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SHEEP AND GOATS IN HUMID WEST AFRICA

PROCEEDINGS OF THE WORKSHOP
ON SMALL RUMINANT PRODUCTION SYSTEMS
IN THE HUMID ZONE OF WEST AFRICA,
HELD IN IBADAN, NIGERIA,
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ABSTRACT

These proceedings summarize the results of research on dwarf sheep and goat production in humid West Africa. Among the topics discussed are disease profiles of village sheep and goats; feed intake, growth and reproduction rates of West African Dwarf goats; integration of the small ruminant enterprise into the wider farming system of the zone; and the economics of the improved production systems for ruminants.

KEY WORDS

/West Africa//Nigeria//sheep//goat//animal health//productivity//farming systems//livestock production systems/–/growth//reproduction//feed intake//marketing//West African Dwarf goat/

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PREFACE

This volume contains a selection of papers presented at a workshop on Small Ruminant Production Systems in the Humid Zone of West Africa, held in Ibadan, Nigeria, from 23 to 26 January 1984. The workshop organizers sought to bring together individuals active in sheep and goat research in the zone, with the objective of fostering a more holistic appraisal of the problems and potentials of the further development of small ruminants as a livestock resource.

By virtue of generally being a minor farm activity, sheep and goat production in humid West Africa is particularly well suited to the farming systems research approach. The importance of understanding small ruminant production in the context of the larger farming and social systems was a major theme of the workshop, and it is emphasized in several papers in this collection.

The workshop was sponsored by the International Livestock Centre for Africa (ILCA) and the Federal Livestock Department of the Federal Republic of Nigeria. Additional support was provided by the Ford Foundation and the International Development Research Centre (IDRC) of Canada.

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INTRODUCTION

Sheep and goats in humid West Africa

J.E. SUMBERG and K. CASSADAY

The humid zone of West Africa has traditionally depended on areas to the north to meet its demand for animal protein. The disease trypanosomiasis, transmitted by the tsetse fly, has generally limited livestock production in the humid zone, and most resident animals are the indigenous, trypanosomiasis-tolerant dwarf breeds. Dwarf sheep and goats are the most common ruminant species found, with an estimated 14 million dwarf sheep and goats within the zone in 1979 (Table 1) (Jahnke, 1982).

rarely mentioned in any detail in descriptions of farming systems in the area.

All the available evidence suggests that small ruminants are owned by a large proportion of the rural population in the humid zone: ILCA's village surveys in southwest Nigeria indicate that up to 75% of the population in some villages may own these animals. Small ruminants are also widely reported to be owned by individual men and women rather than by domestic units or kin

Table 1. *Small ruminant and human agricultural populations (in millions) in humid West Africa.*

Country	Small ruminants						Human agricultural population	Small ruminant/ human population ratio
	goats		sheep		total			
Nigeria	5 621	(6 634)[a]	3 476	(1 886)	9 097	(8 520)	11 955	0.76
Ghana	1 200	(246)	990	(344)	2 190	(590)	4 347	0.50
Ivory Coast	816	(426)	874	(533)	1 690	(959)	1 555	1.09
Liberia	190		190		380		1 268	0.30
Guinea	79		86		165		1 104	0.15
Sierra Leone	59		20		79		1 601	0.05
Togo	45	(304)	33	(342)	78	(646)	233	0.33
Benin	–		–		–		–	–
Total	8 010		5 669		13 679		22 063	0.62

[a] Data in parentheses have been taken from ILCA (1979); p. 4.

Source: Jahnke (1982); pp. 235, 237–238.

While census data such as those cited in Table 1 are only crude estimates, small ruminants would appear to be a major underexploited food and capital resource in the humid zone. These animals are raised exclusively for meat, providing a flexible financial reserve for the rural population and playing important social and cultural roles. However, there have been few systematic attempts by farmers or development agencies to increase small ruminant production, and small ruminants are

groups. The majority of rural owners are male farmers engaged in food and tree crop production, or women involved in food processsing or marketing. Both groups of owners have relatively limited skills in livestock husbandry.

Sheep and goat production throughout much of the zone is one of a number of minor farm enterprises that lend a measure of diversity to the larger farm economy. Small ruminant keeping is not generally integrated with crop production in the zone. Few forage crops are grown, and manure is not generally returned to cultivated plots.

The nature of small ruminant production in the zone varies from extensive, low-input systems based on free grazing and village scavenging to more intensive cut-and-carry feeding of confined animals and commercial grazing of sheep flocks. Although there has been no systematic reconnaissance of production systems in the zone, it is probable that the majority of animals are kept in free-roaming flocks which may or may not be tethered during the cropping season. In southwest Nigeria, for example, individual owners typically keep two to four breeding animals; goats are more commonly kept than sheep. In general, owners of free-roaming animals provide no special feed, housing or veterinary care. The major investment is in acquiring new stock; however, caretaking of animals is commonly practised, thereby greatly reducing the initial cash investment.

Mortalities from disease are high, particularly among goats. *Peste des petits ruminants* (PPR), a rinderpest-related viral disease, is perhaps the most important cause of mortality, and can quickly decimate whole flocks. Small ruminant production therefore entails a considerable degree of uncertainty. Other diseases often mentioned as important causes of mortality include pneumonias and gastro-intestinal parasites. Studies of diseases under village conditions are rare, however, and with the possible exception of southwest Nigeria, it is currently impossible to determine the actual importance of these as causes of mortality. There is still considerable discussion concerning the importance of PPR in different countries in the zone, and the efficacy of available control measures (ILCA, 1983). Despite high mortality, the potential returns from sheep and goat keeping under the traditional management system are high (Upton, 1985).

The potential complementarity between smallstock husbandry and other farm activities is evident in the combination of food processing and goat rearing common among women in many rural areas. Household wastes, combined with cassava peels or other crop byproducts of small-scale commercial food processing, are important feed resources available to livestock owners having no direct access to land or to fodder crops. Indeed, this kind of feed supplementation is one of the few discernable management inputs in the free-roaming production system. Individual ownership of a relatively limited number of animals makes this an attractive and efficient combination of enterprises.

Small ruminants are an important item of trade within humid West Africa. Demand and consumption patterns for sheep and goats are different, but the large importation of northern animals from the north indicates a vast potential market in the south for locally produced animals. Sheep are consumed primarily during Muslim religious holidays, while goats are used for all ceremonies throughout the year, such as births, deaths, marriages and festivals. Demand for goats is therefore consistently high. There is a clear price premium for male sheep during the festival period, and some early purchasing for fattening and re-sale takes place.

Under traditional management sheep appear to yield a higher output and rate of return than goats. Goats are considerably more prolific, but sheep are bigger, heavier, and experience lower mortalities, in addition to fetching a higher price (Upton, 1985). Sheep require somewhat more attention than goats because of their tendency to wander and to damage crops; under the free-roaming system in southwest Nigeria they are often tied or tethered during the cropping season. Small-scale sheep production is a somewhat more specialized enterprise than goat rearing, demanding greater management input while offering higher returns. This specialization, often involving older men with more available time, is a direct response to market forces, and illustrates one potential development path for small ruminants in the zone. The commercial sheep flocks currently found in Ivory Coast and Ghana are a further example of this type of specialized development.

Most research with West African Dwarf goats and sheep has taken place on experiment stations, often under the auspices of university departments of animal science and veterinary medicine. The results of much of this work have recently been reviewed by Ademosun et al (1983) and Berger (1983). These studies can give some indication of the animals' biological potential and their potential productivity under certain 'improved' management practices. Comparatively little research has concentrated on describing current village production systems, or evaluating modifications in village systems *in situ*.

The selection of papers in these proceedings gives an account of current research focussed primarily on village-based small ruminant production systems. The contributors emphasize the need to understand the current position and the development potential of sheep and goats in the rural production environment. This important aspect of the 'systems' approach to agricultural research and development would appear to be particularly relevant to small ruminant producers in this zone. It is hoped that these papers will stimulate further research and development efforts with small ruminants in humid West Africa.

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A strategy for small ruminant development in Africa

H.P. JOSSERAND

INTRODUCTION

Small ruminants are found in every subregion of the African continent, but their distribution and the sheep/goat mix are uneven. Half of all sheep and goats are estimated to be in northern Africa and the Sahel, the next highest concentration (close to one third of all sheep and goats; c.f. Winrock International, 1978; ILCA, 1981) being in Ethiopia, Somalia, Kenya, Sudan and Tanzania. Although the proportion of small ruminants to total livestock is high in West and central Africa, absolute numbers are relatively low, the only notable exception being Nigeria. Because of their wide distribution, greater flock dynamism, and the greater extent to which they may be transported through nonspecialized channels, it is more difficult to assess the status of small ruminant populations than to make similar estimates for cattle. Reliable estimates of small ruminant populations in individual countries and ecological zones are scarce, and this lack of such basic information further complicates development planning. Official estimates of sheep and goat numbers are not uncommonly revised upwards by a factor of 1.5 or 2 after careful sampling.

The various breeds of sheep and goats found in Africa differ in their environmental adaptation. Sheep range from the North African fat-tailed, coarse wool variety, to the leaner, tall, red-brown Masai in East Africa, and the Fulani in West Africa. Similarly, goat types vary from the long-legged Nubian and Jamnupari in the north, and the Galla of East Africa, to the West African Dwarf variety found predominantly in humid areas.

The importance of small ruminants to African economies may be appreciated through a brief survey of overall demand and consumption patterns. Throughout Africa, and in humid West Africa in particular, small ruminants must be considered primarily as sources of meat and meat products. There is ample evidence from several African regions that meat demand remains strong and is increasing (Staatz, 1979; Josserand and Sullivan, 1979; Delgado and Staatz, 1980; ILCA, 1981). This reflects greater urbanization, and associated higher incomes, which have led to large domestic and international trade movements (e.g. from the Sahelian nations to the west coast). Demand outside of Africa is also strong because of the sharp rise in income among oil-producing states in the Near and Middle East.

As an urban phenomenon, the mutton and goatmeat trade displays several interesting features, the first few being linked to consumers' apparent preference for mutton and goatmeat over available substitutes. Except in Nigeria, mutton and goatmeat prices consistently remain above the price of beef: 25 to 30% premia are common. These prices are comparable to the weight equivalent cost of poultry (Staatz, 1979; Josserand and Sullivan, 1979; Delgado and Staatz, 1980; ILCA, 1981). In addition to preferring the taste of the meat and the dietary variety it provides, consumers are also motivated by cultural and religious considerations. The ceremonial use of sheep to celebrate *Tabaski* and other Moslem holidays is the example most frequently cited in literature. *Tabaski* involves such a sharp increase in demand for sheep (solid white rams are at a premium) that live small ruminant prices can double or near-double as the holiday approaches. Some people purchase animals a month or so in advance, either to avoid, or take advantage of, the price rise which takes place days prior to the feast. Many people also buy rams and wethers in advance to fatten.

The question of whether consumers have a marked preference for sheep or goats is often posed, but there can be no general and definitive answer. Sheep are preferred by Moslems for ceremonial purposes; some groups prize the leaner goatmeat over mutton while others do the opposite, and in many cases local sheep and goats are morphologically so similar that buyers of small cuts may be unable to ascertain exactly what they are getting at the market.

LIVESTOCK PRODUCTION AMONG AGRICULTURAL GROUPS

Agricultural groups derive most of their food and cash income primarily from cultivation. In subhumid zones the number of livestock they manage is usually limited by the local availability of grazing land, and by labour requirements for farming, so that the livestock to person ratio is quite low. Agriculturalists hold some cattle for draught, and occasionally fatten steers over the dry season, in addition to keeping small ruminants and other smallstock. Small ruminants are kept largely as a readily convertible source of cash. Often, when agricultural families do decide to own cattle as a form of saving or investment, these are entrusted to nearby pastoral or agropastoral groups for management. There is commonly a fair amount of interaction between agriculturalists, pastoralists and agropastoralists, examples being the traditional millet for milk exchange, the manuring of fields in exchange for stubble, herding services etc.

In humid zones, such as the west coast or central Africa, a great deal of farming is done as shifting cultivation (bush fallow), so that there is apparently more land and forage available per family than in drier areas. Actually, the African humid zones do not currently support much livestock. Trypanosomiasis, parasites, infectious and respiratory diseases account for part of this. Forage, although abundant, is generally of low quality (especially for large ruminants), and the labour requirements of expanded herds or flocks can be sizeable compared to the minimal labour involved in following the current free-roaming practice. For these reasons, the current species mix in the humid zone displays a very high degree of small ruminant specialization.

As one goes from the subhumid to the humid zone, livestock becomes less integrated with the crop production system, and less important overall. In both zones small ruminants are considered primarily as readily convertible savings, and as a source of meat for home consumption. Contrary to the practices of agropastoral and pastoral people amongst agricultural groups, and particularly in the humid zone, small ruminants are not herded, no breeding control or selection is carried out, and little veterinary care is extended.

STRATEGIES FOR SMALL RUMINANT DEVELOPMENT

This section addresses institutional and infrastructural issues related to small ruminant development, as well as research and training. A brief review of the experience of development efforts to date will be included; from this, and from our understanding of the systems and our view of expected trends, a set of objectives will be derived. Finally, recommendations on how to overcome constraints to these objectives will be offered.

Institutions and infrastructure

Critical evaluations of livestock projects in Africa make up an increasingly voluminous body of literature (see Hoben, 1979; Sandford, 1981; Gall, 1981; Honadle and McGarr, 1979). From these evaluations one may determine that problems on the part of host countries and donors alike have generally stemmed from:

1. Incorrect assumptions about the workings of livestock systems and their links to the rest of the primary sector and the economy at large;
2. A misconception and lack of reconciliation of diverse interests among the various groups involved;
3. The consequent use of inappropriate inputs and outputs;
4. A rather narrow technical orientation;
5. A failure to rely upon the inherent positive factors of systems targeted for intervention: i.e. the knowledge and experience of herding groups, and the leverage available in local socio-political structures. Hoben (1979) emphasizes that problems stem from basic misconceptions at the design stage, rather

than from shortcomings in implementation. Even with due regard to the great difficulties common in the execution of projects, we agree with him that "livestock projects appear to suffer similar difficulties in respect to effectiveness, regardless of the quality of their management".

On the part of African and outside institutions there has been a pronounced bias in development efforts in favour of large ruminants. Small ruminants and other domestic animals have been largely ignored. These development efforts have also been heavily biased in favour of meat as an output of economic value, and have tended to ignore other substantial benefits derived from the herds. There has also been a lack of concern for existing and potential interactions between animal husbandry and cropping; the institutions, administrations, and projects concerned with crop production and livestock raising remain widely separate in their point of view. Some reasons for this emphasis on cattle are readily apparent: cattle represent a more concentrated and 'obvious' target than small ruminants, and beef constitutes a larger share of urban meat consumption. Many African governments believe that they have a fair chance of controlling cattle movements across borders, for political or economic reasons, or to control disease. Small ruminants have been another matter altogether. Finally, sheep and goats are spatially less concentrated than cattle and are thus much harder to reach for censuses, animal health and other extension services. The end result has been a situation in which domestic and foreign resources in research, project activities and infrastructure have gone mostly to cattle. (African governments allocate an average 10% of total livestock budgets to small ruminants – Winrock International, 1978).

Small ruminants are scattered over all African countries, and the size of individual flocks, particularly in humid West Africa, is quite small. This makes the task of 'reaching the target population' more difficult than for cattle. As a heavy administrative and physical infrastructure is not generally economically justifiable even in the case of cattle, it becomes patently impossible where sheep and goats are concerned. The kind of activity carried out in parts of Kenya, for example, where *bomas* (livestock shelters) have been built expressly for goats belonging to women's associations, is already impractical on any but the smallest scale. Speaking in terms of 'specific projects' for sheep and goat development will make even less sense than it does for cattle. Aside from particular instances of organized fattening near large urban areas, the goal of activities will have to go very much counter to established tendencies; it will have to be based on a major decentralization of activities.

Even if we assume some budgetary reallocation to small ruminant development, the limited resources available will force this approach to be quite basic and to rely as much as possible on existing local resources and talents, both public and private. The diffused distribution of small ruminants throughout each country implies that no single plan (decentralized or not) is likely to be suitable. Development activities will have to span a number of production systems, from primarily pastoral groups managing mixed herds and flocks, to sedentarized farmers owning only a few small ruminants.

On the positive side of the issue we recognize that investment in small ruminants should show much quicker payoffs than investment in cattle. These payoffs will necessarily be diffuse at the production and supply levels before they have concentrated effects on urban consumption, but they will be real nonetheless. Quicker returns may mitigate the common tendency to avoid waiting for observable results in livestock production by immediately setting up tangible product 'output' such as buildings, holding pens etc. Payoffs will be quicker with small ruminants for two main reasons: biological parameters, such as fertility and prolificacy, favour small ruminants; and returns to expenditures (if suitably basic and diffuse) should be much superior, even at the margin, to similar expenditures on large ruminants. The expectation of superior returns to expenditures is based on the fact that there has been so little previous investment in sheep and goat husbandry.

A strategy for small ruminant development may thus be formed around the following six points:

1. The current and potential role of small ruminants must be assessed in light of the re-

structuring needed in the primary sector.

2. Infrastructure in livestock development projects is invariably too heavy although the institutions themselves are often weak, and primarily geared to address specific, concentrated and technical tasks.
3. Given the diffuseness of small ruminants, and thus the diversity of suitable approaches, a development strategy for sheep and goats cannot be based on a 'project' or 'blueprint' approach. With only a few exceptions, decentralized interventions will be required.
4. In view of resource constraints, decentralized and flexible interventions will have to be basic, involve local resources and talent, and rely largely on existing outreach structures. By 'basic' we mean the simplest health care intervention such as deworming, vaccination, deticking (provided at cost, on a voluntary basis), and advice on elementary control of mating and breeding cycles. Specific interventions will be worked out for different areas as described in the 'Research and training' section below. In many cases the agricultural extension service is better organized and has had more experience with village-level extension work than have livestock services or agencies. Given that most small ruminant owners are at least partially involved in agriculture, and given the relatively simple nature of needed interventions, and the greater participation sought of agriculture and animal husbandry agencies, a much greater cooperation between the two agencies will be required at the field level. It is important to realize that institutional attitudes, as well as farmers' practices, will have to breach the crop/livestock gap.
5. In addition to the general strategy outlined here, there are a few specific areas with great development potential that may be more amenable to a 'project' approach. These consist of short-term fattening schemes near urban areas and increased benefits from sheep and goat skins. Because of population and income trends, and a possible reallocation of some cattle to non-beef uses, demand for mutton/goatmeat is expected to increase sharply in urban areas. As we know, demand for mutton is also extremely strong in connection with Moslem ceremonies. There are presently a few private enterprises profitably fattening sheep and goats for urban markets. In our view, small ruminant fattening offers two major advantages over cattle fattening: the initial investment required is much smaller, and the supply of animals is more constant throughout the year. The encouragement of small- and medium-scale private sheep/goat fattening near large urban areas can therefore be a valid component of any overall meat supply strategy.
6. Finally, one should discourage further attempts on the part of some governments and agencies to control or 'rationalize' small ruminant marketing channels. In spite of occasional imperfections in the traditional livestock marketing system, it functions well under the existing constraints and can adapt to change successfully (Staatz, 1979; Josserand and Sullivan, 1979; Delgado and Staatz, 1980; Sandford, 1981; Gall, 1981). There is no single instance where the public sector has demonstrated greater efficiency in this activity than have private agents.

Research and training

The kind of research and training consistent with the strategy outlined in this paper will require a definite shift in institutional views, from highly technical, insular, station-based research to more basic, decentralized, field-level studies. There are two compelling reasons for this. First, in virtually every country, small ruminants are raised under diverse ecological conditions and thus within a range of different production systems. Second, although sheep and goat husbandry may not be well integrated with the overall farming system, it is clearly an element in the household economy that has important implications for intra-household processes, and should be treated as such in field research.

The first phase of field research should provide a *basic understanding* of the various components in the local production system, and of how small ruminants fit into it. A second phase would look at the possible effects of promoting or introducing simple changes in the small ruminant component of the system, and making an assessment of their overall impact. Research should include a number of topics, and their relative emphasis would naturally depend on the specific farming system studied. They might include:

- forage and feed use, and their effect on the local invironment;
- use of crop stubble and agricultural by-products;
- use of manure on fields and gardens;
- individual and communal herding practices;
- existence of cut-and-carry feeding or grazing areas;
- impact of basic health care;
- effect of controlled breeding and selection.

Under certain conditions other specific issues may be examined, such as brush control on tree crop plantations, or grazing on steep slopes not suitable for cultivation.

Training for field-level researchers should involve people from the general research area, with a few years of technical schooling, and be carried out jointly by the livestock service and the agricultural extension agency. The first point would facilitate local acceptance and help eliminate the belief that farmers and herders are ignorant and that they blindly follow inefficient practices because of tradition. The second point would help ensure that small ruminant activities are seen as part of a larger production system, even in apparently simple cases.

Finally, training should emphasize the fact that at the second phase of research, proposed interventions should be viewed as rational hypotheses to be tested, rather than as certain and proven steps to be carried out.

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ANIMAL HEALTH

Disease profiles of sheep and goats in two groups of villages in southwest Nigeria

S.A.O. ADEOYE

ABSTRACT

Small ruminant diseases observed over 12 months in two sets of villages in southwest Nigeria are discussed. The efficacy of annual vaccination against peste des petits ruminants and of monthly dipping with acaricide is examined, following their introduction in one of these village groups. Two aspects of small ruminant diseases are considered: their incidence and consequent mortality.

INTRODUCTION

The climate of humid West Africa is characterized by high but variable rainfall and high relative humidity and temperature; both conditions generally favour livestock diseases and pests. Although the humid zone of Nigeria is estimated to carry approximately 10 million goats and sheep, actual livestock density is low, and disease is considered to be a major constraint to small ruminant production. Disease hinders production directly, by causing death, or indirectly by restricting growth rates and reproductive performance.

