PN-ABM-287 79285

HAIR SHEEP PRODUCTION IN TROPICAL AND SUB-TROPICAL REGIONS

With Reference to Northeast Brazil and the Countries of the Caribbean, Central America, and South America

M. SHELTON
E. A. P. FIGUEIREDO
Co-Editors

Cover Design: Paul Robinson
Photography: William L. Johnson, Maurice Shelton, Elsio Figueiredo
Editorial Assistance: M. Iya-Ilu Moses, Frank Byrnes, Mary Keane
Word Processing: M. Iya-Ilu Moses, Mary Keane
Printing: University of California Printing Department, Berkeley
Copies available from: Management Entity, Small Ruminant CRSP, University of California, Davis, California, 95616, U.S.A.

Funding Provided by
United States Agency for International Development
DAN 1328-G-SS-4093-00

HAIR SHEEP PRODUCTION IN TROPICAL AND SUB-TROPICAL REGIONS

With Reference to Northeast Brazil and the Countries of the Caribbean, Central America, and South America

M. SHELTON
E. A. P. FIGUEIREDO
Co-Editors

Centro Nacional de Pesquisa de Caprinos
Ministerio da Agricultura Empresa Brasileira
de Pesquisa Agropecuaria
EMBRAPA, Sobral CE
Brazil

Small Ruminant Collaborative Research Support Program
University of California, Davis
Davis, California
U.S.A.

Printed in Berkeley, California
for the Small Ruminant Collaborative Research Support Program
University of California, Davis
April, 1990

Table of Contents

List of Contributors

Foreword

i Introduction
M. Shelton and E.A.P. Figueiredo

1 Chapter One

THE PLACE AND POTENTIAL FOR SHEEP IN TROPICAL AND SUBTROPICAL REGIONS
M. Shelton and E.A.P. Figueiredo

7 Chapter Two

AVAILABLE GENETIC RESOURCES: The Origin and Classification of the World's Sheep
E.A.P. Figueiredo, M. Shelton, and M.E. Barbieri

25 Chapter Three

IMPROVEMENT PROGRAMS
E.A.P. Figueiredo and A.A.O. Fernandes

37 Chapter Four

NUTRIENT REQUIREMENTS OF HAIR SHEEP IN TROPICAL AND SUBTROPICAL REGIONS
J.R. Kawas and J.E. Huston

59 Chapter Five

FORAGE RESOURCES IN NORTHEAST BRAZIL: Their Value and Management
E.R. Leite, J.A. Araujo Filho, and R.C.M. Mesquita

79 Chapter Six

SUPPLEMENTAL FEED RESOURCES AND THEIR UTILIZATION BY HAIR SHEEP
W.L. Johnson, N.N. Barros, and E.R. de Oliveira

97 Chapter Seven

REPRODUCTION IN SHEEP
A.M.X. Eloy, A.A. Simplicio, and W.C. Foote

113 Chapter Eight

HERD HEALTH MANAGEMENT OF SHEEP IN THE SEMIARID TROPICS
H.J. Olander, H.E.A. Berne, J. Santa Rosa, and L. da S. Vieira

125 Chapter Nine

FACILITIES AND INSTALLATIONS FOR HAIR SHEEP PRODUCTION
M. Shelton and E.R. de Oliveira

135 Chapter Ten

PRODUCTS AND MARKETING
E.A.P. de Figueiredo and J. de Souza Neto

147 Chapter Eleven

TROPICAL SHEEP PRODUCTION SYSTEMS
J. de Souza Neto and E.A.P. Figueiredo

155 Chapter Twelve

SOME SUGGESTIONS FOR IMPROVED PRODUCTIVITY THROUGH MANAGEMENT
M. Shelton and E.A.P. Figueiredo

165 Chapter Thirteen

RECOMMENDATIONS FOR FURTHER RESEARCH
M. Shelton and E.A.P. Figueiredo

List of Contributors

Barbieri, M. E., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Barros, N. N., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Berne, H. E. A., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Eloy, A. M. X., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Fernandes, A. A. O., Researcher, Ceará State Agricultural Research Agency, Quixadá, Brazil.

Figueiredo, E. A. P., Chief, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Filho, J. A. Araujo, Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Foote, W. C., Professor of Animal Science, Utah State University, Logan, Utah, 84322, U.S.A.

Huston, J. E., Texas A&M University Agricultural Research and Extension Center, San Angelo, Texas, 76901, U.S.A.

Johnson, W. L., North Carolina State University Project, INIAA, Apartado 110097, Lima, Peru.

Kawas, J. R., Univ. Autonoma de Nuevo Leon, Ave. Las Torres #4600, Unidad Universitoria Mederos, Monterrey, N. L., Mexico.

Leite, E. R., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Mesquita, R. C. M., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Neto, J. de Souza, Economist, Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Olander, H. J., Professor of Veterinary Pathology, University of California, Davis, California, 95616, U.S.A.

de Oliveira, E. R., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Santa Rosa, J., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Shelton, M., Professor of Animal Science, Texas A&M University Agricultural Research and Extension Center, San Angelo, Texas, 76901, U.S.A.

Simplício, A. A., Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

Vieira, L. da Silva, Researcher, CNPC/EMBRAPA, Sobral CE, 62.100, Brazil.

FOREWORD

Ten years ago, research on sheep in the tropical Americas was scattered and fragmented, and scientists worked in relative isolation from each other. The establishment of the Small Ruminant Collaborative Research Support Program (SR-CRSP) was a major step toward linking isolated scientists and bringing to light "hidden" knowledge about tropical sheep raising. In Brazil, a memorandum of understanding was signed in 1979 between the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), or Brazilian Agricultural Research Agency, and the University of California, Davis (UCD), the management entity for SR-CRSP.

Since then, much research has been accomplished in Northeast Brazil and the United States. While EMBRAPA has been the host institution in Brazil, state research agencies in Bahia (EPABA), Ceará (EPACE), and Paraíba (EMEPA) also have participated.

Collaborating U.S. institutions are UC Davis for animal health; University of Missouri for sociology; North Carolina State University for nutrition; Texas A&M University, College Station and San Angelo, for animal breeding, management, and systems analysis; Utah State University for reproduction and range management; and Winrock International Institute for Agricultural Development for economics.

Although sheep make up only a small portion of the animal population of the tropical regions of Central and South America, there is a great potential to increase the contribution of this species. This may come from increasing numbers or improved productivity of existing flocks. The greatest potential for an increase in numbers may come from establishing new flocks to take advantage of mixed species grazing. Available data suggest that the offtake from flocks of sheep in tropical regions is low compared to their potential. Research under this project should contribute to realization of this potential.

The results of the collaborative research serve as the basis for the suggestions for technology improvement set forth in this volume. It is hoped that the information presented will be useful to extensionists and others who deal directly with hair sheep producers, and also for teaching sheep science in universities throughout the region. The information presented here will be useful for improving many facets of sheep production, not only in Northeast Brazil, but also for other regions with similar ecological characteristics.

These accomplishments also demonstrate the appropriateness and the effectiveness of the Title XII legislation that established the CRSP concept and laid the base for collaboration among U.S. universities and overseas institutions. Funding support from the U.S. Agency for International Development and matching resources from EMBRAPA and the six U.S. institutions are acknowledged with

great appreciation. Without them, the program would not have been possible.

This publication also is expected to be available in Portuguese at a later time.

J. W. Oxley, Program Director
Small Ruminant Collaborative
Research Support Program
University of California,
Davis, U.S.A.

E.A.P. Figueiredo
EMBRAPA
Sobral, Ceará
Brazil

September, 1989

INTRODUCTION

The terms "tropics" or "subtropics" are not easily defined. In geographical terms, the tropics refers to the area between the Tropic of Cancer (23°27'N) and the Tropic of Capricorn (23°27'S). In climatic or biological terms, it generally implies an area where high temperature and humidity singly or in combination result in stress to man or his animals for part or all of the year. The term "subtropics" is even less well-defined, but the writers interpret this as a larger area, perhaps encompassing the additional strip of land found between 30°N and 30°S latitude and including regions that are more arid than those normally thought of as tropical. A substantial area located between the Tropic of Cancer and the Tropic of Capricorn may not be truly tropical because of elevation or low rainfall. A sizable amount of land is found in tropical regions of Africa, Asia, Central America, and northern South America.

Only a small part of the world's sheep population is found in the true tropics, and essentially all of these are hair type sheep. This report is addressed to producers of this type of sheep. If the larger area of the arid or semiarid subtropics is included, many sheep are involved, as this encompasses much of Australia, Southern Brazil, parts of Argentina, India, and a large part of continental Africa. Many of the sheep in this larger area are wool-type sheep and are not considered in this publication.

Within Central and South America and the Caribbean, there are between 65 and 70 million sheep located in the 30°N and 30°S latitude zone. Restriction of the area to that between the Tropic of Cancer and the Tropic of Capricorn reduces this number to 40 to 45 million. Even within this more restricted area, some of the countries are located largely in the high Andes (Peru and Bolivia) and the environment is not tropical. The numbers used here are obtained from the FAO Yearbook of Agriculture, and in many cases are approximations as the geographical boundaries used do not coincide with political or country boundaries by which the data are tabulated or reported.

The largest populations of sheep located within the area that might be called tropical are in Mexico and Northeast Brazil. Small numbers of sheep are reported in Central America. One of the largest collections is in Guatemala, but many of these are in the mountains. Within the Caribbean region, the largest numbers of sheep are in Cuba, the Dominican Republic, and Haiti.

The relatively small numbers of sheep in Central America and the Caribbean may be viewed from two standpoints: first, the land areas in most of the countries are relatively small, and the actual concentrations of sheep in some of these regions may be quite high. Second, this may be viewed as an opportunity and a challenge to develop genotypes and production systems to exploit the large amount of forages produced in the tropics. There is a great potential to increase sheep production in these areas.

In many countries of Central America and the Caribbean, sheep make a greater social contribution than that indicated by their numbers since they contribute directly to the welfare of small farmers and are a part of their production systems. These flocks generally consist of less than [illegible], many of which roam freely

in commonly grazed areas. The exceptions to this are a few larger flocks which are managed on an industrial basis in fenced pastures and the other extreme which are flocks of less than 10 head which are kept confined or tethered.

This publication is based largely on work conducted by Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) in Northeast Brazil in collaboration with the U.S. AID Small Ruminant Collaborative Research Support Program (SR-CRSP) and various universities which were associated with this latter program. However, in the preparation of this report, attempts have been made to extend the information wherever possible to make it applicable to the larger region of Central America or the Caribbean.

The chapters in this publication have been prepared by various authors who have been associated with the work at different locations at some point in time. However, the approach taken and the content of the various chapters represent the thinking of the various authors and do not necessarily carry the endorsement of EMBRAPA or the SR-CRSP. Also, there is a great deal of variability in the degree to which the various authors have extended their comments to encompass areas outside Northeast Brazil.

Maurice Shelton **E.A.P. Figueiredo**

Chapter 1

THE PLACE AND POTENTIAL FOR SHEEP IN TROPICAL AND SUBTROPICAL REGIONS

M. Shelton and E.A.P. Figueiredo

Only a small percentage of the world's sheep population is located in the tropics. For instance, Williamson and Payne (1978) estimated this value as 20% while Seifert (1984) estimated 64% of the world's cattle, and Shelton et al. (1984) suggested 66% of the world's goat population were in the tropics. These values are estimates, as the method of identifying the tropics and the approach to estimating livestock numbers by geographic regions are not exact. It seems safe to conclude, however, that sheep are under-represented in the tropics, both relative to other species and to the proportion of the total land mass located in equatorial regions. By contrast, sheep make up a majority of the livestock in polar regions (Shelton, 1978).

There must be a reason for only a small part of the world's sheep population being in the tropics, and speculation concerning the reasons should suggest some of the problems to be overcome if sheep production is to improve in these regions. The under-representation of sheep in the tropics suggests the potential for a large increase in these areas. Also, FAO data indicate sheep numbers in the tropics are increasing at a more rapid rate than in other areas of the world.

Prior to domestication (approximately 10,000 years ago), the original wild types of sheep were restricted largely to higher elevations in an arc leading from Central Europe through the Near East, the Himalayas, across the Bering Strait and down the Rocky Mountain chain into Northern Mexico. Dixon (1979) stated that the preferred habitat for wild sheep were "broad high pasturelands and treeless, grassy, sloping mountains." Domestic sheep have moved into the tropics in comparatively recent times, and the process of adaptation to tropical climates is continuing. Many, though perhaps not all, sheep in the tropics are wool types that have invaded the tropics and still possess a vestigial type of fleece that is being lost gradually as they adapt to the warmer climate. This applies to the genotypes as they evolve under tropical conditions, and also to individual animals, as the young often have a more complete coat than older animal.

It is clear that as a species there is no sheep of a unique tropically adapted type such as the Zebu in cattle. Also, it is generally accepted that sheep require a higher quality of diet (especially for protein and energy) than the larger ruminants, and that tropical forages (especially grasses) are lower in feed value than those grown in temperate climates (Kearl, 1982). Adaptation of sheep to the tropics may require not only a loss of the fleece, but alteration of some physiological parameters as well. Sheep in the tropics also require improved parasite and disease resistance.

With these complications, why attempt to raise sheep in the tropics? First, sheep are not likely to replace cattle as the

primary species to utilize tropical forages. However, there are some advantages or positive aspects to consider about sheep production in the tropics. At the higher latitudes, photoperiodism places serious constraints on reproduction. Near the equator there is relatively little seasonality, and it is possible to take advantage of the potential to produce lambs more often than once per year. Also, many types of hair sheep have the characteristics of early sexual maturity and higher than average lambing rates. If these aspects of reproduction are exploited, the sheep has the potential of producing meat more efficiently than competing ruminants. Direct comparisons between sheep and goats (Fernandes et al., 1985) have shown that except under environmental conditions where the latter are uniquely adapted (i.e., where browse is the predominant feed source), sheep are more efficient meat producers than goats. There is obviously some advantage for sheep production over cattle under smallholder conditions where resources do not support maintenance of a herd of cattle or an individual animal.

Probably the most important reason for sheep is the unique niche they serve in forage utilization (Warren et al., 1983). Sheep tend to graze more heavily on forbs than other domestic ruminants. Mixed species grazing usually will result in more total production than single species. The one exception to this may be cattle grazing a monoculture of cultivated forages, but even under these conditions, the presence of sheep in the grazing system will tend to retard the encroachment of forbs or brush which are usually undesirable in cattle pastures. Limited data suggest that hair sheep tend to browse more heavily than wool sheep (Warren et al., 1983). This suggests that hair sheep will utilize a much wider range of plant species than cattle and may resemble goats in this respect.

Increases in production may derive from two sources: (a) through an increase in numbers, and (b) from increased "offtake" from existing flocks or populations. On a global basis, the under-representation of sheep in the tropics suggests a potential for increased numbers. The estimated total of 40 million head of sheep in the tropical regions of North, Central and South America, and the Caribbean is small compared to the total carrying capacity in these areas. In general, increases in numbers should be obtained from establishment of new flocks in areas not currently utilized by sheep.

Perhaps more important is the potential for increased production from existing numbers. The two largest concentrations of sheep in the area of interest in this report are in Mexico and Northeast Brazil. Mexico reports 6.5 million sheep in 1985 whereas Brazil reports 17.5 million. In Brazil, it is estimated that two-fifths of the total are in the more tropical regions, and the remainder are wool sheep in the south of the country. Essentially all of Mexico is located in tropical or subtropical regions, although many of the sheep there are wool-type sheep.

Measurements of productivity on a flock basis are highly variable. These may be lamb-crop raised and marketed as a percentage of the breeding ewes present in the flock. Other terms sometimes used are offtake, extraction rate, or simply the number of animals sold expressed as a function of total numbers or the total number of adult animals in the flock. Oscarberro et al. (1985) gave three estimates from farm flocks in Mexico. Two of

these values were 8.5 and 17.5 animals sold as a percentage of the total animals in the flock for two regions of the country and a third value in the same paper shows 16.3 animals sold as a percentage of the adult animals in the flock. De Boer and Fitzhugh (1983) report offtake estimates of 19% and 15% for the Caribbean and tropical America, respectively. Survey data from Northeast Brazil (Souza Neto, 1987) indicated that the offtake rate for 1980 was 13.9% which represented the slaughter of 864,000 head out of a total population of more than six million. It has been estimated that with significant inputs, values as high as 40 to 66% might be realized (EMBRAPA, 1980). On a theoretical basis, values much higher than this can be postulated.

It is difficult to arrive at a value indicative of the true potential production from this species. It is not unusual that offtake values of 100% are realized for well-managed flocks under temperate conditions. Many genotypes found in the tropics have the genetic potential for a high lambing rate, and the potential for more frequent lambing in tropical regions is apparent. Thus, the potential for increased production from existing flocks is great. The potential also exists for a higher level of reproduction from sheep in tropical regions. A realization of this potential could increase production dramatically. In many areas, however, especially the more arid regions or the wet-dry tropics, overgrazing by all species or over-utilization of the resources is a major problem with serious long-term consequences. Improved production or improved offtake might permit a reduction in total numbers without reducing productivity. If the same improvement happened with other species such as goats and cattle, the long-term benefit to society or to the ecosystem could be substantial.

An improvement of offtake or an overall high level of productivity may be necessary to justify sheep production in the tropics. As a species, sheep are a multipurpose animal with meat, fiber, and milk as the major products and skins or hides, fertilizer, sport, etc. as secondary products. It has been estimated that on a world basis approximately 43.4% of the total value of products produced by sheep is from meat, 39.3% from fiber, and 15.0% from milk. Other products are of minor value.

Meat and wool production from sheep is largely worldwide except for the absence of wool from tropically adapted hair sheep. Milk production from sheep tends to be concentrated in arid environments, particularly those characterized by nomadic systems or where high value specialty products are produced from sheep milk.

It is important to remember that sheep production in tropical regions is based largely on meat, with skins as a secondary product. Thus, it would appear to be imperative that they be efficient meat producers. This potential exists, but for the most part it presently is not being accomplished. Efficient meat production from sheep requires a high level of net reproduction and a good growth rate or slaughter weight of the offspring relative to the size of the breeding stock maintained. If a portion of the maintenance or production costs can be returned from sales of fiber or milk products, then the emphasis on reproduction and growth rate becomes comparatively less important, but they still rank high in importance in most production systems.

Under smallholder conditions or in developing countries, technology constraints to production often may be less important than socioeconomic constraints. Also, small producers, especially those without land resources, are difficult to influence with development programs. This may be less true if they raise sheep rather than goats. Although it is difficult to reach many sheep producers in tropical regions, this is not a reason for not making the effort, and professional workers should feel free to work with that segment of the industry in a position to respond.

Development of sheep production in the tropics will be a slow process, but the trend can only be upward.

Literature Cited

De Boer, A.J. and H.A. Fitzhugh. 1983. Sheep and goats in developing countries - their present and potential role. World Bank Technical Paper.

Dixon, K.L. 1979. The influence of quaternary environments on the evolution and distribution of world sheep (ovis spp.). *The Domestication of Sheep: Their Ancestors, Geography, Time Period and People Involved.* Utah State University, Logan, Utah.

EMBRAPA/EMBRATER. 1980. Sistemas de produçãra caprinos e ovinos. Estado do Ceará. Report No. 70.

Fernandes, A.A.O., J.M.S. Andrade, F.A.B. Menezes, A.G. Catunda and E.A.P. Figueiredo. 1985. Recria de caprinos nativos e ovinos 'Morado Nova' em pastagem de capim-buffel. Pesq. Agropec. Bras., Brasilia 20(8):975.

Kearl, L.C. 1982. Nutrient requirements of ruminants in developing countries. International Feedstuffs Institute, Utah State University, Logan, Utah.

Oscarberro, R., S. Fernandez and L. Tovar. 1982. La produccion ovino en la zona de Rio Frio, Edo. de Mexico. In: *Memorias del primer seminario nacional cobre sistems de produccion pecuaria.* pp. 269-286. Universidad Autonoma Chapingo, Mexico.

Seifert, G.W. 1984. Selection of cattle for beef production in humid and sub-humid tropical environments. In: *Proceedings of 2nd World Congress on Sheep and Beef Cattle Breeding* 1(13):1-5. Pretoria, R.S.A.

Shelton, M. 1978. Reproduction and breeding of goats. J. Dairy Sci. 61:994.

Shelton, M., G. Snowder and E.A.P. Figueiredo. 1984. Meat production and carcass characteristics of the goat. U.S. AID SR-CRSP Report No. 45.

Souza Neto, J. 1987. Demanda potencial de carne de caprinos e ovinos e perspectivas da oferta. 1985-1990. EMBRAPA/CNPC, Documentos 2. Sobral, Ce. Brazil.

UNFAO. 1986. *FAO Production Yearbook*, Food and Agr. Organization of the U.N., Rome.

Warren, L., J.M. Shelton and D.N. Ueckert. 1983. Genetic influence on foraging behavior (diet selection) of ruminants (sheep and goats). SR-CRSP Tech. Rept. 32.

Williamson, G. and W.J.A. Payne. 1978. *An Introduction to Animal Husbandry in the Tropics*. Longman, London.

Chapter 2

AVAILABLE GENETIC RESOURCES: The Origin and Classification of the World's Sheep

E.A.P. Figueiredo, M. Shelton and M.E. Barbieri

The world's sheep population (including Europe, U.S.S.R., North America, South America, Asia, China, Africa, and Oceania) may be as much as 1.1 billion head (FAO, 1985).

In biological classification, sheep belong to the following: Subkingdom, Vertebrata; Class, Mammalia; Order, Ungulata; Suborder, Artiodactyla; Group, Ruminantia; Family, Bovidae; Subfamily, Caprinae; Genera, Ovis; and Species, aries. The O. aries is believed to have descended from wild species such as the Asian and European Mouflon (O. orientalis and O. musimon), the Argali (O. ammon) and the Urial (O. vignei). Another subspecies of sheep, the North American Bighorn (O. canadensis), apparently has not been domesticated.

Primitive sheep had a coat of wool and hair interlaced. According to Gallinal (Vieira, 1967), there are about 1,410 breeds or strains of sheep. Among these, some are long-legged or short-legged, wooled or non-wooled, polled or horned, thin- tailed, fat-tailed, fat-rumped, and many other major variations.

Antonius (Vieira, 1967) classified sheep according to the tail characteristic: long-tailed, fat-tailed, short-tailed, and fat-rumped.

Sheep also can be classified according to type of wool or the absence of wool. This chapter deals only with those genotypes that are tropically adapted and thus largely free of wool. The latter group tends to be long- and thin-tailed, but the tail length is not as long as that found with wooled sheep. Some tropical sheep also show the influence of fat-tail or fat-rump breeding.

Most of the sheep in Central America and the Caribbean can be traced to one or combinations of four sources. The first, generally known today as the Criollo or Crioula type, arrived with early settlers from Spain and Portugal. These were wool sheep, but under tropical conditions much of the fleece has been lost or markedly reduced. A second source was hair sheep from Africa. These have rise to most of the truly woolless sheep of the area. As a third source, most of the traditional breeds of wool sheep of European origin have been introduced to the region at some time. In a few cases, these are used as a basis of commercial programs of limited scope, but for the most part these sheep have not persisted and have no place in tropical regions. But they may have contributed genes to some of the present strains. A fourth type, the Wiltshire Horned, has made a definite contribution, especially in the Caribbean. Although this animal is of English origin, it is considered woolless and has been introduced intentionally to the region. In fact, this animal should more properly be identified as a shedder since it produces fiber that is shed, especially at a young age.

Previous Page Blank

The hair sheep in the Americas that are of African origin came from countries between Nigeria and Angola in West Africa during the slave trade (Mason, 1980b). It is supposed that two types of thin-tailed sheep came to the Americas. One, without mane, probably came from savannah zones in the Congo area, including northern Angola and countries above it up to Cameroon. These are supposed to be the ancestors of the Morada Nova of Northeast Brazil and other hair sheep without mane (Mason, 1980b, Bradford and Fitzhugh, 1983). The animals that gave origin to these types of sheep probably were selected from flocks with a high frequency of tan color and its combinations. The other type of thin-tailed sheep, which gave origin to the hair sheep carrying a mane and throat ruff, probably came from a different population, the Fouta Djallon of Cameroon. The animals in that region do not present high prolificacy as do the Barbados Blackbelly in the Caribbean, but that trait could have been developed through selection or crossbreeding.

Among the most common tropical sheep breeds in the Americas are the Criollo or Crioula of Central America; the Barbados Blackbelly in the Caribbean (Barbados) and in the United States; the St. Croix in the Virgin Islands and the United States; the Pelibuey in Mexico and Cuba; the hair sheep in the Dominican Republic; the Bahama native, the Katahdin; the Red African of Venezuela; the African sheep in Colombia; the Somali Blackhead in the Caribbean and Brazil; and the Morada Nova, Santa Inês, Rabo Largo, and Bergamacia of Brazil.

Criollo or Crioula of Central America

Most of the sheep in the Americas belong to Criollo (Spanish) or Crioula (Portuguese) type or their crosses. Both terms may be translated as native or indigenous. These sheep are presumed to have come from Europe, mainly Spain and Portugal. They most likely derived from the Churro (Spain) and Bordaleiro (Portugal) sheep. Churro and Bordaleiro sheep came to the Americas during the time of early settlement.

After the initial introduction, a great number of breeds from other countries in Europe (Great Britain, France, Germany, and Italy), Oceania (Australia, New Zealand), and Africa were brought in and may have intercrossed with the original Churros and Bordaleiros. Some of these two breeds may have been maintained in a near pure state with or without selection. Today the Criollo sheep are a heterogeneous population containing some contribution of the Churro and Bordaleiro, African types, and fine wool and dual purpose sheep. Although the original introductions were wool sheep, the present population has a vestigial fleece (at least in Brazil) that generally is not shorn. Criollo types at higher elevations, such as the Andes in Guatemala, are shorn to produce a wool that may be sold or used in handicrafts.

Crioula sheep of tropical Northeast Brazil are fertile year round (Simplicio et al., 1980); they are not highly prolific and have a slow growth rate.

Tabasco or Pelibuey Sheep of Mexico

Tabasco or Pelibuey (oxen-hair) sheep, in the eastern coast and Yucatan areas of Mexico, supposedly were introduced from Cuba

in the 1930s or earlier. They have short fine hair, thin-tails, and short, semi-erect ears. Both sexes are polled. Colors include white, tan, red, and occasionally black. Color patterns include solid, spotted, dark tan bodies with lighter bellies, and light tan bodies with black bellies. Some individuals may have a small amount of wool.

Tabasco sheep are well-adapted to heat, humidity, and the relatively high seasonal rainfall of their tropical environment. The male and female measure approximately 66.3 and 64.2 cm in height at the withers and weigh 49 and 35 kg, respectively.

According to Zarazua and Padilha (1983), Pelibuey ewes exhibit estrus throughout the year but have a tendency toward diminished estrus activity between February and April. The ewe lamb exhibits estrus around 404.7 days or at a weight of 23.3 kg in traditional management systems. Fertility of 70.4%, prolificacy of 1.19, mean gestation period of 149.4 days, and average lambing interval of 9.8 months also were reported. Pre-weaning mortality of 11.2% was reported for Pelibuey sheep as compared to higher values for Barbados Blackbelly.

Pelibuey sheep had an average daily milk production of 630 g from ewes nursing twins and 560 g for ewes nursing singles. Birth weights were 2.62 and 2.47 kg for male and female, respectively (Zarazua and Padilha, 1983). The mean daily weight gain of lambs from birth to eight months of age was 106.6 g (Gonzales-Reyna et al., 1983).

Pelibuey Sheep of Cuba

According to Mason (1980b), these sheep apparently came from Africa to Cuba, but precisely when and from where is not known. It is estimated that about 75% of the sheep in Cuba are of the hairy breed originally called "Carnero de Pelo Buey" (i.e., ox-haired sheep) that has been shortened to "Pelibuey." Those sheep also are called Criollo, but they differ from the Criollo of the mainland of Latin America, which are wooled sheep descended from the Churro breed of Spain.

Pelibuey sheep have a variety of colors, including tan (or red), white, tan-and-white, black, etc. The first three colors are the most frequent. The Pelibuey sheep on state farms are either red or white. The red animals, believed to be physically stronger, are preferred. Also, the red color is dominant in the Pelibuey (but not in relation to the white of European breeds).

Barbados Blackbelly

The Barbados Blackbelly take their name from the island of Barbados in the Caribbean. From this location, they have been exported to many places in the region and to the United States.

The Barbados Blackbelly varies in color from light to dark reddish-brown (tan) with black underparts and black points on the face and legs. The animals are leaner, lighter muscled animals than would be desirable for a mutton type. The ears are of medium size and carried horizontally. It is a thin-tail type, normally polled, but scurs occasionally occur on the males and sometimes some individuals are horned. The Blackbelly sheep in the U.S.,

sometimes referred to as Barbado, are of the horned genotype, but only the males are horned; the females have knobs. The genes for horns have been transferred to these sheep from the Rambouillet or Mouflon (Shelton, 1983a).

The Blackbelly sheep are well-adapted to the semiarid tropical environment in which they have been raised for at least three centuries. They seem to tolerate moderate variations in environmental temperatures quite well and at times show some degree of physiological adaptation. They are not particularly well-adapted to periods of feed scarcity.

The ewes show good maternal behavior and normally make excellent mothers. Milk production is good, and they allegedly can rear up to three lambs if adequately fed (Rastogi et al., 1980). They also have been shown to have greater resistance to internal parasitism than traditional wool breeds.

One of the most outstanding characteristics of Blackbelly sheep is their high prolificacy: multiple births (twins and triplets) are common. Litters of five or more lambs occasionally have been recorded. Ewes bred from 1972 to 1977 at three places in Barbados produced 1,079 litters, with 2,194 lambs, at an average litter size of 2.03, and at an average lambing interval of 8.48 months. The birth types were divided in 26.8% single, 47.3% twins, 22.1% triplets, 3.4% quadruplets and 0.4% quintuplets (Rastogi et al., 1980).

Barbados ewes generally can be bred to lamb at one year of age if they are well grown out, but usually they lamb the first time at 14-15 months of age.

Apart from their high prolificacy, another important characteristic of these sheep (and of most tropical breeds) is their ability to breed throughout the year, or at least to have a relatively long breeding season. It is not always possible to distinguish between genetic and environmental (location) influences on the breeding season. In the U.S. (Texas), a flock was run continuously with rams and produced lambs at all months of the year, but fewer lambs were born from matings in February through April (Shelton et al., 1983a). In this respect, they were similar to the Rambouillet. To exploit the phenomenon of the year-long sexual season, breeders have attempted to breed their ewes so as to have three lamb crops every two years with an interval between parturitions of 8 months. However, provided the flock is maintained at a high plane of nutrition and level of management, it is possible to exceed three lamb crops in 2 years, though such an accelerated lambing rhythm cannot be maintained indefinitely because of its adverse effects on the general condition of the ewe and thus litter size and lamb viability.

As with any breed with high prolificacy, lamb mortality is a problem, and for this reason pure Blackbelly may not be suitable under some conditions. Mortality from birth to 6 months can reach as high as 34.5%, and is usually higher among the twins and triplets (32.4 and 36.7%, respectively) than among singles where it reaches 21.6% (Bodisco et al., 1973).

A number of experiments have been conducted with Blackbelly sheep in the United States in Texas (Shelton, 1983a,b), North

Carolina (Goode et al., 1983), Mississippi (Boyd, 1983) and California (Levine and Spurlock, 1983). The results showed that Blackbelly and Blackbelly x Dorset ewes had a better reproductive performance than Dorsets, Suffolks, Finnish Landrace x Dorset, and Finnish Landrace x Rambouillet. They also had more resistance to gastrointestinal parasites than Dorsets, Finnish Landrace x Dorset, and Finnish Landrace x Rambouillet.

Considering ewe reproduction, lamb growth and carcass characteristics, the Blackbelly x Dorset ewes in North Carolina were the most productive for an accelerated-lambing, terminal-cross program. As an average, this type of ewe weaned 6.4 lambs in a 3.5-year period, which suggests that such animals have good potential for intensive or accelerated lamb production.

On 275 lambings of 64 ewes, Levine and Spurlock (1983) reported age at first lambing of 370.4 days, litter size of 1.42 for first lambing and 1.93 for subsequent lambings, and lambing intervals of 222.6 days. Out of 262 lambings, 40% were in the winter, 23% in spring, and 19% each during summer and autumn.

According to Shelton (1983b), Blackbelly-sired lambs can be graded as choice market lambs for the U.S. market, but they require a longer feeding period. The most notable difference in carcass traits was a higher percentage of kidney or pelvic fat in the Blackbelly-sired lambs.

Hair Sheep of the Dominican Republic

According to Mason (1980b), there are about 52,000 sheep in the Dominican Republic and 90% of these are said to be hair sheep. There is a report of some Pelibuey sheep from Cuba coming to the Dominican Republic, but there must have been hair sheep on the island before that as the common sheep are hairy, smaller, and less uniform than the Pelibuey. They are lighter, shorter in the body, and longer in the leg. Their color varies from white to pale tan to dark red-brown. Their coat is less sleek than the Pelibuey, and they carry some wool on their backs. In fact, there are also wooled Criollo in the Dominican Republic, and the common sheep may be derived from crosses between those and hair sheep (Mason, 1980b).

Bahama Native

According to Demiruren (1980), the sheep population of the Bahamas is around 31,000. The hair sheep of the Bahamas are a thin-tailed, medium-sized mutton breed with a well-proportioned skeletal structure. The ewes are polled; the rams have horns. The body cover is a mixture of hair and kemp, and the fiber color is usually white with some brown and black spots. The thin tail is about 25 cm long. The legs are white with brown and black spots over the hoofs, while the face is white with black and brown spots. Ears are medium size. Rams have a Roman nose and powerful horns. The average body weight of mature ewes is 37 kg and mature rams weigh about 65 kg. The animals show distinct evidence of infusions of Wiltshire Horn breeding.

The experiments at the BARTAD station in North Andros Island and observations made on 298 lambings indicate that ewes gave birth to 1.4 lambs per lambing and weaned 1.2 lambs. The average birth

weight of the lambs was 3.3 kg, and they reached 25 kg in 90 days. The interval between lambing averaged 227 days (1.6 lamb crops per year) when the rams were run continuously with the ewes. Using those figures, it was estimated that the average ewe at the BARTAD station dropped 2.25 lambs and weaned 1.9 lambs per year (Demiruren, 1980).

The performance of native ewes and rams is equal to or better than the introduced Barbados Blackbelly, Florida Native, and Suffolk sheep.

Selection programs for these sheep should be aimed at improvement of ewe prolificacy and lamb growth rate from birth to weaning, without sacrificing the ewe lambing interval. This might be accomplished by using fast-growing twin-born ram lambs.

