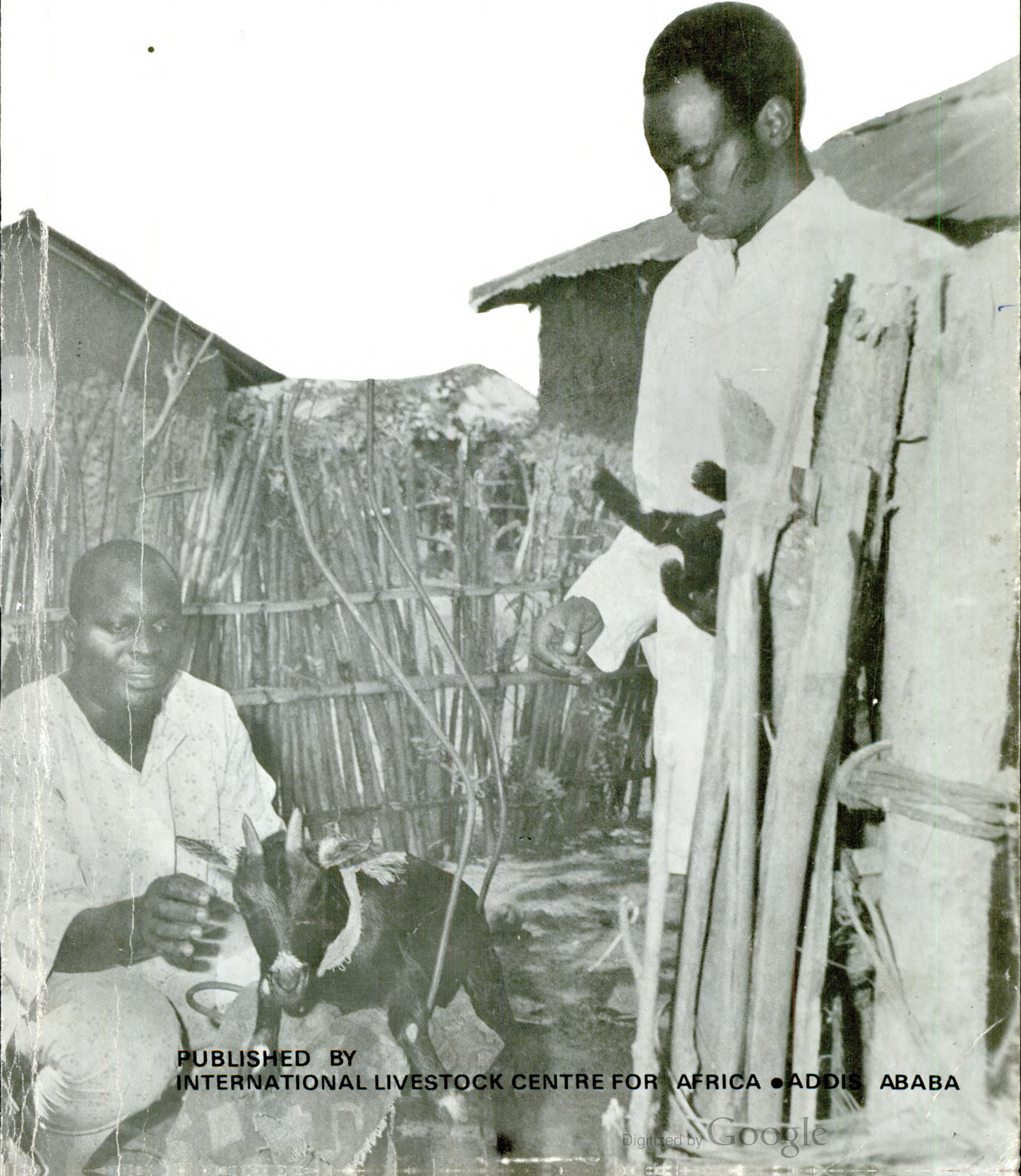
ILCA
SYSTEMS STUDY 3

SMALL RUMINANT PRODUCTION IN THE HUMID TROPICS



PUBLISHED BY
INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA • ADDIS ABABA

ILCA PUBLICATIONS

The **International Livestock Centre for Africa (ILCA)** is an autonomous research and information centre, whose activities and publications are funded by the Consultative Group on International Agricultural Research (CGIAR). The CGIAR members which have funded ILCA to date are the International Development Research Centre, the United Nations Development Programme, the World Bank and the governments of Australia, Belgium, the Federal Republic of Germany, France, Iran, the Netherlands, Nigeria, Norway, Saudi Arabia, Sweden, Switzerland, the United Kingdom and the United States of America. Responsibility for ILCA publications, however, rests solely with the centre and such other parties as may be cited as joint authors.

ILCA Monographs and *Systems Studies* are currently ILCA's two series of scientific publications. Both present information concerned with livestock production systems of tropical Africa, though *Systems Studies* deal with systems as a whole, while *Monographs* deal with aspects of systems and range widely in subject matter, comprising several subseries.

SMALL RUMINANT PRODUCTION IN THE HUMID TROPICS

PUBLISHED BY
INTERNATIONAL LIVESTOCK CENTRE FOR AFRICA 1979
P O BOX 5689 ADDIS ABABA ETHIOPIA

ABSTRACT

Research is reviewed on sheep and goat production in the humid zone of West Africa, including production parameters of the West African Dwarf breeds, feeding strategies based on natural and improved pastures and locally available agro-industrial byproducts, and the incidence of disease, particularly *peste de petits ruminants* and helminthiasis. The economics of small-farm and large-scale commercial production are discussed.

KEY WORDS

Sheep, goats, West Africa, humid tropics, production parameters, animal nutrition, forage production, *peste de petits ruminants*, helminthiasis.

PREFACE

In pursuit of its mandate to conduct research, training and documentation activities which will lead to improvements in livestock production in tropical Africa, the International Livestock Centre for Africa (ILCA) is focussing its research programme on existing production systems in the four major ecological zones of the region - the arid, subhumid and humid zones and the African highlands. The goal of this research is to design and test practicable innovations which will lead to increased livestock production and benefit the people of the area.

Such a research programme begins with the analysis of existing production systems, their potentials and constraints. This initial analysis is based on reviews of the relevant scientific literature, discussions among scientists working in the area and visits in the field. ILCA initiated a research programme on sheep and goat production in the humid zone of West Africa in 1978: the present report reflects the results of the initial analysis, which has been completed. Further work has involved a baseline survey of production systems in the area, followed by the design and testing of packages of innovations. ILCA's research in the humid zone also includes a special study on the use and potential of trypanotolerant cattle, sheep and goats, carried out in cooperation with the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP) (ILCA, 1979).

The decision to carry out a study focussing on small ruminant production was based on a number of considerations. The diet of the local population, based on cassava and yam, tends to be deficient in protein, and there is a serious shortage of meat throughout the region. It should be possible to increase the supply of meat substantially in a relatively short period through the improved production of sheep and goats, given their high rates of growth and reproduction, if present problems and constraints can be alleviated.

Sheep and goats are already kept by a substantial proportion of the population - approximately 4 to 5 million rural households in the region - and sheep and goat meat is accepted by local consumers. One survey indicated that 50% of the meat consumed in the humid zone of Nigeria comes from these small ruminants. Sheep and goat production is also attractive to small farmers in the region because of the low initial investment required, relative to cattle production, and the corresponding small financial loss incurred with the death of individual animals. Furthermore, small ruminants can be fed roughage and crop byproducts which are not utilized effectively by other livestock species. By contrast, pigs and poultry frequently compete with people for food, and cattle production often involves the establishment and maintenance of improved pastures, which is a relatively expensive undertaking. The labour requirements for sheep and goat production are also low relative to many other agricultural activities, and in some areas their manure is used to enhance crop production.

At present, the main constraint on small ruminant production in the humid zone is the high incidence of disease. Veterinary knowledge and treatment have already been developed, however, which could substantially alleviate this problem, and for this reason the focus of present work is on the more effective application of existing knowledge to traditional production systems.

This report is the result of an extensive literature review and a survey mission to four West African countries - Ivory Coast, Ghana, Togo and Nigeria. The survey team consisted of Prof K C Sellers, a veterinarian and leader of the mission, Dr A K Mosi, an animal nutritionist, and Mr W Keddeman, an economist. In

Nigeria, the team was joined by Dr R Borel, a forage agronomist. Their analysis focussed on management, reproduction, feeding, breeding, animal diseases and the socio-economic aspects of small ruminant production. At a later stage, the study was expanded to include information supplied by Dr C Devendra, an animal nutritionist, Dr G Montsma, an animal geneticist, and Dr J C Bille, a range ecologist. The study was coordinated by Mr C de Haan and the report was edited by Ms S B Westley and Mr S Chater and typed by Mrs G Maloba.

SMALL RUMINANT PRODUCTION IN THE HUMID TROPICS

Contents

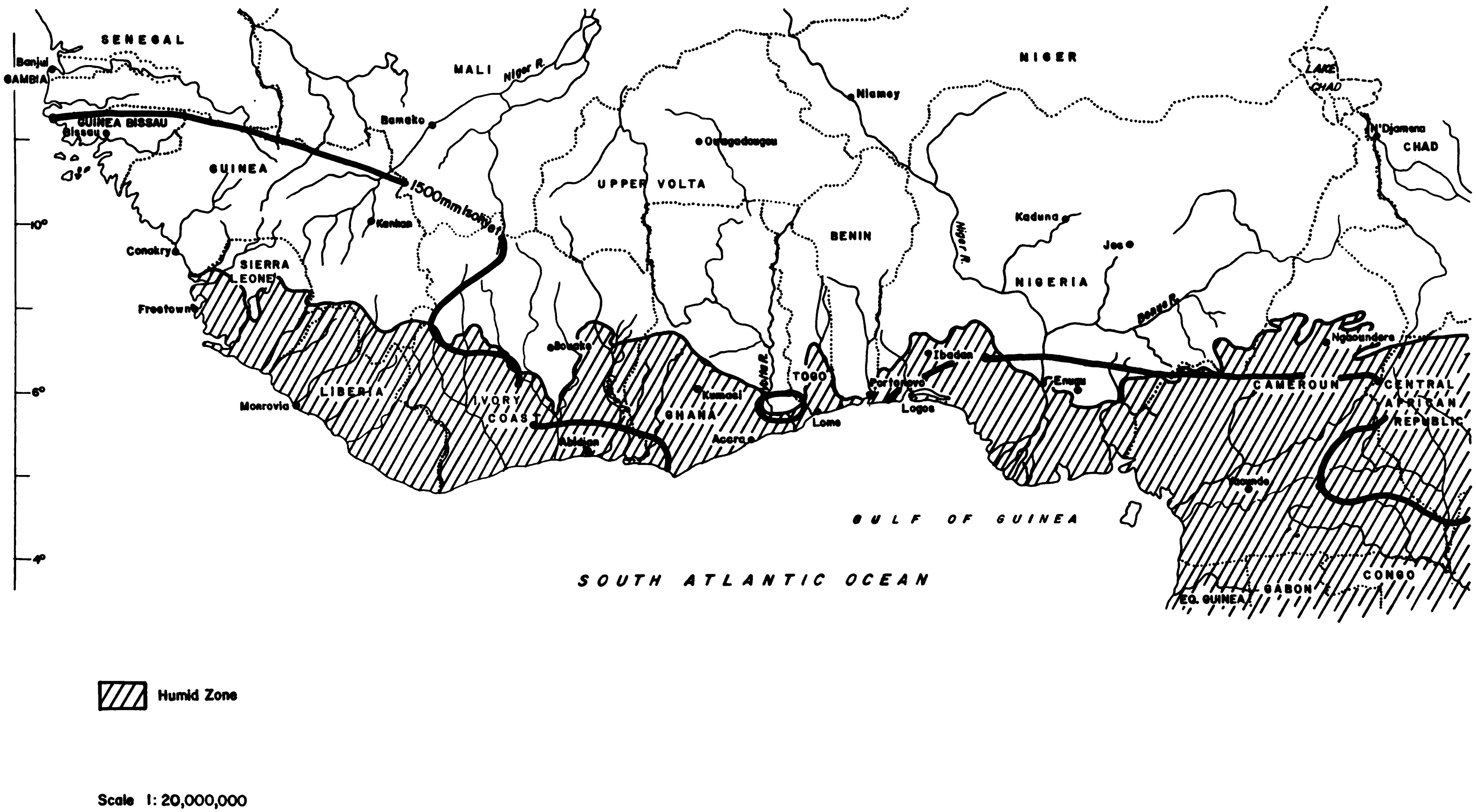
1. BACKGROUND INFORMATION

CLIMATE AND ECOLOGY

The ecological zones of tropical Africa have been named and defined in various ways by a number of scientists. For the purposes of this report, the humid zone has been defined as the low-lying, forested areas of West and Central Africa with an annual rainfall averaging between 1 250 and 1 800 mm. The area included by this definition is about 2 million km^2, as shown in Figure 1. The rainy season is slightly bimodal, with one dry season of less than five months between January and May and a second unreliable dry period in July and August. Temperatures range from 27^o to 32^oC and the relative humidity averages 80 to 90%.

The area is covered by tropical rain forest, and has been described as 'lowland forest' by Crowder and Chheda (1977), 'zone Guinéene' by le Houérou (1977) and 'secteur Guinéen forestier' by Boudet (1975a). It is bordered by a transition region between forest and savanna areas which is primarily a fire subclimax of the forest zone. This region has been called 'derived savanna' by Crowder and Chheda (1977), 'zone sud Soudano-Guinéene' by le Houérou (1977) and 'secteur préforestier' by Boudet (1975a).

Figure 1. The humid zone of West and Central Africa



Source: Derived by C de Haan from a map prepared by A Blair Rains.

POPULATION AND LIVESTOCK NUMBERS

The total human population of the zone is estimated at 75 million. Population densities are generally high relative to those of the savanna belt to the north, but there are considerable variations within the humid zone. Eastern Nigeria is the most densely populated area, with over 150 inhabitants per km^2 and densities approaching $400/km^2$ in some districts. High population densities are also found in the Central and Ashanti Regions of Ghana, with about 58 to 77 inhabitants per km^2. By contrast, the western areas of Ghana and Ivory Coast are relatively thinly populated, with less than 20 inhabitants per km^2.

As the entire region is infested with tsetse flies which carry trypanosomiasis, livestock production is generally limited to those species and dwarf breeds which are tolerant of the disease. Estimated sheep and goat populations in Ivory Coast, Ghana, Togo and Nigeria are given in Table 1, broken down into the humid and non-humid zones. More detailed figures are given in the Appendix. It is estimated that there are just over 10 million sheep and goats in the humid zones of the four countries covered by the survey, with over 8 million in Nigeria. Overall, goats outnumber sheep by a ratio of 2.5 to 1, though this ratio is derived from the fact that goats outnumber sheep by about 3 to 1 in Nigeria, which accounts for the largest total number, while sheep actually slightly outnumber goats in the other three countries. Ratios of one goat to four sheep were encountered in some local areas, while the reverse was found in others, though little information is available concerning the reasoning behind local preferences. In some areas more religious and ceremonial importance is attached to goats, in others to sheep. Preferences expressed informally mainly concerned the fact that goats are more prolific but sheep are more docile.

Annual population estimates over the past several years, as given in the Appendix, suggest that national sheep and goat populations have remained fairly static in Ivory Coast, Togo and Nigeria but have risen in Ghana. The distribution of small ruminants between the humid and non-humid zones does not appear to have shifted to any considerable extent in recent years.

In considering these figures, it should be borne in mind that they were collected in different ways in each of the countries, at different seasons and in different years. They also suffer from the usual defects of large-scale data collection operations. The figures given here probably reflect the real situation within a range of accuracy of ± 20 to 30%.

Table 1. Sheep and goat populations in the humid and non-humid zones of Ivory Coast, Ghana, Togo and Nigeria, 1973[a] ('000)

	Goats	Sheep	Total
Ivory Coast			
humid zone	426	533	959
non-humid zone	139	170	309
total	565	703	1 268
Ghana			
humid zone	246	344	590
non-humid zone	496	529	1 025
total	742	873	1 615
Togo			
humid zone	304	342	646
non-humid zone	335	316	651
total	639	658	1 297
Nigeria			
humid zone	6 634	1 886	8 520
non-humid zone	15 698	5 732	21 430
total	22 332	7 618	29 950
Four countries			
humid zone	7 610	3 105	10 715
non-humid zone	16 668	6 747	23 415
total	24 278	9 852	34 130

a. The humid zone figures for Togo and Nigeria have been estimated by applying the 1971 proportions for Togo and the 1966 proportions for Nigeria to the national figures for 1973. The total small ruminant population of the humid zone of West Africa is often estimated at 25 million. Assuming population densities in other countries are similar to those recorded here, this would seem a reasonable estimate.

Source: Compiled by authors.

CROP AND LIVESTOCK PRODUCTION

Crop production in the humid zone focusses on root crops, such as yam and cassava, for subsistence needs and tree crops which are important as a source of cash income. The production system until recently has been described as 'shifting cultivation' where a plot is cleared and cultivated for a few years, followed by a period of natural fallow of 7 to 15 years when cultivation is shifted to a new area. Increases in production have consisted of expansion, rather than intensification: people from existing villages have set out to clear virgin forest and establish new settlements. Because of these movements, most of the villages in the region are of relatively recent origin.

With increasing population and the expansion of areas devoted to cash crops, the land available for subsistence cultivation is declining, with the resultant threat of declining food production. Already, large quantities of food, including meat, milk and fish, are imported into Ghana and Nigeria, largely for consumption in the urban areas, and there is a danger that the shortfall in national food production will increase unless agriculture can be intensified without loss of soil fertility. However, the general response to dwindling land resources has been simply to reduce the fallow periods (Upton, 1967; Lagemann, 1977). In eastern Nigeria, by contrast, there are indications of increased diversification, multistorey cropping which combines tree, grain and root crops, better water control and fertilization. More detailed descriptions of these trends are found in Anthonio and Ijere (1973) and Lagemann (1977).

Data on livestock holdings tend to be unreliable. Chickens are common throughout the zone, found in 60 to 70% of rural households. Sheep and goats appear to be less widely distributed: they are found in 25% of the farm households in Ivory Coast, 20 to 30% in western Nigeria and up to 50% in eastern Nigeria. In some areas the distribution of small ruminants appears to have become more skewed over time: the Yoruba cocoa farming survey carried out in western Nigeria in 1951 found that 74% of rural households kept goats and 49% kept sheep, while less than half these proportions were found in a 1972 study of Western State, which indicated that the wealthiest 10% of households owned 45% of all the goats and 56% of the sheep (Galletti et al., 1972; see Appendix). This observation, that small ruminants are kept by a declining proportion of households, has been confirmed by several village-level surveys, notably Upton (1967 and in Oluwasanmi et al., 1966) and Mathewman (1977). Substantial variations are also found between villages in the proportion of households owning sheep and goats and the size of household flocks: a recent study of three villages in eastern Nigeria suggests that these differences may be related to population pressure (Lagemann, 1977). Data from the ILCA survey should help clarify the role of small ruminant production in the humid zone and the distribution of livestock holdings among rural households.

Information on the size of household flocks suggests averages of four to five small ruminants in Ivory Coast and two to three in Nigeria (see Appendix), but these averages are somewhat misleading. A cross-tabulation of data from Ivory Coast on farm and flock size suggests a strong positive correlation, i.e. farmers with larger holdings also keep larger flocks (see Appendix). However, the ILCA survey has not indicated a similar correlation in western Nigeria.

Three main production systems are found - the traditional village system, modified forms of the traditional system and commercial production. The traditional village system is by far the most common throughout the zone. Oyenuga (1967) describes traditional sheep and goat production as a 'low labour input and a low priority adjunct to the traditional arable and cash crop farming'. Small ruminants are not herded or grazed systematically, but are allowed to roam freely over the compounds, roads and uncultivated areas to browse and scavenge. During the growing season, they are generally tethered during the day to protect the crops, and they usually return to the household compounds in the evenings where they spend the night. They are fed household refuse when available, such as cassava, plantain and yam peels, but no other form of improved feeding is practised. The animals receive no veterinary care, and mating is not controlled.

Deliberate production practices are limited to culling and sales, and flock structure data collected by Rombaut and van Vlaenderen (1976) and Matthewmann (1977) suggest that males and older females are regularly sold or consumed. Emergency selling of diseased stock also occurs. The timing of offtake is generally determined by cash needs and the occurrence of festivities when meat is consumed, rather than according to a deliberate strategy to maximize production.

It is generally felt that traditional sheep and goat production in the humid zone is limited primarily by the incidence of endemic diseases, as well as the occurrence of epidemics, depending on the size of village flocks. The traditional village production system is characterized by a state of low-level equilibrium.

Throughout the humid zone there are also instances where the traditional system has been modified or improved. Notably in eastern Nigeria, goats and sheep are commonly tethered, feed is cut and brought to them (e.g. the fronds of *Aspila africana* and *Ariva bateri*) and their manure is collected and spread on the fields to maintain soil fertility (Oluwasanmi et al., 1966; Upton, 1967; Mecha, 1975; Lagemann, 1977).

A few instances of commercial sheep production were observed in the humid zone and no commercial goat production, but large-scale commercial production may assume economic significance in the future, either as a full-time or a part-time undertaking. Commercial sheep production in Ivory Coast, Ghana, Togo and Nigeria has evolved in a few cases from modified village production. Farmers who have improved their husbandry practices have found their flocks increasing to such an extent that they have moved their animals from the villages and established farms specializing in livestock production, where goats, cattle, pigs and poultry are also usually kept.

On almost all these commercial farms, grazing forms the bulk of the feed supply, and rotational grazing is widely practised. The animals are generally housed at night, and purchased or cut feed is offered in the evening. Veterinary services are provided, and, in some cases, farms are staffed by personnel trained in agricultural institutes.

Some of the major production problems which have been encountered on these commercial farms include:

a. initial high mortality rates, especially when foundation stock are introduced from various parts of the country without adequate quarantine measures;

b. inadequate training in commercial farm management, resulting in overstocking of established pastures and deterioration of grazing.

c. high capital inputs due to the construction of overly elaborate farm buildings when less expensive structures erected from local materials would be adequate; and

d. irregular supply of supplementary feeds and veterinary drugs and occasional problems in obtaining professional advice.

2. GENETIC RESOURCES

Information on the breeds and types of dwarf sheep and goats in West and Central Africa is largely limited to descriptions of size, colour and conformation (see Mason, 1951; Epstein, 1953). Little information is available on production parameters.

A major characteristic of these breeds is their small size and body weight. A number of reasons for this small size are cited in the literature, including limited feed supply, metabolic efficiency and reduced heat loss, but none of them appears completely convincing. It is perhaps worth asking whether these dwarf types are in fact unusually small or whether other types are unusually large. In Western Europe, for example, the body weight of sheep and cattle has increased by about 200% over the past two centuries, primarily as a result of improved feeding plus selection. Selection for higher meat production per animal obviously leads to increased size, and it would also appear that selection for individual high milk production leads to larger animals with bigger appetites.

Improved feeding and management plus effective selection might well lead to larger and therefore faster growing animals over a century or so, though this might not be the best strategy if productivity per unit of body weight is considered rather than productivity per animal. At any rate, these three factors have largely been absent in West Africa until recently. A further consideration is that maintaining a small flock of large animals entails higher risks than maintaining a large flock of small animals, especially in a situation where disease is the main production constraint. Up to a point, high fecundity can lead to higher survival rates than larger size or body weight. High fecundity can also be manipulated to increase production by taking advantage of early growth, though if fecundity is too high maternal stress can lead to increased mortality among the young. Selection goals can therefore be defined only after careful scrutiny of the entire production environment.

The most suitable approach at this stage would be to classify the dwarf sheep and goats of the region into two populations, one larger and one smaller, each with different local types resulting from seclusion or importation. Mecha (1978) has attempted to distinguish different breeds among the goats of southern Nigeria on the basis of size. He divided the goat population arbitrarily into three groups according to height at withers, and found that about 27% measured 40 cm or less, 67% measured 41 to 50 cm, and only 6% measured over 50 cm. He made a further subdivision of the dwarf types into pituitary dwarfs, which were small but with regular proportions, and achondroplastic dwarfs, which had irregular proportions with short legs. As the achondroplastic type forms a very small proportion of the population, attention for the present can be focussed on the pituitary type.

Specific conformational differences are sometimes striking. In Nigeria, for instance, many goats with wattles were observed, while virtually all the goats in Ghana were wattle free. More important differences in genetic makeup with regard to physiological functions, such as appetite, digestive capacity, fat deposition and innate immunity, are likely to be less striking, however. One reason for the variations in breed types and characteristics is that there has hitherto been very little control over breeding or selection within the populations, and breeds have been crossed, such as West African Dwarf and Red Sokoto, indiscriminately. Just as more information is needed on the production environment before specifying goals for genetic improvement, more needs to be known about the genetic characteristics of existing populations.

PRODUCTION PARAMETERS

Little information is available on production characteristics such as weights at birth, weaning and maturity, growth curves and lactation yields. Some of the data which have been recorded will be presented here. Data on reproductive performance will be presented in a separate section.

Birth Weight

For goats in Ghana, Sada and Vohradsky (1973) recorded a mean birth weight of 1.40 kg, with a range of 0.54 to 2.48. This average birth weight is about 6% of the average mature female weight, recorded at 25 kg, which is roughly similar to percentages recorded for other small and large breeds (see Devendra and Burns, 1970). The ILCA village survey under way in southern Nigeria has given a preliminary average birth weight for all goats of 1.2 kg. If the weights of individual young are much less for multiple births, then the proportion which survive to weaning is likely to become less with increased prolificacy. Devendra and Burns (1970) recorded an overall kid mortality of 20% but did not relate this to litter size or birth weight.