Studies of free-roaming flocks of sheep and goats in southwest Nigeria have identified two diseases, *peste des petits ruminants* (PPR) and sarcoptic mange *(Sarcoptes scabiei)*, to be the major causes of morbidity and mortality, particularly among goats (Opasina, 1984; Adeoye, 1984). This paper further describes the disease picture in these flocks, detailing changes in morbidity and mortality following interventions to control PPR and mange mites.

MATERIALS AND METHODS

Observations were made over 12 months (May 1982 to April 1983) in two groups of villages, Badeku and Ikire, lying to the east of Ibadan. Treated animals at Badeku received an annual vaccination with tissue culture rinderpest vaccine (TCRV) to control PPR, and were dipped monthly in gamma-benzene hexachloride (GAMMATOX®) to control mange. Control flocks in Ikire remained untreated.

All animals monitored in the two groups of villages were the trypanosomiasis-tolerant West African Dwarf breeds. At the start of the observations, animals for which there were no histories were aged on the basis of their dentition and tagged to enable continuous identification. During the survey, 145 sheep and 376 goats were enrolled in the Badeku villages and 124 sheep and 270 goats in the Ikire villages. A random sample of households was selected monthly, and all sheep and goats within these households were weighed and examined. Diseases and pests were identified through clinical examination of the oculonasal, respiratory, alimentary, musculo-skeletal, integumentary, urogenital, and nervous systems, and through laboratory examinations of blood and faecal samples. Packed cell volume (PCV %) was determined by the standard technique, and trypanosomes were detected using the buffy coat technique employing dark-ground phase contrast (Muray et al, 1979). Faecal samples were collected from animals with suspected cases of helminthiasis and/or coccidiosis. Helminth egg and/or coccidia oocyst counts were made using McMaster's technique.

Diseases were classified as potentially acute (likely to result in death), debilitating, and non-debilitating, as indicated in Table 1. Animals in which no ailments were observed were regarded

Table 1. *Classification of small ruminant diseases and pests encountered during the survey.*

Potentially acute	Debilitating	Non-debilitating	
PPR	babesiosis	footrot	lymphadenitis
pneumonia	mange	vulvovaginitis	anaplasmosis
trypanosomiasis	other ectoparasites[a]	orf	abortion
helminthiasis		keratoconjunctivitis	accidents
		pox	photosensitization
		abscessation	nasalbot
		mastitis	

[a] Ticks, fleas and lice.

as 'clean'. Each examination of an individual animal was considered to be a separate case.

RESULTS AND DISCUSSION

During the observation period 21% of the 398 untreated sheep cases and 24% of the 543 untreated goat cases were diagnosed as 'clean' (Table 2). Sheep suffered particularly from potentially acute diseases, among which pneumonia ranked as the most important. Sheep also suffered from ectoparasitic infestations of ticks, fleas and lice, rather than from mange.

Table 2. *Incidence of pests and diseases in small ruminants in southwest Nigeria.*

Disease category	% morbidity	
	sheep	goats
Potentially acute		
PPR	–	1.1
pneumonia	23.9	8.7
trypanosomiasis	–	–
endoparasites	12.1	10.3
Total	36.0	20.1
Debilitating		
babesiosis	5.8	5.0
mange	4.0	22.5
other ectoparasites[a]	20.6	16.2
Total	30.4	43.7
Non-debilitating	13.1	12.7
Clean	20.6	23.6
Number of cases	398	543

[a] Ticks, fleas and lice.

Debilitating diseases affected almost half the goat cases seen, and among these, mange and other ectoparasites predominated. Potentially acute diseases were less common among goats than debilitating diseases.

The relative significance of the different disease categories did not change for sheep or goats treated for PPR and mange (Table 3). It is relevant to note the low incidence of PPR recorded in

Table 3. *Effect of PPR and mange control on incidence of disease (%) in small ruminants.*

Disease category	Sheep		Goats	
	control	treatment	control	treatment
Potentially acute	36.0	38.7	20.1	27.5
Debilitating	30.4	34.2	43.7	32.8
Non-debilitating	13.1	7.4	12.7	13.1
Clean	20.6	19.5	23.6	26.5
Number of cases	398	405	543	505

the disease survey, compared with the significance generally attributed to it as a cause of mortality among goats. Animals affected by PPR may die within 5–14 days; it would seem that in many cases this incubation period did not coincide with the clinical examination. The significance of potentially acute diseases would have been enhanced if the diseases had been diagnosed during incubation, and treatment for PPR would then be expected to increase the proportion of 'clean' animals.

During the 12 months of the survey 87 untreated animals died: 76 goats and 11 sheep (Table 4). In total, this represented 28% of the untreated goats and 3% of the untreated sheep in the survey. The most commonly suspected cause of death was PPR, which probably accounted for 50% of the goat mortalities. No other single disease appeared to result in a significant number of deaths; overall, however, the potentially acute diseases accounted for almost two thirds of all goat mortalities.

Table 4. *Causes of mortality among untreated sheep and goats in southwest Nigeria.*

Cause of mortality	% mortality	
	sheep	goats
Potentially acute diseases		
PPR	–	51.3
pneumonia	-	3.9
helminthiasis	27.3	2.6
coccidiosis	9.1	1.3
Total	36.4	59.1
Debilitating diseases		
babesiosis	–	3.9
mange	–	5.3
other ectoparasites[a]	18.2	5.3
Total	18.2	14.5
Non-debilitating diseases		
orf	–	2.6
accidents	36.4	3.9
others/unknown	9.1	19.7
Total	45.5	26.2
Number of deaths	11	76
Total number of animals	124	270

[a] Ticks, fleas and lice.

The control of PPR and mange dramatically reduced mortalities among the goats (Table 5). Annual vaccination with TCRV and monthly dipping reduced average monthly mortality of goats by 87% and of sheep by 79%.

Among treated goats, helminthiasis, babesiosis and coccidiosis were the only diseases diagnosed as causing mortalities. Of these diseases, helminthiasis caused 47%, babesiosis 12%, and coccidiosis 6% of all mortalities. A large proportion (20%) of mortalities of untreated goats could not be explained, or were sole cases of a disease.

Although mange is not considered to be an important cause of mortality, treatment by monthly dipping did reduce the incidence of mange by 50% in sheep and 75% in goats.

While the control of PPR and mange led to a significant reduction in mortalities, the incidence of disease in the treated animals remained the same (Table 6). This is due to the difficulty in diagnosing PPR, and perhaps because dominant diseases mask others which only appear when the dominant disease is controlled. In particular, ectoparasites continued to be important, even

Table 5. *Mean monthly mortality of treated and untreated goats and sheep (May 1982–April 1983).*

	% mortality/month	
	goats	sheep
TCRV/dipping	0.45	0.39
Untreated	3.28	1.88

Table 6. *Effect of PPR and mange control on incidence of disease in goats.*

Disease category	% morbidity	
	treated	untreated
Potentially acute		
PPR	–	1.1
pneumonia	16.2	8.7
trypanosomiasis	0.2	10.3
endoparasites	11.1	–
Total	27.5	20.1
Debilitating		
babesiosis	8.7	5.0
mange	6.7	22.5
other ectoparasites[a]	17.4	16.2
Total	32.8	43.7
Non-debilitating	13.1	12.7
Clean	26.5	23.6
Number of cases	505	543

[a] Ticks, fleas and lice.

though the incidence of mange was reduced. This may be explained by the fact that some of the ectoparasites may have developed resistance to the acaricide. The incidence of babesiosis was directly linked to tick infestation.

The low incidence of trypanosomiasis does not correspond with the significance attributed to this disease in literature. Its low incidence in the surveyed villages can be linked directly with low challenge: no tsetse flies were trapped in the Badeku area in a tsetse survey conducted concurrently with this disease survey (ILCA, 1983).

CONCLUSIONS

While the number of diseases that can be observed in small ruminants is large, it is clear from these observations that only a few diseases affect a significant proportion of the population. The number of important diseases is even smaller if their effect on productivity is considered. Survival of offspring is a major component of livestock productivity, and the control of a single fatal disease such as PPR can significantly increase overall productivity (Mack, 1983; Upton, 1985).

The consequences of widespread PPR control are uncertain. Other diseases that are currently masked by mortality due to PPR may assume increased importance. On the other hand, the control of rinderpest in cattle (a disease closely related to PPR) has not generally led to the emergence of other major diseases. If PPR control eventually leads to larger flocks, it may be more likely to result in nutritional problems, which can cause slower growth and reduced survival.

The fact that sheep are apparently less susceptible to potentially acute disease than goats is interesting, especially since sheep are less common than goats in the two groups of surveyed villages. Disease would not appear to be a major constraint on sheep production in these village systems.

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Serological survey of some viral infections in goats in southern Nigeria

T.U. OBI

ABSTRACT

Peste des petits ruminants (PPR) is the major disease constraining small ruminant production in southern Nigeria. Although the tissue culture rinderpest vaccine (TCRV) seems to control PPR effectively in goats under village conditions, other pneumonias continue to cause some level of morbidity and mortality. A broad-based serological survey for antibodies against some viruses that may produce clinical signs resembling PPR provided evidence of PPR virus, rinderpest virus (RV), adenovirus, foot-and-mouth disease (FMD), bovine virus diarrhoea (BVD), bluetongue (BT), infectious bovine rhinotracheitis (IBR), parainfluenza type 3 (PI-3), and orf virus activities in goats in several locations in southern Nigeria. The results are discussed in relation to the diagnosis, overall importance and control of PPR and other viral diseases of small ruminants.

INTRODUCTION

Little information exists on the prevalence of viral infections that may resemble *peste des petits ruminants* (PPR) in small ruminants in southern Nigeria. Johnson (1958) reported rinderpest in sheep grazed with infected cattle in Nigeria, although natural rinderpest is rare in small ruminants. A serological study by Taylor (1979) suggested that the rinderpest virus was not active in the sheep and goat population.

Clinical bluetongue (Henderson, 1945; Mettam, 1947; Bida and Eid, 1974) and serological evidence of widespread BT virus activity (Moore and Kemp, 1974; Milree et al, 1977) have been reported in the country. In southern Nigeria the only evidence of active BT virus infection derives from limited serological examination of samples collected from the University of Ibadan Teaching and Research Farm (Moore and Kemp, 1974; Durojaiye, 1979).

Two adenovirus types have been isolated from Nigerian goats that died of PPR infection (Gibbs et al, 1977), although the significance of the isolates was not immediately known. Sheep and goat pox exists in Nigeria (Bida et al, 1975; Asagba and Obi, 1984) and the presence of contagious ecthyma (orf) in the country has been confirmed by Obi and Gibbs (1978).

Although foot-and-mouth disease occurs most commonly in cattle, a report by Ikede and Onyekweodiri (1977) shows that the disease can occur in sheep kept in close contact with infected cattle. There is serological evidence of bovine virus diarrhoea (BVD) activity in Nigeria (Taylor et al, 1977a), although clinical BVD has not been reported. Similarly, Taylor et al (1975) reported on the presence of antibodies against PI-3 virus in cattle, sheep and goats in northern Nigeria.

Peste des petits ruminants is the only viral disease of small ruminants that has been described in detail in Nigeria. Although PPR has characteristics distinguishing it from the diseases mentioned above, those diseases should be considered in the differential diagnosis of PPR (Taylor et al, 1977a; Appel et al, 1981). In conjunction with the Small Ruminant Programme of the International Livestock Centre for Africa (ILCA), a study was carried out to assess serologically the evidence for PPR, rinderpest, bovine virus diarrhoea, bluetongue, foot-and-mouth disease, infectious bovine rhinotracheitis, adenovirus, parainfluenza type 3, and contagious ecthyma virus infections in goats in southern Nigeria.

MATERIALS AND METHODS

Serum samples

Blood was collected from goats kept at the ILCA Fasola Station and the villages of Fasola, Olukosi, Abulle/Idiata and Badeku, in Oyo State; in Imo and Anambra States, blood was collected from goats in Okwe and Mgbakwu villages. Serum samples were extracted from clotted blood and stored at $-20^{\circ}C$ until they were analysed.

Serological tests

Samples were examined for antibodies against the PPR virus using a modification of the serum neutralization test (Taylor, 1979). Rinderpest virus antibody was assayed with the microneutralization test in secondary bovine kidney cells (Obi et al, 1983). Bovine virus diarrhoea, infectious bovine rhinotracheitis, parainfluenza-3 and contagious ecthyma antibodies were assayed by serum neutralization tests. Antibodies against adenovirus and bluetongue virus were detected by the agar gel precipitation test (AGPT), while the FMD virus-infection-associated antibody was detected by the enzyme-linked immunosorbent assay (ELISA).

RESULTS AND DISCUSSION

The serological survey of antibodies against selected viruses that may produce clinical signs similar to PPR indicated the presence of PPR, rinderpest, adenovirus, foot-and-mouth disease, bluetongue, orf, infectious bovine rhinotracheitis, bovine virus diarrhoea and parainfluenza-3 virus infections in goats in southern Nigeria. In seven locations BT virus and orf were the most common virus infections, occurring in approximately 67% of all tested animals. Antibodies against PPR, IBRV, RV and PI-3 were found in 29, 26, 24 and 21% of the tested sera respectively. The least prevalent infections were BVDV, FMDV and adenovirus (Table 1).

Bluetongue and contagious ecthyma viruses emerged as the most prevalent of the eight examined. The high prevalence of BTV antibodies may exist because there are at least 14 BTV types circulating in the country (Lee et al, 1974; Herniman et al, 1983) and there is no cross-immunity between the various types. Despite the evidence

Table 1. *Summary of screening tests for antibodies against selected viruses.*

Viral infection	Number of samples	% positive
BTV	455	68
Orf	110	67
PPRV	478	29
IBRV	196	26
RV	42	24
PI-3	175	21
Adenovirus	443	13
FMDV	380	10
BVDV	38	3

of widespread BTV activity it seems unlikely that bluetongue can be considered important in small ruminants in Nigeria. Although clinical bluetongue has been reported in sheep, indigenous sheep and goats are considered tolerant; this view is supported by the failure of Tomori (1980) to produce clinical disease in West African Dwarf sheep infected with BT type 7 virus.

Contagious ecthyma, on the other hand, is thought to be an important cause of morbidity in sheep and goats in Nigeria. The results obtained in this survey suggest that contagious ecthyma is endemic among southern Nigerian goats. Although morbidity with orf infection may be as high as 100% (Gardiner et al, 1967), mortality in uncomplicated cases rarely exceeds 1% (Schmidt and Hardy, 1932). However, with secondary bacterial complications mortality may be in the range of 20 to 50% (Aynaud, 1923; Jacotot, 1924). Adeoye (1985) reported that orf caused about 2.6% mortality in goats in a survey area of southwestern Nigeria. Mortality apart, infection with the orf virus leads to production losses due to the reduced growth rate of infected kids (Bruner and Gillespie, 1973). Vaccination of animals with locally produced vaccine prepared from vesiculo-pustular lesions is effective in controlling the disease (Robinson and Balassu, 1981); however, the potential benefits from widespread vaccination are unclear.

PPR antibodies were found in goats at all locations except Ikire and Mgbakwu. Very few goats were found to be immune to the infection in Okwe (Table 2). High values of approximately 61

Table 2. *Prevalence of antibodies against selected viruses in parts of southern Nigeria.*

Viral infection	Fasola villages	Fasola station	Abulle/ Idiata	Badeku	Ikire	Okwe	Mgbakwu
BTV							
no. samples	204	52	55	54	20	41	29
% positive	68	77	71	67	90	44	59
Orf virus							
no. samples	58	–	–	–	27	4	21
% positive	67	–	–	–	67	75	67
PPRV							
no. samples	203	71	53	50	22	42	37
% positive	30	61	17	44	0	7	0
IBRV							
no. samples	78	–	–	–	31	40	47
% positive	22	–	–	–	3	15	57
Adenovirus							
no. samples	204	51	16	60	30	44	38
% positive	6	8	0	0	37	30	50
FMDV							
no. samples	204	52	70	54	–	–	–
% positive	13	4	7	6	–	–	–
PI-3 virus							
no. samples	92	–	–	–	15	39	29
% positive	28	–	–	–	13	8	17

and 44% positives were obtained from the Fasola Station and Badeku village, where PPR outbreaks were known to have occurred. These positive cases were taken from a large proportion of survivors. At other sites, particularly at Ikire, Okwe and Mgbakwu, few goats had PPR antibodies, and it would seem that these villages had escaped a recent PPR outbreak and are consequently at risk in the event of a new one.

Although infectious bovine rhinotracheitis is primarily a disease of cattle, Mohanty (1972) showed that the disease can occur naturally in goats. Clinical symptoms of this disease are seldom observed among village goats in the areas where this serological survey was conducted, indicating a low susceptibility among West African goats. About 26% of the goats sampled had IBRV antibodies, and a higher percentage of immune animals was detected in Mgbakwu than at the sites in Oyo State. This figure is somewhat higher than the 11% prevalence reported by Taylor et al (1977a) for northern Nigerian goats. The failure of Maurice and Provost (1970) to produce clinical infection in goats in Chad, using a bovine strain of the IBR virus, suggests that the indigenous goats used in their study had a low susceptibility to the virus.

It is interesting to note that about 24% of the 42 goat sera that were examined for rinderpest contained RV neutralizing antibodies. Taylor (1979) suggested that RV was not active in the small ruminant population in Nigeria. Recently Obi et al (1983) in Nigeria, and Rossiter et al (1982) in Kenya, found evidence of RV activity in sheep and goats. The present observation makes it desirable to carry out parallel screening and titrations of sera against PPRV and RV in making a diagnosis of PPRV infection by serum neutralization test. Using this approach, it is possible to identify which of the two viruses is responsible for the neutralizing antibodies. This method is based on Taylor's observation (1979) that goats infected with PPRV developed cross-neutralizing antibodies against RV, whereas those infected with RV developed antibodies almost entirely to that virus.

Although there is no documented evidence of clinical adenovirus infection in small ruminants in Nigeria, two adenovirus types have been isolated from goats that died of PPR (Gibbs et al, 1977). The value obtained in this survey is somewhat higher than the 4.5% prevalence reported by Jerome et al (1977) for goats in northern Nigeria. It is pertinent to note that two areas of Oyo State, Badeku and Abulle/Idiata, seemed to have escaped recent adenovirus infection, whereas villages in Anambra State had a higher percentage of immune animals. Until the pathogenicity of the caprine adenovirus is determined, it will be difficult to assess the role of adenoviruses in the causation of respiratory and enteric diseases in goats in Nigeria.

Foot-and-mouth disease can occur naturally in cattle, sheep, goats and pigs. About 10% of the goats sampled in this survey were immune to the FMD virus. This result seems to indicate a relatively low level of previous exposure to the virus, especially considering the fact that the disease is endemic in Nigeria and that there are at least three types of the virus circulating in the cattle population. As clinical foot-and-mouth disease is rarely observed among the goats in the area in which this survey was conducted, this disease cannot be considered an important aspect of small ruminant health in the region.

Although relatively few samples were examined for evidence of BVD virus infection, it seems as if this virus is not an important cause of disease in goats in southern Nigeria. Taylor et al (1977a) reported a 4.5 and 12.7% prevalence of BVD antibody in goats and sheep respectively, in northern Nigeria. Nevertheless, they were unable to reproduce clinical disease in Nigerian sheep and goats inoculated with the NADL strain of the BVD virus (Taylor et al, 1977b). In another survey (Obi, unpublished) 16.8% of 95 goats sampled were positive for BVD antibodies. The antibody titres in this previous study were also very low, and evidence of previous infection was restricted to only two areas.

Approximately 21% of the goats screened were immune to PI-3 virus. Taylor et al (1975) reported a 50% prevalence of PI-3 antibody in goats in northern Nigeria. Provost (1973) isolated PI-3 virus from the lungs of goats that died of *Kata*-like disease (PPR) in Chad, and also demonstrated seroconversion in about half of the goats in the affected flock. Parainfluenza-3 virus is a known respiratory pathogen either alone or together with bacteria and mycoplasmas. It is suggested that the possible role of PI-3 in caprine pneumonias in southern Nigeria is worth investigating.

In general, the present serological survey has shown that some viral infections are more prevalent than others among goats in parts of southern Nigeria. Apart from PPR, this survey indicated the need to investigate the importance of PI-3 and contagious ecthyma in small ruminants. It also identified some sites at great risk with respect to PPR, the most important and lethal of the viral infections surveyed.

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POTENTIAL PRODUCTIVITY

Growth and reproduction rates of West African Dwarf goats under high levels of feeding and management

P. HOFS, G. MONTSMA AND S. NABUURS

ABSTRACT

Since 1978 a flock of West African Dwarf goats has been kept largely indoors and fed grass hay ad libitum plus 30 to 60 $g.kg^{-0.75}.d^{-1}$ of a commercial concentrate. Routine observations and measurements of reproduction and weight gain have been made. Results are summarized and discussed using a productivity index. It is concluded that in this system the cumulative effect of 0.1 more kid per litter at birth, a kidding interval shortened by 20 days, 10 g more gain per day and a 0.1 kg higher birth weight would increase productivity of meat production (kg goat per year) by 28%. Separate effects of these changes were 5.5, 9.0, 11.1 and 1.4% increase in productivity respectively. The productivity of the flock to date is 21.0 kg of weaned goat per doe joined per year.

INTRODUCTION

One of the research topics of the Department of Tropical Animal Production (the Netherlands) is the efficiency of meat production in West African Dwarf goats. The department has kept a flock of these goats since 1978, mainly for nutritional studies and to investigate climatic effects on production. Kids are raised at least once a year, and it is from this regular breeding cycle that routine data on reproduction and weight gain are recorded. Reproduction and growth rate are important factors in meat production, and the major parameters affecting these are litter size at birth and weaning, litter weight at birth and weaning, gestation length, and gain from birth to weaning. The combination of these parameters leads to information on animal productivity in terms of meat production per doe per gestation, per year, or per lifetime.

