.7[a]
1C	37.1[a]	37.1[a]	1.4[b]	-52.9[c]
1D	37.1[a]	32.9[a]	30.0[c]	-75.7[d]
P			*	**

Means within rows with different superscripts are different from each other.

* = P<0.05; ** = P<0.01

Lamb performance

The mean birth weights are presented in Table 4. Uninfected dams had heavier (P<0.05) lambs compared with their infected counterparts. Only 15% of the lambs in group 1B survived longer than 48 hours post-partum, therefore the group was not included in the statistical analysis of lamb performance. Analysis of variance showed that dam treatment and sex of lambs had no effect on lamb growth rate. Estimated pre-weaning growth rates are presented in Table 4. Lambs nursed by uninfected dams were heavier (P<0.05) at weaning compared to lambs nursed by infected dams.

Table 4. *Growth performance (kg) of lambs produced by T. vivax infected and control ewes.*

Groups	Birth weight (kg)	Lamb growth rate (g/day) Early lactation	Late lactation	Weaning (kg)
1A	1.4[b]	88.0[a]	26.0[a]	5.0[a]
1B	1.0[a]	ND	ND	ND
1C	1.9[c]	76.0[a]	39.0[a]	7.1[b]
1D	2.0[c]	77.0[a]	33.0[a]	7.1[b]

Means within rows with different superscripts are different from each other (P<0.05).

ND = not determined.

Experiment 2

Feed intake

Feed intake data for early and late lactation periods are presented in Table 5. All measured parameters differed (P<0.05) across the groups, except nutrient digestibility, which was not affected by the infection.

Milk yield and composition

Figure 2 shows the lactation pattern based on the mean milk yield of the ewes. Rate of milk production in the first half of lactation was not affected by infection. Mean daily milk yields on a group basis are presented in Table 6. Differences in mean daily milk production became significant only during late lactation. Mean daily yields during both phases of lactation were contrasted and the differences subjected to analysis of variance. The drop in daily milk production was highest in group 2A while 2B and 2C did not differ from each other.

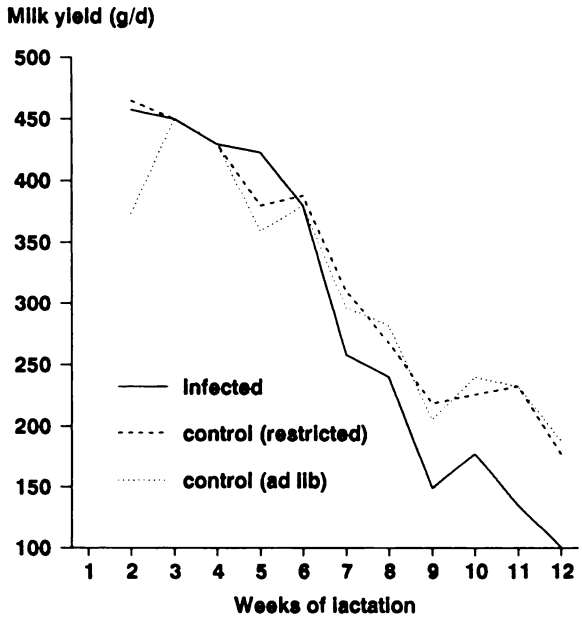
The difference in milk constituents became significant during the late lactation period with infected ewes producing less (P<0.05) milk compared with control ewes.

Mean component concentrations of the milk are presented in Table 7. Milk total solids increased with lactation period. All other components except milk ash followed this trend. The differences in these components between treatment groups were not statistically significant.

Ewe liveweight changes and lamb performance

Rates of live weight changes over time are presented in Table 8. Infected ewes showed a rapid decline in weight gain immediately post-infection. This pattern was maintained until the end of lactation. Control ewes fed restricted diets lost weight during early lactation. This trend was reversed during late lactation when the ewes increased their rate of gain. Control ewes fed *ad lib* consistently gained weight throughout the study.

Figure 2. *Average daily milk yield of T. vivax infected and control WAD ewes.*



Discussion

Infection was confirmed by the presence of parasites in the buffy coat area (Murray et al, 1983) eight days after infection in both trials. Inoculated animals were febrile and anaemic. These two symptoms have been widely reported as hallmarks in the diagnosis of trypanosomiasis. All animals gained weight during early pregnancy. The weight changes observed in the control ewes fed *ad lib* were similar to those reported by Orji and Steinbach (1980) in pregnant WAD ewes. During the post-infection phase of this study, infected ewes (groups 1A and 1B) were anorexic, anaemic and lost weight. Weight loss in pregnant ewes was reported by Reynolds and Ekwuruke (1988) due to trypanosomiasis. This is associated with reduction in dry matter intake (Akinbamijo et al, 1990), reduced nitrogen and energy balance (Zwart et al, 1991; Verstegen et al, 1991), increased basal metabolic rate (Zwart et al, 1991 and Stephen, 1986), increased catabolism of tissue reserves (Akinbamijo et al, 1992) and possibly uptake of host nutrients by the parasites. Infected ewes were losing weight and in a poor body condition towards end of pregnancy. Compared with the findings of Adu et al (1974) and Osuagwuh and Aire (1990), control ewes did not differ in the liveweight pattern expected of pregnant WAD ewes. Weight changes in control ewes were positive and consistent through pregnancy. The reduction in feed intake from mid-pregnancy onwards was possibly masked by the effect of the previous level of nutrition. The limited feed allowance may also have been high enough to meet maintenance requirement and support weight gains.

Lamb birth weight and growth rate have been described as functions of pregnancy nutrition and maternal weight at parturition (Peart, 1967; Treacher, 1970; Adu and Olaloku, 1979; Gibb and Treacher, 1980 and 1982). They are also strongly correlated with dams' mothering ability. The findings of this study support these views. All infected ewes ended pregnancy with low maternal weights and a depressed feed intake, hence lambs were born with lower birth weights. Control ewes on the other hand had higher maternal weights at parturition and hence heavier lambs.

Of the lambs born to ewes infected at late pregnancy, 85% died within 48 hours of birth. They were all born weak as their dams were probably denied adequate nutrition during pregnancy due to the infection. Both dam and foetal nutrition have been described as critical during late pregnancy (Osuagwuh and Aire, 1990). Although the ewes were treated after lambing, weaning weights of lambs differed between groups mainly because of differences in birth weights.

In a complementary study (Experiment 2) with ewes infected immediately post-partum with *T. vivax* (same strain as in experiment 1), all ewes had adequate nutrition during pregnancy. There were sufficient body reserves to meet the daily milk yield demand during early lactation. Lactation is generally associated with an

Table 5. *Mean intake and digestibility performance of WADS during early and late lactation under different dietary treatments.*

Variables	Early lactation (Mean ± SE)				Late lactation (Mean ± SE)			
	2A	2B	2C	P	2A	2B	2C	P
n	10	5	5	-	10	5	5	-
DMI	81.6±2.98^{b}	61.5±4.21^{a}	96.0±4.21^{c}	0.001	76.4±2.98^{b}	63.8±4.21^{a}	89.6±4.21^{c}	0.0001
OMI	74.4±2.74^{b}	55.7±3.87^{a}	7.9±3.87^{c}	0.001	69.1±2.74^{b}	57.5±3.87^{a}	81.2±3.87^{c}	0.0001
DOMI	47.2±2.23^{b}	33.9±3.16^{a}	54.0±3.16^{c}	0.001	41.8±2.23^{b}	35.7±3.16^{a}	49.5±3.16^{c}	0.0002
NI	2.53±0.11^{b}	1.8±0.6^{a}	3.01±0.16^{c}	0.001	2.36±0.11^{b}	1.91±0.16^{a}	2.83±0.16^{b}	0.0001
DMD	56.9±1.55	54.1±2.19	54.8±2.19	0.500	52.6±1.55	54.2±2.19	53.2±2.19	0.5004
OMD	63.0±1.22	60.8±1.73	60.8±1.73	0.73	60.3±1.22	62.0±1.73	60.8±1.73	0.7288

DMI = Dry matter intake. DOMI = Digestive organic matter intake.

OMD = Organic matter digestibility. OMI = Organic matter intake.

NI = Nitrogen intake. DMD = Dry matter digestibility.

Table 6. *Mean daily milk production of T. vivax infected and control WAD ewes.*

Variables	Groups (Mean ± SE)			
	2A	2B	2C	P
Early lactation	426.4± 18.52[a]	417.6 ± 26.2[a]	399.4± 26.2[a]	
Late lactation	181.7 ± 12.0[a]	238.0± 17.0[b]	240.1 ± 17.0[b]	**
Entire lactation	295.3 ± 12.8[a]	318.2 ± 18.1[a]	312.0 ± 18.1[a]	
Mean difference	244.8 ± 17.4[a]	179.6± 24.6[b]	159.3 ± 24.6[b]	*

Means within rows with different superscripts are different from each other.
* = P<0.05; ** = P<0.01.

Table 7. *Milk composition (g/100g milk) of control and infected dams during early and late lactation.*

	Early Lactation			Late Lactation		
	Group 2A	Group 2B	Group 2C	Group 2A	Group 2B	Group 2C
Total milk solids	15.49	15.62	15.42	17.92	17.78	18.72
	(0.74)	(1.06)	(1.04)	(0.46)	(0.32)	(0.46)
Milk fat	5.77	5.49	5.62	7.13	6.43	7.05
	(0.21)	(0.30)	(0.30)	(0.20)	(0.29)	(0.29)
Milk solids non fat	9.72	10.13	9.8	10.79	11.35	11.67
	(0.50)	(0.72)	(0.70)	(0.30)	(0.42)	(0.42)
Milk protein	5.04	4.91	5.04	6.12	5.61	6.00
	(0.04)	(0.05)	(0.05)	(0.02)	(0.03)	(0.03)
Milk ash	0.97	0.95	0.98	0.92	0.90	0.91
	(0.05)	(0.07)	0.07)	(0.02)	(0.07)	(0.02)

Figures in brackets are SE.

Table 8. *Live weight changes (SE) of T. vivax infected and control lactating WAD ewes and their lambs.*

Variables	Ewe group				Lamb group			
	2A	2B	2C	P	2A	2B	2C	P
Initial weight (kg)	23.4	21.6	20.2	**	2.13	1.94	1.96	NS
	(0.64)[a]	(0.91)[ab]	(0.91)[b]		(0.10)	(0.14)	(0.14)	
Early lactation (g/day)	-37.2	-7.3	30.86	**	75.1	71.4	77.3	NS
	(10.8)[a]	15.27[ab]	15.27[b]		5.1	7.1	7.1	
Late lactation (g/day)	-52.0	6.24	12.28	***	34.9	37.6	35.1	NS
	(6.28)[a]	8.89[b]	8.89[b]		4.5	6.4	6.4	
Entire lactation (g/day)	-45.0	-5.4	12.08	***	59.25	53.00	55.53	NS
	(5.66)[a]	8.00b	8.00[b]		3.2	4.5	4.5	
Final weight (kg)	19.35	21.1	21.3	*	7.15	6.9	6.9	NS
	(0.38)[a]	0.54[b]	0.54[b]		0.32	0.45	0.45	

Means within rows with different superscripts are different from each other.

* = P<0.05 ** = P<0.01; *** = P<0.001; NS = not significant

Figures in brackets are SE

increase in feed intake. It is not surprising, therefore, that infected lactating dams were consuming more than 1.5 times their maintenance requirement per unit metabolic size per day. Although the infected dams had a reduced nutrition intake, lactation normally continues for some time even in the event of anorexia. The animal is then forced to catabolise body tissues which is associated with increased heat production. In bioenergetic terms, Langland et al (1963) equate 1g DOMI to 3.64 kcal metabolisable energy (ME). Kearl (1982) suggested 105 kcal ME per unit metabolic size as the maintenance requirement for healthy lactating ewes and about 130 kcal ME for febrile lactating dams. The nutrient drain caused by an increased maintenance requirement further decreases the net energy available for production. In this study, 2A, 2B and 2C ewes had an excess of 67, 18.4 and 128 kcal ME. In relation to the liveweight pattern, it could be adduced that ewes in groups 2A and 2B catabolised body reserves to supplement dietary nutrients required for milk production (Gibbs and Treacher, 1982). During the late lactation phase, the milk yield differed significantly, with group 2A producing less milk than 2B and 2C.

Lamb birth weights were similar to those reported by Orji and Steinbach (1980). There was no difference between groups as all ewes were identically treated during the pre-natal period. According to Owen (1976), lamb growth rate is strongly correlated with the dam's milk yield during early lactation. This relationship, however, weakens with time as lambs begin to depend less on milk as the sole nutrient supply. As milk yield did not differ in early lactation, growth rate was also not different between groups. The difference in milk yield during late lactation therefore had less effect on growth rates, because lambs supplemented their milk intake from their dam's diet. A biological implication on reproductive rate, however, is that loss of weight and the resulting poor body condition might lead to a delayed return to oestrus. In its extreme it could cause a cessation of oestrus and hence increased parturition intervals. As ewes infected during late pregnancy showed the highest level of lamb wastage, a prophylactic treatment is suggested during late pregnancy to prevent the incidence of perinatal losses.

Conclusion

1. Trypanosomiasis induces loss of body condition in pregnant and lactating dams.
2. Animals infected during gestation had lambs with low birth weights and poor performance.
3. Milk composition was not affected by the disease but yield was reduced during late lactation.
4. The performance of lambs nursed by infected dams was not affected by trypanosomiasis.
5. Trypanosomiasis caused foetal and neonatal losses in WAD sheep.

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Normes et variations de l'hématocrite et de la formule leucocytaire et particularités histologiques leucocytaires chez la brebis Djallonké du sud du Sénégal

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Résumé

Cet article est consacré à l'étude de l'hématocrite et de la formule leucocytaire chez des brebis Djallonké adultes de la zone de Kolda, au sud du Sénégal. Les données obtenues sur un total de 355 prélèvements effectués sur des animaux âgés de plus de 12 mois permettent une bonne interprétation sémiologique des résultats de prospections cliniques faisant appel à la valeur de l'hématocrite et à la formule leucocytaire.

Les brebis, dont l'examen clinique n'avait révélé ni symptôme ni lésion et dont l'examen du frottis de sang réalisé simultanément n'avait pas non plus permis de détecter des hémoparasites, avaient un hématocrite moyen de 30,68% avec respectivement 30,02 et 31,34% comme valeurs minimum et maximum. Leur formule leucocytaire moyenne se présentait comme suit: neutrophiles 33%, éosinophiles 9%, lymphocytes 55% et monocytes 2 à 3%.

Les variations de ces constantes hématologiques ont été appréciées en fonction de l'infestation ou non par des hémoparasites, de l'état corporel, de la saison et du mode de conduite. Par ailleurs, les particularités histologiques des leucocytes des Djallonké ont été précisées.

PCV and differential leukocyte count standards and variations and histologic leukocyte characteristics in West African Dwarf sheep in southern Senegal

Abstract

This article presents a study of PCV and differential leukocyte count in adult West African Dwarf sheep in the Kolda area, in southern Senegal. Data from 355 samples taken on animals over 12 months old make it possible to diagnose properly symptoms based on the results of clinical investigations using PCV values and differential leukocyte count.

Ewes with no apparent clinical symptoms or injuries and no blood parasites detected in blood smears had an average PCV of 30.69%, with minimum and maximum values of 30.02 and 31.34, respectively. The average differential leukocyte count was as follows: neutrophils 33%, esinophils 9%, lymphocytes 55% and monocytes 2–3%.

Variation in these values was estimated according to infestation or non-infestation by blood parasites, body condition, season and management. Histologic characteristics of leucocytes of West African Dwarf sheep are specified.

1. Introduction

Dans les zones du Sénégal exposées à la trypanosomiase, la brebis Djallonké, réputée trypanotolérante, constitue la base démographique et génétique des troupeaux ovins des élevages extensifs traditionnels. Aussi est-il urgent de développer la recherche en matière de sémiologie médicale sur ce groupe qui, de par son importance démographique et zootechnique, sera vraisemblablement la cible principale de toutes les actions futures d'amélioration sanitaire. La définition des normes de l'hématocrite et de la formule leucocytaire de la brebis Djallonké du Sénégal présentée dans cette étude va dans ce sens.

2. Matériel et méthodes

2.1 Les effectifs

Au Sénégal, les femelles Djallonké constituent l'essentiel des troupeaux d'élevage extensif traditionnel, dont elles assurent la base génétique et démographique. Elles ne sont exploitées que de façon exceptionnelle, contrairement aux mâles dont l'exploitation est systématique dès le sevrage et principalement au moment de la fête du mouton. Le renouvellement génétique des troupeaux se fait par l'achat de femelles, puisqu'il n'existe aucun programme de reproduction centré sur des géniteurs sélectionnés. De par leur fonction de génitrice, les femelles assurent la pérennité

et la dynamique de production des troupeaux. Aussi cette étude se limite-t-elle aux brebis adultes, c'est-à-dire âgées de 12 mois et plus.

Des prélèvements de sang ont été effectués sur 159 femelles durant la saison des pluies, et sur 193 femelles durant la saison sèche 1990/91. Bien qu'entretenues selon un mode extensif traditionnel, ces brebis avaient la particularité d'appartenir à un réseau de troupeaux surveillés dans le cadre d'un programme de recherche. A ce titre, elles bénéficiaient d'un léger encadrement zootechnique et sanitaire destiné à fidéliser les propriétaires, et avaient été vaccinées contre la pasteurellose et la peste des petits ruminants en août 1990.

En même temps que les prélèvements, on a procédé à l'examen clinique des animaux et à l'attribution d'une note de pointage reflétant l'état d'entretien des brebis. Le mode de conduite des animaux au pâturage (pâture libre ou avec gardiennage, ou mise au piquet) a également été enregistré.

2.2 Réalisation et lecture du microhématocrite et du frottis

Suivant les individus, la prise de sang a été réalisée tantôt par ponction de sang veineux à la jugulaire, tantôt par ponction des capillaires de l'oreille. Des tubes et microtubes héparinés ont été utilisés ainsi que des lames dégraissées à l'alcool.

Selon Murray et coll. (1983), les résultats de l'hématocrite et de la formule leucocytaire sont en effet aussi fiables à partir de sang périphérique qu'à partir de sang veineux. La recherche de parasites sanguins à partir du sang périphérique est cependant plus sensible de 20% que celle effectuée à partir de sang veineux.

Pour établir la formule leucocytaire et l'hématoscopie parasitaire, les frottis ont été colorés par la méthode RAL 555. Cette méthode de coloration panoptique fait intervenir trois solutions, à savoir le fixateur, l'éosine et le bleu de méthylène. Le frottis est trempé pendant cinq secondes dans chaque solution et la lame mise à égoutter verticalement pendant cinq secondes entre chaque solution. Après trempage dans la troisième solution, elle est lavée à l'eau déminéralisée. La lecture se fait au microscope optique à faible grossissement (x 100).

2.3 Détermination de la note d'état

La note d'état des femelles Djallonké a été déterminée d'après l'échelle de Russel et coll. citée par Richard (1990).

Note 1: apophyses épineuses et transverses saillantes; arc vertébral et apophyses mamillaires aisément palpées du fait de masses musculaires peu abondantes;

Note 2: arc vertébral moins net et apophyses transverses moins pointues, voire même légèrement arrondies; apophyses épineuses et mamillaires toujours aussi faciles à différencier;

Note 3: apophyses épineuses ne peuvent plus être pincées entre le pouce et l'index mais leur pointe encore individualisable à la palpation; transverses couvertes par les masses musculaires mais espaces entre deux apophyses transverses encore différenciés sous la pression des doigts; arc vertébral et apophyses mamillaires non palpables.

2.4 Analyse des données

Les paramètres statistiques de référence utilisés sont la moyenne arithmétique des valeurs d'hématocrite, les fréquences moyennes relatives des types cellulaires et les fréquences absolues d'animaux porteurs d'un type d'hémoparasites ou d'une association d'hémoparasites. Les comparaisons de moyennes de groupe ont été effectuées par la méthode dite de la variable réduite Z de distribution normale pour les échantillons de grande taille, et par la variable *t* de distribution de Student pour les groupes de moins de 30 individus.

3. Résultats et discussion

3.1 L'hématocrite

Le tableau 1 présente les valeurs moyennes et les écarts types de l'hématocrite pour les différents facteurs de variation considérés indépendamment.

3.1.1 Hématocrite et saison

L'hématocrite varie de 14 à 36% en saison des pluies et de 19 à 47% en saison sèche. La valeur de la variable réduite Z (11,7) révèle que la supériorité de l'hématocrite de saison sèche est statistiquement significative ($P<0,05$).

La baisse de l'hématocrite lors de la saison des pluies peut s'expliquer par l'action concomitante de divers facteurs:

- le parasitisme gastro-intestinal tel que constaté par divers examens coproscopiques;
- le parasitisme externe attesté par la présence dans le sang de parasites transmis par des insectes hématophages (glossines, tiques).

En saison sèche par contre, les animaux ont un environnement alimentaire et sanitaire tout autre:

- la divagation leur permet d'accéder à diverses ressources alimentaires (champs post-culturaux et pâturages naturels, ordures ménagères);
- la complémentation est souvent pratiquée en fin de saison sèche par les éleveurs qui disposent de réserves fourragères (fanes d'arachide, tiges de mil) (Merlin et coll., 1990);
- le parasitisme digestif va en s'amenuisant et perd de sa gravité clinique; la sécheresse du milieu ambiant limite les réinfestations (Vassiliades, 1978);

- le parasitisme externe évolue de même, du fait de la grande mobilité des animaux qui ne sont plus attachés ni soumis à la promiscuité des abris de saison des pluies.

3.1.2 Hématocrite et note d'état

D'après les résultats des tests de différence de moyennes, il apparaît que:

- au cours d'une même saison, les hématocrites d'animaux affectés de notes d'état différentes (tableau 1) sont toujours significativement différents au niveau de 0,05.

- la supériorité de l'hématocrite de saison sèche sur celui de saison des pluies se confirme pour les animaux présentant des notes d'état identiques, sauf en ce qui concerne la note 3 pour laquelle les hématocrites ne sont plus statistiquement différents au niveau de 0,05 (tableau 2).

3.1.3 Hématocrite et présence d'hémoparasites

La présence d'hémoparasites dans les frottis a été observée en saison des pluies uniquement. 31 brebis se sont révélées porteuses d'hémoparasites, avec une prévalence estimée comme suit:

Anaplasma centrale	12,55%
Theileria sp.	1,88%
Trypanosoma brucei et *vivax*	1,88%
Anaplasma centrale et *Theileria* sp.	3,14%

L'hématocrite varie de manière significative ($P<0,05$) avec la présence (animal porteur) ou non (animal non porteur) d'hémoparasites dans le frottis (tableau 1). Signalons que Toure (1982) a constaté une baisse significative de l'hématocrite chez des moutons Djallonké expérimentalement infestés par *Trypanosoma congolense*.

Tableau 1. *Valeurs moyennes de l'hématocrite des brebis Djallonké selon la saison, la note d'état corporel et le statut hémoparasitaire*

		n	Moyenne	Ecart
Saison	Saison des pluies	159	24,71	4,86
	Saison sèche	193	30,68	4,61
Interaction saison x note				
Saison sèche	Note 1	79	21,59	3,32
	Note 2	54	27,35	3,57
	Note 3	9	33,00	2,00
Saison des pluies	Note 1	40	26,82	3,73
	Note 2	91	30,42	3,66
	Note 3	57	33,91	3,88
Présence d'hémoparasites				
	Animaux porteurs	31	22,51	5,15
	Animaux non porteurs	125	25,08	4,55
Mode de conduite				
	Piquet	40	23,45	4,84
	Gardiennage	31	28,06	4,54

Tableau 2. *Valeurs de Z ou de t pour une comparaison inter-saison des moyennes d'hématocrite par notes d'état*

	Saison des pluies		
Saison sèche	Note 1	Note 2	Note 3
Note 1	7,47 S	0,69 NS	4,7 S
Note 2	16,66 S	4,95 S	2,06 S
Note 3	19,55 S	13,66 S	0,68 NS

S = significatif; NS = non significatif (au niveau de 0,05).

L'aggravation de la baisse de l'hématocrite, déjà nette et statistiquement significative en saison des pluies, que provoque la simple présence d'hémoparasites laisse perplexe quant à la prétendue rusticité du Djallonké.

3.1.4. Hématocrite et conduite du troupeau

Le tableau 1 donne la valeur moyenne de l'hématocrite mesuré sur deux troupeaux, dont l'un était maintenu au piquet durant toute la saison des pluies et l'autre géré en pâture libre. Le second mode de conduite est associé à une plus forte valeur de l'hématocrite ($P<0,05$).

3.2 Formule leucocytaire

3.2.1 Formule leucocytaire et saison

Le tableau 3 donne les taux moyens des différents types de leucocytes pour la saison sèche et la saison humide. La formule leucocytaire ne diffère pas significativement d'une saison à l'autre.

3.2.2 Formule leucocytaire et statut hémoparasitaire

Contrairement à l'hématocrite, la formule leucocytaire n'est pas modifiée par la présence d'hémoparasites (tableau 4).

Il ressort de ces données que l'infestation hémoparasitaire réduit d'abord l'hématocrite; lorsque la parasitémie s'aggrave, on assiste à l'apparition des signes cliniques de l'infestation.

3.3 Caractéristiques morphologiques et histologiques des leucocytes

Les neutrophiles matures présentent un noyau lobé, mais la morphologie des lobes varie d'une cellule à l'autre. Dans la majorité des cas, il s'agit de plaques concentriques réunies entre elles par un filament de chromatine. Il arrive cependant que le noyau ne soit pas segmenté, auquel cas il se présente en une bande de chromatine dense.

Les lymphocytes (grands et petits) se différencient facilement, contrairement à ce que rapporte la littérature. Le rapport nucléocytoplasmique varie d'une cellule à l'autre. Le noyau présente une morphologie variable (ovale, en cloche ou en raquette de tennis). Le cytoplasme est basophile, avec parfois des granules éosinophiliques de taille et de nombre variables.

Les éosinophiles sont conformes à la description classique qui en est faite. Cependant, des éosinophiles dont les granules sont plus basophiles qu'éosinophiles ont été observées dans certains cas. Ce phénomène pourrait être lié au colorant utilisé.

Les monocytes se présentent comme des cellules de grande taille et de morphologie variable. Ce sont en général des cellules rondes avec un cytoplasme légèrement basophile. Le noyau n'a pas de structure bien définie; il peut être en cloche, en fer à cheval ou bilobé. Le rapport nucléocytoplasmique est élevé. La distinction entre monocytes et lymphocytes est souvent difficile à établir.

Un type cellulaire à morphologie tenant à la fois du monocyte et du lymphocyte a souvent été observé. Il existe en outre un type cellulaire binucléé à cytoplasme plus neutrophile que basophile.

Les examens n'ont pas révélé de polynucléaires basophiles.

4. Conclusion

L'hématocrite des brebis Djallonké subit des variations significatives en fonction de la saison, de l'état du sujet face aux hémoparasitoses et du mode de conduite, étant entendu par ailleurs que le mode de conduite et la saison ont un effet déterminant sur le régime alimentaire des animaux et sur leur susceptibilité aux infestations par les helminthes et les hémoparasites.

Des valeurs références de l'hématocrite en fonction de la saison et du mode de conduite peuvent être dégagées de cette étude. La note d'état permet une bonne prédiction de l'hématocrite. La formule leucocytaire ne subit pas de variations saisonnières et n'est pas modifiée par la simple présence d'hémoparasites.

Sur le plan histologique, la signification sémiologique de la plus grande fréquence de granulations éosinophiliques en saison des pluies et de la rareté des polynucléaires basophiles reste à élucider.

Tableau 3. *Formule leucocytaire par saison*

	Saison des pluies (n = 159)				Saison sèche (n = 193)			
	Neutro	Eosino	Lympho	Mono	Neutro	Eosino	Lympho	Mono
Moyenne	32,84	9,16	55,61	2,37	33,26	5,95	57,31	3,52
Ecart type	6,77	6,22	8,45	1,31	5,80	3,79	6,26	2,02

Tableau 4. *Formules leucocytaires et statut hémoparasitaire*

	Animaux porteurs (n = 31)		Animaux non porteurs (n = 125)	
	Taux (%)	Ecart type	Taux (%)	Ecart type
Neutrophiles	32,61	6,40	32,8	6,85
Eosinophiles	7,19	3,64	9,73	6,63
Lymphocytes	57,61	7,29	55,13	8,73
Monocytes	2,5	1,23	2,33	1,34

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Haemagglutination-inhibition technique for definitive diagnosis of peste des petits ruminants virus specific antibody

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Abstract

A simple and rapid serological method for definitive identification for Kata virus or peste des petits ruminants (PPR) virus specific antibody is described. The technique is based on adsorbing out the cross-reacting antibodies to rinderpest antigen from a PPR serum and leaving the specific antibody to PPR which is determined by haemagglutination-inhibition test.

Utilisation de la réaction d'inhibition de l'hémagglutination pour la détection de l'anticorps contre le virus de la peste des petits ruminants

Résumé

Cette étude décrit une méthode sérologique simple et rapide utilisée pour l'identification définitive de l'anticorps contre le virus Kata ou contre le virus de la peste des petits ruminants. La technique est basée sur l'adsorption des anticorps réagissant à l'antigène de la peste bovine dans un sérum de peste des petits ruminants. L'anticorps spécifique de la peste des petits ruminants qui reste dans ce sérum est ensuite déterminé au moyen de la réaction d'inhibition de l'hémagglutination.

Introduction

The causative viral agents of both peste des petits ruminants (PPR) disease and rinderpest disease belong to the same Morbillivirus subgroup of the genus Paramyxovirus and show a great deal of cross-reactivity. They cross-react in the immunodiffusion and complement fixation tests (Johnson and Ritchie, 1968; Ihemelandu et al, 1976; Nawathe, 1983), immuno-osmo-precipitation test (Majiyagbe et al, 1984) and indirect haemagglutination-inhibition test using measles virus and monkey red blood cells (Nawathe, 1983).

Even the serum neutralisation test (SNT) currently being used as the confirmatory diagnosis for PPR and rinderpest also shows cross-reactivity (Mornet et al, 1956; Taylor, 1979; Obi, 1984). Wosu (1985) first demonstrated the haemagglutinin or PPR homogenate antigen, to porcine erythrocytes.

Wosu (1977) employed an adsorption technique to make a definitive differentiation between very closely related and cross-reacting strains of the *protozoan Trichomonas foetus* var. brisbane, var. belfast, and var. manley. It was therefore thought desirable to try the adsorption technique in this virological system to see if it could eliminate the cross-reactivity between PPR virus (Kata virus) and rinderpest virus (RV) and make a definitive diagnosis of the PPR specific antibody in a single test. This is of special interest in West Africa where both rinderpest and PPR are endemic.

This report details the technique used in eliminating the cross-reactivity between PPR virus and rinderpest virus serologically.

Materials and methods

A known lymph node homogenae PPR antigen (Tambo), a known rinderpest cultured antigen and a known PPR immune serum were obtained from the National Veterinary Research Institute, Vom, Nigeria. Porcine red blood cells (RBC) collected in Alsevers anticoagulant were used. The porcine red blood cell suspension (0.6%) was prepared as described by Wosu (1984).

The diluent was phosphate buffered saline (PBS) at pH 6.8. The adsorption technique described by Johnson (1967) and Wosu (1977) was used as the basis for the removal of antibodies cross-reacting with rinderpest virus from known PPR serum.

A known PPR immune serum was divided into two portions, A and B. Complement was removed from A and B by heating at 56°C for 30 min. In addition, natural agglutinins and non-specific serum inhibitors were removed from portion B by adsorption with porcine erythrocytes and kaolin respectively, as described by Joo (1976). The treatment of the PPR immune sera A and B involved adding 0.5 ml of known rinderpest antigen (Tambo) to 0.5 ml of each of the sera and 0.5 ml of each of the known PPR antigens to another 0.5 ml of

each of the sera. Another 0.5 ml of each sera was untreated and used as a control.

All the portions were incubated at 37°C for two hours and centrifuged for 10 minutes at 3000 rpm. The supernatants were used for the haemagglutination-inhibition (HI) test as described by Wosu (1985), involving V-bottomed microtitre plates and microtitre pipettes. Four haemagglutinating units (HAU) of the PPR homogenate antigen were used.

The procedure for the HI test involved adding 0.05 ml of PBS (pH 6.8) to each well of the V-bottomed microtitre plate. Serial double dilutions of 0.05 ml of each of the test sera were made on the same plate. Next 0.05 ml of the PPR homogenate antigen containing four HAU was added to each well. This was incubated at room temperature (25°C) for one hour. Then 0.05 ml of 0.6 % porcine RBC suspension (the same porcine RBC sample used in determining the four HAU) was added to each well. Controls for the four HAU of the PPR virus and the porcine erythrocytes were included in the protocol. The plates were incubated at 4°C for six hours. Five repeats of the HI test were carried out immediately and the treated sera A and B stored at -20°C for preservation. After a month, HI tests were carried out on the preserved serum portions.

Results and discussion

The HI titre of the PPR immune serum adsorbed with rinderpest antigen was less than the non-adsorbed portion and the titre of the serum adsorbed with PPR antigen was zero. Thus adsorption with rinderpest antigen neutralised the common antibodies leaving only antibodies specific to PPR antigen. This was confirmed by the fact that the HI titre of a portion of the same serum adsorbed with PPR was zero. The PPR antigen therefore neutralised both the antibodies it shared with rinderpest and those which were specific to the PPR virus.

Differences between treatments were maintained even after the removal of serum natural haemagglutinins and non-specific serum inhibitors as shown in Table 1. This eliminated the possibility that the difference in titre could have arisen from serum non-specific haemagglutinins or non-specific inhibitors.

Table 1. *HI titres of PPR immune serum.*

Serum treatment	Titre		Remarks
	Serum A	Serum B	
Adsorption with rinderpest antigen	1:1024	1:512	Control for four HAU and RBC were good
Adsorption with PPR antigen	Zero	Zero	–
No adsorption	1:4096	1:2048	–

Repeats of the HI test, carried out on the same treated serum samples immediately after the adsorption, gave the same titres as above.

The treatment of serum A alone is quite adequate for a rapid qualitative survey or epidemiological work, but for quantitative work treatment of serum B would be necessary. Since the result was obtained, the technique has been used on many PPR and rinderpest serum samples with the same outcome.

Definitive tests for antibodies due to either antigen have generally been based on carrying out at least two tests with the two antigens by SNT. It was evident that the antibody was due to the virus which gave the higher titre due to cross-reactivity between the two antigens by SNT (Mornet et al, 1956; Taylor, 1979; Obi, 1984). However this procedure was rather laborious. More importantly, when the results of the two tests were close, it was very difficult to ascertain the correct antigen. Moreover, it was frequently necessary to know whether a known serum would neutralise and consequently identify an unknown antigen or vice-versa.

The technique described in this paper appears to have elucidated the problem of cross-reactivity which exists in the diagnosis of PPR and rinderpest. Indeed, this HI technique was used in a virological system. An immune serum was made more specific by adsorption with a heterologous virus of the same group. Adsorbed serum tested for haemagglutination-inhibition (HI) activity reacted only with homologous and not with heterologous strains of arboviruses, thereby facilitating the identification of strains (Jawetze et al, 1978). It is suggested that this treatment of serum samples be applied to the other tests in order to eliminate cross-reactivity between PPR and RV. A comparative study could be made to determine the optimal test for identifying the specific antibody to PPR antigen.

The disappearance of differences in HI titres after the tested sera were stored at -20°C for one month was a chance finding (Table 2). While the cause of the differences was not investigated, it may be attributed to viral elution from antibodies (Nathalie et al, 1973). An investigation is needed to determine how long the treated sera can be stored at -20°C without elution.

Table 2. *HI titres of PPR serum portions as in Table 1 after storage at -20°C for one month.*

Serum treatment	Titre		Remarks
	Serum A	Serum B	
Adsorption with rinderpest antigen	1:4096	1:2048	Control for four HAU and RBC were good
Adsorption with PPR antigen	1:4096	1:2048	–
No adsorption	1:4096	1:2048	–

The HI test, especially in less sophisticated laboratories, is a very useful, quick and accurate method for determining the antibody levels in a given immune serum (Johnson, 1971). Where there are closely related antigens which cross-react, the test cannot readily be a

definitive diagnosis of a specific antibody unless it is possible to eliminate the cross-reactivity due to the other related antigens.

It is possible to make a definitive serological diagnosis of PPR specific antibodies by haemagglutination-inhibition test using the adsorption technique.

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Peste des petits ruminants (PPR) and rinderpest (RP) antibodies in clinically normal small ruminants in the Cameroon and Nigeria

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Abstract

An investigation was conducted in the small ruminant producing areas of the northern part of Nigeria and the Adamawa Province of the Cameroon (Garoua and its suburb) to assess the prevalence of peste des petits ruminants (PPR) and rinderpest (RP) antibodies in apparently normal and non-vaccinated sheep and goats. This study was aimed at providing a better understanding of the epidemiology of PPR in relation to a clinically similar disease, RP.

The virus-specific monoclonal antibody (Mab) based competitive ELISA (enzyme-linked immunosorbent assay) technique was used to analyse 702 serum samples from the surveyed area for PPR and RP.

The results show that overall, 46.7% (328/702) had PPR antibodies while 18.2% had RP antibodies. For Cameroon, (N = 320), 35% and 3.1% had PPR and RP antibodies respectively, while for Nigeria (N= 382), the corresponding values were 56.5 and 30.9%.

Comparison of the spectrum of antibody profiles showed that some animals reacted solely to either PPR or RP virus infection, while others simultaneously possessed antibodies for both viruses. This observation has serious implications for the on-going Pan-African Rinderpest Campaign (PARC) program to eradicate rinderpest from the African continent.

Présence d'anticorps contre la peste des petits ruminants et la peste bovine chez des petits ruminants du Cameroun et du Nigéria ne présentant pas de signes cliniques de maladie

Résumé

Une enquête a été réalisée dans les zones d'élevage de petits ruminants de la région septentrionale du Nigéria et de la province de l'Adamaoua au Cameroun (Garoua et sa périphérie) afin d'évaluer la prévalence des anticorps contre la peste des petits ruminants et contre la peste bovine chez des ovins et des caprins bien portant en apparence et non vaccinés. Cette étude avait pour objectif d'aider à mieux comprendre l'épidémiologie de la peste des petits ruminants par rapport à une infection cliniquement semblable, la peste bovine.

La technique immuno-enzymatique basée sur les anticorps monoclonaux du virus a été utilisée pour analyser 702 échantillons de sérum prélevés dans la zone d'étude. Les résultats révèlent que, dans l'ensemble, 46,7% des sujets abritaient des anticorps contre la peste des petits ruminants et 18,2% des anticorps contre la peste bovine. Ces chiffres étaient respectivement de 35% et de 3,1% au Cameroun (n = 320), et de 56,5% et 30,9% au Nigéria (n = 382).

En comparant entre eux les spectres des profils des anticorps, on a noté que certains animaux réagissaient uniquement au virus de la peste des petits ruminants ou à celui de la peste bovine, alors que d'autres possédaient des anticorps contre chacun de ces deux virus. Cette observation a des conséquences importantes sur le programme de la Campagne panafricaine contre la peste bovine qui s'emploie à faire disparaître cette maladie du continent africain.

Introduction

Livestock are very important for both the subsistence and economic development of the African continent. They provide a flow of essential food products throughout the year. In some countries they are a major source of government revenue and export earnings. They also sustain the employment and income of millions of people in rural areas, contribute draught energy and manure for crop production and are the only food and cash security available to many Africans (Brumby, 1990). In Nigeria, as in other African countries, small ruminants (sheep and goats) contribute a substantial proportion of the nation's meat supply.

Jahnke (1982) stated that 21.5% of the nearly 104 million sheep and 25.4% of the 125 million goats in tropical Africa are located in the humid and subhumid zone. Some 13.6% of the sheep and 16.2% of the goats

are located in the humid zone, while 7.9% of the sheep and 9.2% of the goats are found in the subhumid zone. There are an estimated 22 million sheep and 34.5 million goats in Nigeria (FDLPCS, 1991). The indigenous breeds of sheep in order of importance are Yankassa (60%), West African Dwarf (WAD, 20%), Uda (10%) and Balami (10%). For the goat breeds, the order is Red Sokoto goat (50%), West Africa Dwarf (45%) and Sahel (5%) (Osinowo, 1992).

In sheep and goats, PPR is considered the most important single cause of morbidity and mortality. It is a highly contagious rinderpest-like viral disease that particularly affects goats, but also affects sheep. The disease is characterised by fever, oculonasal discharge, necrotic stomatitis, bronchopneumonia and gastro-enteritis. The disease is caused by the PPR virus, a member of the Morbillivirus genus which includes rinderpest, canine distemper and measles. PPR is endemic in the humid zone and to a lesser extent in the subhumid zone of the West African subregion. Its economic importance in these areas is enormous. It can quickly decimate whole flocks either by itself or in combination with other diseases, such as pneumonia or gastro-intestinal parasitism (Majiyagbe, 1985). In susceptible flocks, morbidity may be 100% and mortality greater than 90%, especially amongst animals under six months of age. This has caused severe economic hardship to many small ruminant producers. Clinically, PPR occurs as an acute disease in goats, while in sheep it is generally benign. Surviving animals usually develop a dual immunity to PPR and RP viruses.

In practice, tissue culture rinderpest virus (TCRV) vaccine is used in immunoprophylaxis against PPR in the absence of a homologous vaccine. Control of PPR is therefore paramount to efficient small ruminant production in the West African subregion.

Currently, the PARC (Pan African Rinderpest Campaign) to control and subsequently eradicate rinderpest from the African continent is being carried out in over 22 countries. The target animals for the campaign are cattle. Small ruminants, being animals of the Artiodactyla group, are also susceptible to rinderpest virus and are hence occasionally infected with bovine rinderpest. However, the PPR virus causes a non-clinical disease in bovines; infected cattle sero-convert and become immune to RP and PPR viruses. This will interfere with successful TCRV vaccination and has serious implications when cattle are sero-surveyed to determine the level of protection against rinderpest.

To provide a better understanding of the epidemiology of PPR and RP in small ruminants, an investigation was conducted in small ruminant producing areas of the northern part of Nigeria and the Adamawa Province of Cameroon (Garoua and its suburbs). Its purpose was to assess the prevalence of PPR and RP antibodies in apparently normal and non-vaccinated sheep and goats.

Materials and methods

Sera samples

A total of 702 sheep and goat sera samples were collected from 352 survey regions in Nigeria and 320 survey regions in Garoua and its environs in the Adamawa Province of Cameroon. Serum was aseptically separated from the blood clot and kept chilled while being transported to the laboratory for analysis. Details of samples collected and species distribution are shown in Table 1.

Serum testing for PPR and RP antibodies

A competitive ELISA (C-Elisa) for the detection of antibodies to RP and PPR viruses was used for serum analysis. This is a monoclonal antibody (Mab) based test. Two types of Mab are used, one specific against the hemagglutinin (HA) protein of RP virus and the other specific against the H-protein of the PPR virus. Unlike the indirect ELISA and the virus neutralisation test (VNT), the RP C-Elisa detects only antibodies to RP

Table 1. *PPR and RP antibodies in clinically normal small ruminants from Nigeria and Cameroon (%).*

	PPR+pos. only (1)	PPRneg	RPV+(2)	RPVneg	PPR+ RPV–(3)	RPV+ PPR–	PPR++ RPV++	PPR– RP–
Global summary (n=702)	46.7	53.3	18.2	81.8	34.9	6.8	11.4	46.44
(Cameroon + Nigeria)								
Cameroon (n=320)	35	65	3.1	96.9	32.8	1.6	1.6	63.4
Nigeria (n=382)	56.5	43.5	30.9	69.1	36.6	11.3	19.6	32.2
Nigerian control TCRV vaccinates (n=192)	62	38	60	39.1	22.4	21.9	39.1	16.2
Sheep (n = 303)	50.5	49.5	1.3	98.7	50.2	0.9	0.3	45.2
Goats (n =399)	43.9	56.1	31.1	68.9	23.8	11.3	19.8	38.6

Cameroon – samples from Boklé (IRZ, LANAVET), Lagdo, Ngong and Garoua Abbatoir.

Nigeria - samples from Bauchi State (Soro and Alkaleri) and Plateau State (Vom, Jos and Eviron).

Vaccinated control samples from Ife and Shika Research Farms.

virus and gives no cross-reactivity with antibodies to PPR virus.

The Mab used in the PPR C-Elisa also gives a high level of specificity to the PPR virus. However, some anti-sera to rinderpest do compete against this PPR specific Mab. The test was performed as outlined in the C-Elisa kit manual (Majiyagbe et al, 1991; Anderson et al, 1991). The ELISA test reagent kits were supplied in two parts, Buffers + Conjugate, from the joint FAO/IAEA (Food and Agriculture Organization of the United Nations/International Atomic Energy Agency) Agricultural Laboratory in Seibersdorf, Austria and RP and PPR antigens kits from the Pirbright Laboratory, Pirbright, Surrey, UK.

Results

Table 1 shows that just under half of the samples had PPR antibodies, while one fifth had RP antibodies. The rest were negative to both viruses.

Because of the discriminating nature of the monoclonal antibodies used in the test, it was possible to distinguish between specific PPR and RP virus induced antibodies in these animals' serum samples. Comparison of the spectrum of antibody profiles showed that some animals reacted solely to either PPR or RP virus infection.

Discussion and conclusion

Serum samples collected from small ruminant producing areas in Nigeria and the Cameroon showed that some of the animals possessed antibodies to PPR and RP viruses. None of the animals were less than one and a half years of age and they had not been vaccinated with either TCRV or homologous PPR vaccine. The source of these antibodies can therefore only be from an unapparent infection or from immunity gained through recovery from a field outbreak. Animals that recover from field outbreaks posses a durable immunity, as an infected animal either dies or survives. Antibodies can therefore be found in the blood of surviving animals.

The West African subregion is considered an endemic zone for PPR. The disease is considered the single most important cause of morbidity and mortality in small ruminants, especially goats. The most effective form of protection against PPR is through vaccination. Since the causal agent of PPR is a morbillivirus related to rinderpest virus, the use of TCRV vaccine has been shown to be effective in offering protection against PPR; a single vaccination confers immunity for at least 12 months (Majiyagbe et al, 1991; Rao et al, 1984). Vaccinated animals are therefore able to withstand the virulent PPR virus in the field.

Field experience, however, shows that these animals are rarely vaccinated. Their survival therefore depends on being able to overcome a field outbreak of PPR or infection with the closely related RP virus. Observations from the last RP outbreak in Nigeria showed that very few goats and sheep exhibited evidence of infection (Majiyagbe, 1985). This was probably due to prior PPR exposure or infection with a mild RP virus strain. A small ruminant adapted strain of RP virus is know in India (Dardiri et al, 1976; Rao et al, 1984) and there is evidence that this strain circulates within cattle, sheep and goats. Experimental studies (Anderson et al, 1991) have shown that cattle may be infected by contact with the PPR virus, but will not exhibit any symptoms and will resist RP. Similarly Anderson et al (1991) have shown that goats with circulating antibodies to PPR virus will not respond to rinderpest vaccination.

In the absence of vaccination, the presence of PPR and RP virus antibodies indicates that PPR and RP are circulating in the population, even if only at low levels. This observation has serious implications for the on-going PARC seromonitoring program, particularly in the assessment of immunity levels to RP after vaccination. In a situation where the PPR virus infects cattle before RP vaccination, the animal would not respond to the vaccination and would be considered an animal at risk and test negative in the RP C-Elisa test used in evaluating sero-conversion. Our own results show that a similar situation occurs in small ruminants and this could influence the results of seromonitoring in the current PARC program.

The goal of the current PARC program is to eradicate RP from the African continent. For a country to be able to declare itself free from disease, a sufficiently high level of immunity (>95%) must be achieved in the national herd and vaccinations against RP must cease.

The contribution of PPR virus immunity to animals' resistance to RP must be properly quantified. Appropriate tests such as the C-Elisa must be used for a meaningful evaluation of survey results.

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Diseases of small ruminants in central Tanzania

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Abstract

Information on diseases affecting small ruminants in Tanzania has not been extensively documented. More than 14 years' worth of data on disease cases in sheep and goats was analysed from records kept at the Veterinary Investigation Centre (VIC) and Livestock Training Institute (LTI), Mpwapwa. Results showed that the majority of the disease cases were parasitic infections (53.1%), followed by bacterial infections (23.6%), other infectious diseases (12.6%) and non-infectious conditions (10.7%).

This study shows that the diseases affecting sheep and goats in Tanzania, particularly the central zone, need to be diagnosed and documented in order to implement more effective disease control measures.

Pathologie des petits ruminants en Tanzanie centrale

Résumé

Il existe peu d'études sur la pathologie des petits ruminants en Tanzanie. Des données sur les cas de maladies relevés pendant plus de 14 ans sur des ovins et des caprins au Centre de recherche vétérinaire et à l'Institut de formation en élevage de Mpwapwa ont été analysées. Les maladies les plus répandues étaient les parasitoses (53,1%), suivies des maladies bactériennes (23,6%) et d'autres maladies infectieuses (12,6%) et non infectieuses (10,7%).

Cette étude fait ressortir la nécessité de diagnostiquer et de répertorier les maladies qui frappent les petits ruminants en Tanzanie, particulièrement dans la zone centrale, en vue de la mise en place de mesures efficaces de prophylaxie.

Introduction

Among the many constraints which limit productivity in livestock populations, disease and parasites are of major importance. In Africa, however, little is known about small ruminant diseases and parasites.

In Tanzania there is a dearth of information on specific causes of sheep and goat mortality and morbidity. Several reports have been written on livestock diseases in the country, but with very little attention to small ruminant diseases. Nyange (1984) mentioned the incidences of diseases such as caprine pleuropneumonia and sheep pox in northern Tanzania. while Mbise et al (1984) reported incidences of anthrax and brucellosis. Matovelo et al (1987) reported that parasitic gastroenteritis, pneumonia and diarrhoea were the dominant problems in small ruminants in the eastern part of the country.

Control of animal diseases is essential for realising the potential of small ruminant production. For proper control to be instituted, however, diseases and their dynamics must be known. This paper reports disease findings for cases brought to the Veterinary Investigation Centre (VIC) and Livestock Training Institute (LTI) laboratories at Mpwapwa for routine diagnosis between 1978 and 1991.

Materials and methods

The area covered in the study is the central zone of Tanzania. The zone lies roughly between latitudes 4° and 8°S and longitudes 32° and 39°E. It is predominantly a livestock area occupied by sedentary pastoralists. There are approximately half a million sheep and 1.2 million goats in this zone, representing about 16 and 18%, respectively, of the total small ruminant population in the country. The sheep and goats are predominantly local breeds which are usually kept extensively.

The data was collected from records of cases diagnosed at the VIC and LTI laboratories. Sheep and goats have been grouped together. The data reported are either confirmed diagnoses or conclusions. The methods used in diagnosis were clinical examination, post-mortem findings and laboratory tests such as bacterial cultures and serological tests.

Results

Table 1 shows the major diseases identified and their prevalence.

Table 1. *Diseases diagnosed in small ruminants classified by major aestological groups.*

Disease group	Number of diagnoses	Per cent of total diagnoses
Parasitic infections	278	53.1
Bacterial infections	124	23.6
Other infectious diseases	66	12.6
Non-infectious diseases	56	10.7
Total	524	100.0

Of the parasitic infections, helminthiasis was the most common (Table 2). Coccidiosis, flea (*Ctenocephalides canis*) infestation and *Oestrus ovis* larvae infestation were other parasitic infections diagnosed in high incidences. Mange and anaplasmosis, though in lower incidences, were also reported.

Bacterial infections ranked second in the diseases affecting small ruminants (Table 1). There were high incidences of foot rot, abscess, pneumonia and dermatophilosis (Table 3). Other bacterial diseases occasionally diagnosed included anthrax, pasteurellosis, streptococcosis, mastitis, caseous lymphadenitis, tetanus, colibacillosis and brucellosis.

Table 2. *Parasitic infections diagnosed in small ruminants.*

Disease condition	Number of diagnoses	Per cent
Helminthiasis	278	64.4
Coccidiosis	52	18.7
Flea infestation	27	9.7
Oestrus ovis larvae infestation	12	4.3
Mange	5	1.8
Anaplasmosis	3	1.1

Table 3. *Bacterial diseases diagnosed in small ruminants.*

Disease condition	Number of diagnoses	Per cent
Foot rot	47	37.9
Abscess	26	21.0
Pneumonia	24	19.4
Dermatophilosis	11	8.9
Anthrax	4	3.2
Pasteurellosis	3	2.4
Streptococcosis	2	1.6
Mastitis	2	1.6
Caseous lymphadenitis	2	1.6
Tetanus	1	0.8
Colibacillosis	1	0.8
Brucellosis	1	0.8

Table 4 shows other infectious diseases, including viral, fungal and systemic diseases for which the etiological agent could not be determined. In this group, incidences of caprine ophthalmia had the highest frequency. Contagious ecthyma (orf) was the only viral disease reported in this study. Dermatomycosis was the only fungal disease reported in the area.

Table 4. *Other infectious diseases diagnosed in small ruminants.*

Disease condition	Number of diagnoses	Per cent
Caprine ophthalmia	28	42.4
Contagious ecthyma	21	31.9
Enteritis	9	13.6
Dermatomycosis	6	9.1
Peritonitis	2	3.0

Table 5. *Non-infectious disease conditions diagnosed in small ruminants.*

Disease condition	Number of diagnoses	Per cent
Fracture	15	26.7
Wounds	10	17.8
Poisoning	9	16.1
Dystocia	5	8.9
Retained placenta	4	7.1
Stillbirth	3	5.4
Senility	3	5.4
Starvation	2	3.6
Hernia	2	3.6
Abortion	2	3.6
Rectal perforation	1	1.8

Fractures, wounds and poisoning were the commonest non-infectious conditions (Table 5). Reproductive problems such as abortion, dystocia, stillbirth and retained placenta were recorded. Hernia, senility and rectal perforation were also observed.