St. Croix of Virgin Islands and United States

The typical Virgin Islands sheep, sometimes called Virgin Islands White, is a white hair sheep, polled in both sexes. Occasionally, sheep are brown or brown with black belly, or a tricolor-brown and white with black belly. Some sheep have a small amount of wool on the back, and the males have a throat ruff and slightly convex facial profile. The tail hangs to the hocks, the ears are short and horizontal, and the eyelids are black. The general impression is of a sheep with a better mutton conformation (less rangy) than the Blackbelly. They measure around 63.5 cm in height at the withers; this is shorter than Barbados sheep. An adult male can weigh up to 90 kg (Hupp and Deller, 1983).

Ewes lamb the first time at approximately 14 months of age. In five flocks, the litter sizes were 1.4, 1.5, 1.0, 2.0, and 1.3 (Mason, 1980a). The adult males averaged 60-75 kg and females 40-55 kg. Eighteen percent of the births are singles, 50% twins, 21% triplets, and 5% quadruplets, giving a prolificacy rate of 213%.

In the United States, the breed has been studied in Utah, Ohio, Texas, Florida, and California (Foote, 1983). Fertility and prolificacy rates varied among locations and probably were influenced by lambing frequency. In Utah, prolificacy rates were 2.00 to 2.50 for ewes bred at one year and older; in Ohio, this rate ranged from 1.50 to 2.12 for ewes bred at these ages. Prolificacy rates were lowest in Florida (1.40 to 1.50), but this measurement included ewes of all ages. In Utah, prolificacy rates of lambs and yearlings were 1.60 and 1.75, respectively. In Florida, fertility rates were 77 to 90% within an annual lambing schedule (Foote, 1983).

Katahdin

According to Mason (1980a), the Katahdin breed was obtained from crossbreeding of various British breeds, such as Suffolk and Wiltshire Horn. Intense selection for growth rate, mutton conformation, and prolificacy, and against wool and horns produced the breed which was named after the highest mountain in Maine.

The Katahdin has a hairy coat with an undercoat of fine wool that it sheds in the spring. White is the most common color, but animals with color, particularly on the points, are common. Most

animals are polled. The tail is 20-25 cm long. The mature weight of rams is 68-90 kg; ewes weigh 55-73 kg.

Ewes can be bred to lamb as early as one year of age if well grown out. Prolificacy can be as high as 200% for well-fed adult ewes during good seasons. The average has been 168% for all ages and years. This is made up of 45% singles, 42.5% twins, and 12.5% triplets (including one quadruplet set). Milk yield is sufficient for ewes to feed twins or triplets. Lambs were weaned at 19.5 kg at 90 days of age. They exhibit a flocking instinct and allegedly show some resistance to internal and external parasites (Mason, 1980a). These animals are included in a discussion of tropically adapted animals because they do not produce wool. However, having been developed in a temperate region, this might be open to question. No data are available to the authors about Katahdin performance in tropical environments.

West African or Red African of Venezuela

African sheep can be classified into groups of various shades of red, tan, yellow, or white. In the colored types, the head and the belly usually are lighter than the rest of the body. These hair sheep sometimes show patches of wool. Adult males usually have a mane. The ears are carried horizontally, and generally the animals are polled. This type of sheep, with different names, also is found in other parts of Latin America (Stagnaro, 1983).

These sheep are produced in the semiarid tropics of Venezuela because of their apparent adaptability to a hot climate (either humid or arid), resistance to diseases, hardiness, and ability to withstand great seasonal variation and variation in forage quality. Other advantages are their precocity, fertility, maternal ability, and ability to breed throughout the year.

As Stagnaro (1983) reported, weights were as high as 40.7 kg for mature ewes and 57.0 kg for mature rams; height at wither of 65.2 and 69.9 cm, and heart girth of 82.8 and 92.4 cm were reported for females and males, respectively. The estrus cycle occurs on average intervals of 17.1 days and lasts for an average of 26.7 hours. In one study, puberty occurred at 286 days of age at 20.9 kg when the animals reached 61% of mature weight. The lambing interval, under a system of continuous exposure to males, averaged approximately 8 months.

Fertility percentage of 88.6, litter size of 1.14, interval from lambing to conception of 86.9 days, gestation length of 149.2 days for first lambing and 150.9 days for second and greater parities, and lambing interval of 235.9 days were reported (Stagnaro, 1983).

The mortality for lambs from birth to 8 months of age was 24.6% as an average of five flocks, or 21.5% for singles and 29.0% for multiples.

Weights of 2.36 and 2.32 kg at birth, and 15.3 and 13.2 kg at 120 days of age, were reported for male and female, respectively. In pastures, lambs were finished at 27.2 kg as compared to 31.8 kg and 28.8 kg for the semi-confined and confined, respectively. Average daily gains were found to be 77, 172, and 136 g/day for these same groups, respectively, while dressing percentages were

40.8, 43.2, and 47.2, respectively. Additional data were reported (Martinez, 1983) for other flocks in Venezuela with essentially the same pattern.

African Sheep in Colombia

The African sheep in Colombia are similar to the Pelibuey of Mexico. The yellow or sudan type varies in color from yellow to reddish brown (Otero and Cruz, 1980).

African sheep also are known as Pelona or Camura and have existed in Colombia for more than 300 years. Some of the outstanding features of this breed include adaptation to hot climates, hardiness, and meat quality. It generally is accepted that these sheep came from West Africa on slave ships. In Colombia, hair sheep usually are kept in small flocks of less than 50 animals that graze the less productive areas of farms. They receive little special care and obtain much of their feed from browse, shrubs, and by-products on the ranches.

Their gestation period is reported to be 151.7 days for single lambings with lambing intervals of 213.6 days (Pastrana et al., 1983). The animals weigh 2.5 kg at birth, 15 to 18 kg at weaning (4 months of age), 35 to 40 kg as a yearling, and 49.0 and 45.0 kg for male and female, fattened to 12 months of age, respectively. An adult male under well-fed conditions may weigh as much as 80.0 kg (Otero and Cruz, 1980). In another report, adult females and males weighed 36.7 and 48.7 kg and measured 78.0 and 84.0 cm of heart girth and 62.9 and 68.7 cm height at withers, respectively (Pastrana et al, 1983).

The average age at first lambing is 15-19 months. Fertility rates reach 98%, with a prolificacy rate of 1.34.

Hair Sheep of Brazil

Several distinct types of sheep exist in Northeast Brazil and each of these are described briefly.

The Morada Nova

This breed comes closest to being a native type unique to Brazil. Breed or record associations exist with the result that this animal fulfills most of the requirements of a true breed. These animals, found in superior flocks, are hair types with essentially no vestigial fleece. Their origin is a subject of controversy. The name Morada Nova derives from a city of the same name in the state of Ceará. Domingues (1954) first used this name after observing the sheep in this area. Some believe this breed evolved from Portuguese introductions, whereas we believe it carries, in addition, genes from hair sheep of African origin. The animals are small with the females weighing about 30 kg and measuring approximately 60 cm (Figueiredo, 1980) in height at maturity under field conditions. Males would be expected to be larger. Red to cream appears to be the preferred color, but white animals exist. The ears tend to be short and erect or semi-erect. Tails are of moderate or intermediate length, considerably shorter than traditional wool breeds. The hair coat is short and fine, producing a good quality skin. The strongest point about these animals is their adaptation to conditions of the Northeast. The

animals weigh around 2.4 kg at birth, 14.0 kg at weaning (112 days old) and 23.0 kg as yearlings (Figueiredo et al., 1982b; Fernandes, 1985; Figueiredo, 1986; Rajab, 1987). The mortality rates reach 29.0% (Rajab, 1987). Figueiredo (1986) reported prolificacy and preweaning survival rates of 1.32 and 73%, respectively. In respect to carcass traits, Figueiredo et al. (1982a) reported that Morada Nova lambs slaughtered at 213 days of age weighed 22.85 kg and yielded 10.98 kg of hot carcass weight.

Santa Inês

Another type of hair sheep in the Northeast is the Santa Inês, which also is recognized as a true breed. It is considered to come from crossing the Bergamacia with the Crioula and Morada Nova, followed by a period of selection and/or evolution for the absence of the fleece. The color may be red or white with various degrees of spotting between these colors. Black types also exist. The most obvious difference between these and the Morada Nova is their larger size, the Roman nose, and large pendulous ears. Both of these traits can be traced directly to the Bergamacia. The lambs weigh around 4.9 kg at birth, 23.0 kg at weaning at 112 days of age (Sousa, 1987), and 27.2 kg as yearlings (Rajab, 1987). Santa Inês sheep show a lower prolificacy rate than the Morada Nova. There are prolificacy reports of 1.25 (EMBRAPA, 1979), 1.26 (Sousa, 1987), and 1.31 (Rajab, 1987). Fertility reports are around 84% (Rajab, 1987).

Data on mortality show a 32% loss from birth to weaning (Sousa, 1987). Under field conditions, the ewes range between 40-50 kg, and the males, when well-fed, may reach as much as 100 kg. It seems a safe assumption that these animals are less well-adapted to the conditions of the Northeast than are the smaller Morada Nova or Crioula. This breed would come closer to serving the role of a sire breed for use in any type of stratified cross-breeding scheme than any other breed available in the region. However, because of the appeal of their larger size, producers show a preference for this breed, and it will in all likelihood grow in numbers at the expense of other breeds. Limited research does not necessarily support this as being desirable.

Somali Blackhead

The Somali Blackhead breed can be traced to the Blackhead Persian sheep imported to Brazil, some Caribbean Islands, and some parts of Colombia in an earlier period. The breed appears to be well-adapted to tropical environments.

In Brazil, this breed is sometimes called Somalis Brasileira and is recognized as an official breed by the Brazilian Sheep Breeders Association. It is a non-wool producing or hair sheep, which can be readily distinguished from the other Brazilian breeds previously discussed. The most distinguishing feature is their color, which consists of a white body with a black and sometimes red head and neck. A similar type of ewe can be found on a number of islands in the Caribbean, including Trinidad-Tobago and Curacao. Under well-fed conditions, the males especially have a distinct accumulation of fat in the rump area, but much less than that found with Blackhead Persian types from Africa. The Brazilian Somali are small. Available data imply they are smaller than the Morada Nova. Breed standards suggest that ewes weigh in the range of 30-40 kg,

but available data suggest values close to the lower end of the range. Simplício et al. (1982) reported an average weight of 25.8 kg at Sobral in the state of Ceará.

EMBRAPA (1979) reported rates of 89.5% for fertility and 10.5% for abortion. The maximum prolificacy observed was 1.39 (Rajab, 1987). The females reached puberty around 334 days of age (Simplício et al., 1982). The mortality rates, from birth to weaning, reported by Simplício et al. (1982) were 12.2% and 8% for Rajab (1987). These figures for mortality are generally lower than for other breeds.

The weights at birth, weaning, and one year of age seem to be lower than Morada Nova and Santa Inês. Rajab (1987) reported these respective weights to be 2.0, 13.2, and 19.4 kg.

Fertility data is limited, but the Somali Blackhead are not noted for a high lambing rate: they commonly produce singles, which paradoxically is sometimes cited as an advantage because of their higher survivability and thus reduced lactation stress in the ewes.

On a per head basis and under average conditions, these animals do not compare favorably with other types of hair sheep. However, there is good reason to hypothesize an advantage for them under more arid conditions such as the interior of Northeast Brazil. Performance data from one flock (Ribeiro et al., 1986) showed offtake values higher than many flocks in the region. There are no comparative data involving other breeds under these same conditions.

Rabo Largo

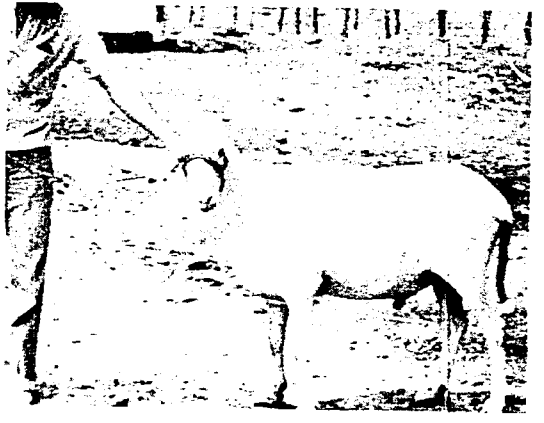
This fat-tail type of sheep is found in modest numbers in the interior of the state of Bahia. Fat-tail types are thought to have been introduced from South Africa in an earlier period (Mendonca, 1951). The fat-tail has been diluted by crossing to the Crioula with the result that only modest amounts of fat are found in most individuals. This type of animal, not an established breed, shows various degrees of crossing or blending with other breeds. They presently are restricted largely to the drier parts of the interior of the Northeast. Production parameters and the uniqueness of their adaptation to arid regions have not been established. Color is highly variable, with white and red or patches of both colors being common. The majority produce small amounts of coarse white wool. This may or may not be shorn.

Bergamacia

The Bergamacia, of Italian origin, was introduced into Brazil several decades ago. Animals are big, wooled with a minimal cover of coarse white wool, long and pendulous ears, Roman nose, and long legs. Under field conditions, the ewes tend to be a little bigger than Santa Inês, and the males, when well-fed, may weigh up to 120 kg. There are few pure flocks in the Northeast, and most represent a Brazilian type of a European breed. Not known for a high lambing rate, they are good milkers. The number of Bergamacia sheep in the area is small. The males have at times been used as sire breeds, thus reintroducing fleece cover. It is doubtful if these sheep should be used in pure form, but they have contributed positively to the Santa Inês.

Sheep Breeds of Brazil

Crioula



White Santa Inês

Morada Nova

Red or Mixed Color Santa Inês

The Brazilian Somali

Similar animals are found at other locations in the Caribbean. These animals appear to have an advantage in the more arid regions. These pictures show that these animals obviously trace to the Persian Blackhead. Note in the lower picture that some also segregate out with red heads.

Other Types of Hair Sheep

St. Croix White

This is a mature ram on the range in Texas, U.S.A., with yearling Rambouillet rams in the background.

African Red

This photograph was taken at the Blenheim Station on Tobago and shows an African Red in the foreground.

Potential Improver Breeds

The Blackbellied Barbados

These sheep are widespread in the Caribbean region. They generally have a higher lambing rate than other hair sheep, but may not be superior in other respects.

The Dorpor

This sheep is not presently found in Brazil or Central America. However, this breed or another similar type might serve a very useful role as a sire breed for use with hair sheep.

Literature Cited

Bodisco, V., C.M. Duque and A.S. Valles. 1973. Comportamiento productivo de ovinos tropicales en el periodo 1968-1972. Agrônomia Tropical, 23(6):517.

Boyd, L.H. 1983. Barbados Blackbelly sheep in Mississippi. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 299-304. Westerview Press. Boulder, Colorado.

Bradford, G.E. and H.A. Fitzhugh. 1983. Hair Sheep: A General Description. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 3-22. Westerview Press. Boulder, Colorado.

Demiruren, A.S. 1980. Bahama native. In: I.L. Mason (Ed.), *Prolific Tropical Sheep*. pp. 33-34. Food and Agriculture Organization of the United Nations. Rome.

Domingues, O. 1954. Sobre a origem do canneiro deslanado do nordeste. Publicação No. 3 da Seção de Fomento Agricola do Ceará. p. 28. Fortaleza, Ceará, Brazil.

EMBRAPA. 1979b. Relatório Técnico Anual do Centro Nacional de Pesquisa de Caprinos e Ovinos Tropicais. p. 54. Sobral, CE

FAO Monthly Bulletin of Statistics. 1985. 8(2):20.

Fernandes, A.A.O. 1985. Genetic and environmental factors affecting growth and reproduction characters of Morada Nova sheep on Northeastern Brazil. Texas A&M University, College Station, Texas. Master's Thesis.

Figueiredo, E.A.P. 1980. Morada Nova sheep in Brazil. In: *Prolific Tropical Sheep*. pp. 53-58. Food and Agriculture Organization of the United Nations. Rome.

Figueiredo, E.A.P. 1986. Potential breeding plans developed from observed genetic parameters and simulated genotypes for Morado Nova sheep in Northeast Brazil. Texas A&M University, College Station, Texas, Ph.D. Thesis.

Figueiredo, E.A.P., A.A. Simplicio, G.S. Riera and K.P. Pant. 1982a. Preliminary studies on the carcass characteristics of native breeds of woolless sheep in hot tropical semiarid Northeast Brazil. Pesq. Agrop. Bras. 17(6):951-960.

Figueiredo, E.A.P., A.A. Simplicio and K.P. Pant. 1982b. An evaluation of sheep breeds for early growth in the tropical Northeast Brazil. Trop. Anim. Hlth Prod. 14:219.

Foote, W.C. 1983. The St. Croix sheep in the United States. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 275-287. Westview Press. Boulder, Colorado.

Gonzales-Reyna, A., I. de Alba and W.C. Foote. 1983. Reproduction in Pelibuey Sheep. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for*

the Tropics. pp. 75-78. Westerview Press. Boulder, Colorado.

Goode, L., T.A. Yazwimski, D.J. Moncol, A.C. Linnerud, G.W. Morgan and D.F. Tugman. 1983. Research with Barbados Blackbelly sheep in North California. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 257-274. Westview Press. Boulder, Colorado.

Hupp, H. and D. Deller. 1983. Virgin Islands white hair sheep. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 171-175. Westview Press, Boulder, Colorado.

Levine, J.M. and G.M. Spurlock. 1983. Barbados Blackbelly sheep in California. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 305-311. Westview Press. Boulder, Colorado.

Martinez, A. 1983. Reproduction and growth of hair sheep in an experimental flock in Venezuela. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 105-117. Westview Press. Boulder, Colorado.

Mason, I.L. 1980a. White Virgin Island sheep. In: I.L. Mason (Ed.), *Prolific Tropical Sheep*. pp. 29-32. Food and Agriculture Organization of the United Nations. Rome.

Mason, I.L. 1980b. Hair sheep in the Dominican Republic. In: I.L. Mason (Ed.), *Prolific Tropical Sheep*. pp. 48. Food and Agriculture Organization of the United Nations. Rome.

Mendonca, A.S. 1951. O carneiro rabo largo a sua introdução na Bahia. Boletim No. 4, 6 pages. Published Secretária da Agricultura Industria e Comércio, Salvador, Bahia, Brasil.

Otero, R.B. and J.J.S. Cruz. 1980. African sheep in Colombia. In: I.L. Mason (Ed.), *Prolific Tropical Sheep*. pp. 48-52. FAO Animal Production and Health paper No. 17. Food and Agriculture Organization of the United Nations. Rome.

Pastrana, R.B., R.D. Camacho and G.E. Bradford. 1983. African sheep in Colombia. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep for Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 79-84. Westview Press. Boulder, Colorado.

Rajab, M.H. 1987. Simulation of genetic and environmental interaction of three tropical hair sheep breeds for meat production. Texas A&M University, College Station, Texas. Ph.D. Thesis.

Rastogi, R.K., H.E. Williams and F.G. Youssef. 1980. Barbados Blackbelly sheep. In: I.L. Mason (Ed.), *Prolific Tropical Sheep*. FAO Animal Production and Health paper no. 17. pp. 5-29. Food and Agriculture Organization of the United Nations. Rome.

Ribeiro da Silva, F.L., F.A. Melo Lima and J.M. Shelton. 1986. Desempenho produtivo e reprodutivo da raça Somalis. In: *Goats and Sheep in Northeast Brazil*. Proceedings of the First Workshop of the SR-CRSP. pp. 347-368. EMBRAPA/SR-CRSP, Sobral, Ceará.

Shelton, M. 1983a. The Barbado Blackbelly ("Barbado") breed in Texas. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 289-291. Westview Press. Boulder, Colorado.

Shelton, M. 1983b. Crossbreeding with the "Barbado" breed for market lamb and wool production in the United States. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 293-297. Westview Press. Boulder, Colorado.

Simplício, A.A., F.B.T. Pinto and J.F. Nunes. 1980. Comportamento produtivo de ovinos Sem Raça Definida (SRD) submetidos as manejo tradicional de criaçaõ. Anais XVII REUNIAÕ ANUAL DA SOCIEDADE BRASILEIRA DE ZOOTECNIA, Fortaleza, CE. p. 213.

Simplício, A.A., G.S. Riera, E.A.P. Figuieredo and J.F. Nunes. 1982. Desempenho produtivo de ovelhas da raça Somalis Brasileira no Nordeste do Brazil. Pesq. Agrop. Bras. 17(12):1795.

Sousa, W.H. 1987. Genetic and environmental factors affecting growth and reproductive performance of Santa Inês sheep in the semiarid region of Brazil. Texas A&M University, College Station, Texas. Master's Thesis.

Stagnaro, C.G. 1983. Commercial hair sheep production in a semiarid region of Venezuela. In: H.A. Fitzhugh and G.E. Bradford (Ed.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 85-104. Westview Press. Boulder, Colorado.

Vieira, G.V.N. and V.T. Santos. 1967. Criacao de Ovinos e Suas Enfermidades. 3rd ed. São Paulo, Melhoramentos.

Zarazua, M.V. and E.G. Padilla. 1983. Pelibuey sheep in Mexico. In: H.A. Fitzhugh and G.E. Bradford (Eds.), *Hair Sheep of Western Africa and the Americas. A Genetic Resource for the Tropics*. pp. 55-73. Westview Press. Boulder, Colorado.

Chapter 3

IMPROVEMENT PROGRAMS

E.A.P. Figueiredo and A.A.O. Fernandes

Sheep performance in tropical and subtropical regions of Latin America has been noted as poor (Winrock International Livestock Research and Training Center, 1977). From the animal standpoint, the main limiting factors are slow growth rate, poor reproductive performance, high mortality rate, and low carcass value. From the environmental standpoint, problems arise from ectoparasites and endoparasites, infectious diseases, climatic stress, and low quantity or quality of feed at intervals during the year.

There are important genetic differences among breeds in respect to resistance to diseases and parasites, temperature stress, digestive efficiency, maintenance requirements, growth rate, carcass value, and reproductive performance, etc. The animal breeder's task of improving sheep performance in the tropics resides mainly in identifying differences among and within breeds with respect to desirable aspects of adaptability and production, and in the proper use of such differences through appropriate mating systems (Madalena, 1977, 1981; Gregory et al. 1982) and selection programs. Alternative approaches, such as environmental modification, generally are costly (Frisch and Vercoe, 1978), in some cases relatively temporary; their implementation is largely a function of the prevailing economic climate. On the other hand, genetic improvement of productivity for a particular environment is long-lasting and may be cost-saving in the long run, although some minimum requirements in improvement of environment may be necessary (Gregory et al. 1982).

The type of animal needed in the tropics ideally should possess high efficiency of feed utilization, capability of heat loss, and ability to reduce heat production and allow productive processes to proceed at a normal level even at high air temperatures. Insulation against solar radiation, ability to withstand a high degree of dehydration, a rise in body temperature and some degree of resistance to common diseases and parasites also may come into play. In addition to the above demanding attributes, the genetic potential for growth, milk production (to the extent of doing an adequate job of rearing lambs), and reproductive efficiency must be present for the animal to produce efficiently.

Generally, three approaches are presented as alternative breeding programs for developing more productive animals in tropical areas: (1) selection within the native types (De Alba, 1978); (2) grading up with already improved types or breeds from other countries (Garcia et al. 1982a,b) and (3) development of new types from a crossbred foundation or animals that are graded up only partially to improved types. The choice of any one of the alternatives, according to Dickerson (1969), has to be made in the light of the production objectives and the availability of suitable genetic material to implement a given program. For example, sheep as a species produce meat, milk, fiber (wool and hair), skins,

Previous Page Blank

leisure (as a game animal or pet), and manure, but attempts are seldom made to exploit the same animal for all these purposes. The greater majority are exploited for at least two purposes, meat and fiber, while some of sheep are exploited for meat, milk, and fiber (arid regions of the Near East). Tropically adapted hair sheep may be an example of a sheep kept primarily for meat. The breeding of animals for multiple purposes complicates selection programs.

Selection Within Native Types

In general, native types show a high degree of adaptation to their home environments because of prolonged periods of natural selection for adaptation. Usually such animals possess limited genetic variability for various production parameters. This may result from inbreeding depression (Falconer, 1981) or from fixation of alleles responsible for fitness (Turner and Young, 1969). This may limit genetic response to selection. The generally low productivity suggests that the genes responsible for adaptation are not the same as those responsible for productivity. Crossbreeding systems often provide a better alternative for early improvement in productivity. Also, selection based on crossbred foundations may yield a better response than in those cases where selection is rendered ineffective because of exhaustion of additive genetic variability.

Despite the advantages of crossbreeding, selection within local types offers some advantages in specific cases (e.g., fiber production), where the current product type must not be changed, although quantity or quality can be improved (Turner, 1974). Also, suitable breeds for crossbreeding purposes may not be available. In addition, improvement programs within native types are important when they are used as a pure breed or crossed in crossbreeding systems.

There are essentially no reports of experiments on selection in tropical hair sheep.

One example of possible interest is the Somali Blackhead found in Northeast Brazil, some of the Caribbean Islands, Venezuela, Colombia, etc. Moreover, some specific flocks of other breeds are believed to have similar backgrounds. In Northeast Brazil, the Somali Blackhead sheep have been raised in closed flocks or a closed population for a long period of time mainly because of limited numbers and their clearly identified breed characteristics. The breeders wanted to maintain their stock pure. This has resulted in genetic uniformity and lowered reproductive efficiency. These are obvious signs of inbreeding depression. Low genetic variability and low selection intensity (because of low reproductive rate) results in small genetic gain through selection. In this case, there appears to be an obvious need to increase genetic variability by obtaining new genetic stock. This breed could be used beneficially in crossbreeding programs in the more extreme arid parts of Northeast Brazil.

A characteristic of breeding programs for tropically adapted sheep has been a lack of well-defined breeding objectives. The main constraints in this type of production are high lamb mortality, slow growth rate, and poor carcass value. Breeders generally select for growth, but they attempt to do this through

visual appraisal of size, color, and conformation. This way of estimating breeding value is poor as the environment plays a major role. What the breeder sees is often a result of good environmental conditions (nutrition and health) instead of genetic potential for growth. Furthermore, differences in age or type of birth can hide the positive genetic potentials of animals.

To practice selection, the breeders need pedigree records as well as date of birth information. In addition, they need weights (kg) and/or size (cm) to select for growth, litter size for the individual and/or of their female relatives in order to select for reproduction. To select for cutability, they need carcass measurements of the individual or of their relatives. This information is not obtained easily but as tropical sheep are exploited only for meat, it is important that reproduction, growth, and carcass value receive emphasis. It may be necessary to have institutions such as research or extension agencies participate in this effort.

If breeders have been able to record some of this information, they probably will be able to estimate some breeding values. As an example, consider selection for growth based on weaning weight. Within sex, stratify all animals by type of birth such as singles, twins, etc. Perhaps no advantage should be given for triplets or greater. Calculate the age at weaning for each animal. Derive additive factors for age correction by finding the average daily gain from birth to weaning for each animal and multiplying by the number of days the animal is younger or older than the average weaning age. If the animal is younger than the weaning age, add that amount to the weaning weight. Conversely, if the animal is older, subtract that amount from the weaning weight. When this is completed, a listing of age-adjusted weaning weights will be available for each sex and type of birth.

Breeding values may be calculated within type of birth or can be corrected for type of birth by adding a weight to the twins equivalent to the difference between singles and twins. Once these corrections have been made, the difference between each weight and the average multiplied by 0.35 (heritability of weaning weight as an average of estimates reported by Fernandes (1985) and Figueiredo (1986) for Morada Nova bred in Northeast Brazil) will provide an estimated breeding value for each animal. Choose the ones with higher breeding values to sire the next lamb crop.

In terms of sire selection, it is not difficult to find 4% of the best males. If it is desired to select for reproduction also, choose sires associated with multiple births. The emphasis to be placed on multiple births should vary with production conditions. Under adverse (arid) environments, less emphasis should be placed on multiple births. In terms of female selection, approximately 20 to 25% may be required for replacements. One approach is to select the best multiple-born ewe lambs if multiple births are considered desirable, and then complete the necessary number with the best singles.

This type of selection can be relatively easy for producers to use and is possible for most sheep breeds. More sophisticated methods of selection (such as a selection index) may require greater expertise or professional assistance.

Crossbreeding Systems

On a world basis, crossbreeding systems have been used extensively and successfully by the livestock industry to exploit heterosis (Willham, 1979), breed complementarily as in the use of dam and sire lines (Cartwright, 1970), and the general and specific combining ability (Henderson, 1952) resulting from crossbreeding. These multiple advantages and the marked gain realized from the use of crossbreeding suggests that this approach will continue to be important. Crossbreeding often is uniquely useful in adverse environments or where no well-adapted genotype exists.

One strength of crossbreeding systems is the utilization of genetic diversity among breeds. According to Dickerson (1969), the relative efficiency of crossbreeding as compared to purebreeding depends on several considerations: magnitude of breed differences in individual versus paternal performance of the straightbred; magnitude of crossbreeding heterosis for the individual, maternal, and paternal performance; loss in epistatic superiority of straightbreds because of the recombination of gametes produced by the crossbred parents; reproductive rate of the species; and importance of interactions of genetic components with management and/or marketing systems. It is the authors' thesis that where native, adapted but low-producing, types are available along with more productive exotics, crossbreeding offers the most immediate means of improving productivity.

Specific crossbred combinations make maximum use of breed differences in superiority as in male versus female parents. Thus, in two-breed crosses, one gains the full heterosis for individual performance and one-half of the pure breed difference in maternal performance. Essentially, maximum utilization of heterosis and of breed differences in maternal and paternal performance is obtained in the specific three-breed cross of a superior male breed with the F1 cross of two superior female breeds. The four-breed cross utilizes full heterosis in individual, paternal, and maternal performance, and any difference in breeding value for maternal performance between the two lines on the female side and those on the male side. However, there is twice as much opportunity for recombination effects in gametes producing the progeny.

Rotation crossbreeding requires only male replacements from purebred matings and uses a high proportion of maximum potential heterozygosis, with recombination effects kept relatively low because only female parents produce recombination gametes. There is the disadvantage, however, that the same average genotypes must be accepted for individual and maternal performance except for that controlled by the sex chromosome. Furthermore, there is less opportunity for adaptation to particular environments, as genotypes of progeny and of dams are determined half by the breed of sire used last.

Some of the advantages of specific and rotation crossbreeding can be combined by mating males from a superior sire breed to females produced through a rotation crossbreeding program designed to maximize maternal heterosis. Maternal heterosis can therefore be utilized with relatively little handicap from the recombination effects. Breed differences in both maternal and paternal performance thus can be used with a source of pure bred as the sole requirement.

No work has been reported on estimating heterosis in crosses of some of the tropical hair sheep breeds. For tropical meat production, crosses among the hair breeds seem well worth exploring (Turner, 1974).

The crossbreeding approach presents some problems in the tropics, such as that of finding parental breeds well-adapted to produce efficiently but sufficiently unrelated to produce significant heterosis when crossed (Frisch and Vercoe, 1982). It also is difficult to implement and conduct a systematic crossbreeding scheme under small holder conditions. Furthermore, the continued improvement of the crossbred animals relies on improvements of the parent breeds that may well not be a result of selection. As applied to tropically adapted hair sheep, there clearly is a problem of having a suitable sire breed to use in a terminal cross to produce market lambs. In the absence of a clearly superior sire breed, this step should be ignored. One candidate breed to be considered is the Santa Inês. Although no crossbreeding data are available involving this breed, its larger size almost certainly assures a faster growth rate for its offspring. The benefit of this cross would be obvious in the case of the Somali. Exploitation of such a cross will in many cases result in keeping female offspring and thus a breed shift.

Another option might be to use one or more of the sire breeds from temperate climates. However, sires of these breeds likely would not function satisfactorily under farm conditions, and exploitation of this cross would require artificial insemination. Keeping female offspring from these crosses would, in most cases, prove disastrous because of poor adaptability of exotic sire breeds. Thus, consideration of this option should be discouraged except under intense and isolated production schemes. Some specific breeds that might be considered for crossing are the Dorper and the Katahdin, but their use should first be tested under experimental conditions.

Development of New Breeds

Because a high percentage of tropically adapted sheep on a global basis are in flocks too small to use well-organized crossbreeding systems on a self-sustaining basis and because of the wide fluctuation in breed composition between generations, in rotational crossbreeding systems composite breeds represent good alternatives to continuous crossbreeding systems. With this approach, the goal should be to achieve and maintain the most optimum additive genetic composition aimed at combining general adaptability and performance characteristics of the genetic resources, with the existing production environment and market requirements. There is some loss of initial heterozygosity following crossing and subsequent inter se matings.

The loss of heterozygosity occurs between the F1 and F2. Retention of heterozygosity favors the inclusion of a large number of breeds in composite populations.

Synthetic populations, as they are called, offer much the same opportunity as rotation crossbreeding for retaining individual and maternal heterosis, plus some heterosis in male reproductive performance in commercial matings. Synthetics are subject to

maximum recombination effects, however, and do not permit use of different genotypes for male parents. The major advantage of composite breeds over rotational crossbreeding systems is the opportunity to achieve and maintain the most optimum contribution by each breed and to eliminate the need to maintain more than one breed or population. This advantage is particularly important for breeding sheep that have an optimum production response capability in tropical environments.

Another potential advantage of composite breeds relative to rotational crossbreeding systems in that the response to selection may be greater in composite populations than in contributing parental breeds. This is because of the increased genetic variation and greater selection intensity possible within composite breeds because of their higher reproduction rate as a result of heterosis (Dickerson, 1973). An important consideration in the development of a composite breed is to maintain population size large enough so that the initial advantage of increased heterozygosity is not dissipated by early reinbreeding.

In practical terms, Dickerson (1969) criticized the development of new breeds from crossbred foundations, but new breed development may be indicated, especially when there are new objectives or radically altered management conditions, and in areas where simplicity of the breeding program is essential.

It is apparent that the reproductive rate and the relative magnitude of heterosis, recombination effects and of breed differences in individual, maternal, and paternal performance determine the most advantageous method of utilizing genetic differences among breeds. When individual and maternal heterosis is large, there is a greater advantage in crossbreeding or in synthetic breeds over the pure breeds. When there are large differences in maternal or paternal performance or in adaptation to particular management systems, it is advantageous to use some type of specific cross rather than rotational crossbreeding or synthetics. If the potential recombination loss is important, crossbreeding has greater advantage over synthetics as a means of utilizing existing breed differences. Of course, the lower the reproductive rate, the greater are the costs for specific crossbreeding systems and the greater the advantage in rotational crossbreeding or synthetic breeds.

Grading Up to Improved Types

The validity of the "grading up" approach depends upon the definition of the term "improved types." If one envisioned the exotic types that are indeed more productive under the good feed conditions of temperate regions, then the term "improved" is probably not fitting under tropical conditions. Thus, grading up is not an appropriate approach although it is often practiced. If an improved breed is defined as one that has been developed and tested in the same or a similar environment, then it is indeed a fitting approach although it may require a long time to identify or develop such a breed. From a breeding standpoint, the grading up process is simple and direct and can be accomplished efficiently. The period of time required to reach a high grade status (three-fourths or higher) depends on the reproductive rate and the generation interval.