A description of such productivity figures is given by Turner and Young (1969). With sheep data, they use a formula in which all components from mating of does to weaning of kids are taken into account. The result is a productivity index representing the number of kids weaned per doe from the original mating group. This figure gives useful information about how reproduction affects the yield of weaned offspring. In terms of meat production, we can expand Turner and Young's formula to give kilograms of goat produced per doe, per gestation, or per year, by multiplying their productivity figure by number of kiddings per doe per year and by liveweight of kids at weaning.

Sensitivity analysis is possible by varying the parameters in the formula in order to determine the effect of each parameter on total productivity.

MATERIALS AND METHODS

Most dwarf goats in the Netherlands are kept exclusively as pets and were originally imported from West Africa, particularly from Cameroon. Our Department's experimental flock was purchased in 1978 in the Netherlands. Their conformation is still similar to the original West African Dwarf goat although mature weight and body measurements are up to 50% higher in some animals. (These differences are possibly due to some crossbreeding in the past and/or to better feeding). There is no evidence of a particular breeding season. In the past 5 years about 300 kiddings have taken place, and the reproduction data presented in this paper are based on these events.

Housing

The goats are kept mainly indoors in group pens with plywood walls and concrete floors bedded with wood scrapings. In these pens separate feeding cubicals are available, and are sometimes used to feed concentrates individually. Kidding takes place in individual pens, but does and kids are usually returned to the group pens within 1 or 2 days post partum.

Feeding

The flock is kept on a high plain of nutrition. All goats receive hay *ad libitum*. Pregnant and lactating does receive concentrates at a level of 60 g. $kg^{-0.75}.d^{-1}$ during the last month of pregnancy and in the suckling period. Kids have access to creep feeding, where rhoughage, concentrates and water are available *ad libitum*.

Breeding

Based on the requirements for experimental animals, controlled breeding of the flock is practised. Mating of does takes place by admitting the buck three times daily to a group of animals to serve the does on heat. The number of matings per buck per day is restricted to three. If a second or third goat is on heat while the one that was served before is still willing, the second or third goat is served. In one breeding period the buck joined a group (group 005) of suckling does 10 days post partum. Here a marker was used to detect oestrus and/or matings. The use of markers was not very successful because of many misreadings, and because some does consumed them.

Measurements

The following data are routinely recorded: doe number, group, number of matings, buck number, expected kidding date, parity, litter size, litter weight, individual birth weight, weaning date, weaning weight of litter and individuals, litter size at weaning, liveweight (weekly), and particulars on kidding, gestation, suckling and disease.

Analysis of data

The productivity figure (Turner and Young, 1969) is estimated by the following formula:

$$L_{X_iJ} = \prod_{p=0}^{q-1} (1-E_{Y_pY_{p+1}}) \cdot L_{BP} \cdot \prod_{j-0}^{i-1} L_{X_jX_{j+1}} \qquad (1)$$

where

L_{X_iJ} = number of kids surviving to age X_i per doe joined;

$E_{Y_pY_{p+1}}$ = proportion of does which fail from stage Y_p to Y_{p+1}; between joining and kidding are q stages. (For example: $E_{Y_0Y_1}$ = fail to come on heat; $E_{Y_1Y_2}$ = fail to conceive; $E_{Y_2Y_3}$ = lose embryos);

L_{BP} = litter size per doe kidding; and

$L_{X_jX_{j+1}}$ = survival rate of kids from age X_j to age X_{j+1}.

Formula (1) may be shortened to:

$$L_{X_iJ} = E_{PJ} \cdot L_{BP} \cdot L_{X_iB} \qquad (2)$$

where

E_{PJ} = number of does kidding per doe joined;

L_{X_iB} = number of kids surviving to age X_i per kid born.

To arrive at the number of kg of weaned weight per doe per year, we have to combine L_{X_iJ} with data on weight gain and parturition interval as follows:

$$M_{DY} = L_{X_iJ} \cdot 365/I_{BP} \cdot (W_B + A_W \cdot G_D) \qquad (3)$$

where

M_{DY} = weaned weight (kg per doe per year);

I_{BP} = interval between parturitions (days);

W_B = birth weight (kg);

A_W = age at weaning (days); and

G_D = gain per day (kg).

RESULTS

Mean values for the major reproductive and growth parameters are summarized in Table 1. These mean values may be useful to compare with data from literature, and as standards for future comparison, but they do not give direct information on productivity. Therefore, Table 2, which is based on 383 does, provides data on reproductive productivity (L_{X_iJ}). Litter size appears to show little variation. Conception rate and pregnancy rate are somewhat more variable, while kidding percentage and survival rate display relatively

Table 1. *Major reproductive parameters and weight gain in West African Dwarf goats under intensive levels of management.*

Parameter	Number of observations	Mean ± s.d.	Range	
			min.	max.
Litter size				
at birth	174	1.83 ± 0.61	1	4
at weaning	168	1.66 ± 0.55	1	4
Litter weight (kg)				
at birth	168	2.95 ± 0.88	0.82	5.40
at weaning	139	13.73 ± 5.23	5.41	28.18
Gain, birth to weaning (g/day)	139	139 ± 50	39	263
Age at weaning (days)	147	80.2 ± 21.1	28	148
Gestation period (days)	120	146.4 ± 2.3	141	152
Kidding interval (days)	36	193 ± 21	165	239
Birth weight (kg)	308	1.61 ± 0.36	0.54	2.69
Weaning weight (kg)	238	8.15 ± 2.48	2.76	16.40
Gain, birth to weaning (g/day)	238	83 ± 19	25	148

little variation. The resulting variation in reproductive productivity is very high, up to more than 100%.

DISCUSSION

In this paper we will restrict ourselves to the matter of meat productivity and the effects of the different parameters on this value.

The combination of formulas 2 and 3 gives:

$$M_{DY} = E_{PJ} \cdot L_{BP} \cdot L_{X_iB} \cdot \frac{365}{I_{BP}} \cdot (W_B + A_W \cdot G_D) \quad (4)$$

If the mean values for these parameters are used (Tables 1 and 2), a productivity index of 21.0 kg of weaned weight per doe joined per year is indicated. This is based on the following data: $E_{PJ} = 0.81$; $L_{BP} = 1.83$; $L_{X_iB} = 0.91$; $I_{BP} = 193$ days; $W_B = 1.6$ kg; $G_D = 0.883$ kg; $A_W = 80$ days.

A sensitivity analysis of the effects of various parameters on productivity is presented in Table 3. The proportional factors (E_{PJ}, L_{X_iB}) will have a

Table 2. *Reproductive data and reproductive productivity (L_{X_iJ} = number of weaning kids per doe joined) per mating group.*

Mating group	002	003	004	005	006	007	008	009	010
No. of does joined	19	9	52	49	50	78	46	36	44
conception rate[a]	0.64	0.89	0.69	0.47	0.50	–[c]	–[c]	–[c]	–[c]
pregnancy rate[b]	1.00	0.89	0.94	0.96	0.68	0.95	0.98	0.86	0.84
Proportion kidding (E_{PJ})	1.00	0.67	0.94	0.96	0.68	0.87	0.91	0.78	0.50
litter size (L_{BP})	1.79	1.50	1.55	1.86	1.68	1.87	1.93	1.64	1.82
survival rate (L_{X_iB})	1.00	1.00	0.92	0.90	0.91	0.92	0.89	0.72	0.93
reprod. productivity (L_{X_iJ})	1.79	1.00	1.34	1.61	1.04	1.50	1.57	0.92	0.84

[a] Conception rate: $\frac{\text{no. of pregnant does}}{\text{no. of matings}}$

[b] Pregnancy rate: $\frac{\text{no. of does served}}{\text{no. of does joined}}$

[c] Values not yet available.

Table 3. *Percentage effects of various reproductive parameters on meat production (M_{DY}).*

Parameters	Change	Change in (M_{DY}) (%)
Litter size at birth (L_{BP})	+ 0.1 kid	+ 5.5
Kidding interval (I_{BP})	− 20 days	+ 11.6
Rate of gain (G_D)	+ 10 g.d^{-1}	+ 9.7
Birth weight (W_B)	+ 0.1 kg	+ 1.2
Total effect of above parameters		30.5

proportional effect on productivity. The results show the effect of a change in each parameter on overall productivity, and indicate that parameters strongly affected by the environment have the greatest impact on productivity expressed on the basis of weaned body weight.

This is reflected in the data in Table 2 and in the large standard deviations for these parameters given in Table 1. Environmental effects have a tendency to act cumulatively, and in the present example would affect an increase or decrease in productivity of approximately 30%.

In some mating groups, low productivity has only one major cause. In group 006 (Table 2), for example, low pregnancy rate is the major factor affecting productivity, although reasons for this low pregnancy rate are unclear. Groups 009 and 010 were subgroups which were moved to another farm, where housing was less favourable and supervision less strict. In group 009, which kidded during winter, this change was reflected in a high mortality. In group 010, which kidded during summer, a large number of abortions occurred. Here too, the reasons are not clear. A preliminary estimate of productivity in these two groups is approximately 12 kg of weaned weight per year, which is little more than 50% of the average value. Thus it appears that careful feeding, housing and especially management are important prerequisites for high productivity. This is likely to be even more important if genetic traits are improved.

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Feed intake and weight gain of West African Dwarf goats

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ABSTRACT

Two experiments with a total of 46 animals were carried out to measure feed intake and weight gain of West African Dwarf goats when fed ad libitum hay (Treatment A) or ad libitum hay plus varying amounts of concentrates: 30 $g.kg^{-0.75}.d^{-1}$ (B), 60 $g.kg^{-0.75}.d^{-1}$ (C) and ad libitum (D). Mean intake of organic matter (OM) from concentrates was 0, 23.6, 46.2 and 64.7 $g. kg^{-0.75}.d^{-1}$ for treatments A to D respectively, and intake of OM from hay was 49.7, 30.3, 15.3 and 6.7 $g. kg^{-0.75}.d^{-1}$. Total intake of organic matter, expressed as % of body weight, was 2.7, 2.8, 3.2 and 3.7, and mean daily weight gain per treatment was 16, 35, 58 and 87 $g.d^{-1}$ respectively. Intake of digestible organic matter y ($g.d^{-1}$) was related to metabolic weight x_1 ($kg^{0.75}$), and to weight gain x_2 ($g.d^{-1}$), as follows: $y = 26.0\ x_1 + 2.41\ x_2$. These preliminary results suggest that the NRC estimates for maintenance requirements of pen-fed goats are correct, but that energy requirements for gain are 25% higher than is suggested in the feed requirement tables of the NRC. It is suggested that goats should not be looked upon as animals which are less demanding in terms of feed quality than sheep.*

INTRODUCTION

Feed intake and weight gain are important parameters in determining the efficiency of animal production. Many data are available for cattle, pigs, sheep and poultry. However, information on goats, especially meat goats, is scarce with regard to these parameters. Because of the importance of meat goats as farm livestock in the humid tropics of West Africa, the Department of Tropical Animal Production of the Agricultural University in Wageningen, the Netherlands, cooperates with the University of Ife, Nigeria, in a research programme on West African Dwarf goats.

This paper summarizes the results of two feeding trials with West African Dwarf goats in Wageningen. The primary objective of these experiments was to measure feed intake and weight gain of goats fed on hay, or hay plus various levels of concentrates.

MATERIALS AND METHODS

In both experiments, 24 castrated West African Dwarf goats (average age 6 months) that had received *ad libitum* hay plus a limited amount of concentrates (45 $g.kg^{-0.75}.d^{-1}$) since weaning, were divided into four treatment groups of six animals each. The first group (A) received *ad libitum* hay only; the other three received *ad libitum* hay plus varying levels of concentrates: 30 $g.kg^{-0.75}.d^{-1}$ (B), 60 $g.kg^{-0.75}.d^{-1}$ (C) and *ad libitum* (D). The composition of these feeds is summarized in Table 1.

Table 1. *Composition of feeds as % of dry matter.*

Feed experiment	Hay I	Hay II	Concentrate[a] I	Concentrate[a] II
Organic matter	89.6	88.8	90.7	90.8
Crude protein	13.2	16.1	18.4	18.4
Ether extract	–	–	1.8	2.5

[a] Cassava meal (30%), soybean meal (25%), maize (15%), maize gluten feed (10.2%), alfalfa meal (10%), molasses (7%), lime (1.5%), salt (0.8%), mineral mix (0.5%).

All animals had free access to water and salt licks. Throughout the experimental periods, 56

* *National Research Council (USA).*

days in Experiment I and 59 days in Experiment II, the animals were housed in individual metabolism cages with screen floors, which allowed separate collection of faeces and urine. The animals were accustomed to this kind of housing, as well as to the experimental rations, at least 1 week before the beginning of each experimental period. Hay was offered in the morning and in the afternoon in amounts to provide an excess of at least 25%. Concentrates were offered in the morning. Refused feed was removed before the morning feeding. Intake and digestion of feed were measured in both experiments during two 1-week periods: days 12–19 and 47–54 in Experiment I, and days 14–21 and 39–46 in Experiment II. Liveweight (W) of the animals was measured once a week before the morning feeding, except during those weeks when intake and digestibility were measured. The amount of concentrates offered to animals on Treatments B and C was adjusted every 2 weeks according to the last liveweights. Liveweight gain (G) was estimated by linear regression of W in time.

RESULTS

Data on feed intake and weight gain are summarized in Table 2. Data for two animals in Experiment I (one on Treatment C and one on Treatment D) were incomplete and are therefore not included in the analysis. For most parameters no significant differences between the mean values of the two experiments were found. Significant differences between parameters in the two experiments are indicated in the table.

All animals in Treatments B and C consumed the total amount of concentrates offered; i.e. amounts equivalent to 23.6 and 46.2 g $OM.kg^{-0.75}.d^{-1}$ respectively. *Ad libitum* intake of concentrates in Treatment D averaged 64.7 g $OM.kg^{-0.75}.d^{-1}$ or 71.3 g dry matter, with a coefficient of variation of 14.3%. Intake of organic matter from hay decreased sharply with increasing intake of concentrates. This decreased intake of hay as a result of concentrate consumption in Treatments B, C and D, as compared with Treatment A, represents replacement ratios of 0.82, 0.74 and 0.66 g of hay per g of concentrates. Thus, the largest decrease in hay consumption occurred at the lower level of concentrate intake. Animals that received *ad libitum* concentrates ate very little hay. For these animals hay constituted on the average only 9.4% of total intake. For two individual animals, hay intake was less than 5% of total intake. Notwithstanding this high level of

Table 2. *Feed intake and weight gain of West African Dwarf goats on ad libitum hay plus varying levels of concentrates* (± SD).

Treatment	A	B	C	D
No. of animals	12	12	11	11
Amount of concentrates offered (g fresh weight.$kg^{-0.75}.d^{-1}$)	–	30	60	*ad lib.*
Initial weight (kg)	11.5 ± 1.5	12.0 ± 2.1	11.5 ± 1.8	12.1 ± 2.5
Final weight (kg)	12.5 ± 1.8	14.0 ± 2.0	15.0 ± 1.9	17.0 ± 2.0
Intake of organic matter:				
concentrates ($g.kg^{-0.75}.d^{-1}$)	–	23.6 ± 0.3	46.2 ± 0.5	64.7 ± 9.2
hay ($g.kg^{-0.75}.d^{-1}$)	49.7 ± 6.7	30.3 ± 5.2	15.3 ± 7.4[a]	6.7 ± 2.2
total ($g.kg^{-0.75}.d^{-1}$)	49.7 ± 6.7	53.9 ± 5.1	61.5 ± 7.2[b]	71.4 ± 10.8
total ($g.kg^{-1}.d^{-1}$)	26.7 ± 3.5	28.4 ± 3.1	32.1 ± 3.2[c]	36.6 ± 6.9
Intake of digestible organic matter ($g.kg^{-0.75}.d^{-1}$)	30.5 ± 3.8	37.5 ± 3.7	46.6 ± 3.6	55.9 ± 8.5
Weight gain ($g.d^{-1}$)	15.8 ± 6.8	35.1 ± 8.5	58.5 ± 11.1	87.0 ± 21.2
Ratio, intake of organic matter from concentrates/weight gain	–	4.9 ± 1.4	5.7 ± 1.2	5.8 ± 1.1

[a] Exp. I: 21.1 ± 4.7; Exp. II: 10.5 ± 5.6

[b] Exp. I: 67.3 ± 4.5; Exp. II: 56.7 ± 5.3

[c] Exp. I: 34.5 ± 2.1; Exp. II: 30.1 ± 2.5

concentrate intake, no digestive disorders were observed.

Apparent digestibility of consumed organic matter (d, in%) was closely related to the fraction of concentrates (fc, in %) in the consumed feed:

Exp. I : $d = 59.2 + 0.182\, fc$ (RSD = 2.0)

Exp. II : $d = 63.7 + 0.190\, fc$ (RSD = 1.2).

Thus, at the same concentrate/hay ratio, digestibility was about 5 percentage units higher in the second experiment than in the first, and in both cases digestibility of concentrates was nearly 20 percentage units higher than digestibility of hay. As a result, intake of digestible organic matter (DOM) was 1.83 times higher on Treatment D than on Treatment A, whereas intake of total OM was only 1.44 times higher.

Animals on the all-hay ration gained 16 $g.d^{-1}$, which is only 18% of the daily weight gain of animals on hay plus *ad libitum* concentrates. The amount of concentrates consumed per gram liveweight gain varied considerably between individual animals. The mean values for Treatments C and D (5.7 and 5.8 g concentrate OM per g of gain) suggest, however, that the return from concentrates does not diminish when this is offered *ad libitum* compared to a level equal to about 70% of *ad libitum* (Treatment C).

Mean liveweight gain per treatment was linearly related to intake of DOM. The estimate of energy requirements for maintenance and gain resulted in the equation:

$$IDOM = 26.0\ (SE \pm 1.22)\ W_m^{0.75} + 2.41\ (SE \pm 0.152)\ G \quad (RSD = 28.4, df = 44)$$

where

IDOM = intake of DOM in $g.d^{-1}$;

W_m = mean liveweight during the experimental period; and

G = liveweight gain in $g.d^{-1}$.

Transformation of DOM into kJ ME (using the same conversion factors as NRC, 1981) yields the estimates of 410 ± 19.2 kJ $ME.kg^{-0.75}.d^{-1}$ for maintenance and 38.0 ± 2.40 kJ ME per gram liveweight gain.

DISCUSSION

Feed intake varies with weight, physiological status and breed. Although much higher intakes have been recorded for dairy goats, it is widely assumed that for meat goats intake of dry matter will not exceed 3% of liveweight for any extended period of time (Devendra, 1980; Morand-Fehr, 1981). Mba et al (1975) reported intakes by Red Sokoto goats of up to 9% of body weight, but this figure is incompatible with the rest of their data and may be the result of errors. In our experiments, dry matter intake of animals on hay only averaged 3% of body weight. On Treatment D (*ad libitum* concentrates) intake increased to 4%. Naude and Hofmeyer (1981) found a value higher than 3% in Boergoat kids. Apparently dry matter intake of meat goats can be higher than 3% of body weight if good quality feed is offered. It should, however, be realized that expressing feed intake as a percentage of body weight leads to inflated figures when it concerns small animals such as dwarf goats. For comparisons with other animals, it is more meaningful to express intake per unit metabolic weight ($W^{0.75}$). When expressed in this way, the feed intake of West African Dwarf goats, as measured in our experiments, can by no means be considered exceptionally high. Dry matter intake of animals receiving only hay averaged 56 $g.kg^{-0.75}.d^{-1}$ and intake of digestible organic matter averaged just over 30 g. $kg^{-0.75}.d^{-1}$. Thus, when offered *ad libitum* hay with a digestibility of 60% and 13 to 16% CP, West African Dwarf goats ate only 17% more than their maintenance requirements. This confirms our experience with much larger numbers of animals in the flock indicating that West African Dwarf goats do not perform well on hay alone, even if this is of good quality. For these animals to perform adequately, hay needs to be supplemented with concentrates. As our results show, intake of hay then decreases. Maximum gains are only obtained with high levels of concentrates which almost entirely replace the intake of hay. The average intake of digestible organic matter of animals on *ad libitum* concentrates (55.9 $g.kg^{-0.75}.d^{-1}$) was equivalent to 2.15 times the estimated maintenance requirements, and similar to the maximum intake of energy by growing sheep and cattle.

Reliable data on growth rates of West African Dwarf goats are scarce. Data on growth rates of West African Dwarf goats in Ghana were presented by Sada and Vohradsky (1973), and Adebowale and Ademosun (1981) presented data on growth rates of Nigerian West African Dwarf goats. Wilson (1958) published data on East African Dwarf goats in Uganda. In several cases, the levels of feeding described in these papers are not clear. The reported weight gains, even when the plane of nutrition is described as high or improved, are in most cases lower than the maximum group average of our experiments. In particular it is noted that Adebowale and Ademosun measured a weight gain of only 30 to 50 $g.d^{-1}$ in animals that received *ad libitum* concentrates. Wilson's data on East African Dwarf goats showed maximum gains of 85 to 100 $g.d^{-1}$, which is about the same as was found in our experiments. Much higher weight gains of West African Dwarf goats, 400 $g.d^{-1}$ or more, were reported by Akinsoyinu et al (1975; 1976) and Oyenuga and Akinsoyinu (1976). It would appear, however, that these data are unrealistic: if such gains could be achieved, West African Dwarf goats would reach their mature weight in a few months' time.

Estimates of the energy requirements for maintenance of goats have recently been reviewed by Devendra (1980), Sengar (1980), Morand-Fehr (1981) and NRC (1981). There is considerable variation in the reported estimates. The differences may partly be explained by the fact that some of the quoted values refer to lactating dairy goats while other values refer to meat goats. However, in some cases, different reviewers derived different figures from the same original papers.

Besides simple misquoting, this may reflect confusion as to the way in which values were obtained. Several of the original estimates are based on experiments of questionable design, with very small numbers of animals and/or questionable analyses of the data. Our estimate of 410 kJ $ME.kg^{-0.75}.d^{-1}$ for pen-fed West African Dwarf goats is close to the value of 424 kJ which is used for pen-fed goats by NRC (1981).