Turning to sheep, the ILCA village survey found an average birth weight of 1.8 kg. Dettmers et al. (1976) recorded birth weights of individual males in a flock of West African Dwarf sheep in southern Nigeria and calculated average weights of 1.9 kg for singles, 1.6 kg for twins and 1.5 kg for triplets. They also found a much higher mortality rate of 35 to 47% among triplets than among twins and singles, at 12 to 22%. At the Agricultural Research Station, Nungua in Ghana (University of Ghana, 1976), the average birth weight for Nungua Blackheads, a cross between West African Dwarf and Blackhead Persian, was approximately 2.25 kg, compared with 1.13 kg for the local type. As the prolificacy rate was 100% for the Nungua Blackhead and 144% for the local type, the total birth weights were 2.25 and 1.62 kg respectively.

Ngere (1973) compared the birth and mature weights of West African Dwarfs (which he refers to as 'forest type') and Nungua Blackheads with data for Suffolk sheep recorded in the United Kingdom. He obtained averages as shown in Table 2.

Table 2. Comparison of birth and mature weights for three breeds of sheep

	West African Dwarf	Nungua Blackhead	Suffolk
birth weight (kg)	1.66	2.56	5.26
mature weight (kg)	21.00	32.00	76.00
birth weight as % mature weight	8%	8%	7%

Source: Ngere (1973).

These calculations show that the relative birth weights of the two small breeds compare favourably with the figures obtained in Britain.

Growth Rates

As in the case of birth weights, it is important to consider growth rates in relation to prolificacy and mature weights. For single lambs in Ivory Coast, Ginisty (1978) recorded growth rates of 55 to 60 g per day among Djallonké sheep, a West African Dwarf type, compared with 100 g for crossbreds with the larger Sahelian types.[1] As with birth weights, Ngere's study in Ghana (1973) indicated that absolute daily weight gains were higher for Nungua crosses than for local sheep, but relative weight gains compared with mature weights were similar.

1. Average birth weights of 2.3 to 2.8 kg for the dwarf types and 2.0 for the crossbreds were also constructed by subtracting the sum of daily weight gains from the weights at four months, but these estimates are probably inaccurate. More precise data may be available soon.

For West African Dwarf goats, Sada and Vohradsky (1973) recorded average daily growth rates of 53 g among male and female twins up to three months, resulting in a relative body weight at that age of 25% of mature weight. At one year, body weights averaged 12.85 kg, or 50% of mature weight, but the range was from 10 to 19 kg, or 40 to 80% of mature weight. It is difficult to compare these figures with others, however, because of the substantial effects of differences in birth and mature weights and levels of nutrition. Among mixed dwarf goats in the Netherlands, daily growth rates of 90 ± 22 g were recorded for the first 100 days (ranging from 50 to 140 days) under an excellent feeding regime (Montsma, personal communication).

Notwithstanding their early sexual maturity, it appears that goats mature late in terms of growth. Sada and Vohradsky (1973) observed that females were still growing at three years, in terms of both weight and size. However, a sharp drop in the growth rate was observed between three and four months, so that late growth may result partly from improved nutrition. Wilson (1958) found that nutritional levels affected the growth rates of East African Dwarf goats by 50% in males and 57% in females.

Nonetheless, the considerable variations in birth weights and growth rates recorded in the humid zone, especially for goats, suggest that substantial improvements could be achieved by selection, since a fair proportion of the variation is likely to be due to genetic factors. The wide variability also indicates that fairly large samples will be required to achieve statistical significance in research work.

Lactation Rates and Milk Composition

Under present production conditions, lactation in dwarf sheep and goats in the humid zone is important primarily in terms of the nutrition of the young, especially when prolificacy is high. For goats, the only data on milk yields and composition have been recorded by Akinsoyinu et al. (1977) in Nigeria. Milk yields of about 40 kg over an 18-week lactation were recorded for six mature goats over 12 lactations. This would result in an overall average daily yield of 317 g, though in fact more than 90% of the milk was produced in the first 12 weeks, with a peak of 5 kg per week, or 714 g per day, around the fifth week. These yields were obtained by hand milking; it is likely that yields are higher with suckling.

As regards milk composition, Akinsoyinu et al. (1977) reported an energy content of 455 kJ/100 g for goat milk, which is very high, mainly due to the high lactose content (6.3%) and the high fat content (6.9%). Protein content was 3.91%. In another trial carried out at Ibadan in Nigeria, Mba et al. (1975) compared the milk composition of nine goats, three each of the Saanen, Sokoto Red and West African Dwarf breeds, over a lactation period of 12 weeks. Daily milk yields averaged from 500 to 1 000 g, with the Saanen ranking highest and the West African Dwarf goats lowest, but the order was reversed in terms of milk composition. The West African Dwarf goat milk contained approximately 70% more energy and protein than the Saanen milk. Furthermore, the yields for the West African Dwarf and Saanen goats were similar in terms of kg of body weight, though the yields recorded for the Saanen goats were low for the breed, especially considering the fact that they are accustomed to hand milking.

Rombaut and van Vlaenderen (1976) recorded milk yields of 40 kg per lactation for Djallonké sheep under village conditions, and 90 kg under improved feeding.

In efforts at genetic improvement, it would seem more practicable to select for high preweaning growth rates, rather than trying to measure milk yields directly. Converting the milk yields obtained by Akinsoyinu et al. (1977) and Mba et al. (1975) into estimated daily weight gains at a ratio of approximately 8 : 1, growth rates of 65 g per day are obtained for West African Dwarf kids. Assuming that suckling would produce 25% more milk than the yields obtained in hand milking trials, the projected daily growth rate would rise to about 80 g. Growth rates derived in this way are expressed in terms of litters rather than individual animals; the growth rate of individual animals would also depend on fecundity and survival rates. The data available at present are not sufficient to determine whether milk yield is an important factor limiting kid survival and growth.

Weaning Weights

Hill (1960) reported an average weight at three months of 8 kg for male and female West African Dwarf lambs at Ibadan, Nigeria. Out of a group of 306 lambs, losses to 18 months were 38%, with over 40% of these occurring from one week to three months. Given a flock fertility rate of 150%, the net weaning weight at three months was 7.08 kg per ewe. At Nungua (University of Ghana, 1976), weaning weights for Nungua Blackheads averaged 12.6 kg, compared with 8.1 kg for West African Dwarf lambs. Prolificacy was 100% and 143% and mortality to weaning 59% and 16% respectively, giving net weaning weights per parturition of 5.2 and 9.7 kg. Net weaning weights could also be expressed in terms of 100 kg of ewe body weight. Expressed in these terms, the net weaning weight for the Nungua Blackhead was 10 kg compared with 40 kg for the West African Dwarf.

Ginisty (1978) reported an average body weight for Djallonké sheep in Ivory Coast at four months of 9.5 kg compared with an average weight of 14 kg for crossbreds with the larger Sahelian types. The weaning weights for the Djallonké averaged 40% of their mature body weights. Prolificacy averaged 110% among the Djallonké and a similar rate was assumed for the crossbreds, giving net weaning weights per parturition of 9.5 kg for the Djallonké and 9.8 for the crossbreds. Assuming annual fertility at 150%, the weight of weaned lamb produced by the Djallonké was 13.75 kg per ewe per year, compared with 14.7 kg for the crossbreds. As at Nungua, the West African Dwarf breed produced a greater weight of weaned lamb per 100 kg of ewe body weight than the crossbreed.

Turning to goats, Sada and Vohradsky (1973) and Vohradsky and Sada (1973) found average prolificacy rates of 184%, average weaning weights at four months of 6.26 kg and average mortality up to three months of 21.4%. This results in a net weight at weaning of 9.1 kg per parturition. With a fertility rate of 141%, the annual production of weaned kid per 100 kg of doe body weight was 51 kg, which compares with levels of production achieved by typical mutton breeds in the temperate zone. It is better than the typical levels achieved by beef cattle, which average 20 to 30 kg of weaned calf annually per 100 kg of cow body weight.

Carcass Quality

Under a traditional production system, carcass quality is not of great significance because most of the animal is consumed, including the skin. Under a commercial system, dressing out percentages, meat-to-bone and meat-to-fat ratios are likely to become more important. These characteristics depend to some extent on genetic traits, but far more on levels of nutrition and age at slaughter. Because a variety of factors are involved, comparisons in different situations have limited value. For goats, Akinsoyinu et al. (1975) recorded an average dressing out ratio of 50 to 51% among 12 castrates used in a feeding experiment. Body weights ranged from 14.5 to 17 kg. Ginisty (1978) recorded an average dressing out ratio of 49.6% among nine wethers fattened before slaughter with an average body weight of 25 kg. These figures suggest that both West African Dwarf sheep and goats achieve satisfactory dressing out ratios.

For the goats recorded by Akinsoyinu et al. (1975), the ratio of fat in the lean meat was just under 10%, which is adequate for cooking but a bare minimum for roasting or processing. However, these animals were immature and had not been finished. Ginisty (1978) found an average of 64% muscle tissue for the nine wethers, 20% fat and 16% bone. These animals had been fattened but they were not mature; they were probably between 1.0 and 1.5 years old.

Fibre Production

Most West African Dwarf sheep and goats have short, sleek coats. In sheep, coats with longer hair sometimes occur and some young lambs display mixed coats which pad and are shed later on. Present knowledge indicates that wool growth would be undesirable in the humid tropics, for both physiological and technical reasons, but further research on coat and skin characteristics from a physiological and climatic point of view would be desirable.

STRATEGIES FOR GENETIC IMPROVEMENT

Variations in production parameters among sheep and goats of the West African humid tropics appear to be substantial, probably due to variations in production conditions and the absence of deliberate selection strategies. Before major efforts are expended towards genetic improvement, the goals should be clearly defined in terms of the relevant production environment, which may vary in different parts of the region and among different producers.

Projects undertaken in the region so far aimed at the genetic improvement of sheep, and to a lesser extent of goats, have largely focussed on increasing size and body weight by introducing exotic northern types, such as the Blackhead Persian in Ghana. The reason for this emphasis on increased size is not clear, as a larger, longer-legged animal may have an advantage under ranch conditions but not necessarily under village conditions.

The major drawback of the northern breeds is a greater susceptibility to disease, especially haemonchosis and trypanosomiasis. For example, the Nungua Blackhead in Ghana is not well adapted to the high levels of worm infestation which accompany year-round humidity, and consequently prolificacy is low and lamb mortality high, even with frequent deworming. According to Ginisty (1978) the mortality rate among crossbreds between Djallonké and Sahelian sheep averages 29.8%, compared with 10% for the Djallonké.

Improvements in animal production in the temperate regions have, by and large, been achieved by maintaining an equilibrium between the animals' genetic potential and the environment in which this potential has to be realized. If priority is given to improving such environmental factors as animal health and feeding, genetic improvement will occur automatically because of the shift in survival values. However, this process can be substantially accelerated by selective breeding programmes carefully tuned to existing and anticipated environmental conditions.

3. REPRODUCTION

Information on the reproductive performance of sheep and goats in the humid zone of West Africa is very limited and largely refers to experience under research conditions. Technical data derived from traditional production systems are virtually non-existent. Although some authors have distinguished different types or breeds of small ruminants in terms of different levels of reproductive performance, these traits generally have a low heritability. Differences in performance are more likely to be due to differences in feeding and management, and efforts to increase reproduction rates should probably focus on these factors rather than on genetic improvement through selection.

Both rams and bucks exhibit high libido, high fertility and early sexual maturity. In an experimental herd of West African Dwarf goats from Cameroon kept in the United States, Rogers et al. (1969) observed male sexual maturity at three months, and it proved necessary to separate the sexes prior to that age to prevent indiscriminate breeding. It should be remembered, however, that these observations were made under a high level of management and feeding. In West Africa, Ginisty (in CNRZ, 1977) recorded conception rates among sheep at first service at 73% in January/February and 87% in July/August. He attributed the lower figure to low fertility in one ram, but a seasonal effect on fertility in rams or ewes cannot be completely excluded.

OESTRUS

In goats, the lowest age reported for the onset of oestrus was about three months (Rogers et al., 1969), though this was under excellent conditions in the temperate zone. Vohradsky and Sada (1973) recorded the onset of oestrus at around four months among goats in Ghana under experimental conditions. Rombaut and van Vlaenderen (1976) recorded a range of 4.5 to 6.5 months for the onset of oestrus among sheep, and Ginisty (in CNRZ, 1977) observed an average of 8.6 months, with a range of 6.9 to 10.7 in a flock of 437 sheep. From these observations, it would appear that efforts to lower the age of puberty among dwarf sheep and goats should not be given priority.

The duration of oestrus and the timing of ovulation are not of great importance at the present level of production. The duration of oestrus in goats was recorded by Otchere and Nimo (1975) at 17.0 ± 9.7 hours, while Jarosz et al. (1971) estimated 2.82 days for 'pure' dwarf goats and 4.2 days for seven-eighths pure dwarf goats, using cytological methods in the temperate zone at different times of the year. Ginisty (in CNRZ, 1977) recorded a mean of 36 hours oestrus in sheep, ranging from 12 to 60 hours. There is very little information on the timing of ovulation, though Jarosz et al. (1971) reported ovulation at 4.25 days after the first signs of oestrus among Toggenburg goats and at 3.10 days among West African Dwarf x Toggenburg crosses.

An average cycle length for goats of 24 days was recorded by Jarosz et al. (1971), with a range from 16 to 31. Otchere and Nimo (1975) reported an average cycle of 24 days, ranging from 14 to 34,and detected a significant effect of season on cycle length, though their observations were only over five months. These very large ranges in cycle length are not explained by the authors. For sheep, Ginisty (in CNRZ, 1977) recorded an average cycle of 17.7 days, ranging from 16 to 19 days only. This range is surprisingly narrow, and may be indicative of a regular feed supply for this research station flock. Jollans (1960a), however, recorded a cycle ranging from 6 to 24 days for a flock of West African Dwarf sheep kept on a research station in Ghana's forest zone, with a 'fair number' of ewes cycling only every 32 to 37 days.

In the humid tropics, most research workers have observed dwarf sheep and goats breeding throughout the year. The seasonal peaks which do occur are more likely the result of fluctuations in feed availability, rather than changes in photointensity. Vohradsky and Sada (1973) observed a peak in kidding around April and a smaller peak around September at an experimental station on the Accra plains in Ghana, which would imply conception peaks in November and April. Although these peaks were likely due to levels of nutrition, this cannot be proven as the feeding regime was not reported. Seasonal birth peaks may also be due to previous seasonal peaks in mortality, though Ragan et al. (1966) and Rogers et al. (1969) suggest that differences in photointensity at different times of year may affect the occurrence of oestrus. Montsma (personal communication) reports that oestrus occurs among dwarf goats in the Netherlands in early spring, while Devendra and Burns (1970) state that oestrus among dwarf goats in Europe occurs year round.

Orji (1977) simulated traditional management conditions with a flock of West African Dwarf sheep, fed only roughage or roughage with some supplementation. He found no significant effect of season or nutritional status on the oestrus period or cycle, which continued throughout the year. Hill (1960) observed a flock of dwarf sheep from 1950 to 1959 under traditional management conditions at the University of Ibadan in Nigeria with a minimum of supplementary feeding. The ewes bred throughout the year, though lambs born during the dry season from November to March were slightly heavier, averaging 8.1 kg at birth, than lambs born during the wet season from April to October, who averaged 6.9 kg. As the ewes averaged three lambings over two years, it was originally decided to synchronize breeding so lambing would occur in December, August and February/March, but subsequent work suggested that a year-round breeding programme would be more productive because many ewes would lamb twice in one year.

AGE AT FIRST CONCEPTION AND PARTURITION

The gestation period for dwarf sheep and goats is approximately five months. For goats, various authors in Ghana and Nigeria give a range of 133 to 153 days, while Ginisty (in CNRZ, 1977) recorded an average of 149.3 days for sheep with a range of 145 to 152 days. The gestation period for twin births averages about 1.2 days less than for singles. Variations in gestation period are usually associated with such factors as multiple births, weight of offspring and age and parity status of the dam, though the underlying causes are largely hormonal.

Rombaut and van Vlaenderen (1976) observed an average age at first lambing of 11.5 months among sheep kept under traditional management, with a range of 9.5 to 14.0 months. This implies an average age at first conception of 6.5 months, ranging from 4.5 to 9.0. These average ages are probably not optimal, however, because only 11% of the lambs born to ewes mated between four and eight months survived to one year (see also Table 3). Dettmers et al. (1976) found an average age at first lambing of 20.5 months, ranging from 8 to 72 months; 37% of these ewes lambed again within one year and 66% within 13.3 months. Ngere (1977) studied a flock of West African Dwarf sheep kept under experimental conditions to determine the optimum age at first mating. His findings are shown in Table 3.

Table 3. Pregnancy and birth rates and average lamb weights for first-lamb ewes at various ages

Age in Months	Number Exposed	% Pregnant	% Live Births	Average Birth Weights (kg)
8	12	42	17	1.6 ± 0.3
9	13	77	54	1.7 ± 0.2
10	8	75	38	1.7 ± 0.4
11	9	100	100	2.0 ± 0.4
12 and over	9	100	100	2.0 ± 0.4

Source: Ngere (1977).

It appears from Table 3 that, under the conditions of the experiment, the optimal age at first mating for West African Dwarf ewes is about 11 months. Data are not presented on ewe body weights, however, and it is likely that the best criterion for age at first mating would be derived from a consideration of age and body weight combined.

Among goats, Vohradsky and Sada (1973) recorded an average age at first parturition of 12.1 months, ranging from 9.3 to 16.2, giving an average age at first conception of around 5.5 months. Kid mortality averaged 21.9% up to three months, with a seasonal peak of 46 to 60% in the cooler months of June/July, mainly due to cases of acute pneumonia. These relationships are illustrated in Figure 2.

PARTURITION INTERVAL

Research indicates that dwarf sheep and goats tend to have a short reproduction cycle. Matthewman (1977) observed ewes suckling their young for 70 to 98 days or more and suggested that the onset of oestrus might be delayed by lactation. Orji (1977) recorded postpartum anoestrus averaging 54.91 days and also hypothesized that lactation might delay oestrus. Others, however, have reported that oestrus occurs among dwarf goats shortly after parturition in spite of lactation. Ginisty (in CNRZ, 1977) reported that oestrus occurred within 43 days for 95% of a flock of 44 suckling ewes, with a range of 22 to 66 days.

Parturition intervals averaging 258 days were recorded by Vohradsky and Sada (1973) for dwarf goats kept under research conditions in Ghana, with a range of 175 to 310 days. Otchere and Nimo (1976) reported an average of 254 days, ranging from 119 to 499. Matthewman (1977), Vallerand and Branckaert (1975) and others consider the optimum interval to be three parturitions in two years.

FERTILITY, PROLIFICACY AND FECUNDITY

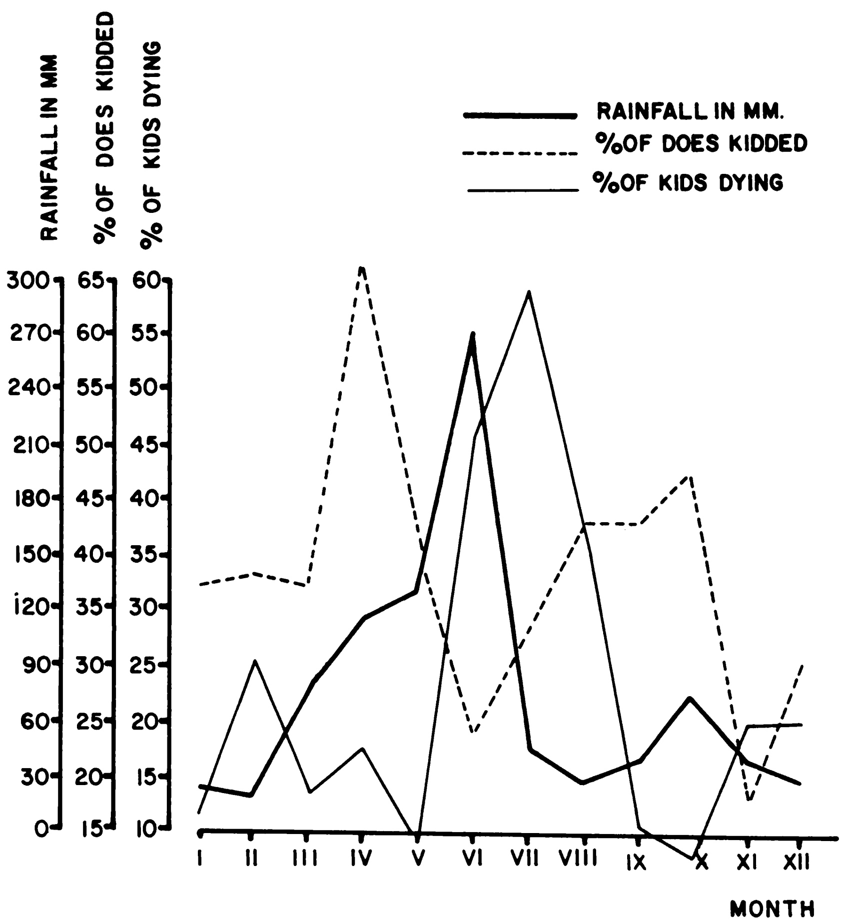
In measuring reproductive performance, fertility refers to the number of parturitions per annum, prolificacy to the average number of young in each litter and fecundity to the number of young produced per year. Data on these parameters for West African Dwarf sheep and goats are limited and somewhat conflicting, but it seems likely that cases of infertility are associated with nutritional deficiencies or debilitating disease.

Among goats kept at the Agricultural Research Station, Nungua in Ghana, Vohradsky and Sada (1973) found a kidding interval of 285 days, as already mentioned, which implies a fertility rate of 124%. Of all births recorded, 32.1% were singles, 52.9% twins, 13.7% triplets and 1.3% quadruplets, giving an average prolificacy rate of 184% which leads to a fecundity rate of 260%, meaning that on average each doe produced 2.6 kids a year. Otchere and Nimo (1976) calculated an average fecundity rate of 267% for their sample.

Mecha (1978) attempted to classify the goats of southern Nigeria according to body size. He found that the medium size, or pituitary dwarf type, was the most fertile: 'The kidding interval is short and twin, triplet and quadruplet births occur many times in their life span'. The smaller achondroplastic dwarfs, on the other hand, were characterized by 'a long kidding interval with one kid per birth throughout most of the period ...'. Among the larger types, twin births were common. This work might usefully be extended to include calculations of fertility and fecundity as well as prolificacy.

Production parameters of sheep and goats have been recorded at the University of Science and Technology in Kumasi, Ghana for more than ten years; the final analysis of these data should be available soon. Fertility rates observed among goats have been calculated by Buadu (1972), averaging 154%, and prolificacy rates 184%, which gives an average fecundity rate of 293%.

Figure 2. Percentage of does kidding from total number of does on hand, percentage of kids dying and mean monthly rainfall in mm



Source: Vohradsky and Sada (1973).

Turning to sheep, Ginisty (in CNRZ, 1977) observed a number of flocks in Ivory Coast maintained under both traditional and commercial conditions. He reported an average fertility rate of more than 160% under traditional conditions but a prolificacy of only about 110%, meaning that only about 10% of the births were twins. This resulted in a fecundity rate of about 175%, though approximately 50% of the lambs died before the age of four months, resulting in a net fecundity rate of 87.5%. At the Agricultural Research Station, Nungua, a prolificacy rate of 143% was recorded for West African Dwarf sheep, together with a lamb mortality rate of 16.7% (University of Ghana, 1976). Prolificacy in Nungua Blackheads was found to be lower, at 100%. Dettmers et al. (1976) found a fertility rate of 145% and a prolificacy rate of 172%, giving an annual fecundity rate of 249%. Comparing sheep and goats, Matthewman (1977) observed fertility rates of 155% for goats and 115% for sheep in two villages in southern Nigeria. Survey data from the humid zone in Nigeria gathered in 1972 confirm these results. Records of reproductive performance are also being maintained by the Société de Développement de la Production Animale (SODEPRA) in Ivory Coast and by Bennet and Bonniwell in a forest-zone village in Ghana, but the results have not yet been published.

REPRODUCTIVITY WASTAGE

Rather than increasing production in every case, early maturity, high prolificacy and short parturition intervals may lead to substantial reproductive losses. Rombaut and van Vlaenderen (1976) found a strong positive correlation between length of parturition interval and survival of lambs under simulated traditional production conditions. Their findings are summarized in Table 4.

Table 4. Influence of parturition interval on survival rate of lambs: Percentage of losses

Deaths	Period Between Lambings	
	under 7 months	over 7 months
Abortions and perinatal	22	0
Up to 1 month	30	20
1 - 6 months	41	40
Surviving at 6 months	7	40

Source: Rombaut and van Vlaenderen (1976).

They also found significantly higher mortality rates among the offspring of ewes which were first mated between four and eight months, compared with the offspring of ewes which were not mated until maturity.

These two authors described the condition resulting from a rapid succession of pregnancies as '*fatigue des mères*'. Not only do the ewes lose weight, but there is a steady deterioration in the health of the young over successive lambings: 86% of the lambs born to non-fatigued ewes survived to four months and 81% to seven months, while only 53% of the lambs of fatigued ewes survived to four months and 24% to seven months. These lambs were less robust and more susceptible to the effects of disease and poor nutrition. Lamb mortality reached a peak at four months, corresponding with reduced lactation, and at seven months, corresponding with subsequent parturition. It should be pointed out, however, that work with sheep in Ghana did not reveal a similar correlation between lamb survival rates and parturition interval. More research on optimum parturition interval and age at first mating is called for, taking into account the role of nutrition levels, to serve as a basis for improved management strategies.

Reproductive wastage might also be reduced if breeding were controlled on a seasonal basis to reduce the incidence of helminthiasis, most prevalent in the form of parasitic gastro-enteritis and most damaging to the young. Through the year there are wide fluctuations in parasitic larval challenge. Young animal who are weaned and begin grazing during the wet season are exposed more intensely to infective larvae at a susceptible age than others who are weaned during the dry season and are not exposed until they are older and better able to withstand damaging infestations.