Discussion

In small ruminants, the majority of diseases reported in central Tanzania were parasitic infections with helminthiasis and coccidiosis being the most prevalent. Matovelo et al (1987) observed that the diagnosed disease conditions affecting sheep and goats in the eastern part of the country were mainly parasitic gastroenteritis.

The economic impact of helminthiasis is enormous. Herlich (1978) estimated that the total animal loss due to helminthiasis worldwide is equivalent to 30 million goats and sheep. Constraints to animal production attributable to helminthiasis include inefficient food conversion, poor growth and reduced fertility.

Protozoan diseases of small ruminants have received very little attention in Tanzania. Coccidiosis has been reported as the major protozoan disease of small ruminants in the region. Other protozoan diseases of small ruminants have been reported in the country.

Toxoplasmiosis has been diagnosed serologically in southern Tanzania (Connor et al, 1985 as cited by Otaru, 1985), whereas trypanosomiasis has been reported in the eastern part of the country (Matovelo et al, 1987).

Ectoparasitism accounted for about 15.8% of the parasitic diseases reported in this study. Of the ectoparasites, *Ctenocephalides canis* appears to be the most important in the region. Fleas have been reported to occur in sheep and goats in other areas of the country. Kilonzo and Khama (1989) observed that goats and sheep in north-east Tanzania were heavily infested with the cat flea *Ctenocephalides felis*. General infestation of sheep and goats by fleas produces debilitating effects on their hosts. Heavily infested goats and sheep are weak, anaemic and emaciated. Heavy flea infestation of lambs and kids may cause death.

Oestrus ovis larvae infestation was the second most prevalent ectoparasitism in small ruminants. *O. ovis* larvae infestation has also been recorded elsewhere in Tanzania (Matovelo et al, 1987). The larvae at the nostrils of sheep or goats annoy the animals and cause them to avoid the fly and seek shelter. Snorting, stamping of the feet and shaking of the head are common. Such actions interfere with normal grazing/browsing. The spiny surface of *Oestrus ovis* larvae causes irritation of the nasal mucosa resulting in sneezing, mucopurulent discharge and difficult, snoring respiration. *Oestrus ovis* may deposit larvae in the eye, nose or on the lips of man and is thus an important myiasis in some countries (Blood et al, 1983).

Mange is another important ectoparasitic infection diagnosed in sheep and goats in central Tanzania. The disease has been reported to occur in other areas of the country (Matovelo et al, 1987). Mange can be a very stubborn condition, particularly in goats, causing much damage to the skin.

Bacterial diseases were the second most prevalent diseases of small ruminants in central Tanzania. Of the specific bacterial diseases, foot rot was the most prevalent. Most outbreaks occur during the warm and wet months of the year. In serious outbreaks, lameness may be so severe that many animals are forced to walk on their knees.

Although pneumonia and abscess have been reported with higher incidences, in many cases they have been due to non-specific bacteria. Pasteurella species, however, were isolated in three cases of pneumonia. Several investigations have reported Pasteurella organisms as causing some types of pneumonia in goats (Ngatia et al, 1989). Dermatophilosis was another prevalent disease of small ruminants. Outbreaks have frequently been reported in the region (TVA, 1991).

Though figures of anthrax reported in this study are not very significant, outbreaks killing several hundred cattle, sheep and goats have been reported in northern Tanzania (Mbise et al, 1984). Brucellosis is a cause of abortion and infertility in small ruminants (Tekelye and Kasali, 1990). Although only one case of brucellosis was reported from the viewpoint of human health, the disease is important because the causative organism causes human brucellosis when fresh milk from infected goats or sheep is consumed or when direct contact is made with infected placenta following abortion.

Caseous lymphadenitis, colibacillosis, mastitis, streptococcosis and tetanus are also important bacterial diseases of sheep and goats. Caseous lymphadenitis is usually clinically unapparent and is observed during post-mortem examination. It causes high economic losses through condemnation of affected carcasses and organs at slaughter and through losses in production and reproduction (Kuria and Ngatia, 1990). Few cases of mastitis in small ruminants have been reported in other areas of the country (Madsen and Mtenga, 1989).

Of the other infectious diseases, caprine ophthalmia and contagious ecthyma have been reported with higher frequencies. Caprine ophthalmia causes ocular pain and poor vision, so affected goats do not eat properly and fail to thrive. Where treatment is delayed, affected goats become blind. Blind goats are difficult to move and are often discriminated against when they are sold at auction. Contagious ecthyma causes some economic losses. It appears to be endemic in the region as many farmers have complained of several outbreaks in their flocks.

In the other infectious diseases group, enteritis, dermatomycosis and peritonitis were also reported. Enteritis is in most cases manifested by diarrhoea. Although enteritis was reported in few cases in this study, reports from eastern regions of the country have shown that diarrhoea is one of the dominant problems for small ruminants (Matovelo et al, 1987). Dermatomycosis of animal origin may affect humans and its diagnosis and treatment are often difficult (Blood et al, 1983).

There are many non-infectious diseases of sheep and goats which result in the animal's death and cause great economic losses, but have not received sufficient attention. Fractures, wounds, poisoning and dystocia represent the largest proportion of conditions in this group. Reproductive disorders such as abortion, dystocia, retained placenta and stillbirth contribute highly to flock infertility. Stillbirth and dystocia appear to be among the primary causes of pre- and perinatal lamb and kid losses in the area. The economic losses attributable to injuries such as fractures, wounds and rectal perforation are difficult to assess owing to the limited data available on their incidence, prevalence, morbidity and mortality rates. However, expenses charged in treatment and nursing may result in large economic losses.

Conclusions

It can therefore be concluded that helminthiasis, coccidiosis, foot rot, caprine ophthalmia, flea infestation and pneumonia are the major specific diseases affecting small ruminants in central Tanzania. Although similar

diseases have been reported in other parts of the country, their relative frequency and economic importance have not been assessed. In the absence of reliable epidemiological and economic data, it is impossible to quantify precisely the losses incurred as a result of small ruminant diseases in Tanzania. Although these have been recorded at low incidences, the stock owners do not recognise early clinical signs. Consequently they are late in seeking veterinary advice and suffer losses through lack of timely treatment.

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Mortalité des chevreaux croisés Alpine au Burundi

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Résumé

Les données recueillies en 1990 et 1991 sur 200 petits élevages de chèvres suivis dans le cadre du Projet caprin de Ngozi ont mis en évidence un pic de mortalité entre mars et juillet chez des chevreaux âgés de moins de 6 mois. Afin de simuler la survie de cohortes de chevreaux indépendamment des ventes et d'autres raisons de sorties, le taux de mortalité des chevreaux a été estimé chaque mois de février à juillet par l'analyse de ressemblance maximum. Les facteurs de pondération considérés sont l'année, l'âge du chevreau au premier jour du mois étudié, le génotype, la taille de la portée et le sexe du chevreau.

En 1991, la mortalité des chevreaux a été quatre mois sur six plus forte (P<0,05) qu'en 1990. La probabilité de mortalité était chaque mois plus élevée chez les triplets que chez les chevreaux issus de naissances simples ou gémellaires. L'effet global du génotype n'était significatif qu'en juin et juillet, mais la divergence des courbes simulées de survie indiquait une meilleure performance des chevreaux de race locale par rapport à ceux issus des croisements les plus fréquents (50% et 75% de sang alpin) et dont les taux de survie étaient similaires. Les rétrocroisements avec des boucs de race locale présentaient une courbe simulée de survie intermédiaire. Les classes d'âge les plus affectées chaque mois correspondaient aux chevreaux âgés de 60 à 120 jours, soit approximativement l'époque du sevrage, alors que la mortalité des très jeunes chevreaux était la plus faible. Par simulation de cohortes, on a montré que 63% des chevreaux nés en janvier ou en février atteindront l'âge de 6 mois.

Mortality of Alpine cross-bred kids in Burundi

Abstract

Data collected in 1990 and 1991 on 200 small-scale goat farms monitored by the Ngozi Goat Project showed a peak in mortality between March and July in kids below six months old. The monthly mortality rate of the kids was estimated using a maximum likelihood analysis to simulate kid cohort survival irrespective of sales and other reasons of disposal. Weighing factors were: year, age of kids on the first day of the month, breed group, litter size and sex of kids.

In 1991, kid mortality was higher (P<0.05) than in 1991 for four months out of six. Mortality probability was higher in triplets compared to twins or singles each month. Total effect of breed group was significant in June and July only, but the difference between survival simulation curves showed that local kids performed better than the most common crossbreds (50% and 75% Alpine blood) with similar survival rates. Back crosses with local rams had an intermediary survival simulation curve. Each month, the most affected age groups were the kids aged 60 to 120 days, which is roughly the weaning period, while the lowest mortality was observed in very young kids. Cohort simulation showed that 63% of the kids born in January or February will reach the age of six months.

Introduction

Située dans la région du Buyenzi, la province de Ngozi fait partie de la région des Hauts Plateaux du Burundi. Elle est caractérisée par une forte densité de population (plus de 350 habitants/km^2), une altitude moyenne de 1 800 m et une pluviométrie annuelle moyenne de 1 400 mm répartie selon un régime bimodal.

Depuis 1980 le Projet caprin de Ngozi développe un programme de croisement des chèvres de race locale avec des boucs de race alpine (8 000 saillies en 1989; Schmidt, 1991) ainsi que la production de lait (70 000 litres en 1991 contre 24 000 litres livrés à la laiterie en 1986 (Michel et Mukankusi, 1992).

Les données recueillies en 1990 et 1991 dans la zone d'intervention du projet ont mis en évidence un pic de mortalité des chevreaux âgés de moins de 6 mois entre les mois de mars et de juillet.

La présente étude a pour objectifs de déterminer l'influence d'un certain nombre de paramètres sur la mortalité des chevreaux entre février et juillet, et de comparer la survie des jeunes au cours de cette période en fonction de leur âge et de leur type génétique.

2. Matériel et méthodes

2.1 Matériel

Les données utilisées provenaient du suivi d'un échantillon de 200 élevages de chèvres établis dans la zone d'intervention du Projet caprin de Ngozi. Les exploitations ont été visitées tous les 15 jours par 8 enquêteurs, qui ont collecté les informations relatives à

la démographie et à la productivité du troupeau: naissances, mortalités, entrées et sorties, évolution pondérale, production laitière.

2.2 Méthodes

Le taux mensuel de mortalité des chevreaux a été utilisé pour étudier la mortalité des chevreaux de moins de 6 mois durant la période considérée (début février à fin juillet). Il est défini comme le rapport entre le nombre de chevreaux morts durant le mois considéré et le nombre de chevreaux vivants au début de ce mois. Les chevreaux sortis pour d'autres raisons (ventes, dons, abattage familial) durant un mois donné ont été arbitrairement considérés comme vivants au dernier jour du mois, mais ne sont pas entrés dans l'analyse du mois suivant.

L'analyse de vraisemblance maximum (SAS, 1987) utilisée pour l'étude des taux mensuels de mortalité a été effectuée en tenant compte des effets fixes suivants:

- l'année;
- l'âge du chevreau au premier jour du mois étudié; les chevreaux nés durant le mois sont exclus de l'analyse pour le mois considéré;
- le génotype: chevreaux de race locale (petite chèvre d'Afrique de l'Est); chevreaux croisés (race locale x race Alpine): F1 (50% de sang alpin), R1 (75% de sang alpin), R2 et R3 (75% et 87% de sang alpin respectivement); autres produits croisés issus de la monte de chèvres croisées par un bouc de race locale;
- la taille de la portée ou le mode de naissance: simple, double ou triple;
- le sexe du chevreau.

Les valeurs probabilistiques estimées des taux de mortalité pour chaque classe d'âge et l'erreur type de l'estimation ont été obtenues par la procédure LOGMLVAR (Rege, 1992).

Le taux mensuel de survie (Q_s) a été défini comme étant l'opposé du taux de mortalité ($Q_s = 100 - Q_m$). Afin d'étudier le comportement des chevreaux de moins de 6 mois au cours de la période considérée, on a simulé leur survie en cumulant les taux de survie:

$$SURVIE_{mois\ 2} = Q_{s1} * Q_{s2}$$

Le taux de survie a ainsi une valeur probabilistique pour une cohorte donnée de chevreaux, indépendamment du système d'exploitation dans lequel ils sont maintenus.

3. Résultats

3.1 Taux de mortalité mensuel

Le tableau 1 présente les moyennes des taux de mortalité mensuel des chevreaux de moins de 6 mois entre février et juillet en fonction des divers facteurs de variation considérés (année, genre, mode de naissance, génotype et âge).

- ***Année***

Le taux de mortalité variait en fonction de l'année. Le taux de mortalité en 1991 était significativement plus élevé en avril et mai ($P<0,01$), et en février et juillet ($P<0,05$).

- ***Genre***

Le sexe des chevreaux a peu influé sur le taux de mortalité, qui n'était significativement plus élevé ($P<0,05$) qu'au mois de mai chez les chevreaux mâles. Pour les autres mois, il n'y avait pas de différence significative entre les mortalités des chevreaux quel que soit leur sexe.

- ***Taille de la portée***

La taille de la portée avait un effet significatif sur le taux mensuel de mortalité aux mois de mars ($P<0,01$) et d'avril ($P<0,05$). Le taux de mortalité des chevreaux de portée double n'était pas différent de celui des chevreaux nés simples (sauf en avril). Celui des chevreaux nés de portées triples était significativement plus élevé que celui des chevreaux nés simples sauf en mai, et en général plus élevé que celui des jeunes nés doubles. Le taux de mortalité des triplets était en moyenne deux fois plus élevé que ceux des autres types d'agneaux, mais son coefficient de variation était également chaque fois plus important.

- ***Génotype***

Le génotype avait un effet significatif sur le taux de mortalité mensuel aux mois de juin ($P<0,01$) et juillet ($P<0,05$). En juin, la mortalité des chevreaux de race locale et des croisements divers était similaire ou inférieure à celle des chevreaux F1, R1, R2 et R3. En juillet, elle était plus élevée chez les chevreaux R2 et R3. Pour les autres mois, les seules moyennes n'ont fait apparaître aucune tendance constante.

- ***Age des chevreaux***

L'âge des chevreaux au premier jour du mois avait un effet significatif sur le taux de mortalité aux mois d'avril ($P<0,01$), juin et juillet ($P<0,05$). Pour ces trois mois, la mortalité mensuelle des chevreaux âgés de moins d'un mois était la plus faible (toujours inférieure à 5%). La mortalité la plus élevée était enregistrée en avril et juin chez la classe d'âge des 2 mois et en juin et juillet chez celles de 3 et 4 mois. Une tendance similaire s'observait durant les autres mois, mais les différences n'étaient pas significatives.

3.2 Survie simulée de février à juillet

Le tableau 2 présente les taux simulés de survie sur six mois pour 100 chevreaux vivants et âgés de moins de 6 mois au 1er février. Les facteurs de variation sont les mêmes que ceux présentés dans la section 3.1.

- ***Année***

L'importante variation entre les taux mensuels de mortalité de 1990 et de 1991 se répercute sur le taux de survie cumulé au 31 juillet; ce dernier était supérieur de

Tableau 1. *Taux de mortalité mensuel de chevreaux de 1 à 6 mois entre février et juillet*

Facteurs	Février	Mars	Avril	Mai	Juin	Juillet
Valeur réelle	2,35	3,77	5,30	7,47	7,60	5,30
Moyenne estimée	2,21	5,75	5,33	7,18	8,32	5,87
Année						
(Prob)	0,0305	0,6296	0,0072	0,0006	0,6886	0,0405
1990	1,30	5,32	3,76	4,84	8,70	4,39
1991	3,73	6,20	7,51	10,55	7,95	7,81
Sexe						
(Prob)	0,9116	0,4950	0,8242	0,0194	0,8984	0,7630
Femelle	2,16	6,36	5,47	5,59	8,21	6,11
Mâle	2,26	5,19	5,19	9,19	8,43	5,64
Mode de naissance						
(Prob)	0,2231	0,0001	0,0240	0,2354	0,1049	0,1021
Simple	3,53	3,53	2,97	5,35	5,88	3,58
Double	2,94	3,00	5,33	6,46	6,90	4,86
Triple	0[a]	16,67	9,40	10,64	13,90	11,35
Génotype						
(Prob)	0,2029	0,1905	0,0867	0,5430	0,0018	0,0484
Croisé	4,00	6,13	4,92	7,22	3,88	5,96
F_1	2,74	7,47	7,61	6,70	13,20	3,73
R_1	3,50	8,34	6,73	9,97	10,52	4,34
R_2 et R_3	1,27	4,94	5,68	5,57	13,64	13,69
Race locale	1,06	3,27	2,97	7,08	5,13	5,07
Age au 1er du mois						
(Prob)	0,3244	0,1253	0,0003	0,1364	0,0156	0,0299
0–30 jours	0,81	3,59	1,93	2,84	4,23	2,05
31–60 jours	2,53	5,94	8,28	6,23	6,58	3,70
61–90 jours	1,89	6,39	11,80	8,74	16,54	5,97
91–120 jours	3,72	14,20	3,37	9,17	10,80	11,84
121–150 jours	2,57	2,10	4,25	11,59	9,82	11,75
151–180 jours	3,08	8,25	7,98	8,05	6,44	6,07

(Prob) = valeur probabilistique

0[a] est une valeur exacte non incluse dans les analyses.

Tableau 2. *Taux de survie de cohortes de chevreaux entre février et juillet, Ngozi (Burundi)*

Facteurs	Février	Mars	Avril	Mai	Juin	Juillet
Valeur réelle	97,65	93,97	88,99	82,34	76,08	72,05
Moyenne estimée	97,79	92,17	87,25	80,99	74,25	69,89
Année						
1990	98,70	93,45	89,93	85,58	78,14	74,71
1991	96,27	90,30	83,52	74,71	68,77	63,40
Sexe						
Femelle	97,84	91,62	86,60	81,76	75,05	70,46
Mâle	97,74	92,67	87,86	79,78	73,06	68,94
Mode de naissance						
Simple	98,35	94,88	92,06	87,13	82,01	79,08
Double	97,06	94,15	89,13	83,37	77,62	73,85
Triple	0[a]	83,33	75,50	67,46	58,09	51,49

0[a] est une valeur exacte non incluse dans les analyses.

11 points (soit 18%) en 1990 par rapport à 1991 (74% de survivants contre 63%).

- ***Sexe des chevreaux***

En valeur cumulée fin juillet, la survie des femelles était très légèrement (1,5%) supérieure à celle des mâles, ce qui reflète l'absence de différences significatives entre les taux de mortalité pour ce facteur.

- ***Mode de naissance***

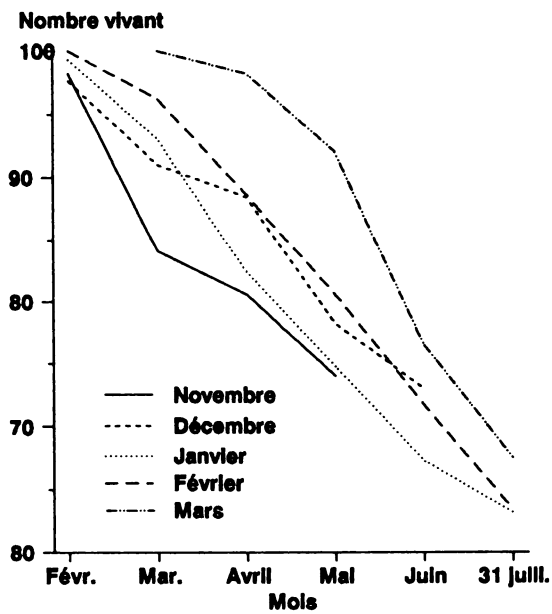
Sans être toujours significative, la différence entre les taux de mortalité des chevreaux nés simples et de ceux nés doubles se traduisait par une probabilité de survie cumulée des premiers supérieure de 5,3 points (soit 7% de différence) à celle des seconds.

Les chevreaux nés triples avaient une probabilité de survie très inférieure à celles des chevreaux nés simples ou nés doubles (28 points par rapport aux premiers et 22 points par rapport aux seconds). La moitié seulement des chevreaux nés triples survivait jusqu'à 6 mois pendant la période considérée.

- ***Génotype***

L'évolution mensuelle entre début février et fin juillet du taux de survie simulé de chevreaux appartenant à différents génotypes et âgés de moins de 6 mois est illustrée à la figure 1.

Figure 1. *Survie de cohortes de chevreaux de moins de 6 mois de differents génotypes.*



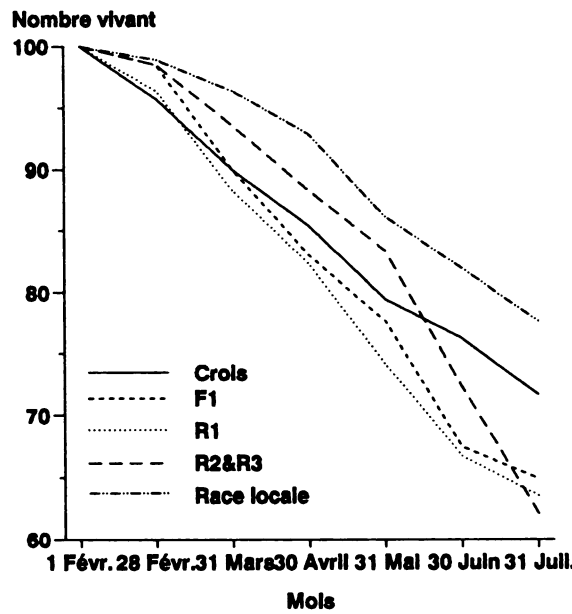
La courbe fait apparaître de faibles différences entre les pourcentages d'animaux croisés (F1, R1, R2 et R3) survivants: 1 point entre chaque groupe, avec un taux de survie croissant en fonction inverse du taux de croisement. Par rapport à ces chevreaux, la probabilité de survie jusqu'à 6 mois des jeunes de race locale était supérieure de 14,5 points.

La courbe de survie des chevreaux issus d'autres croisements avait un comportement intermédiaire: au 30 juillet, elle se situait à 8 points en dessous de celle des chevreaux de race locale et à 9 points au-dessus de celle des produits de croisements d'absorption.

- ***Mois de naissance***

La figure 2 présente la courbe de survie simulée pour la période considérée, pour des chevreaux nés à des mois différents. Jusqu'à l'âge de 4 mois, les jeunes nés en janvier ont une meilleure chance de survie que ceux nés en février (3 points) et en mars (10 points). En supposant une faible mortalité après l'âge de 180 jours ainsi qu'aux mois de décembre et janvier, et en tenant compte de l'erreur inhérente à la simulation, il apparaît que la période de naissance la moins favorable se situe aux mois de janvier et de février (63% de survie espérée fin juillet).

Figure 1. *Survie simulée de chevreaux nés différents mois.*



Discussion

Le taux de mortalité des chevreaux variait en fonction de l'année, du mois, du type de naissance et du génotype. Pour les six mois considérés, il n'y avait pas de différences entre les taux de mortalité des chevreaux femelles et des chevreaux mâles, bien que la littérature indique généralement une meilleure survie des femelles. La comparaison des taux de mortalité aux précipitations mensuelles relevées à la station du Projet (Projet caprin de Ngozi, 1991) et à leur somme pour les deux années ne permet pas de corroborer l'hypothèse selon laquelle une plus forte pluviométrie serait directement liée à un taux de mortalité plus élevé: la saison des pluies est à son maximum en février-mars, se termine fin mai, et les mois de juin et juillet sont parmi les plus secs.

La mortalité supérieure des chevreaux nés triples pourrait s'expliquer par les difficultés de leurs mères à les allaiter.

La race locale est généralement supposée plus rustique et mieux adaptée aux conditions tropicales que les produits de croisement. Les taux de mortalité des chevreaux locaux étaient plus faibles aux mois de février, mars, avril et juin que ceux des chevreaux croisés, mais la différence n'était significative qu'au mois d'avril. Le taux de survie, estimé par simulation, est cependant plus élevé pour la race locale. La simulation a aussi montré que l'effet cumulé de la mortalité des chevreaux était inversement proportionnel au degré de croisement alpin (croisements d'absorption) des animaux.

Les classes d'âge affichant la mortalité la plus élevée au cours des mois considérés étaient celle des 60–120 jours, soit approximativement la période du sevrage. Ceci pourrait s'expliquer par le fait qu'à cette période de leur vie, les chevreaux ont besoin d'une attention particulière en raison des problèmes liés au changement d'alimentation et aux risques d'infestation parasitaire. Les principales causes de mortalité dans la région du Buyenzi seraient en effet d'origine parasitaire et alimentaire (Shulze-Althoff *et al.*, 1986).

Les taux de mortalité périnatale très faibles, voire nuls, enregistrés pour les chevreaux âgés de 0 à 30 jours résultent certainement d'une erreur d'enregistrement des données.

Conclusion

L'analyse des facteurs influençant la mortalité des chevreaux âgés de moins de 6 mois entre février et juillet 1990 et 1991 fait ressortir les effets de l'année, du mode de naissance et du génotype des chevreaux.

Parmi les causes possibles de mortalité, les verminoses joueraient un rôle important. Pour déterminer leur part dans le pic de mortalité, un protocole expérimental est actuellement mis en place dans les exploitations couvertes par l'étude. Des mesures prophylactiques efficaces seront ensuite déterminées.

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Stocking rate of sheep and survival of helminth infective larvae on *Brachiaria* pastures

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Abstract

A study was undertaken at Mankon, Cameroon, to determine a pasture grazing system for sheep that would produce optimum animal performance and herbage yield as well as limit the hazards of helminthiasis.The optimum stocking rate for Cameroon Grassland Dwarf ewes was determined by comparing animal performance, herbage yield, pasture contamination and infectivity of the animals. The animals were grazed on predominantly Brachiaria pastures at three stocking rates: 29, 39 and 47 animals/ha. The results indicated that helminth infestation rate and pasture contamination rose as the stocking rate increased. Pasture contamination at 29 animals/ha remained insignificant till after 12 weeks of grazing. Live weight was little affected by stocking rate.The results of the regression of herbage yield over time differed ($P<0.01$) with the stocking rate. Helminth larvae survived on Brachiaria pastures for about 11 weeks during the wet season. This study indicates that optimum animal performance and herbage yield can be achieved at a stocking rate of 29 animals/ha, provided animals are moved after three months to allow for the previously grazed pasture to be decontaminated.

Taux de charge ovine et survie des larves infestantes d'helminthes sur pâturages à Brachiaria

Résumé

Une étude a été entreprise à Mankon (Cameroun) afin d'établir un système d'alimentation en vert destiné à des ovins et qui permette d'obtenir des performances zootechniques et une production de matières vertes optimales, tout en limitant les risques d'helminthiase. Pour déterminer le taux de charge optimum pour des brebis Djallonké du Cameroun, on a procédé à une comparaison des performances zootechniques, de la production de matières vertes, de la contamination des pâturages et de l'infectiosité des animaux. Ceux-ci étaient conduits sur des pâturages à dominante Brachiaria à raison de 29, 39 et 47 animaux par hectare. Les résultats font apparaître un accroissement du taux d'helminthiase et de la contamination des pâturages avec l'augmentation du taux de charge. La contamination des pâturages qui portaient 29 animaux à l'hectare demeurait insignifiante jusqu'après la 12e semaine de pâture. Le taux de charge n'avait presqu'aucun effet sur le poids vif. Les résultats de la régression de la production de matières vertes sur le temps ($P<0,01$) variaient en fonction du taux de charge. Les larves d'helminthes survivaient sur les pâturages à Brachiaria pendant 11 semaines environ au cours de la saison des pluies. Il ressort de l'étude que les meilleures performances zootechniques et la production optimale de matières vertes s'obtiennent avec un taux de charge de 29 animaux par hectare, à condition de déplacer les animaux après trois mois afin de permettre la décontamination du pâturage.

Introduction

Stocking rate is the most important management factor influencing the output of animal products on pasture, the stability and persistence of the pasture components and also the financial returns which the farmer receives (Humphreys, 1978).

Overstocking reduces the opportunity for selective grazing. This may result in overgrazing, poor nutrition of the animals and an increased risk of helminthiasis, with consequent reduction in the condition of the animals. There is little information in Cameroon on the relation between flock management practices, the level of parasitism and the production of herbage. This study was therefore undertaken to determine a pasture grazing system for sheep that would produce optimum animal performance and pasture yield as well as limit the hazards of helminthiasis.

Materials and methods

Experiment 1. Studies on stocking rate

Recently bred Cameroon Grassland Dwarf ewes were maintained at three stocking rates (29, 39, 47 ewes/ha) on paddocks of predominantly *Brachiaria* pastures for 14 weeks during the rainy season (July to September). The rates chosen were based on previous experience of

grazing sheep and goats at the research station and were similar to those used by Cameron and Gibbs (1966). The animals were dewormed with Ivermectin at 200 g/kg of body weight prior to the start of the study. Supplementary feeding was not practised. However, water and salt were provided *ad libitum*.

Data collected included measurements of live weight, faecal strongyle egg counts, pasture larval counts, feed availability measured at ground level (forage yield/ha) and grazing pressure (leaf–stem ratio).

Experiment 2. Survival of strongylid infective larvae on pasture

The method used was similar to that described by Okon and Enyenihi (1977). The study was carried out on a 1/8 hectare fenced area of level pasture land consisting predominantly of *Brachiaria ruziziensis*. Twelve experimental plots were used, each of 2 m^2 and with boundaries marked by 20-cm wide shallow furrows. The grass on each plot was maintained at a uniform height of 6 cm by periodic clipping, the clippings being allowed to remain on the plot. During the first three days of each month throughout the calendar year, fresh goat faeces containing a known number of strongyle eggs were spread uniformly on one of the 12 plots. A sample of the faeces spread each month was cultured for two weeks at ambient temperature to determine the proportion of eggs of each species in the sample. One week after the last faeces were spread on the pasture, a 100 g grass sample was collected at random from the plot and infective larvae were extracted and counted using a modification of the technique of Lancaster (1970). The collection of grass samples was continued weekly until no larvae could be extracted for two successive weeks. The procedure was repeated for each plot until all 12 plots had been examined. Daily records of minimum/maximum temperature and rainfall were kept throughout the study period.

Statistical analyses were carried out according to the methods described by Steel and Torrie (1960). Differences in faecal egg counts between animals on the three stocking rates were determined by the Kruskal-Wallis test (Neter and Wasserman, 1974). Changes in liveweight with time within stocking rates were subjected to the paired t-test. The regression slopes for forage yield were compared using multiple regression (least squares regression). The differences in survival period on pasture for infective larvae of *Haemonchus contortus* and *Trichostrongylus* were assessed by Mann Whitney u test (Snedecor and Cochran, 1967). The correlation between rainfall and relative transmission potential was assessed by Spearman's rank correlation coefficient (Snedecor and Cochran, 1967).

Results

Liveweight changes

The data on liveweight changes under the three stocking rates are shown in Table 1. The weights adjusted for lambing were not significantly affected by stocking rate ($P>0.05$). The regressions had similar slopes and did not differ in magnitude. Parturition and lactation, on the other hand, generally resulted in a progressive decrease in the live weight of the ewe for at least 10 weeks, the decrease already being significant ($P<0.001$) by two weeks post parturition.

Parasitology

The parasitological data are presented in Tables 2 and 3. The infection rate generally rose as the stocking rate increased from 29 animals/ha to 39 animals/ha, although the difference in egg count was not significant. The pasture stocked at 29 animals/ha remained free of contamination for 12 weeks from the start of grazing (Table 2). The animals grazing on this pasture maintained a median egg count of less than 500 eggs per g of faeces during this period. By contrast, the median egg count increased to more than 600 eggs per g of faeces between the 6^{th} and 12^{th} weeks in the ewes stocked at 39 and 47 animals/ha. Egg counts and pasture contamination were generally lower at 47 animals/ha than at 39 animals/ha (Table 2). Ewes stocked at 29 and 39 animals/ha had lambing rates of 67 and 71% respectively. The post-parturient rise in faecal egg counts was more pronounced at 39 animals/ha. At 47 animals/ha only two ewes lambed, the first at 10 weeks and the second at one week before the end of the experiment. The post-parturient rise in egg count was evident in the ewe that lambed earlier, where the egg count rose from 100 eggs to 3250 eggs per g of faeces within 2 weeks of lambing. *Haemonchus contortus* was the predominant helminth species in the animals of the

Table 1. *Mean initial liveweight and mean weight changes in Cameroon Grassland Dwarf ewes at three stocking rates on predominantly Brachiaria pastures.*

Stocking rate (animals/ha)	Class of animal	No. of animals	Initial weight (kg)	Liveweight change (kg)
29	Ewes that lambed	7	32.3	-2.4
	Ewes that did not lamb	2	30.5	4.5
39	Ewes that lambed	5	32.6	-3.4
	Ewes that did not lamb	2	32.0	4.5
47	Ewes that lambed	2	35.5	2.0
	Ewes that did not lamb	4	31.8	4.2

three groups, accounting for 91% of the strongyle eggs in the faeces. *Trichostrongylus* sp and *Oesophagostomum* eggs together comprised only 9% (Table 3).

Table 2. *Larval contamination of pasture grazed by Cameroon Grassland Dwarf ewes at three stocking rates.*

Stocking rate (animals/ha)	Infective larval counts per kg dry matter (DM) of pasture (weeks)*						+
	2	4	6	8	10	12	14
29	0	0	0	0	0	0	146
39	0	0	0	0	278	250	268
47	0	0	0	20	105	86	124

* Period after the start of study.

Production of herbage

The leaf-stem ratios measured from the eighth week of the experiment are shown in Table 4. The leaf-stem ratio was lower at 39 and 47 animals/ha than at 29 animals/ha, but the difference was not statistically tested. The regressions of herbage yield on time differed according to the stocking rate ($P<0.01$). The regression slopes were -0.14, -0.17 and -0.21 at 29, 39 and 47 animals/ha, respectively, but these were not significantly different from each other.

Survival of infective larvae on pasture

The duration of survival of infective larvae on pasture in relation to the month of deposition of the faeces containing the eggs is shown in Table 5. Infective larvae developed from eggs deposited on pasture between April and October (rainy season). None developed from eggs deposited between November and March (dry season) except in December when there were unseasonal rains. The shortest survival time during this period was for larvae hatched from eggs deposited at the beginning of April. Infective larvae that hatched during the rainy season survived on pasture for an average of 10 weeks, with a range of 6 to 13 weeks. Larvae of *H. contortus* survived longer than those of

Table 3. *Proportion of each strongyle egg type in faeces from sheep grazing at three stocking rates at Mankon, Cameroon.*

Stocking rate (animals/ ha)	Proportion of egg type in faeces (%*)		
	Haemonchus	Trichostrongylus	*Oesophagostomum*
29	90.5	7.5	2
39	93.5	1.5	5
47	90.0	4.0	6

* Mean values at the 12th and 14th weeks from the start of the study.

Table 4. *Leaf-stem ratio for pastures grazed by Cameroon Grassland Dwarf ewes at three stocking rates.*

Weeks from the start of grazing	Leaf-stem ratio		
	29 animals/ ha	39 animals/ ha	47 animals/ ha
8	1.0	0.5	0.3
10	1.0	0.4	0.3
12	0.9	0.3	0.3
14	0.6	0.2	0.2

Table 5. *Survival of infective larvae of H. contortus and Trichostrongylus on pasture at Mankon.*

Month of deposition of eggs on pasture 1988–89	Duration of survival of infective larvae on pasture (weeks)		Number of infective larvae recovered		Relative transmission potential (No. of days x % eggs)	
	HC	TC	HC	TC	HC	TC
April	7	6	430	2884	0.98	38.64
May	13	11	6570	17455	16.38	154.77
June	10	10	4087	4214	32.20	51.10
July	11	9	4411	3564	25.41	15.12
August	10	9	1747	9057	45.50	103.95
September	12	12	27664	15561	10.44	39.48
October	13	9	7968	9504	29.12	97.65
November	0	0	0	0		
December	6	6	338	56	0.84	0.42
January	0	0	0	0	0	0
February	0	0	0	0	0	0
March	0	0	0	0	0	0

Table 6. *Seasonal variation in population of H. contortus (HC) and Trichostrongylus (TC) on pasture at Mankon.*

Period (month in 1988–89)	No. of infective larvae on pasture plots			% of infective larvae of each species on pasture	
	HC	TC	Total	HC	TC
April	376	2704	3084	12.2	87.8
May	5248	16308	21556	24.3	75.7
June	4487	5167	9654	46.5	53.7
July	3068	2966	6034	50.8	49.2
August	3073	8548	11621	26.4	73.6
September	14496	12092	26528	54.6	45.4
October	18196	12816	31012	58.7	41.3
November	3178	1662	4840	65.7	34.3
December	981	62	1043	94.1	5.9
January	112	26	138	81.2	18.8
February	0	0	0	0	0
March	0	0	0	0	0

Trichostrongylus sp (11 and 9 weeks, respectively), but the difference was not significant.

Table 5 also shows the number of infective larvae recovered from each experimental plot as a percentage of the number of eggs spread and gives the relative transmission potential of these larvae. A significantly ($P<0.05$) greater proportion of eggs of *Trichostrongylus* sp successfully developed into infective larvae during the rainy season than did eggs of *H. contortus*. The relative transmission potential was highest in August for *H. contortus* and in May for *Trichostrongylus* sp. The correlation between rainfall and transmission potential was significant ($P<0.01$) for both species (*H. contortus*: $r = 0.8$; *Trichostrongylus* sp: $r = 0.73$).

Table 6 gives data on the proportion of each larval type present on the plots during each month of the year. The data revealed that the proportion of infective larvae of *H. contortus* on pasture steadily increased as the rainy season progressed. The proportion of *Trichostrongylus* sp larvae on the pasture was highest at the beginning of the rains and decreased progressively towards the end of the rainy season.

Discussion

The results of this study show that the best performance of Cameroon Grassland Dwarf ewes grazing on predominantly *Brachiaria* pastures can be obtained at a stocking rate of 29 animals/ha. The changes in body weight adjusted for parturition were not different between the three stocking rates. However, there was an indication that grazing for longer than 12 weeks would depress body weight at stocking rates higher than 29 animals/ha.

More obvious was the effect of stocking rate on helminth infestation. The greater mass of herbage at the beginning of the study plus a washing effect by the rain probably tended to reduce the concentration of larvae on the herbage. The larval count of zero during the early period of grazing meant that larvae were either absent or were so few that they could not be recovered by the extraction method used. The change in level of pasture contamination and infestation rate with stocking rate was clearly evident as the stocking rate rose from 29 to 39 animals/ha. There was no evidence of an increase in pasture contamination or nematode burden with the increase in stocking rate from 39 to 47 animals/ha.

Cameron and Gibbs (1966) obtained lower counts of *H. contortus*, *Ostertagia circumcincta* and *Trichostrongylus* sp in lambs stocked at 48 animals/ha than in those stocked at 41 or 35 animals/ha. Michel (1964) observed that at a heavier stocking rate the grass is grazed low resulting in a smaller daily intake of herbage per head. While this would result in the ingestion of fewer larvae, a lower nutrition status resulting from low herbage intake may reduce the animal's resistance to worm infection and to its harmful effects.

This probably explains why a stocking rate of 39 animals/ha resulted in lower faecal egg counts and lower pasture larval counts than a stocking rate of 47 animals/ha. However, it is also probable that the higher lambing rate of the animals grazing at 39 animals/ha (71%) could have resulted in a more rapid rise in faecal egg counts (post-parturient rise) and pasture contamination than occurred in the group stocked at 47 animals/ha. In this group a 33% lambing rate was recorded only during the last four weeks of the experiment.

The stocking rate of 29 animals/ha resulted in patch grazing with uneven decline in pasture yield since there was an unlimited opportunity for selective grazing. At 39 and 47 animals/ha, the grazing pressure was heavy and the pastures were grazed more evenly. Overgrazing was clearly evident at 47 animals/ha. The high stocking rate resulted in a rapid decline in herbage production and less feed being available to the animals.

Haemonchus contortus and *Trichostrongylys* sp are the predominant helminth species affecting sheep and goats in the high- and mid-altitude zone of Cameroon (Ndamukong et al, 1986). One of the most

interesting features of the trichostrongylids is their dependence on climate for development and survival (Dunn, 1978). Rainfall appears to be the basic requirement for development and survival of eggs and larvae of *H. contortus* and *Trichostrongylus* sp on pasture. Shorb (1944) noted that a lowering of the moisture content of the faeces raised the death rate of the eggs. Temperature, on the other hand, did not appear to be a limiting factor for larval development and survival. The mean minimum temperature (14.8 ± 1.8°C) recorded during the study was well above the minimum (10°C) at which infective larvae of *H. contortus* and *T. colubriformis* can develop (Wang, 1967; Ndamukong, 1987).

The results presented here reveal that a significantly greater proportion of eggs of *Trichostrongylus* than of *H. contortus* developed into infective larvae during the rainy season (Table 5). However, the high fecundity constant of *H. contortus* (Crofton, 1957) enabled the latter to leave more surviving infective larvae on pasture at the end of the rains. Although eggs placed on pasture during the dry season did not develop, larvae that had developed during the last month of the rains survived until January. This is in agreement with the finding of Andersen et al (1966) that infective larvae are more resistant to the influence of external conditions than are eggs and pre-infective larvae.

Conclusions

These studies indicate that infective larvae of *Haemonchus* and *Trichostrongylus* on *Brachiaria* pasture die after about 12 weeks on the pasture. The great majority of eggs or larvae probably die within a week after arrival on pasture, but enough survive for 9-11 weeks to produce severe infestations in susceptible sheep and goats. Under a rotational system of grazing management, optimum animal performance and herbage yield can be achieved at a stocking rate of 29 animals/ha. The risk of parasitic gastro-enteritis at this stocking level is minimal. However, animals should not be allowed to remain on the same pasture for more than three months, as pasture larval contamination starts escalating after this time. Safe pastures can be produced from contaminated pastures by resting them for at least three months. Since pastures are virtually free of contamination during the last two months of the dry season (mid January – mid March), the duration of grazing on a pasture during this period could depend on herbage availability rather than on parasitic considerations. These findings can be used in grazing pasture management to limit the intake of infective larvae from pasture and ensure adequate nutrition for the animals.

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Effect of strategic anthelmintic treatment on growth performance and survival rate of native lambs in the subhumid environment in Mali

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Abstract

A study on the effect of strategic anthelmintic treatment on the growth performance and survival rate of native lambs was carried out in a subhumid environment in Mali from May 1989 to April 1990. Daily weight gain was analysed for six observation periods of two months each over the year. The daily weight gain of treated lambs was significantly higher ($P<0.05$) than that of the control lambs during the rainy season (September to December) with a net return of 206 CFA (1US$=250 cfa) per lamb. However, this weight gain advantage could not be maintained for the rest of the year due to the shortage and poor quality of fodder during the dry season. Overall, there was no significant difference in the daily weight gain of Groups 1 and 2 lambs and anthelmintic treatment did not affect lamb mortality ($P>0.10$). The average mortality rate in the experimental lambs was 19%.

To maximise lamb productivity fenbendazole alone should be given to lambs twice a year (in the middle and at the end of the rainy season) along with feed supplementation in the following dry season.

The results of this study also suggest that gastro-intestinal nematode infection has no cumulative negative effect on lamb growth performance in the Malian subhumid environment with a low plane of nutrition. Primary causes of lamb mortality in this environment should be further investigated as nematode infections do not appear to cause many deaths.

Effet de traitements anthelminthiques stratégiques sur les performances de croissance et la viabilité des agneaux indigènes dans la zone subhumide du Mali

Résumé

Une étude de l'effet des traitements anthelminthiques stratégiques sur les performances de croissance et le taux de survie d'agneaux indigènes a été effectuée dans la zone subhumide du Mali de mai 1989 à avril 1990. Les gains moyens quotidiens (GMQ) sur six périodes de deux mois ont été analysés. Le GMQ des agneaux traités était significativement supérieur ($P<0,05$) à celui des témoins pendant la saison des pluies (de septembre à décembre), ce qui permettait d'obtenir un revenu net de 206 FCFA (1 $US = 250 FCFA) par agneau. Cependant, cet avantage pondéral n'a pas été maintenu pendant le reste de l'année en raison du déficit quantitatif et qualitatif des fourrages au cours de la saison sèche. Dans l'ensemble, il n'y avait pas de différence significative entre les agneaux des lots 1 et 2 et le traitement anthelminthique n'a pas influé sur le taux de mortalité des agneaux ($P>0,10$). Ce dernier s'élevait à 19% chez les agneaux de l'expérience.

Pour maximiser la productivité des agneaux, il faut leur administrer du fenbendazole seul deux fois par an (au milieu et à la fin de la saison des pluies) et leur offrir des aliments complémentaires pendant la saison sèche suivante.

Les résultats de cette étude font également apparaître que, dans la zone subhumide du Mali, les nématodoses gastro-intestinales n'ont pas d'effet dépressif sur les performances de croissance des agneaux soumis à un faible niveau d'alimentation. Les principaux facteurs de la mortalité des agneaux élevés dans ce type de milieu devront être recherchés, la mortalité due aux nématodoses se révélant peu importante.

Introduction

In southern Mali, small ruminants (mainly composed of West African Dwarf sheep and goats) are owned by a large proportion of the rural community on account of their ability to tolerate trypanosomiasis which is endemic in that area. Small ruminants serve as the main source of animal protein for the rural community and also provide a valuable income source for smallholder farmers, including women. These small animals are hardy, easy to handle and highly prolific. The main feed supply is the native grassland adjacent to the villages,

sometimes supplemented by cereal grain stubble, straw or crop residues.

Because small ruminants are kept by mixed crop–livestock farmers as a sideline to their crop oriented activities, they are very often neglected. They are herded by village children during the cropping season, but during the dry season are allowed to browse and scavenge freely over the compounds and along the roadsides. The animals sometimes stay in the bush for many days without any guard before returning home. Due to poor health management and inadequate nutrition, the productivity of these animals remains low (Wilson, 1982). An important factor responsible for the mediocrity of small ruminant production in tropical Africa is disease, particularly parasitism (Allonby and Urquhart, 1975; Malaki, 1976; Vercruysse, 1985; Shavulimo, 1986; Pandey, 1991; Waller, 1991).

The objective of this study was to evaluate the effect of strategic anthelmintic treatment on growth performance and survival rate of native lambs in a subhumid environment.

Materials and methods

Area of study

The production system is agro-pastoral in which small ruminants are kept indoors at night and herded by village children during the day as described above. The main vegetation is sudanese type with large broad-leaved deciduous trees, tall grasses and shrubs. The climate is subhumid, with rainfall ranging between 900 and 1100 mm per annum. There are two distinct seasons, the rainy season from May to October and the dry season from November to April. Average temperature is around 20°C with a maximum reaching 35°C in March/April and the minimum 10°C in December/January.

Experimental design

Between May 1989 and April 1990, 552 Djallonké lambs were systematically allocated at birth to three treatment groups. Lambs of groups one and two received fenbendazole at 10 mg/kg^{-1} birth weight at three weeks of age and every month thereafter until October 1989. Lambs of group two received amprolium at the same dose during the same period of treatment. A single treatment was given to lambs born from October onwards. Lambs of group three served as the control group and were left untreated.

Measurements

Faecal samples were taken directly from the rectum of each animal every month from May to November 1989, then every two months from December 1989 to April 90. They were examined by the modified McMaster technique for faecal egg counts (FEC). Liveweight change as a measurement of growth performance was monitored by lift-weighing individual animals every 45 days. Mortality was recorded as it occurred. Temperature and rainfall data were obtained from the local climatology station.

Statistics

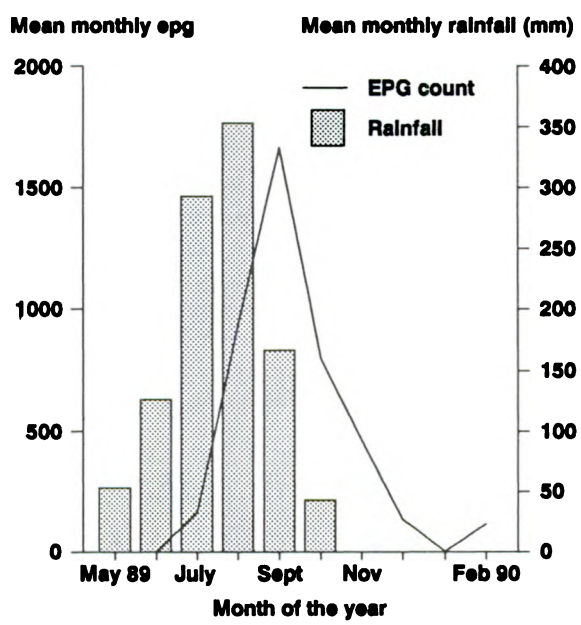
Average daily gain (ADG) analysis was performed only on animals which had been weighed at least twice. Each age group was analysed by one-way analysis of variance (ANOVA) using the SPSS package. Animals over 365 days old were not included in the analysis.

Results and discussion

Faecal egg counts

No strongyle eggs were found in the faecal samples of the treated lambs three days after drenching, indicating a good treatment response to fenbendazole. However, three weeks later massive re-infestation was observed in treated animals resulting in higher egg counts in some cases than in the control animals. This is indicative of loss of host resistance following the total absence of worms within the host as described by Georgi (1974). Faecal egg count of the control lambs and the rainfall pattern are shown in Figure 1. Lambs started excreting eggs in July with a peak in September (mean of 1700 eggs per gram of faeces). Few eggs could be detected from November to April, which corresponded to the dry season.

Figure 1. *Faecal egg counts for the control lambs and mean monthly rainfall.*



Growth performance

The average daily gain was significantly ($P<0.05$) affected by period of year in all groups combined (Tables 1). Differences of 7 to 15 g/day between the treated lambs (Group 1) and the untreated lambs (Group 3) were observed in October/November but could not be

Table 1. *Average daily gain of experimental lambs for different age groups.*

Treatment group	Period of the year						
	1	2	3	4	5	6	
	May–June	July–Aug	Sept–Oct	Nov–Dec	Jan–Feb	Mar–Apr	Mean
				0–183 days			
All groups combined	94.1	66.5	22.4	49	52.7	60	57.45
Group 1	88.6	71.5	33.3	52.1	54.9	64.0	59.8
Group 2	97.0	66.3	29.0	48.1	52.4	54.7	54.0
Group 3	96.3	64.8	13.3	48.1	50.1	64.0	54.5
				184–385 days			
All groups combined	42	24.1	-10.0	18.3	22.8	40.5	20.18
Group 1	50.9	22.4	-7.5	25.8	18.1	30.3	20.6
Group 2	39.8	22.1	0.08	20.9	32.9	44.6	24.2
Group 3 (control)	39.4	25.7	-16.8	4.8	18.7	51.6	17.3
				0–365 days			
All groups combined	71.9	43.6	5.2	31.3	34.8	35.9	37.17
Group 1	75.4	41.1	9.2^{b}	37.4^{a}	35.8	29.8	36.2
Group 2	68.4	46.1	15^{a}	35^{a}	41.7	39.4	38.2
Group 3 (control)	71.5	43.3	-2.6^{c}	22.1^{b}	27.4	40.1	32.2

abc =Means within a column that have different superscripts are significantly different ($P<0.05$)

maintained for the rest of the year. Shortage of forage and its poor quality may account for this. A study of the availability and quality of forage in the region indicated that quality was low between November and the onset of the rainy season, i.e. May–June (Berkmoes and Diabate, 1988).

Rate of mortalities

Table 2 shows that mortality rates varied according to the period of the year. Mortality rates were similar for all groups during the pre-weaning period at four to five months of age. Peaks were observed in June/July and October/November, corresponding to the beginning and the end of the rainy season respectively.

These observations agree with reports by Traore and Wilson (1988), Bourzat (1984) and Wilson (1982) in the agro-pastoral system in West Africa. Causes of mortality were not fully investigated, but apparently were not associated with parasite burdens. Earlier studies in the zone by Berkmoes et al (1988) indicated that deaths of lambs were more likely to be due to malnutrition, disease and management (losses, predators).

Table 2. *Rate of mortality (0–12 month old lambs).*

Date of birth	Number of births	Mortalities	Rate of mortality %
May/June	45	11	24.0
June/July	24	8	33.3
July/August	16	2	12.5
August/September	12	1	8.3
September/October	38	9	23.7
Nov 89–May 90	50	5	10.0
Total	185	36	19.0

Cost-benefit analysis

In an attempt to estimate the influence of anthelmintic treatment on liveweight change under field conditions, a cost-benefit analysis was performed. Labour costs were omitted from the analysis because the opportunity costs were negligible. Variations in growth rates (Table 1) had a negative impact on returns. Table 3 shows the net profit for lambs of Group 1 at the end of the rainy season, but this advantage could not be maintained for the rest of the year.

Table 3. *Cost-benefit analysis of anthelmintic treatment at the end of the rainy season (Oct. 89) for lambs of Group 1.*

ADG (gm)	Period (day)	Gain (kg)	Gross return (CFA)	Anthelmintic cost (CFA)	Net benefit of treatment (CFA)
13.5	120	1.62	406	200	206

1 US$ = 250 CFA

Conclusion

Although fenbendazole at the dose of 10 mg/kg^{-1} body weight was found to be highly effective against gastro-intestinal nematodes, the strategy adopted in the experiment could not maintain a low level of eggs. It eliminated the existing worm population but the animals were quickly reinfested. Unless treatment is continued it is unlikely to reduce the worm burden. However, continuing treatment also precipitates drug resistance, as pointed out by Nansen (1991) and Waller (1991). The most effective approach is a combination of good management, veterinary care and an improved plane of nutrition. However, anthelmintic and other drugs must be available to the farmers at an acceptable price.

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Intensification of goat production in Uganda and associated health risk management

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Abstract

Indigenous goats and traditional goat husbandry systems in Uganda are described. Intensive management is suggested for the benefit of certain social target groups. Corresponding husbandry, nutritional and health requirements and risks, particularly peracute clostridial diseases associated with high planes of nutrition and their management, are presented. Chemopro- and meta-phylaxis and vaccination programmes carried out in the isolation and zero-grazing units can substantially reduce reinfection and corresponding drug exposure of hosts and parasites, and eventual drug resistance of parasites. These could also reduce costs and drug residues in the host.