While Mohammed and Owen (1980) concluded that the maintenance requirements of castrated goats are substantially greater than those of wether sheep, it would appear from our results that the maintenance requirements of pen-fed goats are not lower than those of sheep. As is pointed out by NRC (1981), the maintenance requirements of goats may be considerably higher when the animals are allowed more freedom of movement. In addition to this, our data suggest that the quoted value may only be valid for animals with a high weight of gut fill, as occurs when animals are fed on all-roughage rations. Animals on high levels of concentrates may have a much lower gut fill or a higher empty body weight and, consequently, a higher maintenance requirement when this is expressed on the basis of full body weight.

The estimate of requirements for gain, as used by NRC (30.3 kJ ME per g of gain), is based on three original values from the literature: 42.6, 21.5 and 26.9 kJ. These data differ so much from one another that taking a simple mean must be considered a doubtful basis for formulating feeding standards for goats. The first value is based on work with only six goats by Devendra (1967). Moreover, the figure quoted by NRC (1981) is the one which followed from the first step in the analysis of the data and this value should not, according to Devendra himself, be taken as the appropriate estimate. Whether the other estimates used as a basis for the NRC standards are any more accurate is unclear to us because the original papers could not be obtained.

Our present estimate of the requirements for gain (38.0 kJ ME per g of gain) is 25% higher than the value assigned by NRC (1981). In addition, our estimate would be still higher (44.4 kJ ME per g of gain) if G instead of IDOM were chosen as the dependent variable in the regression equation. There is considerable disagreement in literature as to which procedure should be followed (e.g. ARC, 1980). The value of 30.8 kJ ME per g of gain does not differ markedly from values obtained by similar procedures of analysis for growing sheep. According to NRC (1975), sheep of 30 to 50 kg liveweight require 33 to 48 kJ ME per g of gain.

Goats are sometimes described as exceptionally capable of digesting and utilizing poor-quality feeds, and as having low requirements for maintenance and production. The former part of this suggestion may originate in the fact that farmers in Europe were advised in the past that kitchen offal could be fed to goats. Kitchen 'offal' is, however, not equivalent to low-quality feed; on the contrary, in terms of ruminant nutrition, it may be of very high quality. Utilizing this material for goats was one way of meeting a demand for a variety of feeds, which is a well established characteristic of goats. Louca et al (1982) concluded that goats derive their advantage from an ability to consume vegetation types not normally eaten by other ruminants, and from a higher digestive efficiency for poor-quality roughages. Van Soest (1982), however, suggested that the conclusion that goats digest feed better than sheep and cattle is merely the result of the goats' sharper selection from the material offered.

The first priority for programmes designed to improve goat production is to understand properly the requirements of these animals. Critical experiments, rather than superficial observations tending to confirm existing ideas, are badly needed. Of course, in developing countries, it may not be acceptable to base goat production on *ad libitum* concentrate feeding. The challenge then is to investigate which other feeds can be used to meet the requirements of goats. The great experience of the traditional goat farmer is likely to be the best starting point.

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Goat management research at the University of Ife

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ABSTRACT

To date, results of research on the management of West African Dwarf goats show that intake of dry matter and digestible dry matter from grasses such as Cynodon nlemfuensis and Panicum maximum are too low to sustain reasonable levels of production. Substantial improvements in feed intake and digestibility can be achieved by feeding legumes such as Gliricidia sepium and Leucaena leucocephala, although additional research is needed on the optimum levels at which these legumes can be fed.

INTRODUCTION

Early livestock development programmes in Nigeria emphasized cattle improvement, particularly through disease control. Dwarf sheep and goats have been neglected in livestock development programmes, principally because they were regarded as poor feed converters, slow growers, and animals destined to roam the countryside, subsisting on kitchen wastes and bush grazing. However, these small animals have a definite advantage over other breeds in that they are adapted to the environment of the humid zone: they continue to make substantial contributions to meat consumption; they are particularly favoured for festivals in certain parts of Nigeria; and their meat can be handled easily by small families and communities in the absence of refrigeration.

Investigations were initiated with dwarf sheep and goats at the University of Ife in the late 1960s, when these animals were used mainly in forage evaluation studies. It was soon realized that external assistance and collaboration with other bodies would be required, and in 1978 an approach was made to the Small Ruminant Programme of the International Livestock Centre for Africa (ILCA). This led to negotiations with the Agricultural University at Wageningen, the Netherlands, and ultimately to the present project located at the University of Ife. The broad objectives of the project are:

1. To study the management and economics of production of West African Dwarf goats in the humid tropics;
2. To develop research facilities;
3. To disseminate research results;
4. To train scientists.

The project started in September 1981 and currently has a flock of about 90 goats.

FEEDING STUDIES

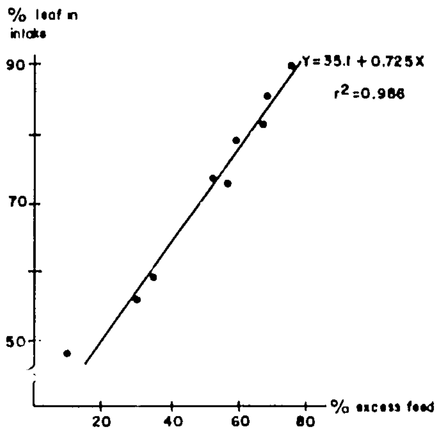
From the beginning it was felt that any improved goat production system in the humid zone of Nigeria would have to be based on locally available fodder resources. Therefore, the main research effort was directed to the assessment of the nutritive value of these forages. In the first experiment, the effect of selective consumption of poor-quality, dry-season Star grass hay (*Cynodon nlemfuensis)* on feed intake and digestibility was measured. The dry matter intake appeared to be very low, ranging from 32 to 40 g per kg metabolic weight ($W^{0.75}$). When more hay was offered, a more leafy diet was selected from the hay. This led to an increase in voluntary intake, higher digestibility, and higher crude protein content in the selected feed compared to the feed on offer (Table 1). There appeared to be a close positive relationship between the percentage excess feed and the amount of leaf in the selected diet (Figure 1). These results further illustrate the selective eating habit of goats; in this example, the most nutritious feed component was consumed first.

Table 1. *Effect of level of Star grass hay (Cynodon nlemfuensis) offered to West African Dwarf goats on voluntary intake, selective consumption and digestibility.*

Number of animals	DM offered ($g.kg^{-0.75}.d^{-1}$)	% leaf in hay offered	% leaf in selected diet	DM intake ($g.kg^{-0.75}.d^{-1}$)	Digestibility (%)	DM intake ($g.kg^{-0.75}.d^{-1}$)	% CP in hay offered	% CP in selected diet
3	44	43.2	54.5	32.3	40.1	13.0	4.3	4.8
3	88	43.2	75.2	40.6	43.2	17.5	4.3	5.7
3	131	43.2	86.7	39.9	46.4	18.5	4.3	6.2

Guinea grass *(Panicum maximum)* was used in several feeding trials. Its nutritive value was

Figure 1. *Selectivity of WAD goats fed on Star grass hay (Cynodon nlemfuensis) as influenced by the level of feeding.*



evaluated when the grass was either young and nutritious, or when it was dry-season standing hay. Dry matter intake (DMI) varied from 54.9 $g.kg^{-0.75}.d^{-1}$ with young, well fertilized grass, to 43.1 $g.kg^{-0.75}.d^{-1}$ with standing hay (Table 2).

Table 2. *Effect of age of regrowth on nutritive value of Panicum maximum offered ad libitum to West African Dwarf goats.*

Age of regrowth (days)	DM intake ($g.kg^{-0.75}.d^{-1}$)	Digestibility (%)	DDM intake ($g.kg^{-0.75}.d^{-1}$)
30[a]	54.9	73.8	40.6
60[b]	48.3	47.5	22.9
90[b]	43.1	46.0	19.8

[a] Four animals; grass fertilized with 100 kg NPK/ha (15-15-15; NPK).

[b] Six animals; grass not fertilized.

These data suggest that the DMI from *Panicum* is sufficient to achieve satisfactory production levels only when the grass is relatively immature.

During the 1982/83 dry season two experiments were conducted in which *Gliricidia sepium* and *Leucaena leucocephala* were used as supplementary feed in combination with *Panicum* hay. With *Gliricidia* intake in the range of 10.8 to 31.8 $g.kg^{-0.75}.d^{-1}$, the DMI of *Panicum* was only slightly reduced as more *Gliricidia* was consumed (Table 3). The digestibility of the consumed feed improved through feeding more *Gliricidia*, and hence the effect of supplementation on digestible dry matter intake (DDMI) was even more pronounced.

Table 3. *Effect of feeding various levels of Gliricidia sepium with Panicum maximum on voluntary intake and digestibility*[a].

DM intake ($g.kg^{-0.75}.d^{-1}$)			Digestibility (%)	DDM intake ($g.kg^{-0.75}.d^{-1}$)
Gliricidia	*Panicum*	Total		
0	43.1	43.1	46.0	19.8
10.8	39.8	50.6	47.7	24.5
21.3	38.1	59.4	51.1	30.3
31.8	37.2	69.0	54.9	37.9

[a] Six animals/feeding level; DM intake of *Gliricidia* represents complete consumption of *Gliricidia* of-

The results of a similar feeding trial using *Leucaena leucocephala* as the legume supplement are given in Table 4. This experiment was conducted in two phases. First, approximately 10 and 30 g of *Leucaena* DM per kg metabolic weight were fed. Afterwards, the animals previously on 30 g of *Leucaena* were put on 20 g of *Leucaena* DM per kg metabolic weight, and those previously on

Table 4. *Effect of feeding various levels of Leucaena leucocephala with Panicum maximum on voluntary intake and digestibility*[a].

Period	DM intake ($g.kg^{-0.75}.d^{-1}$) *Leucaena*	*Panicum*	Total	Digestibility (%)	DDM intake ($g.kg^{-0.75}.d^{-1}$)
1	10.7	39.6	50.3	39.8	20.0
1	31.6	36.8	68.4	47.8	32.6
2	0	48.3	48.3	47.5	47.5
2	20.6	45.5	66.1	52.1	34.4

[a] Six animals/feeding level; DM intake of *Leucaena* represents complete consumption of *Leucaena* offered.

10 g of *Leucaena* were not fed *Leucaena* but were fed only the basal *Panicum* hay. The results are in line with those of the previous trial, except that there appeared to be a marked improvement in both voluntary intake and digestibility over time.

In experiments with either *Gliricidia* or *Leucaena* the improvement in digestibility, dry matter intake and digestible dry matter was linearly related to the amount of legume fed. These results suggest that even higher intake and digestibility might be achieved with higher legume levels, including an 'all-legume' treatment.

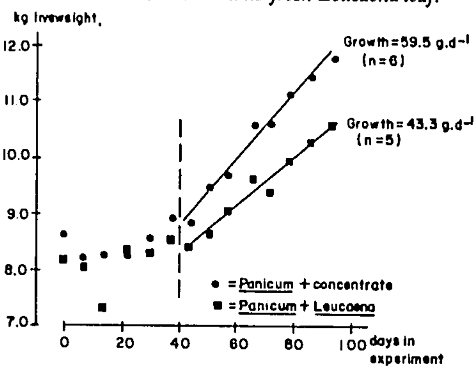
Similar results have been recorded by Zemmelink et al (1984) with West African Dwarf goats in the Netherlands. The feeding of increasing levels of concentrates with a basal diet of *ad libitum* hay resulted in a decreasing intake of hay but increasing total organic matter intake (OMI) and increasing growth rates.

Cynodon and *Panicum* are two grasses commonly evaluated as livestock feeds in southwestern Nigeria. The levels of intake recorded with these grasses are so low that they cannot be expected to sustain reasonable levels of production in goats. The data in Tables 3 and 4 on feeding of *Panicum* hay showed a DDMI of only about 20 $g.kg^{-0.75}.d^{-1}$. Lower intake figures were recorded with *Cynodon* (Table 1). In experiments where hay was fed to West African Dwarf goats in the Netherlands, an OMI of about 50 $g.kg^{-0.75}.d^{-1}$ was recorded. This resulted in growth rates of about 16 $g.d^{-1}$ (Zemmelink et al, 1984). This is considerably higher than the intake levels recorded here.

In June 1983, a first group of eleven young male goats became available for experimental purposes. In order to assess their growth potential, these animals were put on a long-term growth trial. Six animals were fed ***ad libitum*** concentrate and fresh Guinea grass, while five animals were fed the same fresh Guinea grass plus fresh *Leucaena* leaf at the level of 50 g $DM.kg^{-0.75}.d^{-1}$. Animals were permanently housed in metabolic cages, and feed intake and digestibility were measured at regular intervals.

Although the experiment is still in progress, the growth data over the first 100 days are shown in Figure 2. The animals in both groups needed an adaptation period of approximately 40 days before they started gaining weight. Over the next 60 days, the animals receiving concentrate grew at a rate of 59.5 $g.d^{-1}$, while the animals receiving *Leucaena* grew at 43.3 $g.d^{-1}$.

Figure 2. *Liveweight gains of young male WAD goats when fed fresh Panicum maximum and ad lib concentrate or ad lib fresh Leucaena leaf.*



These growth data are similar to other results recorded in the humid zone (Ademosun, 1973; Adebowale and Ademosun, 1981). However, they are lower than those recorded for the same breed of goats in the Netherlands (Hofs et al, 1984).

MANAGEMENT AND HOUSING

During the first year of the project newly purchased goats were kept under grazing. *Cynodon nlemfuensis* was the main roughage fed, and later *Panicum maximum* was offered in restricted amounts. A concentrate mixture of whole maize (50%), rice bran (30%), brewers' dried grains

(10%), groundnut cake (7.5%), and minerals and salt (2.5%), was provided at a rate of 200 g. d^{-1} for dry animals and 500 g. d^{-1} for lactating animals. Even with this substantial supplement, it was extremely difficult to maintain body condition and herd health. Both ecto- and endoparasitic infestations required expensive treatment. Voluntary grazing time was limited, and mortality of offspring was extremely high.

Consequently, in September 1982 the flock was confined, and cut-and-carry feeding was substituted for grazing. The main forages used were *Panicum maximum, Gliricidia sepium* and *Leucaena leucocephala*. Concentrate supplement, as indicated above, was still provided individually for adults and growers, whereas creep feeders were used to provide concentrate and forages to suckling kids. The use of bamboo as a low-cost building material was tested by constructing slatted floors expected to improve hygienic conditions (especially for kids), facilitate collection of faeces for application to farm land and to eliminate cleaning of pens.

Based on the experience gained from constructing the bamboo floors, a low-cost goat shed with a wooden frame and bamboo-slatted floors, walls and partitions, was designed and constructed. Galvanized corrugated sheets were used for roofing. The shed provides space for 10 to 12 adult females, a breeding buck, and all offspring up to slaughter weight. The cost of the building materials in 1983 was US$ 364. This house will be used to test the profitability of goat keeping under the management system outlined above.

The management package incorporates health care, feed supply and housing. Feed will be supplied mainly from browse plants such as *Gliricidia* and *Leucaena*, from household wastes, and from industrial byproducts such as brewers' grains. Future research will revolve around improvements in health, feeding and housing. It is expected that farmers will be identified who will participate in pilot projects in Oyo and Ondo States. This will involve a team of animal scientists, agronomists and extension specialists. It is hoped that this project will make a significant impact on goat production in southwest Nigeria.

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SHEEP AND GOATS IN THE FARMING SYSTEM

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Small ruminant feed production in a farming systems context

J.E. SUMBERG

ABSTRACT

ILCA's research with integrated alley farming and browse feeding is discussed in relation to the role of small ruminants in the farming systems of southwest Nigeria. Cut-and-carry browse feeding for sheep and goats, and a grazed fallow system for sheep, are outlined. Preliminary biological and economic parameters for both systems are presented. The potential application of these approaches in other areas of humid West Africa is discussed.

INTRODUCTION

In southwest Nigeria agriculture is dominated by arable food and tree crops, including maize *(Zea mays* L.), yam *(Dioscorea* spp.), cassava *(Manihot esculenta),* cocoa *(Theobroma cacao)* and oil palm *(Elaeis guineensis).* Although sheep and goats are present in many rural households, they appear to be poorly integrated in the agricultural production system (Matthewman, 1980). The majority of small ruminants in this part of Nigeria are kept in free-roaming village flocks with only limited management or capital inputs. The average flock ranges from two to five animals per owner, with goats being more common than sheep. Feeding household scraps to animals is a common practice. Few animals receive veterinary care, and mortalities within the first 3 months after birth are high. *Peste des petits ruminants* (PPR), a rinderpest-related disease, is perhaps the most important cause of early mortality, particularly among goats. Preliminary results from village trials show that PPR can be effectively and economically controlled with tissue culture rinderpest vaccine (TCRV) (Opasina, 1984; Adeoye, 1984).

The Small Ruminant Programme of the International Livestock Centre for Africa (ILCA) at Ibadan, Nigeria, is aimed at improving the productivity of indigenous breeds of sheep and goats in this area. Apart from disease, nutrition is probably the most important factor limiting productivity. While it is difficult to demonstrate a seasonal feed shortage under present management conditions, there are compelling reasons why the feed situation deserves attention. PPR control is expected to reduce mortalities substantially, and may thus increase animal numbers and heighten demand for feed. Larger animal populations, in combination with future pressure to control animal movement around villages, gardens and farms, will likely result in some form of animal confinement. Total confinement of sheep and goats is already common in some parts of eastern Nigeria, necessitating cut-and-carry feeding and an easily accessible feed supply.

The importance of crop production relative to livestock production in this area dictates that the increased attention given to small ruminant production must also show a positive effect on crop production. For this reason, ILCA is evaluating ways of linking crop and small ruminant production based on the use of fast-growing leguminous trees such as *Leucaena leucocephala* and *Gliricidia sepium.* The foliage of these trees can be used as a high-quality fodder and as a nitrogen-rich mulch for crop production.

Kang et al (1981) described an alley cropping system in which crops are grown in alleys between rows of frequently pruned trees. The large input of nitrogen and organic matter from the tree foliage can potentially support continuous cropping at intermediate yield levels. Alley cropping appears to be an attractive alternative to the traditional bush fallow system of maintaining soil fertility. Small ruminant production can be integrated with alley cropping by cut-and-carry feeding of a portion of the tree foliage, or, at a somewhat higher management level, by grazing the natural fallow regrowth and trees during periodic fallow years. While cut-and-carry feeding is applicable to sheep and goats, the grazing system is limited to sheep because goats readily de-bark the trees.

This paper describes ILCA's experiences and current research with both approaches to integrated alley farming. The rationale for emphasizing alley farming and browse feeding will be developed, and the potential for these approaches in other areas of West Africa will be discussed.

ALLEY FARMING

The fast-growing leguminous trees *Leucaena leucocephala* and *Gliricidia sepium* are the focus of much of ILCA's agronomy, feed and nutrition work because of their potential role in linking crop and animal production. These trees can provide high-quality fodder and nitrogen-rich mulch for crop production. When properly managed, the trees will provide fodder throughout the year. Unlike grasses and some herbaceous legumes, browse shows relatively little decline in nutritional quality during the dry season. Trees have traditionally played an important role in the farming systems of humid West Africa, and the browse trees that are the basis of alley farming can be seen as an extension of this tradition.

The integrated alley farming approach is based on the initial work of the Farming Systems Program of the International Institute of Tropical Agriculture (IITA). Crops are grown in 4-m wide alleys between rows of densely planted trees which are pruned three to five times during each growing season. Trees managed in this way can produce 4 to 8 t of mulch DM/ha/year, yielding over 100 kg of N for crop production.

The trees in an alley farming system are effective nutrient pumps, bringing minerals from the lower soil profile to the surface where they can be used by the crop. If leguminous trees are used, significant quantities of N are also added to the soil; indirectly from the foliage as mulch, and directly from decaying roots and nodules. This large input of minerals and organic matter can support continuous cropping at intermediate yield levels. In addition, alley cropping addresses two key issues related to the loss of bush fallow as a useful strategy for maintaining soil fertility in the humid zone – a rural labour shortage for bush clearing, and a consequent inability to maintain fertility with ever shorter fallow periods.

CUT-AND-CARRY BROWSE FEEDING

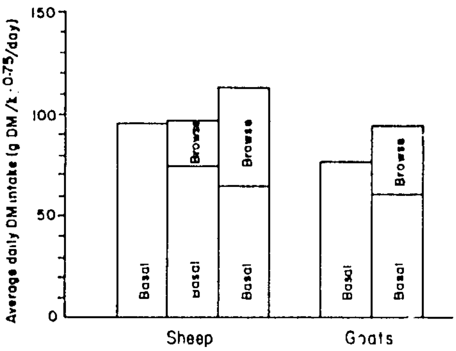
With cut-and-carry feeding of some portion of the tree foliage, small ruminant production can be linked with alley farming. The cut-and-carry system is highly flexible and can be used with free-roaming or confined animals. Depending on the availability and quality of other fodder resources, a range of browse feeding strategies can be developed. For example, browse may be fed as a protein supplement or as a sole feed. It may be fed on a year-round basis or only during the dry season. Feeding browse to only particular classes of animals, such as growing weaners or lactating dams, may be desirable in some circumstances. In order to give sufficient benefit to the crop, and avoid the possibility of soil mining, we currently recommend that approximately 75% of the available tree foliage be applied to the soil as mulch. An annual tree foliage yield of 4 t DM/ha would then give 1 t of DM for feed. This amount would be sufficient to support approximately 14 adult animals per hectare as a year-round supplement (25% of daily feed intake), or 4 animals per hectare as a sole feed.

The management of browse trees within the alley farming context must take into account the requirements of the crop for nutrients and light, as well as the seasonality of the demand for fodder. Year-round browse feeding, for example, will require a different tree management strategy than simple dry-season supplementation. One aspect of our current research involves this relationship between tree management and feed requirements.

In two long-term browse supplementation trials, West African Dwarf sheep and goats are being fed varying amounts of a mixed browse supplement in conjunction with an *ad libitum* basal diet. The objective of the trial is to determine the effect of browse supplementation on long-term dam productivity and short-term weaner growth. The basal diet consists of *Panicum maximum* of reasonable quality (freshly chopped, green, primarily vegetative growth). The diet is meant to mimic a diet of reasonable but seasonally variable quality which might be consumed by free-roaming animals in this zone. While the limitations of this approach are fully acknowledged, the experimental difficulties inherent in working with free-roaming animals are considerable.