MALE-FEMALE RATIOS

The experience of research institutes and commercial sheep farms has indicated that male to female ratios ranging between 1 : 20 and 1 : 60 are sufficient to ensure efficient conception rates. However, much higher proportions of males tend to be kept in flocks under traditional husbandry systems.

In a survey conducted in southwestern Nigeria, Sellers et al. (1974) found that 120 rural households kept a total of 118 adult rams and 327 adult ewes, giving a ratio of 1 : 2.8. In 745 rural households, 381 adult bucks were kept and 1 635 does, or a ratio of 1 : 4.3. Matthewman (1977) found 11 adult bucks kept with 153 does, or a ratio of 1 : 17, and he reported that sires were usually under one year old. Van Vlaenderen (personal communication) found 130 adult rams and 663 adult ewes over five months old in a survey of 20 villages in Ivory Coast. Differences in the ratios cited may reflect differences in the definition of maturity in both males and females or a slower growth rate in males which leads to slaughter or sale at a later age.

4. ANIMAL NUTRITION AND TROPICAL FORAGES

Under traditional management systems, sheep and goats in the humid tropics are fed almost entirely on natural grazing and browse, sometimes supplemented with small quantities of household refuse. Animal feeding is limited by the quantity and quality of nutrients available from indigenous grass and shrub species throughout the year.

NUTRITIONAL REQUIREMENTS AND FORAGE QUALITY

The nutritional requirements of sheep and goats in the humid tropics were recently reviewed by Oyenuga and Akinsoyinu (1976). These authors found that the daily metabolizable energy (ME) requirements for maintenance were approximately 100 kcal per kg metabolic weight[2] for both species. Assuming normal growth and lactation yields, the daily requirements for ewes were an additional 194 kcal for lactation and 857 kcal for growth per kg metabolic weight, while for does the equivalent requirements were 187 and 591. The digestible crude protein (DCP) requirements for maintenance ranged from 0.74 to 1.96 g per day per kg metabolic weight, while for growth 0.26 to 2.2 g DCP were required per g liveweight gain. These energy and protein requirements for maintenance are comparable, though slightly lower, than the values calculated earlier by Devendra and Burns (1970).

2. One kg metabolic weight was calculated as equivalent to 0.734 kg liveweight.

A number of studies have been carried out on the quality and chemical composition of feedstuffs available in different tropical areas. In West Africa, these include studies by Oyenuga (1958, 1968), Mabey and Rose Innes (1964), Bille et al. (1970) and Boudet (1975b) and ongoing work at the Agricultural Research Station, Nungua (University of Ghana, 1975, 1976). Other work has been carried out by Dougall (1960) in Kenya, Devendra and Gohl (1970) and Devendra (1977a) in the West Indies, Sen and Ray (1971) in India, Castillo and Gerpacio (1976) in the Philippines and Devendra (1979) in Malaysia.

In addition, studies of voluntary feed intake have been carried out with cattle, buffaloes, sheep and goats. These have been based on indoor feeding trials, mainly because of management difficulties and the lack of reliable methods for measuring intake under grazing conditions. On the basis of such trials, the nutritive value of tropical grasses has been reviewed by Miller and Blair Rains (1963), Hardison (1966), Butterworth (1967) and Minson (1971). The nutritive value of tropical legumes has been reviewed by Stobbs (1971) and tropical hays by Marshall et al. (1961), but the effects of selective feeding on intake have not been studied systematically.

A review of this work indicates that tropical grasses are relatively low in energy and protein and high in fibre content compared with species in the temperate zone, largely as a result of their more rapid physiological growth and early maturation, as influenced by temperature and light (French, 1957; Osbourn in University of Ghana, 1976; Devendra and Gohl, 1970; Stobbs, 1971). Tropical legumes are subject to a similar process, though their loss of nutrients is less rapid and they generally retain higher levels at maturity than the grasses (Milford and Minson, 1966).

While energy consumption is the limiting factor on animal production in temperate regions (Holmes, 1951; Crampton, 1957), dietary protein is the primary deficiency among livestock in many parts of the world (Moir, 1963). In the tropics, both factors are often limiting and seriously impair animal performance, with protein deficiencies particularly important during lactation. The protein content of tropical forages has been shown to be generally low (French, 1957; Bredon and Horrell, 1961, 1962; Butterworth, 1967), falling rapidly with growth to the time of flowering. During the dry season, the crude protein content of tropical forage drops even further, reaching critical levels below 7%.

Protein and energy consumption are interlinked. When the protein content of forage is inadequate, food intake drops and the digestibility of energy is reduced (Campling et al., 1962; Blaxter and Wilson, 1963; Eliot and Topps, 1963; Smith, 1962). Milford and Minson (1968) found that the intake of sheep decreased when the crude protein content of their diet fell to 7%.

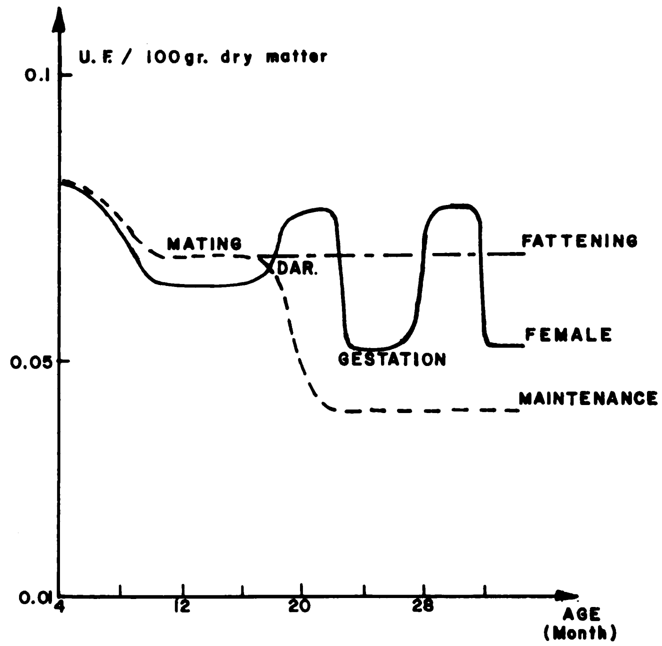
Rombaud and van Vlaenderen (1976) estimated the energy requirements of sheep at different physiological stages in terms of the nutrients required per 100 g dry matter (DM), and the digestible crude protein requirements in terms of percentage of DM, as shown in Figures 3 and 4. If these requirements are compared with the nutrients available from some of the common grasses and legumes in the humid zone, it appears that these forages are only adequate nutritionally when the plants are very young.

Shrubs and trees, however, often retain high levels of nutrients during the dry season, which increase with the first flush of new growth before the rains. At the time of year when the nutrients available from grass and legumes are inadequate, these plants become a particularly valuable source of feed, at least for goats. The value of browse plants and the extent of their intake have recently been reviewed by Devendra.

DIGESTIBILITY AND FEED INTAKE

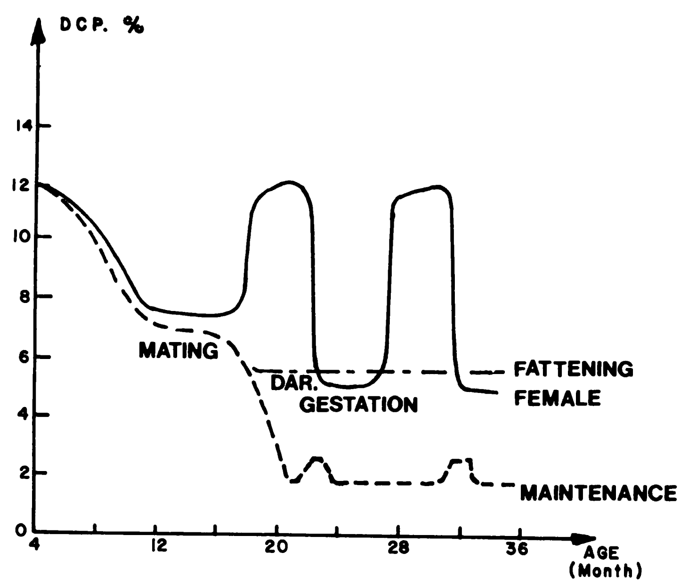
Digestibility is affected by the botanical composition and stage of maturity of the forage and also by processing and chemical treatment (Miller, 1961). Improved digestibility means that a greater proportion of the feed is actually absorbed by the

Figure 3. Energy requirements of sheep at different physiological stages



GESTATION

Figure 4. Digestible crude protein requirements of sheep at different physiological stages



GESTATION

Source: Rombaud and van Vlaenderen (1976).

animal. Lower digestibility leads to higher voluntary feed intake in the temperate zone (Blaxter, 1967), but this relationship is less clear cut in the tropics due to the different lengths of time required to digest tropical feeds (Milford, 1967). For a number of tropical species, including *Chloris gayana* (Milford and Minson, 1968), *Panicum* spp. (Minson, 1971) and legume species (Stobbs, 1971), the level of voluntary feed intake has been shown to decrease with decreased digestibility, compounding, rather than compensating for, the effects of an inadequate diet.

In general, it is rarely possible to achieve a digestibility level of over 70%. In practical terms, adult ruminants (except dairy goats) are unlikely to consume a dry matter equivalent of more than 3% of their body weight daily if fed mature forage of only 40% digestibility. It has been shown that the daily dry matter intake of goats increases considerably if digestibility increases up to 70%.

Feed intake in the tropics may also be restricted because of the high water content of the herbage. In the West Indies, for instance, Butterworth et al. (1961) found a dry matter content of 39.3% for pangola grass *(Digitaria decumbens)* during the dry season and only 23.4% during the wet season, and similar levels were observed in Thailand. As a result, the herbage contributes a large proportion of the total water consumed by the animals, but if dry matter content falls below 20% it is likely that the energy intake will be inadequate. Differences in voluntary intake may also be due to differences in chemical composition of the fodder, such as ash content.

Jollans (1960b) has suggested that one constraint on small ruminant production in the humid tropics might be that a great deal of grazing time is required to ingest the full bulk of herbage necessary to obtain an adequate level of nutrients. In order to increase intake, he carried out an investigation using supplementary light to extend the grazing day for a flock of wethers, but this produced no measurable effect on their growth rates.

Notwithstanding these observations, it is probable that some of the improved tropical grasses, such as Napier grass *(Pennisetum purpureum)*, can produce relatively high digestible dry matter (DDM) ratios, above 65%, provided that they are grazed or cut at an early age. Different strains also vary in terms of digestibility and intake. Minson (1971), for example, reported from a study of *Panicum* cultivars that at a given level of digestibility the intake of var. *Hamil* was 27 to 50% higher than of var. *Kabulabula*. Devendra (1977b) found similarly for goats and sheep that at a given level of digestibility the intake of var. *Coloniao* was higher than of var. *Serdang*. Goats also showed higher levels of digestible dry matter consumption than sheep. With var. *Coloniao* cut at 16 to 19 days, the DDM ratio for goats was 74.6% and for sheep 68.8%. When the grass was cut at 21 to 28 days, goats showed a DDM ratio of 72.4%, compared to 68.4% for sheep. At 28 to 35 days, these ratios were 72.1% for goats and 64.1% for sheep; at 35 to 42 days, they were 64.3% for goats and 60.0% for sheep; and at 42 to 49 days, they were 61.2% for goats and 55.5% for sheep.

POTENTIAL LIVESTOCK PRODUCTION BASED ON TROPICAL PASTURES

Glover and Dougall (1961) and Payne (1963) have suggested, perhaps optimistically, that milk production from cattle on tropical pastures can reach levels similar to those achieved in temperate regions. While this hypothesis is based on theoretical considerations, Hardison (1966) concluded from a critical examination of a great deal of published data that milk output from cattle on tropical pastures would be limited to 5 kg per day by the level of total digestible nutrients available, while the digestible crude protein available would be sufficient for maintenance and the production of 10 kg of milk daily. Dirven (1970) calculated that 9 000 kg of milk could be produced per ha of tropical pastures annually, while 1 650 kg of liveweight gain could be produced annually per ha from beef cattle in the tropics, compared with 1 000 kg/ha in the temperate zone. Butterworth (1963) concluded from a study of 29 forage species in Trinidad that adequate nutrients were available for commercial beef production. More recently, Holder (1967) demonstrated that milk pro-

Table 5. Stocking rates and liveweight gains (LWG) in the humid zone of West Africa

Pasture species	Months and Seasons	No. of days	Animal Species	Stocking Rate actual	Stocking Rate head/ha corrected	Liveweight gain g/head equivalent[b]	Liveweight gain kg/ha per day	Liveweight gain kg/ha per period	Source
Brachiaria	V - X w	180	cattle	5	50	40	2.00	360	Messager (1977)
	XI - IV d	180	cattle	2	20	20	0.40	72	
Digitaria	V - X w	180	sheep	24	24	38[c]	0.91	164	Brinkman (1975)
Cynodon–Centrosema	IV - XI w	250	cattle	3	30	36	1.08	270	Crowder and Chheda (1977)
	XII - III d	110	cattle	3	30	15	0.45	50	
Cynodon–Centrosema				3	30	21	0.63	230	Ruthenberg (1974)
	I - XII w,d	300	cattle	4	40	19	0.76	274	
Pennisetum purpureum–Centrosema	IV - XI w	250	cattle	3	30	32	0.96	240	Crowder and Chheda (1977)
	XII - III d	110	cattle	3	30	6	0.18	20	
Andropogon gayanus	VI - XII w	204	cattle	1.4	14	38	0.53	109	Crowder and Chheda (1977)
	VI - XII w	204	cattle	1.6	16	76	1.22	248	

a. One bovine estimated equivalent to 10 dwarf sheep or goats.
b. 300 g LWG for cattle estimated equivalent to 30 g for sheep.
c. Same LWG with or without concentrate supplementation.

duction as much as 60% greater than Hardison's estimates could be achieved on Kikuyu grass *(Pennisetum clandestinum)* and clarence glycine *(Glycine javanica)* pastures in tropical Australia.

Liveweight gains actually obtained using various forage species in West Africa are shown in Table 6. These production levels are still substantially lower than the potentials calculated by the authors quoted above.

Little information is available on the efficiency of energy and protein conversion among goats and sheep in tropical environments, though several estimates have been published for sheep in the temperate zone (e.g. Holmes, 1970). Devendra (1978a) has estimated the efficiency of energy and protein conversion among goats, as shown in Table 6.

Table 6. Estimated efficiency of energy and protein conversion among goats

	Conversion Efficiencies (%)		
	Energy to Energy[a]	Protein to Protein[b]	Energy to Protein[c]
Milk production	24.0	23.7	14.5
Meat production			
on grass	4.7	9.1	5.1
on grass + concentrates	6.7	10.2	7.5

a. Expressed as Kcal produced per 100 kcal of metabolizable feed energy consumed.

b. Expressed as edible protein produced per 100 g of feed protein consumed.

c. Edible protein produced per Mcal metabolizable feed energy consumed.

Source: Devendra (1978a).

The estimates of milk production efficiency among goats, as reported in Table 6, are higher than those recorded for sheep by Holmes (1970). Holmes reported conversion efficiencies of 21% for energy, 23% for protein and 14.5% for energy to protein conversion. For goat meat production, the energy conversion values reported by Devendra fall within the range of 5.2 to 7.8% previously given by Taylor (1970), but are slightly higher than the range of 2.4 to 4.2% recorded by Spedding and Hoxey (1974). These estimates are generally higher than the conversion efficiencies recorded for cattle, which is consistent with other published material reviewed by Devendra (1975a).

Studies of digestive efficiency comparing goats, sheep and other ruminants have recently been reviewed by Devendra (1978a). Out of 20 studies comparing goats with other ruminants - most often sheep or cattle - 12 showed statistically significant differences indicating the higher digestive efficiency of goats in terms of dry and organic matter, crude fibre and protein digestion. Goats appear to be 3.7 to 29.1% more efficient in digesting crude fibre. Three of the studies demonstrated that this greater efficiency is associated with the intake of poor quality roughages.

Besides the nature of their diet, possible reasons for the apparently higher digestive efficiency of goats may be associated with feeding behaviour, salivation, level of feed intake, pattern of rumen fermentation, concentration of cellulolytic bacteria and rate of movement along the alimentary tract. It has been suggested that as roughages mature, goats are better able to digest crude fibre than sheep or cattle. This implies the higher availability of metabolizable energy (ME) for goats on a fibre diet, as well as possibilities for increasing their overall digestive efficiency by manipulating their selective feeding preferences. The differences in digestive efficiency among species also suggest that digestibility data should be recorded separately for goats (Devendra, 1978a).

Sheep and goats have lower protein and energy requirements than cattle, and most tropical grasses, if fed at an optimum age, should be able to meet their requirements for maintenance and meat production. Very little information is available on sheep and goat production based on tropical forages, however. On a year-round basis, daily liveweight gains vary from 0.6 to 1.2 kg per ha.

During the wet season, daily gains vary from 0.9 to 2.0 kg per ha with a mean of 1.2 kg, while during the dry season they vary from 0.45 to 0.8 kg. Thus an annual liveweight gain of 250 to 300 kg per ha should be feasible. Given their somewhat higher digestive efficiency, goats should be able to produce slightly higher liveweight gains per ha than sheep.

It should be possible to increase meat production from sheep and goats in the humid tropics using a feeding system based on the intensified production of selected fodder species and the careful timing of culling or grazing. Management must also take account of the feeding preferences of the animals. Requirements for increased fibre and milk production are largely unknown, but some supplementary feeding would probably be required. Further research is needed to develop more accurate estimates of nutritional requirements and feed intakes at different times of the year.

5. FODDER PRODUCTION

As the number of small ruminants increases in humid areas due to improved management and disease control, greater feed supplies will be required, calling for intensified fodder production systems. At present, forage is largely grazed directly or collected from natural vegetation, and more information is needed on the feeding value of various indigenous species, possibilities for increasing their production by cultivation and possible toxicity. Feeding with farm byproducts is limited in the humid tropics because the staple root crops do not produce large amounts of edible residues. However, forage crops could be planted in rotation with food crops, either partially or totally replacing the traditional bush fallow, with the dual purpose of restoring soil fertility and providing animal feed. Many kinds of shrubs and trees should be considered for this purpose, in addition to the conventional forage grasses and legumes, as these might be better suited to the environment and the overall farming system. In some instances, more extensive systems of commercial sheep and goat production may be justified, both in the derived savanna area and in the forest zone on commercial plantations, and these operations will also require improved fodder production.

FODDER SPECIES

The choice of suitable fodder species in the humid tropics is wide, including both native and introduced plants. In addition to the grass and legume species available, the browse species are particularly valuable for goat production, adding variety to the diet and providing substantial levels of nutrients, particularly during the dry season when the grasses are of poor quality. Studies in East Africa (Wilson, 1957) show that goats prefer browse, shifting from grass and herbs to browse during the dry season (Malechek and Leinweber, 1972; Coblentz, 1977) when browse may constitute up to 80% of total intake.

A number of authors, including Messager (1977), Crowder and Chheda (1977) and Ruthenberg (1974), have listed useful forage species for livestock production in the humid tropics, taking into account dry matter production, ease of establishment, length of growing season, quality of dry-season feed provided, and in some cases ease of eradication when fodder plants invade neighbouring food crops. Among the grasses, recommended species include *Brachiaria ruziziensis*, *B. mutica*, *Cynodon plectostachyum*, *C. nlemfluensis*, *Panicum maximum* and *Pennisetum purpureum*, as well as their hybrids with *P. typhoides*, *Chloris gayanus* and *Cenchrus ciliaris*. Recommended legumes include *Pueraria phaseoloides*, *Centrosema pubescens* and *Stylosanthes guyanensis*. Less information is available on shrubs, but Asare (1974), Oppong (1974) and Brinkman and Adu (1977) have identified *Leucaena leucocephala*, *Cajanus cajan*, *Flemingia* spp., *Griffonia carpinifolia* and *Baphia nitida* as promising species.

A longer list of the names and primary uses of grasses, herbs, legumes and shrubs found on experimental plots and research stations throughout West Africa is given in the Appendix. This list is far from comprehensive, however, particularly as regards the herbs and shrubs. Lagemann (1977) also lists plants found and widely used by farmers in eastern Nigeria.

PASTURE ESTABLISHMENT

The techniques for establishing pasture grasses and legumes in the tropics are well known and have been reviewed in detail by Messager (1977) and Crowder and Chheda (1977). The best time for planting or sowing is just before the rains, or alternatively during the short August dry season, and the application of a complete nitrogen, potassium, phosphorus (N-P-K) fertilizer is advised.

Brachiaria ruziziensis, *Panicum maximum* and *Cenchrus ciliaris* are normally established from seed, as are all the legume species and *Leucaena*, *Tephrosia* and *Cajanus* shrubs. Establishment from seed is the easiest method, especially if mechanized cultivation is possible, though very thorough seedbed preparation is essential as well as weed control in the early stages of growth. The greatest constraint on establishment from seed at present is the fact that seeds of pasture species are not widely available on the market. *Stylosanthes guyanensis* is the exception, however: the techniques for producing seed from this species are well known (Messager, 1976), it has been found to produce seed readily, and seed farms are functioning in some countries. A government seed production programme is being initiated in Nigeria.

Vegetative establishment requires more labour for planting but less for seedbed preparation. This method is also limited by the fact that plant materials do not withstand long periods in transport. Species such as *Cynodon* spp. and *Brachiaria mutica* are readily established from stolons, but they tend to invade adjacent crops and are difficult to eradicate. It is also difficult to assess the purity of the strain when collecting the stolons for planting. *Pennisetum purpureum* is normally established by shoot cuttings, while *Panicum maximum* and *Tripsacum laxum* may also be established from crown splits, though this is a more delicate operation.

As already mentioned, the major constraint on the establishment of improved pastures in the humid tropics is the lack of seed. This is a problem for research projects and an even greater constraint on efforts to introduce improved pasture species to local farmers. Research projects can rely to some extent on imported seed, but any large-scale extension programme must be based on adequate local seed production. The amount of seed required for establishment and the amount of seed produced are given in Table 7 for a number of promising pasture species.

Table 7. Sowing and seed production rates for tropical forage species

Species	Sowing Rate (kg/ha)	Seed Production Rate (kg/ha)
Andropogon gayanus	10-20	50-60
Brachiaria ruziziensis	25	80-120
Cenchrus ciliaris	5	65-80
Melinis minutiflora	3-4	30-40
Panicum maximum	20-30	80-100
Setaria anceps	8-10	40-60
Pueraria phaseoloides	6-10	60-80
Stylosanthes guyanensis	6-10	60-80

Source: Compiled by the authors.

HERBAGE PRODUCTIVITY

Data available on the dry matter yields of forage crops in the humid tropics derive exclusively from trials conducted at research stations and usually refer to one year only. Generalizations from these data should be cautious, particularly when applied to small-farm conditions.

Trials with giant star grass (*Cynodon plectostachyum*) in Nigeria yielded 16.7 t of dry matter per ha in the first year, while 10 cultivars of this species yielded an annual average of 10 t dry matter/ha over a two-year period (Ademosun and Chheda, 1974; Chheda and Akinola, 1971). In a two-year study in the same area, elephant grass (*Pennisetum purpureum*) and 26 hybrids of *P. purpureum* and *P. typhoides* yielded an annual average of 18 t dry matter/ha during the first year and 14.5 t in the second (Aken'ova et al., n.d.). These results were obtained with the annual application of 364 kg nitrogen fertilizer per ha. Further north, in Nigeria's subhumid zone, annual yields of 6 to 8 t dry matter/ha were obtained for

Digitaria smutsii, 6 t for *P. maximum* and 8 t for a mixture of elephant grass (*Pennisetum purpureum*), *P. maximum*, star grass (*Cynodon dactylon*), *Centrosema pubescens* and *Stylosanthes guyanensis* (De Leeuw, personal communication; Crowder and Chheda, 1977). In Ivory Coast, Messager (1977) recorded average annual yields over three years of 13 t dry matter/ha for *P. maximum*, 10 t for *Brachiaria mutica* and 8 t for *Stylosanthes guyanensis*, while *Andropogon gayanus* yielded 4 t dry matter/ha and *Cenchrus ciliaris* 4.2 t. In Togo, Ruthenberg (1974) estimated annual production on a commercial farm at 16 t dry matter/ha for *P. maximum*, 5 t for star grass (*Cynodon dactylon*) and 7 and 5 t for two types of natural pasture.

In addition to annual yield levels, the production of fodder at various times of the year is an important consideration in planning an animal feeding programme. All grasses produce more abundantly during the wet season, but the variation in productivity according to season differs among plant species. *Cynodon* cultivars, for instance, produce a daily average of 40 kg dry matter/ha during the wet season and only 5 kg during the dry season, giving a ratio of wet season to dry season production of 8 to 1. This seasonal difference is accentuated in the case of the more productive varieties, whose wet to dry season production ratio is 9 to 1 (Chheda and Akinola, 1971).

In addition to differences between wet and dry season, there are different production patterns within the wet season. In one study, 10 varieties of *Cynodon* were cut twice during the growing season. In the first year of establishment, differences in overall yield were due almost entirely to differences in growth which took place between the first and second cut, but during the second year, the differences in yield were all obtained at the time of the first cut. These results suggest that after the first year of establishment the main differences in yield between improved and unimproved plant varieties occur during the early part of the growing season, when all production is at its peak and any excess will be difficult to utilize. In most cases, fertilization with nitrogen also produces excess forage at this time (Ademosun and Chheda, 1974).

The growing season for legumes is one to two months longer than for grasses, and, if kept as standing hay, legumes retain their feed value longer. Messager (1977) reported a crude protein content of 10% for a legume pasture at the end of the dry season, which was the lowest value recorded over a year. Among the grasses, *Brachiaria* spp. appears to remain green at the beginning of the dry season for a longer period than native species, such as *A. gayanus*, probably making better use of the sparse rains and residual soil moisture available at that time (Messager, 1977). As already mentioned, shrubs and trees are particularly valuable as a source of feed during the dry season. Species such as *Griffonia* spp. and *Baphia* spp. remain leafy throughout the dry season with a crude protein content of 15 to 20% (Fianu et al., 1972).