Although grading up can be accomplished efficiently, it has limited application in stressful environments, as highly productive and adaptive genotypes seldom exist in a single breed. It is seldom desirable to consider productive breeds from temperate regions as "target breeds" as they are poorly adapted to the stressful environment. Thus, instead of using the production characteristics of temperate zone breeds, one must make repeated crosses or establish an interbreeding population based on inter se matings. Thus, the term "grading up" is not totally fitting. If this is not a constraint, the level of purity or percentage of the improved breed desired or required depends somewhat on the product produced.

In the case of fiber, which has little relevance to the tropics, many generations are required to develop uniformly desirable fleeces. On the other hand, meat production from the second or third generation may approach that of the target breed. Milk production is somewhat intermediate in this respect.

Suggested Sheep Breeding Plans for Northeast Brazil

Observations, along with limited research (Arruda and Pant, 1984; Arruda et al., 1984), do not indicate a significant direct climate effect on the production of hair sheep in Northeast Brazil. For instance, reproduction has been indicated as one trait greatly affected by high temperature stress. Yet available data indicate that when adequate nutrition is provided, a satisfactory level of reproduction can be expected (Fernandes, 1985). At this time, it is not clear to what extent the indirect effects of climate on forage quality and forage intake limit performance. Also, the above statement relates to indigenous or native types and most likely would not equally apply to exotics. For a certainty, wool sheep introduced to Northeast Brazil would suffer directly from climatic stress.

Thus, with native types, selection for the desired production characteristics within prevailing production conditions would appear to be indicated. In selecting within exotic or crossbred populations, it may be desirable to include some measure or measures of climatic adaptation. The simplest of these would be respiratory rate at critical periods as an adjunct to survival and productivity. Some attention also might be given to the absence of wool cover and color. It appears preferable to avoid entirely white or black animals, and to prefer pigmented skin with light hair coat.

There are relatively few sheep breeds adapted to tropical environments, and it is difficult to envision good candidate breeds for introduction into these areas. The breeds or types available were discussed in the previous chapter.

The Somali Blackhead and, in the case of Brazil, the Rabo Largo, are no doubt the most hardy types in the region. Both types trace to types found in other parts of the world that are known for their hardiness. For instance, the Somali is obviously a derivative of the Blackhead Persian type, which is considered to be among the most hardy. The Rabo Largo traces to some type of "fat tail" sheep, many of which are known for hardiness and adaptation to arid or sparse feed conditions. It seems logical that these types should be maintained and emphasized in the more

arid regions of the interior of Northeast Brazil, but it may be questioned if both types need to be maintained as separate breeds. There is a real possibility that this type/breed will be lost or under-emphasized because of producer preference for size (Santa Inês) without considering the importance of other traits of these sheep.

Any animal must have some mechanism of adaptation to adverse environments such as high temperatures and feed scarcity. Fat-tail or fat-rump sheep as a group are uniquely adapted to intermittent periods of sparse feed. Two mechanisms bring this about: they are vigorous feeders or foragers (a high level of feed intake) when forage is available, and they also put on a large amount of body fat (Shelton et al., 1987). The fact that this fat is placed in the tail or on the rump appears to have some significance with regards to adaptation. Of the two locations, the depositions of rump fat would be preferable, because there would appear to be no interference with reproduction. These animals also need to utilize this fat efficiently to maintain themselves during sparse feed conditions. This type of animal would appear to have distinct advantages in the more arid regions of Northeast Brazil. However, animals of this type that have persisted in the tropics for extended periods of time have begun to lose the tendency for fat accumulation. At this time, it is not known if this is a genetic change, or if the tropical environment suppresses feed intake to the extent that limits fat accumulation. These types of animals normally have high fertility, low prolificacy, and good lamb survival, all of which could be construed as favorable in environments with sparse feed conditions.

These types, as found in Brazil, likely could be improved by the introduction of new gene sources of the Somali or Blackhead breeds to overcome genetic effects of inbreeding depression and degeneration because of neglect or natural selection under tropical conditions. The resulting genotype should be selected under prevailing conditions emphasizing ewe productivity, lamb survival, and growth rate of offspring. Commercial scale production from this type of animal would benefit markedly from crossbreeding to a sire breed, but it is difficult to implement this practice under small farmer conditions. There also is not a good sire breed currently in tropical areas.

The two breeds most distinctive and unique to Northeast Brazil are the Morada Nova and Santa Inês. The Morada Nova is perhaps the older, but they are not found in large numbers or are not identified as such in producer surveys. It is a quite prolific sheep (table 3.1) [Fernandes, 1985], generally smaller, but has a higher lambing rate than the Santa Inês (Rajab, 1987). It seems to be reasonably well-adapted to the region. These traits suggest the most obvious use of this breed would be as a dam breed under somewhat better feed conditions than those suggested for the Somali. By definition, a dam line would be exploited to best advantage in a crossbreeding system, and there are limitations to this [illegible] in the area in question. The writers encourage this app[illegible]ver, and the continued selection of the breed to serve [illegible]. Selection programs would emphasize those traits men[illegible] with general overall performance directed at impr[illegible] suitability as a dual purpose breed. Genetic para[illegible] (Fernandes, 1985; Figueiredo, 1986; Sousa, 1987, [illegible] selection within Morada Nova and Santa Inês

should be effective. Experience has shown that environmental conditions and animal performance place serious constraints on genetic progress.

Table 3.1. Reproductive performance of Santa Inês, Morada Nova, and Somali in Brazil (1980-1983).

Breed	Ewe Prolif.	Total Lamb weight Born (kg)	Total Lamb weight weaned (kg)	Ewe Lambing weight (kg)	Ref.
Somali	1.39	2.9	20.2	27.9	1
Santa Inês	1.31	4.0	26.9	39.9	1
Santa Inês	1.26	4.8	23.5	46.4	2
Morada Nova	1.82	3.4	22.8	30.6	1
Morada Nova	1.35	-	15.0	-	3

Reference: 1) Rajab (1987); 2) Sousa (1987); 3) Fernandes (1985)

Santa Inês is the larger breed developed by crossing the Crioula, the African sheep, and the Morada Nova with exotic types such as the Bergamacia. This breed is larger than the Morada Nova and with lower lambing rates, or at least a lower twinning rate [table 3.1] (Rajab, 1987; Sousa, 1987). Their relative position in respect to adaptation is not clear at present. This breed is increasing in numbers in Brazil and will likely continue to do so. The breed may best serve as a general purpose or a sire breed for use in crossing to the Crioula, Morada Nova, or Somali. Selection in this breed probably should emphasize survival, regularity of breeding, and growth rate. Tables 3.2 and 3.3 show some heritabilities for growth characteristics for some breeds in Latin America.

The Crioula (native or local), a mixed type of sheep, constitutes a large part of the population in the Northeast. It appears to represent a blend of all the breeds introduced to Brazil in modern times (Shelton and Figueiredo, 1981). Selection within the current population is largely nonexistent. The most likely change in this population will consist of the introduction and grading up to Santa Inês. At present, this appears to be a viable, and perhaps desirable, approach. The major question to be resolved is the degree to which these should be graded to or transformed into Santa Inês. It is important that they retain the ability to adapt to producer conditions, and it is likely that the Crioula is superior to Santa Inês in this respect.

In preceding paragraphs, mention was made of the use of a sire breed. None of the tropically adapted breeds currently in the Americas adequately serve this role. Likewise, breeds such as Suffolk, Hampshire, and Texel that serve this role in other regions do not seem to offer potential in this area. The alternatives that appear to offer potential are the Dorper or the Katahdin. The Santa Inês may be developed to serve this role. Sire breeds should

Table 3.2. Heritabilities ($h^2 \pm se$) and repeatabilities ($r \pm se$) for productive characters in Morada Nova (ref. 2, 3) and Santa Inês sheep (ref. 1).

Character	$h^2 \pm se$	$r \pm se$	Ref.
Birth weight	.06 ± .04	.23 ± .04	1
Birth weight	.35 ± .10		2
Birth weight	.20 ± .06	.39 ± .03	3
Weaning weight	.14 ± .14		1
Weaning weight	.33 ± .08	.45 ± .03	3
Weaning weight	.36 ± .11		2
Seven-month weight	.19 ± .09		3
Yearling weight	.30 ± .11	.36 ± .05	3
Yearling weight	.29 ± .12		2
Breeding weight	.52 ± .34	.51 ± .02	3
Lambing weight	.22 ± .31	.61 ± .02	3
Breeding weight		.09 ± .02	3
Lambing weight		.43 ± .03	3
Weaning weight		.38 ± .03	3
Total weight born		.24 ± .04	1
Total weight born		.37 ± .03	3
Total weight weaned		.42 ± .03	3
Incidence of caseous lymphadenitis	.43 ± .26	.22 ± .02	3
Color	.47 ± .25	.87 ± .00	3
Wattles	.41 ± .25	.85 ± .00	3
Prolificacy	.66 ± .30	.14 ± .02	3
Twinning rate		.43 ± .05	1

Reference: 1) Sousa (1987); 2) Fernandes (1985); 3) Figueiredo (1986).

Table 3.3. Heritability and standard error estimates for growth characters (Sousa, 1987).

Characters	$h^2 \pm se$
Birth weight	.06 ± .11
Weight at 28 days	.36 ± .21
Weaning weight[a]	.14 ± .14
Average daily gain[b]	.13 ± .14

[a] At 112 days of age.
[b] From birth to weaning.

be selected primarily for growth rate and carcass value. If they function truly as a sire breed, they may require only moderate adaptation. There is a danger in selecting Santa Inês for a sire breed while also expecting them to serve as a general purpose role. In theory, there is a need to decide which role this breed is to serve, but in reality no mechanism exists to exercise any control over the way a breed is used in farmer hands.

Literature Cited

Arruda, F.A.V., E.A.P. Figueiredo and K.P. Pant. 1984. Variacao da temperatura corporal de caprinos e ovinos sem la em Sobral. Pesq. agrop. bras. 19(7):916.

Arruda, F.A.V. and K.K. Pant. 1984. Tolerancia ao calor de caprinos e ovinos sem la em Sobral. Pesq. agrop. bras. 19(3):379.

Cartwright, T.C. 1970. Selection criteria for beef cattle for the future. J. Anim. Sci. 30:706.

De Alba, J. 1978. Progress in the selection of the Latin American dairy criollo. World Anim. Rev. 28:27.

Dickerson, G.E. 1969. Experimental approaches in utilizing breed resources. Anim. Breed. Abstr. 37:191.

Dickerson, G.E. 1973. Inbreeding and heterosis in animals. In: *Animal Breeding and Genetics Symposium in Honor of Dr. J.L. Lesh.* p. 54. Proceedings, ASAS/ADSA/APSA, Champaign, Il.

Falconer, D.S. 1981. *Introduction to quantitative genetics* (2nd ed.). Longman, London.

Fernandes, A.A.O. 1985. Genetic and environmental factors affecting growth and reproduction characters of Morada Nova sheep in Northeastern Brazil. Texas A&M University. College Station, TX. Master's Thesis.

Figueiredo, E.A.P. 1986. Potential breeding plans developed from observed genetic parameters and simulated genotypes for Morado Nova sheep in Northeast Brazil. Texas A&M University, College Station, TX. Ph.D. Thesis.

Frisch, J.E. and J.E. Vercoe. 1978. Utilizing breed differences in growth of cattle in the tropics. World Anim. Rev. 25:8.

Frisch, J.E. and J.E. Vercoe. 1982. Consideration of adaptive and productive components of productivity in breeding beef cattle for tropical Australia. In: *World Congress on Genetics Applied to Livestock, 2.* p. 307. Proceedings, Madrid.

Garcia, O., J. Bravo, B. Kennedy and E. Garcia. 1982b. Crossbreeding of imported and native goats in a dry tropical environment. II. Production and Reproduction. In: *Proc. Third International Conference on Goat Production and Disease.* p. 509. Tucson, AZ.

Garcia, O., E. Garcia, B. Kennedy and J. Bravo. 1982a. Crossbreeding of imported and native goats in dry tropical

environments. I. Survival and Growth of Kids. In: *Proc. Third International Conference on Goat Production and Disease*. p. 510. Tucson, AZ.

Gregory, K.E., J.C.M. Trail, R.M. Koch and L.V. Cundiff. 1982. Heterosis, crossbreeding and composite breed utilization in the tropics. In: *Proc. 2nd World Congress on Genetics Applied to Livestock Production*. p. 279. Madrid.

Henderson, C.R. 1952. Specific and general combining ability. In: Gowen, J.W. (ed). *Heterosis*. Iowa State Coll. Press, Ames, Iowa.

Madalena, F.E. 1977. Crossbreeding systems for beef production in Latin America. World Anim. Rev. 22:27.

Madalena, F.E. 1981. Crossbreeding strategies for dairy cattle in Brazil. World Anim. Rev. 38:23.

Rajab, M.H. Simulation of genetic and environmental interaction of three tropical hair sheep breeds for meat production. Texas A&M University, College Station, Tx., Ph.D. Thesis.

Shelton, M. and E.A.P. Figueiredo. 1981. Types of sheep and goats in Northeast Brazil. Inter. Goat and Sheep Research 1:156.

Shelton, M., R. Lewis and T. Willingham. 1987. Investigations relating to fat-tail sheep. SR-CRSP Tech. Report No. 91.

Sousa, W.H. 1987. Genetic and environmental factors affecting growth and reproductive performance of Santa Inês sheep in the semiarid region of Brazil. Texas A&M University, College Station, Tx., Master's Thesis.

Turner, H.N. 1974. Some aspects of sheep breeding in the tropics. World Anim. Rev. 10:31.

Turner, H.N. and S.S.Y. Young. 1969. *Quantitative Genetics in Sheep Breeding*. Cornell University Press, Ithaca, NY.

Willham, R.L. 1979. Genetic consequences of crossbreeding. J. Anim. Sci. 30:690.

Winrock International Livestock Research and Training Center. 1977. The role of sheep and goats in agricultural development. Winrock International, Morrilton, Arkansas.

Chapter 4

NUTRIENT REQUIREMENTS OF HAIR SHEEP IN TROPICAL AND SUBTROPICAL REGIONS

J.R. Kawas and J.E. Huston

Hair sheep comprise 7 to 10% of the world's 1.1 billion sheep (Bradford and Fitzhugh, 1983). Compared to wool sheep in temperate environments, hair sheep in tropical and subtropical environments are smaller (adult weight of about 20 to 40 kg for ewes and 30 to 60 kg for rams), slower growing, and earlier maturing. Hair and wool types are similar for most fertility traits, except that with adequate nutrition hair sheep are fertile throughout the year, whereas wool sheep show marked seasonal differences in fertility (Bradford and Fitzhugh, 1983).

Hair sheep have adapted to the extremely adverse conditions of tropical humid and semiarid environments. Feed composition and types of feed available influence dry matter intake and the production responses of sheep. Under-nutrition through restrictions in both the quantity and quality of nutrients may result from limited daytime grazing and overnight confinement, lack of supplemental feed, midday heat and solar radiation, seasonal variations in feed supplies, and deficiencies in energy, protein, and/or essential minerals and vitamins (Fitzhugh and Bradford, 1983; Kearl, 1982; McDowell et al., 1983). Low production and reproductive problems of ruminants grazing pastures with an abundant feed supply in tropical regions have been attributed to mineral imbalances in soils and forages (McDowell et al., 1983). Environmental factors such as disease, poor management, and climate may further compound these deficiencies.

Evidence presented here suggests that nutrient requirements of tropical hair sheep may differ from those of sheep in temperate regions because of differences in size, quantity and composition of gain, milk and wool production, reproduction capabilities, water requirements, grazing habits, and variations in feed intake and composition.

Size of Hair Sheep Breeds

Size of hair sheep has been reported mainly on a weight basis. Weight at birth ranged from as low as 1.8 kg for the West African dwarf sheep to as high as 3.3 kg for the Brazilian Santa Inês breed. Weaning weights of lambs of hair sheep breeds ranged from 8.1 to 16.9 kg for males and 7.1 to 13.9 kg for females (Fitzhugh and Bradford, 1983).

Adult weight of ewes of African hair sheep breeds ranges from a low of 20 kg for the West Africa Dwarf ewe to more than 35 kg for the Sahel type ewe. Approximate mature weight (kg) of ewes of American hair sheep breeds are: 40 (Barbados Blackbelly), 35 (Virgin Islands), 34 (Mexican and Cuban Peliguey), 27 (Black Head Persian or Brasilian Somali), 30 (Morada Nova), and 40 (Santa Inês) (Fitzhugh and Bradford, 1983).

Dry Matter Intake and Growth

Productivity of ruminants in tropical and subtropical regions is limited primarily by the high fiber, low soluble carbohydrate and protein content of tropical forages. Research in Australia (Minson and McLeod, 1970) and Brazil (Barros et al., 1986; Silva and Silva, 1976) has shown that the majority of tropical forages studied had apparent digestibility coefficients lower than those normally found with forages grown in temperate zones. Tropical and subtropical forages have a higher lignin and cell wall content that limits the intake of dry matter (DM) and digestible energy (DE) by ruminants.

The total DM intake by sheep feeding ad libitum is related to their energy needs and to the energy and protein concentrations in the diet. Intake of tropical forages tends to decrease as the fiber content increases. At low fiber levels, which is seldom the case in tropical forages, intake is regulated more by the animal's nutrient requirements than by fiber content of the diet. Pelleting of high fiber diets moderates the intake limiting aspect of fiber and allows atypical increases in DM intake (Kawas et al., 1986). The DE intake of green chopped Napier grass (Pennisetum purpureum) diets by Somali lambs (figure 4.1) ranged from a low of 130.1 Kcal/kg$^{.75}$ to a high of 189.2 kcal/kg$^{.75}$, increasing linearly with an increase in the energy density of the diet from 1.4 to 2.4 Mcal/kg DM (Barros et al., 1986). Dinius and Baumgardt (1970) reported that DE intake of pelleted diets by lambs increased from approximately 1 to 2.5 Mcal/kg DM and decreased linearly above 2.5 Mcal DE/kg DM as a metabolic response to the sheep's satiated energy requirements.

Sheep should consume approximately 50 g DM/kg$^{.75}$ to maintain their body weight (NRC, 1985). Oyenuga and Akinsoyinu (1976) reported that a mean daily DM intake of 58 g/kg$^{.734}$ resulted in a positive balance of major nutrients by West African dwarf sheep. Arruda et al. (1986) reported that Santa Inês lambs weighing approximately 18 kg required about 505 g DM/day or 56 g DM/day/kg$^{.75}$ for maintenance of energy balance.

Ad libitum dry matter intake of ram lambs (3-8 months) of various hair sheep breeds fed Napier grass (Pennisetum purpureum) or corn stover-based diets ranged from 85 to 115 g/kg$^{.75}$ (table 4.1). Weight gains ranged from approximately 44 to 232 g/day. However, ram lambs gained more weight (201 g/day) than did castrated male lambs (163 g/day) consuming the same diet at similar ad libitum intake rates (110 g DM/day/kg$^{.75}$). Gains of 260 g were reported for well-fed Virgin Island lambs in temperate conditions (Foote, 1983). However, postweaning daily gains of lambs grazing native tropical pastures rarely exceeded 100 g and often were as low as 50 g (Fitzhugh and Bradford, 1983).

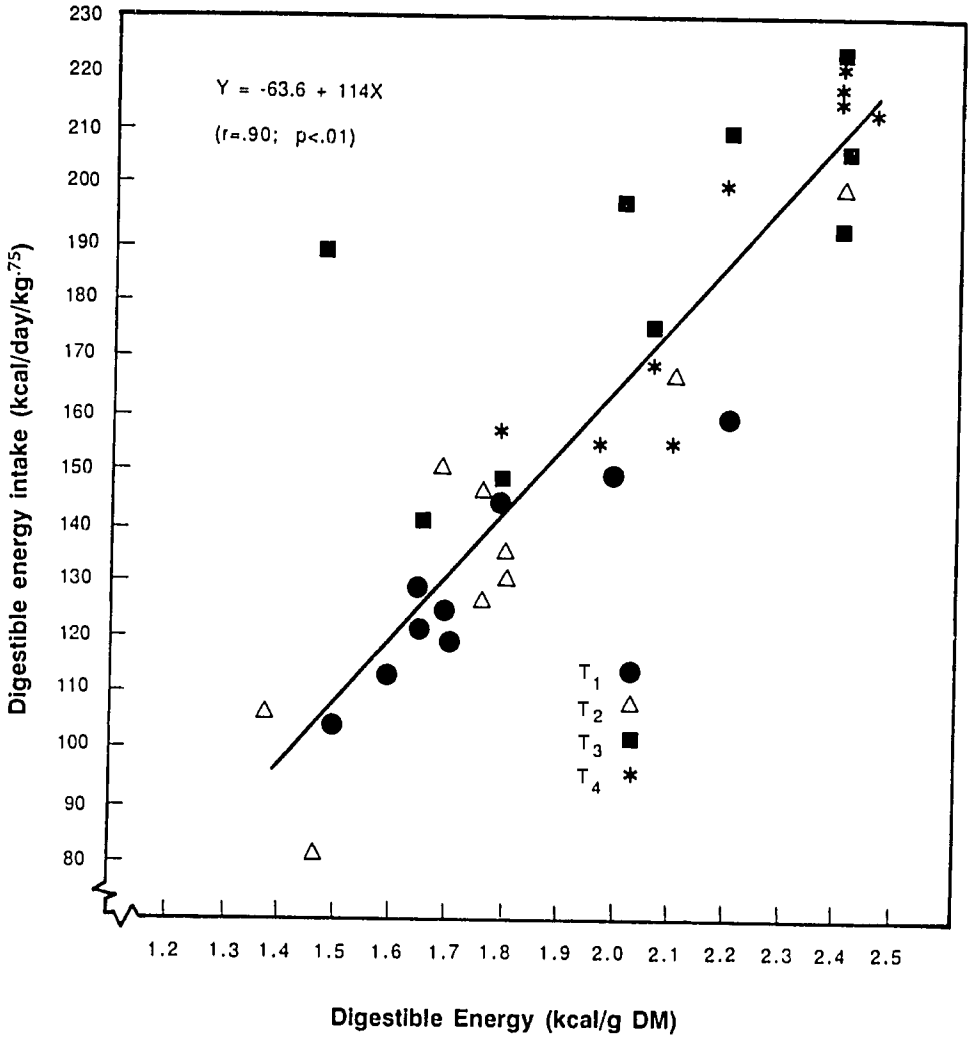


Figure 4.1. Relationship between energy density of the diet and energy intake by Somali sheep. Cassava meal supplementation level of 0.4, 0.8, 1.2, and 1.6% of body weight for T_1, T_2, T_3, and T_4, respectively.

(Source: Barros et al., 1988.)

Table 4.1. Dry matter intake and weight gain of ram lambs (3-8 months) of hair sheep breeds.[a]

Breed	N	Diet CP (%)	Dry Matter Intake g/day	Dry Matter Intake g/day/kg$^{.75}$	Weight gain (g/day)
Brazilian Somali[b]	36	9.2-10.2	812	91 (85-97)	66 (44-95)
Santa Inês & Morada Nova[c]	90	7.5-12.5	1078	106 (83-115)	128 (92-171)
Mexican Peliguey[d]	108	11.3-17.9	1232	105 (96-112)	159 (148-175)
Mexican Peliguey[d]	40	9.5-11.0	1499	110 (105-113)	201 (166-232)
Mexican Peliguey[d,e]	40	9.5-11.0	1498	110 (106-112)	163 (155-183)

[a]Approximate weight range of 15 to 35 kg.
[b]Napier grass-based diets (Barros et al., 1988).
[c]Corn stover-based diets (Kawas et al., 1986).
[d]Corn stover-based diets (Martinez-Avalos et al., 1985)
[e]Castrated lambs.

Pregnant ewes have been observed to consume voluntarily less feed than non-pregnant ewes, perhaps because of the displacement of gastrointestinal space by the gravid uterus (Rattray et al., 1973a). Others have observed an increase in voluntary intake at mid-pregnancy followed by a decrease during late pregnancy suggesting hormonal and/or other metabolic influences (Forbes, 1986). Oyenuga and Akinsoyinu (1976) reported a daily DM intake of 98 ± 3 and 72 ± 5 g/day/kg$^{.734}$ by West African dwarf ewes during their first 14 weeks of pregnancy and from their 15th week of pregnancy to lambing, respectively. Ninety-six pregnant Peliguey ewes grouped by mature weight into light (26.8 kg), medium (31.0 kg) and heavy (36.1 kg), voluntarily consumed an average of 1100 g DM/day or 78 ± 5 g/day/kg$^{.75}$ of four treatment diets with combinations of two levels of protein (9 and 11%) and two levels of energy (2.0 and 2.4 Mcal/kg DM) [Rodriguez-Garza and Bue-Herrera, 1986]. No differences because of mature weight, or energy and protein concentrations, were obtained when intake was expressed on a kg$^{.75}$ basis. Forbes (1986) further summarized research reports that describe increases in dry matter intake during lactation and attributes such increases to both physical enlargement of gastro-intestinal capacity and increased nutrient demands. Recommended daily dry matter intake levels published in NRC (1985) across all weight and levels of production are 63, 68, and 99 g/kg$^{.75}$ for dry, pregnant, and lactating ewes, respectively.

Nutrient Requirements

The National Research Council in its fifth publication on the nutrient requirements of sheep in temperate regions (NRC, 1975) differed from its previous one in that weight increments and gains were increased substantially and nutrient requirements adjusted

accordingly. Furthermore, the sixth edition (NRC, 1985) reports a substantial increase in the expected growth rate of light-weight finishing lambs from its previous published requirements (NRC, 1975). Dietary energy concentrations were increased for lambs of all weight gains considering their limited capacity for dry matter intake. In general, dietary concentrations of crude protein and other nutrients were also increased. Although dry matter intake of hair and wool sheep is similar on a metabolic size basis, hair sheep breeds are smaller and less productive in their own environment (Kearl, 1982; Oyenuga and Akinsoyinu, 1976).

Energy Requirement

Energy in feed is obtained by ruminants primarily from carbohydrates. Heat of combustion or gross energy of structural and non-structural carbohydrates is similar and is not a measure of the energy available to the animal. Gross energy content of feed does not consider energy losses incurred during digestion and metabolism. Ruminal and post-ruminal digestion unlocks energy from carbohydrates that becomes available for bacterial metabolism and growth, and for maintenance and productive processes of the animal.

Digestible energy (DE) is that fraction of the gross energy left after fecal energy (FE) is subtracted. Fecal energy losses increase with an increase in the structural carbohydrate (fiber) content of feedstuffs. The main pitfall of DE as a measure to express the energy value of feedstuffs for ruminants is that it over-evaluates high-fiber feedstuffs, such as hay or straw, in relation to low-fiber feedstuffs, such as grain (NRC, 1981b). Moreover, feed ingredients used in diets for ruminants vary widely in DE content.

Metabolizable energy (ME) is superior to DE for use as a measure to express the energy content of feedstuffs and energy requirements since it considers, in addition to fecal energy losses, losses of energy in the urine (UE) and gases of fermentation (GE). Energy losses in both UE and GE are approximately 18%, thus the conversion of DE to ME generally is estimated as DE X 0.82 (NRC, 1985). Estimation of ME using this formula may be accurate except for high grain rations where a greater ME concentration is obtained (Johnson, 1972). Net energy (NE) is the fraction of gross energy available to the animal for maintenance and productive processes and is obtained after subtracting the heat produced as a result of microbial fermentation in the digestive tract and during nutrient metabolism. This fraction of heat loss is known as heat increment. However, although NE is the most accurate measure of the caloric value of a feed for ruminants, DE and ME are terms more commonly used to express the energy content of feedstuffs and energy requirements of the animal.

Among the factors that affect the ME requirements of sheep, and that can be considered in tables of nutrient requirements are body size, age, pregnancy, lactation, and growth (NRC, 1981a; 1984; 1985). Other factors that affect energy requirements are muscle activity, environment, and its relationship with other nutrients such as protein content of the diet. Major sources of variation in the determination of the maintenance energy requirements include method of determination (respiration calorimetry vs. comparative slaughter technique) and the influences of nutritional,

environmental, and physiological factors on metabolic rate. Major sources of variation to consider in determining the growth energy requirements are gut fill and composition of gain.

Maintenance. The ME requirement for maintenance of growing sheep is the amount of dietary metabolizable energy resulting in zero change in body energy and zero weight gain (NRC, 1985). Energy maintenance occurs when daily ME intake equals daily heat production. The ARC (1980) uses fasting heat production from experiments conducted in respiratory calorimeters as a baseline for describing the maintenance energy requirement of the animal, whereas the NRC (1985) uses comparative slaughter techniques to estimate energy retention during a feeding trial. The difference between the two techniques may be because of systematic errors, probably in both techniques, that result in a slight under-estimation of energy conversion to animal tissue with the comparative slaughter technique and slight over-estimation of energy retention by respiration calorimetry (NRC, 1981b). For growing animals, an extrapolated fasting heat production using comparative slaughter data (Rattray et al., 1973b) is used by the NRC (1985) to estimate the maintenance requirements.

Several estimates of the daily ME maintenance requirements for growing sheep in tropical and subtropical environments have been reported: 73 (Barros et al., 1986), 88 (Benjamin et al., 1977), 73 kcal ME/kg$^{.75}$ (Wilke and Van der Merwe, 1976) and 100 kcal ME/kg$^{.734}$ (Oyenuga and Akinsoyinu, 1976). Other estimates with European sheep breeds were: 112 (Garrett et al., 1959), 120 (Rattray et al., 1973b), and 87.1 kcal ME/kg$^{.73}$ (Bull et al., 1970). The NRC (1975; 1985) publications used values of 119 kcal DE/kg$^{.75}$ and 98 kcal ME/kg$^{.75}$ to tabulate the maintenance energy requirements of sheep. Goats from temperate and cold regions may have up to 57% greater maintenance requirements than goats from tropical wet/dry regions because of lower metabolic rates of the latter (Silanikove, 1986). Lower metabolic rates also may help minimize the water requirements of desert animals.

The maintenance requirements of sheep on pasture or range may be twice as high as that of sheep fed under confinement conditions (NRC, 1975). Maintenance requirements of Awassi and German Mutton Merino sheep grazing a fenced dry annual pasture of Medicago polymorpha in Israel was estimated to be 155 kcal ME/day/kg$^{.75}$, compared to 88 kcal ME/day/kg$^{.75}$ for the same animals in confinement (Benjamin et al., 1977). Higher maintenance requirements (48-77%) of grazing sheep over confined sheep agree with results reported by Coop and Hill (1962a; 1962b). The tables of nutrient requirements of goats (NRC, 1981a) consider three levels of muscular activities needed depending on the availability of feed and water, the distance traveled, and the nature of the terrain to calculate the ME maintenance requirements under grazing conditions: (1) a 25% increment for light activity under grazing conditions of intensive management and under a tropical environment, (2) a 50% increment on semiarid rangeland pasture and slight hilly land, and (3) a 75% increment on sparsely vegetated grassland and on mountainous transhumance pasture.

Growth. Differences exist among breeds of sheep, where an animal of small mature size is fatter at any given body weight, has higher caloric values of weight gain, and slower weight gain for any given energy intake and energetic efficiency than an animal

of a large mature size (Searle and Graham, 1972). High wool producing sheep were larger and heavier than low producers and had greater fat-free body weights and had higher metabolic rates (Graham, 1968). Also, the metabolic rate of lambs, which have leaner bodies, was 80% higher than that of adult sheep (Graham, 1967).

Energy requirements for growth also are affected by gut fill; this may vary from 6 to 35% of live body weight (LBW) in milk-fed and forage-fed recently weaned lambs, respectively (NRC, 1985). Empty body weight (EBW) of Somali lambs fed Napier grass ad libitum and four levels of concentrate was accurately predicted ($r = 0.98$; $p < 0.01$) from LBW with the following equation: EBW (kg) = - 1.677 + 0.834 LBW (kg) (Barros et al., 1988). Gut fill varied from 23 to 30% of LBW with forage DM intakes that ranged from 55 to 68 g/kg$^{.75}$. When estimates of energy requirements for growth are determined on an empty body weight basis (EBW), extrapolation from EBW to LBW is necessary. To predict LBW gains, the NRC (1985) assumes a 9% higher value for LBW gains than for EBW gains to adjust for fill at a 30 kg EBW similar to ARC (1980).

Several estimates of the daily ME required for live weight gain of sheep in tropical environments have been reported: 0.90 kcal/g gain/kg$^{.75}$ (Barros et al., 1988) and 0.91 kcal/g gain/kg$^{.734}$ (Oyenuga and Akinsoyinu, 1976). Similar estimates have been obtained with goats: 0.88 kcal/g gain/kg$^{.75}$ (Itoh et al., 1979); 1.00 kcal/g gain/kg$^{.734}$ (Oyenuga and Akinsoyinu, 1976); and 1.09 kcal/g gain/kg$^{.75}$ (Lu et al., 1987). Preliminary results from a growth study (Kawas et al., unpublished data) with 90 lambs 4 to 7 months of age (table 4.2) suggest that the growth energy requirements of Santa Inês and Morada Nova hair sheep may be

Table 4.2. Daily digestible (DE) and metabolizable energy (ME) requirements for lambs of Santa Inês and Morada Nova breeds[a,b].

Item	Digestible energy, Mcal/kg DM		
	2.2	2.6	3.0
Average body weight, kg	21.4	22.6	22.2
Acid detergent fiber, %	39.2	34.7	27.0
Dry matter intake, g	1127	1116	991
DE intake, kcal[c]	2468	2872	2977
ME intake, kcal[c]	2011	2448	2595
DE for maintenance, kcal	1184	1234	1217
ME for maintenance, kcal	975	1016	1003
DE for gain, kcal	1284	1638	1760
ME for gain, kcal	1036	1432	1592
Body weight gain, g	108	140	140
DE rqmt, kcal/g of gain/kg$^{.75}$	1.20	1.13	1.23
ME rqmt, kcal/g of gain/kg$^{.75}$	0.96	0.99	1.11

a Values are means of 15 Morada Nova and 15 Santa Inês lambs consuming ad libitum diets containing 7.5, 10.0, and 12.5% crude protein.
b Digestion and metabolism data was obtained from a study involving all animals.
c Maintenance DE and ME requirements were calculated using mean values of 119 and 98 kcal/kg$^{.75}$, respectively (NRC, 1975; 1985).

Source: Kawas et al. (unpublished data).

approximately 1.02 + 0.08 kcal ME/g gain/$kg^{.75}$. The lambs were fed ad libitum pelleted diets containing approximately 2.2, 2.6, and 3.0 Mcal DE/kg DM.

Pregnancy and Lactation. Fetal growth, substantial in the last 6 weeks of pregnancy, contributes to the total requirements of the ewe. Low energy intake by the pregnant ewe can result in low birth weights with reduced viability in the lambs, and reduced reproductive rate and conception rates. An excessive energy intake enhances obesity of single-bearing ewes that are more prone to have birth difficulties (NRC, 1975).