Intensification de la production caprine en Ouganda et gestion des risques sanitaires associés

Résumé

Cet article fournit une description des chèvres indigènes et des systèmes traditionnels de production caprine de l'Ouganda. Un mode intensif d'élevage profitable à certaines catégories sociales cibles est proposé. Les besoins correspondants en matière de conduite des effectifs, de nutrition et de santé et les risques liés à ce type d'élevage, notamment les clostridioses suraigües associées à la conduite d'une alimentation hautement nutritive, sont ensuite exposés. Les traitements chimioprophylactiques et métaphylactiques ainsi que les programmes de vaccination réalisés dans des conditions d'isolement et de zéro-pâturage engendrent une diminution considérable des réinfections, donc de l'exposition des hôtes et des parasites aux médicaments, soit, à terme, de la chimiorésistance chez les parasites. Ils peuvent par ailleurs contribuer à réduire les frais ainsi que les résidus de médicaments chez l'hôte.

Introduction

Goats in Uganda have not been artificially selected along breed characteristics to distinguish them phenotypically. Stiff natural selection over the years, however, has produced a population that could be better characterised by two phenotypes: the Small East African Goat which is a small and low weight type, and the Mubende which is a fairly heavy and tall type. Their spatial distribution is obviously not distinct and stunted growth resulting from marginalisation could obscure an otherwise better phenotypic performance. This is chiefly due to opportunistic breeding, feeding and husbandry methods. In 1963 the goat population was estimated to be 2.5 million compared to 0.8 million sheep and 3.2 million cattle (Jameson, 1970). Devendra and Burns (1970) compiled the following data on Ugandan goats: average birth weight of 2.1–2.4 kg; sexual maturity at four months with an average body weight of 14–15 kg; no seasonal breeding; three kiddings in two years with 10–30% twinning; and adult live body weight of 35 kg (range: 20–50 kg). Over 1.5 million goats and sheep were slaughtered in 1960 for human consumption and 1.4 million skins were exported. Jameson (1970) and Okello and Obwolo (1985) stressed the significance of goats as producers of meat, as it is generally preferred over other meats. Mubende goat skins are also of outstanding quality, but there is a prejudice against consumption of goat milk outside Karamoja. Socio-economically, goats play a traditional role as part of a dowry and, more recently, as a financial asset. Amann (1972) reported that a pound of goat meat fetched 50 cents more than beef and highlighted the suitability of a smaller carcass within a rural context. The average herd size ranges between 5–10 according to Sherman (1991).

Generally, traditional goat husbandry systems are determined by land availability, intensity of crop cultivation and availability of young family members or underpaid herdsmen to attend to the goats. Where the area of fallow and marginal land is comparatively small, tethering is the predominant practice, rather than extensive grazing and browsing on free range together with cattle. The characteristics of goat production systems are presented in Table 1.

Because of pressure on land due to an estimated 3% annual human population growth and reduced available child labour due to free primary education in the near future, extensive production methods will have to be replaced with intensive ones. This will require intensive research into potentials and limitations in order

Table 1. *Characteristics of traditional goat husbandry systems practiced in Uganda.*

Comparison Risks/requirements	Tethering	Zero-grazing
Labour inputs	low	high <> very high
Capital inputs	negligible	modest <> very high
Land inputs	marginal	favourable
Gains	low	high <> very high
Controlled breeding	unfavourable	favourable
Theft	more likely	unlikely
Strangulation	likely	unlikely
Dog attacks	very likely	unlikely
Nutrition	poor <> fair	excellent
Forage losses	more likely	less likely
Plant poisoning	possible	unlikely
Snake bites	likely	unlikely
Management	poor	excellent
Crop-owner conflict	likely	unlikely
Environment damage	likely	unlikely
Intensification	risky	controlled & low risk
Health	conditional	good <> excellent
Rabies (risk of infection)	high	low/nil
Ticks and TBD-risks*	high	low/nil
Helminth infection risks	high	low/nil
Reinfection	very high	very low
Fly attacks	few <> many	few
Disease resistance	promoted	lost
Drug exposure (H/P)**	negligible	low
Drug resistance (P)***	negligible	low
Drug residues	negligible	low

*TBD = tick-borne diseases **H/P = host/parasite ***P = Parasite

to utilise efficiently the abundant small ruminant resources in Uganda.

Considerations for the intensification of goat production

Health risks management

Only clinically healthy individuals without any behavioural abnormalities should be selected. All goats kept under intensive regimes must be free from tuberculosis, brucellosis and certain other zoonotic diseases. Standard criteria for the interpretation of intradermal comparative tuberculin-test after inoculation of bovine and avian PPD, using the Hauptner™ test kit and reading results 72 hours later, are to date not available. Similarly, no conclusive evidence is available to verify the prevalence of *brucella melitensis* in Uganda (Nakavuma, personal communication, 1991).

It is advisable to vaccinate the goats twice within a fortnight against enterotoxaemia and other clostridial toxico-infections. Enterotoxaemia in particular has been a significant killer of goats. Any considerable intake of concentrates could precipitate this toxico-infection with only half an hour between the onset of clinical signs and peracute death, leaving no time for successful therapy. Covexin 8™ multivalent vaccine (Cooper) conferred at least partial protection against the aetiological agents types A and D of *Clostridium perfringens*. The incidence of the disease was reduced and the few affected suffered a more chronic course with more time for charcoal soda drench/intraruminal injection therapy (Thedford, 1990). However, many goats reacted visibly, forming sterile abscesses at the cervical hypodermic inoculation site of the vaccine.

The contagious ecthyma (Orf) epidemic proved to be another killer disease, predominantly of kids. Attenuated tissue-culture vaccine, non-pathogenic to human, is not yet available. Vaccination with this

Table 2. *Combined/alternative essential isolation measures.*

Risks	Identification	Measures
Ticks and tick-borne diseases (TBD)	collection ante/post mortem	Ivermectin TM SC or Deltamethrine percutaneous
TBD	parasitological blood/serum tests	chemo-vaccination antibiotic metaphylaxis
Tsetse/biting flies	improved and treated traps collection	reducing population and Deltamethrine percutaneous
Trypanosomes	parasitological blood-\serum tests	drug availability? chemoprophylaxis/ prophylaxis/metaphylaxis?
Mycoplasmoses	clinical/serology	LA-tetracyclines
Clostridial toxicoinfection	bacteriologically	polyvalent clostridial
	GC VFA-pattern	toxoid vaccine 2*3 ml
Enterotoxaemia		6-week interval (and/2weeks ante partum)
Tetanus, etc.		
Contagious ecthyma (Orf)	clinical/serology	attenuated TC-vaccine
		no human pathogenicity

vaccine should be given priority since enterotoxaemia can be better controlled by delayed concentrate provision. Inoculation of fully virulent vaccine in a more suitable site could become a risky alternative because of the zoonotic properties of the Orf virus.

Both ectoparasitosis (including nose-bots and tick-borne diseases) and roundworm endoparasitosis can be controlled by the injection of avermectine. However, it is not always available and costs may be prohibitive even when it is available. Ticks and flies (including tsetse) can be controlled by spot-on™ (Cooper) application and a suitable broad spectrum anthelmintic such as Fenbendazole or, where still active, Thiabendazole. Long acting tetracyclines can control subclinical infections, especially subclinical mycoplasmoses. Sufficient time should be allowed between individual measures and withdrawal periods must be observed.

Non-endemic diseases can attain epidemic proportions (in case of infections); this requires diagnostic monitoring and corresponding modification of isolation periods. Presently the period covers at least three weeks which seems insufficient for Orf. But since the viability of the virus is extremely high and of long duration, any extension of the isolation period becomes an economic issue. In Table 2, alternative isolation measures are presented in view of drug costs, ease of application and side effects.

Once the goats have been carefully selected and isolated, certain prophylactic and metaphylactic measures have to be taken into account: essentially, environmental control. Most parasites or their vectors requiring a suitable microenvironment can be successfully controlled by altering the environment to the parasites' disadvantage. Zero-grazing units offer a controlled environment. Smooth walls and clean concrete floors or deep litter that absorbs moisture and covers infective stages are not conducive to parasite survival and propagation. Once the animals have been cleared of parasites in the isolation unit they can be maintained on low challenge, providing the cut-and-carry fodder originates from an enclosed controlled area.

Improved housing

Two types of housing are proposed: a high cost, more durable type for high income groups and a low cost, less durable type for low income groups.

Low cost version

Roofing is similar to traditional grass thatched huts with an additional polythene sheath between the upper and lower grass or papyrus-mat layers at the lower edge of the roof. The plastic sheath can be folded and suspended to make a gutter for rain-water collection. The enclosure is made of scrap timber ensuring that the lower 50 cms of a 1.50 m fence is keeping the deep litter coffee husk layer of at least 30 cm inside. The animals are kept in pens (same height) and fed from troughs; water is provided *ad libitum*. No additional walking area is

provided. Bedding must be changed when faeces and urine visibly accumulate; it provides excellent manure for crops and forage.

High cost version

Roofing is made from corrugated iron sheets. The surface is cement, and a cement walking area is provided. Resting places are roofed and have slatted floors. Feeding is from troughs and mangers. The unit should be cleaned twice daily and the sewage processed in a biogas plant before being used to fertilise crops and forage.

Improved feeding

Most of the provisions which proved useful in zero-grazing cattle systems have been experimentally adopted and are now under trial. Improved *Pennisetum purpureum* (Kawanda variety) cut as roughage at 1 m height, chopped to a length of approximately 5 cms and offered *ad libitum* is supplemented by not more than 1/3 *Leucaena leucocephala* to prevent mimosin intoxication. This browsing species is drought-resistant and apparently very palatable. A legume mixture of *Desmodium intortum* and *Uncinatum, Centrosema pubescens, Macroptilium atropurpureum, Dolichos lablab* and *Stylosanthes spp.* is readily taken as an enriched supplement. Keeping a feeding calendar would improve feeding management and cost effectiveness.

Farm-produced concentrates provide fresh, high quality meals vis-a-vis substandard commercial products. Like any new ration component, concentrates must not be introduced abruptly otherwise bloat (in case of overeating) or enterotoxaemia could cause death.

Some dairy cow farmers still find it wasteful to provide mineral supplements to their cows, but unlike game, the cows are confined or restricted in their movements. Therefore they are less able to seek mineral rich soils from which they can obtain their mineral requirements. This situation is worse with small ruminants and only free-range husbandry could allow goats to seek mineral-rich soils actively. However, geophagia increases the risk of lesions in the oral and gastro-intestinal tract linings and toxico-infection by clostridial pathogens. Kids born with signs of bone deformities which respond favourably to injectable mineral glucose depots or the provision of salt licks are an indication of this condition. Intensification must therefore provide for mineral supplementation either mixed in the ration or fed separately.

Multipurpose indigenous goat breeds respond well to the provision of crude rock salt blocks and, in particular, of compound MEN (M = mineral, E = energy, N = non-protein-nitrogen) salt licks.

Opportunities for and benefits of intensified goat production

Traditional or opportunistic husbandry systems produce hardy animals by natural selection; the potentials of this are not systematically exploited. Merely importing exotic breeds is not an effective exploitation measure. The few exotic goats which have found their way into Uganda as an adjunct to NGO (Non Governmental Organisation) sponsored zero-grazing cattle systems have been introduced without due consideration of the inputs required to meet expected outputs. Within opportunistic husbandry systems, the exotics (British Alpine, Toggenburger and Angora) cannot be expected to display superior performance.

The systematic exploitation of indigenous resources should serve as a good starting point. Selection of well adapted indigenous goats is imperative so that their adaptation to parasitic, nutritional and climatic stress can be fully exploited. This should be followed by education on scientific husbandry methods.

After the farmers have received training on the advantages of scientific husbandry methods, suitable exotic breeds should be selected along their adaptive and productive potential within each distinct environment e.g. tropical montane, dry savannah, moist savannah, rain forest and islands. They should then be performance-tested in controlled crossbreeding trials. Goats, like other small domesticated stock species (rabbits, poultry, fish), are excellent experimental material for studying indigenous resource potentials and utilisation alternatives. They could offer relevant and exciting exemplary learning and teaching alternatives in formal and adult education of farmers. Since women's ownership of goats is empirically much less contested in Uganda than the ownership of cattle, gender issues could be defused in a productive way in this vital socio- economic sector.

Intensified goat production could provide socio-economic care and vocational training opportunities for over 1.5 million war- and AIDS-orphaned young people (equivalent to >10% of the total population).

Feedlot methods in or around cane plantations can utilise cane-tops and other by-products to promote offtake in seasonally overstocked areas. This makes better use of available biomass, which is often burned and does not need high capital investments.

Acknowledgement

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Editors' note

Readers interested in the composition of MEN salt licks should contact the authors.

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Enquête écopathologique sur les pneumopathies des chèvres en saison fraîche au Tchad: un outil au service du développement

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Résumé

Cet article décrit la méthodologie d'une enquête écopathologique effectuée par le Laboratoire de Farcha pour déterminer les facteurs de risque intervenant dans la pathologie respiratoire et la mortalité des caprins au Tchad. Des prémodèles conceptuels d'analyse à l'échelle de l'individu, du troupeau de concession et du troupeau de jour ont été constitués afin d'assurer la pertinence et l'exhaustivité des informations recueillies.

Surveying the ecology of lung diseases in goats during the cold season in Chad: A tool for development

Abstract

This article describes the methodology of an ecological survey of diseases used by the Farcha Laboratory to define risk factors of lung diseases and mortality in Chadian goats. Conceptual analytical preliminary models at the individual animal, individual herd and collective herd levels have been designed to ensure relevance and completeness of collected data.

Introduction

En saison fraîche, les pneumopathies des petits ruminants sont une préoccupation majeure des éleveurs tchadiens. De nombreuses recherches ont été effectuées sur ce problème au Laboratoire de Farcha, recherches dont la synthèse a été faite par Lefèvre (1977). Celui-ci estime que les pneumopathies spécifiques dues à un seul agent infectieux responsable de l'ensemble des symptômes et des lésions observées sont rares. En revanche, les pneumopathies à étiologie multiple sont de loin la cause essentielle de la mortalité par maladie infectieuse. Cette notion de pathologie multifactorielle ne s'arrête pas aux seuls agents infectieux: les conditions de vie des animaux jouent également un rôle très important (Le Jan *et al.*, 1987). Le Laboratoire de Farcha et le CIRAD-EMVT (Centre de coopération internationale en recherche agronomique pour le développement - Département d'élevage et de médecine vétérinaire) ont donc décidé de réaliser une enquête pour tenter d'élucider ce problème, en s'imposant comme contraintes de tenir compte de tous les phénomènes susceptibles d'influer sur la pathologie respiratoire et d'obtenir rapidement des résultats vulgarisables.

Pour ce faire, le Laboratoire a réalisé une enquête écopathologique dont la méthodologie est présentée ici mais dont les résultats seront publiés ultérieurement.

2. Méthodologie

2.1 L'écopathologie

Le concept d'écopathologie est apparu, en France, à la fin des années 70 devant l'inaptitude du modèle pasteurien classique (un germe, une maladie) à expliquer certaines pathologies de groupe. Considéré sous l'angle de l'écopathologie, le niveau d'équilibre entre performances zootechniques et sanitaires est la résultante des caractéristiques du milieu d'élevage, de la pression des contaminants, des caractéristiques du peuplement animal et des pratiques d'élevage (Landais, 1991). Branche de l'épidémiologie, l'écopathologie a pour objectifs de déterminer parmi ces éléments les facteurs de risque des pathologies multifactorielles (Madec et Fourichon, 1990) ayant une importance économique et de proposer des solutions rationnelles propres à rétablir un équilibre plus favorable à l'éleveur. Jusqu'à présent, la démarche écopathologique a été appliquée aux élevages intensifs (Ganière *et al.*, 1991). Elle paraît intéressante pour les systèmes extensifs des pays tropicaux car, par son approche globale, elle est susceptible d'offrir une alternative aux programmes sanitaires classiques basés sur des prophylaxies médicales. De sérieux aménagements méthodologiques sont cependant nécessaires pour pallier les contraintes liées à l'environnement tropical. Plusieurs tentatives sont en cours: étude des facteurs de risque d'avortements chez la chèvre au Brésil (Faye et Quirin, 1991), de la mortalité des chevreaux au Zimbabwe dans le cadre du Projet vétérinaire caprin, et des pneumopathies des petits ruminants au Sénégal dans le cadre du programme Pathologie et productivité des petits ruminants (Merlin *et al.*, 1990).

2.2 Matériel

En termes d'épidémiologie, l'écopathologie s'appuie sur des enquêtes longitudinales de type suivi de cohorte. Il était donc nécessaire de trouver des éleveurs coopératifs et facilement accessibles. Une typologie des élevages de petits ruminants a été réalisée (Lancelot et Mopaté, 1991), de manière à définir des critères objectifs de choix: éleveurs ne possédant pas de bovins et dont le troupeau caprin s'élevait à 20 têtes au moins. 59 éleveurs ont été choisis dans 13 villages au nord de N'Djamena, le long d'un axe goudronné, à un maximum de 55 km de la capitale.

2.3 Dispositif d'enquête

Un dispositif de suivi individuel a été établi pour déterminer les indicateurs des niveaux de productivité et de santé. Une fréquence bimensuelle des visites a été instaurée. Les informations ont été stockées sur micro-ordinateur, grâce au progiciel PIKBEU (Planchenault et Sahut, 1989) qui permet la saisie et le contrôle des données. Il permet également de calculer les indicateurs démographiques et de croissance usuels et de réaliser des extractions de fichiers pour analyses ultérieures. Les animaux ont été identifiés par des boucles auriculaires plastifiées: au 1er juillet 1991, environ 3 500 petits ruminants étaient répertoriés, dont 85% de chèvres.

2.4 Méthodologie d'enquête

L'enquête s'est déroulée du 15 décembre 1991 au 31 mars 1992. Entre juillet et décembre 1991, les éleveurs et les enquêteurs ont été formés au suivi. Les neuf mois allant de début juillet 1991 à fin 1992 représentent environ un cycle de production et l'on a donc pu comparer les données entre élevages.

Il était nécessaire de rendre compte de la complexité du système de production et de récolter des informations couvrant toutes les facettes des élevages suivis, notamment les aspects socio-économiques, zootechniques, agropastoraux et pathologiques. Une équipe pluridisciplinaire a donc été constituée. Ce noyau de chercheurs a réalisé des enquêtes auprès des éleveurs et consulté la bibliographie afin d'établir une liste pertinente et exhaustive des hypothèses relatives aux facteurs de risque. Il a également défini les phénomènes à expliquer. Deux groupes d'indicateurs ont été retenus: le premier caractérisant la pathologie respiratoire et le second, la mortalité. En effet, la pathologie respiratoire recouvre l'essentiel des symptômes rencontrés en saison fraîche et il est vraisemblable qu'une part importante de la mortalité observée lui soit imputable.

2.5 L'échantillon

La population étudiée était la cohorte des caprins présents au jour J_0 de l'enquête. Cette cohorte a été subdivisée en 4 sous-cohortes: 0–3 mois, 3–12 mois, 1–4 ans, plus de 4 ans. Chacune des variables caractérisant la pathologie respiratoire et la mortalité a été calculée sur les sous-cohortes. Les quotients ont ensuite été établis pour chaque troupeau, en pondérant l'importance relative de chaque sous-cohorte des animaux des 59 élevages.

2.6 Les paramètres utilisés

Trois paramètres ont été utilisés pour décrire la pathologie respiratoire: la fréquence, les récidives et la gravité. La fréquence est le nombre total d'animaux malades observés par troupeau au cours des passages successifs, rapporté à l'effectif du troupeau (cohorte). Le quotient de récidive est le pourcentage d'animaux chez lesquels des signes de maladie ont été observés plus d'une fois. Une échelle de gravité a été construite pour calculer une note individuelle de gravité, permettant d'établir une note moyenne de troupeau (figure 1). La mortalité a été déterminée en rapportant le nombre des animaux morts (toutes causes confondues) pendant la période de l'enquête à l'effectif de la cohorte.

2.7 Les échelles d'observation

Les phénomènes à expliquer étant précisés, trois échelles d'observation ont été choisies: l'individu (caprin), le troupeau de concession (animaux appartenant à un éleveur et passant la nuit dans la même concession) et le troupeau de jour (animaux conduits au pâturage par un même berger). Un prémodèle conceptuel d'analyse a alors été bâti pour chacune des échelles d'observation. Ces schémas (figures 2, 3 et 4) résument toutes les interactions présumées entre les hypothèses de facteurs de risque et les phénomènes à expliquer. Leur élaboration est indispensable pour s'assurer de la pertinence et de l'exhaustivité des informations recueillies. Les prémodèles conceptuels d'analyse permettent la constitution d'une base de données rationnelle et facilitent le dépouillement de l'enquête.

Les fiches d'enquête ont ensuite été réalisées et testées. L'informatisation de la saisie a été préparée avant le début de l'enquête, pour permettre l'enregistrement et le contrôle des données en temps réel.

2.8 Analyse statistique

A ce stade, les grandes lignes de la stratégie statistique du dépouillement ont été tracées. Aucun résultat préalable n'autorisait la définition d'un modèle pertinent d'interaction entre variables explicatives et variables à expliquer. Les techniques exploratoires ont donc été privilégiées (analyse des correspondances, classification). Ces méthodes permettent de décrire la structure des tableaux de données (Benzécri, 1973; Faye et Lescourret, 1991), pour élaborer éventuellement un modèle adéquat (Ducrot et Climarosti, 1991). L'analyse a été effectuée dans deux sens, à savoir le sens ascendant (c'est-à-dire de l'individu vers le troupeau de jour) et le

Figure 1. *Echelle de gravité des symptômes respiratoires*

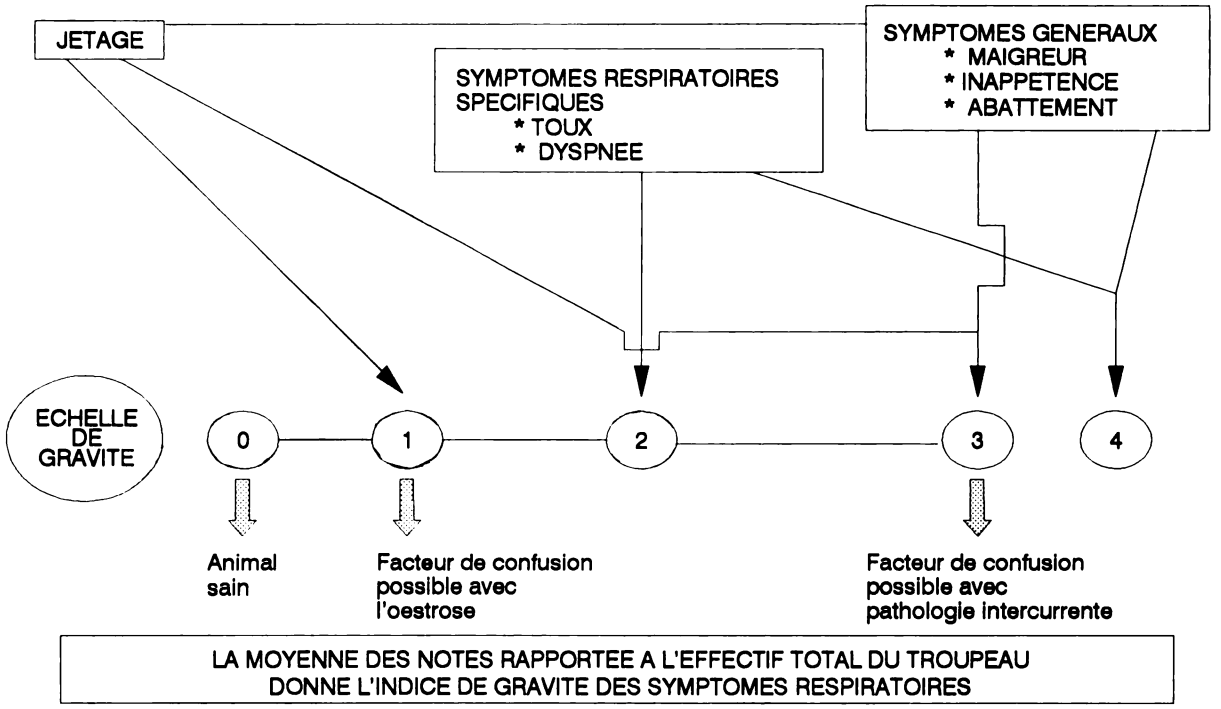


Figure 2. *Prémodèle conceptuel d'analyse à l'échelle de l'individu*

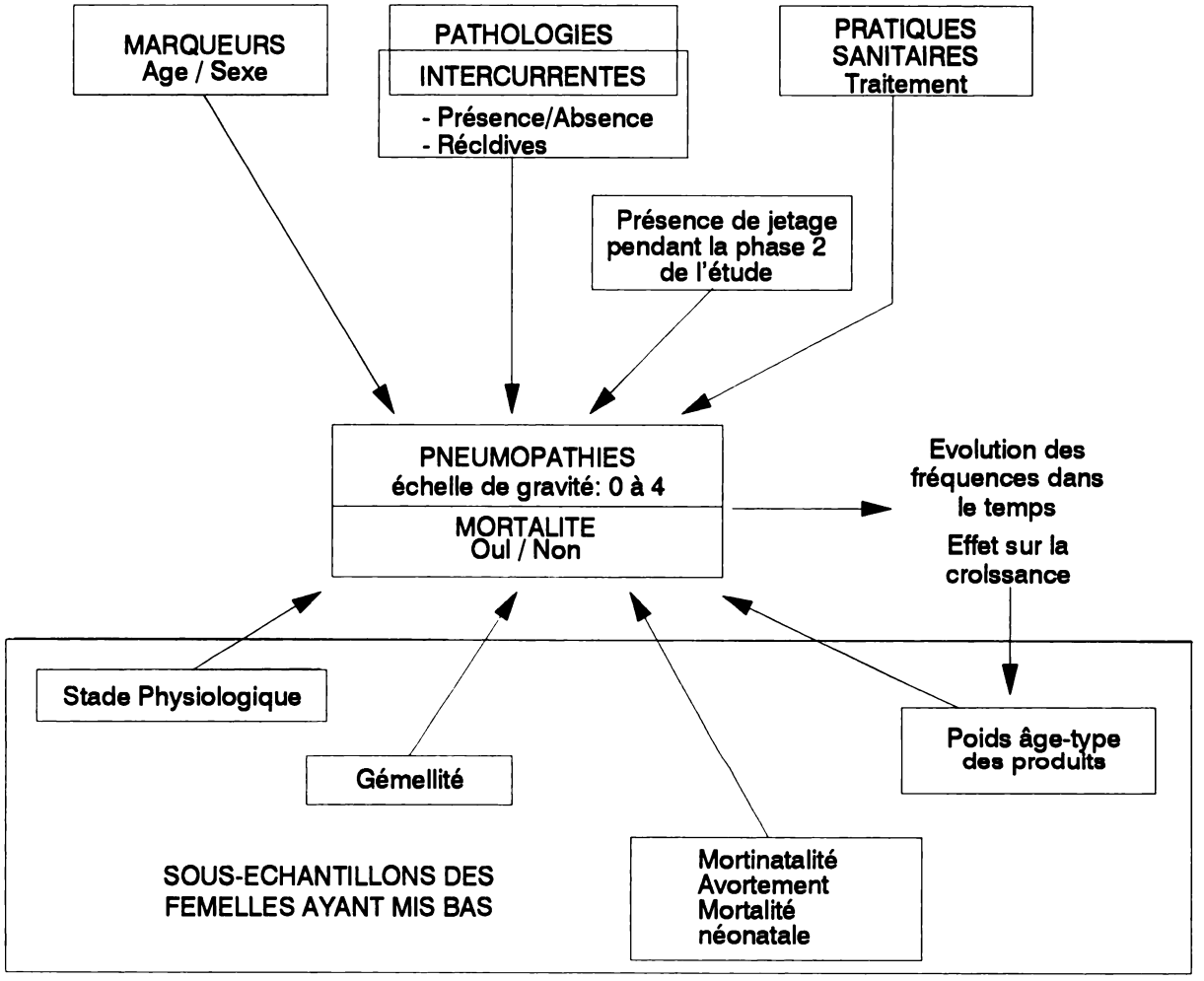


Figure 3. *Prémodèle conceptuel d'analyse à l'échelle du troupeau de concession*

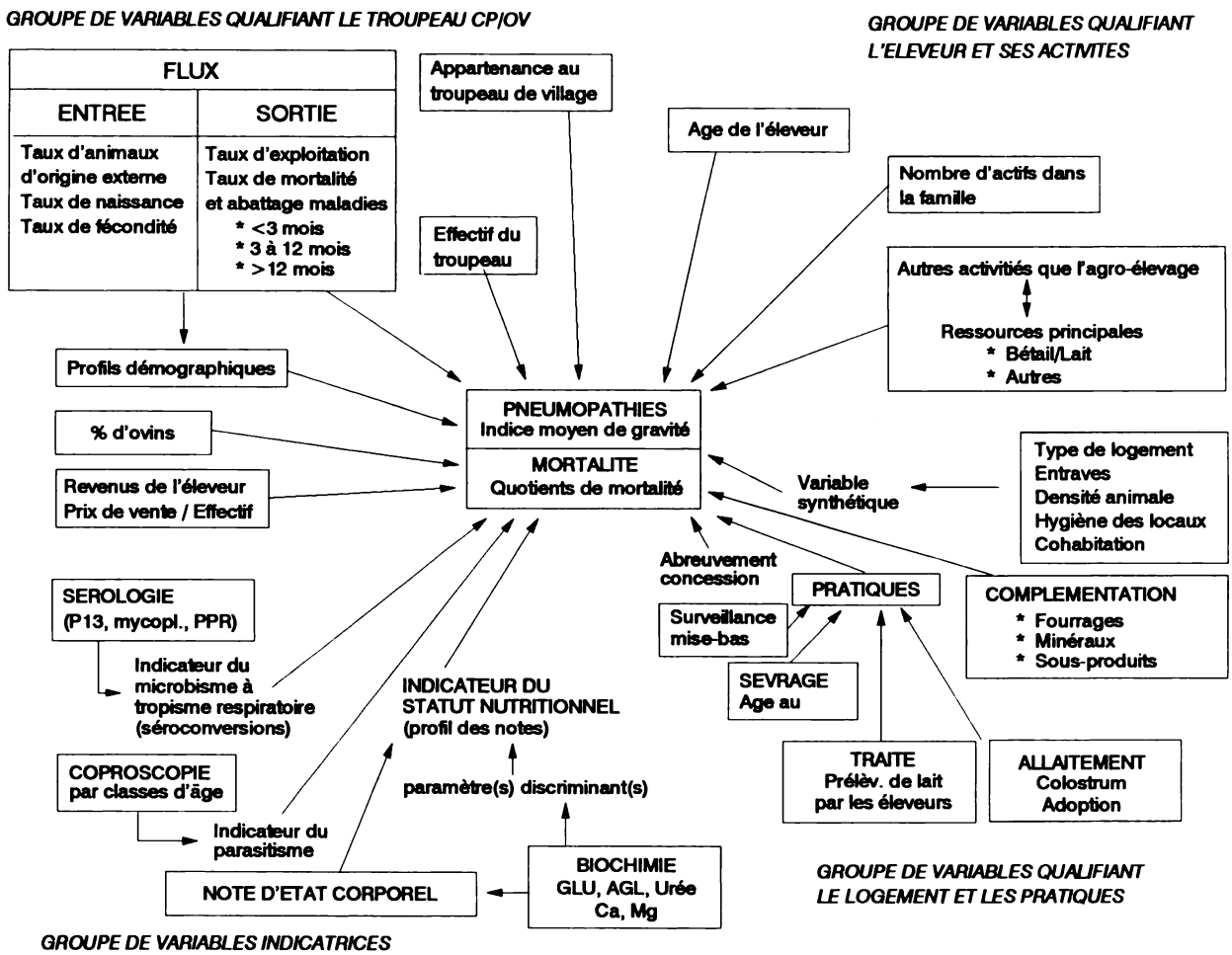
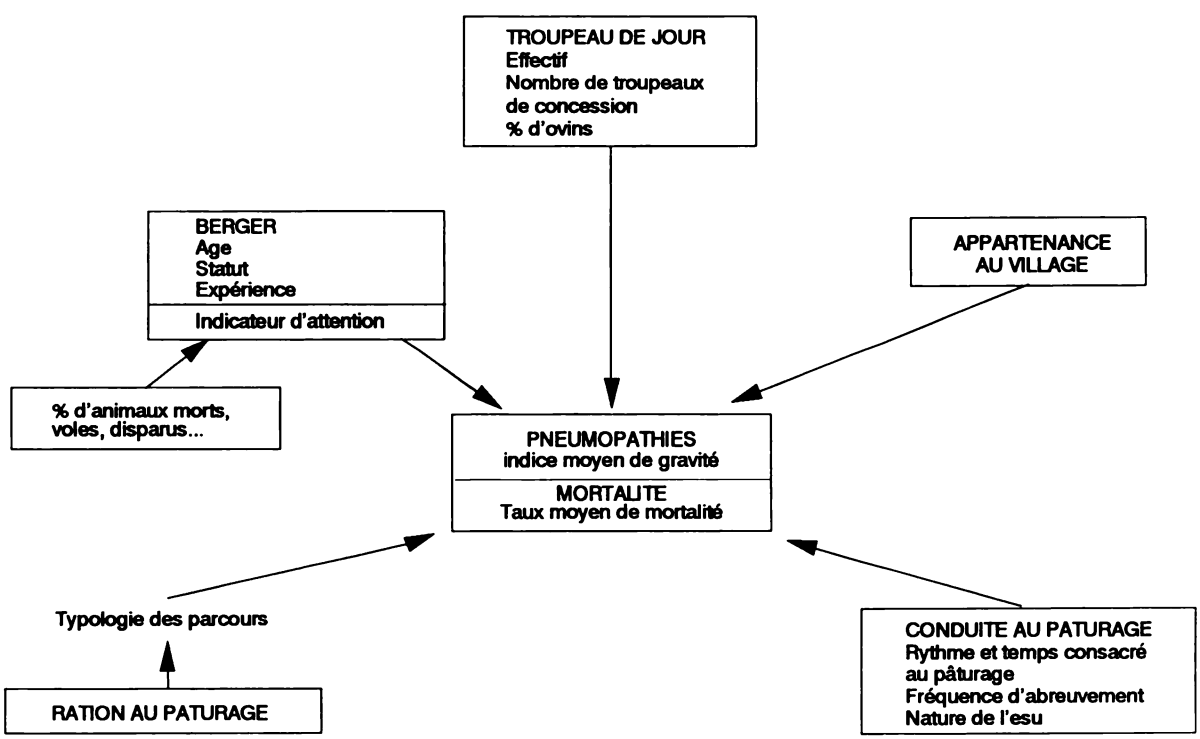


Figure 4. *Prémodèle conceptuel d'analyse à l'échelle du troupeau de jour*



sens descendant (c'est-à-dire du troupeau de jour vers l'individu). A chaque échelle, les facteurs associés à la mortalité ou à la pathologie respiratoire ont été recherchés puis reportés en éléments supplémentaires à l'échelle supérieure (sens ascendant) ou inférieure (sens descendant). De cette façon, il a été possible de détecter et de corriger les facteurs de confusion.

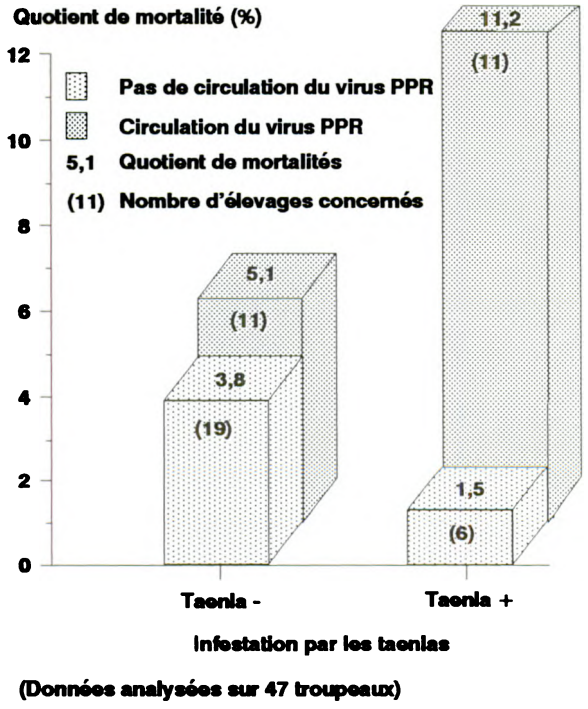
A la fin du dépouillement, le groupe de travail s'est réuni pour procéder à un examen critique des résultats obtenus. Les thèmes améliorateurs ont été choisis et mis en forme en vue de leur vulgarisation auprès des éleveurs et des services de développement.

Discussion et conclusion

Le dépouillement des résultats de l'enquête permet de déterminer les facteurs associés à la pathologie respiratoire et à la mortalité. En toute rigueur, on ne peut pas parler à ce stade de facteur de risque. Il s'agit en effet d'observations et non pas d'expérimentations (problème de l'inférence causale). Cependant, à la lumière de connaissances antérieures, des présomptions fortes peuvent suffire à préconiser certains thèmes améliorateurs.

Les facteurs de risque rencontrés isolément dans un élevage n'ont guère de poids et peuvent même donner lieu à des interprétations contradictoires, comme le démontre bien l'exemple suivant tiré de l'enquête (figure 5). Ainsi, la seule présence de ténias ou de virus de la peste des petits ruminants est associée à un taux de mortalité assez proche de celui observé en l'absence de ces deux facteurs. En revanche, dans les élevages où la peste des petits ruminants et le ténia coexistent, le taux de mortalité augmentait considérablement.

Figure 5. *Relationa entre la circulation du virus de la peste des petits ruminants, l'infestation par le ténias et le taux de mortalité des chèvres*



Il faut la conjonction de plusieurs facteurs dans un même élevage pour entraîner une incidence accrue ou une plus grande gravité de la pathologie. Dans les programmes de vulgarisation, il sera donc nécessaire de personnaliser les conseils aux éleveurs en fonction d'un diagnostic préliminaire (recherche des facteurs de risque dans chaque élevage).

L'accent a été mis sur la recherche des facteurs de risque relevant des pratiques des éleveurs: logement, complémentation, traite, sevrage, conduite au pâturage. Les thèmes améliorateurs correspondront donc à des éléments concrets et bien connus des éleveurs, ce qui devrait contribuer au succès des programmes de vulgarisation qui découleront de ce travail.

Au demeurant, l'écopathologie est un outil performant adapté à la mise au point d'une politique d'amélioration des productions et de la santé animales, car elle appréhende globalement et dans sa complexité le fonctionnement du système d'élevage.

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SESSION 4

Small Ruminant Feeds and Feeding Systems

Selectivity in sheep and goats fed *Albizia, Gliricidia, Leucaena and Tamarind* multipurpose trees

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Abstract

Selectivity of Blackhead Persian sheep and Small East African goats fed *Albizia lebbek, Gliricidia sepium, Leucaena leucocephala* and *Tamarindus indica* was determined through behavioural and intake studies conducted at the Sokoine University of Agriculture, Tanzania between May and July 1991. The four sheep used were 1–2 years old. The four goats were 4–5 years old. The weight of the animals was between 20 and 29 kg. During the behavioural study, animals were confined into pens of 170 x 160 cm. Time spent by each animal on feeding, ruminating and idling activities was monitored from 0900 hours to 1700 hours for four consecutive days. The amount of dry matter (DM) of tree species eaten by animals was recorded for two consecutive days.

The behavioural and intake studies showed that leucaena was the most preferred tree species. Sheep and goats spent 155 and 160 min per eight hours respectively eating leucaena and consumed 40.2 ± 15 and 46.50 ± 11.32 g DM/kg$W^{0.75}$ per day. *Gliricidia sepium* was the tree least preferred by both animal species and time spent on it and amount consumed was negligible. There was no difference ($P<0.05$) between sheep and goats in utilising these tree species during the behavioural study, but there was a difference ($P<0.05$) between animal species during the intake study. *Albizia lebbek* was more favoured by sheep ($P<0.05$) than by goats. Sheep and goats did not differ ($P>0.05$) in utilising *Tamarindus indica*. The need for further investigation is highlighted in this study.

*Choix alimentaires d'ovins et de caprins recevant du fourrage d'*Albizia, Gliricidia, Leucaena *et* Tamarindus, *espèces à usages multiples*

Résumé

*De mai à juillet 1991, des études de comportement et de consommation ont été effectuées à l'Université agricole de Sokoine, en Tanzanie, pour déterminer les choix alimentaires de moutons Blackhead Persian et de petites chèvres d'Afrique de l'Est recevant du fourrage d'*Albizia lebbek, Gliricidia sepium, Leucaena leucocephala *et* Tamarindus indica. *Les 4 moutons utilisés étaient âgés de 1 à 2 ans, et les 4 chèvres, de 4 à 5 ans. Le poids des animaux variait de 20 à 29 kg. Pour l'étude de comportement, les animaux étaient enfermés dans des box de 170 x 160 cm. Le temps consacré par chaque animal à l'alimentation, à la rumination et au repos a été observé entre 9 et 17 heures pendant quatre journées consécutives; la quantité de matière sèche des espèces ligneuses consommée par chaque animal a été relevée sur deux journées consécutives.*

Leucaena s'est révélé l'espèce ligneuse la plus appréciée. Sur une période de huit heures, les ovins et les caprins consacraient respectivement 155 et 160 min au broutage de cette espèce, dont ils consommaient respectivement 40,2 ± 15 et 46,50 ± 11,32 g de MS/kg de $P^{0,75}$ par jour. L'espèce la moins recherchée tant par les ovins que les caprins était Gliricidia sepium; *le temps consacré à son broutage et les quantités consommées étaient négligeables.*

L'étude de comportement n'a pas fait apparaître de différence ($P<0,05$) entre les caprins et les ovins pour ce qui est de l'utilisation de ces espèces ligneuses, mais une différence ($P<0,05$) entre espèces animales a été observée dans l'étude de consommation. Albizia lebbek *était plus apprécié par les moutons ($P<0,05$) que par les chèvres. Aucune différence ($P>0,05$) n'a été observée entre les moutons et les chèvres pour ce qui est de l'utilisation de* Tamarindus indica. *L'article souligne la nécessité de poursuivre cette étude.*

Introduction

The use of multipurpose trees (MPTs) has been advocated in the tropics for several reasons. These include: supply of fodder to livestock; wind breaks; providing protection and supplying nutrients to the soil and therefore to plants; supplying fuel for cooking and heating; acting as live fences; and providing shade to both man and livestock. In Tanzania, the cut-and-carry system of using MPTs is common in many areas,

particularly Kilimanjaro, Arusha, Mbeya and Tanga. The MPTs play a special role in supplying the animals, particularly sheep and goats, with protein and energy during the dry season.

There has been little study however of the physical and chemical composition of the MPTs commonly used by farmers. There is also limited information on the behavioural aspect of sheep and goats when fed several cut MPTs simultaneously. The aim of this preliminary study was to determine the physical and chemical composition of the cut MPTs and to assess the eating preferences and selectivity of sheep and goats.

Materials and methods

Location, animals and feed

The experiments were conducted at the Department of Animal Science and Production, Sokoine University of Agriculture, Tanzania between May and July, 1991.

Four female mature Blackhead Persian (BHP) sheep and four female mature Small East African goats were used. The sheep were 1–2 years old and weighed between 20–25 kg. The goats were 4–5 years old and weighed between 21–29 kg.

The tree species used in the study were *Albizia lebbek*, *Gliricidia sepium*, *Leucaena leucocephala* and *Tamarindus indica Chloris gayana* hay was provided as a basal ration to the animals.

Experiment I: behavioural study

Two sheep and two goats were confined in separate groups in pens of size 170 x 165 cm inside the main sheep/goat house. Branches of the tree species were tied separately and placed at different heights for maximum exploitation of the grazing/browsing behaviour and for ease of observation during the experiment. *Chloris gayana* hay and drinking water were also available *ad libitum*. The pens were cleaned and the previous day's residues removed before the feed or water was replaced.

There was a preliminary adjustment period of seven days followed by the trial period of four consecutive days. The animals were observed from 0900 hours to 1700 hours every day. The animals' behaviour actions towards fodder were observed as described by Lehner (1987). The way an animal utilised the four randomly placed tree species and *Chloris gayana* hay was monitored. Records kept included: time in minutes spent on each tree species; time spent eating hay; time spent drinking water; time spent walking; time spent lying and ruminating; time spent standing and ruminating; and time spent idling. The plant parts browsed/grazed by the animals were also noted. At the end of every observation day animals were transferred to other pens where they were housed at night without any feed.

Chemical analysis

Dried samples of favoured plant parts i.e. leaves, pods and bark were taken for chemical analysis. Materials were ground to pass through a 1.25 mm screen in a Christy and Norris 20 cm laboratory hammer mill. Chemical components such as dry matter (DM), Ash, ether extract (EE), crude fibre (CF), calcium (Ca) and phosphorus (P) were determined by standard methods (AOAC, 1990). Nitrogen-free extract (NFE) was calculated by using the formula:

NFE = 100 - (Moisture + CP% + CF% + EE% + Ash%)

Statistical analysis

Data on time spent by both sheep and goats on different tree species were subjected to analysis of variance as outlined by Snedecor and Cochran (1989). Parameters considered during the analysis included means, standard deviations and standard errors or the difference between means. These were calculated according to the following model:-

$$Y_{ijk} = \mu + T_i + A_j + E_k + (TA)_{ij} + (TE)_{ik} + AE_{jk} + (TAE)_{ijk} + R_{ijkl}$$

where:

μ = general mean

T_i = effect of tree species

A_j = effect of animals species

E_k = effect of the day of test

$(TA)_{ij}$ = interaction between animal and tree species

$(TE)_{ik}$ = interaction between tree species and day of test

$(AE)_{jk}$ = interaction between animal species and day of test

$(TAE)_{ijkl}$ = interaction between tree species, animal species and day of test

R_{ijkl} = residual

Experiment 2: intake study

The eight animals used in Experiment 1 were put in individual pens and provided with the four tree species, hay and water for a preliminary period of seven days. Samples of the branches of trees fed to animals were taken before feeding and fractionated separately into leaves (including tender branches), pods, bark and wood. The samples were weighed when fresh, dried in an oven at 60 - 62°C for 24 hours, then weighed again.

The measurement period was two consecutive days for each of the tree species provided per animal. To ensure that every animal had a continuous access to the feeds, every fodder tree was provided to allow for 20% refusals. Clean water was available all the time.

Refusals were collected, fractionated and dried in an oven at 60–65° C for 24 hours for dry matter (DM) determination. The quantity of leaf materials eaten by an individual animal was calculated by the difference

between weight of leaves given (gDM) and the weight of leaves refused (gDM).

Chemical analysis

Chemical analysis of *Albizia lebbek, Gliricidia sepium, Leucaena leucocephala, Tamarindus indica,* and *Chloris gayana* hay was as described in Experiment 1.

Data processing and statistical analysis

Data on leaf, bark and wood fractions eaten or refused of each tree species were expressed simply as percentages of total amount of each tree plant material offered.

Data on the amount of leaf materials eaten were subjected to the same ANOVA (Snedecor and Cochran, 1989) model used for experiment 1.

Results and discussion

The physical and proximate composition of MTPs and hay fed to the sheep and goats are presented in Tables 1 and 2, respectively.

Table 1. *Physical composition of samples of multipurpose trees fed to sheep and goats (%).*

Trees species	Parts			
	Leaves	Bark	Pod	Wood
Albizia lebbek	38	16	13	33
Gliricidia sepium	40	16	–	44
Leucaena leucocephala	39	16	–	45
Tamarindus indica	22	14	36	28

Table 2. *Proximate composition of leaves of the multipurpose trees and hay fed to sheep and goats (%).*

Tree species	DM	CP	CF	Ash
Albizia lebbek[1]	38.7	21.9	28.3	7.3
Gliricidia sepium	23.7	25.2	17.9	11.1
Leucaena leucocephala[3]	33.0	24.0	22.2	6.7
Tamarindux indica[2]	46.5	11.5	20.8	9.1
Chloris gayana hay	90.8	6.6	44.4	8.2

[1] Pods of *A. lebbek* had 20.3% CP.

[2] Pods of *T. indica* had 8.7% CP.

[3] Barks of *L. leucocephala* had 11.8% CP.

The chemical composition of *Albizia lebbek* leaves (Table 2) compared well with values reported by NAS (1971) and FAO (1981) in terms of CP but slightly higher values of CF were obtained in this study (28.3% vs 26.5%). The variations in the chemical composition between different parts are due to the physiological fractions of the parts such as photosynthesis in the leaves and storage in the pods. Variations are also caused by the stage of growth of the plant parts (Brewbarker and Hulton, 1979).

The chemical composition of *Gliricidia* leaves and *Leucaena* leaves was similar to values reported by Atta-Krah and Reynolds (1989). For *Gliricidia* leaves, however, slightly higher values of protein were obtained when compared to the value obtained by Semenye et al (1986). The crude protein and crude fibre contents of *Leucaena* leaves were within the ranges reported by Atta-Krah and Reynolds (1989). The ash value is similar to that of 6.95% obtained by Hulman et al (1978). Le Houérou (1980) reported average crude protein and crude fibre contents of tamarind leaves to be 10.9% and 14.8%, respectively. Results from *Tamarindus indica* for crude protein were similar to those reported by Le Houérou, but in this study the crude fibre content was higher.

The stage of regrowth of different forages were reported to cause differences in nutritive values (Brewbaker and Hulton, 1979). This could account for variations in the chemical composition reported by different workers. The plant materials in this study were collected from different locations and were at different stages of growth. Variation in chemical composition of different parts of the same plant species could also be due to the functional role of the plant part and its stage of growth in relation to the other parts.

Behavioural and intake studies

In the behavioural study (Tables 3, 4 and 5), sheep and goats showed no difference ($P<0.05$) in utilising *Gliricidia sepium* and *Leucaena leucocephala.* However, these animals differ ($P<0.05$) in the way they utilise *Albizia lebbek* and *Tamarindus indica.* The behavioural study showed that sheep find *Albizia lebbek* more palatable than do goats. Similarly, the intake study showed that there was a difference ($P<0.05$) in the amounts of *Albizia lebbek* consumed by the goats and sheep. Goats consumed an average of 112 g DM/day of *Albizia* leaves, compared to sheep whose daily consumption was 289 g DM/day.

The study showed also that pods of *Albizia lebbek* were not eaten by either sheep or goats. This is contrary to what was reported by Singh et al (1989). Palatability and selectivity are determined partly by the animal's prevailing nutritional and physiological status and partly by the environmental circumstances. Environmental circumstances include the relative availability of various parts from which the choice is made (French, 1970). These factors may contribute to the differences observed in this study.

Table 3. *Time in minutes spent by sheep and goats on eating the multipurpose trees and hay on free choice basis for eight hours.*

Feed	Sheep	Goat
A. lebbek	20.5[a]	5.1[b]
	(5.67)	(1.47)
G. sepium	0.3	1.3
	(0.63)	(0.18)
L. leucocephala	155.1	160.1
	(42.15)	(45.90)
T. indica	53.7[b]	100.3[a]
	(14.59)	(28.78)
C. gayana hay	138.5[a]	81.8[b]
	(36.91)	(23.7)

Figures in brackets represent percentage time.

ab = Values within rows bearing different superscripts are significantly different ($P<0.05$).

Table 4. *Time in minutes spent by sheep and goats on different activities during the eight hour study period.*

Activity	Sheep	Goats
MPTs	229.4	267.1
Eating hay	138.5	82.0
Ruminating	68.3	33.8
Drinking water	31.2	85.2
Walking	1.3	1.4
Idling	11.1	9.7

This study shows that the animals did not like *Gliricidia sepium*. Both species spent very little time eating this plant. Studies in India also showed that cattle did not like this tree species. The intake study showed that goats ate only 45 g DM/day (4.6 g DM/$W^{0.75}$). However, Onwuka (1986) reported an intake of 176.83 g/day and Mba et al (1982) reported an intake of between 233.80 to 294 g/day by goats. Onwuka (1986) used dry *Gliricidia* leaves to feed his goats while Mba et al (1982) used fresh materials. In both studies periods of up to six months were used. It is probable that longer periods of exposure are required before the animals can accept *Gliricidia*. Chadhokar and Kantharaju (1980), however, reported that *Gliricidia maculata* was found palatable by both cattle and sheep even when fed in very large quantities over a long period.

Although the difference in intake by sheep and goats of wilted and fresh *Gliricidia* has not been well documented, wilting is believed to increase the acceptability of the forage leaves.

The ranking of tree species eaten is shown in Table 5. Semenye et al (1986) ranked *Gliricidia* last and *Leucaena leucocephala* as number one among the six protein feed resources studied in their experiment. Meulen et al (1979) reported the presence of secondary plant metabolites such as *beta – carotene* and *xanthophyll* in *Leucaena*. These may make *Leucaena leucocephala* the most preferred of the four tree species.

The results of this study are contrary to the report by Wilson (1957) that goats are not very selective regarding plant species. Selectivity by goats and sheep was shown to be related to the species of the plant materials offered, especially in the cut-and-carry system (Semenye, 1991). Knowledge of the palatability of plants fed to sheep or goats may be used as a tool to increase dry matter intake (DMI) of animals by offering the least palatable first and the most palatable last (Semenye, 1991). Palatability ranking could have been clearer if more forage tree species had been included.

Conclusion

The higher crude protein and lower crude fibre contents in leaves and pods of MPTs suggests that they may be used as supplements to low crude protein feeds such as *Chloris gayana* hay particularly during the dry season. However, acceptability of the different fractions of MPTs differ between sheep and goats. The chemical composition of a plant or plant part may not determine its acceptability to the animal. Techniques of sampling and measuring yield and nutritive value of edible parts (leaves, bark, pods) of MPTs also need to be developed.