Substantial reductions in annual dry matter yield have also been observed for various fodder species between successive years of establishment. A drop of about 50% in dry matter yield has been reported by Asare (1974) between the first and second years of establishment for a number of pasture species and Ademosun and Chheda (1974) reported a similar drop of 33% for *Cynodon* spp. Some examples of reductions in dry matter yields from the first to the third year of pasture establishment are given in Table 8.

Table 8. Reductions in annual pasture yields from first to third year of establishment

Species	- Annual Yields (tonnes dry matter/ha) -	
	first year	third year
P. maximum	19	9
B. mutica	15	8
S. guyanensis	10	5

Source: Messager (1977).

FERTILIZATION

Fertilization, particularly with nitrogen, has a dramatic effect on tropical pastures, not so much in raising overall yield levels as in maintaining the level achieved during the first year of establishment over successive years (Messager, 1977). With fertilization, *P. maximum* and *B. mutica* yields have been boosted to annual levels of 24 t dry matter/ha with annual averages over three years as high as 32 t. Smaller applications of nitrogen (88 kg per ha) may increase production by 50 or even 100% (Crowder and Chheda, 1977). Without fertilization, drops in dry matter yield of 55% have been recorded for *P. maximum* and 40% for *B. mutica* during successive years of production, but these were reduced to 10% with the application of nitrogen. At Bouaké in Ivory Coast, Cathou found that the production of 20 t dry matter/ha of good quality forage could be maintained with the application of 300 kg nitrogen, 100 kg phosphorus and 400 kg potassium annually. Ademosun and Chheda (1974) recorded drops in *S. guyanensis* dry matter yields of 50% without fertilization, reduced to 36% with modest fertilizer application, while Messager (1977) found drops in *Cynodon* spp. yields of 33% with or without fertilization.

The effects of nitrogen application on the dry matter yields of various forage species are illustrated in Table 9. These figures show that on average an increased yield of 50 kg dry matter/ha can be expected from the application of 1 kg nitrogen. This ratio is consistent with general findings under tropical conditions. The extent to which it is desirable to use fertilizers depends on price relationships and alternative investment possibilities.

The application of fertilizer at the end of the growing season does not appear to increase the productivity of grasses substantially during the dry season. For example, Chheda and Akinola (1971) found that the application of 170 kg nitrogen per ha doubled normal pasture production during the dry season, but the amount produced, 1 t dry matter/ha, was insignificant compared with the wet season yield of 13.2 t.

Table 9. The effects of nitrogen application on dry matter yields of selected forage species at various sites in West and Central Africa

Forage Species	Fertilizer Application (kg nitrogen/ha)	Yield (t dry matter/ha)	Country
Andropogon gayanus	0	4	Ivory Coast
	150	7	Ivory Coast
Brachiaria ruziziensis	0	5	Congo
	300	15	Zaire
	600	49	Upper Volta
Brachiaria brizantha	0	5	Cameroon
	200	18	Central African Empire
Brachiaria mutica	400	27	Senegal
	700	33	Senegal
Chloris gayana	400	16	Upper Volta
	300	22	Central African Empire
Panicum maximum	0	7	Congo
	120	12	Ivory Coast
	300	25	Cameroon
	400	33	Senegal
	600	38	Upper Volta
	700	41	Senegal
Hyparrhenia rufa	0	4	Central African Empire
	300	14	Zaire
Pennisetum merkere	0	8	Zaire
	120	11	Senegal
	300	14	Ivory Coast
	400	33	Senegal
	700	38	Senegal
Tripsacum laxum	150	20	Central African Empire
	300	26	Ivory Coast

Source: Compiled by J C Bille.

GRAZING OR CUTTING STRATEGIES

Most recommendations on intervals between grazing or cutting pasture grasses in the humid zone suggest six weeks as a compromise between the aims of maximizing forage production and quality and assuring the regrowth of the plants. Somewhat shorter intervals of four to five weeks are recommended for *P. maximum*, at least during the growing season, and somewhat longer intervals for *Stylosanthes* spp. (Asare, 1974; Messager, 1977).

Barring extremes, the height of cutting does not seem very important. The optimum cutting height for *Stylosanthes* spp. is 10 cm in the first year of establishment, rising gradually to 25 cm in the third year. For *P. maximum*, fairly low cuts at 10 cm twice during the growing season are preferable to more frequent cuts at 25 cm (Crowder and Chheda 1977; Messager, 1977; Guerin, 1977). As with *Stylosanthes* spp., *Hyparrhenia rufa* should be cut at gradually increasing heights.

OFFER-RESIDUE RATE

The offer-residue rate refers to the proportion of the forage on offer taken by the grazing animals. It is an estimate calculated by subtracting the amount of dry matter left in the pasture after grazing from the amount available before grazing. It is not exactly the same as dry matter consumption because it includes other losses of dry matter, due to trampling and insects for instance, but it is a useful indication in situations where no precise measures of dry matter intake are possible.

The offer-residue rate varies according to pasture species, variety, season, age and management strategy. It is affected by the relative palatability of the plants and the intensity of grazing. During the early part of the growing season, a *Cynodon*-legume mixture gave an offer-residue rate of 60%, while elephant grass (*Pennisetum purpureum*) and *P. maximum* pastures gave 45%. From May to September, *P. purpureum* x *P. typhoides* hybrids gave an offer-residue rate of 45%, while a pure strain of *P. purpureum* gave 35%. *Stylosanthes guyanensis* tends to have a lower offer-residue rate than *S. humilis* because of its thicker stems (Crowder and Chheda, 1977; Brinkman and Adu, 1977). Crowder and Chheda also observed offer-residue rates of 60 and 45% during the early wet season compared with 25% for the same pastures during the dry season.

In general, heavy stocking during a short period will result in an offer-residue rate close to 60%, while continuous stocking at a lower level results in a rate of 34 to 40% independent of pasture species. Messager (1977) found that *P. maximum* gave an offer-residue rate of 78% when grazed at four-week intervals, while the rate dropped to 35% when the pasture was grazed at six-week intervals and to 18% with grazing at eight-week intervals. Chheda and Saleem (1973) calculated an offer-residue rate of 45% for *Cynodon* IB8 slashed regularly from May to January at 10 to 18 cm after grazing, while the rate for the same period dropped to 25% when the grass was slashed at 25 cm or not at all.

CONCLUSIONS

Overall, it would appear that average annual yields of 4 to 6 t dry matter/ha can be expected from tropical pastures over a two- to three-year period. Yields can be increased substantially by fertilizer application, particularly with nitrogen, but this may not necessarily be economically justified in many situations. Among the grasses, dry matter yield and protein content fall sharply during the dry season, while shrubs and certain legumes maintain their quality and productivity. The improved varieties developed so far only tend to increase production when it is least needed, i.e. during the early part of the growing season. Without fertilization, substantial drops in production are reported after the first year of establishment, so any evaluation of dry matter yields should cover at least two or three years.

Of the forage produced, only around 40% is actually available for grazing, and the actual amount consumed is 15 to 30% lower than this. This implies an annual consumption rate of approximately 2 000 kg dry matter/ha which in turn implies a carrying capacity of about 300 kg liveweight per ha.

6. SUPPLEMENTARY FEEDING BASED ON AGRO-INDUSTRIAL BYPRODUCTS

Agro-industrial byproducts in the humid tropics are abundant and varied and represent a substantial resource for increasing animal production. The use of these byproducts for supplementary livestock feeding is justified when the forage supply is inadequate for the animals' needs, either in terms of quantity or quality, or when the cost of the supplementation is less than the value of increased animal production achieved. Supplementary feeding is also justified in times of drought or other feed shortages when the importance of providing the animals' immediate nutrient requirements to keep them alive sometimes outweighs other considerations, including the cost of the feed. Concentrate supplements are crucial in such crisis situations, though their quality need not be high. One consideration in the use of supplementary feeds for livestock, however, is possible competition with alternative uses for human consumption, particularly in the case of high-quality feeds.

In the West Indies, strategic supplementary feeding of small ruminants in times of fodder shortage is common, particularly during the dry season. The ingredients used are the byproducts from citrus and coconut cultivation, citrus meal and copra cake, usually in equal proportions (Devendra, 1977d, 1978b). McIntosh et al. (1976) have shown that feeding cottonseed cake at a rate of 0.43 kg per day to Virgin Islands x Persian Blackhead x Barbados Blackbelly sheep is justified economically.

A few trials have been carried out in West Africa to study the effect of supplementation on the main production parameters under field conditions. Ginistry (in CNRZ, 1977) studied the performance of 161 West African Dwarf ewes over a period of 18 months. Out of this group, 53 animals were grazed on natural pasture only throughout the period, 55 received 200 g of rice bran and molasses daily in addition to grazing, and 54 received this supplementation plus a further 400 g of concentrates during the flushing and steaming-up periods in addition to grazing. Half the ewes in each group were also given regular anthelmintic treatment.

The results indicated that the ewes on the most intensive feeding system gained 2.2 kg more during the trial period than the other two groups. They were also more fertile, with a 118% lambing rate compared with 88% for the other two groups. The most intensively fed group produced ten twin births during the period, compared with seven for the intermediate group and six for the group on grazing only, resulting in net lambing percentages of 128.3, 88.3 and 93.3% for the three groups respectively. The increased concentrate feeding during flushing and steaming up did not reduce ewe mortality, but reduced stillbirths and increased the number of pregnancies carried to full term. The anthelmintic treatment, on the other hand, did not appear to be effective: there were no clear differences in weight gain between the animals which were treated and those which were not.

Table 10 lists a number of agricultural byproducts which are used as animal feeds, along with their approximate extraction rates. This list is based on data from Asia: it is not complete and not entirely applicable to other parts of the world. However, a number of the byproducts listed in the table are widely available in Africa and are therefore of interest to this discussion.

Strategies for the effective utilization of various byproducts as animal feeds were recently discussed in depth by an FAO technical consultation on the subject (FAO, 1977). Useful reviews of the utilization of byproducts are presented in this report by Adegbola for Africa, by Chicco and Shultz for Latin America, by Skouri for the Near East and by Devendra for Asia and the Far East. The general conclusion from these studies is that various widely available byproducts are potentially highly valuable as animal feeds and that considerable increases

Table 10. Byproduct feeds from trees, field crops and animal sources in Asia, with approximate extraction rates

Crop	Byproduct Feed	Approximate Extraction Rate (%)
TREE CROPS		
Cocoa beans	cocoa bean waste	5-10
	cocoa husk	70
Coconuts	coconut meal	35-40
Oil palm (fresh fruit bunches)	oil palm sludge (dry)	2
	palm press fibre	12
	palm kernel meal	2
Rubber seeds	rubber seed meal	55-60
Sago trunks	sago refuse	55
Mangoes	mango kernels	50-55
FIELD CROPS		
Castor seeds	castor meal	45-50
Cotton seeds	cotton seed meal	40-45
Maize grains	maize bran	8-10
	maize germ meal	16-18
Rice (plants and grains)	broken rice	4-5
	rice bran	10
	rice husk	15-17
	rice straw	100[a]
Sugarcane plants	bagasse	12-15
	green tops	15-20
	molasses	3-4
Tapioca roots	tapioca waste	55-59
Wheat (plants and grains)	wheat bran	10
	wheat straw	100[a]
Groundnut (plants and beans)	groundnut vines (stems + leaves)	41-57
	groundnut meal	53-57
Pineapples	pineapple waste	60-80
Sesame seeds	sesame cake	60
Soya beans	soya bean meal	70-75
Sweet potatoes	sweet potato vines (stem + leaves)	24-34
ANIMAL PRODUCTS		
Poultry	poultry litter (dry)	26.0[b]
Ruminants	blood meal	0.6[c]
	meat and bone meal (dry)	25-30[d]
	rumen contents (wet)	0.8[c]

a. Implies weight equivalent to the yield of grains.
b. Based on assumed daily faecal production of 110 g per adult bird.
c. Percentage of liveweight. d. Percentage of the weight of wet offals.

Source: Devendra in FAO (1977).

in goat and sheep production could be achieved on the basis of their more intensive utilization.

To use these byproducts more effectively, their nutritive value can in many instances be enhanced by chemical or physical processing. For instance, possibilities now exist for chemical treatment, particularly of cereal straws, at the commercial and farm level (Homb et al. in FAO, 1977). In India, these processes have been shown to be justifiable economically (Jackson, 1977).

Some of the more important byproducts available in Africa, which could potentially contribute to improved small ruminant feeding programmes, will be discussed in more detail.

SUGAR CANE

The main byproducts of sugar cane production which are potentially of value as animal feeds are sugar cane tops or leaves, molasses, bagasse and filterpress mud. Sugar cane leaves, if not burnt at harvest time, can be cut and fed to animals. O'Donovan (1970) conducted a feeding trial giving chopped sugar cane leaves to a herd of commercial dairy and beef cattle. The leaves provided enough nutrients to meet the maintenance requirements of all the animals and produce 2 kg of milk daily per dairy cow and 0.25 kg liveweight gain daily per beef animal. Production was further increased when more energy and protein were supplied. Donefer et al. (1975) found in the West Indies that ensiled sugar cane tops fed together with sugar pith produced significantly greater weight gains in cattle than those achieved by feeding sugar pith or pangola grass alone.

Molasses has traditionally been used to supply energy or to increase the palatability of feeds, especially mixed with course roughages. Lofgreen and Otagaki (1960a, 1960b), however, found that net energy was reduced in mixed diets containing more than 10 to 15% molasses, though this varied with the overall feed ration composition. Hatch and Beeson (1972) reported that replacing 5% rolled maize with molasses had no apparent effect, but replacing 10 to 15% increased nitrogen retention, energy and dry matter digestibility and the level of butyric acid in the rumen.

Large quantities of molasses are now available in many tropical countries, and recent advances in its effective utilization have increased the potential importance of this byproduct. In Cuba, reports indicate that molasses may provide up to 80% of the metabolizable energy supplied to beef cattle, and daily liveweight gains of 700 to 900 g were recorded under specific conditions where forage supply was restricted and additional protein was provided by fish meal (Preston et al., 1967; Elias et al., 1968). In Malaysia, Devendra (1975b) investigated molasses-urea diets fed to sheep, with molasses levels ranging from 65 to 78%. He found the optimum rice straw content for maximum digestibility on this regimen was 30% of the feed.

Sugar cane bagasse consists of an outer portion, called the rind, and a finer inner part, known as pith. This is a low-quality feed because of its high ligno-cellulose content. However, Davis and Kirk (1958) reported an increased intake of bagasse with the addition of up to 55% molasses in concentrate diets. Since bagasse is a good carrier of molasses, it can be useful when fed at an optimum level of about 20 to 30% of the diet (Kirk et al., 1962). The nutritive value of bagasse can also be improved by alkali and possibly heat treatment. This has the effect of rendering the complex carbohydrates contained in bagasse more digestible.

Filterpress mud is the product which results from the sugar clarification process. It is composed of the first broth of boiled cane juice plus fine bagasse or pith, and has a relatively high phosphorus content. De Sainte Antoine and Vignes (1962) reported from studies in Mauritius that the inclusion of 20% filterpress mud in the diet of dairy cows gave comparable increases in milk production.

COCOA

Three cocoa byproducts are useful for animal feeding: cocoa husk, cocoa meal, which is composed of bean fragments, beans and shells, and discarded cocoa bean meal. Of these, cocoa husk is by far the most important.

In Ghana, Owusu-Domfeh et al. (1970) suggested that cocoa husk is a good roughage and a good source of vitamin D (28 IU/g). In Nigeria, it has been proven useful in maintenance diets of sheep and goats (Adeyanju and Ogutuga, 1974), with the optimum portion in the diet of sheep recently estimated at around 30%. The use of cocoa and coconut byproducts in livestock diets has recently been reviewed by Devendra (1978b).

OIL SEEDS

Byproducts from cotton, coconut, groundnut, soya bean and palm oil production are potentially useful as animal feeds. Of these, the most important are probably cotton and oil palm byproducts. Ogunfowora (1975) reports using up to 30% cottonseed hull for fattening animals in Nigeria, and this byproduct is widely used as a supplementary feed during droughts.

The byproducts of palm oil cultivation are much less widely used, but may become more important in future in view of the significance of this crop in West Africa. Three main palm oil byproducts can be used as animal feed: palm press fibre, palm kernel cake and palm oil sludge. Devendra (1977c) reported from a study conducted in Malaysia that the optimum levels in feed rations were 30% palm press fibre and 40% oil sludge. Palm kernel cake was shown to be a medium-quality source of protein in studies on the utilization of rice straw by sheep (Devendra, 1977c).

COFFEE

Ledger and Tillman (1972) showed that the addition of 10 to 20% coffee hulls to the diet of Boran steers did not affect feed intake, conversion or liveweight gains, but performance was reduced when the proportion of coffee hulls was increased to 30%. Coffee pulp has been ensiled with grass and molasses for periods of up to four months, and was proposed by Ogunfowora (1975) as a useful animal feed during the dry season.

7. HOUSING

Housing for small ruminants in the humid tropics is important to protect the animals from rainfall and heat. Excessive moisture without proper shelter leads to a greater incidence of diseases such as pneumonia and worm infestation.

When no housing is provided, the build up of heat load in the animals' bodies may also become acute. Heat accumulation results in various symptoms of stress. Local breeds, such as East African goats for example, have been shown to possess considerable tolerance to heat, possibly due to their ability to increase ventilation and reduce water loss in urine and faeces and their shiny coats which do not absorb the sun's rays. Exotic animals, by contrast, require good housing when introduced into the tropics to reduce the effects of temperature, humidity and rainfall.

Very little is known at present about the efficiency of different types of animal houses and how they influence production. One of the reasons for the increased disease incidence which occurs widely with commercialization may well be housing which is inadequate under intensive production conditions. In West Africa, small ruminant housing for commercial production generally consists of ground-level sheds with open sides. In tropical Asia, however, housing for goats is usually built on stilts to protect the animals from waterlogging and worm infestation. Materials vary from discarded wood or tree branches to high quality timber, with roofs of thatch, leaves or metal sheets. Slatted floors of wood, bamboo or metal may also be used.

Housing for small ruminants should be designed to provide good ventilation and drainage as well as protection from the sun and rain. The construction need not be elaborate or expensive, but the houses should be easy to maintain and clean. The possibility of insect damage to housing materials must also be considered. There should be a rood overhang of at least 1 m to prevent rain from splashing in at the sides, and the animals should have access to the houses at all times of the day and night.

Ground-level housing prototypes for small ruminants are being developed by ILCA using inexpensive local materials. A shed developed to suit local conditions in the derived savanna area is illustrated in Figure 5.

Figure 5. Small ruminant housing designed by ILCA in the derived savanna zone of Nigeria

8. ANIMAL HEALTH

Disease is the most important constraint on sheep and goat production in the humid tropics of West and Central Africa. However, information on the incidence of disease under traditional production systems is very limited, and little is known about the interaction of disease with other production factors such as husbandry and nutrition levels. Apart from a few village-level studies, largely carried out in the francophone countries, information on disease incidence is largely related to isolated episodes on institutional farms or research stations. Meat inspection records have not generally proven to be useful sources of information because very few small ruminants from the humid zone are slaughtered in abattoirs subject to sanitary control. Veterinary coverage, except in areas near universities and research centres, is also insufficient for monitoring disease situations and trends. More information should become available in future, however, as the role of small ruminants in the agricultural economy of the region is beginning to be stressed and veterinary services and diagnostic facilities are becoming more widespread.

MORTALITY RATES

Figures on mortality due to disease must be treated with caution because actual field data are so limited. Deaths occur irregularly in different places and at different times, while most estimates are based on observations over short periods in very limited areas. In three states of southern Nigeria, however, annual mortality rates were calculated from 1965 to 1968 as percentages of the total flocks in the region at the beginning of each six-month period. These figures are given in Table 11.

Table 11. Annual mortality rates among small ruminants in southern Nigeria (%)

	Approximate Population	- Mortality Rates (%)			-
		1965	1966	1967	1968
Western State					
Goats	1500	16.3	19.2	43.6	13.6
Sheep	1500	22.2	25.6	10.3	16.9
Midwestern State					
Goats	1500	29.4	36.2	19.4	27.0
Sheep	1500	34.2	21.4	17.4	22.9
Eastern State					
Goats	1500	15.7	20.2	-	-
Sheep	1500	15.1	25.1	-	-

Source: Nigeria, Federal Office of Statistics (1972).

This table indicates that there were considerable differences in mortality rates among the three states surveyed and wide fluctuations between years.

Matthewmann (1977) recorded annual mortality rates of 10 and 14% in two villages near Ibadan in southwestern Nigeria with a total adult sheep and goat population of just over 200; he estimated preweaning mortality at 15%. In Ghana, the annual mortality rate among sheep and goats throughout the country was estimated at 6.3% (Cockcroft, 1977), but no figures were given for specific climatic zones. Likewise, national figures for Ivory Coast indicate an annual mortality rate between 5 and 7% for adult sheep and up to 21% for recently assembled flocks on private farms. Bonniwell (1978) reported annual mortality rates of 35.6% for village sheep and 7 and 9% for sheep on two commercial farms in Ghana, while deaths among Nungua Blackhead lambs were 84.5 and 89.9% on two farms at the University of Ghana during the period 1971 to 1973 (University of Ghana, 1975).

There is very little information on mortality which suggests the relative importance of various causes of deaths. Vallerand and Brankaert (1975) recorded annual mortality rates among West African Dwarf sheep in Cameroon averaging 32.2% from 1966 to 1970 and 24.1% from 1971 to 1974, and attributed the difference between these two periods to the implementation of a disease control programme in the area. Among the young, they found mortality rates of 44% during the first period and 33% during the second for twins, and 29% during the first period and 21% during the second for single births. Bonniwell (1978) found a peak in mortality in Ghana during the second half of the rainy season, and it is generally considered that mortality rates are higher during the rains (Vohradsky and Sada, 1973). This hypothesis should be further tested, because, if proven correct, it would have important implications for the implementation of animal health measures.

MORBIDITY AND DISEASE PREVALENCE

It is possible that morbidity, due to chronic and sub-clinical diseases such as low-grade helminthiasis and pneumonia, has a greater effect on production levels than mortality, but information on morbidity under traditional production systems is virtually non-existent. Visibly sick animals are often slaughtered for home consumption, and such cases may be recorded as deaths, inflating mortality figures and masking the level of morbidity.

Based on numerous studies of sheep in Cameroon, Vallerand and Branckaert (1975) listed the most important disease problems as foot disease, respiratory diseases, enterotoxaemia, toxaemia of pregnancy, parasitic gastroentritis, including strongylosis and monieziasis, external parasitism and contagious pustular dermatitis. They mentioned that blood parasites were unimportant, although the insect vectors were present in the area: only one case of trypanosomiasis was diagnosed in nine years.

Rombaut and van Vlaenderen (1976), working in Ivory Coast, mentioned the importance of parasitism, presumably helminthiasis, and felt it would be impossible to eradicate this problem in humid tropical areas. Under good husbandry conditions, however, they found that the dwarf Djallonké sheep developed a natural immunity. Two cases of heartwater were diagnosed, but no cases of disease carried by insects, though the vectors were found in the area.

Oppong (1974) referred to the 'pneumonia-diarrhoea complex' as an important cause of losses in Ghana, especially during the rainy season. He also mentioned the occurrence of helminthiasis, tick infestation, heartwater, contagious pustular dermatitis and, under improved feeding regimes, enterotoxaemia. Bonniwell (1978) reported a high incidence of pneumonia and diarrhoea, also in Ghana, together accounting for approximately 50% of all clinical cases recorded. 'Ataxia collapse syndrome', probably toxicosis, was also noted on a commercial sheep farm. Post-mortem analyses at the Kumasi Veterinary Laboratory indicated that haemonchosis, heartwater and *peste des petits ruminants* were the most important causes of death, together accounting for about 60% of all mortalities. Heartwater was also found, mostly in sheep imported from Upper Volta.

VIRAL AND BACTERIAL DISEASES

Peste des petits ruminants

Peste des Petits Ruminants (PPR) is a paramyxo-virus, closely related to, but nevertheless distinct from, other morbilliviruses such as measles, rinderpest and canine distemper. It is referred to as *kata* in Nigeria, or as pseudorinderpest. PPR is often rendered more severe by secondary bacterial pneumonia and concomitant helminthiasis, which has led to the introduction of the descriptive term 'stomatitis-pneumoenteritis syndrome' in Nigeria.

Although PPR has probably been present in West African sheep and goat populations for some time, it was first identified as a distinct disease by francophone workers in the early 1940s in Benin and Senegal and described by Cathou in Benin and Gargadennec and Lalanne (1942) in Ivory Coast. It was called *peste des petits ruminants* because of its similarity to rinderpest (*peste bovine*).

Interest in PPR was largely confined to the francophone countries until the 1960s. Zwart and Rowe (1966) found neutralizing antibodies to the rinderpest virus in sera from goats and sheep in northern Nigeria and interpreted this to suggest the presence of PPR in Nigeria. Whitney et al. (1967) described a disease known as *kata* in southwestern Nigeria with clinical signs similar to those of PPR, although no cross-protection with rinderpest was demonstrated. Later, Rowland and Bourdin (1970) and Rowland et al. (1971) demonstrated cross-protection with rinderpest, and also found that PPR and *kata* were clinically and pathologically indistinguishable. Isoun and Mann (1972) described a stomatitis and pneumoenteritis complex among sheep in Nigeria which appeared to be PPR, though no virus isolation was achieved. Nduaka and Ihemalandu (1973) described a stomatitis-pneumoenteritis syndrome in eastern Nigeria, which was later shown by Hamdy et al. (1976) to be associated with the PPR virus, and also suggested that *ạbu-nini*, a contagious disease of goats and sheep in Sudan involving pleuropneumonia-like organisms (Olte, 1960), might have a similar aetiology.