The NRC (1975; 1985) considers an average increase in the total feed requirements of 1.2 and 1.7 times maintenance during pregnancy for single and twin pregnancies, respectively. Average litter size for hair sheep breeds reported by Fitzhugh and Bradford (1983) were Barbados Blackbelly, 1.84; Morada Nova, 1.76; Virgin Islands, 1.61; Brazilian Somali, Peliguey, Forest, Santa Inês, and West African, 1.24; and Blackhead Persian, 1.08.

The ME was utilized with lower efficiency for pregnancy (17.5% and 16.0% for diets containing 2.35 and 2.58 Mcal/kg DM, respectively) than for maintenance (64.9% and 63.0%) or gain (47.8% and 40.6%) [Rattray et al., 1973a]. However, the efficiency of ME utilization may vary with diets that differ markedly (NRC, 1985). The daily ME required for maintenance of pregnant West African dwarf ewes was 170 kcal/$kg^{.734}$ (Oyenuga and Akinsoyinu, 1976). This value is comparable to 152 and 187 (mean of 170) kcal ME/$kg^{.75}$ for ewes with a 130-150% and 180-225% expected lambing rate, respectively (NRC, 1985), and 177 kcal for goats (NRC, 1981a). Energy intake of ME by Peliguey ewes fed diets with combinations of two levels of protein (9 and 11%) and two levels of energy (2.0 and 2.4 Mcal/kg) ranged from 195 to 221 (mean of 206) kcal ME/$kg^{.75}$ (Rodriguez-Garza and Bue-Herrera, 1986). The increase in ME from 2.0 to 2.4 Mcal/kg increased the LBW gains of the ewes by 48%. These latter values are higher than other values reported elsewhere.

The energy requirements for pregnancy may be determined from the difference between the ME for non-pregnant ewes and ME for pregnant ewes. In Cyprus, the maintenance energy requirement for dry non-pregnant Chios ewes was estimated as 98 kcal/$kg^{.75}$ (Hadjipanayiotou, 1987). Moreover, the maintenance requirements of non-pregnant white-faced ewe lambs consuming diets with 2.58 and 2.35 Mcal ME/kg DM were 98 and 10[illegible] kcal ME/$kg^{.75}$ (Rattray et al., 1973a). These three values yield a mean of 100 kcal ME/$kg^{.75}$; this is comparable to values of 100 kcal ME/$kg^{.75}$ for sheep in temperate regions (NRC, 1985) and 101 kcal ME/$kg^{.75}$ for goats (NRC, 1981a). Considering the ME for maintenance of pregnant ewes of 170 kcal/$kg^{.75}$ and the ME for non-pregnant ewes of 100 kcal/$kg^{.75}$, the ME for pregnancy (MEp) would result in 70 kcal/$kg^{.75}$. An additional allowance of 20% of the ME for maintenance of pregnant does was included for multiple births by the NRC (1981a).

The energy requirements of lactating ewes are estimated as the sum of maintenance and milk production requirements. However, estimates of quantity and composition of milk of ewes are difficult to determine because of a relatively short lactation period and to the need to nurse their young (NRC, 1985). The efficiency of utilization of ME in feed for milk production was estimated to

range from 63 to 83% during a twelve-week lactation period (Gardner and Hogue, 1964). Energy requirements for lactation were 1246 kcal ME/kg of 4% fat-corrected milk (FCM) for goats (NRC, 1981a) and 1240 kcal/kg FCM for dairy cattle (NRC, 1978).

Few estimates of the milk yield of hair sheep breeds are available. Gonzalez-Reyna et al. (1983) reported that mean daily milk yield was higher ($P<.025$) for Peliguey ewes nursing twins (630g) than for ewes nursing singles (506g). West African dwarf ewes consuming 75, 100, and 125% of the ARC (1965) energy standards produced a mean daily milk yield of 321, 408, and 533 g/day (Oyenuga and Akinsoyinu, 1976). Oyenuga and Akinsoyinu (1976) recommended a mean daily intake of 194 kcal ME/kg$^{.75}$ for lactating ewes. Mean values obtained from the NRC (1985) were 240 and 274 kcal/kg$^{.75}$ for single and twin-bearing ewes, respectively.

Protein Requirements

Symptoms of deficiency of both protein and energy are similar and related in sheep (NRC, 1975). The primary sign of protein deficiency in ruminants is depressed appetite, which leads to a combined deficiency of energy and protein (NRC, 1975; 1978; 1981a; Kawas et al., 1986). Thus, previous publications on the nutrient requirements of sheep and goats considered a ratio of digestible protein (DP) (g/d) to DE (Mcal/d) of 20:1 for sheep (NRC, 1975) and 22:1 for goats (NRC, 1981a) in determining the protein maintenance requirements.

However, use of digestible protein to express requirements is not adequate as apparent digestibility of feed proteins varies widely and is related to the amount and the source of protein. Low quality roughage-based diets result in lower apparent digestibilities as metabolic fecal nitrogen represents a greater percentage of the total fecal nitrogen (NRC, 1975). Moreover, Kawas (1984) reported that dietary protein supply was extensively degraded in the rumen of sheep fed good quality alfalfa hay as the only forage, but degradation decreased with an advance in forage maturity. Bacterial nitrogen (N) as a percentage of the total non-ammonia N (NAN) flow to the duodenum decreased from 81% for a low fiber-prebloom alfalfa to 53% for a high fiber-mature alfalfa, whereas feed N, mostly associated with the plant cell walls, increased. Thus, the lower protein degradation and lack of energy of the low quality forage adversely affected microbial protein synthesis and reduced the nitrogen retention by sheep. The NRC publications for dairy (1978), beef cattle (1984) and sheep (1985) recognize the need to develop a more accurate system to express the protein requirements. However, researchers have not agreed, and these publications still use crude protein rather than digestible protein to express the protein requirements of ruminants.

Maintenance. The maintenance requirements for protein in the diet have been estimated based on methods such as (a) nitrogen balance and (b) factorial calculations. The rationale behind the first method is to determine directly the minimum amount of dietary protein needed to keep the animal in nitrogen equilibrium. Nitrogen equilibrium is defined as the state in which nitrogen intake matches nitrogen output. The nitrogen balance concept has been questioned (Lassiter and Edwards, 1982), as adult animals can adjust their nitrogen output and reach equilibrium at lower levels of nitrogen intake even though some part of the body may not be

supplied adequately with nitrogen. Earlier recommendations of the National Research Council for the maintenance protein requirements of dairy cattle (NRC, 1978) were based on nitrogen balance studies.

The factorial method of computing the total protein requirements was first adopted for ruminants by the British Agricultural Research Council (ARC, 1965). More recently, the National Research Council has used the factorial method to determine the protein requirements for beef cattle (NRC, 1984), dairy cattle (NRC, 1978), and sheep (NRC, 1985). The maintenance total protein requirements have been reported to be 4.72 $g/kg^{.75}$ for sheep (NRC, 1985) and 4.15 $g/kg^{.75}$ for goats (NRC, 1981a).

Growth. There is a positive relationship between energy intake and nitrogen balance in the ruminant (Brooster, 1973; Kawas et al., unpublished data). At low protein intake, protein was used with high and constant efficiency regardless of energy density. As protein intake increased, efficiency of utilization decreased at a given energy intake. However, protein utilization increased in response to additional energy intake. Moreover, additional protein at constant energy intake increased the body bone and protein conten while decreasing fat content. Increasing energy intake while keeping the protein intake constant increased fat deposition (Brooster, 1973).

Preliminary results of a growth trial with 90 Santa Inês and Morada Nova lambs (Kawas, unpublished data) suggest that the average crude protein growth requirements were 0.306, 0.474, and 0.701 g/g gain (table 4.3) for lambs fed ad libitum, pelleted diets containing approximately 7.5, 10.0, and 12.5% crude protein, respectively. The CP growth requirements were estimated as the difference between CP intake and the total maintenance requirement based on the value of 4.72 $g/kg^{.75}$ (NRC, 1985) and yielded a mean value of 0.494 g/g gain. Lu et al. (1987) reported CP growth requirements of 0.50, 0.62, and 0.82g CP/g gain in goat kids fed

Table 4.3. Daily crude protein (CP) requirements for lambs of Santa Inês and Morada Nova breeds[a,b].

Item	Crude Protein, % dry matter		
	7.5	10.0	12.5
Average body weight, kg	21.0	22.3	23.0
Dry matter intake, g	976	1085	1174
CP intake, g	77.5	114.7	151.9
CP for maintenance, g[c]	46.3	48.4	49.6
CP available for growth, g	31.2	66.3	102.3
Body weight gain, g	102	140	146
CP requirement, g/g of gain	0.306	0.474	0.701

a Values are means of 15 Morada Nova and 15 Santa Inês lambs consuming ad libitum diets containing 2.2, 2.6, and 3.0 Mcal/kg DM.
b Digestion and Metabolism data was obtained from a study involving all animals.
c Maintenance requirements were calculated using a mean value of 4.72 $g/kg^{.75}$ obtained factorially (NRC, 1985).

Source: Kawas et al. (unpublished data).

ad libitum 11, 13, and 15% CP, respectively, in the diet. For West African dwarf lambs, a value of 0.19g digestible protein (DP)/g gain/$kg^{.75}$ was recommended by Oyenuga and Akinsoyinu (1976). Assuming a CP digestibility of 68% (NRC, 1981a), the CP requirement would be 0.28 g/g gain/$kg^{.75}$. Most estimates for sheep are higher than the 0.284 g/g gain reported for goats by the NRC (1981a).

Pregnancy and Lactation. Only one estimate of the protein requirements for pregnancy and lactation for hair sheep of 10.5g DP/$kg^{.734}$ was found in the literature (Oyenuga and Akinsoyinu, 1976). Values of 4.79g DP or 6.97g CP were used to calculate the late pregnancy requirements of does (NRC, 1981a). Peliguey ewes fed diets with combinations of two levels of protein (9 and 11%) and two levels of energy (2.0 and 2.4 Mcal/kg) consumed an average of 9.38 g/$kg^{.75}$ during the last 10 weeks of pregnancy. Crude protein intake did not affect pregnancy weight gains of the ewes (Rodriguez-Garza and Bue-Herrera, 1986). A crude protein content of 47.875 g/kg of milk (ARC, 1980) was used to estimate the protein requirement for lactation.

Mineral and Vitamin Requirements

At least 15 mineral elements are nutritionally essential for sheep. Major mineral nutrients are calcium (Ca), phosphorus (P), sodium (Na), chlorine (Cl), magnesium (Mg), potassium (K) and sulfur (S). Minor or trace mineral nutrients are iodine (I), iron (Fe), molybdenum (Mo), copper (Cu), cobalt (Co), manganese (Mn), zinc (Zn), and selenium (Se). Various factors that affect the requirements of sheep for these minerals include type and level of production, age, level, and chemical form of minerals in feed ingredients, interrelationships with other nutrients, supplemental mineral intake, breed, and animal adaptation (McDowell et al., 1983; NRC, 1985).

Mineral deficiencies and imbalances have been reported from almost all tropical regions (McDowell et al., 1983). The mineral elements most likely to be lacking under tropical conditions are Ca, P, Na, Co, Cu, I, Se, and Zn. In some regions, under specific conditions, Mg, K, Fe, and Mn may be deficient and excesses of fluorine (F), Mo, and Se are extremely detrimental.

In tropical and subtropical regions most ruminants depend primarily on forage to satisfy mineral requirements. Concentrations of mineral elements in forages depend upon interactions among factors such as soil, plant species, stage of maturity, yield, pasture management, and climate (McDowell et al., 1983). Inadequate intake of forages by grazing ruminants that occurs as a result of a low protein content, increased lignification, and increased cell wall content may likely reduce the total minerals consumed. Moreover, abundance of forage supplying adequate quantities of energy and protein for ruminants grazing during the wet season in semiarid tropical regions of the world may favor rapid weight gains. Under these conditions, mineral requirements increase and deficiencies are more prevalent. In determining the requirements of mineral nutrients, availability to the animal should be considered. Perdomo et al. (1976) determined the availability of various mineral elements in four tropical grasses fed to West African x Barbados crossbred wethers. True absorptions were 71.7% for Ca, 32.9% for P, 90.6% for K, 76.8% for Na, 51.2% for Mg, 57.8% for Fe, 82.6% for Cu, and 64.5% for Zn.

Mineral requirements for sheep were reported by the NRC (1985). Requirements of major minerals (percentage of diet DM) are: Ca, 0.20-0.82; P, 0.16-0.38; Na, 0.09-0.18; Cl, unknown; Mg, 0.12-0.18; K, 0.50-0.80; and S, 0.14-0.26. Requirements of trace minerals (ppm or mg/kg of diet DM) are: I, 0.10-0.80; Fe, 30-50; Cu, 7-11; Mo, 0.5; Co, 0.1-0.2; Mn, 20-40; Zn, 20-33; Se, 0.1-0.2; and F, unknown. Tolerable levels for sheep of trace minerals (ppm or mg/kg of diet DM) are: I, 50; Fe, 500; Cu, 25; Mo, 10; Mn, 1000; Zn, 750; Se, 2; and F, 60-150.

Requirements of calcium and phosphorus have been estimated using a factorial method (NRC, 1985). Daily dietary requirements (percentage of diet) were calculated from net estimates for maintenance, growth, pregnancy, and lactation by dividing by the coefficient of absorption, and also by daily DM intakes. Absorption coefficients used by the NRC (1985) for estimating dietary Ca requirements were: maintenance, 0.4; gestation, 0.5; and lactation and growth, 0.6. For absorption of P, coefficients were: maintenance and first 15 weeks of gestation, 0.6; and last 4 weeks of gestation, lactation, and growth, 0.7. These coefficients may be higher than expected for sheep fed tropical forage-based diets. Although other factors may affect the requirements for gestation, only the size of the ewe at mating and the type of birth (single or twins) were considered in estimating the Ca and P requirements for gestation. Calcium and phosphorus contents of ewes' milk that were used to calculate the requirements for lactation were 0.18 and 0.14%, respectively.

Grazing ruminants in tropical and subtropical regions should consume adequate levels of vitamins to maintain health (NRC, 1981a). Of the fat-soluble vitamins, vitamin A is of concern especially if weathered hay is consumed as the only source of forage for prolonged periods of time. Vitamin A also may be deficient for sheep grazing a dry and weathered vegetation at the end of a prolonged dry season in the semiarid tropics. On the other hand, none of the water soluble vitamins are considered essential. The B vitamins normally are synthesized in enough quantities by microorganisms in the rumen. A vitamin B12 deficiency can develop under conditions of a low cobalt intake.

Nutritional Stress in Hot Environments

The hot regions of the world are in three principal categories: wet tropics, semiarid tropics, and deserts. The combination of uniformly warm environments and high humidities of the wet tropics and semiarid tropics does not favor animal production. Diwivedi (1976) observed that exotic breeds of sheep and their crosses with indigenous breeds of India had higher respiration rates during the hot and humid rainy season (29-32°C; 72% humidity) than during the hot dry season (30-37°C; 38% humidity).

Panting and evaporation from the respiratory tract is the most important mechanism for heat loss in sheep (Brockway et al., 1965). Respiratory rates may vary from rates of 20 per minute to more than 300 per minute under heat stress. High humidity and high ambient temperature further increase the respiratory rate, which is related both to the rise in humidity and to the rise in deep body temperature (Bligh, 1963). Sweating in sheep has some cooling

value under heat stress, especially in sheep with a hair coat. Hafez et al. (1956) reported that both between seasons and between days within seasons, body temperatures and respiration rates of tropical hair sheep were related positively to air temperature. Furthermore, a curvilinear regression of respiration rate on ambient temperature was reported for sheep in Australia (McFarlane et al. 1958).

As ambient temperature rises or as body heat production increases from increased metabolic activities, animals are able to adjust heat flow to prevent more than a slight or moderate rise in body temperature. Species adapted to high environmental heat loads will have a low insulation, well-developed evaporative capacity, and, in many cases, a lower basal metabolism. Cold-adapted species, on the other hand, tend to have greater insulation (Robertshaw, 1981). Body temperature of a shorn sheep (or sheep with a hair coat) increases more rapidly with increasing environmental temperature, but it also cools faster in the shade, wind, or with decreasing ambient temperature than for sheep with a wool coat. Shorn sheep have lower respiration rates in the shade and a higher critical temperature than those unshorn (NRC, 1985).

A high plane of nutrition tends to increase heat production in sheep and results in an increase in respiratory rate (table 4.4). Arruda et al. (1986) observed that Santa Inês lambs exposed to the sun during the dry season in Northeast Brazil could maintain body temperature by increasing their respiratory rate. Provision of shade did not have a significant effect on rectal temperature, but it did reduce significantly ($P<0.05$) the respiratory rate. This difference, however, was small (2.63 respirations per minute). Respiratory rates of lambs were higher in the afternoon than in the morning (61 vs. 36). Plane of nutrition significantly affected

Table 4.4. Means for the effects of various factors on rectal temperature (c) and respiratory rates (respirations/minute).

Variable	Rectal temp	Respiratory rate
Sun	39.45^{a}	50.37^{b}
Shade	39.40^{a}	47.00^{a}
Plane of nutrition		
High	39.63^{c}	53.35^{c}
Medium	$39.47^{b,c}$	$51.25^{b,c}$
Maintenance	$39.36^{a,b}$	$47.40^{a,b}$
Below maintenance	39.25^{a}	42.75^{a}
Time of day		
Morning	39.16^{a}	35.85^{a}
Afternoon	39.69^{b}	61.52^{b}

^{a,b,c} Means in the same column, not sharing a common superscript, differ ($P<.05$).
Source: Arruda et al. (1986).

both body temperature and respiratory rate, both values being increased with an increase in feed intake. Although significant, these differences tended to be of low magnitude and likely represent the increased heat of fermentation from digestion of the additional feed consumed. Nevertheless, heat stress during the humid wet season is expected to be greater than during the dry season. Lawson and Shelton (1983) reported respiratory rates between 100 and 200 for wool sheep exposed to direct sunlight.

Alterations in nutrient intake, digestibility, and requirements of ruminants can occur in hot and humid environments (NRC, 1981c). Feed intake and rumination may decline and water intake may increase under high environmental temperature (Terrill, 1968). Sheep exhibit their adaptability to marked changes in temperature by the natural tendency to increase feed intake under cold conditions and with a decrease in appetite under hot conditions. Depressed DM intake with elevated temperature and humidity is more severe for high-roughage rations as compared to low roughage diets. On the other hand, temperature and nutrient digestibility appear to be positively related. The effect of temperature on digestibility is greater for roughages than for concentrates (NRC, 1981c).

For adapted animals, maintenance energy expenditure decreases rectilinearly in association with increasing temperature. Adapted animals should have their requirements adjusted to allow for changes in basal metabolic rate and, possibly, for acute exposure for heat stress, whereas unadapted animals should have their requirements adjusted only for acute exposure (NRC, 1981c). Depending on the severity of acute heat stress, maintenance energy requirements should be adjusted accordingly. Severity may be detected by the respiration rate of the animal. For rapid shallow breathing, the maintenance energy requirement should be increased by 7%, whereas for deep open-mouth panting the requirement should be increased from 11 to 25% (NRC, 1981c; 1984).

Conclusions

Hair sheep in tropical and subtropical regions are smaller and less productive than wool sheep from temperate regions. Values for DM intake and requirements of energy, protein, calcium and phosphorus for hair sheep at various physiological and productive stages were estimated from the literature (tables 4.5 and 4.6).

Mean values of 53, 78, and 104 g/kg$^{.75}$ were used to calculate the DM intake for maintenance, pregnancy, and growth (lambs 3-8 months old), respectively. Metabolizable energy requirement for maintenance was 98 kcal/kg$^{.75}$ for sheep in confinement with some activity. The maintenance requirement of animals may increase up to 75% for sheep grazing mountainous or arid range. One kg of total digestible nutrients (TDN) was equivalent to 4.4 Mcal of DE. Digestible energy was estimated as ME/0.82. A mean value of 0.90 kcal/g of gain/kg$^{.75}$ was used to calculate the growth requirement of lambs. For maintenance of pregnant ewes, a mean value of 135, 170, and 205 kcal/kg$^{.75}$ was assigned for ewes with expected lambing rates of <125%, 125-175%, and >175%, respectively. The energy requirement for a lactating ewe was calculated assuming that a kg of 4% fat-corrected milk contains 1243 kcal ME and that milk yields of ewes with expected lambing rates of <125%, 125-175%, and >175% are 490, 560, and 630 g/day, respectively.

Protein requirements for maintenance were calculated using a value of 4.72 $g/kg^{.75}$. Growth requirements were estimated using a mean value of 0.494 g/g of gain/day. A value of 9.38 $g/kg^{.75}$ was used to determine the protein requirement during the last 8 weeks of pregnancy. A crude protein content of 47.875 g/kg of milk was used to estimate the protein requirement for lactation.

Absorption coefficients used for estimating dietary Ca requirements were: maintenance, 0.4; gestation, 0.5; and lactation and growth, 0.6. For absorption of P, coefficients were: maintenance and first 15 weeks of gestation, 0.6; and last 4 weeks of gestation, lactation, and growth, 0.7. These coefficients may be higher than expected for sheep fed tropical forage-based diets. The size of the ewe at mating and the type of birth (single or twins) were considered in estimating the Ca and P requirements for gestation. Calcium and phosphorus contents of ewes' milk that were used to calculate the requirements for lactation were 0.18% and 0.14%, respectively.

Table 4.5. Daily requirements of major nutrients for ewes of hair sheep breeds at various physiological stages.[a,b,c]

Body weight (kg)	Dry Matter Intake g	Dry Matter Intake % of BW	Total digestible nutrnts (kg)	Digestible energy (Mcal)	Metabolizable energy (Mcal)	Crude protein (g)	Calcium (%)	Phosphorus (%)
Maintenance								
20	530	2.5	0.26	1.13	0.93	45	1.1	1.1
25	630	2.4	0.30	1.34	1.10	53	1.3	1.3
30	720	2.3	0.35	1.54	1.26	61	1.4	1.4
35	810	2.2	0.39	1.72	1.41	68	1.6	1.6
40	890	2.1	0.43	1.90	1.56	75	1.8	1.8
45	970	2.0	0.47	2.07	1.70	82	1.9	1.9
Gestation - Last 6 weeks (single pregnancy or <125% lambing rate)								
20	740	3.7	0.39	1.71	1.40	68	2.2	1.6
25	870	3.5	0.46	2.10	1.65	80	2.6	1.9
30	1000	3.3	0.52	2.30	1.89	92	3.0	2.2
35	1120	3.2	0.59	2.59	2.12	102	3.4	2.5
40	1240	3.1	0.65	2.85	2.34	113	3.7	2.7
45	1350	3.0	0.71	3.11	2.55	123	4.1	3.0
Gestation - Last 6 weeks (125-175% expected lambing rate)								
20	740	3.7	0.45	1.99	1.63	79	2.6	1.7
25	870	3.5	0.53	2.34	1.92	93	3.0	2.0
30	1000	3.3	0.61	2.68	2.20	107	3.5	2.3
35	1120	3.2	0.68	3.01	2.47	119	3.9	2.6
40	1240	3.1	0.76	3.33	2.73	131	4.3	2.9
45	1350	3.0	0.82	3.62	2.97	144	4.7	3.1
Gestation - Last 6 weeks (>175% expected lambing rate or twin pregnancy)								
20	740	3.7	0.52	2.27	1.86	90	3.0	1.8
25	870	3.5	0.61	2.68	2.20	106	3.5	2.1
30	1000	3.3	0.70	3.07	2.52	122	4.0	2.4
35	1120	3.2	0.78	3.44	2.82	136	4.5	2.7
40	1240	3.1	0.86	3.80	3.12	150	5.0	3.0
45	1350	3.0	0.90	4.15	3.40	164	5.4	3.2
Lactation - First 8 weeks (single pregnancy or <125% lambing rate)								
20	900	4.5	0.65	2.85	2.34	163	2.9	2.3
25	1060	4.3	0.72	3.16	2.59	182	3.4	2.8
30	1220	4.1	0.79	3.46	2.83	200	3.9	3.2
35	1370	3.9	0.85	3.75	3.07	218	4.4	3.6
40	1510	3.8	0.91	4.02	3.30	235	4.8	3.9
45	1650	3.7	0.98	4.30	3.52	251	5.3	4.3
Lactation - First 8 weeks (125%-175% expected lambing rate)								
20	950	4.8	0.68	3.01	2.47	171	3.4	2.6
25	1120	4.5	0.76	3.32	2.72	190	4.0	3.1
30	1280	4.3	0.82	3.61	2.96	208	4.5	3.5
35	1440	4.1	0.87	3.81	3.20	226	5.1	4.0
40	1590	4.0	0.95	4.18	3.43	243	5.6	4.4
45	1740	3.9	1.01	4.46	3.65	259	6.8	4.8
Lactation - First 8 weeks (>175% expected lambing rate or twin pregnancy)								
20	1000	5.0	0.72	3.17	2.60	179	3.9	2.9
25	1180	4.7	0.79	3.48	2.85	198	4.6	3.4
30	1340	4.5	0.86	3.77	3.09	216	5.2	3.9
35	1510	4.3	0.92	4.07	3.33	234	5.9	4.4
40	1670	4.2	0.99	4.34	3.56	250	6.5	4.8
45	1830	4.1	1.05	4.62	3.78	267	7.1	5.3

[a] Vitamin A requirements can be calculated assuming a value of 85 IU/kg live weight per day for ewes in late gestation and during lactation (NRC, 1985).

[b] Maintenance nutrient requirements should be increased by 10% for first parturition ewe lambs.

[c] Under grazing conditions, add the following increments of maintenance energy for all physiological stages: 25% for light activity for grazing under intensive management and tropical pastures; 50% for semarid rangeland and hilly pastures; 75% for sparse desert vegetation or mountainous regions.

Table 4.6. Daily requirements of major nutrients for postweaning growth of lambs of hair sheep breed.

Body weight (kg)	Daily gain (g/day)					
	Main-tnce	50	100	150	200	250
Dry matter intake, kg						
10	0.31	0.48	0.51	0.53	0.56	0.59
15	0.42	0.53	0.69	0.72	0.76	0.80
20	0.52	0.80	0.85	0.90	0.95	0.99
25	0.61	0.95	1.01	1.06	1.12	1.16
30	0.71	1.09	1.15	1.22	1.28	1.35
35	0.79	1.22	1.30	1.37	1.44	1.50
Total digestible nutrients, kg[b]						
10	0.15	0.20	0.29	0.36	0.43	0.50
15	0.21	0.30	0.40	0.49	0.59	0.68
20	0.26	0.38	0.49	0.60	0.73	0.85
25	0.30	0.44	0.58	0.72	0.86	1.10
30	0.34	0.50	0.66	0.83	0.99	1.14
35	0.39	0.57	0.75	0.93	1.10	1.29
Digestible energy, Mcal[b]						
10	0.67	0.97	1.29	1.58	1.90	2.20
15	0.91	1.33	1.76	2.17	2.58	3.00
20	1.13	1.66	2.17	2.68	3.20	3.73
25	1.34	1.95	2.56	3.17	3.79	4.40
30	1.52	2.23	2.93	3.63	4.34	5.03
35	1.70	2.50	3.29	4.08	4.86	5.66
Metabolizable energy, Mcal[b]						
10	0.55	0.80	1.06	1.30	1.56	1.81
15	0.75	1.09	1.44	1.78	2.12	2.46
20	0.93	1.36	1.78	2.20	2.63	3.06
25	1.10	1.60	2.10	2.60	3.11	3.61
30	1.25	1.83	2.40	2.98	3.56	4.13
35	1.40	2.05	2.70	3.34	3.99	4.64
Crude protein, g						
10	27	52	76	101	126	151
15	36	61	85	110	135	160
20	45	70	94	119	144	169
25	53	78	102	127	152	177
30	61	86	110	135	160	185
35	68	93	117	142	167	192
Calcium, g[c]						
10	0.6	3.9	4.2	4.4	4.6	4.8
15	0.8	3.6	4.7	5.2	5.2	5.4
20	1.0	4.3	4.6	5.1	5.1	5.4
25	1.2	5.0	5.4	5.9	5.9	6.2
30	1.4	5.6	5.9	6.5	6.5	6.9
35	1.6	6.5	6.9	7.6	7.6	8.0

(continued on next page)

Table 4.6. **Daily requirements of major nutrients for postweaning growth of lambs of hair sheep breed (continued)**

Body weight (kg)	Daily gain (g/day)					
	Main-tnce	50	100	150	200	250
Phosphorus, g[c]						
10	0.6	1.8	1.9	2.0	2.1	2.2
15	0.8	1.6	2.1	2.2	2.4	2.5
20	1.0	1.9	2.0	2.2	2.3	2.4
25	1.2	2.3	2.4	2.5	2.7	2.8
30	1.4	2.6	2.8	2.9	3.1	3.2
35	1.6	3.2	3.4	3.6	3.7	3.9

[a] Vitamin A requirement can be calculated assuming a value of 47 IU/kg live weight per day (NRC, 1985).

[b] Under grazing conditions, add the following increments of maintenance energy for all weight gains: 25% for light activity for grazing under intensive management and tropical pastures; 50% for semiarid rangeland and hilly pastures; and 75% for sparse desert vegetation or mountainous regions.

[c] Calcium and phosphorus values were calculated using NRC (1985) data.

Literature Cited

Agricultural Research Council (ARC). 1965. *The Nutrient Requirements of Ruminant Livestock*. No. 2. Ruminants. London.

Agricultural Research Council (ARC). 1980. *The Nutrient Requirements of Ruminant Livestock*. No. 2. Ruminants. London.

Arruda, F.A.V., R. Bezerra, F.L. Ribeiro, J.W. dos Santos, J.R. Kawas and J.M. Shelton. 1986. The interaction of environmental variables (time of the day and shade vs. sun) and level of nutrition on animal response (body temperature, respiratory rate, water intake and weight gains) with hair sheep. In: *Proc. of the First Workshop of the Small Ruminant Collaborative Research Support Program*. pp. 259-65. University of California, Davis.

Barros, N.N., J.R. Kawas, L.C.L. Freire, J.A. Araújo Filho, J.M. Shelton and W.L. Johnson. 1986. Digestibility and intake of various native and introduced forages by goats and hair sheep in Northeast Brazil. In: *Goats and Sheep of Northeast Brazil. Proc. of the First Workshop of the Small Ruminant Collaborative Research Support Program*. pp. 219-26. University of California, Davis.

Barros, N.N., J.R. Kawas, W.L. Johnson and J.M. Shelton. 1988. Energy utilization by Somali lambs fed napiergrass *ad libitum* and an energy supplement at incremental levels. *Pesquisa Agropecuaria*

Brasileira. In Press.

Benjamin, R.W., M. Chen, A.A. Degen, N.A. Aziz and M.J. Al Hadad. 1977. Estimation of dry and organic matter intake of young sheep grazing a dry Mediterranean pasture and their maintenance requirements. J. Agric. Sci. (Camb.) 88:513.

Bligh, J. 1963. The receptors concerned in the respiratory response to humidity in sheep at high ambient temperature. J. Physiol. 168:747.

Bradford, G.E. and H.A. Fitzhugh. 1983. Hair sheep: A general description. In: H.A. Fitzhugh and G.E. Bradford (Ed.) *Hair Sheep of Western Africa and the Americas: A Genetic Resource for the Tropics*. Westview Press. Boulder, Colorado.

Brockway, J.M., J.D. McDonald and J.D. Pullar. 1965. Evaporative heat loss mechanisms in sheep. J. Physiol. 179:554.

Brooster, W.H. 1973. Protein-energy interrelationships in growth and lactation of cattle and sheep. Proc. Nutr. Soc. 32:115.

Bull, L.S., J.T. Reid and D.E. Johnson. 1970. Energetics of sheep concerned with the utilization of acetic acid. J. Nutrition 100:262.

Coop, I.E. and M.K. Hill. 1962a. The energy requirements of sheep for maintenance and gain. I. Pen fed sheep. J. Agric. Sci. 58:179.

----. 1962b. The energy requirements of sheep for maintenance and gain. II. Grazing sheep. J. Agric. Sci. 58:187.

Dinius, D.A. and R.R. Baumgardt. 1970. Regulation of food intake in ruminants. 6. Influence of caloric density of pelleted rations. J. Dairy Sci. 53:311.

Diwivedi, L.S.D. 1976. Studies of the adaptability of exotic breeds of sheep and their crosses with indigenous breeds. (1) Fluctuations in body temperature, pulse rate and respiration. Indian Vet. J. 53:938.

Fitzhugh, H.A. and G.E. Bradford. 1983. Productivity of hair sheep and opportunities for improvement. In: H.A. Fitzhugh and G.E. Bradford (Ed.) *Hair Sheep of Western Africa and the Americas: A Genetic Resource for the Tropics*. Westview Press. Boulder, Colorado.

Foote, W.C. 1983. The St. Croix sheep in the United States. In: H.A. Fitzhugh and G.E. Bradford (Ed.) *Hair Sheep of Western Africa and the Americas - A Genetic Resource for the Tropics*. Westview Press. Boulder, Colorado.

Forbes, J.M. 1986. The effects of sex hormones, pregnancy, and lactation on digestion, metabolism and voluntary intake. In: L.M. Milligan, W.L. Grovum and A. Dobson (Ed.) *Control of Digestion and Metabolism in Ruminants*. pp. 420-435. Prentice-Hall, Englewood Cliffs, New Jersey.

Gardner, R.W. and D.E. Hogue. 1964. Effects of energy intake and number of lambs suckled on milk yield, milk composition and

energetic efficiency of lactating ewes. J. Anim. Sci. 23:935.

Garrett, W.N., J.H. Meyer and G.P. Lofgren. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J. Anim. Sci. 18:528.

Gonzalez-Reyna, A., J. De Alba and W.C. Foote. 1983. Reproduction in Peliguey sheep. In: H.A. Fitzhugh and G.E. Bradford (Ed.) *Hair Sheep of Western Africa and the Americas: A Genetic Resource for the Tropics*. Westview Press. Boulder, Colorado.

Graham, N. McC. 1967. The metabolic rate of fasting sheep in relation to total and lean body weight, and the estimation of maintenance requirements. Aust. J. Agric. Res. 18:127.

----. 1968. The metabolic rate of merino rams bred for high and low wool production. Aust. J. Agric. Res. 19:821.

Hadjipanayiotou, M. 1987. Intensive feeding systems for goats in the Near East. Presented at the 4th Int. Conf. on Goats. Brasilia, Brazil.

Hafez, E.S.E., A.L. Badneldin and M.A. Sharafeldin. 1956. Heat tolerance studies of fat-tailed sheep in the subtropics. J. Agric. Sci. (Camb.) 47:280.

Itoh, M., T. Haryu, R. Tano and K. Iwasaki. 1979. Maintenance requirements of energy and protein for castrated Japanese native goats. Nutr. Abstr. Rev. 49(4):142.

Johnson, D.E. 1972. Heat increment of acetate and corn and effects of casein infusions with growing lambs. J. Nutri. 102:1093.