Table 5. *Palatability ranking and dry matter intake (g DM/day) by sheep and goats.*

Feed	Sheep		Goats	
	Intake	Rank	Intake	Rank
L. leucocephala	432 ± 16	1	453 ± 25	1
	(40.2 ± 15.6)		(46.5 ± 11.3)	
T. indica	229 ± 75	3	251 ± 87	2
	(21.3 ± 6.9)		(25.8 ± 14.1)	
A. lebbek	289 ± 99	2	112 ± 60	3
	(26.9 ± 90)		(11.4 ± 6.2)	
G. sepium	18 ± 4.0	4	45 ± 22	4
	(1.7 ± 1.0)		(4.6 ± 2.2)	

[1]Figures in brackets show intake in g/kg$W^{0.75}$

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Influence of amount of feed offered on growth, intake and selectivity: observations on sheep and goats

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Abstract

Comparisons were made between 24 Ethiopian rams and 24 Galla goats for voluntary intake, feed selectivity and growth performance when offered three levels of sorghum stover. The levels observed were 25, 50 and 75 g/kg live weight per day. Measurements of intake, growth and feed selectivity were taken over a period of 10 weeks.

Both sheep and goats consumed more stover (P<0.001) as rate of offer was increased (22, 31, 32 gDM/kg live weight per day; 19, 26, 29 g/kg live weight per day, respectively, for sheep and goats). Increasing the level of offer beyond 50g/kg live weight per day did not, however, promote a substantial increase in intake. No difference (P>0.05) was observed in the pattern of feed selectivity between sheep and goats. Both species showed a similar preference for leaf and sheath matter as the level of offer was increased.

Sheep gained weight faster (P<0.001) than goats at all rates of offer, (28.0 vs 9.0; 54.0 vs 23.0; 62.0 vs 31.6 in favour of sheep). Those on a higher level of offer showed a faster rate of gain than those on a lower level of offer.

It was concluded that both species can benefit from generous offers and that the benefit, judged by improved intake and growth, is due to selective feeding.

Effet de l'offre alimentaire sur la croissance, la consommation et les choix alimentaires chez les ovins et les caprins

Résumé

L'ingestion volontaire, les choix alimentaires et les performances de croissance ont été comparés chez 24 béliers éthiopiens et 24 chèvres Galla auxquels de la paille de sorgho avait été servie selon trois niveaux de rationnement (25, 50 et 75 g/kg de poids vif/j). Les mesures de l'ingestion, de la croissance et de la sélectivité à l'égard des aliments ont été réalisées sur une période de 10 semaines.

La consommation de paille augmentait (P<0,001) avec l'augmentation du niveau de rationnement (22, 31 et 32 g de MS/kg de poids vif/j chez le mouton et 19, 26 et 29 g de MS/kg de poids vif/j chez la chèvre). Toutefois, aucune augmentation substantielle de l'ingestion n'a été obtenue lorsque le niveau de rationnement était amené à plus de 50 g/kg. Il n'y avait pas de différence (P>0,05) entre les choix alimentaires des chèvres et des moutons. Les deux espèces consommaient de préférence les feuilles et les gaines foliaires dans la mesure où les apports alimentaires augmentaient.

Les moutons réalisaient de meilleurs (P<0,001) gains de poids que les chèvres, quels qu'aient été les niveaux de rationnement (28,0 contre 9,0, 54,0 contre 23,0, et 62,0 contre 31,6, au bénéfice des ovins). Les gains de poids étaient plus rapides chez les animaux soumis à un niveau d'alimentation élevé que chez ceux soumis à un niveau d'alimentation modéré.

En conclusion, il apparaît que les deux espèces sont susceptibles de tirer parti d'un apport alimentaire généreux et, qu'à en juger d'après l'amélioration de la croissance et de l'ingestion, les avantages retirés s'expliquent par la sélection des aliments.

Introduction

Previous studies (Aboud et al, 1992) clearly indicate the value of selective feeding. Sheep were shown to perform better and consume more digestible matter through selective intake of leaf and sheath fractions of sorghum stover as a result of liberal offers. This observation is of practical value for small ruminants in the tropics because the traditional feeding systems depend largely on crop residues. However, there is little evidence in the literature that the approach adopted by Aboud et al (1992) would be as effective for goats as it was for sheep. Results from comparative studies between sheep and goats of selective efficiency are generally conflicting (Huston, 1978; Devendra and Burns, 1983). Goats in the tropics are more able than sheep to consume feed fractions of higher nutritional quality when offered the opportunity to eat selectively (Devendra and Burns, 1983; Hoppe et al, 1977; Huston, 1978). This observation does not agree with studies carried out in

temperate countries, where sheep have been shown to perform better than goats under most practical feeding systems. A comparative feeding and performance study on Small East African goats and the Red Maasai sheep in Tanzania (Shoo, 1986) was inconclusive, although sheep appeared to perform better than goats when offered a basal diet of *Chloris gayana* hay with *leucaena* as a supplementary forage. However, observations in Shoo's (1986) study did not include an assessment of selective feeding ability between the two species. The inclusion of a supplementary forage may have confounded the results, as it is known that goats would preferentially consume browse species (Lu, 1988). Most of the comparative studies in the tropics were made under grazing conditions, whereas those in the temperate countries involved comparisons under stall-feeding conditions in which feed was offered at restricted levels, usually at 35 g dry matter M(D)/kg live weight per day or to achieve 10–20% rate of refusal.

Comparative studies under grazing or in stalls at restricted levels of offer may give misleading results (Demment and Van Soest, 1983). Restricted levels of offer do not usually provide sufficient opportunity for selective feeding (Aboud et al, 1993). This is particularly serious where low-quality crop residues are used in comparisons.

No performance comparison has been made between sheep and goats that have been fed untreated crop residues at levels that would allow selective intake. Alimon (1989) only measured the digestible organic matter (OM) intake of goats offered increasing levels of feed, but did not measure any related growth performance. Aboud et al (1993) showed that certain levels of offer encouraged sheep to eat selectively. By offering goats and sheep the same type of sorghum stover at these levels both species may perform similarly.

Material and methods

The experiment was conducted at the Debre Zeit Experimental Station, an ILCA sub-station located about 1700 metres above sea level, 45 km south-east of Addis Ababa, Ethiopia.

A total of 48 animals were used in this study. Half were Ethiopian lowlands hair-type rams and half were Galla goats. The animals were between 11–13 months old and weighed between 14–16 kg. They were divided into three groups of 16 animals, eight rams and eight goats in each group. The three groups were allocated to three different levels of offer, which were 25, 50 and 75 g stover DM/kg$^{0.75}$ daily.

Sorghum stover (cv. Seredo: a bird resistant variety) was used as the basal diet. In addition, the animals also received 150 g/day of solvent extracted cottonseed cake (Table 1) and mineral lick (Table 2). The animals were fed twice a day. On each occasion half of the daily ration was provided after collection of refusals. The experimental period lasted 10 weeks after an initial adaptation period of 21 days.

Table 1. *Composition of feedstuffs utilised during the adaptation and trial periods (g/kg).*

Composition*	Chloris gayana	Wheat bran	Seredo stover	Cottonseed cake	
				Sample 1	Sample 2
DM	870	876	913	923	932
CP	37	169	46	427	286
CF	37	113	–	–	–
Ash	87	64	9.4	67	70
NFE	444	616	–	–	–
NDF	–	–	697	776	452
ADF	–	–	452	293	376
Lignin	–	–	444	88	92

* DM = dry matter; CP = crude protein; CF = crude fibre; NFE = nitrogen-free extract; NDF = neutral detergent fibre; ADF = acid detergent fibre.

Table 2. *Composition of mineral block.*

DM	(g/kg)	958
Phosphorus	"	43
Potassium	"	11
Calcium	"	71
Magnesium	"	4
Sulphur	"	7
Iron	Mg/kg	74.89
Manganese	"	79.31
Copper	"	197.40
Zinc	"	148.77

Sampling and measurement of feed intake

Before each meal, the refusals from previous meals were removed from troughs and weighed. The difference between amount offered and amount refused was taken as the quantity consumed.

For each animal, a handful of the stover refused during the morning and evening feedings was collected to make a single daily sample. Each daily sample was added to the previous day's sample for one week. At the end of each week, the combined sample was divided into two parts, one for chemical analysis and the other for botanical fractionation. The parts retained for chemical analysis from each individual were then mixed by treatment group and sub-sampled to form a single sample per week from each treatment group. Altogether 10 such samples were collected from each treatment group during the experiment.

Botanical fractionation was based on the weekly pooled samples for each animal. Proportions of botanical components (leaf, sheath and stem) were expressed in g/kg of sample and averaged for each treatment group per week. This provided 10 such averaged values for the experimental period, one per week based on means from eight animals per treatment. Botanical fractions were partitioned using the traditional 'winnowing' process. This involved shaking the sample in a gentle circular motion using a 'safed', a reed woven mat about 1 m across. This trapped the heavier material (stem and sheath) in grooves while the lighter material (leaf) was shaken towards the edge. The fractions were then picked by hand.

Growth performance and measurements

Once a week the animals were weighed, on each occasion at 0700 hours. Prior to weighing, water and feed were withdrawn for at least six hours. A canvas sling hung on a spring balance was used for weighing.

Chemical analyses

Chemical analyses for dry matter (DM), acid detergent fibre (ADF), neutral detergent fibre (NDF), nitrogen (N), ash, silica, ADF-ash and *in vitro* dry matter digestibility (DMD) were done in duplicate on all samples collected. The methods of Goering and Van Soest (1975) were used for fibre analysis and for the *in vitro* digestibility. Results from the *in vitro* digestion were expressed as the residual amount of NDF remaining after 48 hours incubation. N was determined using the macro-Kjeldahl procedure.

Results

Intake of stover

Table 3 shows the main effect means for intake of stover by sheep and goats. Analysis of variance showed no significant interaction between the main effects (species and level of offer) on stover intake. Effects of species and level of offer were highly significant ($P<0.001$). Sheep consumed significantly ($P<0.001$) more stover than goats. Both species improved their DM intake as the level of offer was raised from 25 to 75 g/kg live weight per day. The improvement was particularly large between animals offered 25 and 50 g/kg live weight per day. Increasing the offer to 75 g/kg live weight per day resulted in a small increase in intake.

Rate of refusals and selectivity

Effects of level of offer and of differences between the species were highly significant ($P<0.001$). Figure 1 shows a comparison between the species and effect of level of offer on the rate of stover refusal. Rate of refusal was expressed as rate of utilisation (1 - rate of refusal) to show the fall in the proportion of stover utilised as the amount offered was raised. Goats have lower utilisation values because of their higher rates of refusals. Proportionately more stover was refused as the level of offer was raised.

Summaries of analysis of variance for the comparison of the stover leaf, sheath and stem proportions (g/kg) in the refusals are given in Table 4.

Table 3. *Main effects means for stover intake, rate of stover refusal and growth rate (g/d).*

	Species			Level of offer (g/kg live weight per day)						
	Goats	Sheep	SE	25	50	75	SE	Species	Level	Species x Level
No. animals	24	24	–	16	16	16	–		–	–
Initial live weight (kg)	14.5	17.0	–	-	–	–	–	–	–	–
Stover										
Offered	731	752	–	352	757	1143	–	–	-	–
Refused (gDM/kgDM)	384	298	9.9	101	373	549	12.1	***	***	NS
DM intake										
(g/d)	404	456	13.2	316	468	506	16.2	***	***	NS
(g/kg per day)	25	29	0.4	21	29	31	0.5	***	***	NS
($g/kg^{0.75}$)	50	57	1.0	41	58	62	1.3	***	***	NS
Rate of gain (g/d)	28	53	4.4	22	46	52	5.6	***	***	NS

NS = not significant.

*** = significant ($P<0.001$).

Figure 1. *Effect of level of offer on stover intake and rate of utilisation by sheep and goats.*

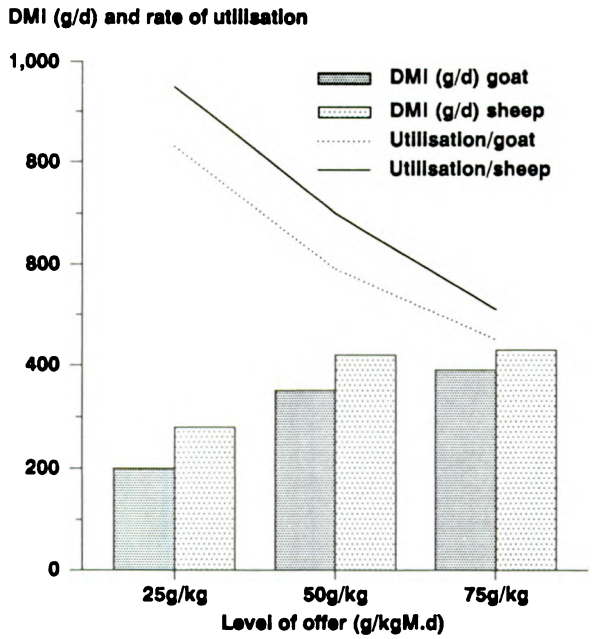
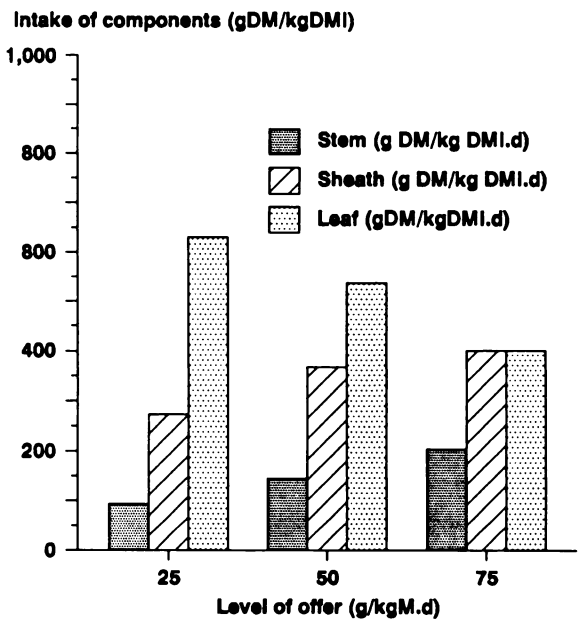


Figure 2. *Effect of level of offer on botanical composition of DMI by sheep and goats.*



For leaf matter proportions, no significant interaction between main effects was observed. Differences between species and effects of level of offer were both significant ($P<0.01$). The stover refused by goats had more leaf ($P<0.05$) than that left by sheep. In both species stover refused from higher rates of offer contained more ($P<0.001$) leaf than that refused at the 25 g/kg live weight per day level.

Significant interactions ($P<0.001$) between main effects were observed in the proportion of sheath and stem in the stover refused. Effect of level of offer and differences between species were highly significant ($P<0.001$). In goats, the proportion of sheath and stem in refused stover increased with increasing level of offer. Sheep had no consistent pattern. Table 5 shows the main effects means of intakes of the three botanical fractions (leaf, sheath and stem). Sheep and goats consumed about the same amount of leaf and sheath fractions. Sheep had a considerably higher intake of stem fractions than goats. More leaf and sheath were consumed by both species as the level of offer was raised (Figure 2). The amount of stem consumed, however, decreased with increasing levels of offer, although differences in intake at the higher levels were about the same.

Rate of growth

Sheep gained nearly twice as much as goats (Table 3). Increasing the level of offer significantly ($P<0.001$) improved the rate of gain in both species, particularly when the offer was raised from 25 g to 50g/kg live weight per day.

Discussion

Effect of level of offer on stover intake and stover selectivity

The results show that sheep and goats respond in almost the same manner when offered increasing quantities of sorghum stover.

Similarly to previous findings (Owen and Aboud, 1988), the response to increasing level of offer appeared to diminish in both species as the level of daily offer was raised beyond 50 g/kg live weight per day. It also appears that both species optimised their DMI and growth performance at the same level of offer. The efficiency with which this was achieved was different between the species. Sheep showed a better utilisation rate than goats ($P<0.01$). The DMI achieved by both species at the 50g/kg live weight per day level of offer was close to the levels reported by Devendra and Burns (1983) for Baribari goats in India where the animals were fed forages *ad libitum*.

Most reports in the literature suggested that goats are more able than sheep to eat selectively (Devendra and Burns, 1983; Lu, 1988). These observations are largely based on grazing animals, most of them on natural rangelands (Lu, 1988). The findings in this study with sorghum stover showed that in general both species are able to eat selectively. The results also suggest that the differences in selection between the sheep and goats used were dependent on the level of feed on offer. The botanical and chemical composition of the stover refused showed that sheep tended not to select when offered stover at 25g/kg live weight per day, whereas

Table 4. *Analysis of variance for comparison of stover refusals by sheep and goats.*

Dependent variable: leaf fraction (g/kg):								
Source	DF	Type I SS	F Value	PR>F	DF	Type III SS	F Value	PR>F
Species (S)	1	21.59801198	5.21	0.0264	1	21.59801198	5.21	0.0264
Level of offer (L)	2	47.29336599	5.71	0.0056	2	47.29336599	5.71	0.0056
S x L	2	17.21797981	2.08	0.1351	2	17.21797981	2.08	0.1351
Dependent variable: sheath fraction (g/kg):								
Source	DF	Type I SS	F Value	PR>F	DF	Type III SS	F Value	PR>F
Species (S)	1	7987.878489	14.24	0.0004	1	7987.87848945	14.24	0.0004
Level of offer (L)	2	66984.34385595	59.71	0.0001	2	66984.34385595	59.71	0.0001
S x L	2	10367.34709726	9.24	0.0004	2	10367.34709726	9.24	0.0004
Dependent variable: stem fraction (g/kg):								
Source	DF	Type I SS	F Value	PR>F	DF	Type III SS	F Value	PR>F
Species (S)	1	18633.39211586	13.11	0.0006	1	18633.39211586	13.11	0.0006
Level of offer (L)	2	57777.98010960	20.33	0.0001	2	57777.98010960	20.33	0.0001
S x L	2	22624.55784522	7.96	0.0009	2	22624.55784522	7.96	0.0009

Table 5. *Main effects means for intake of stover fractions by sheep and goats.*

	Species		Level of offer (g/kg live weight per day)		
	Goats	Sheep	25	50	75
Stover offered (g/d):					
Total amount	731	752	352	757	1143
leaf	61	63	29	63	95
sheath	173	178	83	179	271
stem	451	463	217	467	704
Stover refused (g/d):					
Total amount	281	224	36	282	627
leaf	0.8	0.3	0.04	0.5	2.1
sheath	21.0	22.2	2.1	18.6	82.8
stem	237	197	31	255	519
Intake of components (g/d):					
leaf	60	63	29	63	93
sheath	152	156	81	161	188
stem	214	266	187	212	185
Component proportion (g/kg stover intake):					
leaf	133	112	9	132	180
sheath	338	295	256	338	364
stem	475	503	591	446	358

goats were selective at all levels of offer. At 50g/kg live weight per day and 75g/kg live weight per day there were no substantial differences between the two species in selective feeding, both in ability or efficiency. The pattern of intake of botanical components was similar in the two species. Both showed a preference for leaf and sheath against stem. Figure 2 shows that the intake of leaf and sheath was increasing even at the highest level of offer. The two components were constituting an increasing proportion of the DMI as the level of offer was increased.

Effect of level of offer on growth performance

For both sheep and goats, growth performance improved significantly as the rate of offer was increased. The improvement in performance was remarkable when the rate of offer was raised from 25g/kg live weight daily to 50g/kg live weight daily. Feed conversion efficiency also improved, particularly in sheep.

The difference in rate of gain between the two species cannot be explained by differences in their

ability to eat selectively. Because both species were compared for their absolute gain rather than their relative gain, this may have favoured sheep due to their higher initial weight. It would have been preferable to express the rate of gain as a proportion of the expected mature weight.

Conclusion

The findings in this study clearly support earlier observations that generous offers of feed can promote intake both qualitatively and quantitatively. This possibility should offer opportunities for modifying current practices of supplementary feeding. Where restricted feeding is practised there is always the likelihood of underestimating the potential nutritive quality of forages, especially crop residues.

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The effect of supplementation of cassava peel (CP) diets with graded levels of palm kernel cake (PKC) on the performance of growing Djallonké sheep

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Abstract

Djallonké sheep were fed an *ad libitum* basal diet of cassava peel (CP) supplemented with graded levels (0, 50, 100, 150 and 200 g/head per day) of palm kernel cake (PKC). This study reports the effects of this dietary supplementation on feed intake, bodyweight changes, water intake and mortality. The supplementary levels corresponded to dietary treatments 1–5, respectively. The mortality rates of the animals were 20, 20, 40, 50 and 0% for diets 1, 2, 3, 4 and 5, respectively. Mean daily intakes of CP, CP and PKC supplements and water were not significantly ($P>0.05$) affected by dietary treatments or sex. There was an increase ($P<0.01$) in the intake of PKC as the level of supplementation increased. Generally the intake of PKC was low. This might be attributable to poor quality resulting from its preparation. In another study the degradation characteristics of the two feedstuffs were studied using the nylon bag technique. The insoluble but slowly degradable portion of the PKC was low (about 16%).

Effet de la complémentation de rations à base de pelures de manioc avec du tourteau de palmiste sur les performances du mouton Djallonké

Résumé

Cette étude présente les effets de rations à base de pelures de manioc complémentées par du tourteau de palmiste (0, 50, 100, 150 et 200 g/tête/jour) sur l'ingestion, l'évolution pondérale, la quantité d'eau ingérée et la mortalité de moutons Djallonké nourris ad libitum. *Les niveaux de complémentation correspondaient respectivement aux traitements alimentaires 1, 2, 3, 4 et 5. La mortalité des animaux était de 20, 20, 40, 50 et 0% pour les traitements 1, 2, 3, 4 et 5, respectivement. Les traitements et le sexe des animaux n'avaient pas d'effet significatif ($P>0,05$) sur la consommation journalière moyenne des pelures de manioc ou des pelures de manioc complétées par du tourteau de palmiste, ni sur la quantité moyenne d'eau ingérée par jour. La consommation du tourteau de palmiste augmentait ($P<0,01$) avec l'accroissement du niveau de complémentation mais demeurait faible d'une manière générale, probablement en raison de sa mauvaise qualité, elle-même imputable à une préparation défectueuse. Une autre étude a porté sur l'examen des caractéristiques de la dégradation de ces deux aliments au moyen de la technique des sachets en nylon. La portion insoluble mais faiblement dégradable du tourteau de palmiste était peu importante (près de 16%).*

Introduction

It is the policy of the Government of Ghana to increase the production of small ruminants to meet the animal protein requirements of the population. The Ministry of Agriculture (1988) envisaged an increase in the population of goats from about 1.9 million in 1987 to about 9.2 million by the year 2000; the population of sheep was expected to increase from about 2 million in 1987 to about 6.4 million by the year 2000. The main producers of small ruminants in Ghana are small-scale rural farmers. It is mainly these farmers who will be expected to increase their production. They, however, have serious problems feeding their animals. Increased pressure on the land has forced people to farm near their villages within walking distances of animals. During the cropping season animals are therefore kept in pens for most of the day. They are allowed to graze later in the afternoon, when they are less likely to travel outside the villages and damage the crops.

In the dry season the quality of the sparsely scattered forages is also poor, especially in the northern savanna zones of the country. The rural farmers, unlike the urban backyard farmers, are not able to purchase completely mixed diets or feed ingredients to feed their animals. They have to rely on crop residues generated

from their own farms and also foliage of multi-purpose trees, shrubs and grasses which they harvest from their farms or roadsides. The commonest crop residue fed to animals by farmers in both the south and north of the country is cassava peel (CP), although peels of plantain, yam and cocoyam are also used by farmers in the south.

About 3,327,000 metric tons of cassava is produced in Ghana per year (FAO, 1990) and with an extraction rate of about 20% (Kossila, 1984), about 665,400 metric tons of CP are produced in the country in a year. CP, however, has low nitrogen (Tuah, 1990) and mineral (Adegbola et al, 1988) contents. The objective of this study was therefore to investigate the effects of supplementing CP diets with graded levels of PKC as a protein source on the performance of young growing Djallonké sheep. PKC is available in most villages in the southern forest zone of the country but is not used at present as animal feed.

Materials and methods

Experiment 1

Supplements

The PKC used in the trial was obtained from a palm oil production factory at Ahodwo, a suburb of Kumasi, near the University of Science and Technology, Kumasi, Ghana. To extract the oil from the kernels, they were first dried, then roasted and ground through a hammermill (about 1mm sieve). The ground materials were boiled with water and the supernatant oil skimmed off. The residue kernel cake was dried in the sun.

The CP were obtained from a "garri" processing factory in the city of Kumasi. They were peels of mixed varieties of cassava. The peels sometimes had some cassava tuber pieces in their linings. They were sun-dried before being fed to the animals.

Animals, housing, management and feeding

A growth rate study of twenty three young Djallonké sheep of both sexes was carried out at the Department of Animal Science, University of Science and Technology, Kumasi, Ghana. The animals had a mean live weight of approximately 12 kg and were dipped and dewormed at the start of the experiment. They were weighed after 18 hours without food. The animals were kept in individual pens measuring 1 x 3 m on wooden slatted floors in a building described by Tuah et al (1985). They were randomly allocated to five dietary treatments. Treatment groups were balanced for sex of animals. Dietary treatments 1–5 corresponded to five graded levels of PKC supplements to the basal CP diet (0, 50, 100, 150 and 200 g/head per day). The animals were fed daily at 0800 from wooden troughs described by Tuah et al (1985). The troughs for those animals which received the PKC supplements were partitioned into two compartments with pieces of wood. Water was offered *ad libitum* at 0800 daily. The animals were allowed two weeks to adjust to their respective diets before data began to be collected. Feed and water intake and bodyweight changes were monitored. Leftover feed and water were measured every morning before fresh feed and water were provided. Samples of feed and oats or leftovers were taken once a week and kept for analysis. The animals were weighed every two weeks after 18 hours without food throughout the 12-week study.

Experiment 2

In sacco degradation of CP and PKC

This study was undertaken at the Rowett Institute, Aberdeen, Scotland. Samples of CP and PKC weighing about 3 g each were put in nylon bags. They were then incubated in the rumens of three fistulated wethers to measure degradability of dry matter at various incubation periods. The wethers had a mean body weight of 58 kg. The incubation periods were 4, 8, 16, 24, 48, 72 and 96 hours. The type of bags and the incubation procedures were the same as described by Tuah et al (1986). The sheep were fed 700 g/head per day at 0900 h and 1600 h of a diet containing (per kg): 500 g hay; 300 g barley; 100 g molasses; 91 g fishmeal; 5 g dicalcium phosphate; 3 g NaCl; and 1 g mineral-vitamin premix. The mineral-vitamin premix contained (per kg): 185 g calcium; 104 g magnesium; 2250 mg cobalt; 44,000 mg manganese; 36,400 mg zinc; 1300 mg iodine; 100 mg selenium; 10,000,000 iu retinol; 2,000,000 iu vitamin D^3; and 40,000 iu alphatocopherol.

CP and PKC were ground in a 3 mm sieve and triplicate samples of each were soaked in warm water (about 39–39°) for one hour. The samples were subsequently washed in a washing machine as was done for the CP and PKC samples incubated in the rumens of the sheep. The washing losses were determined after drying the samples in an oven at about 70°C for 48 hours. The equation of Ørskov and McDonald (1979), $p = a + b(1-e^{ct})$, was used to describe the course of degradation of the feeds.

Calculation of energy intake, maintenance energy and rumen degradable nitrogen requirements

It was assumed that the PKC supplied negligible amounts of metabolisable energy (ME). Thus the calculation of ME intakes was based on the energy from the CP only. It was also assumed that all the nitrogen in the CP was degradable in the rumen and that nitrogen in PKC was only 16% degradable in the rumen.

The fractional outflow rate of the particles of CP was assumed to be 0.04/h. The apparent digestibility coefficient of dry matter of the CP was then estimated to be 0.58, based on the *in sacco* degradation characteristics of the peels. The ME content of the CP was estimated using the formula MJ ME/kg dry matter = 0.156 x DOM, given by Roy et al (1977), where DOM is the digestive organic matter per kg of dry matter. The estimate of the ME content of CP (9 MJ ME/kg dry

matter) may have been overestimated because instead of using the *in vivo* DOM content of dry matter, digestible dry matter (DDM) content was used. The mean ME intakes of the animals were then calculated from their mean daily dry matter intakes. The rumen degradable nitrogen (RDN) requirements of the animals were calculated using the requirement value of 1.33 g N/MJ ME (ARC, 1984). The maintenance energy requirement for the animals was assumed to be similar to the requirement of the temperate breeds for which Ørskov and McDonald (1970) reported a value of 420 KJ/kg $W^{0.75}$/day.

Chemical analysis

The dry matter contents of the CP and PKC and the fat content of PKC were determined according to the methods of AOAC (1980). The nitrogen contents of the two feedstuffs were determined by the Kjedahl method (AOAC, 1980).

Statistical analysis

The intake of CP, PKC, CP + PKC and water were subjected to statistical analysis using the 2-way analysis of variance (Steel and Torrie, 1980).

Results

Chemical composition of the feedstuffs

The dry matter contents of the CP and PKC were 84.49 and 86.67%, respectively. The nitrogen contents of the CP and PKC were 5.44 and 33.53 g per kg dry matter, respectively. The PKC contained 10.2 g fat per kg dry matter.

Degradation characteristics of the feedstuffs

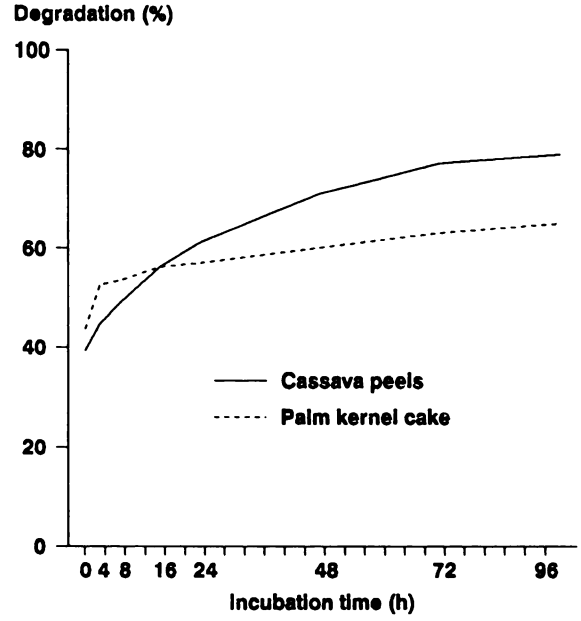
The degradation characteristics of the feedstuffs are shown in Figure 1. The rate and level of degradation of CP were higher than PKC after 16 hours of incubation. Before then, the apparent degradability of PKC was better than that of CP. This may be attributed to particle size differences.

Feed and water intake, bodyweight changes and general performance of the animals

The performance of the animals was generally poor resulting in the deaths of some animals as shown in Table 1.

The mean intake of water, combined CP and palm kernel cake and CP alone were not significantly ($P>0.05$) affected by dietary treatments or sex. The intake of the palm kernel supplement was, however, significantly ($P<0.01$) affected by dietary treatment. As the level of supplementation increased, the intake of the PKC increased. The mean intake of CP alone was 63 g/kg $W^{0.75}$ per day for males and 61 g/kg $W^{0.75}$ per day for females. For the PKC, the mean intake values were 7 and 6.5 g/kg $W^{0.75}$ per day for males and females, respectively. The mean daily water intakes were 269 and 284 ml/kg $W^{0.75}$ for the males and females, respectively. The changes in the body weights of the animals which survived throughout the 12-week study period did not follow any consistent trend. Two of the animals on Diet 1 and one each of the animals fed Diets 3, 4 and 5 maintained their body weights. Two of the animals fed Diet 5 and one of those fed Diet 1 lost weight. All the other animals gained weight (range 0.5 to 2.0 kg/84 days).

Figure 1. In vitro *dry matter degradability values of cassava peels and palm kernel cake at various incubation periods.*



Two animals each from Diets 3 and 4 died while one animal each died from those fed Diets 1 and 2.

Table 2 shows the calculated energy intake, maintenance energy requirements and rumen degradable nitrogen requirements of the animals. The total nitrogen supplied by the PKC for the levels of intake registered is also shown in Table 2.

Discussion

Generally the performance of the animals was poor because of rumen degradable nitrogen deficiency in their diets. This deficiency was not alleviated by supplementing the CP with PKC as the intake of PKC supplements was generally very low. This low intake could not be attributed to the fat content of PKC which was also low (10.2 g/kg dry matter), but could be attributed to the low palatability of PKC (McDonald et al, 1988) Yussof (1985) reported high intakes of diets containing PKC by cattle, but the cake was completely mixed with the other ingredients. The objective of this

Table 1. *Mean weight performance, feed and water intakes and mortality rates of Djallonké sheep.*

Parameter	Diets				
	1	2	3	4	5
Initial body weight (kg)	11.25	12.38	12.00	11.50	13.38
Final body weight (kg)	11.00	13.25	12.33	12.50	12.88
Changes in body weight (kg/84 days)	-0.25	+0.87	+0.33	+1.00	-0.50
Daily dry matter intake of:					
CP (g/kg$W^{0.75}$)	59	60	68	58	64
PKC (g/kg$W^{0.75}$)	–	3^{c}	7^{b}	9^{a}	10^{a}
CP and PKC (g/kg$W^{0.75}$)	59	63	75	67	74
Daily water intake (ml/kg$W^{0.75}$)	320	267	263	263	256
Mortality rate (%)	20	20	40	50	0

abc = Values in a row with different superscripts are significantly different (P<0.05).

Table 2. *Mean performance characteristics of Djallonké sheep.*

	Diets				
	1	2	3	4	5
Initial body weight (kg)	11.25	12.38	12.00	11.50	13.38
Metabolic body weight (kg $W^{0.75}$)	6.14	6.60	6.45	6.24	6.70
Daily intake of CP (g)	362	396	439	362	429
Daily energy intake from CP (MJ/ME)	3.28	3.564	3.951	3.258	3.861
Maintenance energy requirements (MJ ME/day)	2.5788	2.772	2.709	2.6208	2.814
Energy intake (from CP) as a proportion of maintenance energy requirement (x maintenance)	1.26	1.28	1.46	1.24	1.32
Rumen degradable nitrogen requirement for the level of energy intake (mg/day)	4056	4429	4908	4043	4788
Quantity of nitrogen supplied by CP (mg/day)	1969	2154	2388	1969	2334
Mean quantity of nitrogen contained in the PKC eaten (mg)	–	671	1510	1880	2250
Deficiency of rumen degradable nitrogen (mg/day)	2087	2275	2520	2074	2454

study would have been defeated if the two ingredients had been ground and mixed, as rural farmers would not have adopted the feed package because of the cost of grinding. The PKC used by Yussof (1985) was not a product of heat treated kernels as was the case with the solvent-extracted or screw-pressed kernels in this study. The application of heat in the presence of water might have caused the Milliard reaction, which could have rendered the nitrogen unavailable to both the rumen microbes and the host animal. This could also partly explain the low intakes of PKC.

The zero hour dry matter degradability values for PKC and CP shown in Figure 1 may be misleading. The values seem to be high whereas the actual degradability values may not have been. This could be because the PKC was pulverised through a 3 mm sieve into very fine powder, most of which could have leaked out of the nylon bag and therefore not degraded. The filter paper soluble fraction was 17%. The calculated mean energy intakes from CP ranged from 1.24 to 1.46 x maintenance energy requirements of the animals. The calculated rumen degradable nitrogen supplied by CP in this study did not meet the calculated RDN requirement. The deficits ranged from 1969 to 2388 mg/day. These deficits in the requirements of RDN could not have been met by nitrogen supplied by the PKC at the levels of intake recorded, even if all the nitrogen it contained was rumen degradable.

Notwithstanding the deficiency of RDN, about 74% of the animals survived on the diets for three months. The intakes of the diets (59 to 68 g/kg $W^{0.75}$ per day) were also remarkable, though lower than the values (87 to 108 g/kg $W^{0.75}$ per day) reported by Adegbola et al (1988) when they fed CP diets containing adequate amounts of nitrogen to the same breed of sheep.

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Valeur nutritive des résidus de récolte et des sous-produits agro-industriels offerts à des moutons peuls du Sahel

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Résumé

L'effet de rations à base de paille de riz complémentée avec des drèches artisanales, du tourteau de coton et de la poudre d'os sur les performances d'engraissement du mouton peul du Sahel a été étudié au Tchad sur 32 moutons âgés de 1,5 an et pesant en moyenne 24,25 kg. Ces rations ont eu un effet statistiquement significatif sur la consommation de matière sèche (P<0,01). Une corrélation positive (R = 0,96) a été mise en évidence entre la proportion de tourteaux de coton dans les rations et la consommation de paille de riz par les moutons.

L'augmentation du taux de lipides favorisée par l'addition de tourteaux de coton dans la ration a entraîné une diminution de la consommation de matière organique, de cellulose brute, d'extractif non azoté et d'énergie brute, mais non de celle de matières azotées totales. Le type de ration avait un effet significatif sur les gains moyens quotidiens (P<0,01).

Trois moutons peuls du Sahel âgés de 2 ans ont été fistulisés et utilisés pour déterminer la dégradabilité de la matière sèche des fanes et des coques de niébé, des fanes d'arachide et des drèches artisanales sèches après des temps d'incubation de 0, 6, 12, 24, 48 et 72 heures. Le taux de dégradation des fanes d'arachide atteignait son maximum (73,62%) après 24 heures d'incubation, contre 48 heures pour celles de niébé (73,48%) et 72 heures pour les coques de niébé (54%) et les drèches artisanales (47,05%).

Nutritive value of crop residues and agro-industrial by-products fed to Fulani sheep

Abstract

The effect of rations based on rice straw supplemented with brewer's grains, cottonseed cake and bone meal on fattening performance of Fulani sheep was determined in Chad on 32 1.5 year old sheep with an average weight of 24.25 kg. The rations had a significant effect (P<0.01) on dry matter consumption. The proportion of cottonseed cake in the ration was positively correlated (R=0.96) with rice straw consumption by the sheep.

Adding cottonseed cake to the ration increased lipid level and resulted in the consumption of reduced organic matter, crude fibre and nitrogen-protein. The type of ration had a significant effect on mean daily weight gains (P<0.01).

Three two-year old Fulani sheep were fistulated and used to determine dry matter fermentability of cowpea straw and pods, groundnut straw and dry brewer's grains after 0, 6, 12, 24, 48 and 72 hours incubation. The breakdown level was maximum after 24 hours incubation for groundnut straw (73.62%), 48 hours for cowpea straw (73.48%) and 72 hours for cowpea pods (54%) and brewer's grains (47.05%).

1. Introduction

En zones tropicale et subtropicale, et plus particulièrement au Sahel, les ruminants sont entretenus toute l'année sur des pâturages naturels constitués en grande partie de graminées, et dont la valeur nutritive diminue très rapidement en saison sèche. Leurs besoins n'étant alors plus couverts, les animaux doivent quotidiennement parcourir de grandes distances à la recherche d'eau et d'aliments. Cette situation entraîne généralement des pertes considérables de production: chutes de poids et taux de mortalité et de morbidité élevés chez les jeunes et les mères gestantes ou allaitantes.

Dans les zones agropastorales du Tchad, les sous-produits agricoles tels que le tourteau de coton, les fanes et les coques des légumineuses (arachides, niébés) sont généralement utilisés seuls, à grande échelle, surtout en saison sèche. Les drèches de sorgho ne sont pas utilisées judicieusement dans l'alimentation animale.

Le but de la présente étude est d'une part de présenter des rations de complémentation composées de drèches artisanales sèches de sorgho, de tourteaux de coton, de poudre d'os et de sel destinées à l'alimentation du mouton du Sahel en saison sèche, et d'autre part d'étudier la dégradabilité de la matière sèche, des drèches artisanales sèches et de certains sous-produits

de légumineuses. Les meilleures rations pourraient être vulgarisées au niveau des éleveurs sahéliens afin de permettre aux animaux d'éviter des pertes de poids et d'améliorer leur productivité en saison sèche.

2. Matériel et méthodes

2.1 Essais d'alimentation

2.1.1 Animaux

32 moutons mâles peuls du Sahel âgés de 1,5 an environ et pesant en moyenne 24,25 kg ont été utilisés dans cette expérimentation, qui s'est déroulée d'octobre à décembre 1989 (65 jours) au Laboratoire de recherches vétérinaires et zootechniques de Farcha au Tchad.

Après trois semaines d'adaptation, ces animaux, achetés sur le marché de N'Djamena, ont été déparasités au Tigal (ND) et au Vadephen (ND). Ils ont également reçu une injection intramusculaire de Terramycine longue action (ND).

Les animaux, identifiés individuellement par des boucles auriculaires, ont été répartis en 4 lots de 8 moutons chacun. Au cours des expériences, ils étaient maintenus en stabulation libre et pesés tous les 14 jours.

2.1.2 Aliments et alimentation

L'aliment de base était constitué de paille de riz distribuée à raison de 2 kg par lot et par jour. Ces quantités étaient présentées en deux fois aux animaux (à 8 heures et à 16 heures). Des rations de complémentation, composées de drèches artisanales sèches, de tourteaux de coton, de poudre d'os et de sel (tableau 1) étaient distribuées à raison de 50 g/kg $P^{0,75}$/j en une seule fois à 11 heures, c'est-à-dire 3 heures après la distribution de la première portion de l'aliment de base. Après chaque pesée des moutons, les quantités de concentrés à fournir étaient calculées en fonction de l'évolution pondérale des animaux.

Tableau 1. *Composition des concentrés*

Ingrédients (%)	Lots			
	I	II	III	IV
Drèches sèches	97,00	72,00	47,00	22,00
Tourteaux de coton	0,00	25,00	50,00	75,00
Poudre d'os	2,00	2,00	2,00	2,00
Sel (NaCl)	1,00	1,00	1,00	1,00
Total	100,00	100,00	100,00	100,00

Les refus de paille et de concentrés étaient récupérés séparément chaque jour et pesés chaque semaine, ce qui a permis de calculer les quantités d'aliments, de nutriments et d'énergie brute effectivement consommées. L'eau d'abreuvement était fournie à volonté.

2.1.3 Prises de sang et analyses

A la fin des expériences, des prises de sang ont été effectuées par ponction de la veine jugulaire sur tous les animaux. Le sang était recueilli dans des tubes secs en vue de la récolte de sérum après centrifugation. Le sérum a été conservé à -20 °C jusqu'au moment de son analyse.

Après décongélation du sérum, le calcium (Ca), le phosphore (P), le magnésium (Mg) et les protéines totales ont été dosés à l'aide du Technicon R.A. 1000, un auto-analyseur, selon les méthodes décrites par Skeggs et Hochstrasser (1964) et Audege et coll. (1983).

2.2 Digestibilité in sacco

Trois moutons peuls âgés en moyenne de 2 ans et fistulisés ont été utilisés pour l'étude de la dégradabilité de la matière sèche des drèches artisanales sèches et des fanes d'arachides et de niébé.

2 à 3 g d'aliments finement broyés (1 mm) ont été pesés dans des sachets (8 x 14 cm) en tissu Tripette de 46 nm de pores. Six sachets numérotés ont été prévus

Tableau 2. *Composition chimique (en % de MS) des concentrés et de la paille de riz utilisés dans les rations*

	Concentrés				Paille de riz
	I	II	III	IV	
Mat. sèche	96,32	95,89	95,69	92,69	92,67
Mat. organique	73,00	75,50	78,16	79,74	78,16
Mat. azotée tot.	20,31	26,18	30,65	31,51	4,20
Cellulose brute	6,57	7,22	7,57	5,51	31,32
Mat. grasse	7,54	9,99	11,22	13,40	1,43
Mat. minérale	23,32	20,39	17,53	15,95	14,51
Ca	0,74	0,88	0,58	0,66	0,09
P	6,74	0,88	0,91	1,02	0,30

par mouton et par échantillon d'aliment. Cinq sachets contenant des échantillons d'aliments broyés, préalablement séchés à l'étuve et pesés, ont été introduits dans la panse de chaque mouton. Après 6, 12, 24, 48 et 72 heures d'incubation, ces sachets ont été retirés et lavés à l'eau du robinet jusqu'à obtention d'une couleur claire. Les résidus contenus dans les sachets ont été séchés pendant 48 heures à l'étuve à 70 °C. La différence entre les poids avant incubation et après incubation donne les quantités de matière sèche disparues lors de l'incubation.

2.3 Analyse statistique

Une analyse de variance avec test F de Fisher (Essl, 1987) a été effectuée pour comparer les gains moyens quotidiens (GMQ), la consommation de la paille de riz et des concentrés et les constituants sanguins (Ca, P, Mg et protéines totales).

3. Résultats

3.1 Essais d'alimentation

3.1.1 Composition chimique des aliments

La composition chimique des aliments est donnée au tableau 2. La composition organique et minérale des quatre rations était acceptable et permettait de couvrir les besoins des ruminants tropicaux.

3.1.2 Etat de santé et taux de mortalité

Après la première semaine d'expérimentation, la plupart des animaux des lots I, III et IV ont eu des diarrhées et certains présentaient du larmoiement. Plusieurs moutons du lot IV ont présenté des dépilations au niveau de l'encolure, sur le dos et les flancs. A la fin des expériences, un taux de mortalité de 25% a été enregistré dans chacun des lots I et IV. Les causes de cette mortalité n'ont pas été déterminées.

3.1.3 Performance d'engraissement

Les consommations de matière sèche étaient statistiquement différentes selon le type de ration ($P<0,01$). Le tableau 3 fait apparaître la corrélation positive observée entre l'augmentation de la consommation de paille de riz et la proportion de tourteaux de coton dans les différentes rations ($r = 0,96$).

L'accroissement du taux de tourteaux de coton dans la ration a entraîné une augmentation des quantités de lipides ingérées par les moutons de chaque lot. On note une diminution de l'ingestion de cellulose brute, de l'extractif non azoté et de l'énergie brute dans les lots III et IV par rapport au lot II. La quantité de matières azotées totales la plus importante est consommée par les animaux du lot III suivi de ceux du lot II (tableau 4).

Les GMQ du lot I étaient statistiquement différents ($P<0,01$) de ceux des autres lots. Des chutes du poids vif ont été observées au cours des quatre premières semaines dans les lots I et IV, dont les rations contenaient une forte proportion de drèches et de tourteaux de coton respectivement. Après la 4^{e} semaine, les animaux de ces lots ont progressivement repris du poids, pour atteindre l'état d'équilibre vers le 30^{e} jour pour les animaux du lot IV et le 42^{e} jour pour ceux du lot I. Après cette période, aucune différence de poids n'a été notée entre les lots II, III et IV.

3.1.4 Constituants sanguins

A la fin de l'expérimentation, les concentrations des constituants sanguins (Ca, P, Mg et protéines totales) des moutons de chaque lot étaient significativement différentes ($P<0,01$) d'un lot à l'autre (tableau 5).

Tableau 3. *Consommation de rations complémentées avec des drèches artisanales et des tourteaux de coton, et croissance pondérale*

	Lots			
	I	II	III	IV
Poids moyen (kg)	25,00	23,50	24,54	23,94
	(± 3,56)	(± 3,96)	(± 2,85)	(± 1,21)
Consommation partielle				
Paille de riz (g de MS/tête/j)	146,46	177,00	181,35	204,42
Concentrés (g de MS/tête/j)	508,00	607,42	552,00	486,00
(g de MS/100 kg de PV)	2 031,48	2 584,76	2 245,71	2 029,42
(g de MS/kg de $P^{0,75}$)	45,42	56,91	49,99	44,88
Consommation totale				
Paille de riz (g de MS/tête/j)	654,00	784,00	733,00	690,00
(g de MS/kg de $P^{0,75}$)	58,5	73,5	66,5	63,8
Croissance pondérale				
Gain total (kg)	1,00	3,83	4,07	4,33
GMQ (g)	15,38	61,53	62,63	61,54

Tableau 4. *Consommation de nutriments (g/tête/jour) et d'énergie brute par type de concentré*

	Lots			
	I	II	III	IV
Mat. azotées totales	103,15	159,02	169,12	153,02
Cellulose brute	33,36	43,85	41,77	26,76
Mat. grasses	38,29	60,68	61,91	65,07
Extractif non azoté	195,94	195,05	158,46	142,40
Energie (en UFV)[a]	1,06	1,38	1,33	1,22

[a]UFV = unité fourragère viande.

Tableau 5. *Constituants sanguins des moutons du Sahel en fin d'essai d'alimentation*

	Lots			
	I (n = 7)	II (n = 7)	III (n = 8)	IV (n = 4)
Ca (mg/l)	64,57	61,43	64,75	80,00
	(± 6,21)	(± 7,94)	(± 10,38)	(± 12,31)
P (mg/l)	63,33	60,71	75,50	77,00
	(± 12,83)	(± 23,31)	(± 30,06)	(± 18,45)
Mg (mg/l)	12,14	13,00	21,25	21,00
	(± 2,75)	(± 2,87)	(± 5,09)	(± 4,52)
Protéines totales (g/l)				
	56,00	48,71	52,25	65,00
	(± 9,64)	(± 11,94)	(± 9,94)	(± 11,49)

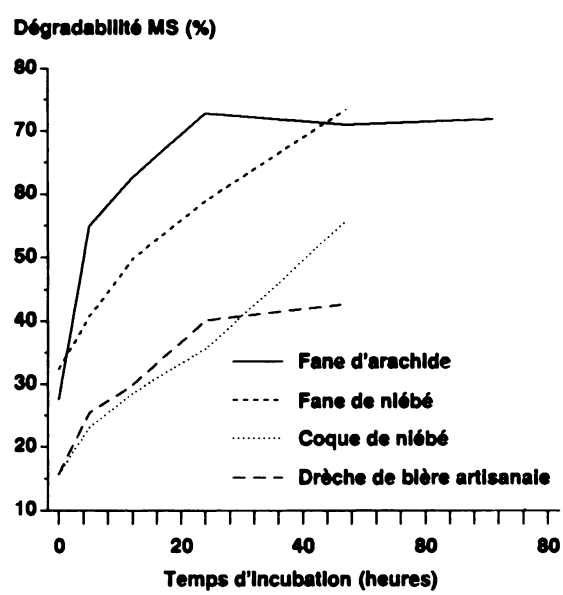
n = nombre de prélèvements.

3.1.5 Digestibilité *in sacco*

Avant l'incubation (0 heure), la digestibilité de la matière sèche des fanes de niébé et d'arachide était nettement supérieure à celle des coques de niébé et des drèches. Les coefficients de dégradabilité des fanes étaient les plus élevés, quelle que soit la durée d'incubation (figure 1).

Après 24 heures d'incubation, la dégradabilité moyenne de la matière sèche des fanes d'arachide et de niébé était respectivement de 73,62% et de 58,97%, contre 35,75% pour les coques de niébé et 39,86% pour les drèches. Les fanes de niébé n'atteignaient leur dégradation maximale (73,48%) qu'après 48 heures, durée d'incubation après laquelle la dégradation des coques de niébé n'était que de 52%, avant d'atteindre 54% au bout de 72 heures. Enfin, la dégradabilité de la matière sèche des drèches artisanales n'était que de 47,05% après 72 heures d'incubation.

Figure 1. *Dégradabilité de la matière sèche des différents aliments*



4. Discussion

4.1 Essais d'alimentation

Les performances d'engraissement des moutons de cette expérience étaient faibles ou moyennes, avec des GMQ allant de 15,32 à 62,63 g/j. Ces résultats pourraient s'expliquer par le fait que les animaux utilisés étaient relativement âgés (18 mois environ). Des GMQ semblables ont cependant été enregistrés par Calvet et Denis (1974) sur des moutons peul-peul sénégalais âgés de 8 à 10 mois.

Des valeurs plus faibles (18,50 g et 20,60 g) ont été obtenues par Fall (1989) sur des moutons peuls du Sénégal âgés de 1 an en moyenne, avec des rations composées de paille de riz, de tourteaux d'arachide et de poudre d'os.

En revanche, Bourzat et coll. (1987) rapportent des valeurs de 86 g/j à 117 g/j chez des moutons peuls âgés de 4 à 5 mois, respectivement non traités et traités aux anthelminthiques dans le nord du Burkina Faso, avec des rations composées de foin de *Stylosanthes* et de concentrés composés de 45% de son de blé, 35% de brisures de riz, 15% de tourteaux de coton et 3% de complexe minéral vitaminé. Avec des rations de complémentation en saison sèche, ces mêmes auteurs ont obtenu un gain moyen quotidien de 126 g/j sur des moutons peuls âgés de 8 mois. Ces résultats démontrent les bonnes aptitudes bouchères des moutons peuls du Sahel, déja mentionnées par Charray et coll. (1980).

Les GMQ de 61,53 g à 62,63 g obtenus avec les rations II, III et IV peuvent être considérés comme satisfaisants, vu l'âge des animaux et la courte durée de la période d'observation (65 jours), l'embouche ovine requérant une période d'observation d'au moins 90 jours, temps utilisé par la plupart des auteurs cités ci-dessus.

La diminution des quantités de cellulose brute, d'extractif non azoté et d'énergie brute ingérées pourrait s'expliquer par l'augmentation de la teneur en lipides des concentrés.

Les taux de calcium et de phosphore sont identiques à ceux rapportés pour les brebis peules du Sahel par Brahim et Gongnet (1987) au Tchad et Assane et coll. (1989) au Sénégal. Les valeurs de calcémie obtenues par Assane et coll. (1989) de 103,71 mg/l à 111,86 mg/l chez la brebis et de 61,43 mg/l à 80,00 mg/l chez les moutons mâles non castrés sont nettement supérieures à celles observées ici.

La calcémie de la brebis peule du Sénégal ne semble subir aucun effet significatif de la gestation (Sawadogo et coll., 1988), mais il est probable qu'elle soit positivement influencée par l'alimentation. Lorsque la ration est composée soit uniquement de drèches artisanales sèches (lot I), soit de 25% de tourteaux de coton (lot II), la phosphorémie de la brebis peule (45,95 mg/l à 66,64 mg/l) (Assane et coll, 1989) est identique à celle des moutons mâles de la présente étude.