Over 14 weeks, a mixed *Leucaena/Gliricidia* browse supplement fed at approximately 200 g DM/doe/day increased the total intake of goats by 30% (Figure 1). Fed at this level, browse constituted nearly 35% of the total DM intake. With sheep, browse supplementation of 200 and 400 g DM/ewe/day increased the total DM intake by 6 and 18% respectively. At 200 g DM/day, browse constituted 22% of dry matter intake, whereas with 400 g DM/day, it accounted for 43% of total intake.

Figure 1. *Effect of controlled browse supplementation on daily dry matter intake.*



Browse supplementation appeared to have little effect on the body weights of breeding ewes and does. Preliminary analysis of a limited number of lamb records indicates that lambs from supplemented dams were 30% heavier at 30 days of age than those from unsupplemented dams.

Over a period of approximately 2 years, the reproductive performance of dams and the survival and growth of offspring will be monitored. It is hoped that these trials will eventually provide sufficient information to evaluate browse supplementation of small ruminants under an alley farming system.

GRAZED FALLOW IN INTEGRATED ALLEY FARMING

Cut-and-carry browse feeding represents a highly flexible, relatively simple, improved feeding strategy which can be implemented with minimal capital or management inputs. The grazed fallow approach with sheep will demand greater management skills, but at the same time it represents a higher degree of integration of crop and livestock production, since all manure is potentially returned to the soil.

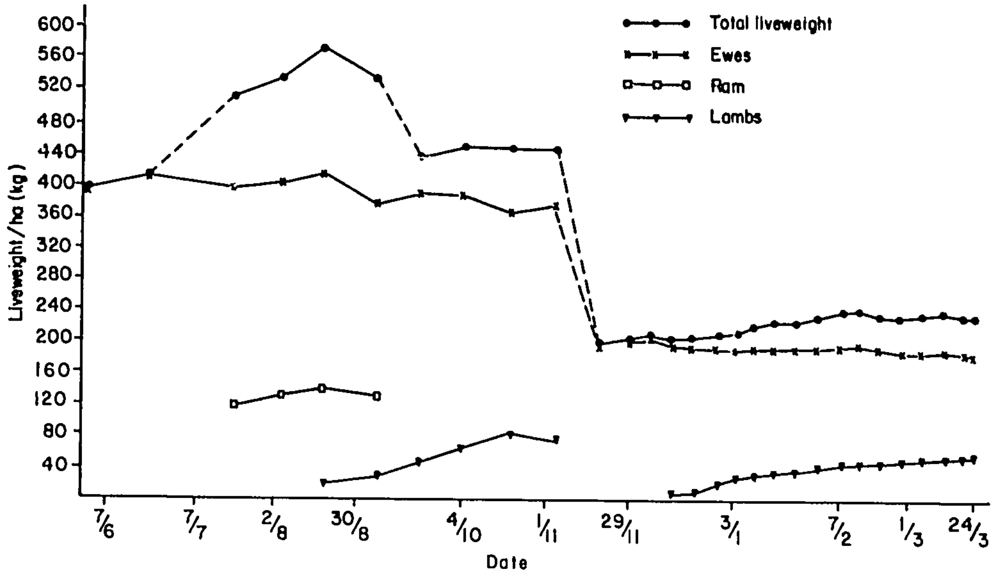
ILCA has stressed the use of natural fallow vegetation grazed in combination with browse trees to avoid the problems inherent in establishing, managing and controlling introduced pasture species. In any case, it would probably be unrealistic to establish pasture species for the small flocks, and relatively short-term fallows are envisioned in this system. The grazed fallow system, as it is now conceived, consists of a rotation of blocks of alleys with 3 to 5 years of alley cropping followed by 2 to 3 years of grazing.

In a preliminary evaluation of the grazed fallow system, two 0.25 ha paddocks containing natural fallow regrowth and *Leucaena* and *Gliricidia* planted in rows 4 m apart, were grazed by sheep between June 1982 and May 1983. Ground vegetation, browse and animal performance were monitored to estimate appropriate stocking rates for similar alley grazing systems, and to identify potential problems and limitations of the system.

The components of animal liveweight (LW) supported per hectare during the grazing period are presented in Figure 2. From 1 June to 15 November, with a stocking rate of 16 ewes/ha, the paddocks supported an average of 472 kg LW/ha. Between 15 November and the end of March, with a stocking rate of 8 ewes/ha, they supported an average of 218 kg LW/ha.

The stocking rate was reduced from 16 to 8 ewes/ha because of what appeared to be nutrition-related health problems. In addition to reducing the stocking rate, a daily *Leucaena* supplement was given to the remaining animals, by bending down and tying two to three trees daily so that the upper foliage became available for consumption. This method of supplementation provided between 100 and 200 g DM/ewe/day and approxi-

Figure 2. *Components of animal liveweight supported over a 10-month grazing period, Ibadan, Nigeria.*



mately 20 to 40 g CP/ewe/day. No further health problems were encountered after the initiation of supplementation, and it would appear that the original stocking rate might have been maintained if supplementation had been started somewhat earlier.

During the rainy season the natural fallow vegetation provided an ample supply of good-quality herbage to support the stocking rate of 16 ewes/ha (Table 1). Standing dead plant material probably provided an important source of roughage during the dry season. Although no in-

Table 1. *Monthly rainfall (mm) and feed components (kg DM/ha) on offer during a 10-month grazing period, Ibadan, Nigeria.*

Month	Rainfall (mm)[a]	Green grass	Other green plants	Dead plants	*Leucaena*	*Gliricidia*	Total DM on offer
J (1982)	1.6	-	-	-	-	-	-
F	44.6	-	-	-	-	-	-
M	92.7	-	-	-	-	-	-
A	87.9	-	-	-	-	-	-
M	124.4	-	-	-	-	-	-
J	166.7	566.7	1 147.3	550.1	694.4	104.0	3 062.5
J	136.9	1 264.5	1 869.0	460.1	968.7	111.7	4 673.9
A	75.6	1 441.8	2 178.8	714.6	1 086.1	129.2	5 550.5
S	66.1	758.7	1 574.7	929.8	727.5	92.5	4 083.2
O	102.2	754.4	1 642.3	851.0	1 089.7	0.0	4 337.4
N	8.9	507.8	1 974.0	984.8	845.3	0.0	4 311.9
D	0.0	115.9	681.8	1 553.0	585.1	0.0	2 935.8
J (1983)	0.0	0.0	0.0	1 379.3	488.7	0.0	1 868.0
F	3.9	0.0	0.0	1 417.4	259.3	0.0	1 676.7
M	3.2	0.0	0.0	1 003.0	210.8	0.0	1 213.8

[a] Rainfall data courtesy of T.L. Lawson, Farming Systems Program, IITA.

formation on feed intake was collected, it would appear that *Leucaena* became an increasingly important component of the diet as the dry season progressed. Indeed, the success of this type of alley grazing system depends on the accumulation of browse during the wet season to supplement the diminishing ground vegetation in the dry season.

The height and flexibility of the *Leucaena* trees played an important role in restricting animal access during the wet season. At the end of the grazing period the *Leucaena* trees were as tall as 7 m. While the trees with thinner trunks (1 to 3 cm in diameter) were still being successfully browsed by the sheep, larger trees were no longer accessible. The method of controlled supplementation by bending trees daily worked satisfactorily and required a minimum of labour. After all foliage was consumed, the trees were released and allowed to recover out of the reach of the animals.

Similar alley farming systems could be based on one or a combination of tree species. There may be an advantage to including several browse species to provide diversity of diet, particularly where mimosine toxicity from *Leucaena* can be important. No adverse effects from *Leucaena* were observed during the course of this trial.

Gliricidia trees suffered heavy damage from the grazing animals, and the disappointing performance of these trees largely appeared to be related to the stake establishment method. *Gliricidia* has traditionally been used for living fence posts and as plantation shade, and for these uses stake establishment has obvious advantages. Observations by ILCA in Ibadan suggest that the root systems of stake-established trees are shallow, less extensive, and significantly less tap rooted than those of seed-established trees. It is unlikely that the sheep would have been able to uproot seed-established *Gliricidia* trees, and certainly no problem of uprooting was seen with the seed-established *Leucaena*. It would also be expected that the root system morphology would have an important effect on dry-season growth and foliage production, as well as adaptation to increasingly arid environments.

The branch damage that occurred during browsing was also related to the stake establishment method. Stake-grown trees tend to sprout and branch from the top of the stake, and it was these branches which were damaged. Seed-grown *Gliricidia* can be managed to branch closer to ground level, and may be less susceptible to damage.

A partial budget analysis of this alley grazing system compared to a common crop production sequence, is presented in Table 2. At a stocking rate of 12 ewes/ha, it would appear that a short-term, grazed fallow period would be economically competitive with more traditional cropping activities. The grazed fallow period might also be advantageous with regard to improved soil fertility and crop yields. The effects of short-term grazed fallows on subsequent crop yields are currently being investigated in two major alley farming trials.

These preliminary observations indicate that alley grazing using short-term fallows and fast-growing trees is a promising approach to the integration of crop and livestock production in the humid zone of West Africa. The attractiveness of the system is its relatively low capital and management requirements. ILCA has developed an inex-

Table 2. *Partial budget analysis (US$/ha) of alley grazing with sheep and maize–cassava intercropping.*

	Alley grazing[a] (12 ewes/ha)		Maize–cassava[b] in alleys	
Gross returns	weaners (16)	768	maize	985
	adults (3)	288	cassava	728
Total		1056		1713
Variable costs	labour	288	labour	808
	salt lick	29	seed/stakes	32
	drugs	20	fertilizer	128
Total		337		968
Net returns		719		745

[a] Sale of weaners at 15 kg, adults at 30 kg at US$ 3.20/kg liveweight. Labour includes provision of water, checking of animals and tree management at 0.5 hr/day at US$ 1.00/hr. Cost of initial stock is not included, but provision is made for replacements. Assumes fertility rate of 1.3 lambs/ewe/year, and mortalities of 12, 7 and 5% in the age groups 0–4 months, 4–12 months and adults respectively. Budget covers 18 months.

[b] Maize yield of 2.5 t; cassava yield of 3.5 t as intercrop. Maize sold at US$ 448/t, cassava at US$ 208/t. Labour at US$ 1.00/hr includes 25 days for pruning tree rows. Budget covers 18 months.

pensive living fence woven from *Leucaena*, which eliminates the need for purchased fencing (Sumberg, 1983). The use of natural fallow regrowth instead of planted grasses and legumes eliminates several important management problems. Natural fallow is ready to be grazed shortly after the end of the cropping cycle, whereas planted pasture would need 3 to 12 months without grazing to ensure proper establishment. The investment involved in pasture establishment would make short-term rotations unattractive and reduce the overall flexibility of the system. The problems of pasture seed scarcity and overproduction of herbage during the wet season are also avoided, as is the danger of introducing new weed problems.

Several areas need further study, particularly the problem of tree management in the transition from cropping to grazing and grazing to cropping. Factors affecting the species composition and productivity of natural fallows also need clarification. In this regard, the effects of different weed control strategies during cropping years on the composition and productivity of subsequent fallow vegetation are being studied.

BROWSE AND ALLEY FARMING IN WEST AFRICA

Small ruminant production is a common minor farm enterprise throughout humid West Africa, and improved feeding will most certainly be an important component of intensified and/or more efficient production systems. Leguminous browse trees provide a flexible, easily managed fodder resource which appears to be particularly well suited to small-scale livestock production where more intensive technology is not applicable. Depending on the characteristics of the other farm enterprises, browse production might be integrated with cropping in a system such as alley farming, or browse trees might be grown in special feed production plots. ILCA is currently investigating the management and use of this kind of 'intensive feed garden' in eastern Nigeria where animal movement is commonly restricted, necessitating daily cut-and-carry feeding.

Alley farming addresses several important issues facing small farmers in the region, for whom fodder production is presently a minor farm concern. Alley farming, therefore, will be considered by these farmers for adaptation primarily as a crop production strategy, and only secondarily for its potential contribution to sheep and goat production. This realization should influence the way alley farming and browse feeding are portrayed by research and extension organizations. In our own on-farm research, for example, the browse trees are presented firstly for their considerable mulch and fertilizer value, and only secondly for their value as livestock feed.

Alley farming is an intensive production technique which has sufficient promise to be tested under a variety of conditions throughout the region. *Leucaena* and *Gliricidia* are the most widely used alley farming browse species, and although other potentially useful species are under investigation, ILCA's work will continue to focus on these two widely adapted, versatile species. It is hoped that our collection and evaluation of new *Gliricidia* germplasm will identify types that are more productive than the present materials, and better adapted to more arid environments (Sumberg, in press). In the coming years we will be interested in having these unique genetic resources evaluated under as wide a range of environmental and management conditions as possible.

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Small ruminant production under pressure: The example of goats in southeast Nigeria

S.D. MACK, J.E. SUMBERG and C. OKALI

INTRODUCTION

Goat husbandry in the humid zone of Nigeria is a low-input, minor farm enterprise offering potentially good but highly variable returns. The majority of rural owners are farmers involved in food and tree crop production, or women involved in food processing and marketing. Both groups of owners have relatively limited skills in livestock husbandry.

The traditional practice of permitting goats to roam freely around the village still predominates in southwest Nigeria (Matthewman, 1979). Specialized housing, systematic feeding and veterinary care are uncommon in this region. Goats depend on their ability to select an adequate diet from the naturally available vegetation. Household scraps are often available, but are probably of limited nutritional significance. The majority of goats appear to be in good condition. The mean weights of dams at 90 days post partum show no evidence of seasonality, which may indicate that they are able to obtain an adequate diet even during the dry season. However, growth rates of kids are low at 35 g/day, and the probability of kids surviving to 90 days is only 0.67 (Mack, 1983). The low levels of both of these parameters might be seen as indirect indications of nutritional stress.

The West African Dwarf goat is both fertile and prolific. Data from villages in southwest Nigeria indicate a mean litter size of 1.5 kids/litter and a mean parturition interval of 259 days (Mack, 1983). The traditional free-roaming system of management takes advantage of this reproductive potential through continuous and uncontrolled breeding. However, early conception in immature females is a potential disadvantage of this strategy, and may contribute to high kid mortality.

In southeast Nigeria, traditional goat husbandry systems are being modified by high human population density and increasing pressure on agricultural land. Lagemann (1977) noted that both goats and sheep may be restricted, either in small stockades or by tethering, to protect crops during the growing season. He further noted that with increasing population pressure compound gardens become smaller and more intensively managed, while the number of goats kept per household increases. In such areas, it would appear that free-roaming animals pose an increasingly important threat of damage to growing crops. This would seem to explain the relatively recent introduction of local laws banning free-roaming animals in ILCA's two village sites in the southeast.

The consequences of such mandated restrictions on animal movement are unclear, yet they surely demand major changes in goat management strategies. Housing, feed, water and breeding strategy become critical once animal movement is restricted. Restricted animals require a higher level of input and management than free-roaming animals, and in no area is this more clear than in the need for daily feeding.

This paper presents a prelimary analysis of some biological parameters of free-roaming and recently restricted animals. The objectives of this work are not so much to compare animal productivity under the two management systems as to describe the animals' and farmers' responses to forced changes in traditional livestock husbandry practices.

MATERIALS AND METHODS

Data for free-roaming goats have been extracted from a larger data set gathered from villages near Fasola, 60 km north of Ibadan in southwest Nigeria. Mgbakwu village in Anambra State and Okwe village in Imo State, southeast Nigeria, are used to assess the impact of restricted animal movement on management and productivity. Animal monitoring was initiated in August 1982 and February 1983 at Mgbakwu and Okwe respectively.

All animals entering the survey were identified by ear tags. Information on age, sex, dam and parity was collected for all animals entering the survey. Reasons for entry and exit were also recorded. All animals were weighed monthly. Some characteristics of the three survey areas are presented in Table 1.

normally be used to compile an index are presented.

Flock dynamics

The structure of the goat populations in each location at the beginning and end of the survey periods is given in Table 2. While the total number of goats in the free-roaming flocks at Fasola increased by 59%, goat populations decreased by 2 and 18% at Okwe and Mgbakwu respectively. In Mgbakwu 65% of households had smaller flocks at the end of the survey period than at the beginning, 14% abandoned goat keeping and 4% lost all their animals due to high mortality. In the village with free-roaming animals only 24% of households had smaller flocks at the end of the period, while none abandoned goat keeping or lost all their animals.

Table 1. *Some characteristics of three village survey sites.*

Location	Management	Number of households	Number of animals	Animals/ household	Breeding males: females
Fasola	free-roaming	15	68	4.5	1:4
Mgbakwu	restricted (tethered/ confined)	105	284	2.7	1:2.6
Okwe	restricted (confined)	65	234	3.6	1:3.8

RESULTS AND DISCUSSION

Due to the relatively short monitoring periods at the two southeastern sites, only a preliminary analysis of animal performance is possible. In none of the locations are the data sufficient to construct a comprehensive productivity index; as an alternative, the various components which would

The ratios of males to females were similar at all locations and averaged 1:1.7. The ratio of breeding males ($\geq$6 months) to breeding females ($\geq$18 months) ranged from 1:2.6 in Mgbakwu to 1:4 in Fasola.

Table 2. *Goat populations at three survey sites.*

Location	Date	Total goats	All females	Breeding females	All males	Breeding males
Fasola	30-4-82	68	57	29	11	2
	31-8-83	108	68	37	40	14
Mgbakwu	31-8-82	284	200	111	84	39
	31-8-83	234	166	100	68	41
Okwe	31-3-83	238	177	106	61	30
	31-8-83	235	172	114	63	28

Reproductive performance

Reproductive performance of does at the three locations is summarized in Table 3. The limited number of parturitions involved to date makes comparisons between sites or management systems difficult. In any case, as has been well illustrated by Upton (1985), changes in mortality (survival) of offspring have a far greater effect on productivity and potential profitability than changes in reproductive performance.

Table 3. *Reproductive performance of goats at three locations.*

Location	Number of parturitions	Litter size[1] (kids/litter)	Parturition interval (days)	Kids/doe year[2]	% of breeding does kidding per month
Fasola	41	1.7a	271 (± 89)	2.3	8.1
Mgbakwu	109	1.5b	263 (± 42)	2.0	8.5
Okwe	57	1.3c	–	–	8.8

[1] Means within columns followed by the same letter are not significantly different at P = 0.05.

[2] $$\text{Kids/doe/year} = \frac{\text{mean litter size} \cdot 365}{\text{mean parturition interval}}$$

Growth

Estimated least square means for kid weights at 30 and 90 days, and growth rate between 30 and 90 days, are given in Table 4. Kids from free-roaming does at the Fasola site were significantly heavier at both 30 and 90 days than kids from restricted does at the southeastern sites. Since there was no difference in growth rates between the sites, these differences in kid weight can be assumed to be related to lighter birth weights at the southeastern sites.

The average body weight of free-roaming does at Fasola was 21% greater than that of restricted does in the southeast. Whether due to nutritional or genotypic causes, the difference in doe body weight probably accounts for the heavier kids at the Fasola site. The similar growth rates of kids at all sites might argue against significant nutritional effects, since nutritional stress strong enough to affect dam body weight would almost certainly affect milk output, and consequently kid growth.

Table 4. *Estimated least square means for weights of 30- and 90-day kids and daily liveweight gains between 30 and 90 days.*

Location	Management system	Kid weight (kg) at: 30 days	Kid weight (kg) at: 90 days	Growth rate (g/day); 30–90 days
Fasola	free-roaming	3.5a	5.7a	36.6a
Mgbakwu	restricted	2.5b	4.7b	36.6a
Okwe	restricted	2.4b	4.4b	33.3a

Means within columns followed by the same letter are not significantly different at P = 0.05.

Mortality

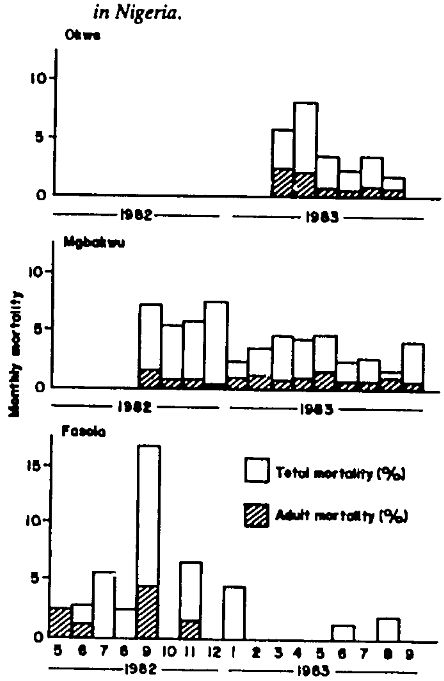
Mortality of free-roaming goats at Fasola (2.7% per month) was significantly lower than mortality at either Mgbakwu (4.5% per month) or Okwe (4.7% per month) (Table 5). Mortalities for each month of the survey period are depicted in Figure 1. Among free-roaming animals at Fasola, mortalities appeared more sporadic than at the southeastern sites. There was one confirmed out-

Table 5. *Mortalities at three locations.*

Location	Management	Average monthly mortality (%)	Aver. kid mortality from 0–90 days (%)
Fasola	free-roaming	2.6 ± 4.4	11.1
Mgbakwu	restricted	4.4 ± 1.8	24.8
Okwe	restricted	4.2 ± 2.5	18.6

break of the disease *peste des petits ruminants* (PPR) at Fasola in September 1982.

Figure 1. *Monthly mortality of goats at three locations in Nigeria.*



Initial health and disease surveys in Mgbakwu and Okwe have been inconclusive, and the major causes of the high mortalities remain unknown. In southwest Nigeria vaccination against PPR reduced mortalities by approximately 75% (Adeoye, 1984; Opasina, 1984). Although PPR is said to be widespread in the southeast, and is identified by owners as a cause of mortality, there have been few confirmed cases of PPR at the two village sites. More intensive disease monitoring has been initiated at these sites in order to identify the causes of high mortality.