Kawas, J.R. 1984. Voluntary intake, retention time and changes in digesta composition in the gastrointestinal tract of sheep fed alfalfa hay of four stages of maturity. In: *Significance of Fiber Level on the Nutritive Value of Alfalfa Hay-based Diets for Ruminants*. University of Wisconsin, Madison. Ph.D. Thesis.

Kawas, J.R., W. Guimaraes, N.N. Barros, O. Sanchez, J.M. Shelton and W.L. Johnson. 1986. Interrelação energia-proteina no crescimento de ovinos deslanados. Anais da 23a Reunião Anual da Sociedade Brasileira de Zootecnia. Campo Grande, Mato Grosso, Brazil.

Kearl, L.C. 1982. Nutrient requirements of ruminants in developing countries. International Feedstuffs Institute. p. 381. Utah Agric. Exp. Sta. Utah State University, Logan.

Lassiter, J.W. and H.M. Edwards, Jr. 1982. *Animal Nutrition*. Resion Books, a Division of Simon and Schuster, Inglewood Cliffs, New Jersey.

Lawson, J.L. and M. Shelton. 1983. Comparative heat tolerance of several breeds of sheep and goats. Texas Agric. Exp. Sta. CPR 4171. pp. 26-29.

Lu, C.D., T. Sahlu and J.M. Fernandez. 1987. Assessment of energy and protein requirements for growth and lactation in goats. Presented at the 4th Int. Conf. on Goats. Brasilia, Brazil.

Martinez Avalos, A.M.M., J. Soriano Torres and A.S. Shimada. 1985. Crecimiento de borregos Peliguey alimentados con rastrojo de maiz tratado con amoniaco anhidro. Tec. Pec. Mex. 48:54.

McDowell, L.R., J.H. Conrad, G.L. Ellis and J.K. Loosli. 1983. Minerals for grazing ruminants in tropical regions. Department of Animal Science and Center for Tropical Agriculture, University of Florida, Gainesville and U.S. Agency for International Development.

McFarlane, W.V., R.J.H. Morris and B. Howard. 1958. Heat and water in tropical merino sheep. Aust. J. Agric. Res. 9:217.

Minson, D.H. and M.N. McLeod. 1970. The digestibility of temperate and tropical grasses. Int. Grassl. Congr. Australia. p. 72.

NRC. 1975. Nutrient Requirements of Sheep (5th Revised Ed.). National Academy Press, Washington, DC.

----. 1978. Nutrient Requirements of Dairy Cattle (5th Revised Ed.). National Academy Press, Washington, DC.

----. 1981a. Nutrient Requirements of Goats: Angora, Dairy and Meat Goats in Temperate and Tropical Countries (1st Ed.). National Academy Press, Washington, DC.

----. 1981b. Nutritional Energetics of Domestic Animals & Glossary of Energy Terms (2nd Revised Ed.). National Academy Press, Washington, DC.

----. 1981c. Effect of Environment on Nutrient Requirements of Domestic Animals. National Academy Press, Washington, DC.

----. 1984. Nutrient Requirements of Beef Cattle (6th Revised Ed.). National Academy Press, Washington, DC.

----. 1985. Nutrient Requirements of Sheep (6th Revised Ed.). National Academy Press, Washington, DC.

Oyenuga, V.A. and A.O. Akinsoyinu. 1976. Nutrient requirements of sheep and goats of tropical breeds. In: P. V. Fonnesbeck, L.E. Harris and L.C. Kearl (Ed.) *First International Symposium, Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*. p. 505. Utah Agric. Exp. Sta., Utah State University, Logan.

Perdomo, J.T., R.L. Shirley and C.F. Chicco. 1976. Availability of nutrient minerals in four tropical forages. In: P. V. Fonnesbeck, L.E. Harris and L.C. Kearl (Ed.) *First International Symposium, Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*. p. 505. Utah Agric. Exp. Sta., Utah State University, Logan.

Rattray, P.V., W.N. Garrett, N.E. East and N. Hinman. 1973a. Net energy requirements of ewe lambs for maintenance, gain and pregnancy and net energy values of feedstuffs for lambs. J. Anim. Sci. 37:853.

Rattray, P.V., W.N. Garrett, H.H. Meyer, G.E. Bradford, N. Hinman

and N.E. East. 1973b. Net energy requirements for growth of lambs age three to five months. J. Anim. Sci. 37:1386.

Robertshaw, D. 1981. The environmental physiology of animal production. In: J. A. Clark (Ed.) *Environmental Aspects of Housing for Animal Production*. Butterworths, London.

Rodriguez-Garza, F. and A. Bue-Herrera. 1986. Respuesta de la oveja Peliguey gestante en confinamiento a dos niveles de proteina y energia en la dieta. Tec. Pec. Mex. 51:96.

Searle, T.W. and N. McC. Graham. 1972. Growth in sheep. I. The chemical composition of the body. J. Agric. Sci. (Camb.) 79:371.

Silanikove, N. 1986. Interrelationship between feed quality, digestibility, feed consumption, and energy requirements in Desert (Bedouin) and temperate (Saanen) goats. J. Dairy Sci. 69:2157.

Silva, J.F.C. da and D.J. da Silva. 1976. Nutritive value of tropical forage in Brazil. In: P.V. Fonnesbeck, L.E. Harris and L.C. Kearl (Ed.) *First International Symposium, Feed Composition, Animal Nutrient Requirements, and Computerization of Diets*. p. 177. Utah Agric. Exp. Sta., Utah State University, Logan.

Terrill, C.E. 1968. Adaptation of sheep and goats. In: E.S.E. Hafez (Ed.) *Adaptation of Domestic Animals*. Lea & Lebiger, Philadelphia.

Wilke, P.I. and F.J. Van der Merwe. 1976. Net utilization of roughage and concentrate diets by sheep. Br. J. Nutr. 35:201.

Chapter 5

FORAGE RESOURCES IN NORTHEAST BRAZIL: Their Value and Management

E.R. Leite, J.A. Araujo Filho and R.C.M. Mesquita

Introduction

Caatinga is a term used to refer to the type of vegetation in Northeast Brazil. This vegetation covers about 803,000 km^2 of the region referred to as Northeast Brazil and constitutes about 10% of the total surface area of Brazil. Generally, the caatinga is composed of deciduous trees and shrubs, with an understory of annual grasses and forbs. More specifically, however, caatinga refers to a wide range of woody vegetation types that have not been completely classified, and species composition and densities vary greatly within small areas and from one district to the next (Bucher, 1982).

Phytomass production from native caatinga is composed mostly of leaves from tree and bush species. The woody species foliage and herb biomass production in caatinga averages about 4 tons/ha yearly (Araujo Filho, 1987). Depending on the site and on the prevailing climatic conditions, more than 84% of the total production may come from leaves of ligneous species (Kirmse, 1984). On the other hand, less than 10% of the total production is forage that is consumed readily by the animals.

This paper attempts to characterize the caatinga ecosystem, focusing on climate, soils, and vegetation. It is also our intention to discuss the influence of caatinga vegetation on diet selection by sheep, to describe methods of caatinga manipulation in order to increase forage production for sheep, and lastly to comment about introduced forages that can serve as sheep feed.

Characterization of the Caatinga Ecosystem

Climate

Northeast Brazil, the most eastern extension of the South American continent, lies between 3° and 18°S latitude and 35° to 46°W longitude (Freise, 1938). The climate is not typical of either an equatorial or subtropical region, being characterized by distinct wet and dry seasons. A four to six-month rainy season (December through May) is followed by a six to eight-month dry period, although periodic droughts may occur and extend the dry season to 11 or 12 months. Severe droughts or disastrous floods are common (Eiten and Goodland, 1979). These anomalies are the result of longitudinal position and proximity to a cold ocean current (Axelrod, 1979).

The caatinga occurs in a transition zone where both northern and southern hemisphere circulation patterns are influential, though neither dominates. Where the cold Benguela current rises off the coast of Northeast Brazil, a layer of cool air forms,

displacing warm, moist air masses and preventing rain. Cool air also stabilizes anticyclonic circulation patterns and weakens storm fronts, which further reduce precipitation (Axelrod, 1979).

Annual precipitation is highly variable, ranging from 150 to 1300 mm (Eiten and Goodland, 1979). The mean temperature in the caatinga region varies little during the year (23° to 28°C), with annual minimum and maximum temperatures of 8° and 40°C, respectively (Fundacao Instituto Brasileiro de Georgrafia e Estatistica, 1977).

Soils

Most of the soils in the caatinga are shallow, well-drained, low in organic matter, and relatively high in soluble bases (Valverde, 1969). These soils are fertile, but water storage capacity is limited. In the dry season, precipitation limits soil moisture, but in the rainy season rainfall frequently exceeds storage capacity and accelerated erosion and flooding occur. Soil losses also occur during the dry season because of wind erosion. Wind is particularly destructive during droughts or when the ground cover is sparse or disturbed (Christiansen-Weniger, 1977). Consequently, excessive erosion not only reduces water storage capacity of the soil, but in some cases its fertility as well.

The occurrence of eroded surfaces of various ages and origins helps to explain the diversity of the soils of Northeast Brazil. Weathering crystalline and sedimentary parent materials produce distinctly different soils.

Anfisols developed from crystalline rocks are the predominant soils of the region (Queirox, 1985). They are moderately shallow, neutral to weakly acid, have medium-to-high base saturation, and are characterized by clay accumulation in the B horizon.

Oxisols also are common. These old soils formed from sedimentary materials are distinguished by a medium texture and residual clay accumulations. Base saturation ranges from high levels to less-saturated, sandy, yellow latisols. Other soil types that may be locally important include lithosols, regosols, solonetz, alluvial, and colluvial deposits (Howell, 1981).

Vegetation

Literally, caatinga refers to light forest (Eyre, 1963), probably because during the dry season the herbaceous vegetation dies and the woody species loose their leaves. However, a more precise definition is: the vegetation formation of the semiarid (less than 1,000 mm/yr) interior of Northeast Brazil, dominated by deciduous or succulent woody species (Veloso and Strang, 1970). Subtypes occur within the caatinga, but it is distinct physiognomically and taxonomically from the forests or grasslands surrounding it.

Caatinga vegetation has been manipulated by man since the 17th century, including slash-and-burn agriculture, selective wood removal, clearing followed by burning, and simply clearing. All of these treatments are superimposed upon grazing by cattle, sheep, goats, and other domestic animals. Clearing and planting by hand-held tools have produced highly localized plant communities

dominated by shrubs and trees, which are extremely variable in physiognomy. Caatinga embraces a wide spectrum of vegetation subtypes that occur in the Northeast (Ferri, 1961).

Some authors (Lima, 1965; Veloso and Strang, 1970; Jacomine et al., 1973; Queiroz, 1985) have emphasized topographic and climatic variations in defining subdivisions within the caatinga, while others (Duque, 1973; Eiten and Goodland, 1979) consider physiognomic differences to be more important. Some subtypes have a tall (7-10 m) canopy that may consist of scattered trees, or have a closed canopy. These types are dominated by trees and shrubs or tall cacti. At the other extreme, some sites have only a few dwarf shrubs and cacti. Most areas support a mixture of woody plants of varying heights and densities. In some types, there is no understory, while others have a rich variety of grasses and forbs.

There are many plant species in the caatinga, but few are confined to a single subtype (Howell, 1981). Differences in the growth form, density, and distribution of the species within types may be more obvious than differences in species composition alone. A system that combines environmental, structural, and taxonomic indicators may be most useful.

Few caatinga species exhibit true xeromorphic features such as sunken stomates and waxy or pubescent leaves, but many show a variety of drought adaptations. Most woody species are deciduous, and evergreen species close their stomates during the dry season. Many species restrict mid-day stomate activity, even during the rainy season; this reduces water losses. Some genera typical of tropical regions use alternate metabolic pathways to fix CO_2 at night and limit daytime stomate activity (Walkins and Caldwell, 1970). It is possible that some caatinga species have this ability. Specialized leaves and thorns, a reduced leaf surface, and photosynthetic bark also minimize water loss.

Some plants store water in underground storage organs (Braga, 1960). Succulence is another way of storing water commonly seen in members of Cactaceae, Euphorbiaceae, and Bromeliaceae families.

The majority of the herbaceous species in the caatinga are composed of annual forbs. Some of the non-leguminous species encountered are *Hyptis spp.*, *Brinvillea spp.*, *Melanthera spp.*, *Ipomoea spp.*, *Bidens spp.*, *Oxalis spp.*, *Evolvulus spp.*, *Iris spp.*, *Alternanthera spp.*, and *Wissadula spp.* The principal annual and perennial legumes are *Centrosema spp.*, *Macroptilium spp.*, *Canavalia spp.*, *Arachis spp.*, and *Phaseolus spp.* The grasses are primarily annuals and predominate the genera *Brachia spp.*, *Digitaria spp.*, *Anthephora spp.*, *Chloris spp.*, *Echinochloa spp.*, *Setaria spp.*, *Aristida spp.*, and *Dactyloctenium spp.*

Although several woody species occur in the semiarid region of Northeast Brazil, only a few are considered because of their abundance or economic importance. They are Pau branco (*Auxemma oncocalyx*), jurema preta (*Mimosa acutistipula*), marmeleiro (*Croton hemiargyreus*), mofumbo (*Combretum leprosum*), sabia (*Mimosa caesalpiniaefolia*), catingueira (*Caesalpinia pyramidalis*), carnauba (*Copernicia cerifera*), pereiro (*Aspidosperma pyrifolium*), juazeiro (*Zizyphus joazeiro*), jucazeiro (*Caesalpinia ferrea*), canafistula (*Cassia excelsa*), Aroeira (*Astronium urundeuva*), and oiticica (*Licania rigida*).

Different combinations and structural arrangements of these species compose the major plant communities in caatinga vegetation. These plants may be associated with topo-edaphic conditions to form the numerous sites. If viewed in broad-terms, these plant communities appear to be related successionally.

Influence of Caatinga Vegetation on Diet Selection by Sheep

The morphological and botanical composition of vegetation can exert marked influence on diet selection by sheep. The factors influencing the choice of grazing site and the choice between alternative plants or plant parts within sites are complex and difficult to understand based on present knowledge. In Northeast Brazil and perhaps other tropical environments, nutrient intake is probably the major factor limiting production from grazing animals. Therefore, it is important to understand the factors influencing herbage intake, ingestive behavior, and forage selectivity in deciduous woodlands. In this section, attention is concentrated on results of research with sheep, such as (1) preference and selectivity, (2) choice in different canopy covers, and (3) nutrient content of the diet.

Preference and Selection According to Season

Although the literature on range science is replete with studies reporting detailed data on dietary selection by sheep, few investigations have been reported for sheep grazing caatinga vegetation.

Knowledge of the availability of forage in this type of vegetation is essential in order to understand the three seasons in the Sertao of Northeast Brazil: (1) the wet season (January to May), (2) the transition from wet to dry (July to August), and (3) the dry season (September to December). Works by Pfister (1983), Kirmse (1984), and Nascimento (1988) showed large seasonal variation in the diets of sheep (table 5.1), that normally depend upon available leaf litter during the dry season. In the dry season, leaf litter and some herbaceous understory form natural hay for grazing animals. Green tree foliage, fruits, and flowers are seasonally important in animal diets. Malecheck (1982) and Malecheck and Provenza (1983) have commented that, in Northeast Brazil, plant parts may be crucial to animal survival at times of nutritional stress. Therefore, fruits and flowers represent an important fraction (15%) of the diet (figure 5.1). During the wet season, the variety, quality and availability of forage are at maximum levels (Mesquita et al., 1986).

Seasonal Nutrition in the Diet

Research conducted at Centro Nacional de Pesquisa de Caprinos (CNPC) in Sobral, Ceará, Brazil (Phister, 1983; Kirmse, 1984; Mesquita, 1985; Oliveira et al, 1986) has shown that nutrient intake prevents improvement in animal production in this zone (table 5.2).

Dietary levels of crude protein (CP) approached or exceeded requirements for castrated male sheep during the entire year (table 5.3). However, the quality or digestibility of this protein is not known; there could be a deficiency of available protein. Neutral

Table 5.1. Mean botanical composition (% and standard deviation) of sheep diets during 10 sample periods, 1981 and 1982, in Northeastern Brazil.

	1981				
	May	June	July	August	September
Forbs					
Jitirana (*Ipomoea spp.*)	43.6 (9.8)	9.6 (6.7)	32.9 (11.1)	58.6 (9.4)	21.4 (4.5)
Paco-Paco (*Wissadula spp.*)	0.0	2.2 (5.9)	4.2 (3.9)	2.3 (3.6)	0.0
Bamburral branco (*Bainvillea spp.*)	0.0	0.0	0.4 (0.5)	2.8 (2.5)	1.1 (1.7)
Bamburral verdadeiro (*Hyptis spp.*)	1.8 (1.8)	0.3 (0.7)	0.0	0.3 (0.6)	1.4 (1.7)
Mariana (*Commelina spp.*)	18.1 (8.0)	18.0 (13.6)	0.4 (0.6)	0.8 (0.9)	0.0
Other forbs	8.8 (1.7)	8.8 (7.3)	0.1 (0.2)	7.0 (3.5)	2.3 (2.5)
Total forbs	72.3 (7.0)	38.9 (18.4)	38.0 (12.0)	71.8 (9.7)	26.2 (2.6)
Browse					
Mororó (*Bauhinia forficata*)	7.4 (4.2)	21.4 (11.6)	48.9 (12.6)	14.6 (6.9)	31.4 (5.9)
Sabiá (*Mimosa caesalpiniaefolia*)	8.6 (6.1)	10.3 (10.6)	5.1 (1.2)	3.7 (2.8)	8.0 (3.4)
Catingueira (*Caesalpinia pyramidalis*)	0.3 (0.7)	0.4 (0.8)	0.8 (0.9)	1.3 (1.1)	5.1 (1.9)
Marmeleiro (*Croton hermiargyreus*)	0.0	0.2 (0.7)	0.0	1.0 (1.4)	18.3 (5.3)
Mofumbo (*Combretum leprosum*)	0.1 (0.4)	0.2 (0.4)	0.3 (0.6)	0.1 (0.2)	1.4 (0.7)
Melosa (*Ruellia asperula*)	0.0	10.2 (9.1)	0.3 (0.4)	0.3 (0.5)	1.0 (0.5)
Pau branco (*Auxema oncocalix*)	0.4 (1.6)	0.0	0.2 (0.4)	0.1 (0.4)	1.5 (1.4)
Other browse	1.8 (2.3)	6.3 (2.1)	0.0	0.4 (0.5)	1.4 (1.7)
Total browse	19.7 (8.4)	49.0 (20.1)	55.6 (13.4)	21.5 (.2)	68.1 (4.9)
Total grass	8.1 (7.9)	10.2 (7.6)	2.1 (1.6)	3.6 (1.7)	1.9 (2.2)
Unidentifiable	1.1 (1.1)	1.7 (1.4)	4.3 (3.9)	3.2 (2.6)	4.8 (3.7)
Leafstem ratio	2.9	7.1	8.2	2.8	5.0

Table 5.1. Continued

	1982				
	May	June	July	August	September
Forbs					
Jitirana (*Ipomoea spp.*)	16.3 (10.2)	17.6 (5.49)	21.0 (10.9)	2.9 (3.0)	2.1 (2.3)
Paco-paco (*Wissadula spp.*)	0.0	0.0	0.5 (0.7)	0.1 (0.3)	10.5 (10.2)
Bamburral branco (*Bainvillea spp.*)	0.3 (0.5)	0.2 (0.3)	8.0 (5.6)	1.4 (1.7)	4.8 (4.8)
Bamburral verdadeiro (*Hyptis spp.*)	0.1 (0.2)	0.2 (0.3)	0.0	2.0 (4.2)	0.8 (1.2)
Mariana (*Commelina spp.*)	2.0 (1.7)	0.8 (1.4)	9.5 (5.5)	5.6 (6.2)	1.3 (1.2)
Other forbs	0.6 (0.6)	0.1 (0.2)	16.1 (8.7)	4.8 (3.2)	10.4 (3.9)
Total forbs	19.3 (10.8)	18.9 (6.2)	55.1 (5.6)	45.2 (21.7)	29.9 (8.7)
Browse					
Mororó (*Bauhinia forficata*)	3.0 (2.1)	5.8 (2.8)	4.0 (2.6)	0.1 (0.3)	2.1 (4.1)
Sabiá (*Mimosa caesalpiniaefolia*)	12.0 (5.9)	7.5 (2.3)	1.0 (1.0)	0.5 (1.1)	1.0 (1.3)
Catingueira (*Caesalpinia pyramidalis*)	27.8 (14.3)	38.1 (7.6)	0.6 (1.0)	0.0	0.0
Marmeleiro (*Croton hermiagryreus*)	3.8 (3.2)	7.8 (3.6)	0.0	0.0	0.0
Mofumbo (*Combretum leprosum*)	0.6 (1.6)	0.6 (1.0)	0.0	0.0	1.4 (1.7)
Melosa (*Ruella asperula*)	3.0 (7.7)	1.4 (1.2)	1.4 (2.2)	1.1 (1.8)	44.1 (8.1)
Pau branco (*Auxema oncocalix*)	1.0 (1.4)	0.1 (0.3)	0.0	0.1 (0.3)	1.8 (1.8)
Other browse	1.2 (1.3)	3.7 (2.1)	3.4 (3.8)	0.3 (0.4)	7.1 (4.6)
Total browse	52.3 (14.9)	65.0 (7.3)	10.4 (4.6)	2.1 (2.0)	57.5 (8.9)
Total grass	13.0 (11.4)	7.1 (3.8)	33.4 (6.7)	51.9 (23.4)	11.1 (9.6)
Unidentifiable	14.5 (5.8)	9.0 (3.5)	0.9 (1.5)	0.9 (0.8)	1.6 (1.1)
Leafstem ratio	2.4	3.1	2.9	5.5	2.7

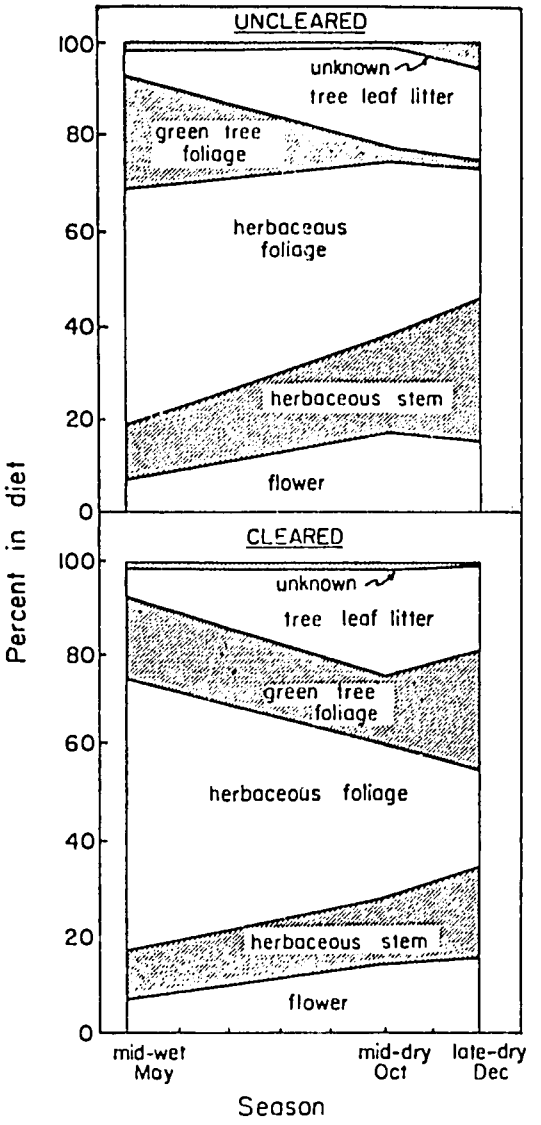


Figure 5.1. Plant parts in the diets of goats and sheep grazing on cleared and uncleared caatinga.

Source: Kirmse, 1984.

Table 5.2. Dietary chemical composition, in vitro digestibility (IVOMD), and daily forage intake for sheep grazing in deciduous woodland.

Collection periods	Crude Protein[a] %	NDF %	Lignin %	IVOMD[b] %	Forage organic matter intake[c] %
May	18.0[d]	-	-	-	-
June	17.3[d]	-	-	-	-
July	12.3[d]	40.9	12.2[d]	51.6	2.8
August	13.4[d]	50.3	9.9[d]	52.3	2.8
Sept.	12.8[d]	49.5	13.6[d]	40.9	1.6
October	13.3[d]	51.0	12.2[d]	48.3	2.5
December	12.2[d]	49.8	11.7[d]	49.7	2.1
January	23.6[d]	34.8	6.7[d]	68.5	2.6
February	16.8[d]	37.2	4.9[d]	67.0	2.2
April	17.1[d]	37.3	9.1[d]	60.6	1.2

[a] Percent of dry matter
[b] Percent of organic matter
[c] Percent of body weight.
[d] Values in the same row and treatment comparison with different superscripts differ (P < .05).

Source: Pfister, 1983.

Table 5.3. Daily forage and digestible energy intake (means S.E.) for sheep grazing caatinga vegetation in Northeast Brazil.

	% BW	g	kcal	kcal/kg/BW
July	2.8 ± .07	726.7 ± 38.8	1793.2 ± 108.7	68.1 ± 3.6
Aug.	2.8 ± .07	740.1 ± 23.8	1715.5 ± 60.0	64.5 ± 1.7
Sept.	1.6 ± .07	436.1 ± 13.7	965.7 ± 33.5	34.8 ± 1.4
Oct.	2.5 ± .08	689.9 ± 14.9	------[b]	------[b]
Dec.	2.1 ± .08	577.1 ± 20.0	1367.9 ± 51.2	50.9 ± 2.3
Jan.	2.6 ± .08	656.9 ± 22.8	2520.3 ± 79.7	99.6 ± 3.8
Feb.	2.2 ± .08	654.3 ± 18.2	2203.6 ± 64.1	73.0 ± 2.7
Apr.	1.2 ± .08	412.4 ± 7.3	1134.9 ± 22.7	33.7 ± .09

[a] Percent of body weight
[b] October values not available.

Source: Pfister, 1983.

detergent fiber (ND) contents of sheep diets showed that a peak occurred during the late dry season (September through December), reaching as high as 30%. As with CP, ND levels during the dry season generally reflected consumption of leaf litter and cured herbaceous material. Sheep selected large amounts of grasses, but these dietary ingredients were not reflected in the total fiber level, even though grasses generally contain much higher ND levels than do browse leaves. Lignin levels were highest during the late dry season.

In vitro, organic matter digestibility (IVOMD) appeared to be relatively high during the dry season; it ranged from about 41% to 50% in the dry season compared to values of 60.6% to 68.5% in the wet season. Digestibility was correlated negatively to lignin content. The presence of secondary polyphenolic compounds in the browse species may have affected IVOMD as well as other diet quality estimates.

Forage intake values were high (2.8% of body weight) during the dry season (July and August). During the wet season (April) they fell to 1.2% of body weight (BW) [table 5.3]. The lowest levels of voluntary intake were observed in April, near the peak of available forage biomass during the wet season. At this time, it was observed that animals spent less than 6 hours per day grazing and much time engaged in vigorous play and agnostic behavior or in seeking shelter from rain. High levels of moisture in the plants also may have limited dry matter intake. Levels of digestible energy (DE) (kcal/kg/BW) fluctuated throughout the year in a similar manner as did intake (table 5.3).

Manipulating Caatinga Vegetation to Increase Forage Availability

Dement and Longhurst (1987) classified sheep as medium selectivity grazers with a tendency to be intermediate feeders based on the selectivity and on the browse-to-grass digestion rate. This means that sheep would prefer grass and forbs but can and will feed on browse species. On native caatinga areas, sheep feed heavily on the herbaceous layer, with grasses and forbs composing up to 86% of the diets (Kirmse, 1984; Nascimento, 1988). This feeding behavior results in virtual disappearance of grasses and forbs (UFC, 1983).

These factors suggest controlling the woody species so that the herbaceous plants could increase in abundance and productivity. This type of manipulation should be more useful for sites grazed by sheep as compared to those grazed by goats. These methods of manipulating the caatinga vegetation have not increased in total biomass production but rather a shift of the forage production from the woody to the herbaceous layer (Araújo Filho, 1987).

Two practices of caatinga manipulation are recommended to increase forage production for sheep: thinning, and enriching or reseeding.

Thinning the Caatinga

This practice consists of a reduction of the density and the canopy of the woody species. This may be done by uprooting the plants, treating with herbicides, or repeated cutting during the

rainy season (Araújo Filho et al., 1982; Hardesty, 1984).

To connect this to the caatinga type vegetation, four considerations are important. First, the thinning needs to be selective with respect to the plant species to be controlled. In most of the caatinga sites, the vegetation is successional and brush dominated. For this reason, all the tree species should be preserved for wood production as well as their forage value and landscaping or erosion control capabilities.

Second, thinned caatinga areas should not have less than 100 trees per hectare in order to maintain a canopy of between 30% and 40%. Third, thinning should not be used in areas with more than 25% slope, because of danger of erosion. However, belt thinning might be a valid option for rough topographic areas. Fourth, the preservation of the drainage system must be considered carefully. A strip of the original vegetation should be preserved on both sides of the stream. The width of the strips is proportional to that of the stream. However, a minimum of 3 meters and a maximum of 10 meters of original vegetation should be left adjacent to streams.

The landscaping aspects of thinning consist of three types known as savannah, grove, and belt.

Savannah thinning consists of leaving the preserved trees as separate individuals. This is advisable mostly for successional caatinga sites, where the trees are naturally isolated among a dense understory layer of brush. However, the use of savannah thinning on tree-dominated sites may result in severe wind damage to the preserved trees by desiccation, branch breakage, and tree felling.

Grove thinning is recommended for old successional or tree dominated caatinga sites. It consists of preserving the sparse tree groups or groves where the tree density is higher. The total areas covered by the groves should not exceed the proposed limits of 30 to 40% of the pasture.

Belt thinning is mostly used in areas of broken topography with slopes in excess of 25%. The belts should be located perpendicular to the slope to reduce erosion.

The proposed limits of 30% to 40% of residual canopy cover on thinned caatinga areas constitute the minimum below which significant increases in phytomass production will not occur (Araújo Filho et al., 1982; Silva, 1985, Saraiva, 1988). However, this is true only for the savannah thinning. The belt thinning did decrease the herbaceous layer production proportional to the growth cover percentage represented by the belt (Silva, 1988).

Forage production on thinned caatinga

The thinning of caatinga in many sites at an altitude ranging from 100 to 350 m results in a substantial increase in the production of forage by the herbaceous layer and a change of its botanical composition. These sites are located mostly on the red-yellow podzolic, solodic planossol, solodized solontz, and litholic soils. However, sites were found where the manipulation of the woody vegetation was not followed by an increase in

herbaceous plant production; mostly grasses and forbs were identified. About 40% of those species were found composing the sheep diets (Nascimento, 1988).

The increase in production by the herbaceous species due to caatinga thinning on some sites varied from 400 to 800% (Araújo Filho et al., 1982). However, climatic conditions, for the most part rainfall, strongly affect both the herbaceous layer production and botanical composition. In a seven-year period (1972-1978), the phytomass production in a thinned caatinga herbaceous layer varied from a minimum of 2,381 kg/ha (DM) to a maximum of 6,816 kg/ha (Araújo Filho et al., 1982). The biomass production in the same area was 1,351 kg/ha in 1983 with 377.9 mm of rainfall and 4,413 kg/ha in 1984 with 975 mm of total precipitation (UFC, 1985). Grasses tend to dominate in dry years while forbs dominate in wet years, thus the increase in biomass production in wet years is almost solely because of the increase in forb production (UFC, 1983, 1984 and 1985; Lima, 1984; Saraiva, 1988).

Sheep production on thinned caatinga

Sheep respond to thinning of caatinga with increased productivity. Thinned caatinga permitted a higher stocking rate for sheep (5.1 ha/AU/year) than native caatinga (9.6 to 12.2 ha/AU/year) [UFC, 1985]. An animal unit referred to here is considered equivalent to eight adult sheep. The weight gain by sheep in thinned caatinga usually reached 20 kg/head per year. These results compare favorably on a per head basis with those obtained on the native caatinga (UFC, 1983, 1984, and 1985).

Enriching the Caatinga

Because of their annual characters, the grasses and forbs of the caatinga rapidly lose their nutritive value in the dry season, resulting in severe nutritional stress as the 6- to 8-month dry season advances. On the other hand, some native woody species are valuable sources of forage in the dry period either by retaining green leaves or by providing forage in the form of leaf litter. However, both the herbaceous layer and the ligneous stratum may be enriched by reseeding with adapted perennial species. Enrichment should be preferred to total replacement because it is ecologically and economically sound to preserve all the available forage species, both woody or herbaceous, which are native to the caatinga. Thus, the enrichment or reseeding should be carried out on thinned caatinga areas.

Several exotic forage species have been evaluated for enriching or reseeding the caatinga. Most of these are grasses or legumes. Among grasses, buffel grass (*Cenchrus ciliaris*) is the most common, but guinea grass (*Urochloa mocambicensis*), bermuda grass (*Cynodon dactylon*), gamba grass (*Andropogon gayanus*), and stargrass (*Cynodon pleistotachyos*) are prominent among the promising species.

Among the legume species, leucaena (*Leucaena leucocephala*), cunhã (*Clitoria ternatea*), canavalia (*Canavalia brasiliensis*), guandu, (*Cajanus cajun*) and algaroba (*Prosopis juliflora*), a pod producer, have received more attention and are more widely recommended.

Thinned caatinga areas enriched with perennial grasses permit a substantial increase in forage production, carrying capacity and animal output in the dry season (Silva, 1988). However, the superior, deep alluvial soil is more commonly used for elephant grass for green chop or silage and cunhá for hay or grazing. Under these conditions, irrigated alluvial areas may produce up to 20 tons of good quality hay per hectare per year. Cunhá hay has been shown to be a good replacement for oilseed cakes for protein supplement or for sheep fattening (Barros, 1986).

Protein banks grown on areas with good potential and cropped with a perennial, drought-resistant legume, are a recommended option for supplemental feeding of sheep in the dry season. The protein banks are subjected to restricted grazing or cut-and-carry feeding. The flock may be allowed to forage the area for a short time in the morning before the animal goes to the thinned caatinga areas. The results obtained suggest that this is a sound and feasible practice to avoid severe losses in sheep performance during the drought. Animals with lower nutrient requirements may be fed on the protein bank areas less often than once per day.

To function as a protein supplement, the legume plots do not need to be used every day, but should be used every 3 to 4 days or at least weekly. In this way, the size of the plot may be reduced and the forage conserved.

Characteristics of diet in manipulated caatinga

The major purpose of brush clearing in semiarid areas of the world is to increase forage production or feeding value. The increase in quantity is usually achieved because dry matter yields of edible material from herbaceous species tend to be higher than those from woody species. Usually, increased yields are attributed to reduced competition for moisture, nutrients, and sunlight. This line of reasoning has evolved primarily in temperate zones where grazing by cattle is the predominant range use and woody plants contribute little to the edible forage components. However, in tropical forage, particularly those used for small ruminant production, removal or manipulation of all tree and shrub components may not be justified easily.