La concentration en protéines totales augmente considérablement lorsque le taux du tourteau de coton des rations est de 75% (lot IV). Les valeurs des protéines totales observées ici sont semblables à celles obtenues par Brahim (1987) chez les brebis peules du Sahel au Tchad.

4.2 Etude de digestibilité *in sacco*

Selon Preston (1986), la dégradabilité de la matière sèche d'un aliment de bonne valeur nutritive doit être égale ou supérieure à 50% après 24 heures d'incubation dans le rumen. Ce ne fut pas le cas pour les coques de niébé et les drèches artisanales utilisées dans cette étude. Par ailleurs les taux de dégradabilité des fanes d'arachide étaient supérieurs aux chiffres de 55,10% et 66,00% rapportés par Parigi-Bini et coll. (1991) pour des fanes d'arachide du Sénégal après 12 et 24 heures d'incubation. Avec les aliments provenant du Tchad, les taux de dégradabilité de la matière sèche étaient ici de 62,99% et de 73,62% respectivement pour les mêmes durées d'incubation.

5. Conclusion

L'amélioration de l'alimentation de saison sèche des petits ruminants au Sahel passe par l'utilisation rationnelle des résidus de récolte et des sous-produits agro-industriels locaux. Ainsi, en formulant des rations composées de tourteaux de coton, de drèches artisanales sèches et de poudre d'os, on s'est aperçu que les chiffres les plus élevés de matière sèche consommée et de gain moyen quotidien étaient respectivement associés à des taux de tourteaux de coton de 25% et de 50% dans les rations.

Les meilleurs taux de dégradabilité de la matière sèche étaient obtenus avec les fanes d'arachide et de niébé, lesquelles pourraient être utilisées pour la complémentation des pâturages naturels pauvres et/ou des rations à base de paille de graminée utilisées pour l'alimentation des ruminants en saison sèche au Sahel.

Remerciements

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Seasonal changes in body condition of the Senegalese Sahel goat: relationship to reproductive performance

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Abstract

The level of feeding was found to be an important determinant of goat body condition and correlated positively with the conception rate. Goats lost body condition with the progressive deterioration of pasture in the dry season. This condition can be improved with a sufficient level of concentrate supplementation. The lumbar area score was more closely related to live weight than the sternum score.

Rapport entre les variations saisonnières de l'état corporel et les performances de reproduction de la chèvre du Sahel au Sénégal

Résumé

Cette étude fait apparaître que le niveau d'alimentation est un facteur déterminant de l'état corporel des caprins et qu'il est positivement corrélé avec le taux de conception. La détérioration progressive des pâturages en saison sèche a entraîné une déperdition de l'état corporel des caprins, qu'une supplémentation suffisante avec des aliments concentrés permet cependant de relever. La note de pointage obtenue à la région lombaire était plus étroitement liée au poids vif que celle du sternum.

Introduction

Lipids are the main form of body energy storage in goats, as in others mammals (Chilliard, 1987). Lipid deposition and mobilisation cycles are essential for reproduction and lactation performance and for ecological adaptation. Numerous reliable methods have been developed to predict *in vivo* changes in body reserves. Morand-Fehr et al (1987) extensively reviewed the use of these methods in goats. With the exception of body condition scoring, most of them are very expensive. Body condition scoring is however easier to use although it is subjective. The purpose of this study was to calibrate it with the Sahel goat and to investigate relationships between body condition and reproductive performance.

Material and methods

The 49 female and six male Sahel goats were on average two years old. They were managed under the same conditions during the dry season in the peri-urban zone, with eight hours a day of pasture grazing. After two months of daily supplementation with 300 g of groundnut cake per animal, oestrus was synchronised with a vaginal sponge containing 45 mg of fluorogestone acetate (Chronogest, Intervet, France). The objective was to encourage kidding at the beginning of the raining season. From March to May, goats were daily offered 200 g of concentrate (66% maize, 30% groundnut cake, 4% CMV) per animal. From June to July, each non-pregnant goat received 400 g of concentrate daily. Pregnant goats were offered 500 g per animal. Pregnancy was tested by progesterone analysis in blood sampled at 10-day intervals six weeks after heat began. Goats were weighed every 14 days and body condition scored early in the morning the day before the vaginal sponge was withdrawn. Thereafter they were weighed once a month according to the method of Santucci (1984), using a 1–5 scale of scoring. The last scoring was done in July (at 16.43 ± 3.1 days before kidding). Three scores (ocular, sternum and lumbar) were assigned after observation and palpation on the lumbar and sternum areas. Goats' grazing behaviour and plant species selected from pasture were studied twice a month. The Student t-test was used to compare the performance of pregnant and non-pregnant goats. In each group, seasonal changes in performance were calculated with a paired t-test.

Results and discussion

Conception rate was 41% and correlated positively ($r = 0.3$) with condition score on the day before vaginal sponge withdrawal. Does that did not conceive had a lower condition score at mating (Table 1), as already reported for ewes by Gunn et al (1969). Figure 1(a) shows the mean condition score performance as based in Morand-Fehr (1992), taking into account sternum and lumbar scores. Pregnant does recorded higher ($P<0.01$) scores than the non-pregnant does. All groups showed a

Table 1. *Seasonal changes[1] in goat body condition scores[2] of Sahel goats.*

Month	OCS		STS		LCS	
	P	NP	P	NP	P	NP
February[3]	2.9 ± 0.5	2.3 ± 0.8				
April	3.1 ± 0.9	2.6 ± 0.9	3.0^a ± 1.1	2.3^b ± 1.1	3.1 ± 0.9	2.7 ± 0.8
May	3.1^a ± 0.7	2.5^b ± 0.7	3.2^a ± 0.6	2.6^b ± 0.7	3.9^a ± 0.5	3.3^b ± 0.6
June	2.5^a ± 0.4	2.1^b ± 0.4	2.6^a ± 0.6	2.1^b ± 0.5	3.1^a ± 0.5	2.7^b ± 0.5
July	3.3 ± 0.6	3.0 ± 0.8	3.1 ± 0.8	2.8 ± 0.9	3.9 ± 0.4	3.6 ± 0.7

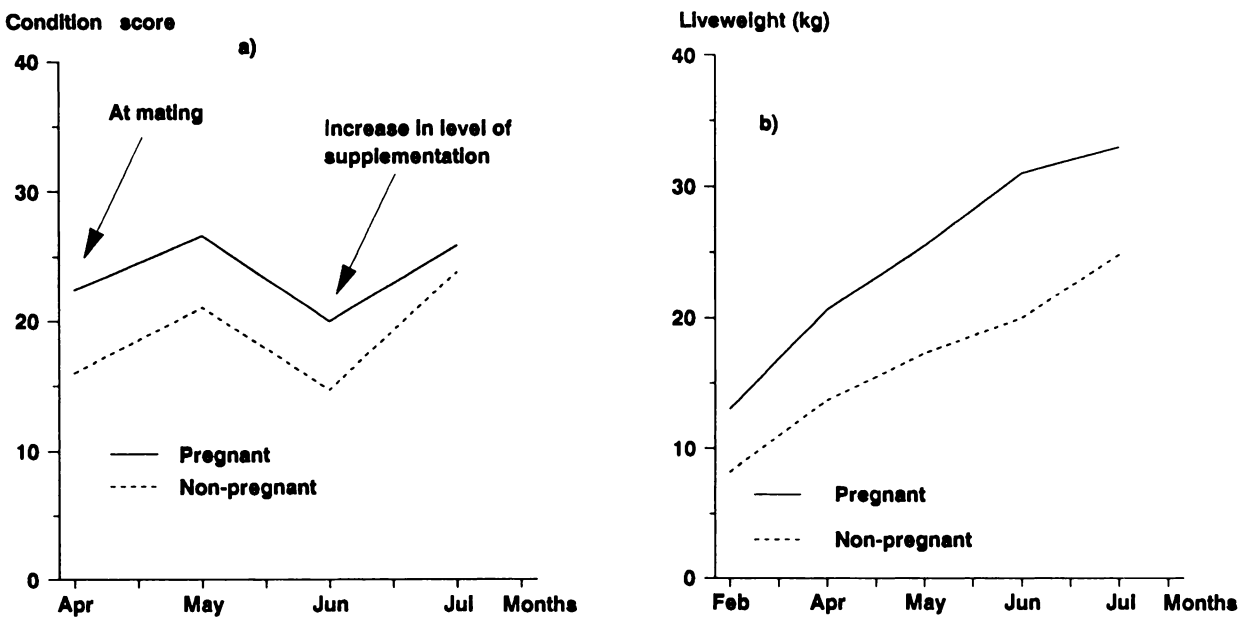
[1]Means (and standard deviation) in pregnant (P, n = 20) and non-pregnant (NP, n= 29) goats.

[2]OCS = ocular condition score, SCS = sternum condition score, LCS = lumbar condition score.

[3]21 February= the day before vaginal sponge withdrawal (i.e. at mating).

All means with different superscripts are different (P<0.01).

Figure 1. *Seasonal change in mean body condition score and liveweight of goats.*



rapid decline in body condition between May and June. This corresponded to a general decline in the quantity and quality of the herbaceous pasture that goats depend on for the major supply of their nutrients. However, pregnant does lost more condition (P<0.01) than the others (-0.63 ± 0.71 vs -0.59 ± 0.43). From June to July the increase in the level of concentrate supplementation improved body condition in all does in agreement with the findings of Santucci (1984) and Branca (1987). Pregnant does, however, recovered slightly less (P<0.01) than non-pregnant does (0.7 ± 0.54 vs 0.85 ± 0.52). This may be related to increased energy needs in gravid does due to foetal growth which could lead to less lipid deposition or an increase in lipomobilisation.

Liveweight changes did not always parallel body condition scores (Figure 1b). This is not surprising because it is well established that body condition reflects body lipids more than live weight because of gut contents (Morand-Fehr et al, 1987). Computations on 196 pooled data from all goats for the period between April and July showed approximately 3.2 kg liveweight change for one unit of mean condition score (Table 2). However, the prediction was more precise with the lumbar score (RSD = 3.9) than that of change in sternum (RSD = 4.1) or ocular score (RSD = 4.2). Generally, there was more correlation between live weight and condition score in non-pregnant than in pregnant does (Table 2). Bias due to calibrating on animals differing in age and physiological stage or overestimating pregnant goats, body condition must be taken into account. Correlations between condition scores and liveweight in this study (Table 2) agree with similar relationships observed by Branca (1987, R = 0.6) and by Morand-Fehr et al (1987, R = 0.57 for sternum score and R = 0.44 for lumbar score). However, we found sternum

Table 2. *Linear regressions (Y = aX + b)*[1] *between live-weight (LW) and body condition scores of the Sahel goat.*

Y	X2	a	b	R	RSD	a'	b'	R'	RSD'
LW (kg)	LCS	3.1	15.5	0.52	3.9	3.5	12.9	0.63	3.3
	SCS	2.4	19.1	0.47	4.1	3.0	16.5	0.61	3.4
	OCS	2.3	19.4	0.39	4.2	2.3	17.3	0.47	3.8
	MCS	3.2	16.2	0.53	3.9	3.7	13.6	0.67	3.2

[1] a, b, R, RSD are calculated from all goats (n= 196) from April to July; a', b', R', RSD' were obtained from non-pregnant goats only (n =116).
[2] See Table 1 plus MCS = mean condition score = (LCS+SCS/2).

and lumbar scores were less related (R = 0.73) than in the study reported by Morand-Fehr et al (1987, R = 0.87). These differences are perhaps due to peculiarities in the adipose deposits of local breeds and/or to the frequent hardening of the skin on the sternum area which disturbed the palpation. This study clearly showed a seasonal change of body condition scores, but absolute values could be expected to be smaller if a 0 – 5 scale scoring (Morand-Fehr, 1992) was used. We found good repeatability of the method (R = 0.9) between two scores from the same observer but reproducibility was somewhat low (R = 0.62) between scores from two observers, partly because of the inexperience of one observer.

Conclusion

Body condition scoring is of great interest in nutritional management and is useful not only for research scientists but also for farmers and development planners. Its validity will be enhanced by complete dissection of the goats and body chemical composition analysis in order to establish relationships between the scores and body lipids and to improve methods for evaluating body condition of the sahel goat.

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Wet season supplementation of West African Dwarf goats raised under traditional management in the subhumid zone of Nigeria

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Abstract

Analyses were conducted on the performance and productivity of West African Dwarf (WAD) goats kept under village conditions in Ganawuri of Plateau State. The analyses covered 420 kids from 264 kiddings over a two-year period (August, 1989 – August, 1991). During the wet season one group of flocks grazed forage legume while another group grazed natural pasture. The average litter sizes were 1.6 ± 0.60 and 1.5 ± 0.5 on the fodder banks (FB) and natural pasture (NP), respectively, and were significantly (P<0.01) affected by parity. The kidding intervals were 259 ± 19.8 and 269 ± 12.4 days, respectively, and were not significantly different. Access to the fodder bank significantly (P<0.05) reduced weight losses in non-pregnant does in the wet season. Cumulative mortality to one year was significantly affected (p<0.05) by birth type and season of birth. Access to FB significantly (P<0.05) improved viability of kids to one year.Weights of kids were significantly affected (P<0.05) by season of birth, birth type and sex but these differences had disappeared by 90 days. Innovations to sustain crop/livestock activities in a predominantly cropping situation are discussed.

Complémentation alimentaire de saison des pluies de la petite chèvre d'Afrique occidentale traditionnelle élevée dans la zone subhumide du Nigéria

Résumé

Les performances et le niveau de production de la petite chèvre d'Afrique occidentale élevée en milieu villageois à Ganawuri dans l'Etat du Plateau, ont été analysés. L'analyse a porté sur 420 chevreaux issus de 264 mises-bas survenues au cours d'une période de deux ans (août 1989 – août 1991). Pendant la saison des pluies, un lot d'animaux pâturaient des légumineuses fourragères et un autre séjournait sur des pâturages naturels. La parité avait un effet significatif (P<0,05) sur la taille moyenne des portées, qui était de 1,6 ± 0,60 pour les animaux nourris sur les banques fourragères et de 1,5 ± 0,5 pour ceux nourris sur les pâturages naturels. Les intervalles de mises-bas étaient respectivement de 259 ± 19,8 et 269 ± 12,4 jours et ne différaient pas de manière significative. L'accès aux banques fourragères engendrait une réduction significative (P<0,05) des pertes pondérales chez les chèvres non gravides pendant la saison des pluies. Le type et la saison de naissance avaient un effet significatif (P<0,05) sur la mortalité cumulée jusqu'à 1 an. L'accès aux banques fourragères améliorait significativement (P<0,05) la viabilité des jeunes jusqu'à 1 an. La saison de naissance, le type de naissance et le sexe avaient un effet significatif (P<0,05) sur le poids des jeunes mais ces différences dispa- raissaient après 90 jours. Les innovations visant à soutenir les activités de culture et d'élevage dans des régions à prédominance culturale sont examinées.

Introduction

Small ruminants, particularly goats, play an important role in the economic life of the smallholder farmer, converting low-cost inputs to high-value products (meat, milk and skins). Indeed the goat has been described as "the poor man's cow" (Mba, 1979) and is well adapted to a relatively harsh environment. The West African Dwarf (WAD) goat is kept by crop farmers as a secondary enterprise in the subhumid zone, defined ecologically as lying between 900 and 1500 mm isohyets and having 180 to 270 plant-growing days (Jahnke, 1982). Goats mature fast and are prolific. Despite high kid mortality rates, goat-keeping could be a profitable enterprise at village level.

In an area where cropping is the major activity, the traditional method of keeping goats during the wet season is by tethering or free-ranging on enclosed fallow land to prevent damage to crops. Often the grazing orbit of the goat is determined by the length of the tether. This restriction does not permit free selection of feed from natural pasture which matures rapidly and has a low N and mineral content (Kapu, 1975; Mohammed Saleem and Otsyina, 1986). Goats therefore experience feed constraints in the wet season resulting in weight losses

in adult goats and high kid mortality rates, partly due to malnutrition, disease and internal parasites.

This study reports on the differences in productivity between goats allowed to graze small plots of forage legume (mini fodder banks) in the wet season and those which grazed natural pasture under village conditions.

Materials and methods

Site

This study was carried out in the Ganawuri district of Plateau State. It is located 9° N and 8° 35' E with an average annual rainfall of about 1400 mm, 90% of which falls between April and October.

Animals

Flocks of goats belonging to smallholder farmers were used. Their histories were obtained and they were tagged at the beginning of the study. They were vaccinated annually against *peste des petits ruminants* (PPR) and dipped fortnightly to control lice and mange. Births, birth types, sales and deaths were recorded as and when they occurred. The animals roamed freely in the village during the dry season consuming browses, grasses, crop residues and household wastes. In the wet season, as the crops were being planted, goats were tethered alongside the road, near the homestead or allowed to graze on enclosed fallow land. In addition, some flocks were allowed to graze fodder banks of *Stylosanthes*. Animals are restrained between August and October. The first crop is maize; after it is harvested, the animals are allowed more freedom but are kept away from late-maturing crops such as millet. At the start of the experiment, there were eight farmers who shared a communal fodder bank where stylo was used for land reclamation. Natural pasture was used by 10 farmers. By 1991 there were 11 fodder banks while 26 farmers used natural pasture. The animals increased from 157 (56 does) in August 1989 to 324 (136 does) and 395 (157 does) in August 1990 and 1991, respectively.

Pasture development

Stylosanthes pasture was established on small plots at a seed rate of 12 kg/ha with 150 kg single superphosphate fertilizer/ha. The size of these plots varied and were determined by a technique described by Lawrence (1991). Random quadrants ($1m^2$) of pasture were clipped, weighed and sorted into stylo, grasses and forbs for botanical composition and dry matter yield determinations.

Description of data and statistical analysis

Births, birth types, weights, weighing dates and parity of does were recorded. Kidding intervals were computed. Data analysis was done using the General Least Squares Models (SAS, 1987). Models for mortality and growth to one year included the fixed effects of year of birth, season, birth type and parity. There were two wet season feed regimes, natural pasture and fodder bank (FB) grazing. Goats on natural pasture were either free-grazing in enclosures where they could eat selectively or were tethered. The seasons were divided into four: late dry (December – February); early wet (March - May); peak wet (June – August); and early dry (September - November). The year 1990 was defined as Aug 1989 to July 1990 and the year 1991 as Aug 1990 to July 1991. Kid mortality included only deaths occurring within one year of birth.

Results

Figure 1 shows the weight changes in adult non-pregnant does during a typical period of restricted movement in the wet season. A similar pattern was observed during subsequent wet seasons. As the wet season progressed, weight losses occurred when feed material decreased. Significant differences ($P<0.05$) occurred between the two groups at the end of the wet season. The kidding intervals were 259 ± 19.8 and 269 ± 12.4days and were not significantly different ($P<0.05$). The litter sizes were significantly affected ($P<0.01$) by parity. About 68% of all kids resulted from multiple births. Kidding was all year round but cumulative mortality (Table 1) was significantly ($P<0.05$) affected by season up to one year of age. The unadjusted cumulative mortality to one year was 17.5 and 35.8% in 1990 and 1991, respectively. Viability, improved by access to FB, became significant at one year of age.

The weights of kids to one year (Table 2) were significantly affected ($P<0.05$) by season of birth and

Figure 1. *Weight changes of adult WAD female goats in Ganawuri in the wet season (August–October).*

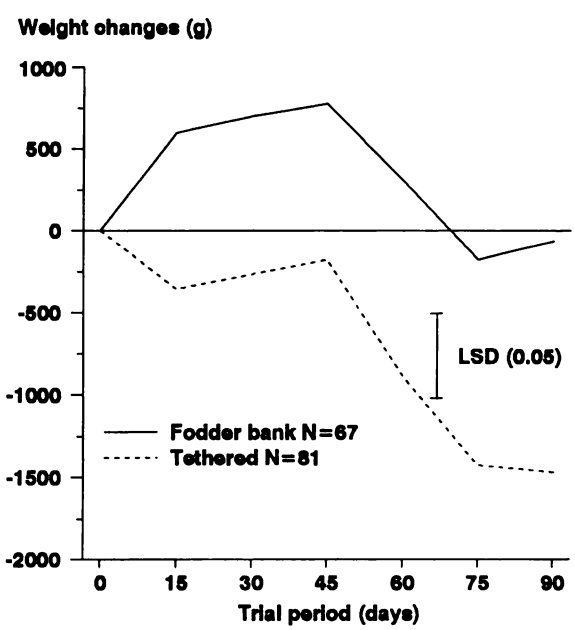

Table 1. *Least squares means ± SE of cumulative mortality (%) of West African Dwarf goat kids from birth to 365 days in Ganawuri with access to fodder bank or natural pasture.*

Variables	No	Age (Days)			
		30 days	90 days	150 days	365 days
Overall	414	4.8 ± 1.92	11.3 ± 3.71	15.3 ± 3.41	24.7 ± 4.09
Year of birth					
1990	68	5.42 ± 2.94	12.9 ± 4.48	16.0 ± 5.72	9.5 ± 8.80
1991	346	4.2 ± 1.82	9.6 ± 2.80	14.6 ± 3.71	39.8 ± 6.70
Season of birth					
Dec-Feb	60	1.3 ± 3.21	3.7 ± 4.97	2.5 ± 6.32	1.71 ± 0.53
Mar-May	122	1.4 ± 2.38	5.4 ± 3.65	11.5 ± 4.71	17.9 ± 8.55
Jun-Aug	122	9.6 ± 2.48	19.3 ± 3.83	22.1 ± 4.92	42.2 ± 8.72
Sep-Nov	110	6.9 ± 2.65	16.7 ± 4.03	22.0 ± 6.32	36.9 ± 8.50
Sex					
F	208	3.5 ± 2.16	11.0 ± 3.29	15.2 ± 4.36	21.4 ± 6.98
M	206	6.0 ± 2.25	11.4 ± 3.46	15.5 ± 4.49	27.9 ± 6.72
Birth type					
Single	132	3.4 ± 2.04	8.8 ± 3.16	15.1 ± 4.07	15.6 ± 6.12
Twin	262	4.2 ± 1.61	10.5 ± 2.45	14.1 ± 3.17	26.8 ± 4.65
Triplet	20	6.7 ± 4.81	14.4 ± 7.29	16.8 ± 9.90	31.6 ± 15.78
Treatment					
FB	192	3.2 ± 2.35	9.3 ± 3.61	11.5 ± 3.21	16.2 ± 7.34
NP	222	6.4 ± 2.07	13.2 ± 3.15	17.6 ± 3.83	33.1 ± 6.48

FB = Fodder bank; NP=Natural pasture; F = Female; M=Male; *P<0.05.

birth type. Prior to introducing the animals to grazing in August, the mini fodder banks produced, on average, 2.6 ± 0.87 tonnes dry matter (DM)/ha while the natural vegetation produced 2.4 ± 0.31 tonnes (DM)/h. The botanical composition of pasture showed 30 – 50% stylo, 40 – 60% grasses while the rest were forbs. Comparisons between treatments were not possible as the flock sizes varied between five and 30. Plots of pasture varied between 0.04 and 0.36 ha and the stylo content of forage also differed.

Discussion

To make goat-keeping profitable, offtake from a flock should be high. There was a prevalence of multiple births which could be exploited through management to ensure greater survival to weaning. The results of this study suggest that supplementation of the does in the wet season leads to reduced weight losses. This could reduce kid mortality in the wet season through improved nutrition. However, the wet season is characterized by the presence of diseases and a high helminth burden (Smith et al, 1986). Drugs could reduce kid mortality. The least squares mean mortality of 25% recorded in this study is lower than the 40 ± 50% recorded in the humid zone (Reynolds et al, 1987). The almost two-fold increase in unadjusted mortality means between 1990 and 1991 was attributed to the annual vaccination against PPR between June and July 1991. This was accompanied by abortions in many does and could be a case of vaccine failure. The overall mortality in Ganawuri of 24% is comparable to that found in Abet (Bayer, 1986b). Bayer (1986a) estimated that the intensity of land cultivation in the zone ranged from 15 to 60%, with the highest intensity in the Ganawuri area. The farmers' practice is to allow periods of fallow to encourage nutrient recycling and restore soil fertility. With increasing pressure on land, fallow periods cannot be extended thus soil fertility declines and the production system deteriorates. Goat production involving the use of mini fodder banks in the wet season can easily be integrated into the existing agricultural system for increased productivity.

In the subhumid zone, ILCA scientists showed that fallow land sown to legume pasture regained soil fertility much more quickly (Mohammed-Saleem and Otsyina, 1986). There were also increased grain yields when fodder banks were cropped three to four years after establishment (Mohammed Saleem and Otsyina, 1986) which made the concept attractive to crop farmers. Farmers have exploited the benefit of incorporating forage legume into their cropping system by putting goats in these mini fodder banks during the wet season. This is borne out by the number of farmers adopting the fodder bank concept: 8 (1989), 17 (1990) and 19 (1991). This study clearly shows that the use of fodder banks reduces weight losses in non-pregnant mature does. Weight losses in adult females are known to influence reproductive performance.

Table 2. *Least squares means ± SE of the weight (kg) of West African Dwarf kids in Ganawuri with access to fodder or natural pasture.*

Effect	No	Birth	30 days	90 days	150 days	365 days
Overall	420	1.6 ± 0.13	3.1 ± 0.74	5.6 ± 1.25	7.7 ± 1.58	12.0 ± 2.14
Year of birth						
1990	68	1.8 ± 0.05	3.1 ± 0.14	5.7 ± 0.24	8.1 ± 0.42	12.4 ± 0.98
1991	352	1.5 ± 0.03	3.1 ± 0.08	5.5 ± 0.15	7.2 ± 0.29	11.6 ± 0.74
Season of birth						
Dec-Feb	60	1.8 ± 0.06	3.4 ± 0.15	6.3 ± 0.26	8.1 ± 0.48	11.6 ± 0.98
Mar-May	120	1.6 ± 0.04	3.3 ± 0.10	5.9 ± 0.19	7.2 ± 0.34	13.0 ± 0.94
Jun-Aug	126	1.6 ± 0.04	2.8 ± 0.11	5.1 ± 0.21	7.3 ± 0.34	12.0 ± 0.98
Sep-Nov	112	1.6 ± 0.05	2.8 ± 0.12	4.9 ± 0.43	7.8 ± 0.43	11.3 ± 0.99
Sex						
F	213	1.6 ± 0.04	3.1 ± 0.9	5.5 ± 0.17	7.6 ± 0.33	12.5 ± 0.70
M	207	1.7 ± 0.04	3.1 ± 0.10	5.6 ± 0.18	7.6 ± 0.34	11.4 ± 0.66
Birth type						
Single	134	1.8 ± 0.03	3.7 ± 0.09	6.0 ± 0.18	8.1 ± 0.31	12.1 ± 0.60
Twin	265	1.6 ± 0.03	3.1 ± 0.08	5.3 ± 0.14	7.4 ± 0.23	11.4 ± 0.48
Triplet	21	1.5 ± 0.08	2.5 ± 0.21	5.3 ± 0.38	7.3 ± 0.76	12.4 ± 1.61
Treatment						
FB	195	1.6 ± 0.04	3.1 ± 0.11	5.4 ± 0.19	7.6 ± 0.32	11.9 ± 0.72
NP	225	1.6 ± 0.04	3.1 ± 0.09	5.8 ± 0.17	7.9 ± 0.30	12.0 ± 0.68

FB = Fodder bank; NP = Natural pasture; F = Female; M = Male; *p<0.0.5.

To make the overall production system sustainable, livestock-crop activities have to be integrated. A trade-off in terms of reduced crop yield and availability of high quality forage for feeding goats is inevitable. In this study the number of goats per flock, the sizes of the fodder banks and the quality of pasture all varied. Further investigation to determine the optimum number of goats per mini fodder bank would be worthwhile in order to sustain this agricultural system.

Acknowledgement

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Performance of weaner lambs fed maize leaves and napier grass

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Abstract

Maize leaves were compared to napier grass in experiments designed to measure their nutritive value and their effect on the growth of weaner lambs under stall feeding conditions. In the first trial, one leaf per plant per week was systematically plucked about three months post-emergence; in the second, green leaves were defoliated from the bottom of the plant about 4–5 months after germination. In both cases, animals fed the maize leaves gained significantly more weight ($P<0.01$) than those fed napier grass. The effect of leaf defoliation on forage dry matter (DM) productivity and grain yield is discussed.

Performances des agneaux sevrés nourris avec des feuilles de maïs et de l'herbe à éléphant

Résumé

Deux expériences ont été mises en place pour mesurer la valeur nutritive des feuilles de maïs et de l'herbe à éléphant et comparer leurs effets sur la croissance d'agneaux sevrés alimentés en bergerie. Dans le premier essai, une feuille par plante était cueillie toutes les semaines trois mois environ après la levée; dans le second essai, les feuilles vertes du bas de la plante ont été cueillies 4 à 5 mois après la germination. Dans les deux cas, la croissance pondérale des animaux nourris avec les feuilles de maïs était supérieure ($P<0,01$) à celles des animaux nourris avec l'herbe à éléphant. L'effet de la défoliation sur le rendement en matière sèche fourragère et en grains de maïs est examiné.

Introduction

Grazing lands in the agriculturally rich highlands and coastal subhumid zones of sub-Saharan Africa are diminishing, mainly due to the increase of human settlements. This is increasingly causing a scarcity of fodder for small ruminants.

In Kenya napier grass has been identified as being productive, persistent and easy to harvest (Mwakha, 1972; Boonman, 1977; Karanja, 1984). It is also palatable and gives reasonable growth rates and milk yields in cattle (Abate et al, 1992). However, under smallholder conditions, the growing of pure fodder may be limited by the farmer's need to meet his own food requirements. Defoliated maize leaves for fodder have been integrated into crop and animal production trials with satisfactory results (Abate 1981, 1982, 1983). A study was undertaken to record the effects of maize leaf and napier grass diets on Corriedale sheep. This paper reports the findings.

Materials and methods

Weaner lambs of the Corriedale breed were allocated to two groups of four. The lambs were approximately five months old and had an average weight of 21 kg. They were dewormed prior to the experiment. One group was the treatment group and received maize leaves *ad libitum*. The control group was offered napier grass *ad libitum*. The trial lasted for 10 weeks. Maize leaves were defoliated from a plot of hybrid maize plants about three months post-emergence at a frequency of one leaf per plant per week. A second plot remained undefoliated as a control. Both the maize leaves and napier grass were chopped before being fed to the animals. Group dry matter (DM) intake was recorded daily and each sheep was weighed once a week. Clean water and mineral licks were freely available. Feeds offered and refusals were sampled weekly, dried in a draught oven and milled through a 2 mm sieve for laboratory analysis.

In an experiment carried out the following year, the digestibility of maize leaves defoliated about 4–5 months after germination was compared to that of napier grass. Maize leaves were obtained by picking green leaves from the bottom of the plant upwards, leaving only the four nearest the cob. The maize leaves and napier grass were chopped before being fed *ad libitum* to the animals. The wethers were fed for a preliminary period of approximately three weeks, then there was a collection period of seven days. Composite samples collected over the seven days were oven-dried at 60°C and ground for analyses. Individual animal weights were

recorded at the beginning and end of the trial. Data from both experiments were subjected to statistical analysis.

Results

Results of the performance trial are given in Tables 1 and 2 and in Figure 1. The maize leaves were similar in DM content to the napier grass but higher in crude protein (CP) levels (Table 1). The concentration of CP in both forages declined with age (Figure 1) at the rate of 1.1% and 0.4% per week for defoliated maize leaves and napier grass respectively. Defoliated maize leaves gave a higher DM intake and a daily gain in weight that was roughly three times higher than napier grass. Efficiency of feed conversion was more than two times higher in the lambs fed maize leaves than in those fed napier grass. Maize defoliation produced approximately 1.5 tonnes of leaf DM per hectare without significantly ($P \geq 0.05$) reducing grain yield (4.90 vs 5.31 tons/hectare).

Table 1. *Chemical composition and effect on weaner lamb performance of defoliated maize leaves and napier grass.*

	Defoliated maize leaves	Napier grass
Dry matter, %	22.4	21.3
Crude protein, %	16.6	8.6
Dry matter intake (g/day)	887.0	683.0
Average daily gain (g/day)	136.0[a]	48.0[b]
Feed conversion efficiency	6.5	14.1

ab = Values in a row bearing different superscripts are significantly different ($P<0.05$).

Figure 1. *Changes in crude protein content of defoliated maize leaves and napier grass.*

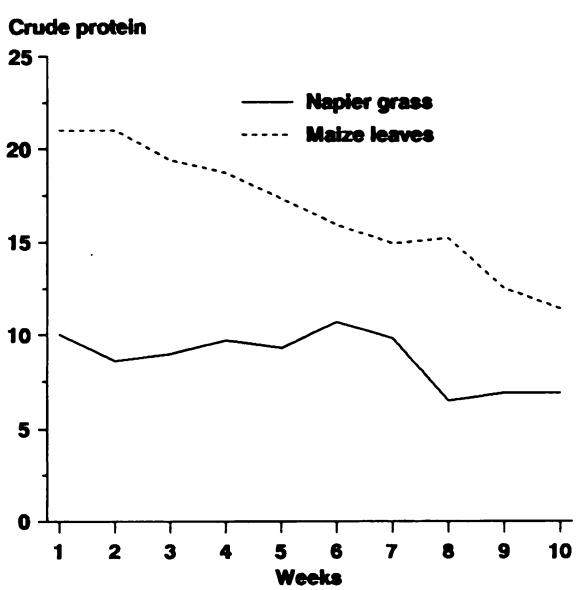

Table 2 shows the results of the digestibility experiment. Both defoliated maize leaves and napier grass were similar in chemical characteristics, although the latter had more fibre. DM digestibility was also similar. However, intake of DM was significantly ($P \leq 0.001$) higher in maize leaves than in napier grass. All wethers fed on maize leaves gained weight while those fed napier grass lost weight; the differences in weight changes were significant ($P \leq 0.05$).

Table 2. *Nutritional characteristics of defoliated maize leaves and napier grass when fed to wethers.*

	Defoliated maize leaves	Napier grass
Dry matter, %	34.5	33.9
Crude protein, %	9.6	8.2
Neutral detergent fibre, %	66.7	73.0
Dry matter digestibility, %	54.6	56.1
Dry matter intake (g/day)	1161.0[a]	662.0[b]
Average daily gain, g	+67.0[a]	–43.0b

ab = Values along a row bearing different letters are significantly different ($P \leq 0.001$) or ($P \leq 0.05$).

Discussion and conclusion

The results of this experiment have shown that defoliated maize leaves can be a source of quality feed for ruminants. The leaves proved to be more acceptable and of higher nutritional value than napier grass. This is significant because for a given weight of DM more meat can be produced from animals fed maize leaves than from those fed napier grass. Earlier, Kayongo-Male and Abate (1982) had shown that fresh maize leaves were nutritionally superior to hay. Stripping one leaf per plant per week spread the use of the leaves over a period of 10 weeks although at the cost of quality. Plucking more leaves per plant per week produces better quality feed but for a shorter duration (Abate, 1983). The effect of defoliation on grain yield is important as maize forms the staple diet of most countries in East Africa. A reduction in grain yield of about 8% is considered small and the liveweight gain would compensate for the loss. Lower reductions in grain yield of 2.6% have been reported before (Abate, 1981).

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Rumen degradation of elephant grass supplemented with graded levels of perennial peanut by West African Dwarf sheep

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Abstract

The effect of 0, 10, 20 and 30 per cent supplementation of elephant grass *(Pennisetum purpureum)* with perennial peanut *(Arachis glabrata)* on rumen degradability of dry matter was investigated in a factorial trial involving 4 treatments, 5 incubation periods, 3 animals and 2 nylon-bag samples per animal per incubation period. Three rumen-fistulated West African Dwarf ewes of 24 months of age and weighing an average of 18 kg were used. Samples were incubated in the rumen of sheep for 6, 12, 24, 48 and 72 hours.

Dry and organic-matter degradation (DM and OM) increased significantly (P<0.05) when the legume fraction in the ration was raised from 0 to 20 per cent. Further increase in legume fraction to 30% of the ration did not result in significant increases in DM and OM degradability. There was also a significant (P<0.05) increase in DM and OM degradability of all rations when incubation time in the rumen was increased from 6 to 48 hours. Degradability of DM was 34% for elephant grass alone and 42, 43 and 46%, respectively, for rations containing 10, 20 and 30 per cent legume after 48 hours' incubation. After 72 hours' incubation, there was no significant increase in DM and OM degradibility.

The estimates of the immediate soluble fraction (a) and the rate of degradability (c) increased with increase in the level of legume in the ration. The lag time necessary for the microbial population to invade the feed also reduced as the level of legume in the diet was raised.

Dégradation de l'herbe à éléphant complémentée avec des niveaux croissants de fourrage d'arachide pérenne dans le rumen de moutons de la race naine d'Afrique de l'Ouest

Résumé

L'effet de la complémentation de 0, 10, 20, ou 30% d'herbe à éléphant (Pennisetum purpureum) *avec du fourrage d'arachide pérenne* (Arachis glabrata) *sur la dégradabilité dans le rumen a été étudié dans une expérience factorielle avec quatre traitements, cinq périodes d'incubation, trois animaux et deux échantillons dans des sacs en plastique par animal et par période. Trois brebis de la race naine d'Afrique occidentale dont le rumen a été fistulé, âgées de 24 mois et pesant en moyenne 18 kg ont été utilisées. Les échantillons ont été incubés dans leur rumen pendant 6, 12, 24, 48, et 72 heures.*

La dégradation de la matière sèche et de la matière organique augmentait significativement (P<0,05) avec l'accroissement de la proportion de légumineuse de la ration de 0 à 20%. L'augmentation de cette proportion à 30% n'entraînait aucun accroissement significatif de la dégradabilité de la matière sèche et de la matière organique. Toutefois, celle-ci augmentait significativement (P<0,05) dans toutes les rations lorsque le temps d'incubation passait de 6 à 48 heures. Après 48 heures d'incubation, la dégradabilité de la matière sèche était de 34% pour l'herbe à éléphant seule puis de 42, 43 et 46% pour les rations contenant respectivement 10, 20 et 30% de légumineuse. Après 72 heures d'incubation, il n'y avait pas d'augmentation significative de la dégradabilité de la matière sèche et de la matière organique.

Le taux de la fraction immédiatement soluble (a) et la dégradabilité (c) augmentaient avec l'accroissement de la proportion de légumineuse dans la ration. Enfin, le temps nécessaire pour permettre à la flore microbienne d'envahir les aliments diminuait avec l'augmentation de la proportion de légumineuse dans la ration.

Introduction

The most widely available low-cost feeds for ruminants in most tropical countries are usually native pasture, crop residues and, to a lesser extent, agro-industrial by-products. Legumes in the farming system may constitute an important feed resource of fermentable nitrogen and of by-pass protein. When fed to ruminants, legumes tend to increase the efficiency of utilisation of the basal diet, which is usually a low nitrogen pasture or a crop residue, at low levels of supplementation. Legume supplements given at levels below 30 per cent of dietary dry matter have a catalytic effect on feed utilisation. They ensure a more efficient environment for digestion of cell-wall carbohydrates, perhaps by

providing micronutrients such as peptides, amino acids, minerals and vitamins which increase fungal biomass and/or the rate of bacterial colonisation of the fibre. The potential of the diet to meet the requirements of the animal for amino acids, glucogenic precursors and long chain fatty acid depends on the pattern of fermentation and on dietary protein lipids and starch that escape fermentation and are digested in the intestines. The extent to which the protein in a supplement escapes the rumen is partly a function of its rate of degradation in the rumen (Preston and Leng, 1987). The objective of this trial was to study the effect of graded levels of perennial peanut (PP) supplement fed with elephant grass (EG) on the degradability of dry and organic matter by West African Dwarf sheep.

Materials and methods

Three female West African Dwarf sheep fitted with rumen cannulae were used for the study. Their average age and body weight were 24 months and 18 kg, respectively. The animals were fed four experimental rations consisting of fresh EG (*Pennisetum purpureum*) only, or supplemented with PP (*Arachis glabrata*, ex-Florida) at 10, 20 and 30 per cent.

Table 1. *Composition (%) of dried forages used in constituting rations incubated in the rumen.*

Proximate components	PP	EG
Dry matter	92.03	92.10
Organic matter	86.18	86.25
Crude protein	17.80	12.50
Crude fibre	22.13	32.50
Ash	3.82	13.75

Table 2. *Composition of experimental diets incubated in the rumen of sheep.*

Proximate components	EG:PP ratio			
	100:00	90:10	80:20	70:30
Dry matter	92.10	92.06	92.04	92.05
Organic matter	86.25	86.20	86.19	86.20
Crude protein	12.50	13.03	13.57	14.11
Crude fibre	32.50	31.35	30.10	29.22
Ash	13.75	13.80	13.79	13.80

Fresh EG and PP were dried in a forced air laboratory oven at 60°C for 48 hours, milled separately to pass through a 2 mm screen, and mixed in the following gramineae/legume proportions, 100:0, 90:10, 80:20 and 70:30. Four grams of ration was placed in a nylon bag (11 x 7 cm, 20 micron porosity) and sealed. The composition of EG, PP and their combinations incubated in the rumen are shown in Tables 1 and 2, respectively. The method of incubation in the rumen of sheep was as described by Orskov et al (1980). Nylon bags were incubated in the rumen for 6, 12, 24, 48 and 72 hours after which they were withdrawn and washed in cold water for 25 minutes and dried to constant weight at 60°C in a forced air laboratory oven and weighed. Six nylon bags containing samples of each ration were soaked in water for 30 minutes and washed in the same manner and dried to constant weight.

The difference in weight of dry matter in nylon bag before and after rumen incubation represented material degraded in the rumen. Similarly, the difference in organic matter weight before and after incubation was equivalent to OM degraded in the rumen.

The degradation characteristics of each ration were described using the following exponential equation (Orskov and McDonald, 1979),

$$P = a + b\,(1-e^{-ct})$$

where a, b and c are constants

a = intercept or immediate soluble fraction
b = insoluble but potentially degradable material at time t
c = rate of degradation per hour
P = level of degradation at time t

Statistical analysis

The experiment was a 4 x 5 x 3 x 2 factorial design (4 rations, 5 incubation intervals, 3 sheep and 2 nylon bags per animal per incubation period). Statistical analysis was carried out according to the procedures of Snedecor and Cochran (1976) for analysis of variance. The Duncan's multiple range test was used to test significant differences between treatments.

Results and discussions

The degradation of dry matter of the rations (Table 3) increased significantly ($P<0.05$) as a result of supplementation of EG with PP. Total dry matter degraded increased from 56.75% in the ration consisting of EG only to 69.47% in the 30% PP ration.

These results confirm findings by Mosi and Butterworth (1983) that the addition of 30% legume forage to a grass basal diet increased total dry matter degradability from 40 – 50% to 60%.

A comparison of DM degradation of the three rations containing legume supplement after 6 and 12 hours' incubation in the rumen indicated a significant difference ($P<0.05$) between the rations containing 10 and 20% legume; but no significant difference between those having 20 and 30% legume. DM disappearance was similar for all rations having legume supplement at 24, 48 and 72 hours of incubation.

After 72 hours of rumen incubation more than 57 per cent of potentially degradable amount of DM in the control ration had disappeared, whereas for the rations containing legume more than 70 per cent had disappeared.

OM degradation in all rations is shown in Table 4. After 12, 24, 48 and 72 hours of rumen incubation all rations with legume supplement had significantly ($P<0.05$) higher OM degradation than EG alone.

Table 3. *Effect of level of supplementation on dry-matter loss in the rumen of sheep (g/100g DM).*

Treatment PP Supplementation rate	Washing loss (g/100g DM)	Incubation period (hours)					a	b	c	Residual mean sq.	a+b	Time lag
		6	12	24	48	72						
0%	7.20	2.08	3.75	9.83	29.09	30.46	2.06	51.25	0.0182	18.76	53.03	5.79
10%	7.90	6.18	8.36	20.20	36.63	39.52	4.64	52.14	0.261	9.46	56.78	2.47
20%	8.00	12.21	14.97	25.31	37.16	40.70	12.47	42.56	0.0281	3.00	55.03	0.00
30%	10.00	12.54	20.88	23.76	38.08	40.17	17.31	38.57	0.0286	9.08	55.88	0.00

NB: a, b and c are constants in the equation $P=a+b(1-e^{-ct})$ where P is the level of degradation at time t; a is the intercept or immediately soluble fraction; b is the insoluble but potentially degradable fraction at time t; c is the rate of degradation per hour while a+b is the maximum degradable fraction (assymptote).

Table 4. *Effect of level of supplementation on organic-matter loss in the rumen of sheep (g/100g DM).*

Treatment PP Supplementation rate	Washing loss (g/100g DM)	Incubation period (hours)					a	b	c	Residual mean sq.	a+b	Time lag
		6	12	24	48	72						
0%	8.46	2.48	4.43	11.65	34.18	35.68	2.43	59.62	0.0185	25.83	62.05	5.75
10%	9.33	7.27	9.80	23.65	42.18	46.30	5.89	61.05	0.253	10.87	66.94	2.29
20%	10.29	13.44	18.60	28.75	42.77	46.83	15.63	48.39	0.0286	1.84	64.01	0.00
30%	11.75	13.46	21.17	27.85	45.53	46.90	17.00	48.30	0.0308	9.42	65.30	0.00

NB: a, b and c are constants in the equation $P=a+b(1-e^{-ct})$ where P is the level of degradation at time t; a is the intercept or immediately soluble fraction; b is the insoluble but potentially degradable fraction at time t; c is the rate of degradation per hour while a+b is the maximum degradable fraction (assymptote).

OM degradation attained a maximum increased value of 13 per cent especially with the ration containing 30% PP. Similar results were reported by Dixon et al. (1979) when supplements of *Leucaena leucocephala* and rice polishing were fed with sisal pulp to cattle. This was associated with increased microbial synthesis.

There was no significant difference between the OM degradation of the control ration and the one containing 10 per cent legume after 6 hours of rumen incubation. Similarly, there was no significant improvement in OM disappearance in the rumen when the level of legume supplement in the ration was raised from 20 to 30 per cent. A significant improvement in OM degradation was evident after 24 and 48 hours incubation of feed samples in the rumen. Extending incubation time to 72 hours did not result in a significant increase in OM degradation.

It was also observed that estimated maximum potential degradable OM in the rations increased with increase in the level of legume supplement in the ration. After 72 hours of rumen incubation 58% of maximum degradable amount of EG organic matter in the control ration had disappeared whereas for the other treatments more than 69% had been degraded.

In the present study supplementation of EG with graded levels of legume resulted in an increase in the rate of DM and OM degradation in the rumen. For DM it increased from 0.0182 to 0.0286 per cent per hour as the level of legume in the ration was raised from 0 to 30 per cent, whereas for OM it increased from 0.0185 to 0.0308 per cent per hour. Also, it was observed that as the level of legume in the diet was raised there was a reduction in the lag time necessary for the microbial population to attack the feed.

Conclusion

It may be concluded from this study that inclusion of PP in the diet of sheep fed EG up to a level of 20 per cent results in a significant improvement in DM and OM degradation in the rumen.

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Metabolisable energy requirements for maintenance and growth of castrate Zimbabwean (Matabele) goats offered diets differing in roughage content either *ad libitum* or restricted

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Abstract

Feed intake and liveweight changes of 53 stall-fed Matabele goats were monitored for 94 days. They were offered diets containing 9.9, 11.3, 12.1 or 12.5 MJ metabolisable energy (ME) per kilogram dry matter, either *ad libitum* or restricted.

ME intake (ME_i) was regressed against liveweight change and liveweight change was regressed against ME_i. Calculated estimates of ME requirements for maintenance (ME_m) and liveweight change (ME_g) from the regression of ME_i and liveweight change were 519 $kJ/kg^{0.75}$ per day and 25.2 kJ/g, respectively. For the reversed regression, the estimates for ME_m) and ME_g) were 482 $kJ/kg^{0.75}$ per day and 34.2 kJ/g, respectively.

Besoins en énergie métabolisable pour l'entretien et la croissance de caprins castrés du Zimbabwe (Matabele) recevant des rations à base de fourrage

Résumé

La consommation alimentaire et l'évolution pondérale de 53 caprins Matabele alimentés en chèvrerie ont été observées sur une période de 94 jours. Les rations, offertes à volonté ou rationnées, présentaient des teneurs de 9,9, 11,3, 12,1 et 12,5 MJ d'énergie métabolisable par kilo de matière sèche.

L'énergie métabolisable ingérée a été ramenée par régression à l'évolution pondérale, et vice versa. La valeur calculée de l'énergie métabolisable requise pour l'entretien et la croissance que l'on a obtenue à partir de la première régression était de 519 $kJ/kg^{0,75}$ par jour pour l'entretien et de 25,2 kJ/g pour la croissance. En ce qui concerne la régression inverse, les valeurs calculées étaient respectivement de 482 $kJ/kg^{0,75}$ par jour et de 34,2 kJ/g.

Introduction

Prediction of an animal's response to nutrients is central to the science and practical application of nutrition. Prediction implies extrapolation (AFRC, 1991), the inherent assumption being that the animals used in determining response are representative of the general population to which the results will be applied (Morton and Ridgeman, 1977).

There are few published reports on the energy requirements of goats. Recommendations used have often been extrapolated from sheep without validation (NRC, 1981; Prieto et al, 1990). It is notable that in those experiments where direct comparisons have been made between goats and sheep, maintenance energy (ME_m) values differ. Mohammed and Owen (1980) reported ME_m values for mature and castrate sheep and goats of 434 v 301 kJ $ME/kg^{0.75}$ ($P>0.01$), respectively. Conversely, Alam et al (1991) reported ME_m values of 440 v 370 kJ $ME/kg^{0.75}$ ($P>0.05$) for growing, castrated kids and lambs, respectively. Such results underscore species differences and the need for efficient and effective diet formulation to generate information specific to goats.

This paper reports estimates of the metabolisable energy (ME) requirements for maintenance and growth of castrate, indigenous Zimbabwean (Matabele) goats fed cereal-based diets in confinement.

Materials and methods

64 castrate Matabele kids, initially about eight months old and weighing approximately 10 kg, were used in an experiment of 94 days duration. Animals were housed in wire mesh pens in an open-sided, asbestos-roofed,

Table 1. *Treatment diet formulation (g/kg) and dry-matter composition (g/kg DM).*

	Diet			
	1	2	3	4
Formulation				
Veld hay*	500	330	220	100
Cottonseed meal	142	118	102	84
Maize meal	238	432	558	696
Molasses	80	80	80	80
Urea	20	20	20	20
Salt	7	7	7	7
Limestone flour	5	5	5	5
Gypsum	5	5	5	5
Vitamins and minerals**	3	3	3	3
Composition				
Dry matter (g/kg)	902	903	902	905
Ash	106	71	63	54
Crude protein	200	187	194	182
Crude fibre	183	126	93	66
Ether extract	37	39	43	40
Metabolisable energy*** MJ/kg DM	37	39	43	40

*For general description of mixed veld hay see Topps and Oliver (1978).

**1 kg = $3x10^6$ i.u. retinol, 35 g manganese, 35 g zinc, 0.6 g cobalt, 0.1 g selection and 0.12 g iodine.

***MAFF (1984).

concrete-floored barn. No bedding was provided and accumulated manure was removed once a week. Each pen had separate feed and water troughs.

At the beginning of the experimental period animals were allocated to one of four experimental diets (Table 1) offered either *ad libitum* (A) or restricted (R). Initial numbers and live weights of goats in the eight treatment groups are shown in Table 2.

Animals fed *ad libitum* were offered feed daily at a level of 20% above the preceding day's intake. For animals on the restricted feeding regimes, those in group R1 were offered air-dry feed daily at the rate of 6% of metabolic body weight. Goats in groups R2, R3 and R4 were offered their respective diets at a level iso-energetic to that offered to animals of the same weight in treatment R1. Feeding levels of animals on restricted diets were adjusted once a week. Daily ME intake was calculated by the difference between the ME content of feed offered and that of feed refused. Water was freely available to animals at all times. Animals were weighed at seven-day intervals and liveweight changes subsequently determined using polynomial regression analysis (Allen et al, 1983). Initial liveweight and linear regression coefficients of each animal were used to estimate live weight (LW) at the mid-point of discrete time periods. Metabolic weight ($LW^{0.75}$) was derived from these estimates of LW.

Table 2. *Initial numbers and live weights of goats in the eight treatment groups.*

		(Live weight (kg)		
Feeding level	Diet	n	Mean	SE
Ad libitum (A)	1	10	10.2	0.54
	2	6	10.3	0.64
	3	6	10.1	0.83
	4	10	10.1	0.45
Restricted (R)	1	10	10.1	0.59
	2	6	10.5	0.73
	3	6	9.9	0.80
	4	10	10.2	0.54

Metabolisable energy requirements for maintenance and growth of the goats were estimated by regression analysis of the ME intake, growth and mean metabolic weight data.

Two equations were fitted; equation 1, as suggested by Abate (1989), and its converse, equation 2, as suggested by Zemmelink et al (1991):

ME intake (ME_i) ($MJ/kg^{0.75}$ per day)
$= a + (b*ADG)$ Equation 1

where;

a = ME requirement for maintenance (ME_m) ($MJ/kg^{0.75}$ per day),

b = ME requirement for growth (ME_g) (MJ/kg)

ADG = average daily gain ($g/kg^{0.75}$ per day)

$ADG = a + (b*ME_i)$ Equation 2

where;

$a = ME_m = -ab^{-1}$

$b = ME_g = b^{-1}$

Animal performance data were analysed using the General Linear Model procedure of the SAS (1990) statistical package. Model variance was apportioned to:

Diet: 3 df, Contrast 1

Feeding Level: 1 df, Contrast 2

Diet* Level: 3 df

Error: (n-1)-7) df

Total: n-1 df

Least squares means are presented for relevant treatment comparisons. Standard errors were calculated using the error mean square as an estimate of residual variance. Where appropriate, means were contrasted as described in SAS (1990). Regression analysis was carried out using the SAS (1990) programme.