The clinical signs and post-mortem lesions in small ruminants suffering from PPR resemble those produced by rinderpest in cattle, which led originally to the assumption by some observers that PPR was caused by a form of rinderpest virus adapted to small ruminants. It was also speculated that a caprinized rinderpest vaccine, widely used in West Africa before the introduction of tissue culture vaccines, might have escaped and established itself in small ruminant populations. In testing this hypothesis, Mornet et al. (1956) and subsequently other workers failed to produce clinical rinderpest in cattle innoculated with material from PPR cases or with PPR virus, though rinderpest virus antibodies were evoked.

The situation has been clarified more recently by studies performed on PPR virus isolates by Gilbert and Monnier (1962), Bourdin and Laurent-Vautier (1967), Laurent (1968), Hamdy et al. (1975, 1976) and Gibbs et al. (1979). This work has clearly indicated that the PPR virus is a paramyxo-virus, a fourth and new member of the genus *Morbillivirus*.

Epidemiology. PPR infection has a four- to five-day incubation period, followed by pyrexia lasting six to eight days. Symptoms include oral necrosis, catarrh, nasal discharge and diarrhoea. In goats experimentally infected with PPR virus, Gibbs et al. (1979) found that nasal excretion of the virus occurred three days after infection and excretion in saliva, urine and faeces at five days. Pyrexia commenced at three days, but no clinical signs of illness were observed until four days. In the same series of experiments, nasal excretion also occurred at five days. This work would suggest that the disease is spread primarily through the respiratory system, a conclusion previously reached by clinicians observing outbreaks in the field.

Many animals die within a week of the onset of pyrexia, and the terminal stages of illness are frequently complicated by secondary pneumonia. Survivors may develop labial dermatitis, with a scab formation similar to that seen in contagious pustular dermatitis. Young animals are more severely affected than adults, and the limited experimental evidence available supports the general field observation that goats are more severely affected than sheep.

Diagnosis is based on clinical signs, although confusion with bacterial pneumonia complicated by helminthiasis may occur. Differentiation from this syndrome and from contagious pustular dermatitis and pox can be achieved by demonstration through gel diffusion tests of serum antibodies and PPR virus antigens in organs and tissues. The virus may also be isolated from mucosal scrapings of the large intestine.

As in the case of rinderpest, it is generally agreed that there are no carriers of PPR, but sub-clinical or unobserved cases may maintain infection and spread it to others. There is no evidence to suggest that either PPR or rinderpest viruses persist in the tissues of recovered individuals, as is the case with measles (see Matumoto, 1969). Although outbreaks are said to be common in the humid zone, and often lead to the loss of entire village flocks, it is not known whether PPR is actually endemic within the zone or whether it is introduced in each instance through animals imported for sale or slaughter from the drier regions to the north. In such cases, introduced animals may be held for a few days or weeks before slaughter and contact with local animals is possible. It is an established fact that heavy disease losses occur, largely attributable to PPR, when several groups of sheep or goats from various areas are housed together.

No cases of PPR among wild ruminants have been recorded in West Africa, though Hamdy and Dardiri (1976) found that the American white-tailed deer, *Odocoileus virginanus*, responds to experimental PPR infection in a similar manner to goats. Nevertheless, indigenous wild ruminants are not likely to play an important role in the dissemination of the disease since they are very few, compared to local sheep and goat populations, and their contact with domestic animals is minimal.

No general survey of the distribution of PPR in West Africa has been undertaken, though it is clear that this is a long-established, common and frequently lethal disease affecting sheep and goats in all climatic zones of the region. In recent years, localized serological investigations of small ruminant populations have shown that a substantial proportion possess antibodies indicating previous exposure to infection. However, rinderpest antigen was apparently used for these serum neutralization tests, and therefore they failed to distinguish between animals which had actually recovered from a PPR infection and those which had merely received tissue culture rinderpest vaccine (TCRV). Subsequently, the development of a serum neutralization test (Taylor, 1979) which distinguishes PPR from rinderpest antibodies has allowed Taylor and Abe Gunde (1979) to demonstrate that between 30 and 40% of small ruminants tested react to the PPR virus, although they possess no rinderpest antibodies unless they have previously been vaccinated with TCRV.

Although the PPR and rinderpest viruses have been shown to be distinct, PPR antibodies confer some degree of protection against rinderpest in cattle. Infection with rinderpest virus will produce a disease indistinguishable from PPR in sheep and goats, though PPR virus produces no clinical symptoms of disease in cattle. For this reason, suspected outbreaks of PPR in areas with substantial cattle populations should be precisely identified, and the use of TCRV to prevent PPR among sheep and goats should be strictly supervised.

Treatment and Control. The treatment of clinical cases of PPR consists mainly of combatting secondary bacterial pneumonia with drugs, but this is unlikely to be effective unless applied at the early stages of the disease. Catho reported that treatment with rinderpest antiserum was useless, but there have been no reports on the value of treatment with PPR antiserum for short-term protection. Treatment of individual animals is also expensive and difficult to carry out on a wide scale.

TCRV has been shown to offer effective protection against experimental PPR virus infections, and field trials with this vaccine, especially in francophone West Africa, are said to have given satisfactory results (Mornet et al., 1956; Bourdin et al., 1970; Bourdin, 1973; Bourdin and Doutre, 1976; Taylor, 1979). A full appraisal of the effectiveness of TCRV is urgently needed and could be carried out at the village level by clearly establishing the presence of a PPR challenge and evaluating the antibody status of vaccinated and control animals before and during the trials. Such trials, which might usefully be conducted in several countries, would firmly establish the effectiveness of TCRV, its dosage rate and the required frequency of application.

If such trials were to indicate that TCRV is not effective against PPR, efforts might be directed towards developing an attenuated vaccine from a PPR virus isolate, though this would be an expensive approach. Ihemelandu and Nduaka (personal communication) have reported that PPR hyperimmune serum was used successfully to prevent, or possibly to control, outbreaks in what they termed 'crisis situations', as, for example, when a station or livestock project is restocked with animals from several areas.

Serological evidence of a second paramyxo-virus, para-influenza 3, has been reported from work with cattle, sheep and goats by Taylor et al. (1975) in northern Nigeria and by the Institut d'Elevage et de Médecine Vétérinaire des Pays Tropicaux (IEMVT) in Chad. No indications were given, however, of the importance of this virus for livestock production.

Goat and Sheep Pox

Goat and sheep pox outbreaks are sporadic, but generally severe when they occur. Three foci of goat pox were reported in Chad by IEMVT, and severe outbreaks of goat and sheep pox occured in the Ashanti Region of Ghana with the virus identified from specimens by Bonniwell (1977). In this case, it was concluded that the infection had been introduced through animals brought down from the north. IEMVT is exploring methods to produce goat and sheep pox tissue culture vaccines in the testicular cells of newborn lambs.

Foot and Mouth Disease

Foot and mouth disease occurs only sporadically throughout the humid zone, usually introduced through animals brought in from the drier regions to the north. This viral disease takes a mild course among indigenous sheep and goats, and vaccination is not warranted at present except for particularly valuable flocks.

Bluetongue

Bluetongue is a viral disease affecting sheep, transmitted by night-flying biting midges, *Culicoides* spp. Indigenous sheep rarely show any clinical signs, but exotic breeds suffer fever, mouth lesions and lameness which can lead to death. Serological surveys have shown evidence of the disease among goats and sheep in Nigeria, and nine serotypes have been identified by Taylor and McCausland (1976).

Contagious Pustular Dermatitis

Contagious pustular dermatitis is widespread throughout the humid zone, but only occasionally causes serious losses. Diagnosis has been based on clinical grounds, and recently Obi and Gibbs (1978) confirmed the presence of the virus in Nigeria. Venereal balanoposthitis and vulvitis have been described, but whether these are separate diseases or a manifestation of contagious pustular dermatitis has yet to be determined.

Other Viral Diseases

Pulmonary adenomatosis, or chronic viral pneumonia, occurs among sheep and goats. These viruses have been identified on the basis of serological evidence in Chad. Gibbs et al. (1977) isolated adenoviruses from Nigerian goats naturally infected with PPR, but were unable to type the isolates by using antisera to known bovine or ovine serotypes. They concluded that the adenoviruses were unlikely to play a significant role in the epidemiology of PPR. Similar symptoms are also caused by herpes viruses: Taylor et al.(1977a, 1977b) demonstrated infectious bovine rhinotracheitis antibodies and antibodies to bovine viral diarrhoea in goats and sheep. They showed that unclassified RNA viruses produced a mild disease in experimentally infected animals, but concluded that there was little difficulty in distinguishing this disease from PPR.

Occasional cases of rabies are reported in goats and sheep, probably contracted from rabid dogs. This disease is of no economic significance, but extremely important in terms of public health.

Mycoplasma and *Pasteurella*

Mycoplasma and *Pasteurella* are the most common bacteria affecting sheep and goats in the humid zone. Eight species of *Mycoplasma* have been identified which cause disease among small ruminants: five are associated with pneumonia and the others with various conditions, including mastitis, arthritis and kerato-conjunctivitis. Mycoplasmosis can produce pneumonia, both as a primary infection, particularly under adverse conditions such as overcrowding or during the long rains, and as a secondary infection to viral diseases such as PPR. The mycoplasmoses of small ruminants have been reviewed by Perrau (1976) and Ojo (1977).

Contagious caprine pleuropneumonia (CCPP) does not appear to occur in its classical form among small ruminants in the humid zone, possibly because animals in this area are generally kept in small household flocks, limiting the spread of the disease, rather than in the large flocks typical of the regions further north. Nevertheless, Ojo (1973, 1976a, 1976b) has isolated both *Mycoplasma mycoides* subsp. *capri*, which causes CBPP, and *M. mycoides* subsp. *mycoides*, which causes contagious bovine pleuropneumonia, from goats in the humid zone. This same reseacher has isolated *M. argini* from goats with arthritis and pneumonia and *M. agalactiae* from lungs (1976b), although no cases of mastitis have been reported from the humid zone. Vaccination against mycoplasmoses is not practised in the region, and the value of chemotherapeutic treatment has received little attention.

Pasteurella are commonly isolated from cases of pneumonia, most often *P. haemplytica* and *P. multocida*. These bacteria cause severe pneumonia, often as a secondary infection to PPR or in situations of stress, such as exhaustion following transit ('shipping fever'), chilling during the rainy season or malnutrition. Endemic pasteurellosis, analogous to haemorrhagic septicaemia in cattle, does not seem to occur among sheep and goats in the humid zone. Ojo (1977) has characterized 200 strains of *Pasteurella* of caprine origin and identified six serotypes.

Other Bacterial Diseases

Other damaging bacterial infections, such as blackleg, tetanus, footrot and streptothricosis, occur, but there is no clear evidence of their extent or economic importance. Enterotoxaemia (pulpy kidney), tetanus and blackleg are most often reported from institutional flocks, with diagnosis in many cases based on case histories, clinical signs and post-mortem examinations. For intensive fattening or finishing operations, polyvalent vaccine is recommended to prevent these diseases.

Classical footrot has been reported and the causal organism, *Fusiformis nodosus*, identified, but outbreaks appear to be confined to institutional flocks. Enteropathogenic serotypes of *Escherichia coli* have been isolated from diarrhoeic infant goats and sheep in institutional flocks in southwestern Nigeria, but their importance as a cause of perinatal losses in village flocks has not been investigated. Streptothricosis has been identified in both goats and sheep, but it causes only minor lesions on the face and ears and seldom results in widespread damage. Anthrax is seldom reported among small ruminants in the humid zone, although animals are vaccinated against this disease in some francophone West African countries. Heart-water, a tickborne infection of *Cowdria ruminatium*, is of some significance among small ruminants in the humid zone, particularly among imported goat breeds.

Corynebacteria, *Streptococci*, *Staphylococci* and other pyogens are frequently reported in association with pneumonia, foot abscesses or ectoparasite damage, though these infections are incidental in themselves and not a serious cause of loss. Other bacterial infections, such as tuberculosis and nocardiosis, are occasionally reported, but there have been no reports of vibriosis, listeriosis or abortions caused by *Chlamydia* infections.

Diseases of public health significance include brucellosis and salmonellosis. Serological surveys indicate that a low level of brucellosis infection exists among small ruminants throughout the humid zone (see Gidel et al., 1974; Falade et al., 1974), but no systematic efforts have been made to identify the *Brucella* biotypes involved, nor to assess to what extent brucellosis contributes to reproductive wastage or constitutes a hazard to human health. Various *Salmonella* serotypes have been identified throughout the humid zone, but their importance has not been assessed.

PARASITIC INFESTATIONS

Many research workers rank helminthiasis, especially in the form of parasitic gastroenteritis, along with PPR and pneumonia as a major constraint on increased sheep and goat production in the humid zone. However, these observations are often based on experience with institutional flocks, which are kept in relatively large numbers on enclosed pastures, often with little rotation. By contrast, under traditional husbandry systems small ruminants are generally kept in small household flocks of less than 10 animals of varying ages, foraging extensively or, in some localities, tethered each day on fresh land. Under these conditions, faeces are deposited over a wide area and the chances of susceptible animals encountering and ingesting infective third-stage worm larvae are considerably less than is the case in institutional flocks.

There is a wide fluctuation in larval challenge throughout the year, with larva survival and development greatly reduced during the dry season. During this period, animals are not exposed to larval antigens and thus suffer a loss of immunity developed from previous exposure to parasitic worms. This will result in the maturation of inhibited larvae in the gut mucosa if histotropic larvae are present, and also in greater susceptibility to new infestations picked up from the herbage when the rains begin. This syndrome has been observed in northern Nigeria (van Veen, 1978; van Geldorp and van Veen, 1976), but may not occur in the humid zone where the dry season is much shorter. As already mentioned, young animals are more susceptible to helminth infestation than adults and animals which first begin grazing during the rainy season, when the larval challenge is greatest, may be more prone to acute helminthiasis than those weaned during the dry season. In the temperate zone, lambs born in the early spring begin grazing just when larval challenge is most severe so that parasitic gastroenteritis becomes a serious problem, but under traditional husbandry systems in the humid zone mating is not controlled and parturition occurs year round.

Parasitic gastroenteritis may also differ in importance among sheep and goats, though no valid comparisons between the two species have been made. Although the same helminth parasites have been found in both species in the humid zone, it would seem logical that sheep would suffer heavier infestations because they graze succulent grasses which provide a favourable environment for the development and survival of worm larvae, while goats prefer to browse trees and shrubs.

Treatment of seriously affected animals is provided only in those areas where veterinary services and anthelmintic drugs are available, and this has little impact on the general situation. The effectiveness of treatment may also be reduced by the occurrence of drug resistance. In northern Nigeria, van Veen has accumulated convincing evidence that resistant strains of *H. contortus* emerge following regular dosage with the imadazole group of anthelmintics. Preventative measures, such as rotational grazing and a treatment regime aimed primarily at young animals, are practised in the temperate zone, but would be difficult to carry out in a situation where grazing is extensive and uncontrolled, where breeding is not seasonal and age groups are not clearly identified. Since the actual importance of parasitic infestations has not been ascertained under traditional management conditions, it is not clear whether the cost of widespread control and treatment measures would be justified in terms of increased production and economic returns.

Nematodes

The most important helminth parasites identified among small ruminants in the humid zone are the nematodes, including *Haemonchus contortus, Trichostrongylus colubriformis, T. axei, Cooperia pectinata, C. curticei, Ostertagia marshali, Gaigeria pachyscelis, Chabertia ovina, Skrjabirema ovis, Trichuris globulosus, T. ovis, Oesophagostomum columbianum, Strongyloides papillosus* and *Bunostomum* spp. (see Okon and Enyenihi, 1975; van Veen et al., 1975). Of these, *H. contortus* is considered the most serious, particularly affecting young animals during the rainy season.

In northern Nigeria, clinical haemonchosis was diagnosed among young lambs in the latter part of the dry season and attributed to the development of histotropic larvae associated with high stocking rates (van Veen, 1978), though no similar observations have been recorded in the humid zone. Under experimental conditions, however, Okon and Enyenihi (1977) demonstrated that rainfall was the most important factor in the development and survival of infective *H. contortus* larvae. Eggs spread on experimental plots developed into infective third-stage larvae when the mean daily rainfall was 3 mm or more. These survived from 28 to 63 days, with survival reduced when the rainy season was interrupted by short intervals of dry weather. From an examination of 480 goats taken from eight states in Nigeria, Okon (1975) found that *Trichuris* spp. infestations were greater during the dry months and that *T. globulosis* occurred more often than *T. ovis*. Increased worm egg counts were found among sheep after parturition on the Accra plains in Ghana (University of Ghana, 1976) and in Zaria, northern Nigeria (van Geldorp and van Veen, 1976), though neither of these areas is in the humid zone and neither observation involved West African Dwarf sheep.

Cestodes and Trematodes

Cestodes found among sheep and goats in the humid zone include *Moniezia expansa, M. benidini, Avitellina centripunctata* and *Stilesia globipunctata*. *Moniezia* spp. are often reported among young animals, with *M. expansa* the more common species. There is some disagreement concerning their importance: some authorities consider them relatively harmless, while others claim that they cause serious problems, perhaps overlooking concurrent nematode infestations. No reports of hydatidosis *(Echinococcus* spp.*)* were encountered, though cysts of other tapeworm genera were sometimes noted in post-mortems. The epidemiology of these infestations and their importance in relation to small ruminant production have received little attention.

Trematodes identified among small ruminants in the humid zone include

Fasciola gigantica, Schistosoma bovis and *Paramphistomum* spp. Liver fluke infestation *(F. gigantica)* occurs in both sheep and goats and is occasionally listed in abattoir records as a reason for condemning liver, but it is not as important a problem among small ruminants as among cattle. *S. bovis* has been reported in Senegal and *Paramphistomum* spp. in Ghana (Oppong, 1973).

PROTOZOAL DISEASES

Protozoa identified among sheep and goats in West Africa include *Coccidia* spp., *Anaplasma ovis, Babesia ovis, Theileria ovis, Eperythrozoon ovis, Trypanosoma congolense, T. vivax, T. brucei* and, indirectly, *Toxoplasma.* None of these causes serious losses among indigenous West African Dwarf sheep and goats, though trypanosomiasis can be a major problem for animals brought down from the north or for exotic imported breeds.

Trypanosomiasis

Tsetse flies, which carry trypanosomiasis, are found throughout the forest and derived savanna of the humid zone. The distribution of the three tsetse groups, *morsitans, fusca* and *palpalis* is shown in a map prepared for OAU/STRC (1973). The indigenous West African Dwarf goats and sheep live under conditions of high tsetse challenge. They become infested with trypanosomes without showing serious clinical symptoms of the disease and are thus classified as 'trypanotolerant'. The pathology of the disease was reviewed by Losos and Ikede (1972), who also recorded the results of experimental *T. brucei* infection among sheep (Ikede and Losos, 1972, 1975). Ikede (1974a) described ocular lesions which were observed during the same series of experiments.

Although little is known about the mechanism of trypanotolerance, it appears that animals of the West African Dwarf breeds inherit a predisposition, but must develop tolerance to the disease through exposure. In East Africa, exotic breeds of sheep have been shown to suffer higher rates of natural infection, with more severe anaemia and greater weight loss, than indigenous breeds. This situation has been confirmed by experiments carried out under FAO (1976) on animals born and reared under tsetse challenge conditions.

It is possible that trypanosome infection among tolerant animals results in poor health which may lower their resistance to other diseases and parasites. Clinical signs may include anaemia, reduced growth and weight gain and poor fertility. *T. congolense* and *T. vivax* are haemoflagellates, primarily confined to the blood, which cause anaemia. However, *T. brucei* also affects the intercellular body fluids, causing degenerative, necrotic and inflammatory changes. For example, experimental infections of sheep with *T. brucei* have been shown to cause testicular degeneration, implying impaired fertility. However, no systematic studies have been carried out among small ruminants under traditional management systems nor of the effects of low-grade trypanosomiasis on productivity.

Coccidiosis

Several species of coccidia have been identified by oocyst culture in Ghana, and coccidial oocysts are commonly mentioned in faecal worm egg counts throughout the humid zone. However, no symptoms occur under extensive traditional husbandry systems where the disease is overshadowed by helminthiasis. Occasional clinical cases are reported among young kids and lambs, especially when they are housed and managed intensively.

Other Protozoal Diseases

Serological evidence of the presence of toxoplasmosis has been found in southwestern Nigeria (Falade, 1974), but without evidence of any associated disease condition. Although evidence of the presence of other protozoal infections is available, such as babesiosis, anaplasmosis and theileriosis, information is limited to occasional reports of disease outbreaks. There is no systematic evidence of their prevalence or of the losses they may cause.

ECTOPARASITES

Ticks are widespread, with *Amblyomma* spp. the most common. They cause local lesions and damage from blood-sucking and transmit a number of diseases, such as heartwater. Dipeolu (1975) also recorded a case of tick paralysis in a sheep experimentally infested with *Amblyomma* larvae, though it is not known whether this occurs among the general population of small ruminants in the humid zone.

Mites cause sarcoptic and psoroptic mange, particularly among dwarf goats under traditional husbandry conditions. Louse infestation is commonly reported, and severe flea infestations occur occasionally. Van Veen and Mohammed (1975) identified *Linognathus stenopsis* and *Ctenocephalides felis strongylus* from louse and flea infestations of small ruminants in northern Nigeria. The sheep nasal fly (*Oestrus ovis*), which carries myiasis, is common throughout the zone. Ogunrinade (1977) reported nasal fly infestations among dwarf goats in southwestern Nigeria throughout the year, but with a peak during the wet season. Biting midges (*Culicoides* and *Lasiohelia*) are common throughout the zone at all seasons. They carry bluetongue and probably a number of other pathogenic viruses. Other biting flies, such as *Stomoxys* occur throughout the zone, but appear to cause little damage to small ruminants.

Uncontrolled grazing and crowded housing are factors contributing to the maintenance and spread of ectoparasite infestations. The treatment of affected animals is haphazard, and control measures, such as routine dipping, are not widely practised.

OTHER ANIMAL HEALTH PROBLEMS

Metabolic diseases and mineral or vitamin deficiencies or imbalances, such as hypocalcaemia, hypomagnesaemia, pregnancy toxaemia and acidosis, are reported occasionally among institutional flocks, but diagnosis is generally based on clinical evidence only and not supported by biochemical findings. Bloat may also occur among animals grazing legume swards following enforced overnight fasting. None of these conditions appears to be of any significance under traditional management systems, but they may become more important with intensification, involving selected forages and increased growth rates.

Fungus infestations occur among small ruminants, though these have never been investigated systematically. Skin conditions caused by dermatophytes are reported occasionally, and systemic infestations are sometimes discovered in the course of post-mortems or meat inspections (Ikede, 1974b). Mycotic abortions do not appear to be important.

The presence of poisonous plants throughout the zone is reasonably well documented, but there are no indications of the extent of loss which results. This is likely to be minimal under traditional husbandry conditions with extensive grazing and a free choice of forage plants. Nwude and Parsons (1977) have compiled a list of plants found in Nigeria which are known to contain poisonous factors. Amagee (1977) has described and demonstrated experimentally a condition called *tournis à Brysocarpus* (*Brysocarpus* staggers) among sheep and goats who have eaten the young shoots of *B. coccineus*, a shrub described botanically by Brunel (1977) which is widespread in West Africa.

Losses from snakebite occur, and deaths from road accidents are an important factor in towns or villages situated near busy highways. Injuries may also be inflicted by local farmers when animals stray on growing crops.

9. ECONOMIC FACTORS

In this section, the wider economic considerations involved in goat and sheep production in the humid zone will be discussed. First, available information on the prices of inputs and outputs will be reviewed which, together with the technical production parameters discussed in previous sections, should provide a basis for evaluating the economic efficiency of small ruminant production. This will be considered from the point of view of the individual farmer and of the national economy.

Throughout the humid zone, three types of goat and sheep production were observed: traditional production, commercial production and an intermediate type. Nearly all small ruminants in the region are kept under traditional free-ranging conditions, with very few cash inputs except for the initial purchase of stock. By contrast, investment and recurrent costs are much higher under the commercial production system. An intermediate system might be feasible which could combine the advantages of both.

INVESTMENT COSTS

No particular investments are required under the traditional management system except the initial purchase of stock. Current sheep prices quoted by respondents in West Africa were ₵ 80 (US $ 70) in Ghana, CFA 6 000 to 8 000 (US $ 30 to 40) in Ivory Coast and N 20 to 25 (US $ 31 to 39) in Nigeria. Thus, the value of one sheep or goat may represent 15 to 20% of a farmer's entire annual cash income in Nigeria, and an even higher proportion in Ghana. These prices, however, refer to larger, consumption-oriented markets and those actually paid in small villages are likely to be lower. No information is available on village prices, however, or on the non-cash transfer or acquisition of stock at the village level.

Capital costs for commercial production at varying levels of intensity were estimated in two feasibility studies which covered three sheep farms in Ghana and Ivory Coast. These are given in Table 12.

ANNUAL RECURRENT COSTS

Recurrent costs under traditional management are usually insignificant, as the animals are left to graze freely on their own. They are sometimes supplemented with household wastes, but the importance of these is not sufficiently known, either in terms of total feed intake or in terms of opportunity costs, if any. It was reported in Ivory Coast, however, that high mortality ensued in one flock when the household wastes were removed from the diet and the animals fed on forage alone (CNRZ, 1977). In those areas where a shift to more intensive, largely commercial production methods has taken place, household wastes are generally no longer fed, so an opportunity cost for this source of feed should be calculated.