Normally, clearing the caatinga increases the proportion of forbs over uncleared caatinga, which produces a greater amount of litter from shrubs and trees. Research in Northeast Brazil showed that partial clearing is the best option for sheep husbandry under caatinga type vegetation. During the wet season, grass, green leaves, flowers, and seedheads from various native species form the major components of sheep diets. During the dry season, the proportion of litter in uncleared caatinga is larger than that in cleared caatinga. On the contrary, the proportion of forbs and grasses is larger in cleared than in uncleared areas. (Mesquita, 1985). Usually the leaf litter on the cleared areas came from trees that remained in the area, which retain their leaves longer into the dry season. Even though leaf litter contributes to sheep diets, it is not enough to maintain body weights.

Introduced Forages

Seasonal fluctuations in forage supply have been recognized as a major constraint to livestock production in Northeast Brazil.

Although significant effort has been devoted to improve the natural pastures of the region, the climatic constraints impose severe nutritional limitations on animal production in native rangeland situations (Malechek, 1986).

In the recent years, several efforts have been made to improve the availability of better quality forages for livestock in the region. Exotic grasses and legumes are being evaluated continuously as a source of silage, hay, protein banks, or cultivated pastures. Some of the species studied are:

Algaroba (*Prosopis juliflora*) Algaroba, a tree legume, is 5 to 7 m in height and has considerable drought resistance (Jardim, 1976). Its fruits have good nutritional value (Zometa, 1986) and are eaten by sheep, goats, and cattle. Its leaves and branches are not highly palatable.

While algaroba pods are considered a good source of energy, they are relatively low in crude protein (12 to 13%) with approximately 83% dry matter (Barros et al., 1981).

The algaroba grows fruit and produces green forage even during prolonged dry seasons. After the third year it can produce 10 to 50 kg of pods per tree, and, in some cases, it produces 2,000 kg/ha/year. It is recommended to cultivate algaroba in a 10 x 10 m spacing. Lower overall production may occur in dense plantings (Jardim, 1976).

Preliminary results (Leite et al., 1988) and observations indicate that algaroba is not a preferred source of forage for sheep. When used as a protein bank, the level of intake is low, seldom exceeding 1%. In large areas where the species has been cultivated, the production of pods is low, especially during periods of extended drought. These observations may come as a surprise to some, but most of the claims attributed to algaroba were based on subjective observations. There are apparently no research reports showing heavy utilization of algaroba by sheep.

Leucena (*Leucaena leucocephala*). Leucaena, a perennial browse plant, can grow in areas of caatinga where the annual precipitation is more than 500 mm, and the temperature does not drop to less than 10°C (Jardim, 1976). Its deep roots make it drought resistant, and it can respond during the severe dry seasons of Northeast Brazil, producing a high quality forage (Leite et al., 1988). In field plantings, leucaena can produce about 12,000 kg of DM/year, with a crude protein content of 22% (Viana, 1983).

Because of its low initial growth and high palatability, it is difficult to introduce or use leucaena in mixed plantings with other shrubs or grasses. It has been used successfully as a protein bank for livestock, being a relatively inexpensive way to supplement their needs during the dry season (Leite et al., 1988).

Leucaena can be cultivated in almost all types of soils found in Northeast Brazil. Because of the growth habits, the forage height may exceed the feeding zone of sheep. The plant should be cut periodically to encourage growth within their reach. The cut material may be fed directly or be preserved as hay (Carvalho Filho and Languidey, 1983).

Leucaena has a mimosine content which can be toxic, especially for horses. However, toxic problems because of mimosine were not reported for sheep.

Cunhá (*Clitoria ternatea*). Cunhá, a perennial herbaceous legume, can reach to 1.0 m in height. While it will grow in poor, shallow soils, it will do better in good soils under irrigation.

Under natural conditions of Northeast Brazil, cunhá can produce 5,000 kg DM/ha/year (Viana, 1983). However, under an ideal situation of soils and irrigation, it has produced up to 21.9 tons of DM/ha/year (Araújo Filho et al., 1981). Under irrigation, cunhá can be harvested as many as eight times a year, with a harvest interval of 42 days (Viana, 1983).

Cunhá has been used in pastures associated with grasses and as protein banks (Leite et al., 1988). It is most commonly used in semiarid Brazil for hay. Studies by Gadelha et al. (1981) and Viana (1983) indicate that cunhá hay can provide up to 25% crude protein on a dry matter basis with up to 82% digestibility.

Elephant Grass (*Pennisetum purpureum*). Elephant grass originated in tropical Africa. It naturally grows where rainfall is above 1,000 mm or under irrigation, in soils of medium to high fertility (Carvalho, 1985). Because of the low potential of seeds to germinate, the most common method of cultivation is by vegetative propagation.

The best nutritive values are obtained when elephant grass is harvested at about 45-day intervals (Carvalho, 1985). Protein content and digestibility may be expected to be lower than legumes such as cunhá. In Northeast Brazil, elephant grass is the most commonly used supplement as green chop, fodder, or silage.

Sorghum (*Sorghum vulgare*). Sorghum, which originated in Africa and Asia, has been used widely throughout the world, including the semiarid region of Brazil. Some of its advantages include drought resistance, high forage or grain yields, and early maturing characteristics (Ferreira, 1984). In this part of the world, two variations are commonly used: grain sorghum and forage sorghum. Grain sorghum is used for human or animal feed, while forage sorghum is used for hay or silage to feed livestock (Avelar, 1982).

In Brazil, forage sorghums are cultivated during the rainy season. The plants develop better in well-drained soils of medium-to-high fertility, but they also can produce well in shallow and relatively poor soils (Ferreira, 1984). There are a large number of varieties of forage sorghums, including a number of hybrids. Yields are highly dependent on soil types, fertilization, and moisture supply. Sorghum forage should be viewed as a source of energy or bulk in the diet, if they are not sufficiently high in protein for use as a protein supplement.

Buffel grass (*Cenchrus ciliaris*). Buffel grass, wide-spread throughout the world, has proved one of the most useful plants for establishment in grazing lands of the semiarid region of Brazil. In general, it grows better in deep, light soils, but also can be established in heavy but well-drained soils (Oliveira, 1981).

Four varieties of buffel grass are common on the ranches in Northeast Brazil: Gayndah, Biloela, American, and Molopo. There are only a few differences in agronomic characteristics of these varieties, but in general, they perform similarly in the semiarid climate. They are located in regions in which precipitation ranges from 350 to 1,000 mm/year (Oliveira, 1981). This grass is normally propagated by seeding. It may be used for grazing or for hay, but the hay is usually of poor quality. It can be used in pure stands or in mixtures with several tropical legumes.

Buffel grass may contain as much as 10% crude protein when harvested in the beginning of the flowering stage. The annual production in the pastures varies with conditions, but may be expected to range from 6,000 to 10,000 kg DM/ha/year (Oliveira, 1981).

Summary

The potential exists to improve markedly the productivity of sheep through improved forage production. This is particularly true in the large area of caatinga in Northeast Brazil, but also in varying degrees to other parts of tropical America. Sheep may be in a position to respond more than some other species, such as goats, as they are less willing browsers and appear to have the genetic potential (relative to meat production) to respond to improved management.

A major opportunity to improve productivity is through caatinga management, or more particularly partial clearing. It has been shown that this increases herbage production, especially forbs. These are preferably and advantageously utilized by sheep.

Another major opportunity for improved productivity is through the use of introduced forages to be used as a replacement for or supplement to caatinga or other existing grazing resources. This may include buffel grass in the more arid regions or legumes such as cunhá under better soil moisture resources.

The use of protein banks for direct utilization or as conserved forages to supplement the diet during periods of feed scarcity appear to offer a lot of potential. This is particularly critical in Northeast Brazil. For sheep, this preferably would be cultivated forage legumes, or tree legumes that may be used directly or as hay. Over the larger area, there are many such crops which should be considered.

Literature Cited

Araújo Filho, J.A. de. 1987. Combined species grazing in extensive caatinga condition. In: *Proceedings of the 4th International Conference on Goats*. pp. 947-954. EMBRAPA-DDT, Brazilia, Brazil.

Araújo Filho, J.A. de, S.M. de S. Torres, J.A. Gadelha, D.F. Maciel and R.G. Catunda. 1982. Estudos de Pastagens nativas do Ceará. Estudos Economicos e Sociais no. 13. Fortaleza, Brazil.

Avelar, B.C. 1982. Aspectos Climaticos. In: *Recomendações para*

a cultura do sorge. p. 22. EMBRAPA, Circular Técnica No. 01.

Axelrod, D.I. 1979. Desert vegetation, its age and origin. In: J.R. Goodin and D.K. Northington (Ed.) *Arid Land Resources*. pp. 78-103. International Center for Arid and Semi-Arid Land Studies, Lubbock, Texas.

Barros, N.A.M.T., F.V. Nobre, C.F. Azevedo, C.A.N. Barbosa and J.N. Brandao. 1981. Algaobeira, importante forrageira para o Nordeste. EMPARN, Boletim Técnico No. 05.

Barros, N.N., J.R. Kawas, L.C.L. Freire, J.A. Araújo Filho, J.M. Shelton and W.L. Johnson. 1986. Digestibility and intake of various native and introduced forages by goats and hair sheep in Northeast Brazil. In: *Goats and Sheep in Northeast Brazil*. Proceedings of First Workshop of SR-CRSP. p. 219-226. EMBRAPA-CNPC/SR-CRSP, University of California, Davis, Ca.

Braga, R. 1960. *Plantas do Nordeste, especialmente do Ceará*. 2nd ed. Imprensa Oficial, Fortaleza, Ceará, Brazil.

Bucher, [illegible]. Chaco and caatinga - South American arid and tropical savannas and thickets. In: J. Nuntley and B.H. Walker (Eds.) *Ecology of Tropical Savannas*. pp. 48-79. Springer-Verlag, Berlin, Heidelberg, and New York.

Carvalho Filho, O.M. and P.H. Languidey. 1983. Engorda de borregos Santa Inês em pastagen de green panic suplementados com leucena. EMBRAPA/UEPAE de Aracaju. Comunicado TécnicoNo. 04.

Carvalho, L.A. 1985. Pennisetum purpureum, Schumachen-Revisão. EMBRAPA/CNPEL. Boletim de Pesquisa No. 10.

Christiansen-Weniger, F. 1977. Possibilities of dry-farming in the region of Northeast Brazil with an unreliable rainfall. In: Paul Wilker (Ed.) *Ecosystem Research in South America*. pp. 101-151. W. Junke Publishers, The Hague, Netherlands.

Dement, M.W. and W.M. Longhurst. 1977. Browsers and grazers: constraints on feeding ecology imposed by gut morphology and body size. In: *Proceedings of the IV International Conference on Goats*. pp. 989-1004. EMBRAPA-DDT, Brazilia, Brazil.

Duque, J.G. 1973. *O Nordeste e as Lavouras Xerofilas*. 2nd Ed. Imprensa Universitária, Fortaleza, Brazil.

Eiten, G. and R. Goodland. 1979. Ecology and management of semiarid ecosystems in Brazil. In: B.H. Walker (Ed.) *Management of Semiarid Ecosystems*. pp. 277-300. Elsevier Scientific Publishing Co., Amsterdam.

Eyre, S.R. 1963. *Vegetation and Soils - A Word Picture*. Aldine Publishing Co, Chicago, IL.

Ferreira, S. 1984. A cultura do sorgo. CATI. Boletim Técnico No. 187.

Ferri, M.G. 1961. Aspects of soil-water-plant relationship in connection with some Brazilian types of vegetation. In: *Tropical Soils and Vegetation*. pp. 103-109. UNESCO, Paris.

Freise, F.W. 1938. The drought region of Northeast Brazil. Geogra. Re. 28:363.

Fundação Instituto Brasileiro de Geográfia e Estatística. 1977. Geográfia do Brasil, Região Nordeste. Vol. 2, SERGRAF, IBGE, Rio de Janeiro.

Gadelha, J.A., R.M. Pereira, J.A. Araújo Filho, J.A. Azevedo and A.R. Azevedo. 1981. Estudo comparativo do valor nutritivo do feno de cunhá (Clitoria ternatea Lo) com a torta de algodáo em rações de bovinos de corte em confinamento. In: *Proc. 18th Annual Meeting of Sociedade Brasileira de Zootecnia*. p. 339. Goiania, Brazil.

Hardesty, L. 1984. Coppicing to improve dry season forage production in the semiarid tropics. Working papers, 2nd Intern. Rangeland Congr., Section 6, Adelaide, Australia.

Howell, L.A. 1981. A review of tropical and subtropical brush management techniques with special reference to Northeast Brazil. Master's Thesis. Utah State University, Logan, Utah.

Jardim, W.R. 1976. *Alimentos e Alimentação de Gado Bovino*. Agronomico Ceres, São Paolo, Brazil.

Kearl, L.C. 1982. Nutrient requirements of ruminants in developing countries. Int'l Feedstuffs Inst., Logan, Utah. p. 381.

Kirmse, R.D. 1984. Effects of clearing on forage production, quality and decomposition in the caatinga woodland of Northeast Brazil: Implications to goat and sheep nutrition. Ph.D. Dissertation, Utah State University, Logan, Utah.

Leite, E.R., J.A. Araújo Filho, R.C.M. Mesquita and S.M.A. Crispim. 1988. Estudo da dieta de caprinos em bancos de proteina no semiarido do Ceará. In: *Proc. 25th Annual Meeting of Sociedade Brasileira de Zootecnia*. p.159. Vicosa, Brazil.

Lima, D.A. 1965. Vegetation in Brazil. In: *Proc. 9th Inter. Grassl. Congr.* pp. 29-47. M.J.T. (ES.), Queensland, Australia.

Malechek, J.C. 1982. Grazing management of goats in extensive rangeland production systems. In: *Proc. Third Inter. Conf. on Goat Prod. and Disease*. pp.404-08. Tuscon, Arizona.

Malechek, J.C. and F.D. Provenza. 1983. Feeding behavior and nutrition of goats on rangeland. World Anim. Rev. 47:38.

Malechek, J.C. 1986. Agroecology of small ruminant production in the Northeast. In: *Goats and Sheep in Northeast Brazil. Proc. First Workshop of the SR-CRSP*. pp. 47-63. EMBRAPA-CNPC/SR-CRSP, University of California, Davis, Ca.

Mason, I.L. 1980. Sheep and goat production in the drought polygon of northeast Brazil. World Anim. Rev. 34:23.

Mesquita, R.C.M. 1985. Seasonal feeding behavior and forage selection by goats in cleared and thinned deciduous woodlands in Northeast Brazil. Master's Thesis, Utah State University, Logan, Utah.

Mesquita, R.C.M., E.A. Lopes and J.C. Malechek. 1986. Manipulação da caatinga visando ao aumento da produção de carne caprina. In: *Reunião Técnico-Cientifica do Programa de Apoio a Pesquisa Colaborativa de Pequenos Ruminantes, 1.* pp. 123-129. EMBRAPA-CNPC/SR-CRSP, Sobral, CE.

Nascimento, A.E. 1988. Influencia da raça na seleção da dieta por caprinos e ovinos em caatinga nativa e raleada no sertão central cearense. Master's Thesis, Universidad Federal do Ceará, Fortaleza.

NRC. 1975. *Nutrient Requirements of Sheep.* N.S. National Academy of Sciences, Washington, D.C. NRC. 1981. *Effect of Environment on Nutrient Requirements of Domestic Animals.* National Academy Pres. Washington, D.C.

Oliveira, M.C. 1981. O capim buffel nas regiões sêcas do Nordeste. EMBRAPA/CPATSA. Circular Tecnica No. 05.

Oliveira, E.R., J.A. Pfister, R.D. Kirmse and R.C.M. Mesquita. 1986. Habitos alimentares e seletividade de caprinos e ovinos em pastoreio: consideracoes a respeito dos requerimentos nutritivos durante a estacao sêca. In: *Reunião Técnico-Cientifica do Programa de Apoio a Pesquisa Colaborativa de Pequenos Ruminantes, 1.* pp. 151-66. EMBRAPA-CNPC/SR-CRSP, Sobral, C.E.

Pfister, J.A. 1983. Nutrition and feeding behavior of goats and sheep grazing deciduous shrub-woodland in northeast Brazil. Ph.D. Dissertation. Utah State University, Logan, Utah.

Queiroz, J.S. 1985. The Acarau Valley of Northeast Brazil: vegetation, soils and land use. Ph.D. Dissertation. Utah State University, Logan, Utah.

Rittenhouse, L.R., C.L. Streeter and D.C. Clantion. 1971. Estimating digestible energy from dry and organic matter in diet of grazing cattle. J. Range Mgmt. 24:73.

Saraiva, F.M.Q. 1988. Efeitos da manipulação do estrato herbaceo sobre as características fitossociologicas do estrato herbaceo em um sitio ecologico do Sertão cearense. Universidade Federal do Ceará. Fortaleza, Brasil.

Silva, N.L. da. 1985. Efeitos do raleamento e do fogo sobre a produtividade e frequência dos componentes do estrato herbaceo d caatinga. Universidade Federal do Ceará. Fortaleza, Brasil.

Silva, V.P. 1988. Composição botanica da vegetação e da dieta de bovinos e ganho de peso vivo em caatinga manipulada. Universidade Federal do Ceará. Fortaleza, Brasil.

UFC. 1983. Relatorio Técnico Anual da atividade do convenio BNB/FCPC. Pastoreio combinado bovino, ovino e caprino. Universidade Federal do Ceará. Fortaleza, Brasil.

UFC. 1985. Relatorio Anual das atividades do convenio BNB/FCPC. Pastoreio combinado bovino, ovino e caprino. Universidade da Federal do Ceará. Fortaleza, Brasil.

Valverde, O. 1969. Brazil. In: *World Atlas of Agriculture. Vol. 3: Americas.* Instituto Geografico de Agostini, Novara, Spain.

Veloso, H.P. and H.E. Strang. 1970. Alguns aspectos fisionomicos da vegetação do brasil. Mem. Inst. Osvaldo Cruz. 10:9.

Viana, J.J. 1983. Efeito da irrigação e época de corte na produção e qualidade nutritiva da cunhá (Clitoria ternatea L.). Master's Thesis. Universidade Federal da Paraíba, Campina Grande, PB, Brasil.

Walkins, G.H. and M. Caldwell. 1970. Leaf anatomy of species in some dicotylodon families as related to C3 and C4 pathways of carbon fixation. Can. J. Botany 48:2135.

Zometa, C.A., P.R.M. Leite, J.M. Shelton, R. Lewis and W.H. Sousa. 1986. The response of lactating native and exotic breeds of dairy goats to complete rations involving varying levels of urea and two energy sources (algaroba pods vs. corn). In: *Goats and Sheep in Northeast Brazil. Proc. First Workshop of SR-CRSP.* pp. 267-276. EMBRAPA-CNPC/SR-CRSP, University of California, Davis, Ca.

Chapter 6

SUPPLEMENTAL FEED RESOURCES AND THEIR UTILIZATION BY HAIR SHEEP

W.L. Johnson, N.N. Barros and E.R. de Oliveira

In regions of the world where the production of hair sheep is common, or where there is a potential to increase their importance, it is likely that the major feed resource will be either native range or cultivated pastures as described in the previous chapter. There are times, however, when some supplemental feed is necessary to increase survival rates and to optimize the productivity of sheep.

In a semiarid tropical climate with a prolonged dry season, as typified by Northeast Brazil, there are times of the year when the natural range or nonirrigated pastures will be deficient in energy, protein, or both. In years when drought is severe, the entire flock will need supplemental feed. Even when rainfall patterns are favorable, it still may be profitable to supplement some animals during the final months of the dry season. Good candidates for supplemental feeding would be those animals that have a high nutrient requirement, such as rapidly growing lambs, and ewes in late gestation or early lactation (especially when suckling twins).

In regions with a more favorable rainfall pattern, supplementation may be desirable for a different reason. In these regions the quantity of forage available may be sufficient, but its quality may be too low to support a high level of production. Rapidly growing tropical grasses contain high levels of cell wall fiber that digests slowly in the rumen. The energy available from the forage alone is limited, as is the animal's intake capacity for such high fiber forage.

Some of the situations in which the use of supplemental feed may be profitable are discussed in this chapter. The energy and protein values of some potentially available supplemental feed resources also are described.

When to Use a Supplement?

Feeding supplements can be expensive, and should only be used when the benefits will justify the costs. When a producer suspects that nutrient availability from the range or pasture may be deficient or marginal, he may consider supplementary feeding. The following guidelines can help in deciding whether or not to use supplementary feeds.

1. It is difficult to generalize about **minerals**. The only valid rule is that if a measurable improvement in animal production is obtained from feeding the animals supplementary minerals, it is usually economically profitable to do so. Whether a particular mineral is needed will depend on local soil conditions, predominant forage species, the stage of growth of pasture plants, and the physiological status of the animals. In many situations, salt, iodine, and phosphorus are

Previous Page Blank

the first limiting minerals. As the general plane of nutrition (energy, protein, and major minerals) improves, other minerals may become limiting, including one or more of the following: calcium, copper, cobalt, selenium, zinc, and sulfur. Advice should be sought from an animal scientist or veterinarian who is competent and familiar with local conditions.

2. Crop **residues**, such as maize stover or cereal straw, can be used as a substitute for pasture or range during periods of extreme, prolonged drought. At other times of the year, availability of such products will only lead the animal to reduce its intake on pasture or range, as there is a limit to the amount of cellulosic cell-wall fiber that can be taken into the rumen each day.

3. Use of **protein supplements** can be profitable when the pasture or range species are mature (the result of undergrazing), or when they have stopped growing (in the dry season), or when selectivity and intake are restricted (because of overstocking). A protein supplement also is necessary when maize and other cereal crop residues comprise the forage base. The quality of the supplemental protein needs to be taken into account, as discussed below.

4. An **energy supplement** may be necessary when the animal's energy requirements are substantially more than the maintenance level, or when a severe weight loss would be undesirable. (Some energy value is obtained from natural protein supplements, but not from urea.) Situations in which supplemental energy may benefit the animal include:

   - finishing lambs for sale for meat;
   - preventing weight loss and permanent stunting of growing replacement lambs;
   - flushing ewes that are in poor condition for breeding, to ensure a weight gain prior to and during the breeding season;
   - preventing severe weight loss in pregnant ewes during the early and middle months of gestation;
   - ensuring weight gains during late pregnancy, in order to prevent birth of underweight lambs and to ensure that the ewe can later produce enough milk for her lamb(s);
   - during the ewe's early lactation, to promote a good growth rate and weaning weight for her lamb(s) (especially for litters of two or more); and
   - immediately pre- and post-weaning, to improve lamb survival and help ease their adjustment to full rumen function.

If a sheep producer's flock performs poorly, strategic supplementation may help. Unthrifty ewes, low fertility rates, low lamb survival and weaning weights, a prolonged interval to market weight (males) or first estrus (replacement females), and long intervals between lambings: any of these conditions may indicate that improvements in the feeding program could be profitable.

Composition and Feeding Value of Common Supplemental Feeds

Each region of the tropics has its own set of locally avail-

able supplemental feeds, depending largely on the local mix of agricultural crops from which byproducts and crop residues can be obtained.

The chemical composition of several feeds commonly available in Northeast Brazil is shown in table 6.1. Crude protein content is based on Kjeldahl analysis. Cell wall fiber--a measure of total cellulose, hemicellulose, and lignin--is based on the Van Soest neutral detergent procedure. Most of the analyses were done at the National Goat Research Center (EMBRAPA) in Sobral, Ceará, Brazil.

If the dry matter digestibility (DMD) of a feed is known, its ME value can be approximated by the following conversion:

Equation 1. ME (mcal/kg DM) = %DMD x .044 x .82

The first coefficient, 0.044, represents the caloric (energy) value of the digestible dry matter; the second coefficient, 0.82, corrects for 18% of loss of digestible energy in the form of rumen gases and urinary products.

The crude protein (CP) content of a diet is useful as a broad indicator of its proteic adequacy. The following percentages are accepted as minimum concentrations of CP in the total diet dry matter for certain physiological functions:

To maintain normal rumen function	-	6- 7%
Maintenance requirement of an adult ewe	-	9-10%
Last 4 weeks of pregnancy	-	11-12%
Lactation	-	13-15%

The main problem with these guidelines is that no allowance is made for protein quality. For example, in some mature tropical forages and by-products a portion of the protein is bound to the cell wall fiber in such a way that it cannot be digested. A similar problem occurs with some byproducts that have been processed with heat. Tannins, present in some tropical plants, also can reduce protein digestibility.

It is well known that urea can provide part of the protein requirement of ruminants. Urea is broken down to ammonia in the rumen, and under proper conditions, the rumen microorganisms will incorporate the ammonia into the amino acids that they synthesize. If urea is added to a diet based on immature tropical grasses, however, much of it will be wasted. The protein in most tropical grasses is solubilized quickly in the rumen, and if urea also is fed, more ammonia will form than can be converted efficiently to amino acids. Moreover, if urea is fed without also feeding a readily available carbohydrate, such as the starch of cereal grains or the sugar of molasses, it will not be utilized efficiently, because amino acids cannot be produced without the carbon chains that starch or sugar can provide.

Table 6.1. Crude Protein (CP), cell-wall fiber (NDF), and In Vitro Dry Matter Digestibility (IVDMD) of commonly available supplemental feeds in Northeast Brazil (dry matter basis).

Diet Ingredient	CP %	NDF %	IVDMD %	Ref.[a]
Crop Residues				
Beans				
leaves	12.3	37.9	---	1
leaves + stalks	8.1	63.8	---	1
pods	8.8	61.2	---	1
stalks	7.4	67.8	---	1
Cotton				
hulls	5.6	58.6	---	1
leaves	15.3	29.3	---	1
Maize				
cobs	3.4	85.5	---	1
husks	4.0	83.5	---	1
leaves	6.8	68.9	---	1
stalks	4.8	74.7	---	1
stover	3.1	79.8	59.4	2
tassels	5.2	73.9	---	1
High Energy Feeds				
Maize grain	6.5	19.1	93.4	2
Maize grain	8.4	20.4	---	3
Molasses	2.2	---	---	4
Sorghum grain	10.5	---	---	4
High Protein Feeds				
Cottonseed cake	24.0	42.1	75.1	2
Cunhã (Clitoria ternatea)				
hay	22.6	49.7	---	5
silage, 42 days	19.2	49.8	---	5
silage, 70 days	17.6	55.9	---	5
Leucena (Leucaena leucocephala)				
hay	20.2	42.3	---	6
Soybean meal	50.5	---	---	7
Other Feeds				
Buffel grass (Cenchrus ciliaris)				
hay	6.5	69.0	---	8
Forage Sorghum				
hay	6.3	72.4	---	5
silage, milk stage	4.6	77.4	---	5
silage, mature	4.9	69.3	---	5

Table 6.1. Continued

Diet Ingredient	CP %	NDP %	IVDMD %	Ref.
Juazeiro leaves (Zizyphus joazeiro)				
hay	15.2	66.7	---	5
Jurema preta, seedpods (Mimosa nigra)				
hay	12.7	52.9	---	5
Marmeleiro (Croton sonderianus)				
hay	8.9	39.8	---	6
silage	7.6	46.9	---	6
Mata pasto (Cassia sericea)				
hay	8.3	50.2	67.2	2
silage	7.0	55.3	---	5
Mata pasto (Cassia sp.)				
hay	14.8	33.1	---	6
silage	10.6	45.4	---	6
Mofumbo (combretum leprosum)				
hay	9.0	24.6	---	6

[a]References:
1 Oliveira et al., 1982.
2 Oliveira et al., 1986.
3 Burstein et al., 1986.
4 Kearl, 1982.
5 Barros et al., 1986.
6 Carneiro et al., 1986.
7 CNPC Nutrition Lab.
8 Johnson et al., 1986.

What does the cell-wall fiber content of forages tell us? It is in fact an useful negative indicator of nutritive value, for two reasons. First, as cell-wall fiber cannot be digested quickly, and will not pass out of the rumen until it has been broken down by repeated mastication (rumination), it occupies space (fill), thus preventing the animal from consuming more feed. Second, high fiber feeds usually have a low digestibility and vice versa. Thus, in general, diets low in total cell-wall fiber will be consumed well and have a high digestibility. High cell-wall fiber levels in the diet, on the other hand, indicate a low potential intake and digestibility. These relationships have been demonstrated in recent research reports, including Brown and Johnson (1985) who studied the utilization of diets with different levels of wheat straw for growing sheep.

Use of Crop Residues

The most commonly available crop residue in Northeast Brazil, at least in terms of total available biomass, is the residue of maize plants after the grain is harvested. Maize residue is low

in crude protein (about 5% in the stalks, 7% in the leaves) and high in cell-wall fiber (70% or more). Contrary to common opinion, high fiber residues cannot be utilized efficiently by sheep or goats. They have limited rumen capacity and consequently need forages that can be digested with a shorter rumen residence time than required for maize residue. If no other forage is available, however, maize residue can help prevent starvation. Allowing the sheep to select only the most palatable parts of the residue, such as the leaves, will help improve the nutrient content of the diet consumed. Adding molasses to the maize residue may improve its palatability and (if it provides essential supplemental sulfur, thereby stimulating rumen microbial growth) its nutritive value.

Wheat and barley straw, if available, is of slightly higher nutritive value than maize residue. Rice straw is not recommended for small ruminants because of its high silica content and poor digestibility. All cereal residues will require energy and protein supplements, even for maintenance, unless they are fed for periods of just a few days.

The residue of legumes, including stems and leaves from soybeans and other edible beans, has a higher digestibility and crude protein content than cereal straw. Their exact feeding value varies widely according to species, variety, and cultural conditions.

There has been research to improve the nutritive value of high fiber forages by treatment or processing. To date, no method has been developed that will return large benefits at low cost and that also would be feasible for limited-resource farmers. The most popular method, ammoniation, uses liquid ammonia, a common fertilizer in the northern latitudes that is not generally available in tropical countries. Another effective treatment agent, sodium hydroxide, has never proven to be economical at the farm level. Recent research has concentrated on treatment with urea, which is readily available in most tropical countries. Another promising approach involves the use of peroxide, but a fully effective method has not yet been developed.

Undoubtedly future breakthroughs through research will allow the large quantities of high fiber crop residues available in the tropics to be used more effectively as animal feeds. Because of economies of scale, however, such methods likely will benefit large ruminants (cattle and water buffaloes) more than sheep or goats. Large ruminants can handle any high fiber feed, treated or not, more effectively than small ruminants.

Medium Energy Feeds

When energy supplementation is called for, the most economical alternatives likely are to be those feeds classified as medium in energy value. These feeds range from 55% to 65% in dry matter digestibility or from 2.3 to 2.6 Mcal of metabolizable energy (ME) per kg of dry matter. Feeds in this category include some brans (especially if mixed with hulls) and other industrial byproducts that contain some fiber. High quality forages also can be classified as medium-energy feeds. Legume forages fall in this category, including leaves of tree legumes (leucaena, sesbania, gliricidia, and others) and vine legumes [stylosanthes, Clitoria ternatea (cunhá), and others]. Other medium energy feeds include

certain high quality annual forages (sorghums and forage maize) and certain leafy crop by-products (sweet potato vines, cassava leaves, and others).

When added in small amounts (less than 20% of total diet dry matter) to a high fiber diet, a medium-energy supplement may cause a slight improvement in the utilization of the basal diet. Total dry matter intake will increase, but the intake of the basal diet will not change. At higher levels, a medium energy supplement of the kind described above will cause a decline in intake of the basal diet, because the cell-wall fiber of the supplement will have to displace some of the cell-wall fiber of the basal diet. Total dry matter intake, and total ME intake, will of course increase.

High Energy Feeds

Maize grain, cassava meal, and molasses are examples of highly concentrated energy sources whose feeding value is well known. As most high energy feeds will not provide sufficient supplementary protein, they must be used in combination with a protein supplement such as cottonseed meal (which also is relatively high in energy value). Cassava meal and molasses contain almost no protein.

High energy supplements fed at low levels will enhance the utilization of low quality forages. At levels of more than 15-20% of total intake, the supplement will replace some of the basal diet, as appetite control shifts from rumen fill to blood levels of energy precursors such as glucose.

Cost is a limiting factor in the use of high energy concentrates. The flock manager will need to calculate expected feed costs carefully before deciding to use maize or other high energy feeds. Then he will have to calculate the expected monetary benefit. The benefit can be in the form of additional lambs to sell, or decreasing the time (and therefore the cost and risk) for lambs to reach market weight. If the value of the expected benefit exceeds the expected feed cost (with an appropriate interest charge added), the use of a supplement can be expected to be profitable.

Any concentrate feed must be preserved and stored properly to maintain its feeding value. In humid climates and during the rainy season in semiarid climates, contamination with mycotoxins is a hazard for maize and other grains that have not been dried properly. Growth and milk production of animals consuming these feeds can be reduced.

Protein Supplements

For a feed to qualify as a protein supplement, it should be able to raise the average protein content of the diet to the level required by the animal (see the general guidelines presented earlier in this chapter). If the basal diet already has a protein level equal to or better than the animal's requirement, no protein supplement is needed. If the basal diet is at an inadequate level, then protein supplement must be added in an amount proportionally sufficient to bring the average protein content to the recommended level. Feeds high in protein (e.g., cottonseed meal, sunflower meal, or peanut meal), will be required in lesser amounts than medium-level protein supplements (e.g., coconut meal). There is much variability in the crude protein content of meals of this

type, depending on the variety and cultural conditions of the original seed, the oil extraction process used, and the content of other components (notably fiber) that may dilute the protein content.

As with high energy feeds, the decision to use traditional oilmeal protein supplements will require an economic analysis. Will the benefit to be derived exceed the cost involved? This question must be addressed by each sheep producer, taking into account the prices currently in effect.

An approach to protein supplementation more likely to prove economical is the use of high quality forages. Most legumes, for example, will fall within the range of 15-25% crude protein, and can be used to help balance both dietary protein and energy intake with the animals' requirements. In Northeast Brazil two forage legumes, matapasto (Cassia sericea) and cunhã (Clitoria ternatea), have been used successfully as partial substitutes for cottonseed meal in diets for confined lambs (Oliveira et al., 1986).

Limitations in the use of forage legumes as protein supplements may be imposed as a result of their fiber content, or, in certain cases, as a result of tannins or other digestibility restricting compounds. The safe procedure when introducing an untried ingredient to the diet is to phase it in gradually, carefully observing the animals for any problems.

There is much discussion in the literature about the potential benefits of bypass protein, which refers to natural proteins that will not dissolve quickly in the rumen and therefore can escape to the lower gastro-intestinal tract where they will be digested and absorbed directly. Bypass protein, then, can supplement the microbial protein that normally passes from the rumen to the lower gut for digestion.

Bypass protein has proven beneficial for high-producing dairy animals, for rapid finishing of slaughter animals, and even for wool-producing sheep. It has not been demonstrated that supplemental bypass protein will benefit hair sheep, since they normally are fed and managed in the tropics.