Results

Two animals on *ad libitum* feeding and nine animals on restricted feeding were removed from the experiment because of refusal to eat the diets or because they died. Final numbers in each treatment sub-group are shown in Table 3. Initial live weight of animals which completed the feeding trial in each treatment sub-group was different from that of the total number of animals initially allocated to their sub-groups (Tables 2 and 3). However, differences between treatment sub-groups were not significant (P>0.05).

Performance of the goats tended to improve with time (Table 3). Liveweight gains in this experiment had a high coefficient of variation (70%). Overall mean liveweight gains of feeding levels R and A were 5 and 47 g/day (P<0.001), respectively. Though energy intakes of animals on restricted feeding were similar (P>0.05), diets influenced liveweight gains (P>0.05), indicating differences in nutrient utilisation. Gross conversion of energy to liveweight gain (LWG) for feeding level A ranked A2>A3>A1>A4 (82, 92, 122 and 130 MJ ME/kg LWG, respectively) from days 68 to 94. The diet x level interactions were not significant (P>0.05) for all variables.

Coefficients of energy intake regressed on liveweight change (equation 1) and its converse (equation 2) for the period 33–68 days are shown in Tables 4 and 5, respectively. Derived estimates of ME_m and ME_g for this period are shown in Table 6. Estimates

Table 3. *Performance of goats offered diets differing in roughage content either restricted or ad libitum.*

	Restricted fed				*Ad libitum* fed				Contrast		
	R1	R2	R3	R4	A1	A2	A3	A4	SE*	1	2
Number of goats	7	5	4	7	10	5	6	9			
Initial live weight (kg)	10.9	11.0	10.2	10.8	10.2	10.7	10.3	10.1	0.24	ns	ns
Overall liveweight (kg) change	0.91	-0.17	1.03	0.15	3.38	3.99	5.78	4.20	0.25	ns	p<0.001
Day 0–33											
Liveweight change (gd^{-1})	10	-5	4	-14	43	27	53	26	5.4	ns	P<0.001
DMI** (gd^{-1})	245	223	209	194	368	317	381	334	11.4	ns	P<0.001
DMI ($gkg^{-0.75}d^{-1}$)	40.2	37.5	36.3	33.3	60.2	51.6	60.5	56.1	1.28	ns	P<0.001
$MJME_i(kg^{-0.75}d^{-1})$ (10^1)	3.8	4.0	4.3	4.1	5.7	5.5	7.0	6.8	0.13	P<0.05	P<0.001
Day 33–68											
Liveweight change (gd^{-1})	6	-8	6	8	29	35	71	52	4.0	ns	P<0.001
DMI (gd^{-1})	314	259	246	231	429	427	440	445	12.5	ns	P<0.001
DMI ($gkg^{-0.75}\ d^{-1}$)	51.8	45.3	43.0	40.5	66.3	65.2	62.6	67.0	1.51	ns	P<0.001
$MJME_i(kg^{-0.75}d^{-1})$ (10^1)	4.9	4.9	5.0	5.0	6.3	7.0	7.3	8.2	0.16	ns	P<0.001
Day 68–94											
Liveweight change (gd^{-1})	33	26	36	23	47	67	68	40	3.6	ns	P<0.01
DMI (gd^{-1})	313	258	264	237	447	469	484	389	10.0	ns	P<0.001
DMI ($gkg^{-0.75}\ d^{-1}$)	50.2	44.3	44.1	40.1	65.5	64.9	63.1	53.5	1.07	P<0.01	P<0.001
$MJME_i(kg^{-0.75}d^{-1})$ (10^1)	4.8	4.8	5.2	4.9	6.2	7.0	7.3	6.5	0.12	ns	P<0.001

*Standard error ** dry matter intake

Contrasts 1 and 2 = diet and feeding level respectively

Table 4. *Linear regression coefficients of daily energy intake (MJ ME/kg$^{0.75}$ per day) on liveweight change (g/kg$^{0.75}$ per day) (Equation 1), for the period 33–68 days, of Matabele goats offered diets differing in roughage concentration.*

Diet	df	a	se_a	b	se_b	S_{yx}	r^2	Significance
1	16	0.508	0.0169	0.225	0.00284	0.061	0.808	P<0.001
2	9	0.551	0.0299	0.0231	0.00494	0.090	0.732	P<0.0016
3	9	0.471	0.0388	0.0251	0.00464	0.074	0.785	P<0.0001
4	15	0.518	0.0328	0.0311	0.00433	0.097	0.7 87	P<0.0001
All	53	0.518	0.0144	0.0252	0.00207	0.085	0.744	P<0.0001

S_{yx} = regression error mean square.

Table 5. *Linear regression coefficients of liveweight change (g/kg$^{0.75}$ per day) on daily energy intake (MJ ME/kg$^{-0.75}$ per day) (Equation 2), for the period 33–68 days, of Matabele goats offered diets differing in roughage concentration.*

Diet	df	a	se_a	b	se_b	S_{yx}	r^2	Significance
1	16	-17.628	2.665	35.869	4.520	2.403	0.808	P<0.0001
2	9	-16.969	4.162	31.680	6.783	3.336	0.732	P<0.0016
3	9	-13.308	3.798	31.303	5.801	2.596	0.785	P<0.0001
4	15	-12.004	2.480	25.271	3.519	2.755	0.787	P<0.0001
All	53	-14.257	1.562	29.560	2.429	2.909	0.744	P<0.0001

Table 6. *Estimates of metabolisable energy requirements for maintenance (ME_m) (KJ ME/kg$^{-0.75}$ per day) and liveweight gain (MEg) (KJ/g) for the period 33–68 days, of castrate Matabele goats offered diets differing in roughage content.*

Diet	ME_m		Me_g	
	Equation 1	Equation 2	Equation 1	Equation 2
1	508	481	22.5	27.9
2	551	536	23.1	31.9
3	471	425	25.1	31.9
4	518	475	31.1	39.6
All	519	482	25.2	34.2

of ME_m and ME_g from the two estimation methods followed a similar trend between diets.

Discussion

The differences in dry matter intake (DMI) and the similarity in energy intake among animals on restricted feeding are artifacts of the planned treatments. Differences in the rate of liveweight gain among these animals may indicate differences in absorption, partitioning and efficiency of utilisation of nutrients. Animal performance on the *ad libitum* feeding regime followed trends similar to those reported previously for mature castrates fed similar diets (Hatendi et al, 1992).

Treatments in this experiment resulted in a wide range of growth rates. The data set was thus amenable to estimation of energy requirements for maintenance (ME_m) and liveweight gain (ME_g) by regression analysis. ME_m is defined here as the level of metabolisable energy required to maintain liveweight stasis. This definition is not synonymous with zero energy retention as found from calorimetric or comparative slaughter studies (Armstrong and Blaxter, 1984). Use of the ME_m estimates based on liveweight stasis is arguably more relevant in the practical feeding of livestock for meat production, where liveweight changes can be measured with relative ease and accuracy.

This study compared two forms of regression, used interchangeably in literature (Zemmelink et al, 1991). The first regressed energy intake (y) on liveweight change (x) (equation 1). In the second, liveweight change (y) was regressed on energy intake (x) (equation 2). The question of which variable should be used as the dependent variable has been comprehensively discussed by Zemmelink et al (1991), who argue that liveweight gain is the observed response to energy intake and therefore should be considered the dependent variable. This approach is similar to that used in the ARC (1980) feeding standards and is central to the theories of animal

response to nutrients as developed by AFRC (1991). Our acceptance of these arguments, and therefore equation 2, represents a change from our earlier publication on this subject (Hatendi et al, 1990), in which equation 1 was used to apportion energy utilisation.

The overall estimates of ME_m in the period 33 to 68 days were 519 and 482 KJ $ME/kg^{0.75}$ per day for equations 1 and 2 respectively. These results are consistent with estimates presented in the literature (Abate, 1989; Hatendi et al, 1990; Zemmelink et al, 1991; Sauvant et al, 1991). Similarly, the ME_g estimates of 25.2 and 34.2 kJ/g liveweight gain for equations 1 and 2, respectively, are consistent with the findings of other workers (Abate, 1989; Hatendi et al, 1990; Zemmelink et al, 1991).

If the inverse of ME_g is considered as an estimate of efficiency of energy use for liveweight gain (Abate, 1989), then the efficiency of gain decreased with increasing dietary energy content and duration of feeding. Efficiencies in this experiment are similar to those reported for kids by Alam et al (1991). Estimated feeding levels in this experiment, based on equation 2 estimates of ME_m, were 1.03 and 1.49 times maintenance for the restricted and *ad libitum* feeding regimes, respectively.

Conclusion

The estimates of ME_m and ME_g presented in this paper are of direct application to confined castrate Matabele goats offered similar diets. However, they may be judiciously applied to related breeds of eastern and southern African goats under similar husbandry systems. Similarly, the increments for medium and high activity proposed by NRC (1981) serve as guidelines and may, as appropriate, be added when considering the energy requirements of goats in other systems such as free-range grazing.

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Effect of energy level on milk production by Mossi ewes and Sahelian does

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Abstract

Two trials were conducted to evaluate the effect of energy level on milk production and composition and to establish the relationship between milk production and growth rate of suckling kids. In the first trial, 20 Sahelian does were divided into four groups to receive one of four isonitrogenous (18% crude protein (CP)) diets providing 42.2% total digestive nutrients (TDN) (diet 1a), 73.4% TDN (diets 2a and 3a) and 83.9% TDN (diet 4a). In the second trial, 18 Mossi ewes were divided into three groups to receive one of three isonitrogenous (17.4% CP) diets providing 62.1% TDN (diet 1b), 73% TDN (diet 2b) and 83.1% TDN (diet 3b). These production diets were formulated to provide subnormal (1a & 1b), normal (2a, 2b and 3a), or high (3b and 4a) levels of energy; the amounts fed were constantly adjusted to milk yield. Additionally, animals were fed a basal diet satisfying all maintenance requirements. Milk production was estimated by the double weighing method, with four equally spaced weighing periods per day. In the two trials, daily dry matter intake (DMI), milk composition and production were not significantly affected by diet. It was concluded that small fluctuations in energy intake do not affect milk production in Sahelian goats or in Mossi sheep. Kid growth is correlated with milk consumption. Sorghum grain may be replaced by Dolichos lablab seeds in diets for lactating small ruminants.

Effet de l'apport énergétique sur la production laitière chez la brebis Mossi et la chèvre du Sahel

Résumé

Deux essais ont été conduits pour estimer l'effet de l'apport énergétique sur la production de lait et sa composition, et pour déterminer les relations qui existent entre la production laitière et le taux de croissance de jeunes allaités au pis. Dans le premier essai, 20 chèvres du Sahel ont été réparties en quatre lots. Chaque lot recevait une ration iso-azotée (18% de protéines brutes [PB]) apportant 42,2% de nutriments digestibles totaux (NDT) (régime 1a), 73,4% de NDT (régimes 2a et 3a) et 83,9% de NDT (régime 4a). Dans le second essai, 18 brebis Mossi réparties en trois lots recevaient une ration iso-azotée (17,4% de PB) apportant 62,1% de NDT (régime 1b), 73% de NDT (régime 2b) ou 83,1% de NDT (régime 3b). Ces régimes avaient été formulés de manière à fournir des apports en énergie inférieurs (1a et 1b), conformes (2a, 2b et 3a) et supérieurs (3b et 4a) à la normale. Les quantités servies étaient constamment remaniées en fonction des quantités de lait produites par les animaux. En outre, le régime de base des animaux couvrait la totalité de leurs besoins d'entretien. La production laitière a été estimée par la méthode de la double pesée, avec quatre pesées quotidiennes espacées les unes des autres par des intervalles de durée identique. Dans les deux essais, le régime n'avait pas d'effet significatif sur l'ingestion de matière sèche, ni sur la composition et la production de lait. Il apparaît ainsi que de faibles fluctuations dans l'apport énergétique ne modifient pas la production de lait chez la chèvre du Sahel et le mouton Mossi. Il y avait une corrélation entre la croissance des jeunes et la consommation de lait. Dans les régimes des petits ruminants en lactation, on peut remplacer les grains de sorgho par des graines de dolique lablab.

Introduction

Limited information is available on the milk productivity of small ruminants in Burkina Faso. Milk from Sahelian goats is consumed by Fulani and other Sahelian livestock farmers. Milk production data is also useful for selection purposes; it is well established that females with high milk output promote faster growth and better survivability of their young.

Available data indicates that Mossi (IEMVT, 1980; Yoni, 1989) and Djallonké (Amegee, 1984a) ewes have a low milk production potential. However, preliminary studies conducted by Ouédraogo (1990) indicate that Sahelian does may produce considerable amounts of milk.

This study evaluated the effects of graded levels of dietary energy on dry matter intake (DMI), milk yield and milk composition. It was also intended to establish the relationship between milk production and the growth of suckling kids.

Materials and methods

A group of 20 Sahelian does and another of 18 Mossi ewes were paired, based on body weight and age. Each animal entered the study 48 hours after kidding. A two-week preliminary phase was observed, during which all animals received the same diet to establish initial production levels. After the preliminary phase, a separate 12-day trial was conducted for each species using different dietary treatments.

Trial 1

Paired does were randomly assigned to one of four production diets (Table 1). Three energy (E) levels were used: diet 1a (low E); diets 2a and 3a (medium E); and diet 4a (high E). Additionally, a maintenance (NRC, 1981) diet composed of 77% sorghum straw, 5% cottonseed meal and 18% wheat bran was fed to all groups. The amount of basal diet served daily was based on body weight. The amount of production diet served varied with milk yield.

Paired ewes were randomly assigned to one of three production diets (Table 2): diet 1b (low E); diet 2b (medium E); and diet 3b (high E). The ewes also received a basal diet composed of 83.9% chopped sorghum straw and 16.2% cottonseed meal (dry matter basis).

In each trial, kids were offered an *ad libitum* supply of sorghum straw and their mother's production diet. Body weights were monitored once a week. Feed intake of mothers was monitored daily during weeks 4, 6, 8, 10 and 12. Milk production was estimated by weighing the kids immediately before and after suckling, four times per 24 hours, one day a week as described by Coombe et al (1960). Milk was sampled during weeks 4, 8, and 12 and preserved at 4°C with 1% of a 35% solution of formaldehyde until chemical analyses were performed.

The milk was analysed for total solids, crude protein (CP), casein and ash using methods described by AOAC (1984). Milk fat was determined by the Babcock method (AOAC, 1984). Lactose was determined by difference.

Data was statistically analysed using the SAS General Linear Models (GLM) procedures (SAS, 1982). Means were separated using Scheffe's Multiple Comparisons Test.

Results and discussions

Intake of dry matter

Dry matter intake (DMI) by goats increased with the increase in energy levels of the diets (Table 3). With ewes, DMI was depressed by the high energy diet (Table 4). Goats appeared to consume more DM than ewes.

Yield and composition of milk

Data on the yield and composition of milk are shown in Tables 5 (does) and 6 (ewes). The milk yield of does on diet 4a was significantly higher ($P<0.05$) than that of diet 1a. Peak milk yields were 1091.67, 1062.5, 1079.2 and 1275g/d for diets 1a, 2a, 3a and 4a respectively. Diets 2a and 3a performed similarly, indicating that *Dolichos l.* seeds may be a good substitute for sorghum grain.

Table 1. *Composition of production diets for Trial 1 (goats).*

Item	Diet			
	1[a]	2[a]	3[a]	4[a]
Ingredient (%):				
Cottonseed meal	17.00	4.00	0.00	22.00
Commercial mix*	17.60	24.00	2.00	0.00
Dolichos l. seeds	5.00	5.00	42.20	0.00
Cottonseed	0.00	0.00	8.00	0.00
Wheat bran	14.50	28.50	23.00	0.00
Sorghum grain	17.50	36.00	10.00	72.50
Ground oyster shells	1.40	2.50	2.30	01.50
Molasses	0.00	0.00	5.00	0.00
Corn cobs	27.00	0.00	8.00	0.00
Cotton oil	0.00	0.00	0.00	4.00
Total	100.00	100.00	100.00	100.00
Expected chemical composition (%):				
TDN	62.16	73.38	73.42	83.87
crude protein (CP)	18.02	18.06	18.01	18.03
Ca	0.62	1.01	0.63	0.62
P	0.66	0.78	0.52	0.56

TDN = total digestible nutrients.

*Cottonseed meal with 47% cottonseed hulls added.

Table 2. *Composition of production diets for Trial 2 (ewes).*

Item	Diet		
	1b	2b	3b
Ingredient (%):			
Cottonseed meal	32.50	12.00	00.00
Commercial mix[1]	17.00	8.00	0.00
Dolichos L. seeds	5.00	42.00	49.50
cottonseed	0.00	3.00	7.00
Wheat bran	10.00	19.00	19.60
Sorghum grain	11.50	7.00	15.00
Ground oyster shells	2.50	3.00	1.70
Molasses	5.00	0.00	0.00
Corn cobs	8.00	27.00	0.00
Cotton oil	0.00	0.00	6.20
Urea	0.00	0.00	1.00
Total	100.00	100.00	100.00
Expected chemical composition (%):			
TDN[2]	62.09	73.03	83.13
crude protein (CP)	17.47	17.43	17.40
Ca	1.04	1.68	0.70
P	0.78	0.65	0.50

[1]Cottonseed meal with 47% cottonseed hulls added.

[2]TDN: total digestible nutrients.

Table 3. *Effect of diet on intake of dry matter (DMI) and average daily gain (ADG) of Sahelian goats.*

Parameter	Diet				
	1a	2a	3a	4a	SE
Does					
Number	6	4	6	4	–
DMI, g/day	975.24	1122.91	1116.07	1178.47	65.63
g/kg$^{0.75}$	84.88	92.57	96.13	101.16	2.96
Body weight, week:					
0	25.25	29.12	25.05	24.50	0.99
2	26.03	28.45	25.10	24.35	0.98
ADG, week 3–14	1.98^{a}	17.56^{ab}	10.71^{ab}	39.29^{b}	4.65
Kids					
Number	8	5	8	7	–
Body weight, week:					
0	2.15	2.26	2.09	2.01	0.04
14	8.64^{ab}	9.78^{a}	8.51^{ab}	7.37^{b}	0.39
ADG week:					
3–14	65.92	70.24	67.26	55.44	3.76
0–14	66.20	76.74	65.56	54.67	4.22

Means in the same row with different superscripts differ significantly ($P<0.05$).

Average composition of the milk from does was not affected by diet (Table 5). However, diet 3a gave a higher ($P<0.05$) CP concentration than all other diets during week six. Milk yields obtained in this study were higher than those reported by Ouédraogo (1990) with hand-milked Sahelian does. However, Ouédraogo (1990) reported higher concentrations of solids (16.42%) and fats (6.03%).

Table 4. *Effect of diet on intake of dry matter (DMI) and average daily gain (ADG) of Mossi ewes.*

Parameter	Diet			
	1b	2b	3b	SE
Ewes				
Number	6	6	6	—
DMI, g/day	1051.50	1052.94	1016.00	23.20
g/Kg0.75	85.95	87.33	79.58	1.95
Body weight, week:				
0	27.60	26.78	28.97	4.16
2	27.47	26.57	28.97	0.94
ADG, week 3–14	5.16	17.26	12.50	3.48
Lambs				
Number	6	6	7	
Body weight, week:				
0	2.76	2.33	2.41	0.43
14	10.33	10.53	8.16	0.64
ADG week:				
3–14	76.19	80.95	54.59	6.17
0–14	77.21_{ab}	83.67_{a}	58.45_{b}	6.29

Means within the same row with different subscripts differ (P<0.05).

Table 5. *Effect of diet on milk yield and milk composition of Sahelian does.*

Parameter	Diet				
	1a	2a	3a	4a	SE
Yield (g/d):					
week 3–14	582^{a}	667^{ab}	631^{ab}	713^{b}	45.72
week 1–14	632^{a}	700^{ab}	675^{ab}	735^{b}	47.98
Solids: %	13.67	12.31	13.38	13.21	0.25
total (g/d)	102.10	106.72	110.22	120.28	8.43
Fat: %	5.22	3.81	4.76	4.47	0.23
total (g/d)	38.66	32.46	38.53	36.95	2.49
Crude protein: %	3.83	4.05	3.76	3.62	0.07
total (g/d)	29.06	34.96	31.12	33.20	2.52
Casein, %	3.08	3.31	3.20	3.05	0.05
Lactose, %	3.84	3.63	4.09	4.33	0.15
Minerals, %	0.77	0.78	0.81	0.77	0.01

Means in the same row with different superscript differ (P<0.05).

Body weights and ADG of all animals are shown in Tables 3 (goats) and 4 (sheep).

Milk yield (MY), milk composition and production of milk constituents by Mossi ewes (Table 6) were not affected by diet.

The MY recorded here were lower than those reported by Amegee (1984a) on Djallonké ewes for mothers of singles (547g/day) and for mothers of twins (772g/day). Amegee also reported higher concentrations of total solids (16.47%) and CP (6.02%).

Goats produced more milk than ewes and goat milk had a higher concentration of total protein, casein and minerals.

Bodyweight changes

Weight gains were low throughout both trials. Does had higher weight gain (P<0.05) on diet 4a than those on diet 1a.

Growth of kids and correlation with milk yield

On average, lambs reached a higher body weight than goat kids at 14 weeks old. There was no effect of dietary treatments on average daily gain (ADG) or body weight of kids.

Table 6. *Effect of diet on milk yield and milk composition of Mossi ewes.*

Parameter	Diet			
	1b	2b	3b	SE
Yield (g/d):				
week 3–14	395.31	387.50	396.35	27.50
week 1–14	444.20	449.29	442.71	26.73
Solids: %	13.06	13.06	12.90	0.31
total (g/d)	89.40	81.55	80.11	7.39
Fat: %	4.94	5.33	4.65	0.21
total (g/d)	27.78	27.78	23.18	1.80
Crude protein: %	5.38	5.05	4.95	0.14
total (g/d)	33.16	29.01	28.40	2.69
Casein, %	4.69	4.16	4.27	0.12
Lactose, %	4.12	3.70	4.18	0.25
Minerals, %	0.86	0.84	0.82	0.01

Correlation analyses indicated that milk consumption (MC) by a suckling kid is best estimated when the weights of the kid at birth (W_o) and at six weeks of age (W_6) are included in the equation (MC in g, W_o and W_6 in Kg):

e.g. For kids ($R^2 = 0.9375$):

$$MC = -327.1092\ W_o + 38.3492\ W_6 + 53.9617\ W_o x W_6 + 1039.4727;$$

For lambs ($R^2 = 0.8619$):

$$MC = -366.92 - 58.40\ W_o + 37.96\ W_6 + 13.70\ W_o x W_6.$$

Good correlations were also obtained between average daily MC in the first 13 weeks (91 days) of lactation, W_o and body weight at 13 weeks of age (W_{13}); (MC in g, W_o and W_{13} in kg):

For goats ($R^2 = 0.897$):

$$MC = -51.8991\ W_o + 4.7041\ W_{13} + 14.3734\ W_o x\ W_{13} + 469.2035;$$

For lambs ($R^2 = 0.7934$):

$$MC = -118.8236\ W_o + 7.7736\ W_{13} + 11.3062\ W_o x\ W_{13} + 503.0907.$$

Multiple factor correlations provide a better estimate of milk production than those established between milk consumption and a single parameter (ADG, birth weight or body weight at 30 or 40 days) by Amegee (1984a,b).

Conclusions

Minor fluctuations in energy intake do not affect milk production in Sahelian goats or in Mossi ewes. Kid growth is highly correlated with milk consumption.

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SESSION 5

Small Ruminant Genetic Resources and Breeding

Indigenous African small ruminants: a case for characterisation and improvement

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Abstract

The accelerating demands of a growing human population and the pressures of economic development are affecting the security and survival of many indigenous African breeds. Until now, these breeds have been a stable part of their particular ecosystems for hundreds of years. There is an increasing tendency to introduce exotic germplasm and/or to concentrate on a narrow range of supposedly more profitable breeds. As a result, indigenous breeds are threatened, even though they have been naturally selected for the local environments and are therefore best adapted. This paper describes the production systems in Africa and highlights the contribution of sheep and goats to subsistence farming systems and the general welfare of society. Problems preventing extensive utilisation and improvement of African animal genetic resources need to be identified. Genetic improvement programmes need to be developed. Breeds already endangered need to be conserved as a matter of urgency even if their economic value is not presently apparent. Concurrently, information should be compiled on biological performance and adaptive characteristics of these AGR (animal genetic resource) populations to aid the development of rational utilisation and conservation programmes.

Nécessité de caractériser et d'améliorer les races de petits ruminants africains indigènes

Résumé

Les demandes d'une population en expansion et les contraintes imposées par le développement économique compromettent la sécurité et la survie de nombreuses races indigènes africaines. Jusqu'à peu, ces races constituaient un élément stable des écosystèmes dans lesquels elles évoluent depuis des centaines d'années. Toutefois, on constate aujourd'hui une tendance à introduire du matériel génétique exotique et à investir dans un petit nombre de races censées être plus rentables. Les races indigènes sont de ce fait menacées, même si elles sont bien adaptées au milieu dans lequel elles évoluent, milieu dans lequel elles ont été soumises à la sélection naturelle. Cet article décrit les systèmes de production pratiqués en Afrique et fait ressortir le rôle des petits ruminants dans les systèmes de subsistance et le bien-être de la société. Les difficultés qui viennent contrarier l'utilisation extensive et l'amélioration des ressources génétiques animales africaines doivent être identifiées. Des programmes d'amélioration génétique doivent être mis en place. Les races déjà menacées doivent être protégées d'urgence, même si leur valeur économique n'est pas encore apparente. De même, des informations sur les performances biologiques et les caractéristiques d'adaptation de ces populations doivent être rassemblées afin de contribuer à l'élaboration de programmes rationnels d'utilisation et de conservation de ces ressources génétiques animales.

Introduction

Indigenous sheep and goat breeds constitute over 95% of the small ruminant population of Africa. They are owned by the majority of smallholder rural farmers for whom this resource is critical for nutrition and income. They are also an important and secure form of investment. They provide the only practical means of using vast areas of natural grasslands in regions where crop production is impracticable. Low genetic potential is often quoted as a major constraint to meat and milk production in sub-Saharan Africa (SSA). Consequently, most livestock improvement programmes in the region have resorted to crossbreeding with imported exotic breeds or directly replacing the indigenous genotypes. This trend continues as the human population and the demand for animal products increases. As previously isolated communities intermingle, indigenous animal populations can interbreed. This, combined with increasing animal movements through trade, presents additional pressures on these populations. In some regions of Africa the effects of drought and famine, compounded by prolonged civil wars, have also taken their toll. Consequently, indigenous African breeds are at risk. However, sustainable livestock improvement cannot be guaranteed for some environments without the adaptive traits of these genetic resources. The rate of developments in biotechnology also suggests that it will soon be possible to identify and manipulate genes, including those which confer disease resistance and

Table 1. *Characteristics of agroecological zones of sub-Saharan Africa.*

Agro-ecological zone	Characteristics of the zone[a]	Proportionate area %	Proportionate human population %	Proportionate TRLU population %	Proportion of cattle population %	Breed type[c]	Predominant livestock production system
Arid	1. 0 – 500 2. <75 days	35	12	29.8	20.7	Indigenous	Traditional nomadic, and transhumant based on communal grazing
Semi-arid	1. 500 – 1000 2. (75 – 180 days)	20	26	27.1	30.6	Indigenous, exotic (+)	Nomadic, transhumant; Smallholder crop–livestock
Subhumid	1. 1000 – 1500 2. 180 – 270 days)	20	27	19.6	22.7	Indigenous, exotic (++)	Smallholder crop-livestock; agropastoral
Humid	1. >1500 2. >270 days	20	20	6.1	6.1	Indigenous	Small crop–livestock
Highland	(<20°C)b	5	15	17.4	19.9	Indigenous, exotic (+++)	Smallholder crop–livestock; animal traction important
Total	–	100	100	100	100	–	–

a) Line 1 = rainfall, mm; 2 = length of growing period, days.

b) Highlands are defined as all those areas in the semi-arid, subhumid and humid zones of SSA where, because of altitude, mean daily temperature during the growing periods is <20°C.

c) Use of exotic ("improved") breeds: +++ = very important; ++ = moderately important; + = some importance; blank = not important.

d) TRLU = Tropical ruminant livestock unit.

physiological adaptation to other environmental stresses. The potential global contribution of the genetic resources of indigenous small ruminants is tremendous. It would be tragic if unique genetic resources resulting from centuries of natural and artificial selection were lost. The rate of erosion of indigenous animal genetic resources therefore threatens prospects of providing the livelihood of present and future human generations. African policy makers and other development agencies need to recognize the role these resources play in today's production systems. Programmes should be set up to conserve and develop these resources in step with the evolving agricultural systems.

This paper discusses the role of indigenous small ruminants in African production systems and highlights the key attributes and functions which justify their conservation and improvement.

Agroecological zones and production systems

Africa is a continent of enormous environmental diversity. This is mainly due to variations in rainfall, altitude and soils. In general, there are close relationships between climate, land use and human population densities. These relationships are particularly strong in systems where there is little or no external input into the production system. Thus, the ecological zones, which are categorised mainly on climatic data, are quite closely linked with the production options and hence production systems (Table 1). In addition to the physical environment, characterising livestock production in these zones consists of assessing the key products and functions of livestock. Accordingly, the major livestock production systems in Africa (Table 1) are: pastoral range systems, usually found in the arid and semi-arid zones; agro-pastoralism in the semi-arid and subhumid zones; mixed crop-livestock systems found in the lowlands of subhumid zones and high rainfall areas of the highlands; and ranching range systems and introduced systems such as modern intensive dairy, beef, poultry and pig production which are increasingly common in peri-urban areas. Major characteristics of these systems have been described (e.g. Pratt and Gwynne, 1977; Jahnke et al, 1988).

ILCA (1987) has classified SSA into five principal agroecological zones. These are the arid, semi-arid, subhumid, humid and highland zones. The arid zone covers over a third of the region. The semi-arid, subhumid and humid zones each occupy about a fifth while the highland areas make up only 5% (Winrock International, 1992) of the total land area. East Africa contains 70% of the highlands and central Africa has about 75% of the humid zone (ILCA, 1987). On the other hand, arid, semi-arid and subhumid zones are important in all subregions of SSA except Central Africa, where the arid and semi-arid zones are marginal.

The close association between agroecological zones and production systems is apparent from Table 1. Both pastoral and ranching systems are largely based on

range, primarily utilising natural vegetation. However, the major outputs and their importance differ between these systems. Pure pastoralism is practised in the arid to very arid ecological zones, defined as those with an annual rainfall of less than 400 mm. The major product from these systems is milk; the major livestock role is for subsistence and cultural or social functions (Jahnke, 1982). The major functions of livestock in the ranching systems are meat and cash incomes. The contribution of livestock in a mixed crop–livestock system is measured in terms of the increase in overall farm productivity attributable to the presence of livestock.

Distribution of small ruminants by agroecological zones

The population of sheep in SSA is estimated at 127 million head, while that of goats is estimated at 147 million (Winrock International, 1992). The arid and semi-arid zones together hold the majority of sheep (57%) and goat (64%) populations of sub-Saharan Africa. However, the arid holds 11% more sheep and 12% more goats than the semi-arid, which contains 23 and 26% of the sheep and goats, respectively. More sheep are found in the highland zone than in the humid zone (21 and 8% respectively), but the humid and the highland zones account for about equal proportions of the population of goats (9 and 10% respectively). The population of sheep and goats in the subhumid zone are 14 and 17%, respectively. Thus, the arid and semi-arid zones account for the majority of small ruminants in the region. However, these species are an important livestock component in all agroecological zones. In addition, small ruminants are found in all production systems ranging from pastoral and agropastoral systems to ranching range systems to smallholder mixed crop-livestock systems.

Special attributes of small ruminants

Sheep and goats are highly adaptable to a broad range of environments. They can utilise a wide variety of plant species and are thus complementary to cattle and camels. They generally do not compete directly with these species for feed. For example, a mixture of animal species on semi-arid rangelands makes it possible to change the stocking rate from 26 ha per tropical ruminant livestock unit (TRLU) (250 kg liveweight equivalent) for cattle alone to 13 ha per TRLU when cattle and goats are reared together and to 10ha per TRLU when camels are included (Schwartz, 1983). It is the complementarity of the ruminant species that maintains the high animal biomass that characterises pastoral production systems. Goats are more effective at grazing selectively than any other domestic livestock species (Winrock International, 1976) and they utilise poor quality forage and browse better than sheep. Goats also walk longer distances in search of food than do other domestic livestock (Wilson, 1991).

Due to their short generation lengths and high reproductive rates, small ruminants have a high production efficiency (Winrock International, 1976). In addition, the energetic efficiency of milk production may be higher in dairy goats than for other dairy animals (Winrock, 1976). Certain breeds of sheep (e.g. Djallonké) and goat (e.g. West African Dwarf) are thought to be tolerant of trypanosomiasis and other diseases, allowing them to be grazed on land not available to other domestic livestock.

Small ruminants are useful to humans during periods of cyclical and unpredictable food shortages. They also help balance the energy and protein supply during normal variations between seasons and years. The small size and early maturity of sheep and goats give them several distinct economic advantages in smallholder situations, such as: they can efficiently utilise marginal and small plots of land; the risk on investment is reduced by smaller individual size, allowing more production units per unit of investment; and there is a faster turnover of capital because they are sexually mature early and are younger at slaughter. Smaller carcasses are also easier to market and can be consumed in a short period of time. This is important as most rural areas lack proper storage facilities. Their strong flocking instinct makes herding by younger and older members of the family possible, allowing labour to be used more efficiently.

Small ruminants produce lower absolute quantities of milk than cattle. However, when their body weight is taken into account, their milk yield is higher than other species with the possible exception of camels (Wilson, 1991). During difficult periods of the year, these minor levels of output become significant (Coppock et al, 1982). It has been estimated that up to 40 years may be needed for cattle to attain the population and production levels existing prior to a drought (Wilson, 1991). Because of their shorter generation length and higher reproductive rate, small ruminants have a much shorter recovery period. For example, following a severe drought, goats conceive as soon as there is sufficient moisture for leaves and browse plants to grow. They kid five months later and consequently produce milk for human consumption at a very early phase of the recovery cycle (Wilson, 1991).

Although regional and breed variations exist, small ruminants appear to withstand drought better than cattle (Campbell, 1978). The droughts of the early 1980s which affected Ethiopia and the Sahel, including Sudan, resulted in cattle losses of 80% or more. Small ruminant losses did not exceed 50% (Wilson, 1991). Shafie (1992) has summarised the physical and physiological characteristics which enable sheep and goats to survive in arid and saline environments. They include: body conformation (slim trunks and slender limbs) which provide a large proportional surface area, helping excess body heat dissipate through non-evaporative cooling; and a respiratory system with a larger proportion of dead space to respiratory space, a structure which facilitates heat dissipation via respiratory water vaporisation

Table 2 *Sub-Saharan Africa's estimated livestock populations and meat and milk output by agroecological zones (1988).*

Species and agroecological zone	Meat output				Milk output		
	Inventory[a] (millions)	Off take (%)	Carcass wt(kg)	Quantity ('000 tonnes)	Inventory[b] (millions)	Lactation (kg)	Quantity ('000 tonnes)
Cattle (total)	162.5	10.4	137	2315	25	330	8200
Arid/semi-arid	84	10	140	1176	13	250	3300
Subhumid/humid	46	10	130	598	7	200	1400
Highlands	32	12	140	538	5	700	3500
Sheep and goats	269	25	14	942			2128[c]
Sub total (red meat)				3257			
Poultry	630	110	1.3	900			
Pigs	11	79	40	348			
Sub total (white meat)				1248			
Total				4505			10,328

Source: Adapted from Winrock (1992).

a) Total population.

b) Milked population only.

c) Calculated from 1985 (FAO, 1987) country statistics.

without the need for severe panting. Due to their adaptation to the environment (including feeding behaviour), small ruminants, particularly goats, are often the last to be affected by catastrophes. This causes them to be blamed for desertification.

Role of small ruminants

Small ruminants as source of food

Human diets will not contain necessary amounts and kinds of amino acids unless they include protein from either animal products or an unusually well designed combination of foods from plants (FAO, 1983).

It is difficult to determine accurately the contribution of small ruminants to human food supply and general welfare. Available statistics are misleading because much of the production from these species does not enter formal trade channels and is therefore not reported. Estimates indicate that ruminants contribute 80% of the total food production from livestock in tropical Africa (Jahnke, 1982). Of this, small ruminants account for about 22%. It is estimated that ruminants supply over 3.2 million tonnes of meat per year, representing over 72% of total meat production (Table 2). Small ruminant meat accounts for about 30% of the total red meat production and over 20% of the total meat output of SSA. Small ruminants account for about 21% of the total milk produced in SSA. This is about 26% of the milk output from cattle in the region (Table 2). The figures on meat production have been calculated from carcass weights which, in turn, were estimated from assumed dressing percentages. In the African context, and indeed in most developing countries, the conventional concept of dressing percentage is inappropriate when almost all parts of the animal are consumed. Thus, actual meat outputs from these species in traditional production systems are expected to be higher than estimates in Table 2. Most importantly, production from these species makes a valuable contribution to food resources in areas where it is most needed.

Small ruminants as producers of manure

Few farmers have access to commercial fertilizers. Manure and urine from domestic animals are therefore essential components for maintaining agricultural production. However, only limited quantitative data are available on the contribution of manure in traditional production systems. While some data are available on the contribution of cattle to manure production (e.g. Rege and Agyemang, 1992), data on the contribution of small ruminants is scanty.

Asset and security functions of small ruminants

One of the reasons usually given for low live animal offtake from traditional herds is the holding of livestock as a status symbol or sign of wealth. Livestock owners in rural areas do not usually have access to banking facilities and have come to rely on investment in their stock. While investment in livestock does carry its own risks, it provides security against crop failure and currency fluctuations. An analysis of income accruing from crops and livestock in a mixed farming situation was carried out in Abet, northern Nigeria. It revealed that, among farm items sold, livestock and livestock products accounted for 56% in value terms (Ingawa, 1986). Crop sales were limited to certain seasons, but the sale of livestock and milk was less season-

dependent. It therefore represents a dependable asset for emergencies. In general, livestock contribute to the stability of farm income because they can be bought following good crop performance and sold following crop failures. Thus, livestock helps to cushion farm enterprises against unstable commodity prices during unfavourable years. Livestock also serves as a "currency" in which social obligations are expressed.

Small ruminants facilitate utilisation of marginal lands

About 13–16 million km^2, or nearly half of the continent south of the Sahara, is desert or arid grassland and savanna. Crop production is a high risk enterprise (Brown, 1971). Nearly all livestock in these zones are indigenous African breeds raised under traditional nomadic and transhumant pastoral systems based upon communal grazing. They are well adapted to the characteristically sharp annual and seasonal variations in rainfall, requiring mobility in search of forage. These land use systems efficiently utilise available vegetative resources and provide a reliable source of food for the population (Cossins, 1983). Frequent reference to low land productivity of the pastoral range livestock production systems ignores the fact that livestock farming is the only way to support any human life at all in much of this zone. Wilson and Light (1986) have reported that as many as 95% of agropastoral families in Mali own goats and that the average flock size per family is over 30 head.

Overall contribution of small ruminants to national economies

A rough estimate of the importance of the livestock sector to the national economy is its contribution to the Gross Domestic Product (GDP). The share of agriculture to the GDP is important in Africa, but varies from 2.2. and 2.3% for Gabon and Côte d'Ivoire respectively, to 35.7% for Zimbabwe, 38.7% for Chad and 81.6 and 86.3%, respectively for Somalia and Mauritania. The average for the continent is 17.4% (Jahnke et al, 1988). The share of livestock in agricultural GDP has been estimated at 25% but this increases to 35% when traction and manure are considered (Winrock International, 1992). However, these averages hide great differences between countries, ecological zones and subregions. For example, the share of livestock in agricultural GDP's ranges from 5% for Ghana and Côte d'Ivoire to 82, 84 and 88% for Namibia, Mauritania and Botswana, respectively (Winrock International, 1992). On the basis of dollar values used by Winrock International (1992) for meat and milk, monetary contributions of small ruminants to GDP were estimated for 1988. Meat output contributed about $1286 million while milk output contributed about $1162 million.

In general, livestock products do not contribute much to direct foreign currency earnings in African countries. The exceptions include countries like Botswana, Swaziland, and Zimbabwe which export beef and mutton and Kenya which exports meat and indigenous animal germplasm (both live animals and semen). Several countries (e.g. Ethiopia) also export hides and skins. However, products from small ruminants offer local alternatives to imported products thereby saving foreign currency. The highest per capita consumption of animal products outside pastoral areas occurs in urban areas. If there were no local supply of these products, the demand would have to be met through importation. Even where small ruminants do not actually produce exportable products, they provide for the local demand, allowing the export of prime beef and mutton from limited high-input systems. In this way they contribute indirectly to export earnings. They also contribute indirectly to the employment of urban labour in the packing industry.

Small ruminant genetic resources of Africa

The majority of sheep and goats in tropical Africa are "indigenous" types, although both species were originally domesticated in Asia (Epstein, 1971). In the last 150 years or so exotic breeds have been imposed, mainly for modern commercial operations (Wilson, 1991). The Republic of South Africa has been in the forefront of this movement. There are large populations of Merino sheep in Kenya and Zimbabwe, and Karakul sheep in Namibia. Merino are also important in the smallholder sector of Lesotho, as are Angora goats (Wilson, 1991). The latter are also gaining prominence under commercial systems in Kenya. Karakuls are present in Angola, Botswana and Rwanda, but in smaller numbers. A composite breed, the Dorper, was bred in the Republic of South Africa from the Dorset Horn and Blackhead Persian. It is rapidly gaining ground for meat production under local conditions, notably in Zimbabwe, Kenya and, more recently, Botswana. Other countries have also imported exotic breeds but on a lesser scale than in the southern African region and Kenya.

In general, pressures of exotic breeds on indigenous types is much less for small ruminants than for cattle, where the contribution of AI to crossbreeding and breed substitution has been considerable. However, as is the case with indigenous cattle, breeds are not distinct from one another. There are hardly any indigenous small ruminant breeds which have been adequately characterised. Even so, it is widely recognised that because these genetic resources have evolved under the stresses of the African environment, they are well adapted to the local conditions.

Performance potential of indigenous breeds

The broad genetic variability of African small ruminant breeds enables them to survive under stressful environmental conditions, including high disease

incidence, poor nutrition and high temperatures. Environmental pressure also maintains a wide range of genotypes, each adapted to a specific set of circumstances. This is clearly the species' genetic response to risk. Under on-station management, indigenous African sheep and goat breeds have shown good growth and reproduction performances, indicating their potential. This shows that they would respond to improvements in management, particularly nutrition and disease control. This should be accompanied by selecting for improved performance. However, African livestock producers are not yet in a position to organise breed improvement programmes. Governments should therefore take responsibility for the development and implementation of selection schemes.

A case for evaluation and conservation

Studies indicate that the performance of small ruminants could be improved through management. Additionally, estimates of genetic parameters point to considerable genetic variation within indigenous populations. This indicates the potential for genetic improvement through selection.

There has been a tendency to over-emphasise the low productivity of indigenous breeds without due consideration of some important characteristics of these breeds. When the small size of these breeds and the harsh environmental conditions under which they are raised are taken into account, their productivity is impressive. Comparative studies of indigenous and exotic breeds to determine their feed utilisation efficiency have not been conclusive. However, it is known that breeds with high maintenance requirements tend to lose the most weight and have the highest mortality rates under stress conditions such as drought (Frisch, 1984). Most breed comparison studies have concentrated on quantifying performance (e.g. live weights and milk production) but not inputs. Indeed, the high-performing temperate breeds cannot survive under traditional management in most African environments. Although the performance of indigenous breeds under improved management has not been adequately assessed, there are indications that they respond to improved husbandry. For example, Kolff and Wilson (1985) have reported that indigenous small ruminants were able to double their daily weight gain rate with only minimal improvements in nutrition and management. The ability to survive under adverse environmental conditions with low inputs makes indigenous breeds a low-risk choice. The low-risk factor of resistant breeds is important where market prices are unstable or where the probability of death from environmental stress is high (Frisch, 1984). In some cases "low productivity" is an adaptive mechanism. For example, delayed age at first parturition and extended parturition intervals in semi-arid environments are mechanisms for coping with seasonal and often unreliable feed availability. In such environments some flock owners deliberately delay first breeding (Wilson et al, 1984). Poor nutrition increases the animals' susceptibility to diseases. Animals that have low maintenance requirements and the ability to make efficient use of poor quality forages are therefore at an advantage. There is a need for comparative evaluation of indigenous and exotic breeds in African environments, taking input costs and output prices into account.

Most imported (temperate) breeds are raised on high potential agricultural land where crop farming is practiced. The critical role of indigenous breeds is in providing the only means of using areas where other forms of agriculture are not practical. It may not be possible to improve some of these environments, especially in the arid zone, to accommodate exotic breeds. However, the strategy will most probably be some kind of crossbreeding to take advantage of breed complementarity and/or upgrading to allow gradual improvement in husbandry. Additionally, recent developments in biotechnology indicate that direct transfer of genes may become a routine method for germplasm improvement. Thus there is need to keep a reservoir of these exceptional genes. Indigenous breeds are crucially important today and will continue to be valuable in the future.

ILCA/FAO plan of action

Several expert panel meetings have addressed the issue of conservation of indigenous breeds, at both global and regional levels. These meetings have involved, among others, the Food and Agriculture Organization (FAO) of the United Nations (UN), the Organization of African Unity (OAU) through its Inter-African Bureau for Animal Resources (IBAR), UN Environmental Programme (UNEP), National Agricultural Research Systems (NARS) and other International Agricultural Research Centres (IARCs), including ILCA. However, efforts in support of Animal Genetic Resources (AGRs) have mainly remained at the stage of studies to identify priorities. Recognising the need to go beyond studying options and actually to implement them, in 1991 ILCA launched a research project to characterise indigenous African AGRs. ILCA's research initiative is aimed at documenting population sizes, biological performance and adaptive or other special characteristics of these AGRs. This information can then be used to develop rational utilisation and conservation programmes. In February 1992, ILCA organised a research planning workshop to work out methodologies and outline the implementation process. The workshop was attended by NARS scientists and AGR experts from FAO, several IARCs and other institutions outside Africa. Details of the AGR programme for Africa proposed by the FAO were presented. It immediately became clear that, given the scale of the undertaking and the common objectives of ILCA and FAO's proposed programmes, a collaborative programme would be more effective.

Subsequently, joint proposals have been prepared and funding is currently being sought.

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Impact sur la productivité des ovins Djallonké de la sélection des béliers sur leur taille

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Résumé

Dans le but d'améliorer les performances de croissance des ovins de race Djallonké, la Côte d'Ivoire conduit depuis 1976 un programme national de sélection ovine (PNSO). Afin de mesurer l'impact de ce programme sur la productivité des ovins Djallonké, une étude est menée pour tester deux hypothèses: 1) la sélection sur la taille des béliers améliore la croissance des ovins Djallonké; et 2) la sélection sur la taille des béliers n'a pas d'effets négatifs sur la santé des animaux ni sur leur résistance ou tolérance aux maladies. L'étude engagée vise à rechercher les indicateurs de maladies et à comparer les performances de production et de reproduction chez les descendants de béliers issus de deux types génétiques: le type sélectionné et le type non-sélectionné.

Impact of selection on size of rams on West African Dwarf sheep productivity

Abstract

A national sheep-breeding programme (PNSO) has been conducted in Côte d'Ivoire since 1976 to improve growth performance in West African Dwarf sheep. In order to measure the impact of this programme on sheep productivity, a study is being carried out to test the following two hypotheses: 1) that selection of ram size improves growth of West African Dwarf sheep, and 2) that selection of ram size has no adverse effect on the health of the animals nor on their resistance to disease. The objectives of the study are to seek disease indicators and compare productive and reproductive performance in the progeny of two types of ram, the selected and the non-selected.

Introduction

Afin de rationaliser l'élevage ovin traditionnel en Côte d'Ivoire, un programme national ovin (PNO) avait été engagé et mis en oeuvre dès 1976 par la Société de développement des productions animales (SODEPRA). Ce programme recouvrait des activités d'encadrement des propriétaires d'animaux et la gestion du Centre national ovin (CNO) ayant pour objectifs la production de géniteurs performants, la mise à l'essai des techniques et du matériel d'élevage et la formation des techniciens et des éleveurs.

Après plusieurs années d'encadrement qui ont vu naître des éleveurs performants, il est apparu opportun de créer un programme national de sélection ovine (PNSO). Cet organisme a pour mission de fournir aux éleveurs encadrés par la SODEPRA des reproducteurs mâles sélectionnés dans le but d'améliorer les performances de croissance du mouton Djallonké. Il apparaît aujourd'hui nécessaire de comparer les béliers sélectionnés aux béliers tout-venant, sur la base des deux hypothèses suivantes:

1. La sélection sur la taille des béliers améliore les performances de croissance des ovins Djallonké;
2. La sélection sur la taille des béliers n'a pas d'effets négatifs sur la santé des animaux ni sur leur résistance ou tolérance aux maladies.

Le présent rapport présente la démarche qui sera suivie dans l'étude initiée par la SODEPRA et l'IDESSA afin a) de mesurer l'impact que la sélection sur la taille des béliers exerce sur les performances de croissance des ovins Djallonké et sur les caractères de reproduction des brebis; et b) d'établir les relations entre la sélection sur la taille des béliers et les indicateurs de résistance aux maladies.

Matériel et méthodes

Les béliers sélectionnés du PNSO seront comparés à des béliers tout-venant achetés sur le marché local et dans les villages (béliers témoins). Des contrôles seront effectués pour s'assurer de leur bon état sanitaire (sang, sperme, selles).

Les deux types de béliers seront mis en lutte avec des brebis tout-venant après une période de quarantaine. Cinq béliers de chaque type génétique seront introduits dans des lots de 20 brebis pendant 45 jours. Les béliers rejoindront les brebis pendant la nuit seulement. Les cinq béliers sélectionnés seront de générations

différentes pour pouvoir comparer les générations entre elles.

Cette étude s'étendra sur trois cycles de reproduction séparés par des intervalles de huit mois. Les animaux seront conduits sur pâturage naturel pendant la journée et recevront 300 g d'aliments complémentaires (son de blé et tourteaux de coton) par animal (bélier, brebis suitées) et par jour.

Les paramètres de reproduction et de croissance suivants seront relevés:

- chez les brebis: la fertilité, la prolificité, la fécondité, les poids avant la lutte et après l'agnelage, la mortalité;
- chez les agneaux: le poids à la naissance, le poids au sevrage (90 jours), les poids à 30 j, 60 j, 80 j, 180 j, 240 j et 365 j, les âges à 20, 25, 30, 35 et 40 kg pour les mâles, la mortalité à la naissance (0–3 j), la mortalité entre la naissance et le sevrage (4–90 j) et la mortalité post-sevrage.

Les indicateurs de maladies suivants ont été retenus:

- la recherche des oeufs et larves dans les fèces par la technique de Mac Master (nombre d'oeufs par gramme);
- la recherche des parasites sanguins (*Babesia ovis*, trypanosomes et anaplasmes) par frottis, goutte épaisse et hématocrite;
- la recherche de témoins d'infection de la sphère génitale telle que la chlamydiose, la brucellose (surtout pour l'épididymite contagieuse des ovins).

Le protocole des prélèvements pour la prise en compte de ces indicateurs est le suivant:

- sur l'ensemble des béliers et brebis: sérologie, OPG, hématoscopie une fois sur un cycle (pendant la quarantaine);
- sur 40 brebis prises au hasard (20 brebis de chaque lot): OPG et hématoscopie pendant la gestation;
- sur 80 descendants (40 agneaux des deux sexes par lot): OPG et hématoscopie tous les mois;
- sur l'ensemble des agneaux: sérologie à l'âge de 3 mois, 9 mois et 1 an.

Un fichier sera établi pour recenser tous les autres problèmes de pathologie. Tout cadavre sera acheminé au laboratore pour autopsie et recherches complémentaires.

L'analyse statistique qui sera utilisée est celle de la méthode des moindres carrés. Les facteurs de variation suivants seront pris en compte:

- pour les caractères concernant les performances de croissance de l'agneau: le type de bélier, le sexe, le mode de naissance, la période d'agnelage, le poids de la brebis;
- pour les données relatives aux béliers sélectionnés: les paramètres indiqués ci-dessus et le facteur génération du bélier;
- pour les caractères concernant les performances de reproduction des brebis: le type de bélier, la période de lutte, la période d'agnelage, l'année, le poids de la brebis.

Les descendants femelles feront l'objet d'études ultérieures visant à évaluer l'effet de la sélection sur les aptitudes maternelles de la brebis Djallonké.

Résultats attendus

Suivi de l'évolution du progrès génétique réalisé entre les différentes générations de béliers sélectionnés:

- détermination du gain génétique réalisé;
- évaluation du schéma de sélection mis en oeuvre par le PNSO;
- contribution à l'amélioration du plan de prophylaxie appliqué par les projets d'encadrement ovin de la SODEPRA dans les élevages de la base de sélection.

Caractères phénotypiques de différenciation et de croissance des agneaux de race pure Djallonké et croisés Sahélien x Djallonké

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Résumé

Pour déterminer les caractères phénotypiques permettant de différencier un agneau Djallonké de race pure d'un agneau croisé Sahélien x Djallonké, une analyse factorielle discriminante et une analyse de variance ont été réalisées sur 64 agneaux contemporains des deux types génétiques. L'analyse discriminante a révélé que les caractères qui permettent de différencier les deux types génétiques étaient le poids à la naissance (PN), la longueur des oreilles (LO) et la longueur de la queue (LQ), caractères entre lesquels il existe une corrélation positive étroite (rLO_LQ = 0,707; rLO_PN = 0,699; rLQ_PN = 0,627). La longueur de l'oreille constituait la meilleure variable discriminante.