While 67% of all households at Fasola experienced some goat mortality during the survey period, most of these houses lost less than 15% of their animals, and none lost more than 50%. At Okwe, mortality occurred in only 43% of households, but a number of these lost over 30% of their animals, and 5% lost all their animals. Mortality was more widespread in households at Mgbakwu, with 80% experiencing some mortality. As at Okwe, many households lost over 30% of their animals, and 4% lost all their animals.

Differences in mortality between households may be indicative of important management variations between households, or may be the effect of some epidemiological characteristics of the primary diseases causing death. In the two southeastern villages where animal movement is restricted, differences in management of individual flocks are apparent in housing, feed quantity and quality, water availability and general concern for the animals' well-being. Without a clear understanding of the causes of morbidity and mortality at these sites, the importance of such management factors is difficult to assess.

Breeding strategies

Few decisions directly related to breeding strategy appear to be made when animal movement is unrestricted. Breeding is uncontrolled and depends on the presence of mature males in the free-roaming village flock. As young males are the principle disposable product of this production system, both sales and mortality can have important implications for the village-wide breeding situation. At Fasola, for example, the ratio of breeding males to breeding females varied from 1:15 at the beginning of the survey, with 2 breeding males in the village, to 1:3 at the end, with 14 breeding males available. Periods when no breeding males were present in village flocks have also been documented in southwestern Nigeria. The effects of these changes in the availability of breeding males on reproductive characteristics such as parturition interval are not yet known.

Breeding management takes on greater importance once animal movement is restricted. At Mgbakwu and Okwe the major breeding options involve keeping a resident male or borrowing/renting a breeding male when required. At

Mgbakwu there is a small number of free-roaming males associated with a local religious shrine. These bucks are relied upon by some goat owners who make receptive does accessible to them. In the two villages studied, approximately 50% of households do not keep a breeding male; the vast majority of the flocks in these villages are single-animal flocks.

Concern over transfer of disease has been cited at both southeastern villages in relation to hesitation to either borrow or lend males for breeding. Both borrowing and renting of males are common, however, with males apparently being transferred for short periods of 2 to 5 days. Although cash payment for breeding services has been reported, some borrowers report that the service of feeding the buck for the borrowed period is considered sufficient payment. This situation illustrates the perceived burden of cut-and-carry feeding at these sites.

The free-roaming management system in southwest Nigeria can be described as a low-level, equilibrium system offering potentially good returns with a minimum of capital, labour or management inputs. Returns from this system are highly variable, however, since the disease PPR can cause significant loss of stock and has been known to destroy whole flocks. The risk of PPR is thought to limit animal populations by discouraging flock expansion.

PPR can be effectively and economically controlled by annual vaccination with tissue culture rinderpest vaccine (TCRV). While the effects of PPR control on the various components of the free-roaming management system are not known, it seems likely that increased numbers, resulting directly from reduced mortality and indirectly from a reduction in perceived risk, will put significant pressure on available feed resources. Once a form of feed production is introduced, it is not unlikely that some level of restriction of animal movement will follow. PPR will probably cause major shifts in goat management in the region. Some of these changes will be similar to those observed in southeastern Nigeria, where animal movement is being restricted by law.

At the two village sites in southeast Nigeria, both the production environment and the management systems are in dynamic states. Relatively recent legislation mandating restriction of animal movement has forced owners either to confine or tether their animals. These restrictions on animal movement have created the need for immediate changes in housing, feeding and breeding strategies.

The extremely high mortality observed at these sites, averaging over 50% per year, clearly indicates that there are major outstanding issues in the production system which have not yet been addressed successfully. Mortality does not appear uniformly in all flocks, indicating that there may be some important management considerations which are not fully appreciated. Great differences in housing and feeding strategies certainly exist, but the importance of these cannot be assessed until the major causes of mortality are identified.

There can be little doubt that if the current level of mortality continues, more households will be forced to abandon goat keeping altogether. Other owners, unwilling to invest the additional labour required by cut-and-carry feeding, will choose to participate in different economic activities. While both of these situations have been observed in the southeastern villages, it is also evident that some owners willingly invest the additional time and labour in goat keeping, and are, in fact, expanding their flocks.

It is evident that restriction of animal movement is a common and important aspect of the small ruminant production environment in southeast Nigeria. A recent survey of 26 Local Government Areas (LGAs) in four southeastern states indicates that restriction of animal movement is encountered where open, derived savanna vegetation predominates, but is less common in heavily forested areas (Table 6). In 15 LGAs in Anambra and Imo States, for example, 86% of households restricted movement of their animals either during the whole year or at least during the cropping season. In contrast, only 16% of households in Rivers and Bendel States restricted animal movement at any time in the year.

It would appear from these data that restriction of animal movement is directly related to the intensity of agricultural land use. Small ruminants can cause serious damage to growing crops, particularly in areas characterized by open vegetation. Restriction of animal movement can then be

Table 6. *Prevalence of restriction of goat movement in four southeastern states, Nigeria.*

	% of households in:			
	Anambra	Imo	Rivers	Bendel
Restricted year-round	65	48	11	9
Restricted, farming season only	27	42	0	12
Free-roaming	8	20	89	79
Number of LGAs	6	9	5	5
Number of households	239	321	244	236
% households without goats	7	7	15	5

seen as a forced response to changes in larger farming and land-use patterns. As is typical of minor farm enterprises in general, and of particular livestock enterprises, the character of the goat production system is determined largely by outside forces. In other words, goat production cannot be usefully discussed in terms of 'optimization' and 'maximization', but rather in terms of its complementarity – lending some measure of additional stability to the overall farming system.

It seems likely, nonetheless, that goat production will evolve from a low-input, minor farm enterprise to a more intensive and specialized enterprise. Thus, successful management will be within the reach of a more limited number of persons. This may be particularly true as specialized food production systems are introduced. There is also a strong interest in the introduction and use of exotic breeding stock in the southeast, and this kind of activity might further stimulate specialization.

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ECONOMICS OF
IMPROVED PRODUCTION SYSTEMS

Models of improved production systems for small ruminants

M. UPTON

TRADITIONAL PRODUCTION SYSTEMS

It is clearly not possible to develop improved production systems without first studying the existing ones. On the one hand, the performance of the existing, traditional system provides a baseline standard with which to compare proposed innovations. On the other hand, an understanding of the resource requirements and constraints of the existing system provides guidance as to which of the possible new technologies are appropriate and worth pursuing, and which are not. Much agricultural research in the past proceeded on the assumption that new technologies could be developed in the isolation of the research station and imposed on farmers from above. It is surely a sign of progress that these attitudes are changing.

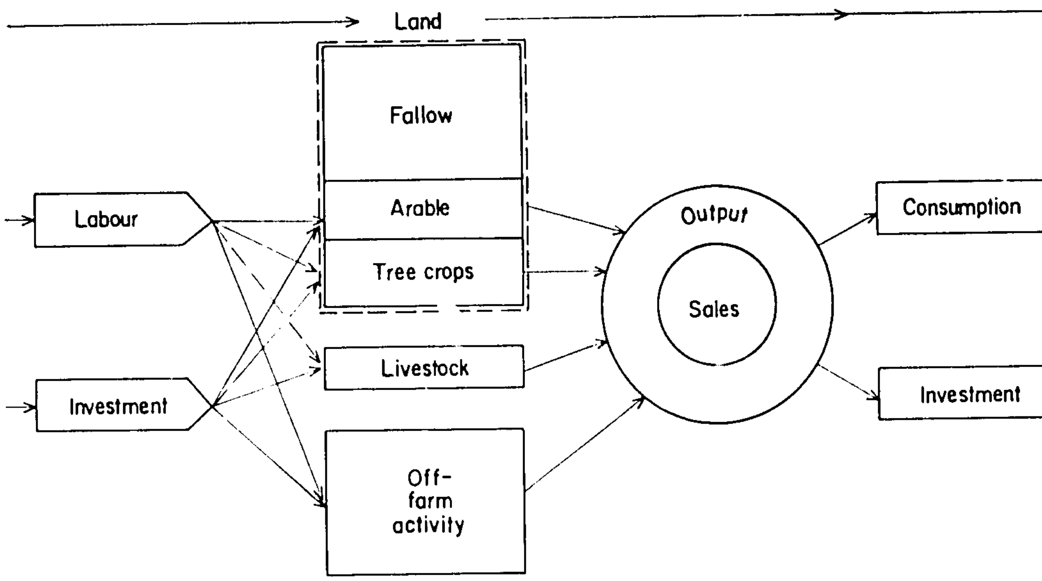
Fortunately, a number of studies of traditional farming systems have been made in southwest Nigeria (Galletti et al, 1956; Upton, 1967; Ay, 1980). The farming systems in this area are typical of many parts of the humid zone of West Africa and perhaps other areas in the humid tropics. Although gradual changes in these farming systems have occurred over the years, the above mentioned studies show that the majority of farm households keep sheep and goats, but only as a supplement to crop production. In spite of the fact that small ruminants are only "a low-labour-input and low-priority adjunct to traditional arable and cash crop farming" (Oyenuga, 1967), they are ubiquitous in rural and even urban areas. Since they are trypanosomiasis tolerant, they greatly outnumber cattle in the region and are much more important in terms of total livestock units (Matthewman, 1977; based on FAO, 1966).

The transition zone between the tropical rain forest and the savanna is a sub-climax of the forest zone, created by burning. As there are fewer trees, the land is more easily cleared for continuous cultivation than the rain forest, but crop yields are apparently somewhat lower on average. Thus there are differences between farming systems in the savanna and the forest transition zone.

In the forest transition zone the typical Yoruba farming household presently consists of the elementary unit of farmer, wives and children. With the spread of primary education, children are rarely available for farm work. Furthermore, since many farmers and the majority of their wives have off-farm occupations, particularly in food processing and marketing, and petty trading, the potential household labour force for farming is only one or two persons. It should also be noted that many Yoruba families have dual residences, one in town and one in the village or farm camp. Long periods are spent away from the village and the farm, especially during the dry season and festivals. At busy times of the year, additional labour is hired. Arable crops are cereals, roots and other vegetables, of which maize and cassava are the most widely grown for home consumption and cash sale. Land is hoe cultivated and crops are interplanted. To restore fertility, land reverts to bush fallow after 3 or 4 years of cropping. This is a fairly extensive system and land is apparently not in short supply. A sketch indicating the pattern of productive activity is given in Figure 1.

Small ruminant keeping is generally not integrated with crop production. Most cropland is some distance from the village centre, typically 15 to 20 minutes' walk, while the goats and sheep remain in the village, where they scavenge and are fed household scraps and crop byproducts. No forage crops are grown and manure is not returned to the cultivated plots. Although most

Figure 1. *The farming system in the humid zone of West Africa.*



families keep small ruminants, the average number per owner is only about three or four animals, with goats predominating. Indeed, in some villages there are no sheep (ILCA, 1979; Matthewman, 1980; Okali, 1979). Although both species are represented by dwarf breeds, sheep are generally larger, though less prolific, than goats.

The animals are rarely housed or tethered, except in areas such as eastern Nigeria where pressure on land is creating competition between crops and livestock, so the latter must be restrained. Where the animals roam freely, the entire village stock can be considered as a single, interbreeding flock, and usually there are no attempts to control mating. Since very few males are required for breeding, most families can sell or consume all the male offspring. Animals receive virtually no veterinary care, and mortality rates are relatively high, though variable. In general these animals receive little attention, consequently labour costs are negligible. However, some supplementary feeding may occur, especially during the dry season. Feedstuffs such as *eri* (maize bran) may be purchased or labour may be spent in cutting and carrying browse (Carew, 1982; Sempeho, 1982).

Farming in the derived savanna zone differs in that the cultivated area per family is almost double that for the forest zone, while the proportion under tree crops is smaller. Complete clearing and de-stumping is easier and tractors are more widely used. Since yields are lower, though, farm incomes are generally below those obtained in the forest zone. In the derived savanna zone there is some evidence that slightly more goats are kept per household, on a more commercial basis, in that breeding stock is owned rather than borrowed and a greater proportion of kids is sold.

Given the lack of integration between crop and livestock enterprises, small ruminant production may be viewed as an independent investment. Furthermore, given the advantages of simplicity and limited scale in model building, there is a case for analysing the small ruminant subsystem on its own, at least as a starting point.

A MODEL OF THE BREEDING FLOCK

A sheep or goat kept for breeding is an item of capital. It could be slaughtered for current consumption but instead it is kept to produce more output in the future. The establishment of a breeding flock is, therefore, a form of capital investment expected to yield a future return. As such, it competes for available resources with alternative forms of on-farm investment, such as clearing bush for cultivation or establishing permanent crops, or with off-farm investments such as petty trading or education of children.

Since many small ruminants are sold in local markets, and price data have been recorded (Okali and Upton, 1985), we may use market prices to estimate costs and returns. Animals that are slaughtered for home consumption or for ceremonial purposes may also be evaluated in this way, since the market price represents the opportunity cost (i.e. alternative income foregone). Commonly, a sheep or goat flock is established by borrowing or caretaking of breeding females rather than by purchase (Okali, 1979). Although this is an interesting social practice, worthy of further study in view of its potential impact on income distribution, it does not alter the fact that a breeding animal is an investment. Caretaking is really not very different from a cash loan, the share of the offspring which are returned to the owner representing an interest charge. Of course, the owner actually receives fewer offspring by lending out, but presumably has good reasons for doing so.

It is convenient initially to consider just one species; indeed in some areas such as Fasola, goat only flocks predominate (ILCA, unpublished data). There remains the question of whether the unit of analysis should be the group of three or four animals kept by a single individual or if it should be the entire, free-roaming, interbreeding village flock. In fact, so long as interest centres on the rate of return on investment, and assuming that there are no economies or diseconomies of scale, the size of unit chosen is unimportant. A single breeding doe may then be used as a unit of analysis, with the results being raised by the appropriate numbers to arrive at individual family or village level figures. Fractional values will appear in the performance of a single doe which will require the services of, perhaps, 1/16th of a buck (mean ratio of adult females to adult males = 16:1) (Mack, 1983), and produce 2.2 kids per year. This is not a problem since the results represent average or expected values.

The factors likely to affect the rate of return on investment in a breeding doe are illustrated in Figure 2. Under traditional systems, so little labour is devoted to tending goats and so little is spent on feed, housing and veterinary care that we may ignore these costs. Recent data on reproductive performance have been collected by ILCA's Small Ruminant Programme in Ibadan (Mack, 1983), and their averages are given in Table 1.

Table 1. *Reproductive performance data for dwarf goats under traditional management.*

A.	Average litter size (kids/litter)	1.5
B.	Parturition interval (days)	259
C.	Annual reproductive rate/kid-drop $\frac{(A \cdot 365)}{B}$	2.1
D.	Survival rate to 3 months (%)	0.67
E.	Survival rate from 3 to 12 months (%)	0.77
F.	Survival rate from 0 to 12 months (D·E) (%)	0.52
G.	Effective kidding rate (kids surviving to 12 months) (C·F)	1.09
H.	Liveweight at 12 months (kg)	10
I.	Productivity – liveweight production per doe (kg) (G·H)	10.9
J.	Number of does per buck	16
K.	Mortality of breeding stock (%)	0.20

Source: Mack (1983).

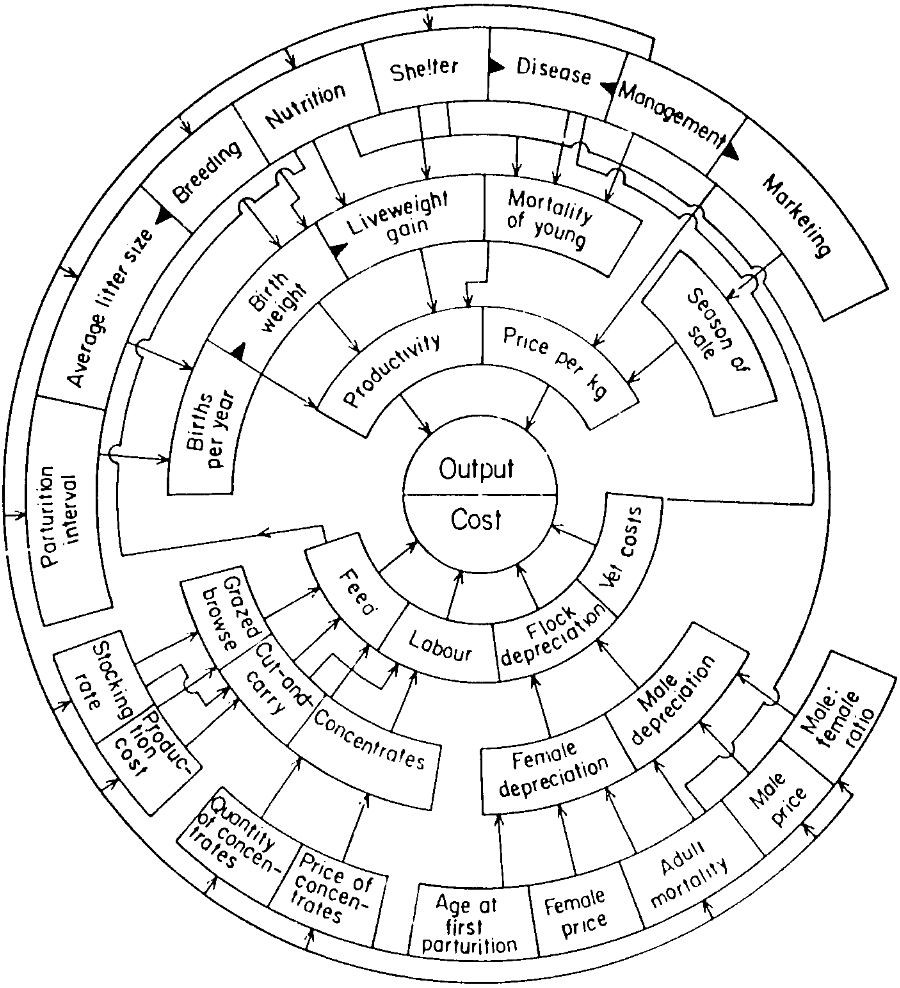
These data may be used to arrive at estimates of the annual productivity per doe as shown below. For this purpose it is assumed that animals are disposed of at the age of 1 year. In practice, many are slaughtered for ceremonial purposes during their first 3 months. The value of such young animals is not known, and they could potentially be raised to 12 months of age (subject to the normal mortality rate of course). Doe mortality is not known, but given that the average doe continues to breed for about 5 years, mortality is estimated as one fifth or 20%. The same figure is used for bucks, and dead animals are assumed to be valueless.

Table 2. *Market prices for dwarf goats, 1982–1983.*

L.	Mean price per kg	US$ 3.35
M.	Price per adult doe	US$ 52.92
N.	Price per adult buck	US$ 44.10

Source: Okali and Upton (1984).

Figure 2. *Factors affecting the rate of return on investment in small ruminants.*



Source: Adapted from Spedding; in Dalton G E (ed.) *Study of agricultural systems.* Applied Science Publishers, London. 1975.

Market prices given in Table 2 can be used to estimate output and costs as follows:

P.	Gross output per doe (I·L)	US$ 36.52
Q.	Doe depreciation (K·M)	US$ 10.58
R.	Buck depreciation (K·N)	US$ 8.82
S.	Breeding stock depreciation $(Q + \frac{R}{J})$	US$ 11.14
T.	Net output per doe per year (P − S)	US$ 25.38
U.	Capital investment per doe $(M + \frac{N}{J})$	US$ 55.68 + 18.25 = 73.93
V.	Annual rate of return $(\frac{T}{U} \cdot 100)$	34%

We see that, on average, traditional, low-input methods of goat keeping produce a satisfactory rate of return. However, there is considerable variation about the mean, caused by variation in mortality. The sensitivity analysis of the results is discussed in the next section. First, comparable data for sheep are presented in Tables 3 and 4, on the basis of which we estimate:

	US$
Gross output per ewe	72.36
Ewe depreciation	10.81
Ram depreciation	14.74
Breeding stock depreciation	11.80
Net output per ewe per year	60.56
Capital investment per ewe	73.79 + 36.17 = 109.96
Annual rate of return	55%

Table 3. *Reproductive performance data for dwarf sheep under traditional management.*

Average litter size (lambs/litter)	1.23
Parturition interval (days)	322
Annual reproductive rate/lamb-drop	1.4
Survival rate to 3 months (%)	0.84
Survival rate from 3 to 12 months (%)	0.83
Survival rate from 0 to 12 months (%)	0.7
Effective lambing rate	0.98
Liveweight at 12 months (kg)	19.7
Productivity – liveweight production per ewe (kg)	19.3
Number of ewes per ram	15
Mortality of breeding stock (%)	0.16

Source: Mack, (1983).

Table 4. *Market prices for dwarf sheep, 1982–1983.*

Mean price per kg	US$ 3.74
Price per ewe	US$ 67.62
Price per ram	US$ 92.61

Source: ILCA unpublished data.

Thus it appears that sheep yield substantially higher outputs and rates of return than goats under traditional management. This is despite the fact that goats are considerably more prolific. Sheep, however, are bigger and heavier, have lower mortalities and are more highly priced. Nevertheless, goats generally appear more popular than sheep, possibly because they are easier to manage and because less capital and labour is involved.

SENSITIVITY ANALYSIS

In an attempt to estimate the risks involved in small ruminant production, and to suggest which factors are most critical in determining returns, sensitivity analysis was carried out. Four key factors were identified – reproduction rate, mortality, growth rate and price – and the effect of variation in each of these factors was estimated. Estimates of the standard errors of most of these variables are available from ILCA surveys. From these estimates the standard errors for an individual flock of four breeding animals were found. Each key variable was adjusted in an adverse direction by one standard error to test the impact on returns. Note that there is a more than 15% probability of such variations occurring by chance. The results for goats are presented in Table 5 and those for sheep in Table 6.