In some village production systems, the animals are tethered and grass and/or leaves are cut and brought to them. The extent or value of this practice is not known, however. It may be that this occurs during the dry season to supplement the feed available to the animals, or during the wet season to prevent excessive growth of grasses or to avoid damage to crops. The most consistent reports are available from eastern Nigeria, where animals are tethered during the wet season to avoid crop damage (see Upton in Oluwasanmi et al., 1966; Lagemann, 1977).

The estimated annual recurrent costs for three commercial sheep farms in

Ghana and Ivory Coast are given, along with estimated capital costs, in Table 12.

Table 12. Investment and annual recurrent costs for three commercial sheep farms in Ghana and Ivory Coast (US $, official rates)

	GHANA		IVORY COAST
	5 000 sheep, 70 ha maize, 500 ha improved pasture, 400 ha natural pasture	100 sheep, 3.5 ha maize, 7 ha improved pasture	100 sheep, 7 ha improved pasture
Investment Costs			
Farm development	77 200	-	-
Building & fencing	123 100	4 200	3 400
Vehicles & equipment	79 500	-	-
Crop & pasture development	35 900	3 800	2 100
Stock purchases	231 800 (4600 head)	8 000	4 900
Contingencies (10%)	54 700	1 600	-
Total capital costs	602 200	17 600	10 400
Annual Recurrent Costs			
Salaries & wages	27 800	710	780
Maintenance & repair of buildings & equipment	12 700	726	1 650
Pasture maintenance	17 500	50	175
Animal management	50 200	960	690
Others	30 000	1 280	-
Total annual recurrent costs	138 200	3 726	3 295
Annual recurrent costs per sheep	27.64	37.26	32.95

Sources: For Ivory Coast, SODEPRA (1976); for Ghana, Cockcroft (1977).

A comparison of the three commercial sheep farms is indicative only. The Ghanaian figures include an important crop component, and the conversion of Ghanaian cedis into US dollars is problematic. Nevertheless, it appears that recurrent costs are slightly lower in Ivory Coast, for which the data, unlike those for Ghana, include depreciation for livestock purchases. The large farm also benefits from economies of scale. Comparing recurrent costs for different management systems, it is clear that costs under commercial management are much higher than under the traditional system.

A breakdown of the annual costs of minerals, feed concentrates and drugs used on the three commercial farms in Ivory Coast and Ghana was also calculated, as given in Table 13. The Ghanaian figures are given in US dollars both at the official exchange rate and at a shadow rate of US $ 1 = ₵ 2.50. Total annual costs calculated in this way were US $ 6.89 per adult female maintained in Ivory Coast, including a 25% provision for contingencies, US $ 9.32 in Ghana at the official exchange rate, and US $ 3.64 at the shadow rate.

Table 13. Estimated annual costs of minerals, concentrates and drugs on three commercial sheep farms in Ivory Coast and Ghana per adult female (US $)

	Ivory Coast	Ghana official rate	Ghana shadow rate
Minerals	1.87 (4.3 kg)	1.12	0.41
Urea supplement	-	1.12	0.41
Concentrates	1.90 (200 g rice bran daily)	3.54	1.41
Drugs	1.74	1.12	0.41

Sources: Same as Table 12.

LABOUR REQUIREMENTS

Labour requirements and organization vary according to the system of flock management. In the forest zone where sheep and goats are usually kept in small household flocks of less than ten animals, the labour required from each family is very low. As the animals are not herded, labour input consists almost entirely of the preparation and feeding of household refuse. The only estimate of labour input under this system was made by Upton (in Oluwasanmi et al., 1966) for eastern Nigeria. He reported from Uboma District that a family spent on average one-half hour per week on livestock-related activities, though this may be an underestimate.

The cost of family labour is expressed in terms of the value of alternative uses to which this labour could be put. In the humid zone, there are few alternative tasks during the dry season, but a high demand for labour during the wet season for crop-related work, such as clearing, burning and planting, which generally takes place in February and March. Lagemann (1977) estimated the productivity of agricultural labour in eastern Nigeria in terms of the average returns from agricultural tasks. These were fairly high, ranging from N 0.53 to 1.12 (US$ 0.83 to 1.75) per man-hour on fields near the compound to N 0.11 to 0.23 (US$ 0.17 to 0.36) on more distant fields. Gross returns per man-hour tended to be higher in less densely populated villages.

Under different management systems, the labour required for tending flocks is organized differently. In Ivory Coast, village flocks of 100 to 150 animals are often managed cooperatively, tended by one person (SODEPRA, 1976). Labour requirements for herding and watering the animals are about three hours a day during the wet season and four hours during the dry season.

On commercial farms in Ghana, flocks of up to 500 sheep are tended by one or two persons who work six or seven hours a day. Daily labour costs are reckoned at ₵4.00 (US$ 3.48) per person. The labour requirements for shepherding are reduced on these farms because the pastures are fenced (Cockcroft, 1977).

RETURNS

If prolificacy in sheep under the traditional management system is estimated at 180%, fertility at 150% and annual mortality at 40 to 50%, then offtake is on the order of 100% and economic efficiency is high. Costs under the traditional system are very low, giving an internal rate of return of 50 to 60%. For a household flock of five adult females with an offtake of 100%, annual gross income would be around US $ 150. Assuming a labour requirement of one-half hour per day, as suggested by the preliminary results of ILCA's survey in western Nigeria, and total costs of about US $ 30 per year, a net income from labour of US $ 0.70 per man-hour can be calculated, comparable to the estimates given by Lagemann (1977) for other agricultural activities in Nigeria.

In addition to calculations of economic efficiency, the element of risk must be considered. Epidemics can wipe out entire household flocks more or less at random, making sheep and goat production a rather speculative undertaking under traditional farming conditions. In addition, mortality rates are positively correlated with flock size, which means that the risks are greater for farmers who increase their flocks. Although other inputs are minimal, the purchase of stock is a significant investment for a small farmer. This cash requirement for an enterprise which entails a high degree of risk may help explain the fact that the overall number of sheep and goats in the humid zone does not seem to be increasing and holdings seem to be becoming more concentrated in the hands of a few relatively wealthy families.

By contrast, commercial production systems appear to be less efficient economically, but have a greater potential for growth. Given an average investment cost of US $ 100 per head of sheep at an annual interest rate of 10% and a recurrent cost of US $ 30 per head, total annual costs per head are on the order of US $ 40. Thus, an offtake of 130% would be required to break even and 150% would be required to obtain an acceptable rate of return. If it is assumed that and fertility prolificacy remain the same under commercial conditions as under the traditional husbandry system, the mortality rate would have to be reduced to about 20% to achieve an acceptable offtake rate. Such a reduction would appear to be feasible. For goats, average prolificacy is higher, in the order of 150%, but mortality is also somewhat higher, so that if mortality could be reduced to the same level the opportunities for an acceptable rate of return would appear to be somewhat greater than for sheep.

The rates of return calculated for four commercial farms in Ivory Coast and Ghana are given in Table 14. These figures are fairly low, partly due to the high cost of inputs, the generally high investment costs and the absence of real improvement in offtakes or weights over the level achieved under traditional production systems. In both countries, the smaller enterprises appear to have a higher rate of return than the larger ones. The two farms in Ghana have also included maize production with sheep rearing in order to improve their short-term returns.

Table 14. Estimated rates of return for four commercial sheep farms

	Rate of Return
Ivory Coast	
50 ewes, artificial pasture	33 - 35%
100 ewes, artificial pasture	18 - 19%
Ghana	
100 sheep, artificial pasture & maize	19%
9000 sheep, artificial pasture & maize	13%

Sources: For Ivory Coast, SODEPRA (1976); for Ghana, Cockcroft (1977).

Given the economic characteristics and constraints of the traditional and commercial systems, it would appear that the best strategy for improving sheep and goat production in the humid zone would be to develop an intermediate system combining the best elements of both. Such a system would be efficient if investment costs for such items as fencing and pasture establishment could be kept at the lowest possible level, while at the same time mortality rates could be reduced.

MARKETING AND PRICES

Household budget surveys in Nigeria indicate that most of the sheep and goats produced under the traditional system are sold rather than consumed at home, though this tendency diminishes with increasing income. In Ghana, the urban meat market is dominated by beef and chicken, with the estimated market share for mutton and lamb only 6.8% and for goat meat only 5.4%. Even so, a substantial proportion of the sheep and goat meat marketed comes from outside the country: live and carcass imports account for as much as 50% of the mutton market and 25% of the goat meat market, though this proportion appears to be declining (Cockcroft, 1977).

According to FAO (1966), goat and sheep meat accounted for 35% of total meat consumption in eastern Nigeria and 45% of the total meat supply. In western Nigeria, goat and sheep meat accounted for only 13% of total consumption and 22% of supply. Consumption patterns, however, may well have changed since these data were collected.

Information on preferences for certain types of meat may be obtained from many sources. For example, Devendra and Burns (1970) reported that 'a carefully planned survey on the meat preferences of people in central Ghana revealed the preference of the indigenous Ashanti people for goat meat'.

Little is known about price patterns in the region. Retail prices for goat meat in Nigeria are on about the same level as beef prices, with mutton prices about 20% lower. The Ghanaian Central Bureau of Statistics (1977) compiled indices of farm-gate prices for sheep, fowl and the main agricultural crops in northern Ghana at Tamale, as shown in Table 15.

Table 15. Farm-gate price indices for principal agricultural products in Tamale, northern Ghana (1967 = 100)

	Groundnuts 180 lbs	Millet 240 lbs	Maize 220 lbs	Fowl	Sheep large	All Local Food: rural prices	All Local Food: national prices
1968	136	157	157	96	112	109	108
1969	128	286	171	104	120	118	116
1970	160	200	157	126	88	125	120
1971	144	157	157	104	104	139	131
1972	192	286	214	148	176	151	144
1973	256	300	257	178	224	181	170
1974	264	475	243	267	288	207	201

Source: Ghana, Central Bureau of Statistics (1977).

These figures reveal several interesting patterns. For one thing, sheep and fowl price increases lagged behind food grain price increases from 1968 to 1971, but began catching up from then onwards. Local food prices, which included all the individual items in the table, rose faster in the rural areas than in the country as a whole and apparently much faster in Tamale, which means that the terms of trade for producers were improving in favour of the Tamale area.

In the Tamale area, sheep production has become somewhat more favourable than groundnut or maize production in recent years. No figures were given on price changes at various times of the year, but it is widely believed that these are linked with the major festivals. Market records of livestock sales are probably available, and the collection and analysis of this information could make a valuable contribution to efforts to improve animal production.

THE ROLE OF LIVESTOCK PRODUCTION IN THE HUMID ZONE

It has already been suggested that the return on labour devoted to livestock production is probably similar to or higher than the return on labour devoted to crops. However, very little labour is required for livestock production, and the opportunities for maximizing income through concentration on livestock are probably limited. Further indications of the role of livestock in the traditional farming system may be obtained by reviewing household budget surveys undertaken in rural Ghana and Nigeria. These surveys include information on expenditures for various inputs related to livestock production and the income received from livestock. The provisional results of a national farm income survey undertaken in Ghana are presented in Table 16. These figures suggest that absolute income from livestock production increases with farm size, but the proportion of income from livestock in total farm income remains roughly constant. The smallest farms appear to receive the highest proportion of total income from livestock production, though the differences are not great. Expenditure data do not give separate figures for livestock-related expenses, which suggests that they are either zero or too small to be shown separately. When these figures are broken down by region, it appears that the proportion of total farm income derived from livestock production is higher in Northern and Upper Regions in the north and Eastern Region in the south than in Brong Ahafo and Ashanti Regions where substantial incomes are derived from cocoa production.

Table 16. Estimated annual farm incomes in Ghana (cedis, US dollars in brackets[a])

Farm size	Crop Income	Livestock Income	Total Farm Income	Livestock Income as % of Total
Up to 1 ha	151 ($131)	16 ($14)	166 ($145)	9.6
1 - 2.5 ha	381 ($331)	23 ($20)	404 ($351)	5.7
2.5 - 5 ha	593 ($516)	50 ($44)	644 ($560)	7.8
5 - 10 ha	1080 ($939)	42 ($37)	1122 ($976)	3.7
over 10 ha	1865 ($1622)	143 ($124)	2009 ($1746)	7.1
Overall	537 ($467)	37 ($32)	574 ($499)	-

a. US $ 1 taken as equivalent to ₵ 1.15.

Source: Ghana (1974).

No comparable national survey has been carried out in Nigeria, but a number of village-level surveys have been undertaken. Galletti et al. (1972) surveyed cocoa-farming families in western Nigeria from 1951 to 1953 and determined that only 1% of total household cash sales were derived from livestock. Matthewman (1977) surveyed 95 livestock owners in two villages near Ibadan and noted that 91% reported that they kept animals for financial gain. He observed that 'to the individual livestock owner, the main role of animals is to provide small, periodic incomes', and estimated that the income derived from livestock, including poultry, averaged about 7.5% of total farm income. It may be significant that an exhaustive study of the Yoruba farming system in western Nigeria undertaken by Zuckerman (1972) made no mention of livestock production. Results from a further village survey in the Ibadan area undertaken by Aye are expected soon.

In eastern Nigeria, the Uboma District was surveyed in 1963 and again, though on a smaller scale, in 1972 (Oluwasanmi et al., 1966; Anthonio and Ijere, 1973). According to the 1963 survey, the average stock-owning household had 12 chickens, 4.5 goats and 1.4 sheep. The cash and subsistence derived from livestock annually averaged only 3.7% of total farm income. It was noted that fresh meat, eaten almost exclusively during the harvest season, contributed only 10% of annual protein consumption, whereas dried fish, eaten throughout the year, contributed 33.5%. Both meat and fish were important purchase items in the household budgets of the area.

The 1972 survey indicated that average farm family incomes, estimated at N 257.50 (US$ 402.34) in 1963, increased to N 511.33 (US$ 798.95) in 1972, though real income did not rise as sharply. Using the Enugu price index quoted by Lagemann (1977), the 1972 income at 1963 prices amounted to N 319.50 (US$ 499.22) only, an increase of 24% over the period or 2.2% per annum.[3] Income from livestock increased sharply from N 9.50 (US$ 14.84) in 1963 to N 48.50 (US$ 75.78) in 1972 in terms of 1963 prices, a rise of over 400%. The share of livestock income in total farm income increased from 3.7% in 1963 to 15.2% in 1972, probably due to the introduction of large-scale poultry farming and rabbit production, practised on four of the six farms surveyed. The income obtained from sheep and goat production increased slightly, from N 4.20 (US$ 6.56) to N 5.47 (US$ 8.55), though it is not possible to determine from available information whether this increase was due to increased numbers, higher prices or other factors.

More recently, Lagemann (1977) surveyed three villages in eastern Nigeria to determine the effects of different population densities on the farming system. The information he collected on ownership of animals and incomes derived from livestock production, as presented in Table 17, reveals substantial differences between the villages with low, medium and high population densities.

3. These figures are only illustrative and are not statistically reliable. They are derived from case studies of only six farms. A less optimistic picture emerges from the fact that increased production over the period was insufficient to offset estimated population increases. On the basis of estimated total district income in 1963, per capita incomes actually appear to decline in real terms over the period in question, from N 59.5 (US$93.0) to N 51.6 (US$80.6) in terms of 1963 prices.

Table 17. Livestock ownership and incomes in villages of low, medium and high population density in eastern Nigeria

Population Density	Average Livestock Holdings per Household			Annual Household Incomes (naira, US dollars in brackets[a])		
	Goats	Sheep	Poultry	Livestock	Total Farm	Total Family
Low	1.4	-	9.1	21 ($33)	480 ($750)	721($1127)
Medium	2.0	0.6	15.6	38 ($59)	321 ($502)	655($1023)
High	3.2	0.5	20.6	58 ($91)	272 ($425)	946($1478)

a. US $ 1 taken as equivalent to N 0.64.

Source: Lagemann (1977).

More livestock were kept in the densely populated areas, but Lagemann noted that the total meat supply was in fact slightly higher in the less densely populated areas, due to the importance of meat from game animals. He calculated average farm incomes in the three areas, including income from game meat, and reckoned the proportion used for subsistence consumption. These figures are given in Table 18, which suggests that income from livestock tends to displace income from crops as population pressure increases, though the ratio of livestock to total income remains roughly constant. The cash income derived from livestock production was about the same for all families in all villages, but subsistence derived from livestock was considerably higher in the more densely populated villages. As the sample sizes were small, however, and a number of measurement problems occurred[4], the interpretation of these data must remain tentative.

4. Inventory changes were not recorded, opening/closing values were assumed to be identical, implying an underestimation of incomes and an unknown bias, and the value of animal manure was not included.

Table 18. Average annual household incomes from livestock production and game meat with subsistence components (naira, US dollars in brackets[a])

Population Density	Income from Livestock and Game Meat	Subsistence Component	Total Farm Income	Subsistence Component	Total Family Income
Low	41 ($64)	28.7 ($44.8)	500 ($781)	173 ($270)	741 ($1158)
Medium	38 ($59)	24.2 ($37.8)	321 ($502)	148 ($231)	655 ($1023)
High	58 ($91)	48.1 ($75.2)	272 ($425)	196 ($306)	946 ($1478)

a. US $ 1 taken as equivalent to N 0.64.

Source: Adapted from Lagemann (1977).

Lagemann (1977) concluded from this survey that farmers put more effort into livestock production as population pressure increased in order to increase their food supplies and cash incomes, and that they also made fuller use of animal manure as a fertilizer in more densely populated areas. The data presented in Table 18 confirm this observation for the most densely populated village, but any increases in livestock production from the low-density to the medium-density villages were masked by accompanying decreases in the use of game meat. The decline in total farm incomes with increasing population density, largely reflecting declining crop incomes, is clear from the table, as well as the increase in total family incomes.

The figures from Uboma District suggest that livestock husbandry intensifies with development, while Lagemann's survey suggests that production intensifies with increasing population pressure. In Uboma, intensification occurred through specialization, but in other areas there might be a more general spread of livestock production among rural households. Neither of these surveys suggests what might be the principal causes of livestock intensification. In the villages surveyed by Lagemann, marketing opportunities did not increase and there were no technical innovations. In Uboma, these two factors might have played a role, whereas increasing population pressure was not a factor.

10. SUMMARY OF PROPOSALS FOR FURTHER RESEARCH

TRADITIONAL PRODUCTION SYSTEMS

Most small ruminants in the humid zone are kept under traditional management systems, usually in small household flocks of five or six animals. The few data available on these production systems suggest that the potential for increasing productivity is substantial, but the main constraint is the incidence of disease. There is very little information quantifying actual losses from disease, however, or indicating the relative importance of specific diseases. Also, little is known about the seasonality of disease incidence or the interaction of different diseases with nutritional or reproductive status. Prophylactic and curative treatments have been developed for the most important diseases affecting sheep and goats in the humid tropics, but in some cases additional testing needs to be carried out, and the economics of comprehensive control schemes are largely unknown.

The nutritional status of small ruminants under traditional husbandry systems appears adequate at present levels of production, but may become a constraint with improved disease control and increased productivity. The role of browse in improved nutritional regimes appears particularly promising.

ILCA is currently carrying out comprehensive surveys of traditional small ruminant production systems and designing a package of innovations for improving productivity. First, a general survey of 1 000 households has been conducted in the forest and derived savanna areas of the humid zone. Livestock ownership patterns were recorded, along with the age and sex composition of household flocks. Information collected on livestock production is being analysed in relation to the main characteristics of the farming systems.

This general survey has formed the basis of a more detailed study of 1 200 individual animals - 800 goats and 400 sheep - which are being monitored for one year. Production parameters, clinical cases of disease and mortality are being recorded. The nutritional status of a small sample is also being recorded, and the role of browse plants as a source of animal feed is being studied in more detail.

At the same time, information is being analysed on the number of small ruminants passing through rural and urban markets in Nigeria and the fluctuations in sheep and goat prices. This information is largely collected by national and local agencies, but data on marketing may also be collected by ILCA directly.

The surveys conducted by ILCA are being carried out in the Ibadan area of western Nigeria. This research work may be expanded to include other geographic areas, however, through cooperative arrangements with other organizations.

Analysis of the original surveys should be completed by the end of 1979. This information will be used as the basis for formulating packages of innovations designed to increase goat and sheep production under traditional management systems. These packages will be introduced for testing at the village level in early 1980, and the results will be recorded and in turn will form the basis for further research and testing.

MORE INTENSIVE PRODUCTION SYSTEMS

In view of the increasing population pressure and demand for animal protein in West and Central Africa, more intensive sheep and goat production systems are likely to assume greater importance in the local economy. Based on currently available bio-technical and economic information, ILCA has designed three intensive production units, to be operated on an experimental basis during the next three years.

These intensive production systems include disease control measures, animal housing and improved reproduction management, introduced with flocks of 150 animals, i.e. on a scale likely to be feasible for smallholders. The main difference between the three systems is the amount of labour and capital invested, as reflected in management strategies, and the degree of pasture development. During the first year, two experimental units are being established, namely:

a. a system based on fallow land improved by interplanting fodder shrubs such as *Leucaena leucocephala* and *Cajanus cajan*, with sheep and goats managed together, and

b. a system based on improved fodder production, including grass, legume and shrub species, with a higher carrying capacity and sheep and goats managed separately.

At a later stage (1980-1981), a zero grazing system will also be established, aimed at the intensive breeding and fattening of sheep and goats.

Experience with these three production units should provide considerable information on the biological and economic efficiency of small ruminant production at various levels of intensity. On the basis of this experience and further information obtained by simulation techniques, optimum packages of innovations will be developed and tested under village conditions.

SPECIFIC RESEARCH NEEDS

Information already available on sheep and goat production in the humid zone suggests a number of components of the production system which require more detailed investigation. For one thing, the main investment requirements for intensive production are improved animal housing and fencing, and the costs of these inputs have a considerable effect on the feasibility of any improved system. Different types of fencing and housing will be compared in connection with ILCA's experimental production units and also in cooperation with national research institutes.

Data on the carrying capacity of natural fallows and improved pastures are also inadequate, though stocking rates can have a crucial effect on the biological and economic feasibility of an intensive production system. Experience with various stocking rates will be obtained from the three experimental management units, but, in addition, ILCA plans to carry out specific trials aimed at determining optimum carrying capacities of various types of pasture. These results will provide a basis for modifying the practices followed on the experimental management units.

The importance of browse plants in the feeding regime of small ruminants in the humid zone has already been mentioned. ILCA is carrying out studies of the most important indigenous shrubs and of a few introduced species in terms of their potential contribution to improved animal feeding regimes.

A preliminary trial is also being carried out of the effects of tissue culture rinderpest vaccine (TCRV) on the incidence of *peste des petits ruminants* (PPR) among sheep and goats in the humid zone. Further research work may be undertaken in this area if the results of village-level surveys and experience with the experimental management units point to the importance of PPR as a constraint on increased small-ruminant production.

Beginning in 1980, the effects of strategic supplementary feeding with locally available crop and agro-industrial byproducts will also be investigated.

This entire research programme, aimed at contributing to the development of small ruminant production in the humid tropics, is based on close collaboration with national and international institutions working in the humid zone. In Nigeria, ILCA is already working closely with the Federal Livestock Department (FLD) and the National Animal Production Research Institute (NAPRI), and specific components of the research programme are being carried out in cooperation with the Universities of Ibadan and Ife. ILCA is also working closely with the International Institute of

Tropical Agriculture (IITA) at Ibadan, particularly in the areas of administration, farming systems research and fodder agronomy. Cooperation with other universities and research and development institutions in West and Central Africa is also envisaged.

REFERENCES

PREFACE

ILCA (International Livestock Centre for Africa) (1979). *Trypanotolerant livestock in West and Central Africa.* Monograph No. 2. Addis Ababa, ILCA.

BACKGROUND INFORMATION

Anthonio, Q B O and Ijere, M O (1973). *Uboma development project, 1964-1972: An appraisal of a technical assistance programme for rural development in Nigeria.* London, Shell International Petroleum Co.

Boudet, G (1975a). 'The inventory and mapping of rangeland in West Africa'. In ILCA. *Evaluation and mapping of tropical African rangelands: Proceedings of the seminar.* Addis Ababa, ILCA.

Crowder, L V and Chheda, H R (1977). 'Fodder and forage crops'. In G L A Leakey and J B Wills, eds. *Food crops of the lowland tropics.* London, Oxford University Press.

Galletti, R, Baldwin, K D S and Dina, I O (1972). *Nigerian cocoa farmers: An economic survey of Yoruba cocoa farming families.* Second edition. Westport, Greenwood Press.

Lagemann, J (1977). *Traditional African farming systems in Nigeria: An analysis of reaction to increasing population pressure.* Afrikastudien No. 98. IFO-Institut. Munich, Weltforum Verlag.

Le Houérou, H N (1977). 'The grassland of Africa: Classification, production, evolution and development outlook'. In *13th international grassland congress.* Leipzig.

Matthewman, R W (1977). 'A survey of small livestock production at the village level in the derived savanna and lowland forest zones of southwest Nigeria'. M.Sc. thesis, University of Reading. 174 pp.

Mecha, I (1975). 'Traditional goat husbandry in southern Nigeria'. *Niger. J. Anim. Prod.* 2 (1), pp. 67-68.

Oluwasanmi, H A, Lang, D M, Corbett, W M, Oguntoyinbo, B A, Okali, C, Dema, I S, Osamo, M D, Adegboye, R O, Upton, M and Ezeilo, W N O (1966).

Uboma: A socio-economic and nutritional survey of a rural community in eastern Nigeria. World Land Use Survey Occasional Paper No. 6. Bude, Geographical Publishers.

Oyenuga, V A (1967). *Agriculture in Nigeria: An introduction.* Rome, FAO.

Rombaut, D and van Vlaenderen, G (1976). 'Le mouton Djallonké de Côte d'Ivoire en milieu villageois: Comportement et alimentation'. *Rev. Elev. Méd. Vét. Pays Trop. 29* (2), pp. 157-172.

Upton, M (1967). 'Agriculture in southwestern Nigeria: A study of the relationship between production and social characteristics in selected villages'. Development Study No. 3. University of Reading. 115 pp.