Pour tous les caractères mesurés, les agneaux croisés présentaient les meilleures performances bien qu'étant les moins âgés. L'analyse de variance sur la croissance présevrage indiquait que l'effet du type génétique sur le poids n'était très important (P<0,001) qu'au jeune âge (de la naissance à 60 jours). Au sevrage, l'effet dû au type génétique avait disparu. De la naissance au sevrage, le poids vif des agneaux croisés passait de 2,17 kg à 7,62 kg en moyenne et celui des agneaux de race pure de 1,76 kg à 7,28 kg. A l'âge de 60–70 jours, le poids vif, le gain moyen quotidien, la longueur de l'oreille et la longueur de la queue avaient des valeurs moyennes de 6,78 kg, 65,5 g/j, 12,4 cm et 21,5 cm pour les croisés et de 6,55 kg, 62,9 g/j, 9,9 cm et 17,6 cm pour les agneaux de race pure.

Phenotypic differentiation and growth traits in purebred West African Dwarf lambs and their crosses with Sahel lambs

Abstract

Discriminant factorial analysis and analysis of variance were made on 64 contemporary West African Dwarf (WAD) and WAD x Sahel lambs to determine phenotypic traits for differentiating purebred WAD from their crosses with Sahel sheep. The discriminant analysis showed birth weight (BW), ear length (EL) and tail length (TL) to be traits for differentiating the two breed groups. These traits were positively correlated (r_{EL-TL} = 0.707; r_{EL-BW} = 0.699; r_{TL-BW} = 0.627). The best discriminant variable was the ear length.

Notwithstanding their younger age, the crossbreds had better performances in all traits measured. The analysis of variance for preweaning growth showed that breed group significantly affected weight (P<0.001) only at an early age (from birth to 60 days). The effect of breed group disappeared at weaning. Live weight between birth and weaning rose from an average 2.17 kg to 7.62 kg in crossbreds, and from 1.76 to 7.28 kg in purebreds. Live weight, average daily weight gain, ear length and tail length at 60-70 days averaged 6.78 kg, 65.5 g/d, 12.4 cm and 21.5 cm, respectively, for crossbreds, and 6.55 kg, 62.9 g/d, 9.9 cm and 17.6 cm, respectively, for purebreds.

1. Introduction

La race Djallonké, une ressource génétique sûre pour la Côte d'Ivoire, se caractérise par une précocité de reproduction des jeunes béliers et antenaises, une aptitude à se reproduire tout au long de l'année, une adaptation aux conditions de l'environnement tropical humide et surtout une tolérance à la trypanosomiase animale, conséquence d'une longue période de sélection naturelle.

Malgré ces qualités, elle présente un poids vif adulte dépassant rarement 40 kg et une croissance très lente des animaux, ce qui limite la rentabilité de la production de viande.

Face au souhait des éleveurs de posséder ou de mettre sur le marché des animaux de grand format, on assiste dans les zones urbaines à des pratiques de croisement entre des moutons de race Djallonké et des animaux de races originaires des pays du Sahel communément appelées "sahéliennes". A l'âge adulte, le poids vif de ces animaux de grande taille peut atteindre 90 kg (Charray *et al.*, 1980; Fitzhugh et Bradford, 1983).

Le département Elevage de l'Institut des savanes (IDESSA) à Bouaké a lancé une étude ayant pour

objectifs la définition des caractéristiques phénotypiques des croisés Sahélien x Djallonké et l'évaluation de leurs performances par rapport à celles des Djallonké de race pure.

Le présent article présente les résultats de la première année de l'étude sur les caractères phénotypiques de différenciation et la croissance présevrage des agneaux Djallonké de race pure (D X D) et croisés Sahélien x Djallonké (S x D).

2. Matériel et méthodes

Un bélier sahélien dont les caractéristiques correspondaient à celles du mouton Peul a été acheté sur le marché à bétail de Bouaké et mis en lutte sur un lot de 26 brebis Djallonké. Par ailleurs, 4 lots de 17 à 20 brebis Djallonké ont été affectés d'un bélier Djallonké chacun; les luttes ont eu lieu simultanément du 22 mai au 6 juillet 1991, soit pendant 45 jours. Il s'agissait de luttes naturelles, sans traitement hormonal préalable des brebis. Les béliers rejoignaient les lots de brebis pendant la nuit seulement.

Les agnelages ont eu lieu en plein air d'octobre à novembre 1991. Un numéro était attribué aux agneaux à la naissance et le poids, le sexe et le mode de naissance étaient immédiatement enregistrés. Le sevrage des agneaux a eu lieu le 29 janvier 1992 à un âge moyen de 90 jours.

Les animaux ont été alimentés sur pâturage de savane naturelle pendant la journée. Le soir, les brebis recevaient 50 à 100 g de tourteau de coton par animal. De la paille de riz était distribuée pendant la saison sèche.

Une série de mesures ont été prises sur les agneaux entre l'âge de 40 et de 90 jours. Ces mesures ont ensuite été analysées par la méthode d'analyse factorielle discriminante du programme STAT-ITCF (ITCF, 1987) afin de déterminer les caractères phénotypiques permettant de différencier les deux types génétiques S x D et D x D. Les variables mesurées étaient le poids à la naissance, l'âge à la pesée, le poids au jour de la pesée, le gain moyen quotidien (GMQ) de la naissance au jour de la pesée, le nombre total de taches, le pourcentage de taches sur le corps à l'exception de la tête et des extrémités des pattes, le rapport entre le nombre de taches sur le corps et le nombre total de taches, la longueur de l'oreille, la longueur du cou, la longueur scapulo-ischiale, la longueur de la queue, et le périmètre thoracique.

Les agneaux ont été pesés à 15, 33 et 71 jours et au sevrage. Les poids aux âges types de 30, 60 et 90 jours et les différents gains moyens quotidiens ont été calculés à partir des différentes pesées.

Une analyse par la méthode des moindres carrés (Harvey, 1988) a été effectuée pour déterminer les effets dus au sexe (mâle ou femelle), au mode de naissance (simple ou double), au type génétique (race pure ou croisée) et à l'interaction entre le sexe et le type génétique sur les différents poids et GMQ des agneaux. Le poids à la naissance et l'âge au sevrage ont été utilisés comme covariables dans l'analyse du poids au sevrage.

3. Résultats et discussion

3.1 Caractères phénotypiques de différenciation

L'analyse factorielle discriminante révèle un pourcentage de 80% d'animaux bien classés parmi les agneaux Sahélien x Djallonké et de 86% parmi les agneaux Djallonké. Le fait que les agneaux croisés soient classés parmi les agneaux de race pure indique que la plupart d'entre eux sont phénotypiquement plus proches des moutons sahéliens. Une faible proportion des croisés avait les caractéristiques typiques de la race Djallonké.

Le poids à la naissance (F = 18,30), la longueur de l'oreille (F = 25,12) et la longueur de la queue (F = 20,94) confirment cette classification (tableau 1). La meilleure variable discriminante était la longueur des oreilles, pour laquelle la valeur de F était la plus élevée. La corrélation était de 0,707 entre la longueur des oreilles et celle de la queue; de 0,699 entre la longueur des oreilles et le poids à la naissance; et de 0,627 entre la longueur de la queue et le poids à la naissance. Le périmètre thoracique de l'agneau s'étant révélé très fortement corrélé avec le poids (r = 0,959), le GMQ (r = 0,852) et la longueur scapulo-ischiale (r = 0,800), il pourrait être utilisé comme indice d'expression du poids ou du GMQ lorsque la pesée est difficile à réaliser.

Bien que constituant la meilleure variable discriminante, la longueur des oreilles ne peut à elle seule permettre de classer les agneaux. Son association avec les autres variables s'avère très importante pour la classification des agneaux, étant donné que le T^2 de Hoteling (tableau 1) est supérieur à la valeur de F pour la longueur des oreilles.

A la naissance, les agneaux croisés Sahélien x Djallonké pesaient 0,5 kg de plus que les agneaux Djallonké. A un âge plus avancé (63–71 jours), la différence de poids entre les deux types génétiques diminuait et n'était plus que de 0,23 kg, avec une différence de la croissance quotidienne de 2,63 g/j (tableau 1). La longueur des oreilles des croisés avait 3 cm de plus que celle des Djallonké et la queue, 4 cm de plus.

La queue des Djallonké se situe au-dessus ou au niveau du jarret et celle des croisés au niveau ou en dessous du jarret, dans une proportion de 50% chaque. Aucun agneau Djallonké n'avait la queue en dessous du jarret et aucun croisé ne l'avait au-dessus du jarret, sauf chez des animaux mal classés. Par ailleurs, avec un pourcentage de taches sur le corps de 9,83% contre 23,93% chez les croisés (tableau 1), les agneaux Djallonké présentaient en général une robe plus uniforme.

Tableau 1. *Valeurs de F et moyennes des caractères mesurés chez des agneaux Djallonké et Sahélien x Djallonké*

Caractères	F (probabilité associée) (T^2 = 58,72)	Moyennes	
		D x D	S x D
Poids à la naissance (kg)	18,30 (0,01)	2,12	2,64
Age (j)	4,46 (3,87)	71	63
Poids (kg)	0,17 (68,29)	6,55	6,78
GMQ (g/j)	0,13 (72,11)	62,87	65,5
Nombre total de taches	1,49 (22,54)	6	5
Pourcentage de taches (%)	5,32 (2,32)	9,83	23,93
Longueur des oreilles (cm)	25,12 (0,00)	9,89	12,39
Longueur du cou (cm)	0,05 (81,98)	17,12	17,31
Longueur scapulo-ischiale (cm)	2,33 (13,10)	35,07	37,21
Longueur de la queue (cm)	20,94 (0,01)	17,58	21,51
Périmètre thoracique (cm)	0,29 (60,24)	43,74	44,49

3.2 Performances de croissance

Il ressort de l'analyse de variance que le sexe, le mode de naissance et le type génétique avaient un effet très significatif sur le poids à la naissance. L'influence de ces facteurs diminuait avec l'âge, puis disparaissait au sevrage (tableau 2). Les poids de la naissance au sevrage des agneaux croisés étaient nettement supérieurs à ceux des agneaux de race pure (tableau 3). S'agissant des gains moyens quotidiens, seuls les effets dus au sexe et à l'interaction type génétique x sexe étaient importants au jeune âge (P<0,05), les autres facteurs n'ayant pas eu d'effet sur le gain moyen quotidien (tableau 4).

Les différences de poids entre les agneaux issus de naissances simples et ceux issus de naissances gémellaires n'étaient significatives (P<0,01) qu'entre 0 et 30 jours, encore que la quasi-totalité des agneaux ait été de naissance simple. Sur 59 agneaux, 4 seulement étaient issus de naissances gémellaires. Il n'y a eu aucune naissance double parmi les croisés.

Tous types génétiques et modes de naissance confondus, il n'y avait pas de différence entre le poids des agneaux mâles et femelles de 30 jours au sevrage (tableau 3). A l'exception du GMQ entre 30 et 60 jours, la croissance pondérale des femelles a été plus rapide que celle des mâles, mais cette différence n'était pas statistiquement significative. En particulier, les croisés femelles avaient une croissance de la naissance à 30 jours (98,6 g/j) significativement supérieure à celle des croisés mâles. De la naissance au sevrage, le poids des agneaux croisés augmentait plus rapidement que celui des agneaux de race pure, mais la différence n'était pas statistiquement significative (tableau 5).

Les faibles performances des croisés enregistrées à l'IDESSA par rapport à celle obtenue par d'autres institutions pour le mouton du Vogan par exemple (Amégée 1983, 1984) pourraient s'expliquer par l'inadéquation de l'environnement sanitaire et alimentaire qui empêche les croisés d'extérioriser tout leur potentiel génétique.

Tableau 2. *Analyse de variance du poids des agneaux de la naissance au sevrage*

Source de variation	Degré de liberté	Naissance	30 j	60 j	90 j	Sevrage
Sexe	1	1,32***	0,33	1,3	0,01	0,39
Mode de naissance	1	1,76***	5,29*	4,67	0,87	0,12
Type génétique	1	1,78***	9,63**	12,17**	3,27	0,56
Sexe x Type génétique	1	0,29	2,53	0,91	0,08	0,08
Régression						
Poids naissance	1					2,67
Age au sevrage	1					8,01
Résiduelle		0,11	0,95	1,81	2,53	2,73
(d.d.l.)		(54)	(50)	(43)	(34)	(32)

*** P<0,001 ** P<0,01 * P<0,05

Tableau 3. *Moyennes estimées du poids des agneaux de la naissance au sevrage (kg)*

Moyenne générale	1,97	4,06	5,64	7,28	7,50
	± 0,09	± 0,29	± 0,46	± 0,64	± 0,71
Sexe					
Mâle	2,15[a]	3,97	5,85	7,31	7,32
Femelle	1,79[b]	4,15	5,42	7,26	7,59
Mode de naissance					
Simple	2,33[a]	4,70[a]	6,32	7,64	7,60
Double	1,60[b]	3,42[b]	4,96	6,93	7,31
Type génétique					
Djallonké	1,76[b]	3,57[b]	4,99[b]	6,93	7,28
Croisés	2,17[a]	4,55[a]	6,29[a]	7,63	7,62

Au sein d'une même colonne, les moyennes affectées des mêmes lettres ne sont pas significativement différentes.

Tableau 4. *Analyse de variance des GMQ des agneaux de la naissance au sevrage*

Source de variation	Degré de liberté	Naiss.-30 j	30–60 j	60–90 j	Naiss.- 90 j	Naiss.-Sevrage
Sexe	1	3306	6383**	977	69	40
Mode de naissance	1	1209	670	59	2	12
Type génétique	1	3068	1290	0	67	73
Sexe x Type	1	5092*	4199*	256	96	30
Régression						
Poids naissance	1					7
Age au sevrage	1					80
Résiduelle		1099	897	497	299	330
(d.d.l.)		(50)	(43)	(34)	(34)	(32)

**P<0,01 *P<0,05

Tableau 5. *Moyennes estimées du GMQ des agneaux de la naissance au sevrage (g/j)*

Moyenne générale	69,5	55,4	41,7	59,1	58,8
	± 9,79	± 10,30	± 8,99	± 6,97	± 7,78
Sexe					
Mâle	60,5	70,3[a]	35,7	57,5	57,4
Femelle	78,6	40,5[b]	47,8	60,7	60,1
Type génétique x sexe					
Mâle	63,0[b]	51,5[b]	38,8	57,8	56,6
Djallonké					
Femelle	58,6[b]	45,9	44,7	57,2	57,0
Mâle	58,0[b]	89,2[a]	32,5	57,2	58,2
Croisé					
Femelle	98,6[a]	35,1[b]	50,8	64,2	63,2

Au sein d'une même colonne, les valeurs affectées d'une même lettre ne sont pas significativement différentes.

4. Conclusion

Phénotypiquement, le croisé Sahélien x Djallonké se rapproche plus du mouton sahélien que du Djallonké. Cette ressemblance se manifeste dans la longueur des oreilles, la longueur de la queue et une présence importante de taches sur le corps. Le poids à la naissance est plus élevé chez les croisés Djallonké x Sahélien que chez les Djallonké de race pure, mais cette supériorité pondérale diminue avec l'âge et disparaît au sevrage. Il est probable que la faible production laitière de la brebis Djallonké ne permette pas à l'agneau croisé de maintenir sa supériorité de poids jusqu'à un âge avancé, malgré les potentialités génétiques qu'il recèle. Il s'ensuit que l'amélioration de la productivité ne devrait pas s'appuyer uniquement sur les performances pondérales mais aussi sur la valeur laitière de la brebis.

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Sheep production in Zambia: A review of sheep breeding

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Abstract

Sheep breeding in Zambia is reviewed, particularly the use of evaluation, selection and mating systems to improve the economic traits of sheep.

Programmes to improve sheep production by evaluating and selecting the best animals should concentrate on the traditional sector. Open national nucleus flocks should be established for the Fat- tailed indigenous sheep which are widespread throughout the country. The improved genotype would be disseminated by the extensive use of rams from the national nucleus flock.

Production ovine en Zambie: étude de la reproduction et de la sélection des moutons

Résumé

Cet article passe en revue les programmes de reproduction et de sélection des ovins en Zambie, et particulièrement les systèmes d'évaluation, de sélection et de lutte utilisés pour améliorer les paramètres de production des ovins.

Les programmes d'amélioration de la production ovine par l'évaluation et la sélection des meilleurs animaux devraient être axés sur le secteur traditionnel et des troupeaux reproducteurs nationaux ouverts de moutons indigènes à queue grasse devraient être constitués. Le génotype amélioré de ce type de mouton, qui se rencontre sur l'ensemble du territoire, serait disséminé par le recours à grande échelle à des béliers issus de ce troupeau reproducteur national.

Introduction

Sheep in Zambia are produced by two farming sectors. The commercial sector has income generation as the main priority of sheep farming. The traditional sector places less emphasis on income and more on nutrition and subsistence. The traditional sector owns 64% of Zambia's 59,720 sheep. In this sector the sheep are mainly of the Fat-tailed and Thin-tailed types, which are indigenous. Traditional sheep production is concentrated in the Southern, Eastern and Luapula Provinces, accounting for 63% of the traditional sheep population found in Zambia. The sheep found in the commercial sector are the exotic type, namely, Blackhead Persian, Dorset Horn, Dorper and Suffolk. The commercial sheep flocks are concentrated in Lusaka and Central Provinces, near the main consumption centres for marketed sheep.

The sheep are kept for meat. Off-take in the commercial sector is 25% while in the traditional sector it is unknown. Most of the mutton consumed in urban areas is supplied by the commercial sector. The annual per capita consumption of mutton is estimated at 0.7 kg of which the rural areas account for 80%. The marketed supply of meat from sheep is relatively small as it accounts for less than one per cent of the total meat supply. There is therefore a need to improve sheep production in order to increase annual per capita consumption of mutton. Better breeding, nutrition, management, disease control and marketing can all contribute to this. This study reviews improving sheep production through breeding.

Breeding in production sectors

Traditional sector

Flock sizes in the traditional sector vary from a few to about 50 animals. This sector keeps the two indigenous breeds, Fat-tailed and Thin-tailed sheep. The more widespread of these is the Fat-tailed sheep, which accounts for 63% of the indigenous sheep. Formal animal breeding practices such as evaluation and selection of individual animals for performance are not practised. All ages and sexes of sheep are left to run together at all times and mating is at random within the flock.

Commercial sector

Commercial sheep production started in 1979 (Productive Farming, 1981). Commercial farmers keep Blackhead Persian, Dorset Horn, Dorper and Suffolk. The Dorper is the most common breed because it has good characteristics such as a long breeding season, high milk yield in the ewe and a good quality carcass (Productive Farming, 1983). Suffolk rams are used in two- and three- breed crosses as the terminal sire to improve lamb growth rate and carcass weight. Commercial farmers have claimed that slaughter weights for Suffolk x Dorper crosses are 30% higher

than those for pure Dorper (Productive Farming, 1981). There is no evaluation and selection taking place on these farms to accompany crossbreeding.

Breeding in research

In 1970 breeding work started at the Mazabuka Regional Research Station, situated in the southern part of Zambia. Its purpose was to evaluate pure Dorper and Blackhead Persian as meat animals. Traits considered were birth weight, pre-weaning mortality rate, weaning weight (at four months) and post-weaning weight gain of male castrates up to the age of three years (MAWD, 1970). Dorper lambs were heavier at birth (4.2 kg) than Blackhead Persian lambs (3.1 kg). However, the pre-weaning mortality rate was better for the Blackhead Persian (10%) than for the Dorper (24.5%). The average weaning weight of single and twin Blackhead Persian lambs was 18.9 kg for females and 20.9 kg for males. At 3.5 years of age the Dorper castrates were about 58% heavier than the Blackhead Persian and the carcass weight was about 49% heavier (MAWD, 1972–73).

In May 1972 another sheep project was initiated at the Mansa Research Station, situated in the northern part of Zambia. The aim of this project was to evaluate the meat production potential of indigenous sheep as purebred and as crossbreds to Dorper and Blackhead Persian sheep. The project was abandoned the same year because of high mortality rates, the reasons for which were unknown.

Breeding in extension

In 1969 the Government established a National Stud Farm of Dorper and Blackhead Persian near Lusaka in the central part of the country. Breeding stock from the Stud Farm were sold to farmers to establish small sheep units in different parts of the country. Due to high mortality rates and lack of expert management, the Farm was abandoned in 1977.

In 1985, the Government drafted a proposal to set up a ranch to keep indigenous breeds. The animals were to be evaluated and selected for growth and hardiness to survive village conditions. Sires from the ranch were to be used on village ewes to improve the quality of village flocks. This proposal has not been implemented.

Future breeding work

The Government's main development objectives for sheep are: to increase substantially the commercial production of sheep; to upgrade the standards and the efficiency of operation of both commercial and traditional producers; and significantly expand the average size of off-take from traditional flocks (MAWD, 1986). The production targets are to increase sheep population by an annual rate of 3.3% and to increase slaughtering by an annual rate of 7%.

The strategy for achieving these objectives includes the improvement of marketing facilities and price incentives, improving extension and animal health services, strengthening applied research activities and establishing strategically located sheep multiplication units for distributing improved genotypes.

In Zambia, material, money and personnel resources are very limited. Improvement through breeding should concentrate on the traditional sector which has the largest population of unimproved sheep. Improvement could therefore make the largest impact. Commercial farmers already have unlimited access to improved genotypes through the import of proven rams, although they do not evaluate and select individual ewes for performance.

Breeding work in the traditional sector should concentrate on establishing an open nucleus flock for Fat-tailed sheep in each of Southern, Eastern and Luapula Provinces. In these flocks evaluation and selection should concentrate on fertility, growth and viability traits. The improved genotypes would be disseminated by the extensive use of rams from the open nucleus flocks.

To improve carcass weights of marketed sheep from the traditional sector, on-farm assessments of the best breed of sire in the terminal cross of indigenous ewes with exotic breed should be carried out concurrently with the establishment of open nucleus flocks. Possible sire breeds to be assessed would be Dorper and Blackhead Persian.

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Prospects for breeding for resistance to endoparasites in small ruminants in Africa — a new ILCA research programme

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Abstract

This paper briefly reviews the evidence for genetic resistance to endoparasites both between and within breeds of sheep and goats. There is extensive evidence for genetic variation in resistance among breeds of sheep outside Africa. Some evidence exists for breed variation in Africa. Almost all published reports to date suffer from poor experimental design, particularly in terms of the small numbers of each breed sampled and lack of information on how the animals were sampled. The evidence for genetic variations in resistance to endoparasites within breeds is more convincing. Heritabilities average about 0.35. In the light of this evidence, ILCA has developed a Pan-African multidisciplinary research programme to investigate and characterise genetic resistance to endoparasites in some indigenous African sheep and goat breeds. This includes the evaluation of: Menz and Horro sheep breeds in Ethiopia; Dorper and Red Maasai sheep and Galla and Small East African goats in coastal Kenya; Peul Peul (Fulani) and Djallonké sheep and West African Dwarf and Sahel goats in Senegal. The experimental design and research protocol for this research programme is outlined and some preliminary results of the research in the Kenyan coastal site are presented.

Perspectives de sélection sur la résistance aux endoparasites chez les petits ruminants africains — un nouveau programme de recherche du CIPEA

Résumé

Le présent article brosse un tableau rapide des facteurs qui démontrent l'existence d'une résistance génétique aux endoparasites inter- et intraspécifique chez les ovins et les caprins. La variabilité génétique de cette résistance entre races de moutons non africains est bien établie. Certains documents font état d'une variabilité interrace en Afrique. Toutefois, la quasi-totalité des rapports publiés à ce jour pèche par l'inadéquation du schéma expérimental, notamment pour ce qui est du petit nombre d'animaux échantillonnés dans chaque race et du manque d'information sur la manière dont les animaux ont été échantillonnés. Les preuves de l'existence de variations génétiques de la résistance aux endoparasites à l'intérieur d'une même race sont plus convaincantes. L'héritabilité est en moyenne de 0,35. A la lumière de ces observations, le CIPEA a engagé un programme panafricain de recherche pluridisciplinaire visant à étudier et à caractériser la résistance génétique aux endoparasites chez certaines races indigènes de moutons et de chèvres en Afrique. Parmi celles-ci figurent les moutons Menz et Horro d'Ethiopie; les moutons Dorper et Massaï et la chèvre Galla et la petite chèvre de l'Afrique de l'Est dans la région côtière du Kenya; les moutons peul peul et Djallonké et la chèvre naine d'Afrique occidentale ainsi que la chèvre du Sahel au Sénégal. Le dispositif expérimental et le protocole de recherche de ce programme sont exposés dans leurs grandes lignes et certains des premiers résultats des recherches effectuées dans la zone côtière du Kenya sont présentés.

Introduction

Gastrointestinal nematodes impose severe economic constraints on sheep and goat production in pastoral systems worldwide. Losses occur through mortalities, reduced production due to subclinical parasitism and direct costs associated with control (Barger, 1982; ILCA, 1992). Existing procedures to control endoparasites rely almost exclusively on curative or preventive treatment with anthelmintics. However, widespread and indiscriminate use of these potent drugs has resulted in the emergence of anthelmintic-resistant strains of nematodes (Waller, 1991). There are also

increasing environmental concerns about chemical residues in meat and on pasture resulting from anthelmintic use.

In most countries in sub-Saharan Africa, endoparasite control options are limited. Access to anthelmintics by smallholder livestock producers is often restricted due to expense or unavailability. In addition, communal pastoral systems do not allow for regulated grazing as a means of lowering exposure to infective larvae on pasture. These considerations provide an impetus to develop alternative or complementary control options which eliminate or at least reduce the reliance on anthelmintics. Exploiting genetic variations in host resistance to endoparasites is an attractive option both to control endoparasites and improve the production efficiency of small ruminants.

Genetic resistance

Breed differences

There have been many reports since the mid-1930s of substantial variations among sheep breeds in resistance to internal parasites, particularly to *Haemonchus contortus, Ostertagia circumcincta* and *Trichostongylus colubriformis*. Gray (1991) tabulated and summarised 23 publications on this subject and this was expanded to 34 studies in a review by Baker et al (1992). For example, the East African Red Maasai (Preston and Allonby, 1978, 1979) and the Florida Native, St Croix, Barbados Blackbelly and Navajo (Courtney et al, 1984; Knight et al, 1973; Gamble and Zajac, 1992) are all relatively resistant to *H. contortus* in comparison with European breeds such as the Rambouillets or Merinos. There are also indications that some of the West African sheep and goat breeds, such as the Djallonké sheep and the West African Dwarf goat, may be relatively resistant to both internal parasites and trypanosomiasis (Osinowo and Abubakar, 1989; Smith, 1989).

Nearly all the studies reviewed by Gray (1991) and Baker et al, (1992) are characterised by very poor experimental design, due to both the numbers of animals of each breed tested, and lack of information on how the breeds were sampled. In addition, very few of the studies took account of variations among sires within breeds. The magnitude of the differences between sires can be the same as the largest differences between breeds (Gray et al, 1987). Many of the breed differences reported could reflect a single sire effect and hence should be interpreted cautiously.

While many of the publications on breed variation for resistance to disease can be criticised due to their poor experimental design, it is reassuring that some breeds have been identified as resistant in a number of independent studies. This applies particularly to the Florida Native, St Croix and Red Maasai sheep breeds. It is very likely these breeds have a real resistance to internal parasites. It is worthy of note that the St Croix sheep breed originated from West Africa and is probably related to the Djallonké sheep (Bradford and Fitzhugh, 1983).

Within-breed genetic variation

Baker et al (1992) tabulated and reviewed the substantial body of evidence reporting heritability estimates for resistance to internal parasites in sheep and goats. Resistance has commonly been assessed by either faecal egg counts (FEC) or haematocrit (packed cell volume — PCV). FEC has been shown to be a good indicator of actual worm burdens (especially in young animals) but can depend on the parasite species. PCV is a good indicator of worm burdens for blood-sucking parasites such as *Haemonchus contortus*.

From the 14 Australian and New Zealand studies that were reviewed by Baker et al (1992) the average heritability for a single FEC measurement following natural or artificial infection was 0.32. Heritabilities were similar for natural and artificial modes of infection and infection with a number of different parasite genera (both single genus infections and mixed infections). The average heritability of PCV (0.35) was similar to that for FEC. The advantage in taking more than one measurement of FEC depends on the repeatability estimate. The repeatability within a single artificial infection with *Haemonchus contortus* is high (0.60) and relatively little is to be gained in selection accuracy from more than one measurement (Woolaston et al, 1991). However, with natural challenge in New Zealand, the repeatability between two separate infections separated by an anthelmintic treatment is lower at about 0.30 to 0.40. This results in a heritability of 0.53 for the average of two FECs taken in lambs at about five and seven months old (Baker et al, 1991).

Estimates of genetic parameters (i.e. heritabilities and repeatabilities) of resistance to endoparasites in sheep and goats in Africa are limited. Those available were reviewed by Baker et al, (1992). Only three heritability estimates are available (Rohrer et al, 1991; Baker, 1992 (unpublished)). These range from 0.22 to 0.40, similar to those found in Australia and New Zealand. There are more repeatability estimates available. These are quite variable, ranging from 0.05 to 0.42. In some studies the low repeatability estimates for FEC have been shown to be affected by the egg counting procedure used. The improved modified McMaster egg counting technique (MAFF, 1977) is recommended and usually gives higher repeatability estimates. It is important that the egg counting technique is standardised in any experimental study on resistance to endoparasites and the procedure finally used is clearly documented in subsequent publications.

A number of divergent selection experiments in sheep for resistance or susceptibility to a number of different internal parasite genera are currently being carried out. In Australia there are five studies, in New Zealand three studies and in France one study. They were reviewed by Baker et al (1992). Successful response to selection has been reported in some of these

studies (Baker et al, 1991; Cummins et al, 1991; Woolaston et al, 1991; Windon, 1991). This confirms the moderate to high heritabilities for resistance to endoparasites.

ILCA's research project

Objectives

The primary objective of the first phase of this research project is to identify and quantify genetic variations in resistance to internal parasites between and within some indigenous breeds of sheep and goats in Africa. Other important objectives include: determining the specificity of genetic variations in resistance to different parasite genera; undertaking parasite epidemiology studies; establishing the relations between FEC, PCV and actual worm burdens; and carrying out a comparative economic evaluation of the use of breeding and chemotherapy for parasite control (ILCA, 1991, 1992).

The second phase of this project will investigate immunological and genetic mechanisms of resistance to endoparasites. Breeds or groups of animals that are most resistant and most susceptible to endoparasites will be used. This may identify immunological or genetic markers of resistance. A desirable marker would be one that does not need infection and that would not be influenced by other environmental or physiological factors. Direct selection for resistance using parasitological measurements (e.g. FEC or PCV) requires artificial challenge or unchecked field infection with endoparasites. It is time-consuming, subject to sampling errors and may interfere with other traits under selection.

Experimental design

Phase 1 of the research was initiated in 1990 in coastal Kenya and in 1992 in Ethiopia and Senegal.

In Ethiopia, Menz and Horro sheep breeds are being evaluated at ILCA's Debre Berhan research site. Each year 340 ewes and 10 rams of each breed will be evaluated. Each breed will be split into two groups (150 ewes mated and 20 unmated) and mated to lamb in two distinct seasons of the year (i.e. wet and dry). In addition to the primary objective of assessing resistance to internal parasites, other studies using the same sheep will assess parasite epidemiology, undertake reproductive physiology studies, measure food intake and investigate fat metabolism and gut capacity.

In coastal Kenya (near Mombasa), during 1990 and 1991, approximately 200 Dorper and 200 Red Maasai x Dorper ewes were mated to 12 Dorper and 12 Red Maasai rams in a diallel crossbreeding design. In 1992 a group of about 100 Red Maasai ewes were added to the study, also being mated to both sire breeds. At the same site Galla goats have been monitored in 1990 and 1991. In 1992 a group of Small East African goats was added to the study to provide a breed comparison with the Galla goats. Beginning in 1993 the Galla and Small East African does (about 120 of each) will be mated to five bucks of each of the same breeds in a diallel crossbreeding design.

In Senegal both on-farm and on-station research components are planned. The on-farm study will monitor Peul Peul (Fulani) sheep and Sahel goats in the northern Sahelian arid zone and Djallonké sheep and West African Dwarf goats in the southern humid zone. This study was initiated in July 1992 and utilises the PPR (Pathology and Productivity of Small Ruminants) programme developed by ISRA (Institut Sénégalais de Recherche Agricole) and IEMVT (Institut d'Elevage et de Médécine Vétérinaire des Pays Tropicaux). The on-station component is being developed in collaboration with the ILCA Trypanotolerance Thrust. It is currently proposed that this will be initiated in 1993 at the ISRA Kolda research station in the southern humid zone of Senegal. Initially the Peul Peul and Djallonké sheep breeds will be evaluated, possibly in a diallel crossbreeding design.

Experimental protocol

The main experimental protocol that will be used to assess resistance to internal parasites at all research sites will involve measurements of faecal egg counts (FEC) and packed cell volume (PCV) in young lambs and kids from weaning (three months) to one year old. All animals will be given an anthelmintic treatment (drenched) at weaning. Then they will be left undrenched on pasture until a monitor group of about 50 lambs or kids (which are sampled weekly) reach a critical FEC which averages 1,500 epg (eggs per gram) in sheep and 1,000 epg in goats. At this stage all animals in the group will have faecal and blood samples taken and will then be drenched. The procedure will be repeated until the animals reach one year of age, about three or four samplings, depending on the environmental conditions. Ewes will be monitored at critical times throughout the reproductive cycle (e.g. mating, three months post-mating, just before parturition and 1, 2 and 3 months post-parturition).

At all sites both faecal cultures and worm counts from slaughtered animals will be undertaken to estimate the numbers and relative frequency of different parasite genera. At each faecal sampling time a buffy coat test for trypanosomiasis will be undertaken and blood stored for subsequent antigen identification of infection (in the Kenyan and Senegal sites).

Some preliminary Kenyan results

Results from the first crop of lambs born in this study at Diani Estate (near Mombasa) in mid-1990 showed that Red Maasai crosses required fewer drenches than Dorper lambs and had a higher survival rate to one year of age (Reynolds et al, 1992). In this crop of lambs, animals were treated with an anthelmintic when their

PCV level dropped below 21%. This results in severely censored data which makes it difficult to assess resistance in terms of FEC and PCV. For all subsequent lamb crops at Diani the new protocol described earlier was used which ensures FEC and PCV is measured in all animals at each sampling time.

Differences among breed groups for lambs born in 1991 (yearlings) and in 1992 (6-month old lambs) of resistance and production traits are shown in Tables 1 and 2, respectively.

lamb crops. The small differences in live weight in favour of heavier Dorper lambs were not significant.

There is also preliminary evidence from this data for within-breed genetic variation. Restricted maximum likelihood (REML) animal model analyses for lambs of all genotypes born in 1991 and 1992 were carried out. Heritability estimates (± SE) were 0.21 ± 0.13 for FEC at weaning, 0.18 ± 0.11 for FEC in five-month old lambs and 0.24 ± 0.16 for live weight in five-month old lambs.

Table 1. *Least squares means for live weight, PCV, FEC and mortality for lamb breed genotypes born in 1991.*

Lamb breed (Sire breed x dam breed)	No. lambs	Yearling lambs		FEC (epg)	Mortality (birth–1 yr) (%)
		Weight (kg)	PCV (%)		
Dorper x Dorper (D)	56	21.7	27.3	1846	45
Dorper x (RM x D)	54	21.7	27.3	1419	37
Red Maasai (RM) x Dorper	68	21.7	29.7	1112	23
Red Maasai x (RMxD)	77	21.0	29.2	1197	23
Significance[1]					
Sire breed (SB)		ns	***	*	***
Dam breed (DB)		ns	ns	ns	ns
SB x DB		ns	ns	ns	ns

[1].ns = P>0.05; * = P<0.05; *** = P<0.001.

Table 2. *Least squares means for live weight, PCV, FEC and mortality for lamb breed genotypes born in 1992.*

Lamb breed (Sire breed x dam breed)	6-month old lambs No. lambs	Weight (kg)	PCV (%)	FEC (epg)	Mortality (birth-6 mo) (%)
Dorper x Dorper (D)	44	12.2	21.9	3817	40
Dorper x (RMxD)	57	11.5	23.5	2467	20
Dorper x Red Maasai (RM)	4	11.0	23.2	85	43
RM x Dorper	47	11.9	24.3	1688	25
RM x (RMxD)	62	11.5	24.5	1759	22
RM x RM	7	11.7	26.3	1333	13
Significance[1]					
Sire breed (SB)		ns	**	ns	*
Dam breed (DB)		ns	ns	ns	ns
SB x DB		ns	ns	*	ns

[1] ns = P>0.05; * = P<0.05; ** = P<0.01.

Only 18 Red Maasai ewes were mated in 1992 which resulted in a small number of Dorper x Red Maasai and straightbred Red Maasai lambs. Subsequent matings at Diani will ensure that about 100 Red Maasai ewes are mated. Despite the small number of straightbred Red Maasai lambs evaluated there is clear evidence that an increasing proportion of Red Maasai blood results in more resistance to endoparasites than Dorper lambs. This is shown by higher PCV, lower FEC and lower mortality. This trend was consistent in both

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Estimate of genetic and phenotypic parameters for the Dorper, Red Maasai and their crosses

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Abstract

Data accumulated over 10 years (1971–1981) by the Ministry of Livestock Development and FAO/UNDP (Food and Agriculture Organization of the United Nations/United Nations Development Programme) were analysed to estimate the growth performance of Dorper and Red Maasai sheep and their crosses. The heritability, heterosis, phenotypic and genotypic correlations were determined for birth weight, average daily gain and weaning weight.

The animals' genotype, year, season and type of birth, sex of lamb and its rearing affected (P<0.01) all the growth parameters. Direct and maternal heterosis made sizeable contributions to birth weight (4.50 and 4.89%), weaning weight (10.95 and 6.50%) and average daily gain (9.36 and 8.93%). The heritability estimates were 0.14 ± 0.8, 0.08 ± 0.05 and 0.10 ± 0.06 for birth weight, weaning weight and average daily gain, respectively. These low estimates indicate that selection will not be an appropriate option for improving weaning weights and average daily gains. The genetic and phenotypic correlation estimates of the growth characteristics of Dorper lambs suggest that birth weight and average daily gain could be increased by selecting for heavier lambs at weaning.

Estimation des paramètres génétiques et phénotypiques chez les moutons Dorper, Red Maasaï et les produits de leur croisement

Résumé

Les données accumulées pendant dix ans (1971–1981) par le Ministère du développement de l'élevage et la FAO/PNUD (Organisation des Nations Unies pour l'alimentation et l'agriculture/Programme des Nations Unies pour le développement) au Kenya ont été analysées afin d'estimer les performances de croissance des moutons Dorper et Red Maasaï et des produits de leur croisement. L'héritabilité, l'hétérosis et les corrélations phénotypiques et génotypiques pour le poids à la naissance, le gain moyen quotidien et le poids au sevrage ont été déterminés.

Le génotype des animaux, l'année, la saison et le mode de naissance, le sexe des agneaux et le mode d'élevage influaient (P<0,01) sur tous les paramètres de croissance. L'hétérosis direct et l'hétérosis maternel intervenaient pour une part importante dans le poids à la naissance (4,50 et 4,89%), le poids au sevrage (10,95 et 6,50%) et le gain moyen quotidien (9,36 et 8,93%). La valeur estimée de l'héritabilité était de 0,14 ± 0,8, 0,08 ± 0,05 et 0,10 ± 0,06 respectivement pour le poids à la naissance, le poids au sevrage et le gain moyen quotidien. Ces faibles valeurs montrent que la sélection n'est pas le moyen à retenir pour améliorer les poids au sevrage et les gains moyens quotidiens. D'après les valeurs calculées des corrélations génétiques et phénotypiques des paramètres de croissance des agneaux Dorper, on pourrait obtenir un accroissement des poids à la naissance et des gains moyens quotidiens en sélectionnant sur le poids des agneaux au sevrage.

Introduction

Maasai sheep are part of a wide variety of indigenous fat-tailed hair sheep scattered over many parts of Kenya, Uganda and Tanzania. They have a medium red-brown body. Maasai sheep and particularly Red Maasai sheep are found in large numbers in the Rift Valley Province of Kenya. Red Maasai sheep attracted the attention of livestock scientists because of their large population, wide distribution, uniformity of body colour and hardiness. It was also observed that with slightly better nutrition, disease control and selection, it was possible for the Red Maasai sheep to increase in body size, grow faster and produce more milk.

The Dorper sheep were first introduced into Kenya in 1952 at the then Katumani research station of the Ministry of Agriculture. As a breed they were developed in South Africa between 1945 and 1950, mainly at Grootfontein , from Dorset Horn and Blackhead Persian sheep. They have a medium-white body with a black head, neck and legs. The Breed Society was formed in South Africa in 1950. By 1970, Dorper sheep had spread to Eastern, Rift Valley and Coast Provinces of Kenya. In the 1970s more Dorpers were imported from Southern Africa for research and multiplication.

When the Kenyan Government decided to initiate a sheep and goat development project in collaboration with FAO/UNDP in 1970, the Red Maasai was identified as the most important indigenous breed of

sheep. Since then, short-term investigative research aimed at characterising the Red Maasai has been conducted. Studies have been carried out to determine the relationships between body weight and body measurements (FAO, 1975). Studies to compare Red Maasai and the Blackhead Persian have also been conducted in Tanzania. There were considerable differences in body weights and average daily gains at different stages of growth and between sexes.

Red Maasai were bred pure to ascertain their production potential. They were also crossbred with Dorper and Hampshire rams to incorporate the superior production traits of the two exotic breeds into the Red Maasai sheep. The Dorper sheep was also used to improve other indigenous fat-tailed sheep in many parts of arid Kenya. The Dorper was considered suitable to Kenyan conditions because it was developed from a desert fat-rumped sheep (Blackhead Persian) very similar to the Somali or the Blackhead sheep of Northern Kenya. According to Erasmus (1968), the Dorper has an ideal body conformation that adapts it to dry conditions. It is also hardy, has a high quality carcass, high lambing percentages, good mothering qualities and is extremely suitable for upgrading haired breeds of sheep.

The Dorper is probably the breed in Kenya that has been studied the longest in research stations. In 1975, the Sheep and Goat Development Project published 15 years of production data on Dorper sheep. The data showed that the Dorper has a birth rate of about 84%, a 24% twinning rate, a birth weight of about 3.5 kg, average daily gain of about 117 g and lamb mortality of 15%.

So far, however, no work has been done to establish the level of some economically important genetic parameters, e.g. heritability estimates of birth weight, average daily gain and weaning weight. The amount of hybrid vigour resulting from crossbreeding Dorper with Red Maasai sheep has also not been established. A breeding project was initiated at the Ol'Magogo division of the National Animal Husbandry Research Station, Naivasha and managed by the Sheep and Goat Development Project/FAO in 1970. It was expected to generate data to help investigate the importance of Dorper and the Red Maasai and their crosses. The sheep data from Ol'Magogo were analysed to fulfill these objectives:

- to estimate breed means for birth weight, average daily gain and weaning weight of Dorper, Red Maasai and their crosses;
- to estimate heritability of birth weight, growth rate and weaning weight;
- to estimate genetic and phenotypic correlations between birth weight, average daily gain and weaning weight; and
- to estimate heterosis of birth weight, average daily gain and weaning weight.

Materials and method

History

The studies that generated this data were carried out at Naivasha National Animal Husbandry research station by officials of the Ministry of Livestock Development and FAO/UNDP between 1971 and 1981. The study was conducted at the Ol'Magogo division of the station. The foundation flock was established from Dorper and Red Maasai sheep already in the country. Dorper sheep were from Mariakani, Katumani and Kiboko research stations. The Red Maasais were purchased from Nanyuki, Gilgil and Baringo (Figure 1).

Activities on foundation flock

The following activities were carried out:

- pure breeding of Dorper and Red Maasai to expand the flocks;
- short-term breed characterisation studies;
- studies on the effects of frequent mating (joining every eight months) on productivity;
- disease tolerance; and
- crossbreeding Dorper and Red Maasai to measure the improvement in productivity and develop a new breed.

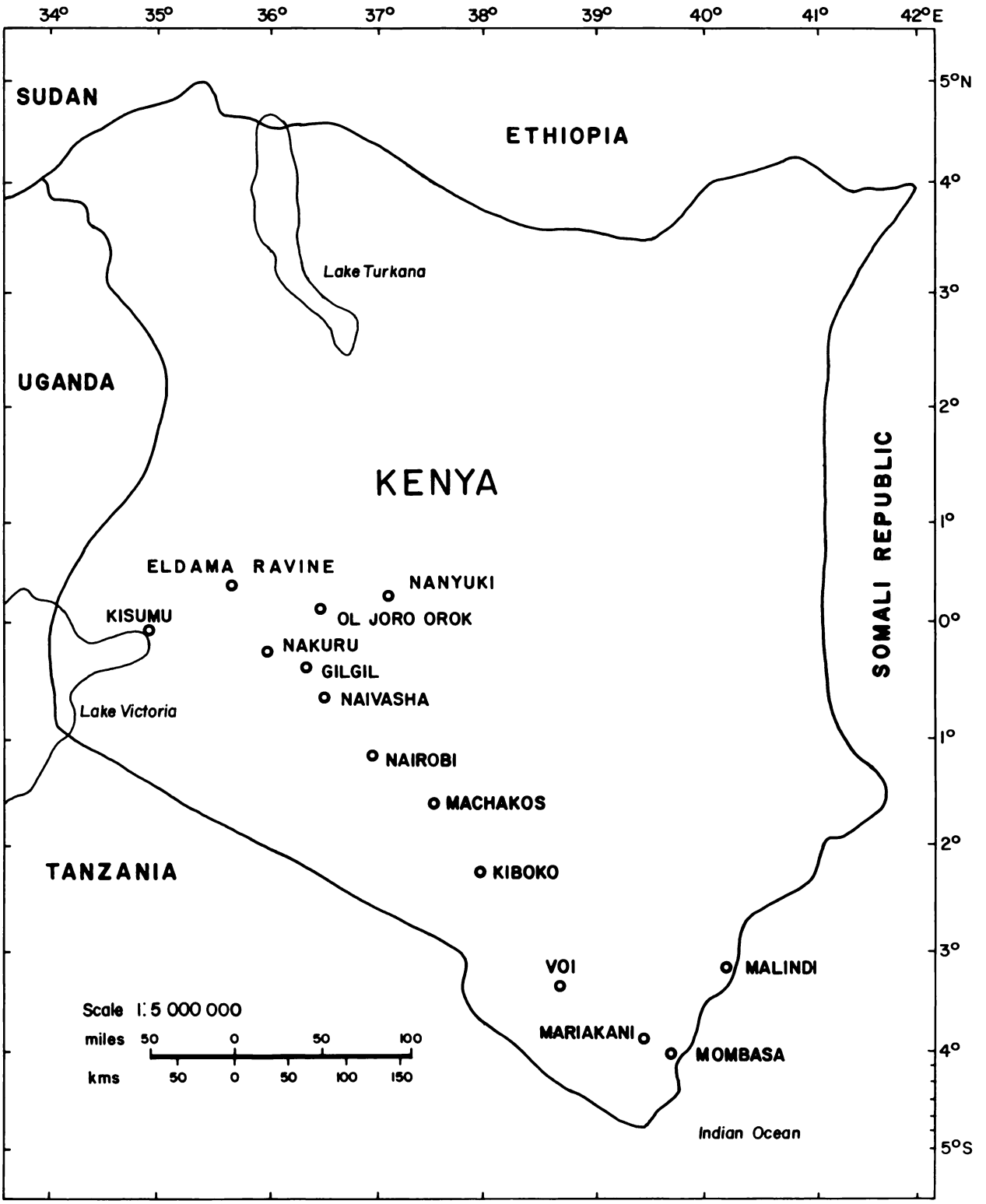
Data collected and records

The breeding policy and the entire management strategies were designed to collect the maximum amount of data on the dam, sire and lambs. The data collected in this study covered the pre-mating and mating periods, lambing, lamb rearing, weaning, postweaning and treatment records. This study reports the results of data analysed up to weaning.

Statistical analysis

Data on growth characters were analysed by ANOVA using SAS (1982). The statistical model was: $Y_{ijklmn} = U + B_i + (YW); + R_k + S_l + E_m + e_{ijklm}$ where U is overall mean, B is breed of lamb, (YW) year of birth-season effect, R is type of birth, S is sex of lamb effect, E is age of lamb effect and e is the random error. The effects of crossbreeding on growth characters were analysed using a model similar to that used by Robinson et al (1981) which was executed using SAS (1982). Analyses for the genetic parameters, i.e. heritabilities and correlations for growth characters were conducted using the Least Square Maximum Likelihood program (LSML76) of Harvey (1982). Heritabilities and correlations analyses were restricted to the Dorper breed because of higher numbers of observations of sires, and to lambs whose sires were known. The genetic and phenotypic correlations were calculated by paternal half-sib procedure (Falconer, 1981).

Figure 1. *Geographical location of Naivasha.*



Results and discussion

Genetic and environmental effects on growth characters

Breed of lamb affected (P<0.001) birth weight (BW), weaning weight (WW) and average daily gain (ADG) of all the breed groups (Table 1). The magnitude of difference in growth characters was closely associated with divergence in genotype (Figures 2 and 3). Lambs which were heavy at birth performed better than light lambs.

Year of birth-season affected (P<0.001) birth weight, weaning weights and average daily gain. The

Table 1. *Least squares means and standard errors for birth weight (BW), weaning weight (WW) and average daily gain (ADG) for each breed and sex of lamb.*

Category	Body characters (kg, SE)		
	BW	WW	ADG
Breed of lamb[1]			
Dorper (D)	3.64 (0.04)[a]	19.50 (0.23)[a]	159.35 (2.27)[b]
Red Maasai (R)	2.90 (0.05)[c]	15.56 (0.28)[c]	127.06 (2.78)[d]
D x R	3.33 (0.06)[b]	17.51 (0.32)[b]	138.61 (3.23)[c]
D x DR	3.64 (0.05)[a]	19.63 (0.26)[a]	161.59 (2.60)[b]
D x DDR	3.49 (0.13)[b]	20.82 (0.70)[a]	169.91 (7.06)[a]
D x DDDR	3.60 (0.13)[a]	19.44 (0.71)[a]	161.69 (7.19)[b]
DDR x DDR	3.58 (0.05)[a]	19.80 (0.30)[a]	162.88 (2.99)[b]
Sex			
Male	3.53 (0.05)	19.44 (0.27)	158.80 (2.70)
Female	3.38 (0.05)	18.34 (0.27)	150.10 (2.71)

[1]Letters on left of x represent sire breed.

SE = standard error.

abcd = Means within a column carrying different superscripts are significantly different (P<0.001).

Figure 2. *Growth trends of Dorper (D), Red Maasai (R) and their crosses.*

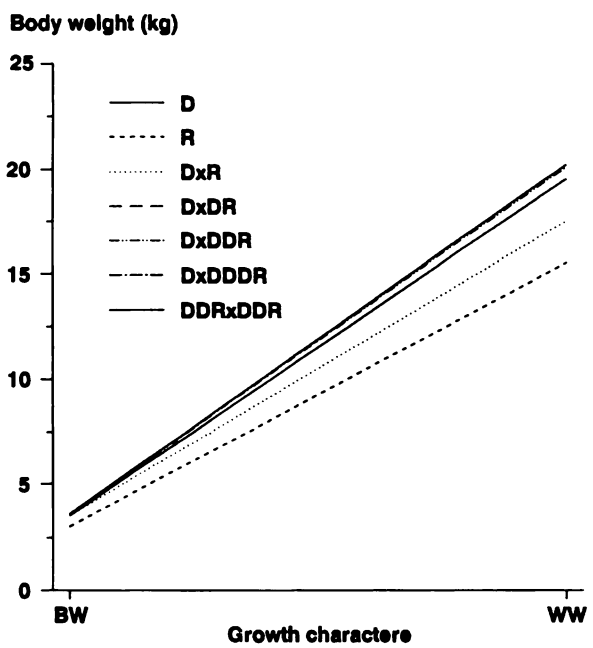
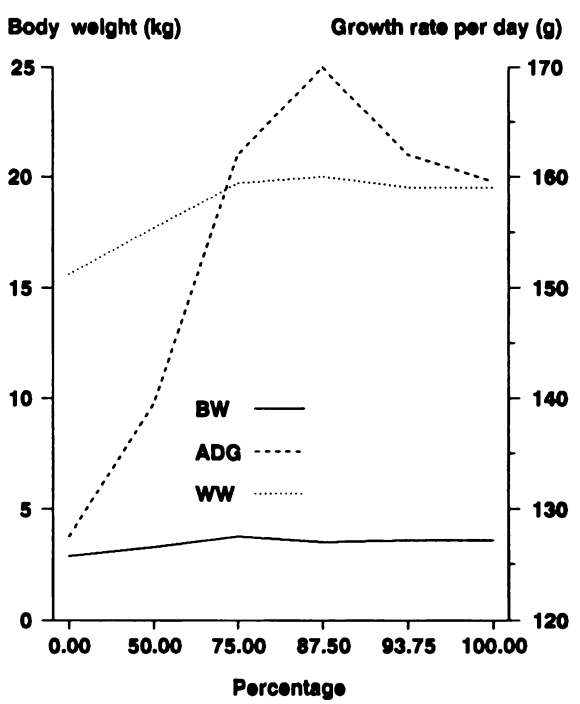


Figure 3. *Effects of percentage of Dorper in the cross on BW, WW and ADG. Percentages of Dorper in the cross are represented by: 0 = Red Maasai (R); 100 = Dorper (D); 50 = DxR; 75 = DxDR; 87.50 = DxDDR; and 93.75 = DxDDDR.*



effect was closely related to rainfall. Type of birth, rearing and sex of lamb affected (P<0.001) all growth characters.

Heterosis

Average direct heterosis shows that crossbred lambs were heavier by 0.15 kg (4.5%) for birth weight, 1.92 kg (10.95%) for weaning weight and 13.8 g (9.36%) for average daily gain. The study shows that heterosis for average daily gain was almost similar to that obtained for weaning weights. Similar observations were made by Sidwell and Miller (1971a, 1971b), Holtman and Bernard (1969) and Singh et al (1981).