It is clear from this analysis that the risks of loss are much higher for goats than for sheep. The additional feed and labour costs associated with sheep – which have been omitted from the present analysis – might absorb some of the extra returns from sheep. Nonetheless, it seems fairly unlikely that losses would be made. With goats, however, losses might easily be made, especially where mortality is high.

Table 5. *Sensitivity analysis of returns to dwarf goat production.*

Parameters changed	Measured value[a]	Adjusted value[b]	Net output per doe (US$)	Rate of return (%)
Reproductive performance				
Mean litter size (kids/litter)	1.5	1.18	–	–
Parturition interval (days)	259	322	12.15	18
Mortality (%)				
Survival to 3 months	0.67	0.50	–	–
Survival to 12 months	0.52	0.31	–	–
Breeding stock mortality	0.80	0.40	−0.45	loss
Growth (kg)				
Liveweight (kg) at 12 months	10	7.9	17.71	24
Price per kg (US$)	3.35	2.91	20.58	29

[a] Rate of return using measured values = 34%.

[b] Values adjusted in an adverse direction by one standard error.

Table 6. *Sensitivity analysis of returns to dwarf sheep production.*

Parameters changed	Measured value	Adjusted value	Net output per doe (US$)	Rate of return (%)
Reproductive performance				
Mean litter size (lambs/litter)	1.23	0.94	–	–
Parturition interval (days)	322	562	19.72	22
Mortality (%)				
Survival to 3 months	0.84	0.62	–	–
Survival to 12 months	0.70	0.41	–	–
Breeding stock mortality	0.16	0.34	17.28	18
Growth				
Liveweight (kg) at 12 months	19.7	11.15	29.15	31
Price per kg (US$)	3.74	3.27	51 47	49

This analysis suggests that the most critical area, i.e. where improvements are most needed, is that of reducing mortalities. The most obvious approach is through veterinary disease control measures such as the control of PPR, which has been evaluated in a number of West African countries and is currently being tested by ILCA. However, improved nutrition might also have an impact on disease susceptibility and therefore on mortality. Variation in growth rate (mentioned below) seems to have a relatively small impact on returns. The second most influential factor on overall economic performance appears to be the reproduction rate. This is most likely to be improved, initially at least, by improved management. Since market prices are subject to seasonal variation (Okali and Upton, 1985), it has been suggested that controlled breeding, to produce marketable animals at periods of peak prices, could improve returns. However, this clearly requires a high standard of management, and the present analysis suggests that the variation in prices has only a relatively minor impact on the return obtained. Efforts to modify the breeding pattern of small ruminants should probably have relatively low priority.

Programmes to control PPR by vaccination, and mange and other ectoparasites by dipping, can be easily evaluated under this model. Trials currently being carried out suggest that these treatments have little or no impact on growth rates, but goat mortalities can be reduced substantially (Opasina, 1984; Adeoye, 1984). Survival rate to 3 months can apparently be increased to 86% on average which, with a similar survival rate from 3 to 12 months, gives an annual rate of 73%. Mortality of breeding adults is reduced to 16%. Substituting these figures in the model above for dwarf goats yields a net output per doe of US$ 40.23. This represents an *increase* of over US$ 14.70 per doe, which must be compared with the cost of health measures. Estimates of the cost are generally well below this figure. Hence large-scale, government-sponsored PPR control programmes would appear to have a significant effect on returns to goat keeping, reflected in a favourable cost-benefit ratio. Risks of loss to individual goat keepers would be much reduced.

PLANNING IMPROVED PRODUCTION SYSTEMS

There can be little doubt that a disease control programme that increases the producer's net return and reduces his risk without affecting the rest of his farming and other activities represents an improvement. However, if it should lead to an increase in the size of the breeding flock, it may also have an impact on the rest of the production system and the household's activities. The same would be true of most other improved production systems.

In order to plan any improvements it is necessary to identify the objectives and constraints on small ruminant production. The main objective appears to be financial gain. Matthewman (1977) reports that 91% of a sample of 95 farmers in two villages said that this was their reason for keeping smallstock. The facts that timing of sales may be adjusted to meet financial emergencies, so that the small ruminant flock acts as a reserve, and that ruminants are slaughtered for ceremonial purposes, do not suggest fundamentally different objectives. Risk avoidance, however, may be an additional consideration.

Given that the main objective is financial gain, and given that on average both sheep and goats offer a satisfactory rate of return, it is not clear why only three or four animals are kept per household. A range of alternative constraints on livestock numbers has been suggested. Farmers themselves have given the following list of limitations: feed, need for fencing, time, cash and disease (Okali, 1979). Clearly, feed is a possible constraint. While animal numbers are limited to three or four per household, especially in the case of goats, it may be possible for them to live mainly by scavenging on household scraps and consuming a small amount of purchased supplementary feed. An increase in numbers might put pressure on readily available feed sources so that forage production would become necessary. If the fodder is to be cut and carried, labour requirements per animal are likely to increase and some form of housing may be needed. If the fodder is to be grazed or browsed, fencing and additional labour for shepherding may be needed. Thus feed, labour and the need for fencing or housing are probably justifiable limitations on expansion.

It is less obvious why disease and capital cost should limit the expansion of sheep and goat production. Clearly, disease limits production from small ruminants. On the other hand, disease control measures can bring about significant improvements. However, even with present average mortality levels it is possible to slaughter some young females and still maintain the size of the breeding flock (see Appendix).

It can be shown mathematically that, for a given mortality rate, the larger the flock, the smaller the risk of total loss. For instance, with a 30% mortality and a flock of four animals, the probability of all of them dying is 0.008 or nearly 1%. With a flock of eight animals, the probability of losing them all is 0.00007 or practically zero. Operating against this is the possibility of a disease spreading more rapidly through a large group of closely confined animals. Nevertheless, on balance, there is probably less proportionate risk associated with increased numbers. Clearly, disease control measures reduce the risks of livestock keeping for all flock sizes.

Capital should not be a serious limitation, partly because flock sizes could be allowed to increase naturally, and partly because borrowing or caretaking is prevalent. In one survey, 54% of farmers kept borrowed animals or their offspring (Okali, 1979). Women in particular acquire stock in this way. It is claimed that social constraints are such that a livestock owner cannot refuse a request for a loan of breeding stock, that the offspring are shared equally between borrower and lender, but that the risk of loss through death is borne largely by the owner (Sempeho, 1981). On this basis, and given the details in Tables 1 to 4, it appears that the lender can still obtain a rate of return of 10% from goats or 37.5% from sheep on the capital value of the breeding female. The borrower receives his or her share of the offspring for consumption or rearing to breeding age, with practically no capital cost. It is arguable that if improved technologies are developed, allowing improved nutrition and expansion of sheep and goat production, the necessary capital could be found within the village community. However, credit might allow more repid expansion.

It has been suggested that the five major direct constraints on productive performance of livestock are breeding, nutrition, health, management and marketing. For sheep throughout the tropics, the order of importance is probably (1) nutrition, (2) disease, (3) management, (4) breeding and (5) marketing (Devendra and McLeroy, 1982). Our discussion of the constraints identified by farmers, and the causes of variation in performance, lend support to this ranking for sheep and goats in humid West Africa, except that disease control might be placed before nutrition in order of priority. Disease control programmes may reduce mortalities and thereby expand productivity with very little change in farming systems. Improvement in nutrition then becomes highly desirable, as does increased fodder production to maintain increased numbers. However, as suggested above, this is likely to impinge on other farming activities and will necessarily require improved management. Few benefits are likely from improved breeding and marketing without prior improvements in health, nutrition and management.

INTENSIFYING PRODUCTION

There are two obvious possibilities for the intensification of sheep and goat production. One is cultivated pasture production for grazing by sheep. The other is permanent housing with cut-and-carry feeding or zero grazing. Both approaches have been tried but serious problems may arise if management is inadequate.

The establishment of pasture competes directly with arable cropping for the use of cleared land. Even though land availability may not be a constraint on crop production, the clearing of bush and land preparation costs are substantial. Thus *cleared* land may well be a limiting resource. Furthermore, pasture or ley farming requires more thorough land clearing than many arable crops, the reason being that the only satisfactory way of cultivating old pasture is by ploughing, whereas crop residues can often be cleared by hoeing (Boserup, 1965). Particularly in the forest zone plots may be too small to justifv tractor cultivation, so land consolidation may be a precondition for pasture production.

Fencing is an additional substantial cost; without it tethering, careful shepherding and supervision are needed. It may also be necessary to carry water to the field daily. In any case, farmers have suggested that additional supervision is needed as the risks of theft increase when livestock are kept on farms away from the village centre. Unfortunately pasture production may be inadequate to support grazing livestock throughout the dry season, so alternative feeding arrangements might have to be made for this period. With inadequate management overgrazing can easily occur, leading to destruction of the sward and soil erosion problems.

Attempts have been made to estimate costs and returns from sheep grazing in southern Nigeria, based on various assumptions regarding stocking rates and cost of establishment. Matthewman (1977) suggests that "if capital costs of establishment could be kept low, then production could be profitable".

On the other hand, housing and hand-feeding are well established in parts of humid West Africa; in parts of eastern Nigeria, for instance, it is illegal to allow livestock to roam free. Clearly housing provides the opportunity for closer control of feeding, diseases and breeding. It prevents crop damage by the animals and reduces risks of accidents. It provides the opportunity for better management, but several additional costs are involved apart from the costs of the shed itself. With poor management, returns may be worse than under the free-range traditional system. Additional labour costs are incurred in cutting and carrying fodder and in fetching water. Furthermore, increased purchases of concentrates and food supplements are likely to be necessary.

Under the free-roaming system very few adult males are needed since a small number can service the whole village flock. Once animals are confined, however, every household must keep a stud male, unless special arrangements are made for temporary caretaking or borrowing of males. The maintenance of larger numbers of 'unproductive' males will again raise costs. Finally, there is some evidence to suggest that confinement of animals increases disease risks. Preliminary analysis of health and production data from confined animals in eastern Nigeria seems to show considerably higher mortalities than are evident among free-roaming animals in western Nigeria. The need for improved management is evident.

Thus it appears that grazed pasture production and permanent housing with stall-feeding require substantially higher standards of management than are practised at present, if the systems are to succeed. Even if these approaches can be proved economically viable on a research station, it might be inadvisable to recommend them widely to farmers unless improvements in management can be ensured.

ALLEY CROPPING

Alley cropping is a system devised by the International Institute of Tropical Agriculture (IITA), in which arable crops are grown in alleys between cultivated hedgerows of leguminous shrubs such as *Leucaenu leucocephala* or *Gliricidia sepium* (Kang et al, 1981). The shrubs are grown from seed planted with an arable crop, and after 12 months they are pruned regularly to provide a surface mulch. Thus these hedgerows serve the function, traditionally provided by the bush fallow, of bringing minerals up from the lower soil profile and restoring fertility. In addition, leguminous shrubs add significant quantities of nitrogen to the soil from the mulch, decaying roots and nodules. It is claimed that such a system can support continuous cropping at intermediate yield levels, possibly indefinitely. In this way, two substantial problems may be overcome: shortage of labour for bush clearing, and the consequent inability to maintain fertility with ever shorter fallow periods.

In comparison with traditional cropping systems, alley cropping offers increased crop yields and avoids the need for periodical bush clearing. However, additional costs are incurred in growing the shrubs, in particular:

- A reduction in the arable cropped area, or arable crop plant density per hectare, because some land is occupied by the shrubs;
- The labour cost of regular pruning, necessary to avoid shading of the arable crop and to return organic matter to the soil.

Although various economic analyses have been made, no field trials have been reported. Thus it is difficult to estimate the benefits to farmers. However, a rough idea may be derived from trials at IITA which gave a net return per cropped hectare of arable crops without fertilizer of about US$ 882, and a net return per hectare of alley cropping of over US$ 1102. These figures are presented in Table 7 with crude estimates of labour and capital requirements. It is suggested that given the higher return per hectare, alley cropping probably yields a higher return per man-day despite the extra labour costs of regular pruning, and a higher return on capital. In fact, the capital sav-

Table 7. *Estimated costs and returns from alternative land use systems.*

	Traditional arable cultivation	Alley cropping	Alley cropping with cut-and-carry	Pasture production for sheep grazing
	Research station standard management, no fertilizer	Research results suggest big yield increase over no fertilizer control[a]	25% of cuttings provide full maintenance for 3 does and followers	Stocking rate: 10 ewes and followers per ha
Gross margin per cropped hectare (US$)	970[b]	1 102	1 176	661
Annual labour cost (man-days)	270	320	345	25
Capital cost, clearing, establishment of crops and purchase of livestock (US$)	294	220	441	1 470[c]
Gross margin per day (US$)	3.52	3.38	3.38	26.46
Gross margin per US$ of capital (US$)	4.85	7.35	3.82	0.73[c]

All estimates are highly tentative and loosely based on previous costings which differ widely, particularly on labour use and costs of bush clearing and crop establishment (see Matthewman, 1977).

[a] Knipscheer et al (1983).

[b] Returns per cropped hectare on farms may only be one third of this figure or less.

[c] Estimates of pasture establishment costs per hectare in Togo are almost twice this figure (Sere and Doppler, 1981). Hence the gross margin per US$ of capital for pasture production is probably even lower than US$ 0.73.

ing is greater than suggested by the figures in Table 3, since land-clearing costs will not arise once the alley cropping system is established.

A certain amount of the hedgerow foliage can probably be removed and fed to livestock, without adverse effects on crop yields. In this way small ruminant production can be integrated with alley cropping without competing for the use of cleared land. Insofar as fodder supply is a constraint on the expansion of sheep and goat production, this adaptation could allow an increase in the number of animals kept. On the assumption that a hectare of alley cropped land will produce 4 t of shrub foliage and that 25% of this is removed for fodder, it is estimated that three does and their offspring could be fully maintained. In practice it may be more appropriate to provide only a part of the food requirement for a larger number of animals at least during the rainy season, but the liveweight production per hectare should be similar in either case. It is thought that the increase in stock numbers will be so slight as not to require additional expenditure on housing. Cut browse can be fed to free-roaming animals as a food supplement.

Clearly this supplementary use of a byproduct of alley cropping should increase the return per hectare of cropped land beyond the level attained under alley cropping. There will be an increase in the labour requirement for cutting and carrying the browse daily, and additional capital is required for confining the goats. Nevertheless, the gross margin per man-day is only slightly reduced on average. In fact, since much of the feeding will be done during comparatively slack periods, the impact on peak labour demand may be slight. Return per man-day at peak periods may be raised. Overall return on capital may be reduced but the rate of return is still high, provided that disease control measures are incorporated. Some estimates of the costs and returns of pasture production are included for comparison. Although return to labour may be high, the low return per hectare and the very poor return on capital make this a doubtful proposition.

If the research results and budgetary estimates are borne out in practice on farms, then a genuinely appropriate technology will have been developed. Alley cropping with cut-and-carry browse requires no new forms of capital (*Gliricidia* and *Leucaena* seed can be produced locally). No foreign exchange expenditure is involved. Indeed, the potential saving in fertilizer requirements may save foreign exchange. The technology is scale neutral in that there are no apparent economies of scale. Large-scale crop growers are more likely to practice mono-cropping while potential large-scale livestock producers are more likely to turn to cattle, pigs or poultry. The system is rather labour intensive, but despite seasonal labour shortages, it is valuable in providing productive employment throughout the year. Returns are obtained quickly in that the system can be fully established and functioning within 1 or 2 years. It provides a satisfying combination of agronomy, forestry and animal husbandry.

Appendix: Modelling a goat flock

There are advantages in formalizing the basic model of production described earlier. The method is illustrated using the goat production and price data given in Tables 1 and 2, but the same principles would apply to other types of livestock. The purpose is to model the patterns of development over time, and of the size and structure of the flock.

It is first necessary to divide time into discrete periods of, say, weeks, months or years so that we can estimate the changes between one period and the next, or more precisely between one date and the next date, which is one period later. Generally speaking, the shorter these periods or time intervals are, the more accurate the analysis will be. However, choice is usually restricted by the data available. Given the data in Table 1, it would be possible to base the analysis on 3-monthly intervals, but for illustrative purposes, yearly intervals are used.

The next step, linked with the first, is to distinguish different sex and age groups or (cohorts). When 3-monthly time intervals are used, animals aged from 0 to 3 months may be distinguished from 4- to 6-month-old animals, and so on. Given yearly data, we need only distinguish five cohorts, namely:

1. Female kids under 1 year
2. Replacement does
3. Breeding does
4. Male kids under 1 year
5. Adult males

If we denote the number of animals in each cohort at time t by x_{1t}, x_{2t}, x_{3t}, x_{4t} and x_{5t}, and use the notations given in Table 1 for production parameters, we can calculate animal numbers (given zero offtake) at time t + 1 (i.e. a year later) as follows:

(1) $0.5C'x_{2t} + 0.5Cx_{3t} = X_{1,t+1}$

where it is assumed that 50% of all births are female and C' represents the kid-drop for replacement females between 1 and 2 years of age.

(2) $Fx_{1t} = X_{2,t+1}$

(3) $(1 - K)x_{2t} + (1 - K)x_{3t} = X_{3,t+1}$

(4) $0.5C'x_{2t} + 0.5Cx_{3t} = X_{4,t+1}$

(5) $Fx_{4t} + (1 - K)x_{5t} = X_{5,t+1}$

This can be set out in a matrix/vector form as follows:

$$\begin{array}{ccccccl} 0 & 0.5C' & 0.5C & 0 & 0 & x_{1t} & = x_{1,t+1} \\ F & 0 & 0 & 0 & 0 & x_{2t} & = x_{2,t+1} \\ 0 & 1-K & 1-K & 0 & 0 & x_{3t} & = x_{3,t+1} \\ 0 & 0.5C' & 0.5C & 0 & 0 & x_{4t} & = x_{4,t+1} \\ 0 & 0 & 0 & F & 1-K & x_{5t} & = x_{5,t+1} \end{array}$$

or more briefly by using the following matrix and vector notation:

$$Tx_t = x_{t+1}$$

Using the data for dwarf goats set out in Table 1, this set of equations becomes:

$$\begin{array}{ccccccl} 0 & 0.6 & 1.05 & 0 & 0 & x_{1t} & = x_{1,t+1} \\ 0.52 & 0 & 0 & 0 & 0 & x_{2t} & = x_{2,t+1} \\ 0 & 0.8 & 0.8 & 0 & 0 & x_{3t} & = x_{3,t+1} \\ 0 & 0.6 & 1.05 & 0 & 0 & x_{4t} & = x_{4,t+1} \\ 0 & 0 & 0 & 0.52 & 0.8 & x_{5t} & = x_{5,t+1} \end{array}$$

Since the age at first parturition is 1.5 years and the first litter size is 1.2 kids, this is assumed to be the annual reproductive rate for replacement females (C'). Their mortality is assumed to be the same as for adult females.

With a given set of offtakes y_1 to y_5, the equations may be modified as follows:

$$\begin{array}{cccccl} 0 & 0.6 & 1.05 & 0 & 0 & x_{1t} - y_1 = x_{1,t+1} \\ 0.52 & 0 & 0 & 0 & 0 & x_{2t} - y_2 = x_{2,t+1} \\ 0 & 0.8 & 0.8 & 0 & 0 & x_{3t} - y_3 = x_{3,t+1} \\ 0 & 0.6 & 1.05 & 0 & 0 & x_{4t} - y_4 = x_{4,t+1} \\ 0 & 0 & 0 & 0.52 & 0.8 & x_{5t} - y_5 = x_{5,t+1} \end{array}$$

or summarized as: $Tx_t - y = x_{t+1}$.

These equations may be manipulated in various ways to estimate production patterns or flock growth over time. It is assumed throughout that:

(i) The maximum growth rate depends only on the constitution of the female flock, so the equations may be limited to those for the female cohorts (three in our example);

(ii) We can treat the individual breeding doe as a unit and relate numbers of other age and sex groups to it (i.e. $x_3 = 1$);

(iii) The buck: doe ratio is fixed (i.e. $x_5 = Kx_3$).

Hence the variables to be determined are:

(a) Relative numbers of kids and replacement females (x_1, x_2 and x_4); and

(b) Rates of offtake of yearling females and males (y_2 and y_5).

Case 1. Zero flock growth, i.e. $x_{t+1} = x_t$

hence: $Tx_t - y = x_t \rightarrow (T - I)x_t - y = 0$

For the above numerical example the results are $x_1 = 1.2$, $x_2 = 0.25$, $x_4 = 1.2$ and $x_5 = 0.08$. The annual offtake is 0.37 female and 0.61 male yearlings, or a total of 0.98 animals per breeding doe. This is slightly lower than the estimate of 1.09 given in the text because allowance is now being made for the breeding of replacements.

Given a weight of 10 kg at 12 months, and a price per kg of US\$ 2.89, the net output per doe can be calculated as:

0.98 x 10 x US\$ 2.89 = US\$ 28.32

In order to estimate the capital investment it is assumed that kids are valued at half the price of a yearling (i.e. US\$ 14.55), to give a total of:

$$\underbrace{(1.2 \times \$14.55)}_{\text{Female kids}} + \underbrace{(0.25 \times \$29.10)}_{\text{Replacements}} + \underbrace{(1 \times \$52.92)}_{\text{Breeding doe}}$$
$$+ \underbrace{(1.2 \times \$14.55)}_{\text{Male kids}} + \underbrace{(0.08 \times \$44.10)}_{\text{Adult males}} = \text{US\$ } 98.65$$

Thus the rate of return is:

$$\frac{19.4}{98.65} = 29\%$$

This method takes full account of the value of followers and is, therefore, preferable to the simple calculations presented in the text.

Case 2. Maximum, steady-state flock growth

This means that offtake and age distribution are such that the proportionate composition of the flock stays constant although total numbers are growing:

$$Tx_t - y = g\,x_t \rightarrow (T - gI)x_t - y = 0$$

In this formulation there are clearly too many unknown variables. However, if it is recognized that fewer males than females need to be retained for breeding, then:

(i) The maximum growth rate depends only on the constitution of the female flock, so the equations may be limited to those for the female cohorts (three in our example);

(ii) Maximum growth implies zero culling of females, hence for the female cohorts: $.c(T - gI)x_t = 0$*

(iii) The number of adult males needed, and hence the culling rate for males, can be estimated from the number of females and the desired male: female ratio.