GENETIC RESOURCES

Akinsoyinu, A O, Mba, A U and Olubajo, F O (1975). 'Studies on comparative utilization of urea and groundnut cake rations by young, growing West African dwarf goats. 2: Effect on carcass quality and chemical composition of the organs and muscles'. *Niger, J. Anim. Prod. 2* (1), pp. 81-88.

Akinsoyinu, A O, Mba, A U and Olubajo, F O (1977). 'Crude protein requirement of West African dwarf goats for maintenance and gain'. *West Afr. J. Anim. Prod. 1* (1), pp. 75-80.

Dettmers, A, Igoche, C A and Akinkuolie, K (1976). 'The West African dwarf sheep. 1: Reproductive performance and growth'. *Niger. J. Anim. Prod. 3* (1), pp. 139-147.

Devendra, C and Burns, M (1970). *Goat production in the tropics.* Technical Communication No. 19. Edinburgh, Commonwealth Bureau of Animal Breeding and Genetics; Farnham Royal, Commonwealth Agricultural Bureaux.

Epstein, H (1953). 'The dwarf goats of Africa'. *East Afr. Agric. J. 18* (3), pp. 123-132.

Ginisty, L (1978). 'Faits saillants de l'operation 05-01: Amélioration de la productivité des petits ruminants'. 8pp.

Hill, D H (1960). 'West African dwarf sheep'. In *Third annual conference of the Science Association of Nigeria.* Ibadan, Ibadan University College.

Mason, I (1951). *The classification of West African livestock.* Technical Communication No. 1. Farnham Royal, Commonwealth Agricultural Bureaux.

Mba, A U, Boyo, B S and Oyenuga, V A (1975). 'Studies on the milk composition of West African, Red Sokoto and Saanen goats at different stages of lactation. 1: Total solids, butterfat, solids-non-fat protein, lactose and energy contents of milk'. *J. Dairy Res. 42* (2), pp. 217-226.

Mecha, I (1978). 'Identification of the existing goat breeds of southern Nigerian origin on the basis of external characteristics'. Nsukka, University of Nigeria, Department of Animal Science. 16 pp.

Ngere, L O (1973). 'Size and growth rate of the West African dwarf sheep and a new breed, the Nungua Blackhead of Ghana'. *Ghana J. Agric. Sci.* *6* (2), pp. 113-117.

Rombaut, D and van Vlaenderen, G (1976). 'Le mouton Djallonké de Côte d'Ivoire en milieu villageois: Comportement et alimentation'. *Rev. Elev. Méd. Vét. Pays Trop. 29* (2), pp. 157-172.

Sada, I and Vohradsky, F (1973). *Sb. Vys. Sk. Zemed. Praze Provozne Ekon. Fak. Cesk. Budejovicich Rada Biol. 6*, pp. 173 ff.

University of Ghana (1976). *Agricultural Research Station, Nungua: Annual report, 1975/76.* Legon.

Vohradsky, G and Sada, I (1973). *Sb. Vys. Sk. Zemed. Praze Provonze Ekon. Fak. Cesk. Budejovicich Rada Biol. 6*, pp. 161 ff.

Wilson, P N (1958). 'The effect of plane of nutrition on the growth and development of East African dwarf goats. 1: Effect of plane of nutrition on the liveweight gain and the external measurements of kids'. *J. Agric. Sci. 50* (2), pp. 198-210.

REPRODUCTION

Buadu, M K (1972). 'The reproductive potential of dwarf goats in the humid forest zone of Ashanti'. In *Proceedings of the fifth animal science symposium.* Kumasi, University of Science and Technology. pp. 7-11.

CNRZ (Centre National de Recherches Zootechniques de Minankro-Bouaké) (1977). *Rapport annuel 1976: Programme 05: Amélioration de la productivité des petits ruminants.* No. 13 Zoot. Minankro-Bouaké, CNRZ.

Dettmers, A, Igoche, C A and Akinkuolie, K (1976). 'The West African dwarf sheep. 1: Reproductive performance and growth'. *Niger. J. Anim. Prod. 3* (1) pp. 139-147.

Devendra, C and Burns, M (1970). *Goat production in the tropics.* Technical Communication No. 19. Edinburgh, Commonwealth Bureau of Animal Breeding and Genetics; Farnham Royal, Commonwealth Agricultural Bureaux.

Hill, D H (1960). 'West African dwarf sheep'. In *Third annual conference of the Science Association of Nigeria.* Ibadan, Ibadan University College.

Jarosz, S J, Deans, R T and Dukelow, W R (1971). *J. Reprod. Fertil. 24*, pp. 119 ff.

Jollans, J L (1960a). 'A study of West African dwarf sheep in the closed forest zone of Ashanti'. *West Afr. J. Biol. Appl. Chem. 3* (4), pp. 74-8.

Matthewman, R W (1977). 'A survey of small livestock production at the village level in the derived savanna and lowland forest zones of southwest Nigeria'. M. Sc. thesis, University of Reading. 174p.

Mecha, I (1978). 'Identification of the existing goat breeds of southern Nigerian origin on the basis of external characteristics'. Nsukka, University of Nigeria, Department of Animal Science. 16 pp.

Ngere, L O (1977). *Niger. J. Anim. Prod.*

Orji, B I (1977). 'Studies in the biology of reproduction of dwarf sheep'. Ph.D. thesis, University of Ibadan.

Otchere, E O and Nimo, M C (1975). *Ghana J. Agric. Sci. 8.*

Otchere, E O and Nimo, M C (1976). 'Reproductive performance in the West African Dwarf goat'. *Ghana J. Agric. Sci. 9* (1), pp. 57-56.

Ragan, H A, Horstman, V G, McLellan, R O and Bustad, L K (1966). 'Application of miniature goats in ruminant research'. *Amer. J. Vet. Res. 27* (116), pp. 161-165.

Rogers, A L Erickson, L F, Hoversland, A S, Metcalfe, J and Clary, F L (1969). 'Management of a colony of African pygmy goats for biomedical research'. *Lab. Anim. Care. 19* (2), pp. 181-185.

Rombaut, D and van Vlaenderen, G (1976). 'Le mouton Djallonké de Côte d'Ivoire en milieu villageois: Comportement et alimentation'. *Rev. Elev. Méd. Vét. Pays Trop. 29* (2), pp. 157-172.

Sellers, K C, Dipeolu, O O, Falade, S and Babalola, R (1974). 'Household livestock survey in the Euruwa District of the Ibarapa Division, Oyo State, Nigeria'. Ibadan, University of Ibadan, Department of Veterinary Pathology.

University of Ghana (1976). *Agricultural Research Station, Nungua: Annual report,* 1975/76. Legon.

Vallerand, F and Brankaert, R (1975). 'La race ovine Djallonké au Cameroun: Potentialités zootechniques, conditions d'élevage, avenir'. *Rev. Elev. Méd. Vét. Pays. Trop. 28* (4), pp. 523-545.

Vohradsky, F and Sada, I (1973). *Sb. Vys. Sk. Zemed. Praze Provozne Ekon. Fak. Cesk. Budejovicich Rada Biol.* 6, pp. 161ff.

ANIMAL NUTRITION AND TROPICAL FORAGES

Bille, J C, Rivière, R, Boudet, G and Lebrun, J P (1970). *Manuel sur les pâturages tropicaux et les cultures fourragères.* Maisons Alfort, Ministère de la Coopération/IEMVT. 184 pp.

Blaxter, K L (1967). *The energy metabolism of ruminants.* Revised edition. London, Hutchinson. 332 pp.

Blaxter, K L and Wilson, R S (1963). 'The assessment of a crop husbandry technique in terms of animal production'. *Anim. Prod.* *5* (1), pp. 27-42.

Boudet, G (1975b). *Manuel sur les pâturages tropicaux et les cultures fourragères*. Second edition. Maisons Alfort, Ministère de la Coopération/IEMVT. 254 pp.

Bredon, R M and Horrell, C R (1961). 'The chemical composition and nutritional value of some common grasses in Uganda. 1: General pattern of behaviour of grasses'. *Trop. Agric.* (Trinidad). *38* (4), pp. 297-304.

Bredon, M M and Horrell, C R (1962). 'The chemical composition and nutritional value of some common grasses in Uganda. 2: The comparison of chemical composition and nutritive value of grasses throughout the year, with special reference to the later stages of growth'. *Trop. Agric.* (Trinidad). *39* (1), pp. 13-17.

Brinkman, W L (1975). 'The feeding value of five different hays as fed to sheep'. *Samaru Res. Bull.* *223*, pp. 225-230.

Butterworth, M H (1963). 'Digestibility trials on forages in Trinidad and their use in the prediction of nutritive value'. *J. Agric. Sci.* *60* (3), pp. 341-346.

Butterworth, M H (1967). 'The digestibility of tropical grasses'. *Nutr. Abstr. Rev.* *37* (2), pp. 349-368.

Butterworth, M H, Groom, C G and Wilson, P N (1961). 'The intake of Pangola grass *(Digitaria decumbens)* under wet and dry-season conditions in Trinidad'. *J. Agric. Sci.* *56* (3), pp. 407-410.

Campling, R C, Freer, M and Batch, C C (1962). 'Factors affecting the voluntary intake of food by cows. 3: The effect of urea on the voluntary intake of oat straw'. *Br. J. Nutr.* *16* (1), pp. 115-124.

Castillo, L S and Gerpacio, A L (1976). Technical Bulletin No. 21. Los Banos, University of the Philippines, Department of Animal Science.

Crampton, E W (1957). 'Interrelationships between digestible nutrient and energy content, voluntary dry matter intake and overall feeding value of forages'. *J. Anim. Sci.* *16* (3), pp. 546-552.

Crowder, L U and Chheda, H R (1977). 'Fodder and forage crops'. In *Food crops of the lowland tropics, with special reference to West Africa*. London, Oxford University Press.

Devendra, C (1975a). 'Biological efficiency of milk production in dairy goats'. *World Rev. Anim. Prod.* *11* (1), pp. 46-53.

Devendra, C (1977a). 'The mineral content of Caribbean feedingstuffs'. *Trop. Agric.* (Trinidad). *54* (1), pp. 29-38.

Devendra, C (1977b). 'Studies on the intake and digestibility of two varieties (Serdang and Colonaio) of Guinea grass (*Panicum maximum*) by goats and sheep'. *MARDI Res. Bull.* *5* (2), pp. 91-109.

Devendra, C (1979). *Malaysian feedingstuffs*. Serdang, Selangor, Malaysian Agricultural Research and Development Institute.

Devendra, C and Burns, M (1970). *Goat production in the tropics*. Technical Communication No. 19. Edinburgh, Commonwealth Bureau of Animal Breeding and Genetics; Farnham Royal, Commonwealth Agricultural Bureaux.

Devendra, C and Gohl, B I (1970). 'The chemical composition of Caribbean feedingstuffs'. *Trop. Agric.* (Trinidad). *47* (4), pp. 335-342.

Dirven, J G P (1970). 'Task of grass-breeding in tropics with special consideration of propogation, yield and feeding value' (in German). *Z. Kulturtech. Flurbereinig.* *11* (2), pp. 92-107.

Dougall, H W (1960). 'Average nutritive values of Kenya feedingstuffs for ruminants'. *East Afr. Agric. For. J.* *26* (2), pp. 119-128.

Elliott, R C and Topps, J H (1963). 'Voluntary intake of low protein diets by sheep'. *Anim. Prod.* *5* (3), pp. 269-276.

French, M H (1957). 'Nutritional value of tropical grasses and fodders'. *Herb. Abstr.* *27* (1), pp. 1-9.

Glover, J and Dougall, H W (1961). 'Milk production from pasture'. *J. Agric. Sci.* *56* (2), pp. 261-264.

Hardison, W A (1966). Research Bulletin No. 1. Philippines, Dairy Training and Research Institute.

Holder, J M (1967). 'Milk production from tropical pastures'. *Trop. Grassl.* *1* (2), pp. 135-41.

Holmes, W (1951). *Proc. Br. Soc. Anim. Prod.* pp. 90ff.

Holmes, W (1970). 'The future of animals as sources of human food'. *Proc. Nutr. Soc.* *29* (2), pp. 237-243.

Jollans, J L (1960b). 'The effect on the growth rate of wethers of supplementary tropical day length'. *West Afr. J. Biol. Appl. Chem.* *4* (3), pp. 41-45.

Mabey, G L and Rose Innes, R (1964). 'Studies on browse plants in Ghana'. *Emp. J. Exp. Agric.* *32* (128), pp. 274-278.

Marshall, B, Bredon, R M and Juko, C D (1961). 'The nutrition of Zebu cattle. 4: The intake of dry matter by cattle with some notes on the digestibility of Rhodes grass and star grass hays'. *J. Agric. Sci.* *56* (2), pp. 191-196.

Messager, J L (1977). 'Production fourragère en Côte d'Ivoire: Etat des recherches'. In *Colloque de Bouaké. Recherches sur l'élevage bovin en zone tropicale humide*. Minankro-Bouaké, CNRZ.

Milford, R (1967). 'Nutritive values and chemical composition of seven tropical legumes and lucerne grown in sub-tropical south-eastern

Queensland'. *Aust. J. Exp. Agric. Anim. Husb.* *7* (29), pp. 540-545.

Milford, R and Minson, D J (1966). 'Intake of tropical pasture species'. In *Proceedings of the ninth international grassland congress.* Sao Paulo. pp. 815-822.

Milford, R and Minson, D J (1968). 'The digestibility and intake of six varieties of Rhodes grass *(Chloris gayana)*'. *Aust. J. Exp. Agric. Anim. Husb.* *8* (33) pp. 413-418.

Miller, T B (1961). 'Recent advances in studies of the chemical composition and digestibility of herbage'. *Herb. Abstr.* *31* (1), pp. 1-9.

Miller, T B and Blair Rains, A (1963). The nutritive value and agronomic aspects of some fodders in northern Nigeria. 1: Fresh herbage'. *J. Br. Grassl. Soc.* *18* (2), pp. 158-167.

Minson, D J (1971). 'The digestibility and voluntary intake of six varieties of *Panicum*'. *Aust. J. Exp. Agric. Anim. Husb.* *11* (1), pp. 18-25.

Moir, R J (1963). 'Ruminant digestion'. *J. Austr. Inst. Agric. Sci.* *29* (1), pp. 3-7.

Oyenuga, V A (1958). 'Problems of livestock nutrition in Nigeria'. *Nutr. Abstr. Rev.* *28*, pp. 985-1000.

Oyenuga, V A (1968). *Nigeria's foods and feedingstuffs: Their chemistry and nutritive value.* Third edition. Ibadan, Ibadan University Press. 99 pp.

Oyenuga, V A and Akinsoyinu, A O (1976). In *Proceedings of the first international symposium on feedingstuffs.* pp. 505ff.

Payne, W J A (1963). In *Proceedings of the world congress on animal production.* Beltsville. pp. 204ff.

Rombaut, D and van Vlaenderen, G (1976). 'Le mouton Djallonké de Côte d'Ivoire en milieu villageois: Comportement et alimentation'. *Rev. Elev. Méd. Vét. Pays. Trop.* *29* (2), pp. 157-172.

Ruthenberg, H (1974). 'Artificial pastures and their utilization in the southern Guinea savanna and the derived savanna of West Africa: *Tour d'horizon* of an agricultural economist'. Stuttgart, University of Hohenheim. 98 pp.

Sen, K C and Ray, S N (1971). *Nutritive value of Indian cattle feeds.* Sixth edition. New Delhi, Indian Council of Agricultural Research.

Smith, C A (1962). 'The utilization of *Hyparrhenia* veld for the nutrition of cattle in the dry season. 3: Studies on the digestibility of the produce of mature veld and veld hay, and the effect of feeding supplementary protein and urea'. *J. Agric. Sci.* *58* (2), pp. 173-178.

Spedding, C W S and Hoxey, A M (1974). In *Proceedings of the 21st University of Nottingham school in agricultural science.* pp. 483ff.

Stobbs, T H (1971). ' Quality of pasture and forage crops for dairy production in the tropical regions of Australia. 1: Review of the literature'. *Trop. Grassl. 5,* pp. 159-170.

Tayler, J C (1970). 'Dried forages and beef production'. *J. Br. Grassl. Soc. 25* (2), pp. 180-190.

University of Ghana (1975). *Agricultural Research Station, Nungua: Annual report, 1973/74 and 1974/75.* Legon. 95 pp.

University of Ghana (1976). *Agricultural Research Station, Nungua: Annual report,* 1975/76. Legon.

FORAGE PRODUCTION

Ademosun, A A and Chheda, H R (1974). 'Regional evaluation of *Cynodon* genotypes'. *Niger. Agric. J. 11* (1), pp. 25-30.

Aken'ova, M E, Chheda, H R and Crowder, L V (n.d.). 'Interspecific hybrids of *Pennisetum typhoides S.* and *H.* x *P. purpureum schum* for forage in the hot humid lowland tropics of West Africa. 2: Evaluation of selected hybrids'. University of Ibadan. 13 pp.

Asare, E O (1974). 'Grassland improvement and cattle production in Ghana'. In *Proceedings of the seventh animal science symposium.* Legon, University of Ghana. pp. 86-96.

Brinkman, W L and Adu, I F (1977). 'The problems of goat production in the savanna region of Nigeria'. Zaria, National Animal Production Research Institute. 5 pp.

Chheda, H R and Akinola, J O (1971). 'Effects of cutting frequency and levels of applied nitrogen on productivity, chemical composition, growth components and regrowth potential of three *Cynodon* strains'. *Niger. Agric. J. 8* (1), pp. 44-62.

Chheda, H R and Saleem, A M (1973). 'Effects of heights of cutting after grazing on yield, quality and utilization of *Cynodon* 1B 8 pasture in southern Nigeria'. *Trop. Agric.* (Trinidad). *50* (2), pp. 113-119.

Coblentz, P E (1977). 'Some range relationships of feral goats on Santa Catalina Island, California'. *J. Range Manage. 30* (60), pp. 415-419.

Crowder, L U and Chheda, H R (1977). 'Fodder and forage crops'. In G L A Leakey and J B Wills, eds. *Food crops of the lowland tropics.* London, Oxford University Press.

Fianu, F K, Attah-Krah, M K and Koram, K (1972). 'Some aspects of dry-season nutrition of small ruminants in Ghana'. In *Proceedings of the fifth animal science symposium.* Kumasi, University of Science and Technology.

Guerin, H (1977). 'Exploitation de pâturages de *Stylosanthes* et de *Brachiaria* en culture sèche: Résultats acquis des campagnes 1975-1976'. Minankro-Bouaké, Ministère de Recherches Scientifiques/CNRZ.

Lagemann, J (1977). *Traditional African farming systems in Nigeria: An analysis of reaction to increasing population pressure.* Afrikastudien No. 98. IFO-Institut. Munich, Weltforum Verlag.

Malechek, J C and Leinweber, C L (1972). 'Forage selectivity by goats on lightly and heavily grazed ranges'. *J. Range Manage.* *25* (2), pp. 105-111.

Messager, J L (1976). 'Fiche technique du *Stylosanthes guyanensis*'. *Journée de la recherche scientifique en region de savanne.* Korhogo, Ministère de la Recherche Scientifique; Minankro-Bouaké, CNRZ.

Messager, J L (1977). 'Production fourragère en Côte d'Ivoire: Etat des recherches'. In *Colloque de Bouaké: Recherches sur l'élevage bovin en zone tropicale humide.* Minankro-Bouaké, CNRZ.

Oppong, E N W (1974). 'Improving sheep and goat production in Ghana'. In *Proceedings of the seventh animal science symposium.* Legon, University of Ghana. pp. 12-15.

Ruthenberg, H (1974). 'Artificial pastures and their utilization in the southern Guinea savanna and the derived savanna of West Africa: *Tour d'horizon* of an agricultural economist'. Stuttgart, University of Hohenheim. 98 pp.

Wilson, P N (1957). 'Studies of the browsing and reproductive behaviour of the East African dwarf goat'. *E. Afr. Agric. For. J. 23,* pp. 138-147.

SUPPLEMENTARY FEEDING WITH AGRO-INDUSTRIAL BYPRODUCTS

Adeyanju, S A and Ogutuga, D B A (1974). 'Cocoa husk, has it any feeding value?' *Niger, J. Anim. Prod. 1.*

CNRZ (Centre National de Recherches Zootechniques de Minankro-Bouaké) (1977). *Rapport annuel 1976: Programme 05: Amélioration de la productivité des petits ruminants.* No. 13 Zoot. Minankro-Bouaké, CNRZ.

Davis, G K and Kirk, W K (1958). 'Bagasse as cattle feed'. *Sugar J. 21* (4), pp. 12-13.

de Sainte Antione, J D and Vignes, E C (1962). 'The extraction of cane juice protein and the assessment of its value as a feedingstuff'. *Rev. Agric. Sucr.* (Mauritius). *41,* pp. 25-30.

Devendra, C (1975b). 'The utilization of rice straw by sheep. 1. Optimal level in the diet. 2. Level of crude protein and urea as the sole source of dietary nitrogen'. *Malays. Agric. J. 50* (2), pp. 169-199.

Devendra, C (1977c). In *Proceedings of the symposium on feedingstuffs for livestock in Southeast Asia.* Kuala Lumpur. pp. 116ff.

Devendra, C (1977d). 'Sheep of the West Indies'. *World Rev. Anim. Prod.* *13* (1), pp. 31-38.

Devendra, C (1978b). Preprint No. 26. International Cocoa and Coconut Conference. Kuala Lumpur. 15 pp.

Donefer, E, James, L A and Laurie, C K (1975). 'Use of a sugarcane derived feedstuff for livestock'. In R L Read, ed. *Third world conference on animal production.* Melbourne, World Association of Animal Production. pp. 563-566.

Elias, A, Preston, T R, Willis, M B and Sutherland, T R (1968). 'Intensive beef production from sugar cane. 4: Molasses/urea as a substitute for grain in low-fibre diets'. *Rev. Cubana Cienc. Agric.* *2*, pp. 55-63.

FAO (Food and Agriculture Organization) (1977). *New feed resources: Proceedings of a technical consultation.* Rome, FAO. 300 pp.

Hatch, C F and Beeson, W M (1972). 'Effect of different levels of cane molasses on nitrogen and energy utilization in urea rations for steers'. *J. Anim. Sci.* *35* (4), pp. 854-858.

Jackson, M G (1977). *Anim. Feeds Sci. Tech.* *2*, pp. 105ff.

Kirk, W G, Peacock, F M and Davis, G K (1962). Bulletin No. 641. University of Florida, Agricultural Experimental Station.

Ledger, H P and Tillman, A D (1972). 'Utilization of coffee hulls in cattle fattening rations'. *East Afr. Agric. For. J.* *37* (3), pp. 234-236.

Lofgreen, G P and Otagaki, K K (1960a). 'The net energy of blackstrap molasses for lactating dairy cows'. *J. Dairy Sci.* *43* (2), pp. 220-230.

Lofgreen, G P and Otagaki, K K (1960b). 'The net energy of blackstrap molasses for fattening steers as determined by a comparative slaughter technique'. *J. Anim. Sci.* *19* (2), pp. 392-403.

McIntosh, C E, Osuji, P O, Birla, S C and Hope, C K (1976). 'Economics of supplementary feeding of grazed sheep with ground cottonseed'. *Trop. Agric.* (Trinidad). *53* (2), pp. 97-103.

O'Donovan, P B (1970). *World Humid Research* (FAO). *13* (32).

Ogunfowora, O (1975). Lagos, Federal Livestock Department.

Owusu-Domfeh, K, Christensen, D A and Owen, B D (1970). 'Nutritive value of some Ghanaian foodstuffs'. *Can. J. Anim. Sci.* *50* (1), pp. 1-14.

Preston, T R, Willis, M B and Elias, A (1967). 'Intensive beef production from sugarcane. 1: Different levels of urea in molasses given ad libitum to fattening bulls as a supplement to a grain diet'. *Rev. Cubana Cienc. Agric.* (1), pp. 33-40.

ANIMAL HEALTH

Amagee, Y (1977). *Annuaire Universitaire du Benin* (Lomé). *3*, pp. 109-115.

Bonniwell, A M (1977). 'The control of sheep diseases in Ghana'. Kumasi, Department of Veterinary Services.

Bonniwell, A M (1978). 'Veterinary problems associated with sheep rearing in the Ashanti Region of Ghana'. Legon, University of Ghana. 13 pp.

Bourdin, P (1973). 'La peste des petits ruminants (PPR) et sa prophylaxie au Sénégal et en Afrique de l'Ouest'. *Rev. Elev. Méd. Vét. Pays Trop.* *26* (4), pp. 71a-74a.

Bourdin, P and Doutre, M P (1976). 'La peste des petits ruminants au Sénégal - données nouvelles'. *Rev. Elev. Méd. Vét. Pays Trop.* *29* (3), pp. 199-204.

Bourdin, P and Laurent-Vautier, A (1967). 'Note sur la structure de virus de la peste des petits ruminants'. *Rev. Elev. Méd. Vét. Pays Trop.* *20* (3), pp. 383-386.

Bourdin, P, Rioche, M and Laurent, A (1970). 'Emploi d'un vaccine antibovi-pestique produit sur cultures cellulaires dans la prophylaxie de la peste des petits ruminants au Dahomey'. *Rev. Elev. Méd. Vét. Pays Trop.* *23* (3), pp. 295-300.

Brunel, J F (1977). *Annuaire Universitaire du Benin* (Lomé). *3*, pp. 155-160.

Cockcroft, F L (1977). *Agricultural development planning project, Ghana: Meat development project.* Rome, UNDP/FAO. 172 pp.

Dipeolu, O O (1975). 'The incidence of ticks of *Boophilus* species on cattle, sheep and goats in Nigeria'. *Trop. Anim. Health Prod.* *7* (2), pp. 35-39.