It is important to provide sufficient <u>rumen-soluble</u> protein for optimum microbial growth in the rumen. Once this level is reached, however, additional rumen-soluble protein (or non-protein nitrogen such as urea) only will be converted to ammonia and wasted. The practical recommendation, therefore, is that dietary protein above those levels that can be used efficiently by the rumen microbial population should be fed in the form of <u>bypass</u> protein. Feeds commonly classified as having low bypass value include soybean meal, sunflower meal, peanut meal, most forage grasses and certain legumes, and, of course, urea. Medium-bypass sources include cottonseed meal, maize, and some of the tree legume foliages. Fish meal is an example of a high-bypass protein feed. Heat processing may increase the bypass value of any protein supplement.

Some of the natural protein in tropical feeds will be completely indigestible and pass intact into the feces. The protein in mature grasses likely is to be bound to cell-wall fiber and thus be unavailable. Excess heat during feed processing can likewise

bind the protein and render it indigestible. As mentioned above, certain tannins can have the same effect. Thus, for precise estimates of the protein available to the animal, a crude protein value will not be adequate. Simple procedures are now being used in some laboratories in the tropics to partition the crude protein fraction into three parts: rumen soluble protein, rumen bypass protein, and indigestible protein. As the use of these procedures becomes more widespread it will be easier for the farmer to obtain precise information about the quality of protein in his sheep feeds.

Mineral Supplements

The concentration of minerals in forage depends on the interaction of several factors including soil, forage species, stage of maturity, pasture management, forage production, and climate. These factors are particularly important in tropical regions where forages have a rapid growth and the undigestible fiber fraction rises accordingly. Christy (1984) indicated that an increase in undigestible fiber is associated with a decrease in mineral absorption.

According to Conrad (1984) and McDowell et al. (1977), forages from tropical soils can be deficient in several macro and micro minerals, which indicates that it might be beneficial to use mineral supplements, at least in areas of demonstrated deficiency. However, care should be exercised to make sure that the amounts used in the mineral mixture are adequate to compensate for possible reductions in their biological availability.

In Brazil, Tokarnia and Dobereiner (1987) studied mineral deficiency in ruminants and found major problems with phosphorus, copper, and cobalt. They indicated that even though iodine deficiency has a lower incidence, it is of great economic importance.

Batista et al. (1987) suggested a possible phosphorus deficiency in goats for the semiarid region of Northeast Brazil.

The majority of papers dealing with mineral deficiency in Brazil relate to cattle. The papers reviewed indicated that there was no response of free-ranging sheep to mineral supplementation, which may be indicative that mineral deficiency in sheep is even less common than in cattle. According to Underwood (1981) sheep have a greater intake per unit of metabolic body weight than cattle, and they also have a smaller proportion of skeletal (bone) tissue to total body mass than cattle. Sheep also are more selective in dietary habits than cattle; this may help them satisfy their mineral needs in marginally deficient pastures.

The response to mineral supplementation for sheep grazing native caatinga in the semiarid Northeast Brazil is questionable. During the dry season, energy and protein are the most limiting factors for adequate growth of sheep, and a deficiency of those nutrients will limit response to mineral supplements. During the rainy season, there is greater availability and diversity of forage with several palatable grasses, forbs, shrubs, and a considerable amount of legumes which have significantly greater concentrations of calcium, potassium, iron, copper, zinc, and cobalt than grasses (Gomide, 1976; Underwood, 1981). Even for phosphorus, one of the most important minerals for livestock, the neutral or even alkaline

pH of soils in the Northeast means that plants are less likely to have problems in phosphorus uptake than in the acidic, high aluminum soils of more humid areas.

During the late dry season, especially in dry years, the available forage may be so poorly digestible that its mineral content is not fully available to sheep. Sulfur may be of special benefit in aiding rumen function in such situations. Otherwise, local soils and vegetation should be tested for phosphorus and trace minerals (cobalt, copper, selenium, etc.) and if pockets of marginal or deficient levels are found, the animal response to the mineral in question tested.

Complete Diets for Confinement Feeding of Growing Lambs in the Dry Season

Table 6.2 shows several diets that have been tested with growing lambs of hair sheep breeds kept in confinement during the dry season at the National Goat Research Center at Sobral, Ceará (Northeast Brazil). All of these diets were formulated with maize crop residues as the forage base. Table 6.3 shows the performance of lambs that consumed these diets during a 70-day feeding period.

Table 6.2. Ingredients and chemical composition of experimental diets fed to lambs of hair sheep breeds in confinement (Northeast Brazil). (Adapted from Baroos et al., 1986.)

	Experimental diets											
	1[a]			2[b]				3[c]				
Treatment No.	**1**	**2**	**3**	**2**	**3**	**4**	**5**	**2**	**3**	**4**	**5**	**6**
					Ingredients (%)							
Maize, crop residue												
-whole plant	51			51	51	51	51	51	51	51	51	51
-husks			25.5									
-cob		51	25.5									
Cottonseed meal	28	28	28	28	23	18	13	28	14		14	
Maize, grain	20	20	20	20	20	20	20	20	20	20	20	20
Mata pasto, hay					5	10	15		14	28		
Cunhã, hay											14	28
Common salt	1	1	1	1	1	1	1	1	1	1	1	1
					Chemical composition (% of DM)							
Crude protein	11	10	10	10	9	8	7	10	8	5	9	7
Cell-wall fiber	54	56	56	56	56	57	58	57	68	66	66	68
Lignin				8	9	9	9	6	9	10	8	9

[a] Arruda et al., 1984.
[b] In Treatment 1, Experiment 2, animals were permitted to graze in the caatinga, without supplement.
[c] In Treatment 1, Experiment 3, animals were permitted to graze in the caatinga, with a supplement of 200 g of maize grain per head per day.

Table 6.3. Performance of Santa Inês and Morada Nova lambs kept in confinement and fed the experimental diets described in Table 6.1.

Exper and treat	Intake of DM per day (kg)	Intake of DM per kg met. wt. (g)	Wgt gain g/day	Feed conv.	Cross yield (%)	Thrx diam. (cm)	DM Dig. (%)
Experiment 1 (Santa Inês)							
Ref. amls[a]					44.1	31.4	
Tmt 1	1.3	92	129[b]		52.5	39.0[b]	
Tmt 2	1.2	88	134[b]		48.7[b]	36.3[b]	
Tmt 3	1.2	92	164[b]		50.3	38.4[b]	
Experiment 2 (Morada Nova)							
Tmt 1	*		-11[c]		45.8[c]	29.8[c]	
Tmt 2	1.0[c]	90[c]	95[c]	10.6[c]	47.4[c]	35.0[d]	
Tmt 3	1.0[c]	90[c]	106[d]	9.4[c]	46.2[c]	35.3[d]	
Tmt 4	1.0[c]	95[c]	103[d]	9.9[c]	46.1[c]	33.5[d]	
Tmt 5	1.0[c]	94[c]	93[d]	11.0[c]	46.8[c]	38.8[d]	
Experiment 3 (Santa Inês)							
Tmt 1	**		42[e]				
Tmt 2	1.1[g]	111[g]	122[f]	10.5[e]			56.4
Tmt 3	1.0[g]	104[g]	113[f]	10.4[e]			54.3
Tmt 4	0.7[e]	78[e]	55[e]	13.3[e]			54.6
Tmt 5	1.0[g]	106[g]	116[f]	16.1[e]			56.0
Tmt 6	0.9[f]	91[f]	102[f]	8.1[e]			55.1

[a] Reference animals, slaughtered at the beginning of the experiment.
[b] Means in the same column followed by the same letter are not different (P>0.05; Experiment 1). Reference lambs were not included in the statistical analysis.
[c,d] Means in the same column followed by different letters are different (P<0.05; Experiment 2).
[e,f,g] Means in the same column followed by different letters are different (P<0.05; Experiment 3).
* Control group, grazed in the caatinga with no supplement.
** Control group, grazed in the caatinga with 200 g/day of maize grain, per animal, as supplement.

Initial weight of the lambs was 27, 17, and 20 kg for Experiments 1, 2, and 3, respectively. In Experiment 1, four reference lambs were slaughtered at the outset, and six similar lambs were assigned to each of the three diets. Weight gains on all three diets were excellent, and carcass yield was improved significantly over the reference animals.

In Experiments 2 and 3, the lambs were smaller at the beginning of the trial, and had slightly lower feed intake and weight gains than the lambs of Experiment 1. Lambs from Experiment 2 also

had lower carcass yields than those of Experiment 1, which might be explained by differences in age, weight, or breed.

In Experiment 2, a control group was allowed to graze in the dry caatinga with no supplementation. These lambs lost weight at the average rate of 11 g/day. In Experiment 3 a similar control group grazed in the caatinga, but with 200 g of maize grain offered per animal per day. These lambs gained about 42 g/day, compared with gains of more than 100 g/day for four of the five confinement diets. Lambs on diet 4 (Experiment 3) did not perform as well as those on the other confinement diets, probably because of the lower-than-expected crude protein content of the diet. The experimental matapasto contained less crude protein than earlier samples had indicated. This is an example of the high degree of variability often found in the nutrient composition of tropical feedstuffs.

These results demonstrate that lambs of hair sheep breeds can be fed to maintain positive energy balance and a good rate of gain through the prolonged dry season, using a diet that is relatively inexpensive. The sheep producer, of course taking into account local conditions, can devise a similar diet for feeding his lambs in total confinement or to use as a supplement to dry season caatinga grazing.

Supplemental Diets for Breeding Ewes

Ewes will need no supplementation if they are consuming an adequate amount of high quality forage. For the periods of high nutritional demand (late gestation and early lactation), a forage of at least 60% dry matter digestibility and 12-14% crude protein probably will require no supplement. For optimum performance, however, the ewe will need diet supplementation in direct proportion to the decrease in basal forage quality below these minimum values.

Flushing. The practice of flushing, or providing extra energy for a period of 6 to 8 weeks around breeding, has been demonstrated to be effective in increasing ovulation rate and embryo survival. It is most effective for ewes that are somewhat thin just prior to the breeding period. Ewes in extremely poor condition may not respond to short periods of flushing; ewes that are already in excellent condition may not benefit greatly.

If it is felt that the ewe flock could benefit from flushing, a medium to high energy diet should be provided from about 2 weeks before to about 4 weeks after breeding. The amount fed daily should not be excessive; the goal is for the ewes to be in positive energy balance, so that they will be gaining weight at a moderate rate (30 to 40 g/day) through this period. The amount of supplement will vary with the quality of the basal forage and the energy concentration of the supplement.

Mature ewes should not continue to gain at this rate during the second to fourth month after conception. The supplement should be reduced or removed, so that the ewes will maintain a nearly constant weight during this period. A <u>slight</u> loss of weight, in fact, can be tolerated if the ewe already has reached her mature weight.

Late pregnancy and early lactation. The period starting about 6 weeks before the expected lambing date, and continuing for the first month thereafter, is the most important period, in terms of feeding, in the entire productive cycle of the ewe. The result of under-feeding ewes before parturition will be lambs with low birthweight and low survivability; and, in extreme cases of malnutrition, the ewe will abort. If at all possible, some supplemental feed should be available for emergency use during the last 3 to 4 weeks of pregnancy.

Under-feeding after birth of the lamb will result in poor lamb growth, vulnerability of the lamb and the ewe to disease and parasites, a sub-optimum weaning weight for the lamb, and a ewe that is prone to fertility problems during the next breeding cycle.

All ewes should be gaining weight at the rate of at least 125 g/day during the last few weeks of gestation. First parity ewes should gain even more, as they still have not reached mature weight. Ewes carrying multiple fetuses also should gain more rapidly. Complicating the situation is that the late-gestation ewe has a reduced intake of forage: she has less capacity in the rumen, because of crowding by the fetus; and she is unable to forage as effectively while grazing, especially in late dry season pasture or range conditions. A medium- to high-energy supplement fed at about 1% of the body weight of the ewe per day will be adequate if the basal forage is not below 50% in dry matter digestibility.

A similar level of supplementation may be necessary while the ewe is actively suckling her lamb(s). At this time the ewe is expected to lose weight, but the rate of loss should not be more than 25 g/day if she is suckling a single lamb or 50 g/day for two or more lambs.

Life cycle feeding and productivity. Good nutrition of the breeding ewe will have an immediate effect on her health and productivity. It also will have a carryover effect that can influence her future productivity. Poor nutrition, likewise, will have a carryover effect, resulting in a long-term detriment that will be difficult to overcome.

Reese (1988) reported the results of a long-term supplementation experiment with native sheep in the tropics. These wool sheep were located in a humid environment, but the lessons learned can nonetheless be extrapolated to other situations. The breed she studied was the Javanese Thintail, a small breed long adapted to the tropics. It is a prolific breed, often producing multiple births; at tropical latitudes it is a non-seasonal breeder.

In Reese's experiment, a control group of about 40 ewe-lambs was allowed to graze natural pastures with no supplement. The predominant grasses in this pasture contained about 70% cell-wall fiber, although there were higher quality species available in small amounts. Other similar lambs, about 40 in each group, were placed on low, medium, or high levels of energy supplementation. The three supplemental diets were offered at daily levels of 0.6%, 1.0%, and 1.4% of the body weight of the ewes. Dietary ingredients were adjusted so that daily crude protein intake would be equal for the three supplemented groups. All ewes were kept on the experiment through puberty and first lambing; about half of the

ewes remained on the experiment through several parturitions.

Table 6.4 presents a summary of the lifetime production and reproduction responses to the various levels of supplementation in Reese's experiment. The low and medium groups had similar responses, so they are combined for the purposes of this table. Numerical results are not shown because they are unlikely to be the same with other breeds or in a different climate or pasture type.

Table 6.4. Productivity responses in Javanese thin-tailed ewes fed various levels of supplement, while grazing a natural pasture under rubber trees in the humid tropics.

Feeding period and production response	Supplementation Level		
	None	Low-Medium	High
Post-weaning to conception			
Time to puberty	long	intermediate	short
Conception rate	good	good	excellent
Litter size	medium	medium	high
Late pregnancy			
Lamb birth weight	low	adequate	adequate
Survival of multiple-birth lambs	low	high	high
Late pregnancy/early lactation			
Interval to next conception	moderate	short	short
Subsequent conception rate	good	excellent	excellent
Increase in subsequent twinning rate	slight	slight	large
Lactation period: rate of gain of lambs			
singles	low	adequate	adequate
twins and triplets	(do not survive)	low	adequate

Adapted from Reese, 1988.

Reese's results show that without supplementation, reproductive performance was modest at best. Puberty was delayed, lamb birth weights were low, twin lambs did not survive, and lamb growth rate was low. The low and medium supplementation levels improved all of these parameters. The highest supplementation level brought about three additional improvements in performance above the low/medium levels: time to puberty was further reduced, average litter size increased, and the preweaning growth rate of the twin lambs improved.

An economic analysis of these data, using prices then prevalent at the experimental location, proved that the highest level of supplementation was profitable, whereas the lowest level

was neutral (increased income exactly offset increased feed cost). The medium level resulted in an economic loss, because this increment of supplement, above the lowest level, did not bring about a corresponding improvement in those parameters that help generate more income.

These results demonstrate an important economic point, that just because a little supplement is good does not necessarily mean that a little more will be better. In this case it took a lot more supplement, above the lowest level, to produce an economical response.

The economics, of course, would have to be reassessed for each situation, because both feed prices and lamb prices will vary with time and location.

Conclusion

Feeding strategies are available for optimizing the productivity of hair sheep in a tropical environment. In most situations, feed resources are also available. The producer will want to maximize the utilization of his range or cultivated pasture resource and use strategic supplementation to ensure optimal health and productivity of his flock. Usually this will involve feeding supplemental energy and protein during a prolonged dry season, or when the forage base is low in quality. Not all of the animals in the flock will benefit from supplementation all the time; the successful producer will adapt carefully both the quality and amount of supplementation to the needs of his animals at any given time.

The animals most likely to benefit from a strategic supplementation program are rapidly growing lambs, as well as ewes at time of breeding, late pregnancy, and early lactation.

Literature Cited

Arruda, F.A.V., A.A. de Souza, W.L. Johnson and K.P. Pant. 1984. Avaliação de rações com diferentes níveis de fibra para ovinos. Pesq. agropec. bras., Brasília, 19(6):777.

Barros, N.N., J.R. Kawas, L.C.L. Freire, J.A. de Araújo Filho, J.M. Shelton and W.L. Johnson. 1986a. Digestibility and intake of various native and introduced forages by goats and hair sheep in Northeast Brazil. In: *Goats and Sheep in Northeast Brazil. Proc. of the First Workshop of the Small Ruminant Collaborative Research Support Program.* pp. 219-26. Small Ruminant CRSP, University of California, Davis, California.

Barros, N.N., E.R. Oliveira, T.W. Robb, F.A.V. Arruda, J.R. Kawas and W.L. Johnson. Acabamento de caprinos e ovinos durante a época seca, no nordeste. 1986b. In: *Goats and Sheep in Northeast Brazil: Proc. of the First Workshop of the Small Ruminant Collaborative Research Support Program.* pp. 285-95. Small Ruminant CRSP, University of California, Davis, California.

Burstein, H.J., W.L. Johnson and E.A. Lopes. 1986. Consumption and digestibility of caatinga leaf litter pen fed to native goats. In: *Goats and Sheep in Northeast Brazil. Proc. of the First*

Workshop of the Small Ruminant Collaborative Research Support Program. pp. 227-33. Small Ruminant CRSP, University of California, Davis, California.

Batista, A.R.P.L.; N.C. das Virgens, A.P. Penna, P.C.C. Maia, W.G.P. Campos and A.G.S. da Silva. 1987. *Niveis de fosforo em caprinãos da regio semi-ãrida baiana*. J. Municipio de Uauã, Curaça, Casa Nova e Juazeiro. Boletim de pesquisa, 10. EPABA, Salvador, Brazil.

Brown, L.E., and W.I. Johnson. 1985. Intake and digestibility of wheat straw diets by goats and sheep. J. Anim. Sci. 60(5):1318.

Carneiro, H., O. Sanchez and W.L. Johnson. 1986. Acceptability of tropical forages fed as silage or hay to sheep and goats. In: *Goats and Sheep in Northeast Brazil. Proc. of the First Workshop of the Small Ruminant Collaborative Research Support Program*. pp. 235-41. University of California, Davis, Ca.

Christy, H. 1984. Fatores que interferem com a absorção intestinal de minerais e uma solução para este problema. In: *Simposio Sobre Nutrição Mineral, 1*. Anais. pp. 19-27. São Paulo.

Conrad, J.H. 1984. Administraçãc racional de suplementos minerais a nível de fazenda. In: *Simposio Sobre Nutrição Mineral, 1*. Anais. pp. 57-64. São Paulo.

Gomide, J.A. Composição mineral de gramineas e legumínosas tropicais. 1976. In: *Simposio Latino-Americano Sobre Pesquisa em Nutrição Mineral de Ruminantes em Pastagens*. Anais. pp. 20-33. Universidade Federal de Minas Gerais. Belo Horizonte, Brazil.

Johnson, W.L., T.W. Robb, C.A. Zometa, W.H. Souza, E.R. Oliveira, and P.R.M. Leite. 1986. Confinement diets for dairy goats in Paraiba. In: *Goats and Sheep in Northeast Brazil. Proc. of the First Workshop of the Small Ruminant Collaborative Research Support Program*. pp. 277-83. University of California, Davis, Ca.

Kearl, L.C. 1982. *Nutrient Requirements of Ruminants in Developing Countries*. International Feedstuffs Institute, Logan, Utah.

McDowell, L.R., J.H. Conrad, J.E. Thomas, L.E. Harris and K.R. Fick. 1977. Nutritional composition of Latin American forages. Trop. Anim. Prod. 2:273.

NRC. 1985. *Nutrient Requirements of Sheep*, 6th edition. National Academy Press. Washington, D.C.

Oliveira, E.R., N.N. Barros, T.W. Robb, and W.L. Johnson. 1982. Utilização de restolhos de cultura na alimentação de caprinos e ovinos. EMBRAPA/CNPC Circular Técnica, 4. Sobral, CE., Brazil.

Oliveira, E.R., N.N. Barros, T.W. Robb, W.L. Johnson and K.P. Pant. 1986. Substituição da torta de algodão por feno de leguminosas em rações baseadas em restolho da cultura do milho para ovinos em confinamento. Pesq. agropec. bras., Brasilia, 21(5):555.

Reese, A. A. 1988. Effect of energy supplementation on Indonesian sheep. Ph.D. Thesis, North Carolina State University, Raleigh, NC.

Tokarnia, C.H. and J. Dobereiner. 1987. Doenças causadas por deficiéncias minerais em bovinos em regime de campo no Brasil. In: *Simposio Latino-Americano Sobre Pesquisa em Nutrição Mineral de Ruminantes em Pastagens*. Anais. pp. 398-408. Universidade Federal de Minas Gerais, Belo Horizonte, Brazil.

Underwood, E.J. 1981. *The Mineral Nutrition of Livestock*, 2 Ed. Commonwealth Agricultural Bureau, London.

Chapter 7

REPRODUCTION IN SHEEP

A.M.X. Eloy, A.A. Simplicio, and W.C. Foote

Reproduction, like all physiological processes, is influenced by the physical or climatic environment. It is affected directly when factors such as temperature influence the homeostatic system or as photoperiod acts on the central nervous system. Environmental factors such as precipitation and temperature also influence reproduction processes indirectly, as they affect feed production.

Environmental conditions of arid and semiarid tropics and subtropics are low and usually variable rainfall (extended periods of drought) followed by periods of precipitation. At or near the equator, photoperiod changes do not occur or are negligible, and the seasonal patterns observed at greater latitudes north or south of the equator do not exist or are of little consequence. The major environmental influence of the arid and semiarid tropics and subtropics, such as Northeast Brazil, is the precipitation pattern of drought and rainfall. This is usually referred to as the dry and wet seasons.

In Brazil, the dry and wet seasons were established as occurring from July to February and from March to June, respectively, for reproduction studies.

Sheep are important enterprises for small farmers in Northeast Brazil. The products obtained are meat and skins. Milk production from sheep for use by man is rare in this region. Sheep in these areas may or may not produce wool. Reproduction plays a major role in all aspects of production whether for meat, milk, or fiber. Without reproduction there can be no production. Reproduction also contributes directly to genetic improvement in at least two ways: (1) length of the generation interval, and (2) selection differential because of the level of prolificacy that influences the available number of animals from which replacements can be selected.

Brazil contains several genotypes of sheep including the Crioula, Morada Nova, Santa Inês, Brazilian Somalis, Rabo Largo, and Bergamacia (Shelton and Figueiredo, 1981). Production from sheep in this area is considered to have a strong economic future (Primov, 1982).

Major problems relating to sheep production in tropical environments are the low quantity of forage produced and the seasonality of production related to the prolonged dry periods in the wet-dry tropics. This results in periods of improved production following seasonal precipitation and longer periods of little or no forage production during the subsequent periods of drought. One of the many advantages of sheep is their ability to complete reproduction and lamb production cycles within one year. Because of the long dry periods, however, even though the timing for these cycles can be modified through management, feed resources

Previous Page Blank

often are too limited to provide for both adequate reproduction and lamb growth.

The major challenge in sheep production, particularly in the tropics, is to match the patterns of forage production with reproduction and lamb production cycles to best utilize available feed and other resources. This chapter attempts to describe the reproduction related events in the forage production pattern of wet and dry tropical regions such as Northeast Brazil.

Reproductive Characteristics of the Female

Puberty

Under the most common management conditions in Northeast Brazil, the lambs are left with their dams until they are removed for slaughter. In less traditional management conditions, the lambs are weaned at approximately 4 months of age and grazed on native pasture. Females of most breeds in the tropics reach puberty within 12 months of age with body weight varying from 18 to 28 kg (table 7.1). Puberal estrus is accompanied by ovulation and over 75 percent of the ewes have ovulated prior to this time (Simplicio, et al. 1981, 1982, 1988; Girão et al., 1986). However, in confinement, where nutrition and other aspects of management are improved, puberty may be achieved as early as 3.5 months of age with body weights as heavy or heavier than those obtained at puberty on native pasture (Silva et al., 1984; Johnson et al., 1985; Foote et al., 1986).

The body weight of adult females from the Morada Nova, Santa Inês, and Somali breeds are 30-35, 40-45, and 25-30 kg, respectively. Assuming that ewe lambs attain 60% of the adult body weight at breeding time, it is possible to obtain satisfactory fertility and prolificacy at first lambing at 15-17 months of age (EMBRAPA, 1983).

Based on the Morada Nova, Brazilian Somalis, and Santa Inês in Northeast Brazil (Silva et al., 1984; Riera and Foote, 1987), the onset of puberty was not influenced by time of year, and the mean body weight at puberty represented 72% of the adult dam body weight at parturition. The same authors also reported a negative correlation between age and weight at puberty, demonstrating that level of nutrition, through its effects on body weight, influences age at puberty; heavier lambs reach puberty at a younger age.

Puberty in the Tabasco (Pelibuey) sheep under tropical conditions was recorded at 300 days and 22.8 kg (Rojas et al., 1977). Tabasco sheep had a lower weight at puberty when compared with sheep in temperate or cold climates (Anderson, 1973; Hafez, 1968). The first estrus in Pelibuey sheep under confinement in Mexico was recorded at 320 days and under native pasture 405 days (Ponce de Leon et al., 1981). These authors concluded that the first estrus in this breed is determined by nutritional and seasonal effects.

Williamson and Payne (1968) report that in general, the first estrus in breeds of sheep under tropical conditions occurs at approximately 12 months of age, but nutrition, through its effects on body weight gain and thus body weight, is a factor that also influences age at puberty.

Table 7.1. Least square mean of weight (kg) and age (day) at puberty (first estrus) in weaning lambs at 112 days and grazing native pasture. Sobral, Ceará, Brazil[1].

Variables	n	Weight	Age
General mean	112	20.66 ± 0.30	306.31 ± 6.30
Breed			
Morada Nova	32	22.49 ± 0.72[b]	277.46 ± 15.09[a]
Somali	63	18.63 ± 0.40[a]	321.61 ± 8.45[b]
Santa Inês	17	27.68 ± 0.77[c]	274.47 ± 16.19[a]
Type of Parturition			
Single	50	24.32 ± 0.59[b]	280.13 ± 12.30[a]
Multiple	62	21.54 ± 0.47[a]	302.22 ± 9.92[a]
Breed x type of parturition			
Morada Nova x single	6	25.10 ± 1.30[a]	249.83 ± 27.21[a]
Morada Nova x mult.	26	19.87 ± 0.62[c]	305.08 ± 13.07[abc]
Somali x single	35	18.39 ± 0.60[c]	314.00 ± 11.27[a,c]
Somali x multiple	28	18.39 ± 0.60[c]	329.21 ± 12.60[c]
Santa Inês x single	8	29.00 ± 1.06[b]	276.56 ± 22.22[a,b]
Santa Inês x multiple	9	26.35 ± 1.12[a,b]	272.38 ± 23.56[a]

[1] P<.01 for means not bearing the same superscript letter.

Source: Simplício et al., 1981; 1989.

Estrous Cycles and Periods

The average duration of estrous cycles over all breeds in Northeast Brazil is 18.2 (7-43) days and is not influenced by wet or dry seasons. The normal range for estrous cycle length varies from 14 to 19 days. The average length of the estrous period over all breeds is 31.3 (6-96) hours (Simplício et al., 1981; Girão and Simplício, 1988) [tables 7.2 and 7.3].

Ovulation in sheep occurs near the end of the estrous period (Carles, 1983). External factors such as suckling, presence of the ram, photoperiod, and probably nutrition exert an influence on estrous activity in the tropics (Carles, 1983). Under some conditions, seasonal variations have been reported to occur in tropical or subtropical areas that are not apparently associated with drought or feed production. The incidence of ovulation and estrus varies during the year for the Corriedale, Junin, and Crioula breeds in the central highlands of Peru and is highest around May, early winter in the southern hemisphere (Cumming, 1977; Cumming and Findlay, 1977). These variations in estrus and ovulation did not appear to be related to nutrition as the animals were maintained under management conditions in which feed was supplemented.

Table 7.2. Mean (SD) duration of estrus period (hour) and estrous cycle (day) in hair sheep grazing in native pasture in Sobral, Ceará, Brazil.

Variables	Estrous Period	Estrous Cycle
General mean	31.3 ± 0.34 (897)[2]	18.2 ± 0.1 (720)
Years		
1978	29.2 ± 1.1[1] (159)	18.4 ± 0.5[a] (132)
1979	31.5 ± 0.7[a] (409)	18.1 ± 0.3[a] (330)
1980	29.8 ± 0.7[a] (329)	18.2 ± 0.3[a] (258)
Seasons		
Rainy	30.3 ± 0.6[a] (428)	18.5 ± 0.3[a] (318)
Dry	30.0 ± 0.7[a] (469)	18.0 ± 0.3[a] (402)
Breeds		
Somali	31.2 ± 0.7[a] (324)	18.9 ± 0.3[a] (260)
Morada Nova	30.2 ± 0.8[a] (300)	17.4 ± 0.3[b] (245)
Santa Inês	29.1 ± 1.0[a] (273)	18.4 ± 0.4[a,b] (215)

[1] P<0.05 for means not bearing the same superscript letter.
[2] () indicates number of observations.

Source: Simplício et al., 1981; Girão and Simplício, 1988.

Table 7.3. Ovulation rate, weight (kg) and age (day) at puberty in lambs weaned at 112 days and submitted to different systems of nutritional management. Sobral, Ceará, Brazil.[1]

Variable	Ovulation Rate	Weight	Age
General mean	1.13	25.17 ± 5.78	303.50 ± 68.23
Breed			
Somali (24)[2]	1.14	21.88 ± 0.62[a]	335.40 ± 12.82[a]
Santa Inês (24)	1.04	29.75 ± 0.61[b]	282.97 ± 14.84
Morada Nova (24)	1.23	23.88 ± 0.64[a]	292.13 ± 11.77[b]
Nutritional Management			
Confinement	1.09	28.16 ± 0.53[a]	250.20 ± 9.56[a]
Native pasture	1.17	22.18 ± 0.53[b]	356.91 ± 9.56[b]

[1] P<.01 for means not bearing the same superscript letter.
[2] () number of animals.

Source: Silva et al., 1984.

In Mexico, Rojas et al. (1977) found the overall length of the estrous period to be 28.4 hours for sheep. There was, however, a tendency for young lactating ewes to show a shorter estrous period than those not lactating or that had not yet produced lambs. Joubert (1962) reported that for the Merino breed and its crosses in South America, estrous period length was 29.2 hours. This is similar to the estrous period length of 31.3 hours reported by Simplicio et al. (1981, 1985) in Brazil for several different breeds of sheep combined. Zarazua et al. (1975) reported estrous period lengths of 24-48 hours in Mexico.

Postpartum and Parturition Intervals

Postpartum interval (PPI) or the period from parturition to first postpartum estrus varies in native hair sheep in Northeast Brazil from 50 to 80 days and is not influenced by the number of previous parturitions. However, the postpartum interval does appear to be influenced by type of birth (single or multiple), by breed, and by year (Silva et al., 1986; Simplicio et al., 1988) [table 7.4]. The consistent differences occurring among years probably reflect the influences of precipitation and its direct effect on the availability of both quantity and quality of forage.

Table 7.4. Post-partum estrus interval (day) in hair sheep under native pasture. Sobral, Ceara, Brazil.

Variables	n	Media ± e.p.[1]
General mean	279	64.96 ± 1.42
Year		
1980	73	66.57 ± 3.40[b]
1981	95	84.35 ± 2.79[c]
1982	111	52.98 ± 3.12[a]
Breed		
Morada Nova	89	65.04 ± 3.20[a]
Somali	118	61.90 ± 2.91[a]
Santa Inês	72	76.96 ± 4.51[b]
Type of parturition		
Single	175	63.67 ± 2.28[a]
Multiple	104	72.26 ± 2.66[b]
Age		
Young	66	62.83 ± 3.58[a]
Adult	213	68.22 ± 1.97[a]

[1] P<.05 for breed and type of parturition and P<.01 between years for means not bearing the same superscript letters.

Source: AA. Simplicio, 1988; Girão and Simplicio, 1988.

Riera and Foote (1987) have reported that differences in the postpartum interval occurred among breeds in Northeast Brazil. The interval was longest for the Santa Inês, intermediate for the Morada Nova, and shorter for the Brazilian Somali. Significant year variation suggested the important role of difference in feed availability. Also, it was suggested that the shorter PPI for the Somali may be because of, at least in part, better adaptation to the drought conditions of Northeast Brazil. Intervals between parturitions in the native hair sheep in Northeast Brazil have been reported from 8 to 9 months where females are exposed continuously to males (Simplicio et al., 1980b, 1982; Girão et al., 1986; Guimarães Filho et al., 1982). Considering a gestation period of 5 months, this indicated an interval of 3 to 4 months from parturition to conception and establishment of the subsequent pregnancy. This demonstrates that lambing can be accelerated and the potential role of management in shortening the parturition interval and in matching the reproduction cycle to annual feed production cycles. Lambing intervals of 8 to 9 months are reported to be quite common in some tropical areas (Carles, 1983).

In lactating Pelibuey ewes in Mexico, the first postpartum interval is reported to vary from 46.2 days (Cruz et al., 1982) to as long as 164.4 days (Valencia et al., 1981) depending upon environmental, management and feeding conditions. Zarazua et al. (1975), also in Mexico, reported postpartum intervals 25 to 60 days for the same breed.

Seasonality Patterns of Reproduction

The hair sheep in Northeast Brazil demonstrate estrous cycles throughout the year as referred to earlier, but the incidence is higher during some periods, apparently because of the environment (Murray, 1970; Silva, et al., 1987; Gonzales, 1984). The effect of photoperiod (Land et al., 1973) and the availability of better quality pasture during the rainy season (Gonzales, 1984) has been reported to regulate the occurrence of the estrous cycles and also to affect ovulation rate (Silva et al., 1987) (fig. 7.1, 7.2, 7.3).

In another study in Northeast Brazil, Figueiredo et al. (1983) reported that 43% of the estrous cycles occurred at the beginning of the wet season under extensive conditions and consequently a higher percentage of parturitions occurred during the dry season. Simplicio et al. (1980b) (table 7.5) showed two peaks of parturitions for native sheep in Northeast Brazil. Silva et al. (1987) also reported an increase in the incidence of ewes that ovulate and in ovulation rates during the rainy season. Guimarães Filho et al. (1982) reported that nutritional supplementation in the critical periods of the year increase the reproduction and production performance. Riera and Foote (1987) reported that the breeds of sheep in Northeast Brazil naturally breed throughout the year, but nutritional stress can limit this reproductive trait. Singh (1965) reported that the level of nutrition positively influenced the number of lambs born and the interval between parturitions.