Using the figures in Table 1 for dwarf goats, the maximum sustainable, steady-state rate of flock expansion is 19.3% per year. Thus flock size could be doubled in 4 years. The flock composition relative to a single doe would be:

$.cx_1 = 1.13,\ x_2 = 0.49,\ x_4 = 1.13$ and $x_5 = 0.08$

The annual offtake would be 0.56 male yearlings.

* Mathematically g is the principal eigenvalue of T while x_t is the corresponding eigenvector in this formulation.

Case 3. Flock expansion

It is assumed that flock expansion begins with a single doe having access to a breeding male, and no culling of female animals is done. Hence for female cohorts:

$$Tx_t = x_{t+1},\ T^2x_t = x_{t+2},\ T^3x_t = x_{t+3}\ \text{etc.}$$

The pattern for dwarf goats over the first 5 years is shown in Table 8.

Table 8. *Growth of a goat flock over 5 years.*

	Year 1	Year 2	Year 3	Year 4	Year 5
Female kids(x_1)	0	1.05	0.84	1	1.37
Replacements(x_2)	0	0	0.55	0.44	0.52
Breeding does(x_3)	1	0.8	0.64	1.06	1.20

Naturally, offtake of males would be possible from the outset. It is worth noting that numbers would decline initially, until a balanced flock of followers is established.

The flock constitution after n years would be $T^n x_0$, or $g^n x_0$.

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The market potential for increased small ruminant production in southwest Nigeria

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ABSTRACT

The paper explores the mrrket potential for increased small ruminant production within the humid zone of southwest Nigeria. It appears that current production of southern breeds is insufficient to meet demand and large numbers of animals are imported from the north. While the urban markets studied handle mainly northern breeds, the rural markets deal predominantly in southern breeds. Despite consumers' supposed preference for sheep, especially during Muslim festivals, many more goats are sold in both rural and urban markets.

INTRODUCTION

The humid zone of West Africa has traditionally depended on areas to the north to meet its animal protein requirements. In the south the disease trypanosomiasis has limited livestock production, and most resident ruminant animals are the indigenous trypanosomiasis-tolerant dwarf sheep and goats.

At present small ruminants represent a major underexploited resource within the humid zone. They are largely kept by arable/tree crop farmers; typically, individuals keep two to four breeding animals, mainly goats, on which spending is minimal. In general, farmers provide no special feed, housing or other inputs, and production is risky due to high mortalities from disease. Nevertheless, potential returns are high (Upton, 1985).

The International Livestock Centre for Africa (ILCA, Ibadan) has shown that significant increases in numbers of small ruminants, particularly goats, can be achieved by the control of a single disease, namely *peste des petits ruminants* (PPR) (Opasina, 1984). ILCA has also shown that the consequently increased feed requirements can be met by planting browse trees as part of an alley farming system. In 1984 the Livestock Production Unit of the Nigerian Federal Livestock Department initiated a small ruminant development programme in southwest Nigeria using TCRV vaccine to control PPR, and alley farming to provide feed. This paper discusses the market potential for the increased livestock production.

MATERIALS AND METHODS

Detailed market information covers the Ibadan–Bodija and Oyo–Akesan urban markets, the rural markets of Egbeda and Apomu to the southeast of Ibadan, and Iware and Oja to the south and west of Oyo. Production information is taken from a number of villages in southwest Nigeria.

Census data are based on the number of animals available for sale on a particular market day. Because of stock movements from one market to another, and the fact that some animals may be removed and returned at a later date if the price offered is too low, the census data can only be used as an indicator of total supplies for these markets. Price data refer to prices received by traders at resale rather than to prices received by producers. Price and census data are collected over 2 weeks in each market every month. Since the two urban markets are daily markets, observations cover 14 days. The rural markets are held at various regular intervals and the number of market days in any month varies between 4 and 10.

RESULTS AND DISCUSSION

The markets

Small ruminant production in southwest Nigeria is limited in scale, and it is insufficient to meet present demand. For various reasons, the humid zone has a comparatively high human population density and a wealthier population than areas to the north. In addition, southwest Nigeria has a traditional urban culture, and towns and cities are an important feature of the society. The area is therefore served by a large number of rural and urban markets which are linked in the exchange of goods, including small ruminants.

Few of the markets specialize in single commodities. In the rural markets small ruminants usually occupy an area on the market perimeter, although in larger rural markets there may be more than one location where small ruminants are sold. Few rural markets have overnight facilities and most animals that remain unsold at the end of the market day are removed. Ibadan has two markets specializing in small ruminants, whereas in Oyo, a much smaller town, they occupy a large area of a general goods market. Animals may remain in these urban markets for a number of days.

Small ruminant marketing in the southwest is dominated, in terms of animal numbers, by importation from northern Nigeria (Figure 1). Livestock move from north to south in two streams, one passing to the eastern part of Nigeria, and one to the west through the Ibadan-Bodija market which serves as the redistribution point. From here they are taken to other markets, both within Ibadan and in other towns and villages. Most sales from Bodija are therefore made to wholesalers. Akesan, the urban market at Oyo, receives all its northern supplies from Bodija and is a terminal market for these northern breeds, as are the rural markets of Egbeda, Apomu, Iware and Oja. Almost all the small ruminants produced within the humid zone and sold in the rural markets are marketed locally.

Although functions vary depending on the position of each market in this chain, the organization is similar. Business is transacted through middlemen or brokers who assist buyers and sellers in reaching agreement. The middlemen receive a variable fee for this service. Unless producers in the south sell locally or to itinerant traders, they do not deal directly with buyers, even in the rural markets where less than 10 animals may be on sale on a market day.

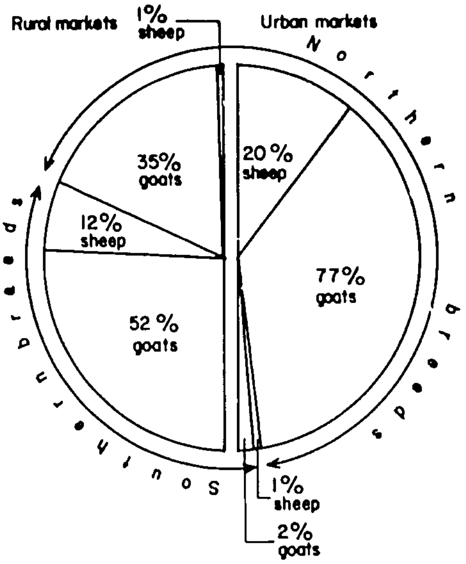


Figure 1. *Small ruminant population in four rural and two urban markets in southwest Nigeria, July 1982 – June 1983.*

Itinerant traders travel through the producing areas in the southwest, bulking animals to sell in the urban and rural markets, but the number of animals involved is small. For example, few southern animals entered the Ibadan–Bodija market in 1982 or 1983. Even the major Ibadan market for these southern breeds (not covered in this survey) invariably has a larger number of northern animals for sale.

Livestock supplies

In the rural markets covered, between 20 and 30 small ruminants were available for purchase on market days in 1983. In Akesan the number of available animals was approximately 200 and in Bodija over 1000.

No record exists of the number of small ruminants entering the southwest from the north. Census data from the two urban and four rural markets during 1983 show that almost all the small ruminants available in the urban markets, and over half the goats in the rural markets, were northern breeds. Although sheep formed a relatively small proportion of animals on sale in the rural markets, they were mainly the southern breed.

The relative scarcity of southern animals reflects production and consumption in the southwest. While up to 75% of the residents of some villages own at least one sheep or goat, flocks owned by individuals are small. Animals are consumed by many households at various ceremonies and festivals throughout the year, but they are not generally used to meet daily meat requirements. In this situation, offtake for sale in the market is small. Mack (1983) reports that only 9% of the total exits from village flocks reflect sales, whereas 10% reflect household consumption and 46% reflect mortalities resulting from disease.

It is clear that consumption of small ruminants is not restricted to urban areas. Information from the Badeku and Eruwa areas of Oyo State shows that even producing areas are unable to meet their own internal demand, and that they purchase additional animals (Table 1). The deficits are not met from other local producing areas; 41% of the purchases over 12 months were of northern animals.

Table 1. *Sales and purchases made over 12 months in two areas in southwest Nigeria.*

	Eruwa villages	Eruwa town	Badeku villages	Badeku village	All localities
			% of responses		
Owners who sold	16.1	2.8	19.0	32.1	16.9
Owners who purchased	12.9	60.0	47.6	50.0	43.3
Number of sales or purchases made	22.5	14.2	16.6	–	13.9
Number of responses	31	35	42	28	136
Number of animals	10	35	38	37	120
Number of animals sold	7	2	10	13	32

Source: Okali (1979).

The relative scarcity of southern sheep for sale reflects the predominance of goat production in the humid zone. All ILCA's village surveys in the south of Nigeria show the clear predominance of goat production (Table 2), and production surveys of flocks in the derived savanna belt all omit sheep because the numbers available for monitoring are insufficient. In many communities and households, sheep are banned because of their potentially destructive grazing habit or for ritual reasons. The latter is true of a number of ethnic groups and not only the Yoruba, who are the dominant ethnic group in this southwestern area.

Table 2. *Ownership of small ruminants in the humid zone of Nigeria.*

	Savanna villages	Forest villages
% population owning small ruminants	59.4	74.2
% owners with:		
goats only	90.5	57.1
sheep only	5.0	16.0
sheep and goats	4.4	26.7
Mean flock sizes		
goats only	3.4	2.0
sheep only	1.2	2.4
sheep and goats	2.3	5.0
all flocks	3.7	2.2

Source: Okali (1979).

Sheep production is more common in the north than in the study areas, and the majority of sheep sold in the urban markets were northern animals. The number of sheep available for sale in urban markets was always less than the number of goats, and only exceeded the number of goats in the rural markets in September 1983 during the Muslim *Ileya* festival (Figures 2 and 3). This was true in spite of the fact that southwest Nigeria is

Figure 2. *Numbers of sheep and goats available per day in four rural markets in southwest Nigeria in 1983.*

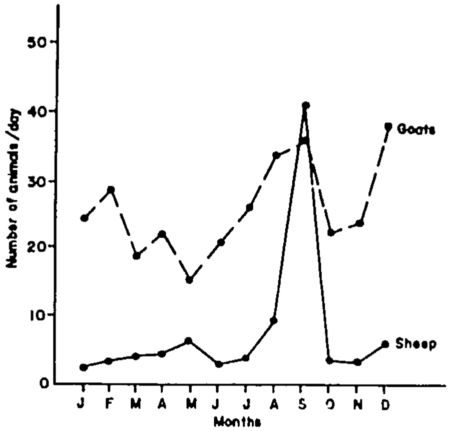
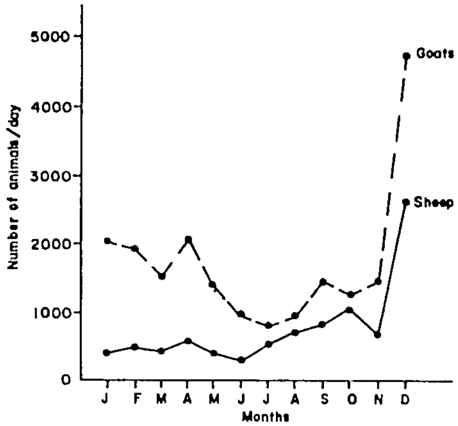


Figure 3. *Numbers of sheep and goats available per day in Bodija market in 1983.*



predominantly a Muslim area, and that the quantity of sheep available in all the markets increased during this Muslim festival period. The difference in supplies of the two species was especially evident in the rural markets where northern sheep accounted for only 1% of the total animals recorded in the census over 12 months. This 1% appeared in only two of the four markets and in only 1 month, September. Even in the Akesan urban market, over 6 months in 1983, including the September festival period, three traders handled 3640 small ruminants of which only 14 were sheep.

A number of reasons may explain this situation. Although rams are traditionally prescribed for slaughter at festivals, goats and other animals may be substituted. Goat sales therefore also increase during festival periods. Possibly more important is the fact that goats, which are smaller and less expensive than sheep, are used for other ceremonies throughout the year, including births, deaths and marriages. Hence at current prices, the demand for goats exceeds that for sheep. It should also be noted that the supply of northern sheep is limited even at festival times, as evidenced by steeply rising prices. This lack of supply may be due to market space constraints and trader association rules, but it is more likely that northern and southern sheep producers are not organized to meet large seasonal fluctuations in demand.

Liveweight prices

Information on prices received by traders refers to observed rather than to reported sales in the market place. Prices are quoted per kg of liveweight.

In general, small ruminants purchased in markets are eventually used for consumption rather than for breeding (Table 3). For breeding stock, southern producers rely on known sources: although there is a shortage of breeding stock, animals can be borrowed even if they are not for sale. Since few veterinary health services are available, producers rely on emergency selling of seriously sick animals to avoid total loss. These emergency sales are an important source of disease in the markets, which explains to an extent why markets are not generally a source of breeding animals. Northern animals are rarely used for breeding in the southwest although they are known to be used for this purpose in the southeast.

While there is a reputed consumption preference in southern Nigeria for southern breeds, and while most of the dwarf animals in the Bodija market, for instance, are used by women food processors working in the market canteens, northern animals are acceptable for consumption.

From July 1982 to June 1983 all buyers, whether final consumers or middlemen, paid an average liveweight price of US$ 3.60/kg (Table 4). Traders received 8% more – US$ 3.90/kg – for sheep which were 27% heavier than goats. In general, however, there appears to be no price premium *per se* for heavier animals. Although there is considerable breed variation within the animals

Table 3. *Reasons for animal purchases over 12 months in two areas in southwest Nigeria.*

	Eruwa villages	Eruwa town	Badeku villages	Badeku village	All localities
			Number of animals		
Goats					
festivals	0	3	8	2	13
ceremonies	9	10	13	28	60
breeding	1	15	1	-	17
Total	10	28	22	30	90
Sheep					
festivals	0	4	12	5	21
ceremonies	0	2	4	2	8
breeding	0	1	0	-	1
Total	0	7	16	7	30

Source: Okali (1979).

Note: Some of the animals which had been purchased for festivals and ceremonies had not been slaughtered. A total of 59 people, 43% of the sample, purchased sheep and goats during the 12 months.

Table 4. *Liveweight price/kg (US$) received by traders in two urban and four rural markets in southwest Nigeria, July 1982–June 1983.*

	Goats				Sheep			
	northern		southern		northern		southern	
	M	F	M	F	M	F	M	F
Urban markets	3.16	2.93	3.63	3.75	3.85	2.90	4.69	4.73
Rural markets	3.59	3.30	3.20	3.70	3.67	3.70	3.70	3.66

grouped broadly as northern and southern, northern breeds available for sale were considerably heavier than the southern breeds – up to 37% in the case of bucks (Figure 4). The smallest animals on sale were the male dwarf goats averaging 9 kg. Traders operating in the rural markets received a lower price for southern animals than the traders operating in urban markets, and vice versa for northern stock. This is to be expected, given the additional transport and handling costs involved. Since the Akesan market imported all its northern stock from the Ibadan–Bodija market, northern animals were more expensive in Akesan than in Bodija.

Although detailed price analysis is yet to be completed, it is clear that there is a considerable price variation throughout the year (Figure 5).

Figure 4. *Liveweights of sheep and goats in two urban and four rural markets in southern Nigeria, July 1982 – June 1983.*

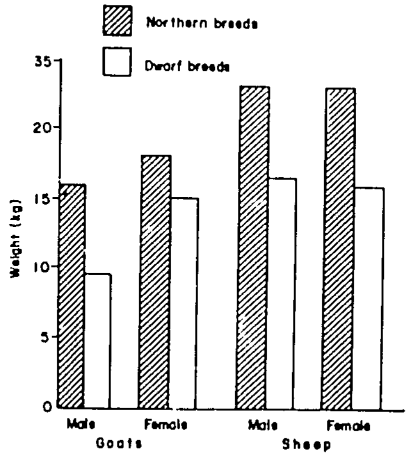
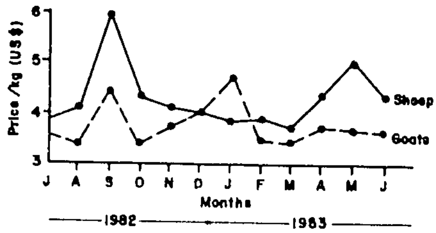


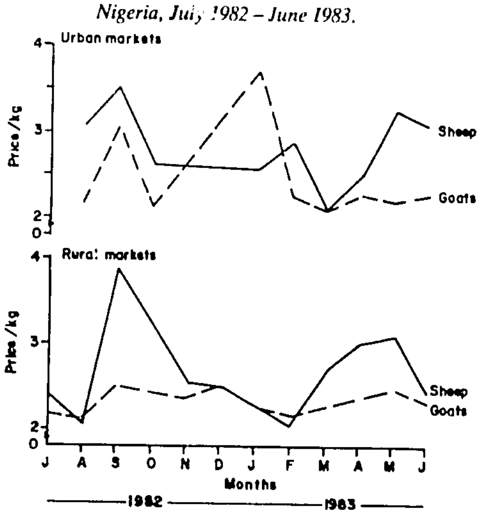
Figure 5. *Liveweight price/kg received by traders in two urban and four rural markets in southwest Nigeria, July 1982 – June 1983.*



The highest prices for sheep were recorded in September and May; the highest prices for goats were in September and January. September and January coincide with two Muslim festivals and increased demand. January is also a period of homecoming for many urban and, in this part of Nigeria, rural residents. 'Home' for a large number of rural residents, such as the people living in farm camps around Ibadan and Oyo towns, is an urban area. It is significant that this January price increase for goats occurred only in the urban markets (Figure 6). The second rise in prices paid for sheep in April/May was not accompanied, as in September, by a similar increase in sheep available for sale, perhaps because all possible oftake had already been sold in September before the onset of the dry season.

The prices received by traders for southern animals in rural markets resemble most closely the

Figure 6. *Liveweight price/kg received by traders in two urban and four rural markets in southwest Nigeria, July 1982 – June 1983.*



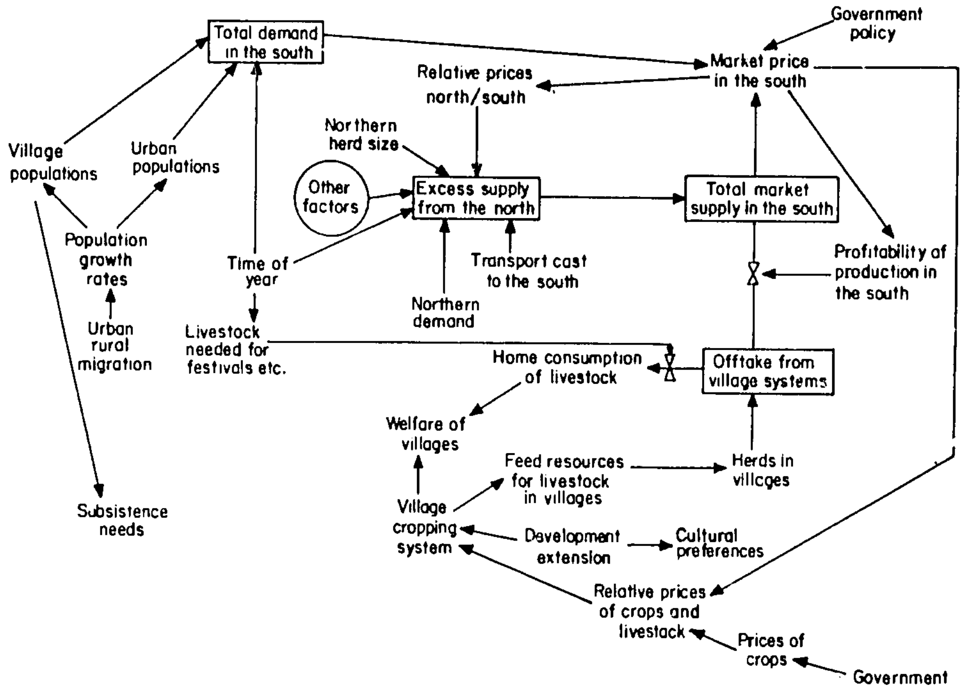
producer price, since this is usually the first, or at most the second, point of sale for these animals. Of the four rural markets, Egbeda is the most local in terms of the source of its southern animals, and the prices received by traders in this market were the lowest. From July 1982 to June 1983, traders received US$ 3.20, 3.24, 3.80 and US$ 3.20/kg liveweight for bucks, does, rams and ewes respectively.

Increased production potential

In an earlier paper (Okali, 1979), a soft model of small ruminant marketing in the south of Nigeria was presented (Figure 7) and attention drawn to three features: the price variation throughout the year, reflecting an increased demand during religious festivals; the expected price difference between northern and southern animals; and the expected price difference between rural and urban markets. This first interpretation of market data from southwest Nigeria further emphasizes the difference between northern and southern animals and rural and urban markets, but not only in terms of prices. Although the southern market appears to be dominated by imports from the north, the rural markets studied clearly serve the southern producers. Sheep production, particularly in the south, appears to be a specialized operation aimed almost entirely at satisfying demand for the Muslim festival in September.

Goats are the main product of the southern production system and the focus of the proposed ILCA/ FLD pilot project. Sheep would appear to be more profitable than goats, especially for rural producers who experience little competition from northern sheep in the rural markets. Goats, however, are in demand throughout the year, even in rural areas, and are potentially a stable income source. According to the census data, southern goats are sold throughout the year in spite of the high mortality due to disease. Although some of the imported northern goats reach the rural markets, the larger proportion remains in the urban markets, where they appear to be insufficient at times of peak demand. The almost total lack of sheep in the rural markets suggests that the importation of northern sheep is unable to satisfy urban needs, or that the effective demand for sheep in rural areas is much larger than that for goats.

Figure 7. *A soft model of the small ruminant market in southwest Nigeria.*



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