Falade, S (1974). '*Brucella* agglutinating antibodies in the sera of persons dwelling in Ibadan and the surrounding districts'. *J. Niger. Vet. Med. Assoc.* *3* (1), pp. 21-23.

Falade, S, Ojo, M O and Sellers, K C (1974). 'A serological survey of caprine brucellosis in Nigeria'. *Bull. Anim. Health Prod. Afr.* *22* (4), pp. 335-339.

FAO (Food and Agriculture Organization) (1976). *Report of the first FAO expert consultation on research on trypanotolerance and breeding of trypanotolerant animals.* Working Paper No. 10. Rome, FAO. 12 pp.

Gargadennec, L and Lalanne, A (1942). 'La peste des petits ruminants'. *Bulletin des Services Zootechniques et des Epizooties de l'Afrique occidentale française.* *5* (1), pp. 16-21.

Gibbs, E P J, Taylor, W P and Lawman, M J P (1977). 'The isolation of adenoviruses from goats affected by peste des petits ruminants in Nigeria'. *Res. Vet. Sci.* *23*, pp. 331-335.

Gibbs, E P J, Taylor, W P, Lawman, M J P and Bryant, J (1979). 'Classification of peste des petits ruminants virus as a new morbillivirus'. *Intervirology*.

Gidel, R, Albert, J P, le Mao, G and Retif, M (1974). 'La brucellose en Afrique occidentale et son incidence sur la santé publique: Résultats de 10 enquêtes epidemiologiques effectuées en Côte d'Ivoire, Haute-Volta et Niger de 1970 à 1973'. *Rev. Elev. Méd. Vét. Pays Trop.* *27* (4), pp. 403-418.

Gilbert, Y and Monnier, J (1962). 'Adoptation du virus de la peste des petits ruminants aux cultures cellulaires'. *Rev. Elev. Méd. Vét. Pays Trop.* *15* (4), pp. 321-335.

Hamdy, F M and Dardiri, A H (1976). 'Response of white-tailed deer to infection with peste des petits ruminants virus'. *J. Wildl. Dis. 12*, pp. 516-522.

Hamdy, F M, Dardiri, A H, Breese, S R Jr, and de Boer, G F (1975). 'Immunologic relationships between rinderpest and peste des petits ruminants'. In *Proceedings of the 79th meeting of the US Animal Health Association*. pp. 168-179.

Hamdy, F M, Dardiri, A H, Nduaka, O, Breese, S R Jr and Ihemelandu, E C (1976). 'Etiology of the stomatitis pneumoenteritis complex in Nigerian dwarf goats'. *Can. J. Comp. Med.* *40*, pp. 276-284.

Ikede, B O (1974a). 'Ocular lesions in sheep affected with *Trypanosoma brucei*'. *J. Comp. Pathol.* *84*, pp. 203-213.

Ikede, B O (1974b). 'The occurrence of deep mycoses in livestock at the University of Ibadan farm'. *Niger. J. Anim. Prod. 1* (2), pp. 127-131.

Ikede, B O and Losos, G J (1972). 'Pathology of the disease in sheep produced experimentally by *Trypanosoma brucei*'. *Vet. Pathol.* *9*, pp. 278-279.

Ikede, B O and Losos, G J (1975). 'Pathogenesis of *Trypanosoma brucei* infection in sheep. 1: Clinical signs. 2: Cerebro-spinal fluid changes. 3: Hypophyseal and other endocrine lesions'. *J. Comp. Pathol. 85* (1), pp. 23-44.

Isoun, T T and Mann, E D (1972). 'A stomatitis and pneumoenteritis complex of sheep in Nigeria'. *Bull. Epizoot. Dis. Afr. 20* (2), pp. 167-174.

Laurent, A (1968). 'Aspects biologiques de la multiplication du virus de la peste des petits ruminants ou PPR sur les cultures cellulaires'. *Rev. Elev. Vét. Méd. Pays Trop. 21* (3), pp. 297-308.

Losos, G J and Ikede, B O (1972). 'Review of pathology of diseases in domestic and laboratory animals caused by *Trypanosoma congolense, T. vivax, T. brucei, T.rhodiense and T. gambiense* *Vet. Pathol. 9* (supplement), pp. 1-71.

Matthewman, R W (1977). 'A survey of small livestock production at the village level in the derived savanna and lowland forest zones of southwest Nigeria'. M. Sc. thesis, University of Reading. 174pp.

Matumoto, M (1969). 'Mechanism of perpetuation of animal viruses in nature'. *Bacteriol. Rev.* *33* (3), pp. 404-418.

Mornet, P, Orue, J, Gilbert, Y, Thiery, G and Sow, M (1956). 'La peste des petits ruminants en Afrique occidentale française et ses rapports avec la peste bovine'. *Rev. Elev. Méd. Vét. Pays Trop.* *9* (4), pp. 313-342.

Nduaka, O and Ihemelandu, E C (1973). 'Observations on pneumonia-enteritis complex in dwarf goats in eastern states of Nigeria: Preliminary report'. *Bull. Epizoot. Dis. Afr.* *21* (1), pp. 87-98.

Nigeria, Federal Office of Statistics (1972). *Rural economic survey of Nigeria: Consolidated results of livestock enquiries, 1965-66 to 1967-68.* Lagos.

Nwude, N and Parsons, L E (1977). 'Nigerian plants that may cause poisoning in livestock'. *Vet. Bull.* (London). *47* (11), pp. 811-817.

OAU/STRC (Organization of African Unity/Scientific, Technical and Research Commission) (1973). *The distribution of tsetse flies (Glossina) in Africa.* Map prepared by J Ford and H M Katondo. Nairobi, Inter-african Bureau for Animal Resources.

Obi, T U and Gibbs, E J P (1978). 'Confirmation of "orf" in sheep and goats in Nigeria'. *Trop. Anim. Health Prod.* *10* (4), pp. 233-235.

Ogunrinade, A F (1977). 'Preliminary observations on *Oestrus ovis* myiasis in West African dwarf goats in Ibadan, Nigeria'. *Bull. Anim. Health Prod. Afr.* *25* (2), pp. 154-156.

Ojo, M O (1973). 'Isolation of two strains of *Mycoplasma* serologically closely related to *Mycoplasma mycoides* var. *mycoides* from pneumonic lungs of sheep'. *Bull. Epizoot. Dis. Afr* *21* (3), pp. 319-323.

Ojo, M O (1976a). 'Caprine pneumonia in Nigeria. 1: Epidemiology and bacterial flora of normal and diseased respiratory tracts'. *Trop. Anim. Health Prod.* *8* (3), pp. 137-146.

Ojo, M O (1976b). 'Caprine pneumonia in Nigeria. 2: Biochemical characterization and serological identification of *Mycoplasmas*'. *Trop. Anim. Health Prod.* *8* (3), pp. 137-146.

Ojo, M O (1977). 'Caprine pneumonia'. *Vet. Bull.* (London). *47* (8), pp. 573-578.

Okon, E D (1975). '*Trichuris* infection in Nigerian goats'. *J. Niger. Vet. Med. Assoc.* *3* (1), pp. 17-20.

Okon, E D and Enyenihi, U K (1975). 'Incidence of *Haemonchus contortus, Gaigeria pachyscelis* and *Oesophagostum columbianum* in goats in Nigeria'. *Bull. Anim. Health Prod. Afr.* *23* (2), pp. 145-153.

Okon, E D and Enyenihi, U K (1977). 'Development and survival of *Haemonchus contortus* larvae on pastures in Ibadan'. *Trop. Anim. Health Prod.* *9* (1), pp. 7-10.

Oppong, E N W (1973). 'Diseases of sheep in Ghana'. *Ghana J. Agric. Sci.* *6* (1), pp. 3-7.

Oppong, E N W (1974). 'Improving sheep and goat production in Ghana'. In *Proceedings of the seventh animal science symposium*. Legon, University of Ghana. pp. 12-15.

Olte, E (1960). 'Clinical studies on "Abu Nini" in the Sudan: A contagious disease of sheep and goats possibly caused by pleuropneumonia-like organisms'. *Vet. Rec.* *72* (8), pp. 140-145.

Perrau, P (1976). *Mycoplasmes et mycoplasmoses: Peripneumonie contagieuse des bovins, mycoplasmoses des petits ruminants*. Maisons Alfort, IEMVT. 40pp.

Rombaut, D and van Vlaenderen, G (1976). 'Le mouton Djallonké de Côte d' Ivoire en milieu villageois: Comportement et alimentation'. *Rev. Elev. Méd. Vét. Pays Trop.* *29* (2), pp. 157-172.

Rowland, A C and Bourdin, P (1970). 'The historical relationship between peste des petits ruminants and "Kata" in West Africa'. *Rev. Elev. Méd. Vét. Pays Trop.* *23* (3), pp. 301-307.

Rowland, A C, Scott, G R, Ramachandran, S and Hill, D H (1971). 'A comparative study of peste des petits ruminants and "kata" in West African dwarf goats'. *Trop. Anim. Health Prod.* *3*, pp. 241-245.

Taylor, W P (1979). 'Serological studies with peste des petits ruminants virus in sheep and goats from northern Nigeria'. *Res. Vet. Sci.* *26* (2), pp. 236-242.

Taylor, W P and Abe Gunde, A (1979). 'Isolation of PPR virus from sheep and goats in Nigeria'. *Res. Vet. Sci.* *26*, pp. 94-96.

Taylor, W P and McCausland, A (1976). 'Studies on bluetongue virus in Nigeria'. *Trop. Anim. Health Prod.* *8* (3), pp. 169-173.

Taylor, W P, Mohmoh, M, Okeke, A N C and Abe Gunde, A (1975). 'Antibodies to parainfluenza 3 virus in cattle, sheep and goats in northern Nigeria'. *Vet. Rec.* *97* (10), pp. 183-184.

Taylor, W P, Okeke, E N C and Shidali, N N (1977a). 'The isolation of adenoviruses from goats affected by peste des petits ruminants in Nigeria'. *Trop. Anim. Health Prod.* *9* (3), pp. 171-175.

Taylor, W P, Okeke, E N C and Shidali, N N (1977b). 'Experimental infection of Nigerian sheep and goats with bovine diarrhoea virus'. *Trop. Anim. Health Prod.* *9* (4), pp. 249-251.

University of Ghana (1975). Agricultural Research Station, Nungua: Annual report 1973/74 and 1974/75. Legon. 95 pp.

University of Ghana (1976). *Agricultural Research Station, Nungua: Annual report 1975/76*. Legon.

Vallerand, F and Brankaert, R (1975). 'La race ovine Djallonké au Cameroun: Potentialités zootechniques, conditions d'élevage, avenir'. *Rev. Elev. Méd. Vét. Pays Trop.* *28* (4), pp. 523-545.

van Geldorp, P J A and van Veen, T W S (1976). 'Periparturient rise in faecal helminth egg counts on Udah sheep in the Zaria area of Nigeria'. *Vet. Parasitol. 1*, pp. 265-269.

van Veen, T W S (1978). 'Haemonchosis in sheep during the dry season in the Nigerian savanna'. *Vet. Rec. 102* (16), pp. 364-365.

van Veen, T W S and Mohammed, A N (1975). 'Louse and flea infestations on small ruminants in the Zaria area'. *J. Niger. Vet. Med. Assoc. 4* (3), pp. 93-96.

van Veen, T W S, Shonekan, R A O, and Fabiyi, J P (1975). 'A host parasite checklist of helminth parasites of domestic animals in northern Nigeria'. *Bull. Anim. Health Prod. Afr. 23* (3), pp. 269-288.

Vohradsky, F and Sada, I (1973). *Sb. Vys. Sk. Zemed. Praze Provozne Ekon. Fak. Cesk. Budejovicich Rada Biol. 6*, pp. 161ff.

Whitney, J C, Scott, G R and Hill, D H (1967). 'The pathology of erosive stomatitis and enteritis of goats in southern Nigeria'. *Bull. Epizoot. Dis. Afr. 15* (1), pp. 31-41.

Zwart, D and Rowe, L W (1966). 'The occurrence of rinderpest antibodies in the sera of sheep and goats in northern Nigeria'. *Res. Vet. Sci. 7*, pp. 504-511.

ECONOMIC FACTORS

Anthonio, Q B O and Ijere, M O (1973). *Ubomo development project, 1964-1972: An appraisal of a technical assistance programme for rural development in Nigeria.* London, Shell International Petroleum Co.

CNRZ (Centre National de Recherches Zootechniques de Minankro-Bouaké) (1977). *Rapport annuel 1976: Programme 05: Amélioration de la productivité des petits ruminants.* No. 13 Zoot. Minankro-Bouaké, CNRZ.

Cockcroft F L (1977). *Agricultural development planning project, Ghana: Meat development project.* Rome, UNDP/FAO. 172 pp.

Devendra, C and Burns, M (1970). *Goat production in the tropics.* Technical Communication No. 19. Edinburgh, Commonwealth Bureau of Animal Breeding and Genetics; Farnham Royal, Commonwealth Agricultural Bureaux.

FAO (Food and Agriculture Organization) (1966). *Agricultural development in Nigeria 1965-1980.* Report to the Government of Nigeria. Rome, FAO. 512 pp.

Galletti, R, Baldwin, K D S and Dina, I O (1972). *Nigerian cocoa farmers: An economic survey of Yoruba cocoa farming families.* Second edition. Westport, Greenwood Press.

Ghana (1974). 'Farm income survey, 1974'. Accra.

Ghana, Central Bureau of Statistics (1977). *Statistical Newsletter*. 16/77. Accra.

Lagemann, J (1977). *Traditional African farming systems in Nigeria: An analysis of reaction to increasing population pressure*. Afrikastudien No. 98. IFO-Institut. Munich, Weltforum Verlag.

Matthewman, R W (1977). 'A survey of small livestock production at the village level in the derived savanna and lowland forest zones of southwest Nigeria'. M. Sc. thesis, University of Reading. 174 pp.

Oluwasanmi, H A, Lang, D M, Corbett, W M, Oguntoyinbo, B A, Okali, C, Dema, I S, Osamo, M D, Adegboye, R O, Upton, M and Ezeilo, W N O (1966). *Uboma: A socio-economic and nutritional survey of a rural community in eastern Nigeria*. World Land Use Survey Occasional Paper No. 6. Bude, Geographical Publishers.

SODEPRA (Société de Développement de la Production Animale)(1976). 'Elevage ovin intensif sur pâturage artificiel: Montants des investissements et comptes d'exploitation'. Bouaké.

Zuckerman, P S (1973). *Yoruba smallholders farming systems*. International Institute of Tropical Agriculture, University of Reading.

APPENDIX

Table A1. Livestock numbers by region - Ivory Coast

	1965/66	1967/68	1969[a]	1973[ab]
North[c]				
sheep	150 000	88 000	58 080	170 051
goats	200 000	16 000	115 725	139 091
Central				
sheep	291 000	357 000	360 115	191 649
goats	280 000	298 000	300 000	140 494
West-Central				
sheep	60 000	52 000	52 513	129 805
goats	110 000	67 000	66 828	123 470
East, West, South				
sheep	213 000	301 000	328 389	231 972
goats	245 000	313 200	295 376	163 095
Total				
sheep	714 000	798 000	799 097	723 477
goats	835 000	694 200	777 929	566 150

a. The administrative boundaries of the regions were changed between 1969 and 1973.
b. The 1973 figures refer to the traditional sector only (units of less than 100 ha).
c. The North Region is considered non-humid; all others are in the humid zone.

Sources: For 1965-1969, Ivory Coast, Ministère de la Production Animale; for 1973, *Recensement national,* Table 4.7.0.

Table A2. Livestock numbers by region - Nigeria

	1965		1966		1967		1968	
	June	Dec.	June	Dec.	June	Dec.	June	Dec.
Western								
sheep	683 000	888 000	837 000	1 790 000	526 000	724 000	511 000	711 000
goats	1 616 000	2 090 000	1 904 000	2 150 000	1 789 000	2 086 000	1 450 000	1 995 000
Mid-West								
sheep	166 000	190 000	101 000	109 000	106 000	146 000	26 000	43 000
goats	586 000	773 000	799 000	836 000	543 000	718 000	355 000	442 000
Eastern								
sheep	893 000	1 100 000	906 000	838 000	-	-	-	-
goats	3 137 000	3 924 000	3 390 000	3 519 000	-	-	-	-
National total								
sheep	7 278 000	9 020 000	9 725 000	9 585 000	-	-	-	-
goats	20 385 000	24 776 000	26 302 000	28 371 000	-	-	-	-

Source: *Rural economic survey of Nigeria* 1972.

Table A3. National livestock numbers, 1967-73 - Nigeria

	1967	1968	1969	1970	1971	1972	1973
Sheep	8 100 000	8 125 000	8 100 000	8 100 000	8 150 000	7 700 000	7 550 000
Goats	23 500 000	25 000 000	23 000 000	23 400 000	23 700 000	22 660 000	22 400 000
Total	31 600 000	33 125 000	31 100 000	31 500 000	31 850 000	30 360 000	29 950 000

Source: ECA, *African statistical yearbook*, various years.

Table A4. Livestock numbers by region - Ghana

	1969	1970	1971	1972	1973	1974	1975
Upper[a]							
sheep	217 020	191 042	187 882	218 990	233 776	251 774	241 303
goats	204 503	214 828	196 261	197 723	234 617	229 924	230 238
Northern[a]							
sheep	169 634	162 749	154 531	160 155	165 166	181 097	224 388
goats	162 304	151 175	138 040	154 476	153 107	166 879	214 615
Brong Ahafo[a]							
sheep	65 948	66 815	72 137	76 676	79 014	80 035	80 089
goats	49 427	31 211	54 972	53 335	55 483	56 510	67 246
Ashanti							
sheep	14 306	30 288	25 105	48 491	68 554	81 308	106 700
goats	8 584	25 191	12 184	23 458	38 837	49 346	63 617
Eastern							
sheep	18 067	18 067	17 488	17 488	29 009	45 415	42 756
goats	14 246	14 246	13 289	13 289	22 686	44 533	39 499
Greater Accra							
sheep	6 562	6 562	11 296	9 530	12 277	15 127	22 291
goats	3 141	3 141	7 582	7 740	10 104	10 215	13 857
Volta							
sheep	57 244	71 300	82 570	109 353	118 228	76 403	84 574
goats	35 024	48 570	47 645	88 543	98 578	62 165	82 358
Central							
sheep	101 949	102 241	102 673	101 207	105 393	106 778	38 433
goats	103 885	104 864	102 929	101 492	100 222	102 209	32 813
Western							
sheep	30 479	27 011	61 499	62 579	61 627	64 299	65 233
goats	11 555	11 847	30 038	27 936	28 578	22 313	34 805
Total							
sheep	681 209	676 075	715 181	804 469	873 044	902 236	905 767
goats	592 669	605 073	602 940	667 992	742 212	744 114	779 084

a. Upper, Northern and Brong Ahafo Regions are considered non-humid; all others are in the humid zone.

Source: Ghana, Veterinary Services Department, Annual Livestock Censuses.

Table A5. National livestock numbers, 1969-74 - Togo

	1969	1970	1971	1972	1973	1974
Sheep	588 807	619 096	492 726	1 320 000	1 296 923	1 420 000
Goats	514 680	546 995	479 223			

Source: Togo, Ministère de Développement Rural, Direction de la Production Animale.

Table A6. Livestock numbers by region and percentage of national population, 1971 - Togo

	Number	%
Maritime[a]		
sheep	103 007	21
goats	93 730	20
Plateaux[a]		
sheep	153 032	31
goats	133 787	28
Central		
sheep	54 630	11
goats	52 040	11
Kara		
sheep	81 587	17
goats	102 719	21
Savanna		
sheep	100 470	20
goats	96 947	20
Total		
sheep	492 726	100
goats	479 223	100

a. Maritime and Plateaux Regions are in the humid zone; the others are non-humid.

Source: Togo, Direction des Services de l'Elevage et des Industries Animales.

Table A7. Distribution of livestock ownership by region, 1973 - Ivory Coast

	% of All Households Owning			Average Number of Animals per Household		
	Sheep	Goats	Chickens	Sheep	Goats	Chickens
Sud-Est	19.8	15.7	70.1	5.1	4.6	15.1
Centre	31.2	24.5	64.3	4.9	4.5	11.8
Centre-Ouest	21.6	20.7	72.2	5.0	4.9	14.4
Sud-Ouest	30.6	23.5	75.6	4.6	4.1	13.0
Nord	32.9	32.1	75.2	4.6	4.1	20.5
Total	27.1	23.2	71.1	4.9	4.4	15.0

Source: Ivory Coast, *Recensement national 1973*, Table 4.8.0.

Table A8. Distribution of livestock ownership by size of holding, 1973 - Ivory Coast

	% of All Households Owning			Average Number of Animals per Household		
	Sheep	Goats	Chickens	Sheep	Goats	Chickens
less than .5 ha	9.9	14.5	49.6	4.4	2.8	6.8
.5 - 1 ha	16.7	12.9	52.1	4.2	3.0	8.2
1 - 2 ha	22.8	20.4	62.3	3.7	3.1	8.2
2 - 5 ha	25.2	20.9	71.2	3.9	4.4	11.3
5 - 10 ha	28.3	23.5	74.6	5.4	5.0	15.6
10 - 20 ha	31.6	23.4	79.1	5.8	5.6	21.2
20 - 50 ha	39.9	18.5	84.5	12.2	10.3	30.8
50 - 100 ha	37.5	47.0	87.0	13.1	6.1	55.3
Total	25.7	21.1	70.1	4.9	4.6	13.6

Source: Ivory Coast, *Recensement national 1973*.

Table A9. Distribution of livestock ownership by regions, 1965-75 - Nigeria

Percentage of Households[a] Owning ... (as of December)	1965	1966	1967	1968	1972	1974	1975
Western State							
sheep	16.0	15.0	6.7	6.0	23.1	20.1	17.1
goats	33.9	34.0	21.0	17.3	46.8	42.4	36.2
poultry	58.5	54.2	46.9	45.6	70.7	69.3	56.7
Mid-Western State							
sheep	8.7	5.1	8.2	2.5	-	-	-
goats	37.7	32.8	29.4	22.9	-	-	-
poultry	71.1	62.0	62.3	50.3	-	-	-
Eastern State							
sheep	13.5	13.8	-	-	-	-	-
goats	45.4	44.7	-	-	-	-	-
poultry	71.7	67.0	-	-	-	-	-

a. The two surveys on which this table is based used different definitions of rural households.

Sources: For 1965-68, Nigeria, *Rural economic survey*, 1972, Table 5; for 1972-75, Nigeria, *Western State agricultural survey*, 1973, 1976, Table 21.

Table A10. Average number of animals per household owning stock, 1965-75 - Nigeria

	1965	1966	1967	1968	1972	1974	1975
Western State							
sheep	2.9	2.8	3.6	2.1	3.6	3.0	1.7
goats	3.2	3.1	1.6	2.8	6.1	3.3	3.4
poultry	9.3	9.7	9.2	10.7	6.8	15.7	8.6
Mid-Western State							
sheep	4.1	2.7	3.3	2.4	-	-	-
goats	3.8	4.0	4.0	3.1	-	-	-
poultry	7.4	9.3	10.4	7.4	-	-	-
Eastern State							
sheep	3.2	3.0	-	-	-	-	-
goats	3.2	3.4	-	-	-	-	-
poultry	8.5	10.8	-	-	-	-	-

Sources: Same as for Table A9.

Table A11. Pasture species reported to be useful for feeding sheep and goats in West Africa

Species, Variety	Use
a. Grasses	
Cynodon plectostachyus	grazing, soil cover
C. nlemfuensis var. *nlemfuensis*, IB8	grazing, soil cover
Paspalum notatum var. Pensacola	grazing, soil cover
Panicum maximum var. S112	cutting
Brachiaria ruziziensis	grazing
B. mutica	flooded areas
B. brizantha	grazing, palatable
B. lata	annual
B. deflexa	annual
B. falcifera	annual
Digitaria horizontalis	annual
D. decumbens	grazing, hay
D. smutsii	
Dactyloctenium aegyptium	annual, grazing
Chloris gayana	
var. Katanbora	thin stem
var. *callide*	thick stem, cutting
Andropogon gayanus	cutting
Pennisetum purpureum	cutting
P. typhoides x *P. purpureum*	cutting
Tripsacum laxum	cutting
Melinis minutiflora	grazing, sandy soils
Cenchrus cilliaris	grazing, hay

Species, Variety	Use
b. Legumes	
Centrosema pubescens	grazing, palatable to goats
Pueraria phaseoloides	soil cover
Sophocarpus palustris	soil cover, mulch
Stylosanthes guayanensis	grazing, hay
Calopogonium mucunoides	grazing
Glycine wightii	soil cover, grazing
Dolichos lablab	annual
c. Forbes, Bushes, Trees	
Ficus elastica spp.	fencing
Cynodendron	fencing, browse
Baphia nitida	browse, cutting palatable
Spondias spp.	cutting, placenta expellant
Vernonia amygdalina	browse, invader
Amaranthus spinosus	browse
A. viridis	grazing
Tephrosia spp.	fallow planting some spp. toxic
Leucana leucocephala	fallow planting
Cajanus cajan	human food cattle feed
Griffonia simplicifolia	fed green to goats palatable
Dichapetalum guineense	browse

Species, Variety	Use
Grewia carpinifolia	fed green to goats
Caparis erythocarpus	
Milletia thononingii	large tree
Tiliacora wanneckii	large tree
Fagara xanthoxyloides	large tree
Richiea reflexa	large tree
Antiaris africana	large tree palatable
Flemingia congesta	large tree palatable
Boerhavia diffusa	browse, drier areas
Trianthema postulacastrum	browse, drier areas
Euphorbia heterophylla	browse
E. hirta	browse
Tridax procumbens	browse
Acanthospermum hispidum	browse
Mimosa pudica	browse
Asystasia gangetica	grazing
Dichrostacys glomerata	browse, invader

Printed by Bird's . Nairobi