Maternal heterosis estimates of 0.16 kg (4.89%), 1.14 kg (6.50%) and 12.8 g (8.93%) were obtained for birth weight, weaning weight and average daily gain, respectively. The results show that maternal heterosis contributed significantly to birth weights, weaning weights and average daily gains of crossbred lambs. Similar observations were reported by Farid et al (1977), Holtman and Bernard (1969) and Willham (1970).

All lambs from known sires were used in the heritability estimates.

Heritability estimates

Heritability estimates (h^2) were obtained from 1202 observations (Table 2). The heritability estimates were low, indicating that it would be difficult to improve weaning weights and average daily gains through selection. Similar observations were reported by Johor and Norton (1977), Suvindra and Tomar (1982) and Shelton and Menzies (1968). The uniformity of the growth traits of the flock might have led to low heritability estimates for weaning weights and average daily gains.

Correlation estimates

Genetic and phenotypic correlations of growth characters for Dorper lambs are shown in Table 3.

Positive genetic correlations were obtained between birth weight and weaning weight and between weaning weight and average daily gain.

Phenotypic correlation between birth weight and weaning weight and weaning weight and average daily gain were positive.

Conclusions

The results obtained imply that little change in either birth weight or average daily gain would be expected by selecting for these traits. They are genetically and phenotypically only very slightly negatively correlated. However, significant improvements to birth weights and average daily gains could be obtained by selecting for heavier weaning weights.

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Table 2. *Estimate of heritabilities (h^2) and standard errors of growth characters of Dorper lambs.*

	Number of sires	Number of observations (lambs)	h^2(SE)
Character			
Birth weight	44	1202	0.138 (0.060)
Weaning weight	44	1202	0.08 (0.051)
Average daily gain	44	1202	0.107 (0.055)

All lambs from known sires were used in the heritability estimates.

Table 3. *Genetic and phenotypic correlations of growth characters for Dorper lambs.*

Growth character	Birth weight	Weaning weight	Average daily gain
Birth weight		0.546	-0.038
Weaning weight	0.199		0.838
Average daily gain	-0.022	0.942	

Genetic correlations above diagonal, phenotypic below.

Correlations were estimated from 1202 observations.

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Productivity of Blackhead Persian sheep in Tanzania

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Abstract

Weight of lambs weaned (at 150 days) per ewe per year (Index I), per kg liveweight of ewe per year (Index II), per kg metabolic body weight ($W^{0.73}$) of ewe per year (Index III), and per lifetime of ewe regardless of ewe weight (Index IV), were computed for 3022 ewes at Malya and West Kilimanjaro research centres in Tanzania. The data analysed covered a period of 24 years (1965–1988). Least squares means for the four respective indices were 24.6 kg (SE 3.19), 675 g (SE 15.7) 1.8 kg (SE 0.04) and 63 kg (SE 1.6). Year, seasons and location significantly (at least P<0.05) affected all the indices except index IV which was not affected (P=0.59) by season. All indices showed a tendency to decline during most of the study period (1966 through 1981). Indices II and III exhibited a small recovery thereafter but this was not subsequently maintained. Dry season lambing was associated with the higher productivity indicated by index I (P<0.01) and index II (P=0.0). Productivity at Malya was consistently superior (P<0.01) to that at West Kilimanjaro, being 3 kg, 152 g, 0.45 kg and 7.2 kg better, respectively, for the four indices. Although Malya was superior to West Kilimanjaro in lamb weaning weight, a large proportion of the between-station differences in productivity indices was attributed to differential preweaning lamb mortality.

Productivité du mouton Blackhead Persian en Tanzanie

Résumé

Les poids d'agneaux sevrés (à 150 jours) par brebis et par an (indice I), par kilo de poids vif de brebis par an (indice II), par kilo de poids métabolique ($P^{0,73}$) de brebis par an (indice III) et par carrière de femelle des brebis, quel que soit le poids de la brebis (indice IV), ont été calculés pour 3 022 brebis aux stations de recherche de Malya et de West Kilimanjaro en Tanzanie. Les données analysées avaient été recueillies sur une période de 24 ans (1965-1988). Les moyennes des moindres carrés des quatre indices étaient respectivement de 24,6 kg (± 3,19), 675 g (± 15,7), 1,8 kg (± 0,04) et 63 kg (± 1,6). L'année, la saison et la station avaient un effet significatif (au moins P<0,05) sur tous les indices, exception faite de l'indice IV qui n'était pas modifié par la saison (P = 0,59). Tous les indices ont montré une tendance à la baisse durant la plus grande partie de la période d'étude (de 1966 à 1981). Un léger redressement des indices II et III a été observé, sans qu'il se soit maintenu par la suite. L'agnelage de saison sèche était associé aux niveaux les plus élevés de productivité que reflètent les indices I (P<0,01) et II (P = 0,0). Le niveau de production observé à Malya dépassait (P<0,01) toujours celui enregistré à West Kilimanjaro, avec des poids supérieurs de 3 kg, 152 g, 0,45 kg et 7,2 kg respectivement pour les quatre indices. Bien que les poids au sevrage relevés à Malya aient été plus élevés que ceux enregistrés à West Kilimanjaro, une grande partie des différences interstations entre les indices de productivité a été attribuée aux différences de mortalité des agneaux avant le sevrage.

Introduction

In Tanzania, the majority of traditional sheep are kept extensively, mostly in mixed livestock crop farming systems. The Blackhead Persian (BHP) sheep comprise a large proportion of the adapted sheep breeds. The BHP sheep were acquired in the early 1960s (Das and Sendalo, 1991) with the purpose of improving the indigenous sheep population through crossbreeding. The breed is mainly located at government research centres and parastatal farms and is used for meat production.

Overall meat production from sheep is affected by several variables, the most important of which are the fertility, prolificacy and mothering ability of the ewes and lamb survivability and weight. Productivity has been measured from these traits by using indices which account for possible pre-weaning dam effects (Wilson, 1987). Productivity indices can be used for selection purposes as well as for comparing flocks when measured either for a fixed period of time or over the entire life-time of the ewe. To incorporate feed requirements, productivity indices may be calculated as weight (kg) of lambs weaned per unit weight (kg) of ewe live weight or unit of ewe metabolic weight (kg) at parturition.

In this study, the productivity of BHP sheep at both research centres (Malya and West Kilimanjaro) was calculated using indices (I to III) proposed by Wilson (1987). A fourth index was developed to calculate total lamb mass production per lifetime of ewe. This index could also be expressed as the lamb mass produced for

each lambing when mean flock size is used in the denominator.

Materials and methods

The records of BHP sheep used in this study were collected from two Livestock Research Centres — Malya and West Kilimanjaro in Tanzania. The Malya Research Centre lies at approximately 4°S latitude and 37°E longitude, at an altitude of about 1050 metres above sea level. The Centre covers an area of 1800 ha of which 1400 have natural vegetation of savannah grassland. The natural vegetation at Malya comprises *Combretum* wood species and grass species of *Bothrichloa, Hyparrhenia, Themeda* and *Cynodon*. A few paddocks are sown with *Chloris gayana*.

The West Kilimanjaro Research Centre lies approximately 3°S latitude and 39°E longitude, at an altitude of about 1270 metres above sea level. It lies on the rain shadow region of Kilimanjaro mountain and covers an area of 5300 ha. *Pennisetum schimperi* is the dominant grass species in the natural pastures. Cultivated pastures include *Digitaria scalprum* and *Bothrichloa spp.*

At both Centres, sheep were grazed from 0800 to 1700 hours and were housed indoors at night. Sheep were bred in both the wet and dry seasons. The wet breeding season extended from March to May, while the dry breeding season extended from September to November. Each breeding season consisted of 50–70 days and the ratio of rams to ewes in breeding groups was about 1:40. Ewe lambs joined the mating groups at the age of 72 weeks. Lambs were ear-tagged soon after birth and left to suckle their dams during grazing until weaning at 16 weeks of age. Lambs were separated at weaning by sex into different weaner flocks. Records taken on lambs included birth and weaning weights and weights at 24, 48 and 72 weeks. Ewes were weighed at mating, lambing and weaning.

Statistical analyses

The productivity indices were constructed for individual ewes using data on corrected litter weight at 150 days, lambing interval, survival of young and post-partum weight of ewe. Lamb live weights were adjusted to 150 days and additionally preadjusted for effect of sex. The corrected weights at 150 days were used to calculate productivity indices I, II and III. The fourth index, index IV, was defined as the lifetime productivity per ewe in terms of lamb mass produced. To obtain a measure of lamb mass (kg) per female per lambing, Index IV was further divided by the average number of parturitions per flock. The four productivity indices were calculated as follows:-

Index I = weight (kg) of young per female per year

$$= \frac{\text{litter weight (kg) at 150 days} \times 365}{\text{subsequent parturition interval}}$$

Index II = weight (g) of young produced per kg live weight of female per year

$$= \frac{\text{Index I} \times 1000}{\text{female postpartum weight}}$$

Index III = weight (kg) of young produced per kg metabolic weight of female per year

$$= \frac{\text{Index I}}{\text{female postpartum weight}^{0.73}}$$

Index IV = total litter weight (kg) at 150 days per female during lifetime

Lamb mass (kg)

$$= \frac{\text{Index IV}}{\text{average number of parturitions per flock}}$$

The analyses were carried out by fixed effects models using the General Linear Model (GLM) procedure of SAS (1987) software package. The fixed effects included in the model were year and season of parturition, age of ewe and location. The residual mean square was used as the error term to test the significance of all differences evaluated among classes. Where analysis of variance depicted significant differences for variables, linear contrasts of least squares means were estimated to test pairwise differences within factors.

Results and discussions

Productivity indices I, II and III

Overall least squares means of indices, I, II and III are presented in Table 1. Year, season of birth and location significantly ($P<0.05$) affected the three indices, but age of ewe at parturition was not significant ($P>0.05$) for any of the indices. All indices tended to decline over the years from 1969 onwards. However, while index I (Figure 1) exhibited a small recovery in the 1986/87 period, indices II (Figure 1) and III (Figure 2) showed substantial recoveries in two periods — 1982 and 1986/87. Indeed productivity in these periods increased beyond the base year (1966) levels. On the other hand, index IV (Figure 2) never recovered to levels attained in the late 1960s.

Year effects on indices were related to climatic factors, especially the amount of annual rainfall. The decrease in availability of fodder in years of low rainfall tended to lower weaning weights of lambs and affected reproductive performances of ewes, thereby increasing parturition intervals. This explains variations in the productivity of ewes between years. Periods characterised by increased lamb mortality, increased lambing intervals and reduced lamb growth are expected to be associated with low productivity. A similar relationship between year of parturition and productivity of station-managed sheep has been reported by Murayi et al (1987) in Rwanda. Murayi et al (1987) attributed differences between years to amount of rainfall and availability of forages.

Ewes that lambed in the dry season had significantly higher productivity indices than those lambing

Table 1. *Least squares means of productivity indices I, II and III by year, season, age and location sub-classes.*

		Productivity index								
		I (kg)			II (g)			III (kg)		
Variable	Level	N	Mean	se	N	Mean	se	N	Mean	se
Overall		3022	24.62	3.19	1304	675.0	15.68	1304	1.76	0.04
Year			(0.0001)			(0.0001)			(0.0001)	
	1965	12	29.45	3.19	–	–	–	–	–	–
	1966	52	26.52	1.59	19	631.1	73.9	19	1.63	0.19
	1967	134	34.29	1.01	72	797.4	39.3	72	2.12	0.10
	1968	110	28.82	1.09	63	707.5	40.6	63	1.86	0.10
	1969	137	30.56	0.95	106	829.3	31.9	106	2.21	0.08
	1970	145	24.79	0.94	104	699.7	31.7	104	1.84	0.08
	1971	129	27.05	1.00	97	768.6	33.4	97	2.01	0.09
	1972	132	18.68	0.98	97	582.8	32.9	97	1.53	0.07
	1973	150	23.21	0.91	123	635.3	28.5	123	1.67	0.08
	1974	127	21.86	0.98	100	626.0	31.4	100	1.64	0.08
	1975	130	24.57	0.97	87	738.8	33.5	87	1.93	0.09
	1976	153	23.00	0.89	70	518.7	37.5	70	1.37	0.09
	1977	235	24.93	0.75	73	610.5	36.3	73	1.61	0.09
	1978	171	21.19	0.86	48	533.8	45.0	48	1.43	0.11
	1979	184	22.20	0.84	36	542.6	52.4	36	1.44	0.14
	1980	189	26.82	0.81	18	580.3	73.4	18	1.52	0.19
	1981	202	24.42	0.79	13	487.1	86.7	13	1.31	0.22
	1982	139	20.69	0.94	8	905.3	110.1	8	2.29	0.28
	1983	148	20.45	0.91	21	682.5	69.9	21	1.78	0.18
	1984	113	21.62	1.05	43	725.3	48.8	43	1.85	0.13
	1985	89	18.68	1.18	48	599.1	45.8	48	1.48	0.12
	1986	77	22.46	1.28	25	729.7	63.3	25	1.79	0.16
	1987	60	28.58	1.44	31	962.3	56.9	31	2.35	0.15
	1988	4	25.99	5.44	2	631.3	217.0	2	1.71	0.55
Season										
	Dry	1365	25.65	0.46	637	699.4	19.0	637	1.82	0.05
	Wet	1657	23.58	0.45	667	650.1	18.6	667	1.69	0.05
Age of ewe (yr)										
	< 2	471	23.65	0.57	165	639.2	27.8	165	1.66	0.07
	2^{+}–3	904	24.31	0.46	375	661.9	20.5	375	1.73	0.05
	3^{+}–4	664	25.07	0.50	289	673.1	21.8	289	1.75	0.06
	4^{+}–5	483	23.90	0.57	206	634.5	25.3	206	1.65	0.07
	5^{+}–6	273	24.97	0.73	132	700.1	30.1	132	1.82	0.08
	6–<4	150	25.91	0.94	85	724.2	36.7	85	1.88	0.09
	≥7	77	24.49	1.29	52	692.0	46.4	52	1.81	0.12
Location										
	Malya	1723	26.15	0.43	719	751.0	18.8	719	1.98	0.05
	WK	1299	23.08	0.47	585	599.0	18.5	585	1.53	0.05

Figures in parenthesis are tail probabilities for the F-tests.

N = number of observations.

se = standard error.

WK = West Kilimanjaro.

in the wet season. This is because lambs born in the dry season were weaned in the middle of the subsequent wet season so were able to obtain adequate milk from their dams and could graze the lush abundant forages available. However, lambs born in the wet season were weaned mid-dry season. They gained less weight by weaning time due to scanty and low quality fodder. In a study of the effect of season of parturition on productivity in Sudan Desert sheep, Suleiman et al (1990) observed that productivity indices were higher for ewes lambing in the wet summer than in other seasons.

In the present study, the age of ewe did not significantly affect any of the productivity indices, though younger ewes tended to have numerically lower indices. This was mainly because younger ewes had longer parturition intervals than older ewes. Similar results have been reported in sub-Saharan Africa (Wilson, 1987; Lebbie, 1991). Differences between locations were significant for these productivity indices. Ewes had lower indices at West Kilimanjaro compared to those at Malya. The lower productivity indices at West Kilimanjaro could be attributed to: lower weaning weight of lambs; higher preweaning mortality of lambs; and the presence of older ewes at the station.

Index IV and mean lambs mass

Overall least squares means of index IV and lamb mass per lambing are presented in Table 2. Index IV tended to decline from 1969 onwards, with a small recovery in the 1978–1980 period (Figure 2). Ewes at Malya had significantly higher Index IV values and lamb mass per

Table 2. *Least squares means of productivity index IV and lamb mass per lambing by year, season, age and location sub-classes.*

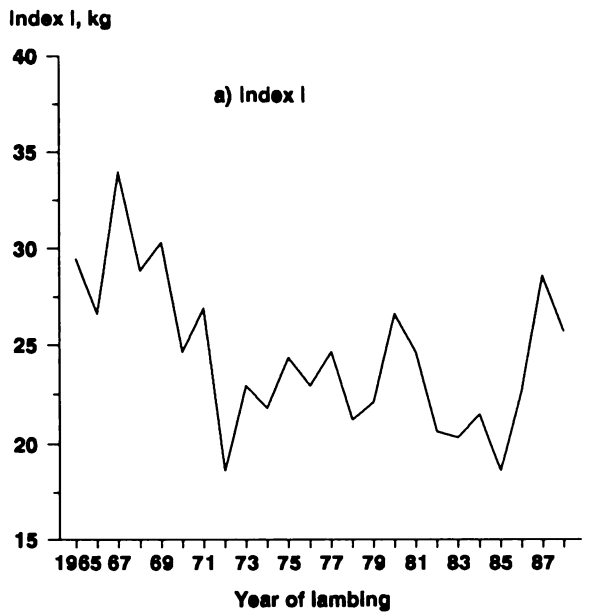
		Index IV, kg			Lamb mass per lambing, kg		
Effect	Level	N	Mean	se	N	Mean	se
Overall		987	63.03	1.62	987	20.81	0.22
Year			(0.0001)			(0.0001)	
	1966	11	18.67	12.93	11	21.63	1.74
	1967	16	28.99	10.74	16	26.52	1.44
	1968	31	35.67	7.62	31	21.95	1.03
	1969	21	62.46	9.29	21	18.84	1.25
	1970	19	84.67	9.73	19	22.26	1.31
	1971	29	101.05	8.11	29	21.73	1.09
	1972	42	67.66	6.55	42	21.76	0.88
	1973	38	52.17	6.97	38	19.19	0.94
	1974	35	85.63	7.09	35	23.94	0.96
	1975	55	85.01	5.71	55	21.31	0.77
	1976	29	85.62	7.99	29	20.47	1.08
	1977	28	86.38	8.15	28	19.41	1.09
	1978	68	41.95	5.20	68	14.32	0.70
	1979	51	54.96	6.02	51	19.99	0.81
	1980	72	77.04	5.07	72	23.75	0.68
	1981	59	81.67	5.56	59	23.97	0.75
	1982	60	77.06	5.52	60	22.05	0.74
	1983	51	62.39	6.06	51	18.97	0.81
	1984	98	64.33	4.31	98	19.01	0.58
	1985	39	40.85	6.90	39	16.49	0.93
	1986	38	47.18	6.81	38	20.39	0.91
	1987	36	54.67	7.19	36	18.78	0.97
	1988	61	52.80	6.15	61	21.53	0.83
Season							
	Dry	375	64.05	2.49	375	20.13	0.34
	Wet	612	62.01	2.45	612	20.49	0.33
Location							
	Malya	600	66.64	2.08	600	22.56	0.28
	WK	387	59.42	2.79	387	19.05	0.37

N = number of observations.

se = standard error.

WK = West Kilimanjaro.

Figure 1. *Trends in productivity indices I and II during the study period.*



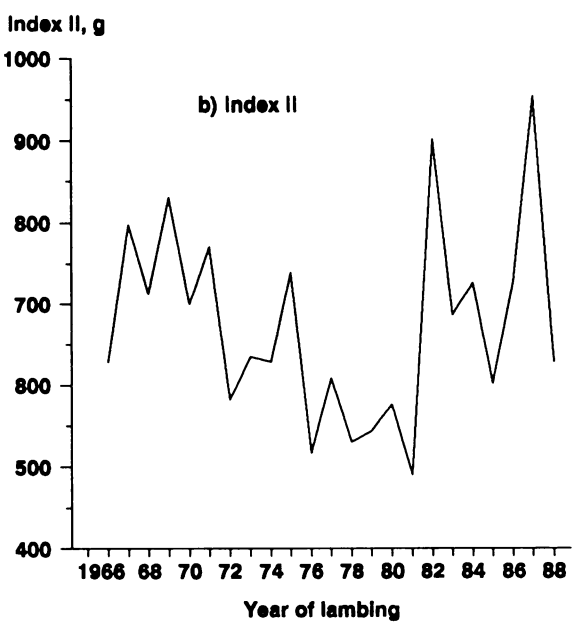
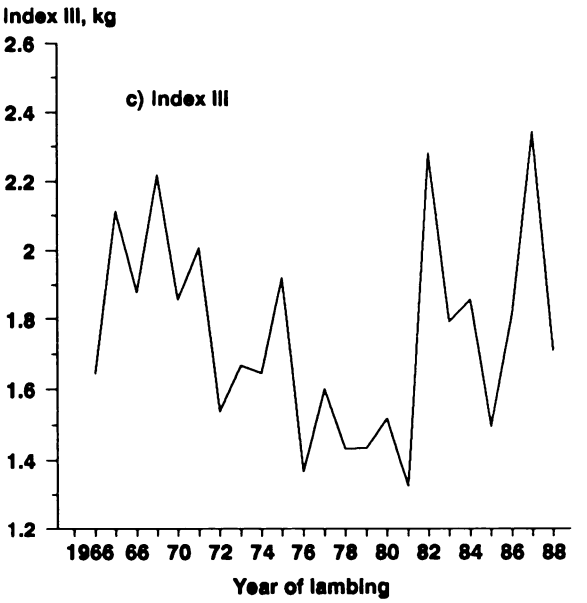
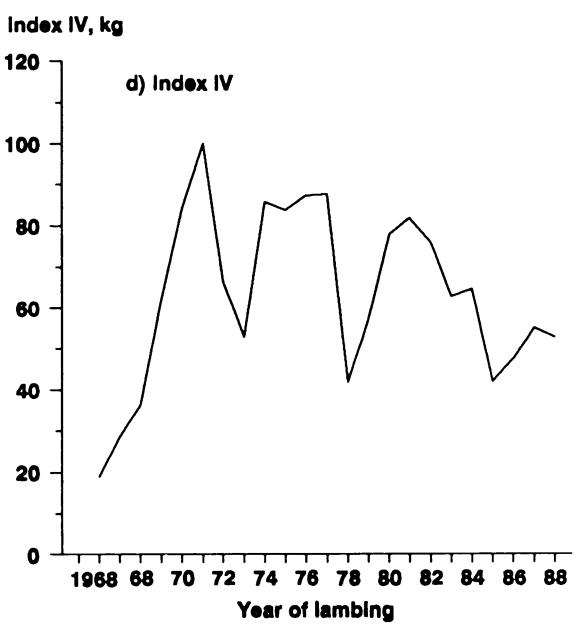


Figure 2. *Trends in productivity indices III and IV during the study period.*





lambing than those at West Kilimanjaro. The superiority of Malya was mainly due to lower weaning weights of lambs born at West Kilimanjaro resulting from poor nutrition.

Conclusion

High variations in productivity indices show that the productivity of BHP sheep in Tanzania can be improved. Strategies should be developed to improve the management systems, such as improving pastures and forages and general nutrition. Ewes should be fed concentrates during the suckling period. Lamb care, especially during the preweaning period, could also be improved in order to increase production.

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Some production parameters of Blended goats in semi-arid regions of Tanzania

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Abstract

Data on blended goats (a three-way cross of Kamorai (55%), Boer (30%) and indigenous Tanzanian (15%) goats) were collected over a period of four years (1987-1990) at Malya and Kongwa Research Stations. These records were analysed to assess the production potential of Blended goats. Birth weights, weaning weights, weight at 72 weeks, milk yield, lactation length and butter fat content of milk were used as parameters.

At Malya the average birth weight was 2.34 kg, the average weaning weight 12.5 kg and the average weight at 72 weeks was 28.0 kg. At Kongwa the averages were 2.31, 11.6 and 27.4 kg for birth weight, weaning weight and weight at 72 weeks, respectively. Milk yields ranged from 90.0 kg to 175.5 kg during an average lactation of 236 days. Season of kidding, age at kidding and birth type all significantly ($P<0.05$) influenced lactation yield. Average milk butter fat content for both stations was 2.9%.

Paramètres de production chez les chèvres croisées des régions semi-arides de la Tanzanie

Résumé

Des données sur des chèvres croisées (croisement trois-voies entre des caprins de race Kamorai [55%], Boer [30%] et indigène de Tanzanie [15%]) recueillies sur une période de quatre ans (1987–1990) aux stations de recherche de Malya et de Kongwa ont été analysées en vue de l'évaluation du potentiel de production de ces chèvres. Les paramètres utilisés étaient: les poids à la naissance, au sevrage et à 72 jours, la production laitière, la durée de la lactation et le taux butyreux.

A Malya, le poids à la naissance était en moyenne de 2,34 kg, le poids au sevrage de 12,5 kg et le poids à 72 jours de 28,0 kg. A Kongwa, ces poids moyens étaient respectivement de 2,31, 11,6 et 27,4 kg. La production laitière variait entre 90,0 kg et 175,5 kg au cours d'une lactation moyenne de 236 jours. La saison de mise-bas, l'âge à la mise-bas et le type de naissance avaient un effet significatif ($P<0,05$) sur la production laitière. Le taux butyreux moyen pour les deux stations était de 2,9%.

Introduction

Raising cattle in arid and semi-arid regions has many constraints which tend to limit the supply of animal protein available to rural farmers in these areas. As goats are more efficient than cattle in feeding and other managerial aspects, they offer more potential for meat and milk production in these areas.

Increasing the meat and milk production of indigenous goats through improved management and increased feed resources is unlikely to be effective under semi-arid conditions. Therefore, genotypes should be developed which are capable of producing more meat and milk within existing environmental constraints. Although production traits are moderately heritable, it would take time to achieve substantial increases by selection within existing indigenous genotypes because the initial level of production is low. More rapid increases can be expected from crossbreeding with exotic genotypes.

Blended goats are a three-way cross between Kamorai (55%), Boer (30%) and indigenous Tanzanian goats (15%). They have phenotypically large pendulous ears and bigger bodies than indigenous goats (Das, 1989). Earlier reports on Blended goats have been presented by Das (1989, 1992).

Data collected over four years (1987–1990) at Malya and Longwa Research Stations were analysed to evaluate the growth and dairy potential of Blended goats.

Materials and methods

Study sites

The two sites were the Livestock Research Centre, Malya in north-western Tanzania and the Pasture Research Centre, Kongwa, central Tanzania. They both have a semi-arid climate with savannah grassland consisting mainly of *Commiphora* and *Combretum* woody species and *Eragrostis, Aristida, Bothriochloa, Hyparrhenia, Themeda* and *Cynodon* grasses. A few paddocks at Malya are sown with *Chloris gayana*, while

at Kongwa, paddocks are sown with *Cenchrus ciliaris* and some are sown with *Siratro* and *Leucaena leucocephala*.

Management of animals

Management at both locations was similar. Kids were eartagged and weighed at birth and allowed to suckle in the morning. They were reared indoors and provided with fodder and water *ad libitum* until weaning at 16 weeks. Does were milked once in the evening. After weaning, does were milked twice a day. Kids grazed on natural pastures from 0800 to 1500 hours in addition to receiving a daily concentrate ration (maize/rice bran and cotton seed/sunflower seed cake) of 30 to 50 grams per kid. Female kids were bred for the first time at 72 weeks of age. Thereafter they were bred twice a year with mating seasons of 70 days each corresponding to the dry (September – November) and wet (March – May) seasons. The buck:doe ratio was 1:30. The animals were vaccinated, dipped and dewormed regularly to control disease, while clinical diseases were treated on occurrence.

Data collection and analysis

A total of 893 records on live weights at different ages and 263 milk records of Blended does from both stations were analysed in this study. Kids were weighed at birth, weaning and at 72 weeks of age. Does were weighed at mating and kidding. Pre-weaning daily milk yield was estimated by doubling the evening milk yield. Parameters analysed included weight for age (at birth, weaning and at 72 weeks of age), and lactation performance (daily milk yield, lactation milk yield, lactation length and % butter fat).

A linear model was used for analysing data on weight for age and lactation milk yield. The model included fixed effects of seasons (wet, dry), birth type (single, twin), sex (male, female), dam age (2–3, 4–5, 5–6, 6–7 and 7 years) and interaction between main effects.

Results and discussion

Growth parameters

Weights at birth, weaning and 72 weeks for Malya were 2.34 ± 0.05 kg, 12.5 ± 0.12 kg and 28.0 ± 0.73 kg, respectively. Corresponding values at Kongwa were 2.31 ± 0.08 kg, 11.6 ± 0.34 kg and 27.4 ± 0.16 kg, respectively. Birth weights of Blended kids were higher than the 2.1 kg reported for indigenous goats and Kamorai x indigenous crosses (Das and Sendalo, 1991). This was also true for weights at 72 weeks. The indigenous and Kamorai x indigenous crosses have been reported to weigh 11.7 kg and 17.5 kg, respectively (Das and Sendalo, 1991). Birth and weaning weights were also higher than those reported for Adal and for Saanen x Adal goat kids in Ethiopia (Kassahun et al, 1989) and those reported for Sudanese goats (Wilson, 1976).

Tables 1 and 2 show the effect of seasons, type of birth, sex and age of dam on the weight (kg) of Blended kids at Malya and Kongwa.

Kids born in the wet season were heavier from birth to 72 weeks old than were those born in the dry season,

Table 1. *Effect of season, type of birth, sex and age of dam on weight (kg) of Blended kids at Malya.*

Variable	Birth weight		Weaning weight		72-weeks weight	
	n	mean	n	mean	n	mean
Season:						
wet	148	2.52	122	12.8	97	28.2
dry	104	2.48	93	12.3	59	27.5
Average SE		0.08		0.26		1.02
Birth type:						
single	96	2.73[a]	81	13.5[a]	56	30.4[a]
twin	156	2.04[b]	134	11.2[b]	90	27.1[b]
Average SE		0.09		0.31		1.08
Sex:						
female	115	2.11[a]	106	12.3	84	27.9[a]
male	137	2.57[b]	109	12.7	62	29.5[b]
Average SE		0.06		0.39		1.12
Age of dam:						
2–3yrs	67	2.15[a]	51	11.8	33	27.4
4–5yrs	110	2.22[a]	95	12.4	61	28.2
6–7yrs	41	2.47[b]	37	11.9	29	29.0
> 7 yrs	34	2.41[b]	32	12.9	23	28.5
Average SE		0.09		0.32		1.03

ab =Means within a column (for each variable) with different superscripts differ significantly ($P<0.05$).

Table 2. *Effect of season, type of birth, sex and age of dam on weight (kg) of Blended kids at Kongwa.*

Variable	Birth weight		Weaning weight		72-weeks weight	
	n	mean	n	mean	n	mean
Season:						
wet	72	2.36	56	11.8	33	26.6
dry	55	2.28	39	11.5	25	27.9
Average SE		0.11		0.49		1.21
Birth type:						
single	51	2.64[a]	42	12.3[a]	28	29.3[a]
twin	76	2.01[b]	53	10.6[b]	30	26.5[b]
Average SE		0.17		0.56		1.45
Sex:						
female	69	2.18[a]	51	9.3a	35	26.8[a]
male	58	2.43[b]	44	12.7[b]	23	28.2[b]
Average SE		0.15		0.52		1.33
Age of dam:						
2–3yrs	42	2.06[a]	31	10.7	18	26.4
4–5yrs	46	2.19[a]	38	10.4	26	28.1
6–7yrs	25	2.34[b]	16	12.2	10	28.3
<7 yrs	14	2.42[b]	10	11.5	4	27.7
Average SE		0.14		0.55		1.41

ab = Means within a column (for each variable) with different superscripts differ significantly (P<0.05).

but mean differences were not significant (P<0.05). Das and Sendalo (1992) reported similar findings on improved goat kids at Malya. They also found that season had a significant influence (P<0.05) on both birth and weaning weights. This could be attributed to the fact that during the wet season, gravid does tend to gain weight from the lush green forages available at the farm.

Kids born single at both sites were significantly (P>0.05) heavier than twins at birth, weaning and at 72 weeks of age. Males were significantly (P<0.05) heavier than females at birth and at 72 weeks old at Malya (Table 1). At Kongwa, males were superior in all liveweight categories (Table 2). The effects of birth type and sex on birth weight, weaning weight and mature weight agree with those reported by Chawla and Bhatnagar (1983) for Barbari and Beetal goats in India. Twins had lower birth weights than singles, probably due to their smaller size and weight in the uterus. After birth, single kids had an advantage over twins as twins had to compete for the milk from their dam. Single kids had sufficient milk for growth to weaning. Higher weights at maturity for single kids could be explained by this advantage and the positive correlation between weaning and mature weights.

Age of dam significantly (P<0.05) influenced birth weight of kids, with older does producing heavier kids than younger does.

The interaction between age of dam and type of birth for birth weights was significant (P<0.05) at Malya. Other interactions between main effects were not significant. The lack of effect of season x birth type interaction on liveweight implies that singles showed superiority irrespective of season of birth.

Differences between sites were significant (P <0.001) for weaning weight only. Similar results of the effect of location were obtained by Das and Mkonyi (1990). These differences may be attributed to differences in management, particularly in feeding subsystems. In Kongwa the availability of maize bran was erratic, but at Malya rice polish and cottonseed cake were abundant.

Dairy parameters

A total of 263 does were studied for their dairy potential, 174 at Malya and 89 at Kongwa. Average daily milk yield per doe was 0.69 kg and 0.66 kg for Malya and Kongwa respectively. Mean lactation milk yield at Malya was 170.6 (SE 4.57) kg for a mean lactation length of 245 (SE 3.11) days. At Kongwa, mean lactation milk yield was 153.4 (SE 5.42) kg for a mean lactation length of 231 (SE 4.38) days.

Daily milk yields at both sites were much lower than those reported for Beetal goats (0.9 kg) (Verma and Chawla, 1987) and Norwegian goats (1.1 kg) (Das and Sendalo, 1991).

The values for lactation milk yield were higher than those reported for Toggenburg and Anglo-Nubian crosses (85 kg and 104 kg in 143 days respectively), but lower than other dairy goats such as Saanen and Norwegian. Mean lactation milk yields of Blended goats were also lower than those reported for Jamnapari goats (202 kg in 191 days) by Sands and McDowell (1978). This could be due to the low genetic potential for milk production of the Boer and indigenous goats which crossed to form Blended goats.

Table 3 shows the effect of type of birth, season and age of dam on the dairy potential of Blended goats at Malya and Kongwa.

Does with single kids had higher lactation milk yields and longer lactation lengths at Malya. At Kongwa

Table 3. *Effect of type of birth, season and age of dam on dairy potential of Blended goats at Malya and Kongwa.*

	Lactation milk yield (kg) and length					
	Malya			Kongwa		
Variable	n	mean (kg)	mean (days)	n	mean (kg)	mean (days)
Type of birth:						
single	96	176.9[a]	251[a]	51	155.7	233
twin	78	165.2[b]	238b	38	152.2	228
Average SE		7.34	6.25		8.44	7.61
Seasons:						
wet	99	178.6[a]	247[a]	56	158.7[a]	235[a]
dry	75	163.1[b]	240[b]	33	146.1[b]	221[b]
Average SE		8.23	7.82		8.63	8.75
Dam age (yrs):						
2- 3	45	161.8[a]	236[a]	33	144.5[a]	228[a]
4 - 5	81	166.2[a]	241[a]	29	151.8[b]	230[b]
6 - 7	27	172.3[b]	247[b]	15	153.9[b]	232[b]
7 yrs	21	176.7[b]	246[b]	12	155.3[b]	232[b]
Average SE		7.68	6.27		8.77	7.21

ab = Means within a column (for each variable) with different superscripts differ significantly (P).

there was no difference in milk yield due to birth type. Does kidding in the wet season had significantly ($P<0.05$) higher lactation milk yields and longer lactation lengths than those kidding in the dry season. This is probably due to the availability of lush, green pastures during the wet season compared to low quality forages in the dry season.

The effect of age of dam was significant ($P<0.05$) for lactation milk yields and lactation lengths at both sites, with older dams having more milk and a longer lactation period than young does. Variations in milk yield due to age of dam were similar to those reported by Steine (1975); lowest yield occured in the first lactation and highest in the fifth.

Average butter fat content was 2.9% and 2.91% for milk from goats in Malya and Kongwa respectively. This is less than that reported for Norwegian goats but higher than Norwegian x indigenous crosses (Das and Sendalo, 1991). The interactions between main effects were not significant.

Conclusion and recommendations

The results of the evaluation of some production traits of Blended goats show that Blended goats have the potential to produce both milk and meat for human consumption.

Values for lactation milk yield, daily yield and milk butter fat content of milk are lower in Blended goats than in other dairy goats in the subtropics. However, the high variation in lactation milk yield indicates that improvements could be made through breeding and selection. The higher live weights and wide variation among Blended goats indicate their potential for meat production.

Blended goats have advantages over indigenous goats for live weight and milk production. They could be used to improve the dairy and meat production by selection and crossbreeding. The introduction of Blended goats and their crossbreeds selected for high milk yields could solve the problem of insufficient milk in semi-arid areas of Tanzania. This could also improve the economic status of goat keepers throughout the country.

Improving feeding and management of practices (housing, disease control) is essential for optimum goat productivity. More studies on the quality of milk and meat produced, reproductive efficiency, disease resistance, nutrition and other managerial aspects are necessary for the establishment and characterisation of Blended goats.

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Performances de reproduction des caprins dans les systèmes d'élevage traditionnels des zones communales au Zimbabwe

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Résumé

Un suivi individuel et par troupeau des performances des caprins a été effectué dans neuf zones communales représentatives de la variabilité des systèmes de production rencontrés en milieu traditionnel au Zimbabwe. Du 1er septembre 1990 au 1er novembre 1991, un total de 6 950 caprins appartenant à 254 exploitations ont été suivis individuellement sur une base bimensuelle.

Les performances de reproduction se sont révélées très différentes suivant les environnements naturels et socio-économiques dans lesquels évoluaient les animaux. Trois situations prédominantes ont pu être observées.

1) Les zones communales d'implantation récente, caractérisées par un environnement naturel non dégradé, une faible pression démographique et une faible densité animale.

Dans ces zones où une brousse arbustive dense occupe la majeure partie du territoire, la présence d'une strate arbustive buissonnante permet aux femelles de reconstituer leur état corporel en fin de saison sèche, avant les premières pluies. Les fécondations ont lieu au tout début de la saison des pluies et les potentiels de reproduction des caprins s'extériorisent pleinement: le taux de fertilité annuelle était de 97% chez les multipares et de 62% chez les femelles de moins de 2 ans; le dessaisonnement était important, avec une moyenne de trois mises-bas en deux ans réparties sur la saison des pluies et la saison sèche; la première mise-bas intervenait entre 12 et 18 mois; la prolificité était en moyenne de 150% pour les multipares et le taux de fécondité de 190%.

2) Les zones communales d'implantation ancienne dotées d'une végétation fortement dégradée et soumises à une forte pression animale.

Dans ces zones, où le surpâturage et l'exploitation intensive du bois par la population ont entraîné la quasi-disparition de la strate arbustive buissonnante, les femelles doivent attendre la pousse de l'herbe en début de saison des pluies pour reconstituer leurs réserves. Elles ne sont fécondées qu'en milieu de saison des pluies. Dans ce cas, les performances de reproduction des caprins sont minimales: la fertilité annuelle était de 86% pour les multipares et de 31% pour les femelles de moins de 2 ans; une seule mise-bas était enregistrée par an, en milieu de saison sèche; la première mise-bas intervenait après 22 mois; la prolificité moyenne était de 120% pour les multipares et le taux de fécondité moyen de 110%.

3) Les zones communales où le milieu naturel est fortement dégradé, avec une forte densité de population et des contraintes alimentaires imposées par les systèmes de culture.

Cette situation s'observe dans les zones dominées par les cultures et dans les zones péri-urbaines à forte densité de population. Aux restrictions alimentaires de saison sèche imposées par la dégradation du milieu naturel s'ajoutent les mesures de lutte contre la divagation des animaux pendant la saison des pluies afin de protéger les cultures. Au milieu de la saison des pluies, les animaux sont enfermés pendant une partie de la journée. La reconstitution des réserves est ainsi interrompue et ne reprend qu'après les récoltes, quand les animaux sont relâchés. Pour la plupart des femelles, les fécondations – quand elles ont lieu – surviennent à la fin de la saison des pluies. Les performances de reproduction s'en ressentent fortement: le taux de fertilité annuelle était de 73% pour les multipares et de 17% pour les femelles de moins de 2 ans; une seule mise-bas était enregistrée par an, en milieu de saison sèche; les premières mises-bas intervenaient après 22 mois; la prolificité moyenne était de 120% pour les multipares et le taux de fécondité moyen de 100%. Dans ces systèmes d'élevage soumis à de lourdes contraintes, 35% des chevreaux meurent avant l'âge de 1 an.

Il ressort des résultats enregistrés que les performances des troupeaux sont d'autant plus homogènes et plus médiocres que les contraintes de l'environnement naturel et socio-économique sont plus importantes. A l'inverse, une diminution des contraintes du milieu se traduit par une plus grande variabilité des performances par troupeau. Ce sont alors les techniques et pratiques individuelles mises en oeuvre par les éleveurs qui permettent l'expression du potentiel des animaux.

Reproductive performance of goats in traditional livestock systems in communal areas in Zimbabwe

Abstract

Individual and herd performances of goats have been monitored in nine communal areas in Zimbabwe which are representative of the various traditionally managed production systems. Between 1 September 1990 and 1 November 1991, 6950 goats belonging to 254 farms were monitored twice monthly on an individual basis.

Results show that reproductive performance varied markedly with the natural and socio-economic environment of the animals. Three situations predominate.

A) Recently established communal areas where the natural environment has not become degraded, with low population pressure and low animal density.

In these areas most of the land is covered by shrub bushland. A zone of brushwood enables females to recover their body condition by the end of the dry season. Conceptions occur at the very beginning of the rainy season and the goats' reproductive potential is fully achieved with an annual fertility rate of 97% for multiparous and 62% for does below two years of age; there is little seasonality of breeding, with an average of three kiddings in two years spread over the rainy and the dry seasons; first kidding occurs between 12 and 18 months; there is mean fertility of 1.5 for multiparous does; and the fecundity rate averages 190%.

B) Old communal areas with heavily degraded vegetation and high animal pressure.

In these zones, overgrazing and overexploitation of wood lead to the near disappearance of the zone of brushwood and females have to wait for the grass growing at the beginning of the rainy season to regenerate their reserves. They do not conceive until the middle of the rainy season. Thus reproductive performance is poor. There is: an annual fertility rate of 86% for multiparous does and 31% for those below two years old; a single kidding in the middle of the dry season; first kidding after 22 months; mean fertility of 1.2 for multiparous does; and a fecundity rate averaging 110%.

C) Heavily degraded natural environment with high population density and food constraints due to cropping systems.

This type of situation is found in areas where crops dominate and in peri-urban areas with high human population density. In addition to food restriction during the dry season, due to the degradation of the natural environment, measures are taken to protect crops against wandering animals during the rainy season. In the middle of the rainy season, animals are locked up for part of the day. Rebuilding body reserves is held up and is resumed after the harvesting period, when the animals are released. When conception does take place, it occurs at the end of the rainy season, thereby heavily affecting reproductive performance. An annual fertility rate of 73% for multiparous and of 17% does females below 22 months; a single kidding in the middle of the dry season; first kidding after 22 months; mean fertility of 1.2 for multiparous does; and a fecundity rate averaging 100% are typical. In these heavily constrained livestock systems, 35% of the kids die before they are one year old.

Results show that the more the environment imposes natural and socio-economic constraints the more herd results become uniform and poor. On the other hand, when animals are not submitted to heavy environmental constraints, considerable variability in herd performances is recorded. The animals' potential is achieved through the individual techniques and practices of their owners.

Posters - Abstracts

Données sur l'association coccidies-helminthes au niveau du polyparasitisme gastro-intestinal des moutons Djallonké en Côte d'Ivoire

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Les examens coprologiques effectués sur trois troupeaux de moutons Djallonké, élevés dans la région de Bingerville révèlent la présence des parasites gastro-intestinaux lorsque les animaux ne sont pas régulièrement déparasités. L'intensité parasitaire est liée à l'état sanitaire, l'âge et le sexe du troupeau. Le polyparasitisme coccidies-helminthes induit un équilibre biologique avec une prédominance aux strongles. La rupture de cet équilibre augmente la densité de la population et l'activité des coccidies.

Effect of concentrate to forage ratio on intake and digestibility in sheep

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Abstract

Eight male Blackhead Persian sheep weighing between 26 and 30 kg, and of between 1 and 2 years of age, were used to determine the effect of concentrate to forage ratio on intake and digestibility. Four dietary treatments (I, II, III and IV) on the basis of concentrate to forage ratio of 20:80, 30:70, 40:60 and 50:50, respectively, were formulated. In a completely randomised design experiment, two animals were randomly allotted to each treatment and fed the diets *ad libitum* in individual crates throughout the 56 days of the experiment. The performance parameters measured were feed intake, digestibility and nitrogen balance.

There were significant differences ($P<0.05$) in feed intake between treatments I and III but not ($P>0.05$) between treatments II and IV. Animals on treatment II demonstrated significantly higher (895.9 ± 14.9 g/day) average daily feed intake than those on treatment I (724.4 ± 12.1 g/day). There was a significant difference ($P<0.05$) between treatment means in terms of growth rate. Animals on treatment II had a higher growth rate (110.0 ± 17.8 g/day) than animals on treatments I, III and IV. Nitrogen balance and apparent digestibility coefficients for DM, OM, CP, EE, NFE, Ash, NDF and ADF were not affected by treatments.

Performance of dairy goats in Mgeta Morogoro, Tanzania

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Abstract

A study was conducted to evaluate the performance of Norwegian dairy goats and their crosses under smallholder farmer conditions in Mgeta village, Morogoro, Tanzania.

Means and standard deviation were estimated for both kid and dam traits studied. The overall kid mean weights (kg) were 2.7 ± 0.4, 13.3 ± 2.5, 20.9 ± 4.5, and 37.1 ± 9.3 at birth, 3 months, 6 months and 12 months of age, respectively. The average daily gains (kg) were 116.0 ± 31.9, 86.5 ± 30.1 and 87.9 ± 31.3 from birth to 3 months, 3 to 6 months and 6 to 12 months of age, respectively. In both traits, male and single kids were superior to females and kids born as twins, respectively. Kids with 87.5% and 50% Norwegian blood levels performed better than the 100% Norwegian kids. The overall mean for lactation milk yield (kg) was 142.0 ± 120.0, the lactation length was 158.6 ± 89.9 days and milk yield per day was 0.87 ± 0.4 litres. Kidding interval (days), twinning rate (%) and litter size were 374.0 ± 98.9, 388.0 ± 71.0, 41.5% and 1.5 respectively. Dam and kid mortalities were 7.8% and 7.5%, respectively.

Pastures for small ruminants

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About 99% of all sheep and goats in Tanzania are raised traditionally on natural pastures. The quality of these pastures varies with season, age and species of plants in association. Pastures in the periphery of the country and highlands are usually rich in plant species composition, making them excellent for the production of well-finished animals all year round. However, for those in the central plateau, species composition is limited and therefore the animal performance is usually poor for large parts of the year. Under natural and cultivated pasture, sheep and goats are complementary to one another in their grazing behaviour. Feeding preference does not exist under stall-feeding.

Growth and reproduction performance of Blackhead Persian sheep in Tanzania

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Data collected at the Livestock Research Centres, Malya and West Kilimanjaro, Tanzania, to determine the effects of genotype and environment on birth weight, weaning weight and weights at 24, 48 and 72 weeks of age were analysed. Records on birth weight (n=6207), weaning weight (n=4444), weights at 24 weeks (n=3494), 48 weeks (n=2633) and 72 weeks of age (n=1874) were collected and analysed for fixed effects: year of birth, season of birth, sex, birth type, age of dam and location of differences.

The overall unadjusted mean weight at birth and weaning were 2.68 and 15.15 kg, respectively. The mean weights at 24, 48 and 72 weeks of age were 18.19, 22.93 and 33.24 kg, respectively. Year had significant effect on birth weight, weaning weight and weights at 24, 48 and 72 weeks of age. Also season significantly influenced all weights except for birth weight and weight at 24 weeks of age. Birth type had significant effect on birth weight ($P<0.001$) and weaning weight ($P<0.05$) but did not significantly affect the post-weaning weights. Age of the dam significantly influenced birth weight and weaning weight of lambs. Differences due to location were highly significant for weights at birth, weaning, 24 and 72 weeks of age. Lambs born at Malya were heavier at all ages than those at West Kilimanjaro.

Role of goats in the utilisation of rangelands of Tanzania

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Abstract

The rangelands resource of Tanzania is vast, covering an area of 60 million hectares. This area is capable of supporting over 20 million Tropical Livestock Units (TLUs) and millions of game animals. There are about 6.4 million goats in the country and they, together with sheep (estimated 3.0 million), produce 30,000 tonnes of red meat for the human population.

Experience with goat raising among the agro-pastoralists has shown that these animals are herded alongside cattle and sheep. The sheep and cattle tend to graze while the goats mostly browse, thus bringing about a balanced utilisation of the rangelands with a concomitant woody weed control effect.

Increased productivity of indigenous goats through an organised extension approach in Newala

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The environment and vegetation in Newala district are favourable for goat production but unfavourable for cattle production; the major constraints being lack of water and suitable grazing; also cattle ownership is beyond the means of most village farmers. Goats are therefore appropriate to the environment and to the farmer.

Baseline studies indicated a high kid mortality rate, being 45% for kids up to 12 months of age. Major causes of death appeared to be helminthiasis (*Haemonchus* spp.), poor nutrition and bad housing.

The long-term objectives of the project are to improve family nutrition, farmer income and family welfare by reducing goat mortality, increasing production, thereby increasing the meat supply, and encouraging milk production. The short-term objectives of the project are to communicate simple and low cost improved goat husbandry practices to farmers particulary in the areas of internal parasites, housing, nutrition, disease prevention and breeding stock management. The project operates, in conjunction with the district livestock and extension (NALERP) offices, by the provision of training and field materials and equipment inputs to field staff, village meetings, use of extension aids (booklets, posters, subject handouts and model goat houses), assistance to initiate primary school and womens' group goat projects and provision of tree/forage planting materials.

The number of goats in the district has increased from 64,000 (1984) to 144,000 (1991). The number of households owning goats has increased from 15% (1984) to 30% (1991); the average flock size of seven has not changed. Ownership of goats provides security.

Browse plants as feed resource for ruminants in Botswana

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Abstract

Eleven browse species in all were sampled from two vegetational locations. Six browse species were obtained from sandveld, (Mmantshwabisi) while nine were sampled from loamy soils (Makgobokogobo). Four browse species were common to the two vegetational zones. The browse plant components (leaves, twigs and pods) were analysed for proximate composition, and also evaluated for *in vitro* dry matter digestibility and nylon bag dry matter degradability at 24h, 48h, 72h and 96h incubation periods using cannulated Simmental steers. The browse samples were analysed for dry matter (DM), ash, crude protein CP, crude fibre and fat. Minerals analysed were P, K, Ca, Na, Mg, Mn and Fe. Sampling was done three times each in both wet and dry seasons i.e. at the beginning, middle and end of each season. Small ruminants in particular depend heavily on browse, especially during the dry season. Nutrient composition of the browse plants in the loamy soil areas varied in CP content from 72.2g/kg DM for *Peltophorum africana* to 165.7g/kg DM for *Acacia mellifera* pods during the dry season. CP content ranged from 78.9g/kg DM for *Peltophorum africana* to 177.0g/kg DM for Acacia fleckil pods in the sandveld during the dry season. Phosphorus content ranged from 0.58g/kg DM for *Dichrostachys cineria* leaves (L) to 1.5g/kg DM for Acacia fleckil (L) in loamy soil area during the dry season. Phosphorus content of *Peltophorum africana* was least with 0.53g/kg DM and Acacia fleckil tops the list with 1.33g/kg Dm of phosphorus during the dry season.

Production de viande des ovins en milieu paysan

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Résumé

Dans le cadre de la présente étude, des analyses ont été effectuées pour déterminer les performances de 121 ovins mâles engraissés en stabulation dans des petites exploitations agricoles de la zone semi-aride du Mali à l'approche de la fête de Tabaski à Banamba. Ces travaux ont été complétés par des études économiques et financières destinées à évaluer la rentabilité de l'opération.

La durée de l'engraissement a été de 66 ± 4 jours pour l'ensemble des deux lots d'animaux. Le gain de poids journalier était de 85,22 ± 24,87g pour le lot expérimental contre 56,55 ± 40,03 g pour le lot témoin.

Le niveau de bénéfice économique par tête embouchée/paysan était en moyenne de 5,430 FCFA et 4,483 FCFA respectivement pour le lot témoin et le lot expérimental.

En zone semi-aride la rentabilité de l'embouche n'est pas liée seulement au gain de poids.

Etablissement d'une formule barymétrique chez le mouton à queue grasse de l'Afrique de l'Est utilisable en milieu rural

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Résumé

La présente étude a pour but de tester en milieu rural, la formule barymétrique établie au Centre National de l'Elevage de Songa à partir des données recueillis sur le mouton local élevé en station.

Pour cela un échantillon expérimental de 400 moutons a été prélevé en milieu rural. Chaque mouton faisant partie de l'échantillon a fait l'objet de relevé de poids et de trois mensurations corporelles en l'occurence le périmètre thoracique, la haute au garrot et le tour spiral.

La comparaison de trois mesures corporelles au niveau de leurs intensités de liaison avec le poids, confirment les résultats trouvés en Station en révelant que le périmètre thoracique reste la mensuration la plus fortement corrélée au poids.

Après l'élimination de la hauteur au garrot et du tour spiral, les données sur le périmètre thoracique et le poids ont été soumises à quatre modèles de régression:

- La régression linéaire simple $Y = a + bx$
- La régression quadratique $Y = ax^2 + b + c$
- La régression exponentielle $Y = ex^{a+bx}$
- La régression multiplicative $T = ax^b$

Les résultats d'analyse de ces derniers font ressortir que le modèle de régression multiplicative permet le meilleur ajustement du périmètre thoracique au poids et que par conséquent il peut être avantageusement utilisé dans l'établissement de la formule barymétrique.

Une table de conversion périmètre thoracique - poids utilisable en milieu rural est proposée.

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