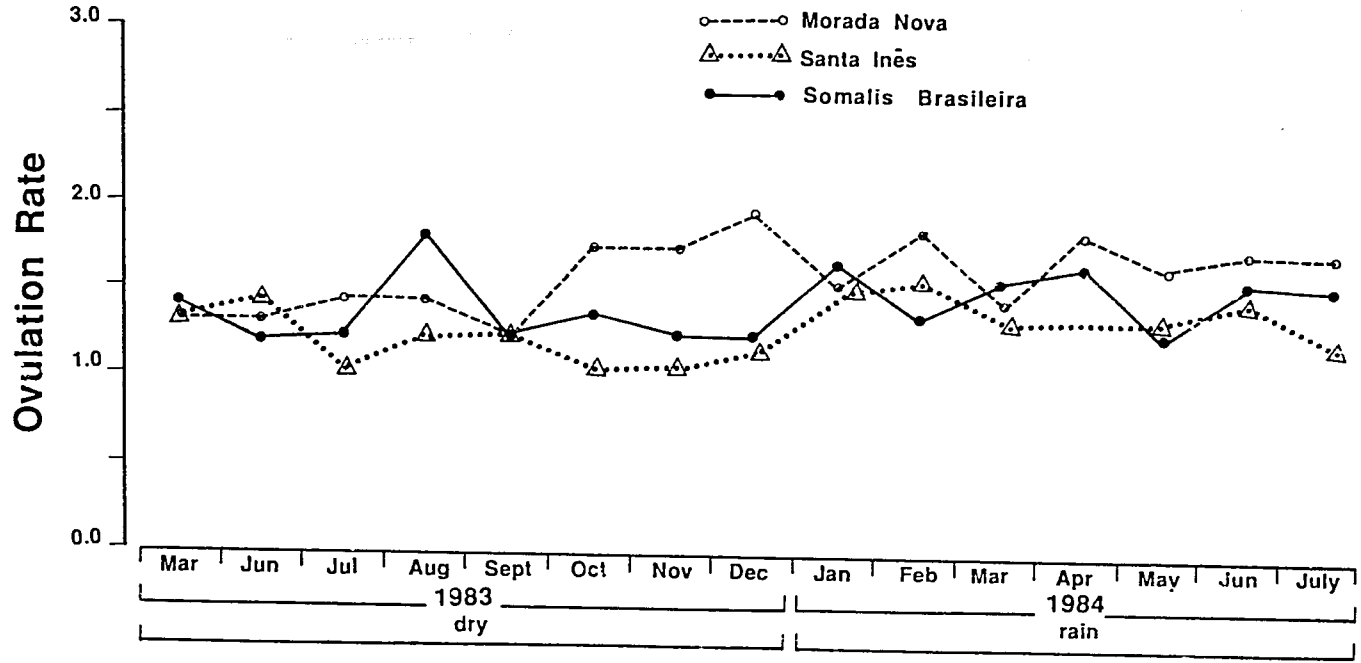


Figure 7.1. Ovulation rate of females Morada Nova, Santa Inês and Brazilian Somalis in relation to months of the year in dry (1983) and rainy (1984) periods.

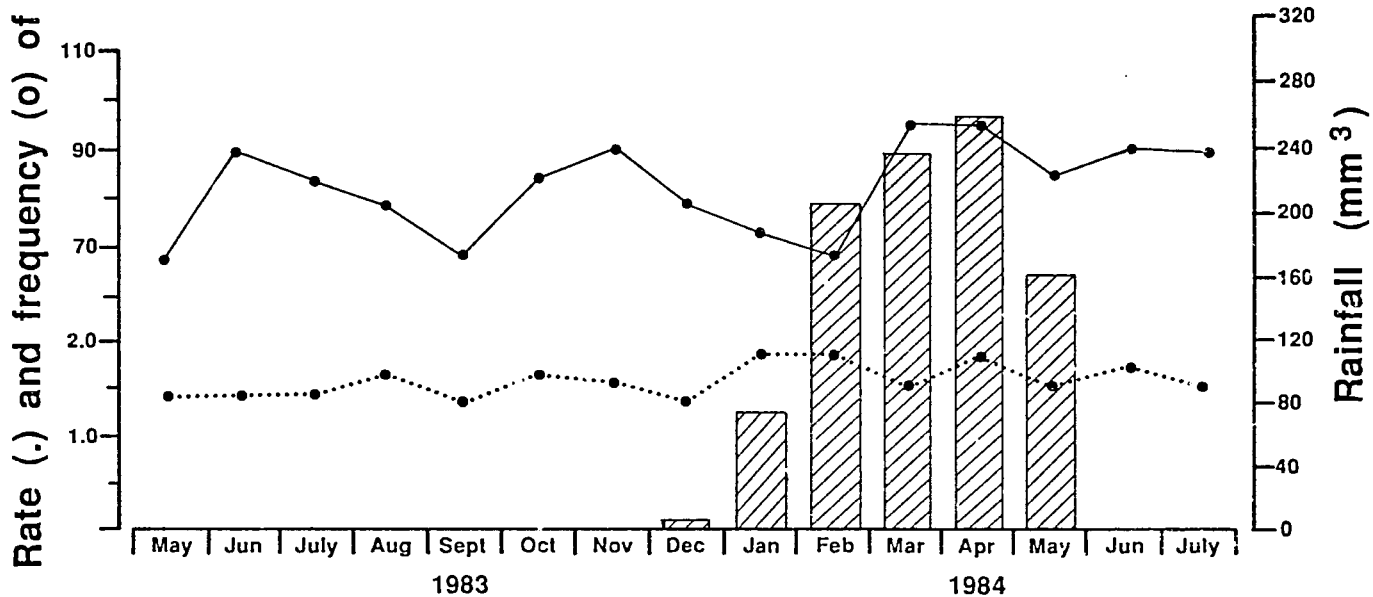


Figure 7.2. Rate and frequency (%) of ovulation (graphic) of females of hair sheep Morada Nova, Santa Inês, and Brazilian Somalis, in relation to seasonal precipitation (histogram).

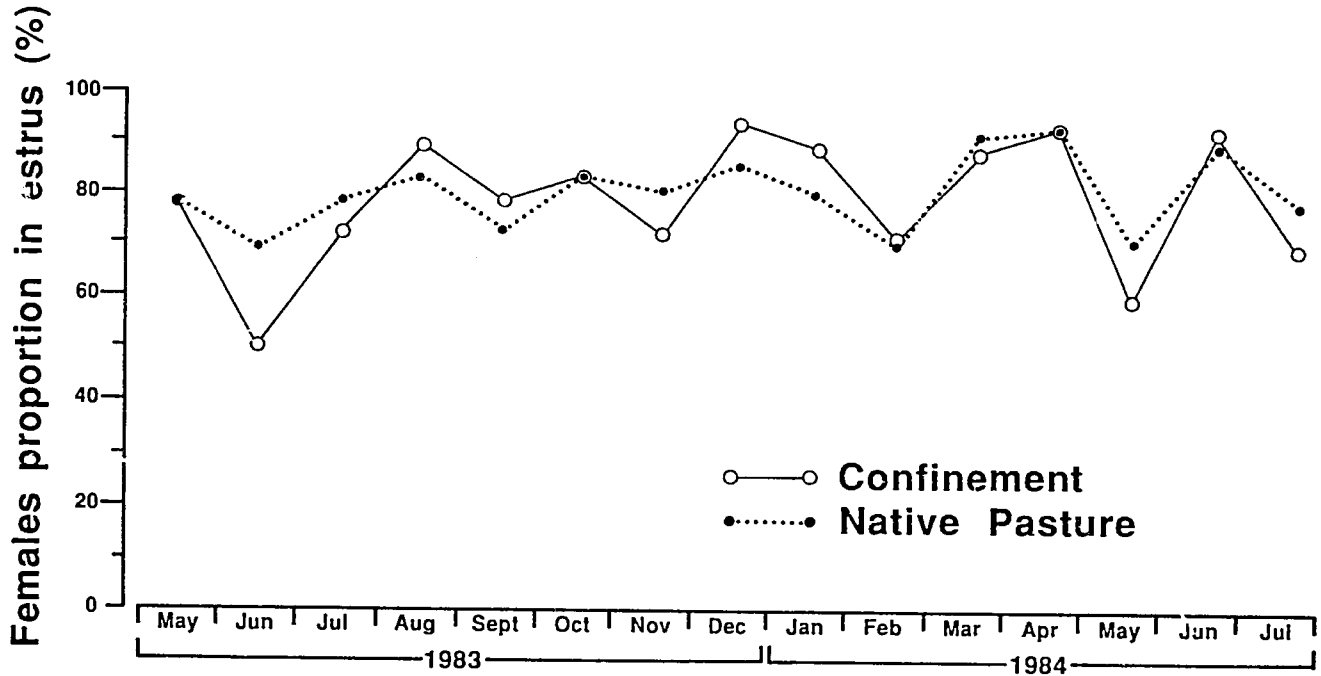


Figure 7.3. Proportion of female hair sheep Morada Nova, Santa Inês, and Brazilian Somalis breed, in confinement and native pasture, in estrus, in dry (1983) and rainy (1984) periods.

Table 7.5. Distribution of parturition in native sheep from June 1978 to July 1979. Sobral, Ceara, Brazil.

Month	N	%
June	3	4.41
July	5	7.35
August	2	2.49
September	7	10.29
October	8	11.76
November	5	7.35
December	1	1.47
January	2	2.94
February	5	7.35
March	14	20.58
April	0	0.00
May	9	13.23
June	3	4.41
July	4	5.88
Total	68	100.00

Simplicio et al., 1980b.

Reproduction Performance

Level and efficiency of reproduction is determined by fertility, prolificacy, parturition interval, and longevity of ewes (Vivanco et al., 1986). Rojas et al. (1977) reported an increased conception rate (93.5%) during the first 60 days of the breeding season when mating occurred 20 hours after the beginning of estrus. Fertility of native hair sheep in Northeast Brazil, when managed in native pasture, varies from 74% to 100% and the prolificacy varies from 1.1 to 2.0 (Figueiredo and Arruda, 1980; Souza et al., 1984; Girão et al., 1986). The reproductive performance of Morada Nova, Santa Inês, and Brazilian Somali from 1979 to 1983 is shown in table 7.6 (EMBRAPA, 1983).

Weight at birth and the interval from parturition to first suckling was measured in Santa Inês, Morada Nova, and Brazilian Somali breeds. Significant differences occurred among breeds for prolificacy, birth weight, and time to first suckling. The Morada Nova had higher prolificacy (1.62) and shorter time to first suckling (22 min.) than the Santa Inês (1.38 and 28) and the Brazilian Somali (1.30 and 41), respectively. The correlations between birth weight and time to first suckling and weaning weight and time to first suckling, were each negative and statistically significant. Although the Morada Nova had the shortest time to first suckling, early lamb losses were also higher. The increased lamb loss was apparently because of increased prolificacy. Within breeds, lamb losses occurred at a younger age for those lambs with longer interval to first suckling.

Methods of monitoring reproductive processes have been

developed for use in both research and practical application by the producer. Methods of pregnancy diagnosis useful to the producer include the use of teaser or aproned rams with painted briskets for determining mating. This must be done during periods when ewes will demonstrate estrus if not pregnant. This method is effective approximately one cycle length after breeding. The abdominal palpation of ewes also provides a reasonable method of determining if a ewe is pregnant, particularly during later stages of pregnancy. The use of ultrasound equipment also can provide an accurate diagnosis from about 60 to 120 days post breeding. Levels of accuracy usually exceed 90% (Riera et al., 1981).

Table 7.6. Reproductive development of hair sheep grazing native pastures with a breeding season of 60 days of duration, in dry period from 1979 to 1983. Sobral, Ceará, Northeast Brazil.

	Breed/Adult Animals					
	Morada Nova (128)		Santa Inês (114)		Somali (157)	
	N	%	N	%	N	%
Mating	128	100.00	113	99.12	155	.73
Abortion	4	3.13	12	10.53	9	5.73
Stillbirth	-	0.00	1	0.88	-	0.00
Normal parturition	115	89.84	94	82.46	127	80.89
Surgery[1]	1	0.78	-	0.00	-	0.00
Fertility	120	93.75	107	93.87	436	86.62
Dry females	8	6.25	7	6.14	21	13.38
Number of lambs	186	-	122	-	175	-
Prolificacy	-	162	-	130	-	138
Sexual proportion	-	60.97	-	51.63	-	53.14
Gestation period (day)	115	150.18 ± 1.16	95	151.00 ± 1.51	127	148.49 ± 1.50

[1] Laparotomy made in a female. The animal was pregnant.

Source: EMBRAPA, 1983.

Reproductive Characteristics of the Male

Seasonal patterns of semen characteristics, libido, and scrotal measurements were recorded for the Brazilian Somalis and Santa Inês breeds in Northeast Brazil (Simplicio et al., 1982b; Riera and Foote, 1987). Significant differences occurred for some semen characteristics such as volume, motility, and concentration, but were not consistent among experiments. An inverse relationship appeared to exist between volume and concentration. There were no clear annual patterns including any consistent indication of a wet and dry season effect. A period of approximately 6 to 7 weeks is required for spermatogenesis to be completed and measurements made. The data collected during one season, in at least some cases, may reflect an effect of the previous season.

Consistent annual changes in libido or scrotal measurements were not detected. These results substantiate that rams in Northeast Brazil are fertile throughout the year. Vivanco (1986), working with indigenous breeds of sheep in the central highlands of Peru, has shown a relationship between age at puberty and release of the penis from prepuberal attachment in the sheath.

The penis is free just before puberty (presence of viable sperm) and can be used as a practical measure of the occurrence of puberty or first fertilizing ability. This can be used to determine when ram lambs must be separated from females to avoid mating.

Acknowledgement

The authors gratefully acknowledge the contribution of the late Dr. G. Simon Riera who played a major role in the planning, conduct, and interpretation of research related to reproduction and management at CNPC/EMBRAPA from 1979-1986.

Literature Cited

Anderson, J. 1973. The estrous cycle in Merino, Masai and Somali sheep. Anim. Breed. Abstr. 41(8):391.

Anuario Estatistico Do Brasil. 1985. Rio de Janeiro. IBGE. v. 46, 760 p.

Carles, A.B. 1983. Sheep Production in the Tropics. Oxford University Press, New York.

Cruz, C., B. Ramirez and S. Fernandez-Baca. 1982. Características reproductivas del ovino Tabasco: pubertad, actividad ovarica posparto y ciclos estrales. In: *Memorias del Congresso Nacional de Buiatria*. Veracruz, Mexico.

Cumming, I.A. 1977. Relationships in the sheep of ovulation rate with liveweight, breed, season and plane of nutrition. Aust. J. Exp. Agr. Anim. Husb. 17:234-41.

Cumming, I.A. and J.K. Findlay. 1977. Evolution of ovarian function in sheep and cattle. Reproduction and Evolution, Int. Symp. Compl. Biol. Reprod., 4, Canberra. pp. 223-5.

Empresa Brasileira de Pesquisa Agropecuária. 1983. *Relatorio Técnico Anual de 1982*. Centro Nacional de Pesqiusa de Caprinos, Sobral, CE.

Figueiredo, E.A.P., E.R. Oliveira, C. Bellaver and A.A. Simplicio. 1983. Hair sheep performance in Brazil. In: H.A. Fitzhugh and G.E. Bradford (Ed.) *Hair Sheep of Western Africa and the Americas: A Genetic Resource for the Tropics*. pp. 125-40. Westview Press, Boulder, Colorado.

Figueiredo, E.A.P. and F.A.V. Arruda. 1980. Produtividade de Ovinos Santa Inês, Variedade Preta e Branca na Região dos Inhamuns-Ceará. Pesquisa em andamento, 3. EMBRAPA-CNPC, Sobral, Ceará.

Foote, W.C., G.S. Riera and A.A. Simplicio. 1986. Factors effecting reproduction. In: *Reunião Técnico-Cientifica do Programma de Apoio a Pesquisa Colaborativa de Pequenos Ruminantes, 1*. Anais. pp. 371-84. EMBRAPA-CNPC, Sobral, CE.

Girão, R.N., L.P. Medeiros and E.S. Girão. 1986. Dexempenho de ovinos deslanados da raça Santa Inês, submetidos a um programa de

tres estações de cobrição em dois anos, no municipio de Campo Maior, PI. In: *Seminario de Pesquisa Agropecuária do Piauí*. EMBRAPA-VEPAE de Teresina, Teresina, PI.

Girão, R.N. and A.A. Simplício. 1988. Eficiencia reprodutiva de ovinos deslanados no Nordeste de Brasil. In: *Congresso Brasileiro de Reprodução Animal, 7, Anais*. Belo Horizonte, M.G.

Gonzales, C. 1984. Comportamiento reproductivo de las razas locales de ruminantes en el tropico americano. In: *Reproduction des ruminantes en zone tropicale*. pp. 1-83. INRA, Point-à-Pitre, Guadaloupe.

Guimarães Filho, C., A.M. Maia, T.N. Padilha, S.G. Albuquerque and E.A.P. Figueredo. 1982. Efeito da suplementação volumosa e mineralização mais vermifugação no desempenho de ovinos e caprinos. I. Performance reprodutiva. Boletim de Pesquisa, 16. EMBRAPA-CPATSA, Petrolina, Brazil.

Hafez, E.S.E. 1968. *Reproduction in Farm Animals*, second edition. Lea & Febiger, Philadelphia, PA.

Joubert, D.F. 1962. Sex behavior of purebred and crossbred Merino and Blackhead Persian ewes. Reprod. Fert. 3:41.

Johnson, W.L., N.N. Barros, E.R. Oliveira, A.A. Simplício and G.S. Riera. 1985. *Feeding to Influence Age of Puberty in Tropical Hair Sheep*. SR-CRSP-EMBRAPA, Sobral, CE, Brazil and North Carolina State University, Raleigh, North Carolina.

R.B. Land, J. Pelletier, J. Thimonier and P. Mauleon. 1973. A quantitative study of genetic differences in the incidence of oestrus, ovulation and plasma luteinizing hormones concentration in the sheep. J. Endocrinol. 58:305.

Primov, G. 1982. Small Ruminant Production in the Sertão of Ceará, Brazil. A Sociological Analysis. SR-CRSP Technical Report 6. University of Missouri, Columbia, Missouri.

Ponce de Leon, J.M., Z.M. Valencia, A.A. Rodriguez and P.E. Gonzalez. 1981. Effecto del sistema de alimeatacion y epoca de nacimiento sobre la aparicion del primer celo en borregas Pelibuey. In: *Memorias de la XV Reunion Anual del Instituto Nacional de Investigaciones Pecuarias*. p. 39.

Riera, G.S., A.A. Simplício, and W.C. Foote. 1981. Diagnostico de prenhez em Ovelhas das raçes Morada Nova, Santa Inês e Brazilian Somalis. In: *IV Symposio Nacional de Reprodução Animal*. p. 47. Bilo Horizonte M.G.

Riera, G.S. and W.C. Foote (ed.). 1987. *Improving Reproductive Performance of Small Ruminants*. USAID Title XII Small Ruminant CRSP Brazil, Peru, USA. Final Reports. Utah State University, Logan, Utah.

Rojas, H.C., J.J.H. Ledezma, J.M. Berruecos and J.J.L. Angeles. 1977. Comportamiento reproductivo del borrego Tabasco mantenido en clima tropical. III. Pubertad y duracion del estro. Tec. Pec. Mex. 32:32.

Shelton, M. and E.A.P. Figueiredo. 1981. Types of sheep and goats in Northeast Brazil. Int. Goat and Sheep Res. 1(4):258.

Silva, A.E.D.F., J.F. Nunes, G.S. Riera, N.N. Barros, E.A. Lopes and W.C. Foote. 1984. Influencia da nutrição na atividade ovariana e apos a puberdade em ovinos das raças deslanadas. In: Simposio Nacional de Reprodução Animal, 5. Anais. Colegio Brasileiro de Reprodução Animal, Belo Horizonte.

Silva, A.E.D.F., M.M. Unanian and N.N. Barros. 1986. Efeito da suplementação no desempenho produtivo e reprodutivo de ovelhas deslandas no Nordeste. Pesq. Agropec. Bras. 21(9):987.

Silva, A.E.D.F., W.C. Foote, G.S. Riera and M.M. Unanian. 1987. Efeito do manejo nutricional sobre a taxa de ovulação e de foliculos no decorrer do ano, em ovinos deslanados no Nordeste do Brasil. Pesq. Agropec. Bras. 22(6):635.

Simplicio, A.A., F.B.T. Pinto and J.F. Nunes. 1980a. Comportamento productivo de ovinos Sem Raça Definida (SRD) submetidos as manejo tradicional de criação. In: *Renuião Anual da Sociedade Brasileira de Zootécnia, 17*. Anais. p. 213. Sociedade Brasileira de Zootécnia, Fortaleza.

Simplicio, A.A., G.S. Riera and E.A.P. Figueiredo. 1980b. Avaliação produtiva de ovinos tropicais. In: *Reunião Anual da Sociedade Brasileira de Zootécnia, 17*. Anais. p. 213. Sociedade Brasileira de Zootécnia, Fortaleza.

Simplicio, A.A., G.S. Riera and J.F. Nunes. 1981. Ciclo estral e estro de ovelhas das raças Morada Nova, Santa Inês e Somalis. In: *Simposio Nacional de Reprodução Animal, 4*. Anais. p. 30. Colegio Brasileiro de Reprodução Animal, Belo Horizonte.

Simplicio, A.A., G.S. Riera, E.A.P. Figueiredo and J.F. Nunes. 1982a. Desemphenho produtivo de ovelhas da raça Somalis Brasileira no Nordeste do Brasil. Pesq. Agropec. Bras. 17(12):1795.

Simplicio, A.A., G.S. Riera, E.A. Nelson and K.P. Pant. 1982b. Seasonal variation in seminal and testicular characteristics of Brazilian Somali rams in the hot semi-arid climate of tropical Northeast Brazil. J. Reprod. Fert. 66(2):736-38.

Simplicio, A.A., G.S. Riera, E.A.P. Figueiredo and W.C. Foote. 1988. Puberty in lamb ewes of Morada Nova, Santa Inês and Somali breeds. Int. Goat and Sheep Res. (In press.)

Singh, S.N. 1965. Investigation on the quality of wool and meat in relation to the nutrition of sheep. Final Report of the Indian Council of Agricultural Research Scheme. 1960-1965. Agra.

Souza, W.H., P.R.M. Leite, W.S. Correia, C.A. Zometa and H.A. Couto. 1984. *Avaliação da Produtividade de Ovinos Santa Inês na Micro Região dos Cariris Paraibanos*. EMEPS Pesquisa em andamento, 12. EMEPS, João Pessoa, PB.

Valencia, Z.M., A.M. Heredia y E. Gonzalez. 1981. Estacionalidad reproductiva en la oveja Pelibuey. In: *Memorias de la XV Reunion Anual del Instituto Nacional de Investigaciones Pecurias*. p. 34. Mexico.

Vivanco, H.W., W.C. Foote, C. Novoa, G. Sides, G.S. Riera, H. Cardenas and J. Camancho. 1986. Estrus and ovulation in Criollo, Corriedale and Junin sheep in the Central Sierra of Peru. Small Ruminant Collaborative Research Support Program Technical Report Series 65. SR-CRSP. Utah State University, Logan, Utah.

Williamson, J. and W. Payne. 1968. *An Introduction to Animal Husbandry in the Tropics*, second edition. Longman, London.

Zarazua, M.V., H.C. Rojas and J.M.V. Berruecos. 1975. Reproduction y manejo del borrego Tabasco o Pelibuey. Tec. Pec. Mex. 29:66-72.

Chapter 8

HERD HEALTH MANAGEMENT OF SHEEP IN THE SEMIARID TROPICS

H.J. Olander, H.E.A. Berne, J. Santa Rosa, and L. da S. Vieira

Information presented here has been derived from the experiences of a number of people associated with the University of California-Animal Health Project of the Small Ruminant Collaborative Research Support Program at the Brazilian National Goat Research Center in Sobral, Ceará State, Brazil. What is presented is a distillate of some perceptions of herd health problems in semiarid Northeast Brazil, how they might be managed, and how they relate to those of other semidesert regions. This chapter is not intended to cover all aspects of herd health management of sheep in the semiarid tropics. Published texts describing the specific diseases and health problems of sheep are available and provide the necessary practical information on methods for their control, treatment, and management more fully than is possible here (Hall, 1977; Howard, 1981; Jensen and Swift, 1982; Martin, 1983; Thedford, 1983).

No other factors are as important in the control of disease as the design and management of the husbandry system. Noninfectious diseases often result directly from mismanagement, and correction of the management factors, such as nutritional or environmental aberrations, may represent the cure. On the other hand, infectious diseases often are predisposed by management factors that determine the balance between an animal's resistance and the challenge of potential pathogens. Controllable management factors can affect both the ability of the animal to respond to infection and the severity of exposure to agents of disease. The success of preventing losses because of infectious disease generally will reflect the extent to which the manager is willing to control those factors. The choices to be made usually are complicated by financial considerations. Nevertheless, the manager decides what the system will be and how well it will function, and financial reckoning ultimately will include the losses from disease as well as the cost of prevention.

The severity of challenge by a disease agent is determined by its virulence and numbers. To a large extent, these can be controlled by several theoretically simple management practices that should be followed in establishing a flock health program.

Use of isolation. Healthy animals in any one flock environment have established an equilibrium between their resistance and any potential agents of disease with which they live. The animals' resistance to newly introduced agents is unpredictable, and such exposure should be avoided. For optimum protection, the sheep flock should be kept as free as possible from contact, direct or indirect, with other sheep or goats. But this often will not be possible. This requires an isolated area and control of all traffic. A closed flock without additions of new animals from other sources is desirable, but if and when new animals are added it should be done carefully, in a controlled fashion.

Previous Page Blank

Acquiring animals. Importation of animals from external political entities, i.e., foreign countries or different states, likely will be affected by regulations imposed by the country of import or export or both. Usually these must be handled by official veterinary health officers. The restrictions and procedures are usually established to protect the commercial trade and animal industries of the countries involved. Some of the methods used are applicable to the livestock producer's needs in establishing and maintaining a healthy herd.

When acquiring animals, only healthy, disease-free animals should be brought into the flock. This requires that you know the flock from which new animals originate and how it is managed, including disease control practices. Prophylactic antibiotic treatments and vaccinations in the source flock may mask the presence of disease agents. The number of sources of animals should be as limited as possible. A single source is best, and sales where conventionally raised sheep from a number of sources are mixed should be avoided. When animals of various origins are mixed, even though they appear healthy, there is likely exposure of susceptible animals from one flock to new pathogens from another. Animals with a high level of resistance to pathogens with which they coexist may develop disease and become active shedders when stressed by transport, co-mingling, environmental changes and other factors. This virtually assures the spread of disease to less resistant contact animals.

Use of quarantine procedures. When it is necessary to add animals, e.g., acquisition of new breeding lines, they should be kept in separate isolation for at least two weeks and observed to be free of disease before being integrated into the flock. In large flocks with a high potential for loss, placing young susceptible animals from the flock with the animals in quarantine and using available serologic tests for potentially dangerous diseases, such as bluetongue, would be a reasonable further precaution.

Care in introducing new animals. Because the recipient flock may be harboring pathogens which are controlled by an acquired resistance, new animals should be introduced gradually to the flock environment. This might be accomplished by placing a few healthy animals from the flock or manure from the nursery environment in the quarantine pens with the newly arrived animals.

Preparation of the environment. When possible, new flocks should be established in environments in which sheep or goats never have been maintained. In the likely absence of such virgin surroundings, allowing the facilities to remain free of sheep or goats for a prolonged period, preferably through one or more dry seasons, can lessen the danger of disease carry over. Thorough cleaning and sanitizing, painting, or even burning of contaminated facilities and repeated cultivation, prolonged drying, and exposure to sunlight of corrals and pastures will further lessen the risks. Such methods may be, or seem to be, impractical, but the level of health in the flock usually will reflect the level of care taken to protect it. In some cases, areas of particular danger or difficulty may be eliminated by preventing access to them by the animals, e.g., by fencing off or burying the source of contamination. The same procedures can be used after removal of a diseased herd during an eradication and repopulation procedure.

Hygiene. Cleanliness is the major means of minimizing the number of pathogens in the environment. Where really thorough cleaning of all animal holding facilities can be carried out regularly, not only can the chance for occurrence of disease be lessened, but the severity of disease outbreaks can be reduced markedly, especially if coupled with rapid recognition and removal of diseased animals from the flock.

In general, achievement of the ultimate objective of maintaining animals in a relatively normal state of health to attain normal productivity and use involves the same goals in the semi-arid tropics as elsewhere. However, the vagaries and extremes of climate, availability of feed stuffs, and economies that often characterize the semi-arid tropics may require approaches that are unique to a specific locale or may make achievement of these goals impossible.

Environmental Management for Improvement of Flock Health

The main constraints on animal health in the semi-arid tropics are the closely interrelated factors of climate, nutrition, and disease. The general seasonal variation from wet to dry and the corresponding variation in quality and available forage can have marked effects on the nutritional status of the animals. During periods of drought, the major factor associated with ill health is poor nutrition involving both inadequate caloric intake and specific nutritional deficiencies and imbalances. Some infectious diseases actually may become less prevalent in dry seasons than in wet because the causative agents are less likely to survive outside of the animal. Extreme drying, heat, and sunlight have markedly suppressive effects on many microbes that have a phase of their life cycle in the external environment. In contrast, some agents have mechanisms for survival in harsh environments, such as spore formation or persistence in protective fomites, and their associated diseases may become prevalent in arid environments. Still other agents that persist in their host animals or that are contagious and spread directly from animal to animal may become extremely devastating in the late dry or early wet seasons when animals are weakened by malnutrition and dehydration.

Poisoning by ingestion of toxic plants and other substances is an additional threat to herd health in times of severe depletion of forage. This is a problem especially of young animals that have not established definite habits of forage selection. As starvation becomes more imminent, an abnormal appetite associated with an empty or poorly functioning gut will lead even adults to sample forages and other materials they would normally reject. Access to poisonous plants is a common problem in pasturing depleted, unimproved, or poorly accessible rangeland, but intoxications by other substances also are likely in such circumstances. For example, botulism may occur when animals in need of calcium and phosphorus ingest carrion contaminated with *Clostridium Botulinum*, and caustic poisoning may be induced by ingestion of agricultural chemicals when animals are seeking salt.

Prevention of toxicosis is best accomplished by avoiding the need for abnormal foraging through maintenance of adequate levels of nutrition. Diagnosis and control require recognition of locally available toxic plants and materials and prevention of access to

them by the animals.

As the dry season progresses, forage becomes scarce and, unless supplemental feed is available, animals will not be prepared for the stresses of the wet season. With the onset of rains, regrowth of forage will occur, but nutrient intake actually may decrease. This occurs in part because of the high water content of the new growth, but also because the animals may forage less, having a tendency to stay close to sheltered areas of confinement, especially when browsing in wet brush.

When confinement is necessary, shelters should be planned to reduce the exposure of the animals to heavily contaminated environments. Housing on elevated, slotted floors, that allow the manure to fall and accumulate in a pit inaccessible to the animals, is an efficient means of reducing massive fecal contamination. Otherwise, frequent, regular removal of manure may be necessary and even obligatory, especially during the wet seasons. In any case, shelters and gathering facilities should be constructed in areas of good drainage, or good drainage should be provided by ditching and grading to create slopes or mounds. During the extremes of the dry season such measures are less critical, but it is obvious that filth accumulated during the dry season is an added burden when the rains arrive.

Elevated, slotted flooring provides an added element of ventilation that may help reduce heat stress in the hot dry seasons and is necessary for the dispersion of gases generated in the manure pits. However, such construction also is conducive to drafts that may be especially stressful during the wet season. Orientation of the open sides of houses away from prevailing storms and providing windbreaks may be critical in reducing chilling of animals that may increase their susceptibility to disease. Good ventilation is especially important in controlling respiratory diseases. The normal mechanisms of resistance in the lungs usually are sufficient to protect animals from the severe effects of infection by common microbial inhabitants such as Mycoplasma, Pasteurella, and Hhaemophilus, but their ability to cause pneumonia is enhanced when the lungs are damaged by inhaled noxious gases or dusts.

The management of range and pastures usually varies with local tradition and the nature of the ecology and resources available. An extensive system of management, e.g., spreading the animals over a wide area and preventing build-up of environmental contaminants, is preferable to an intensive system. Sanitation and health can be improved by using methods that encourage animals to forage widely. Such measures might include distributing shelters and sources of supplemental feed, salt, minerals, and water widely throughout the pastures, controlled herding, and strategic fencing. Dispersal of manure can be enhanced further by scheduled rotation of pastures, usually on a biweekly basis, where this is feasible. Where selective brush clearing is practiced, clearing of the elevated, better-drained areas might help to encourage wider foraging in wet seasons. Sources of feed and water should be placed, usually elevated and protected, so as to prevent fecal contamination.

In summary, the object of maintaining sanitary conditions is to keep the level of harmful microorganisms in the environment low

enough to allow the animal's defense mechanisms to resist establishment of disease. During the dry seasons, sunlight, heat, evaporation, and dispersal of contaminants aid in sanitation. However, the animal's resistance may be reduced by the stress of climate and malnutrition. In the wet seasons, sanitation may be more difficult to maintain, but reducing the likelihood of contamination and avoiding excessive moisture are the main elements of control.

Use of Medications in Maintaining Herd Health

Given normal resistance and consistent, low-level exposure to usual environmental infectious agents, animals may often be reared with little or no prophylactic medication or immunization. In most commercially practical situations, however, animals are raised in large groups and are stressed in a variety of ways that alter their resistance. Animals with different environmental and disease backgrounds often are exposed haphazardly to one another. Under such conditions, medication and vaccination for treatment and control of locally endemic diseases likely will be necessary. The need for and choice of specific procedures will depend on the locale and may be controlled by local regulation. Advice on such needs is best sought from local veterinary health officers, and general information concerning specific diseases can be found in several published texts mentioned previously.

Use of anthelminthics is a virtual necessity in rearing groups of animals. The identity of the predominant parasites must be determined at the local level, and specific prophylaxis or therapy chosen accordingly. As will be indicated later, the seasonal timing of prophylactic medications may be critical.

A general rule in the effective use of medications is that, whenever possible, the medication be directed against the specific causative agent or the specific symptoms of the disease being treated. This practice will reduce the possibility of developing antibiotic resistant microorganisms or untoward reactions in the animal being treated. It is often impractical to demonstrate the specific causative agent in a disease, however, and it may be necessary to treat the animal with the antibiotic of choice against the most likely agent or to use a broad spectrum antibiotic. In any case, treatment with antibiotics should be thorough, using the full dosage and course of treatment recommended by the manufacturer, so the medication will have the greatest possible chance of controlling or eliminating the causative organism. The course of antibiotic treatment should not be excessively prolonged, however, as this can allow overgrowth of other environmental organisms, such as fungi, that are unaffected by the antibiotic. For this reason, especially when it is warm and humid in the tropics, it usually is preferable to treat surface wounds with suitable antiseptic chemotherapeutic agents rather than antibacterial antibiotics.

Environmental Management for the Newborn Lamb

As lambs depend on their dams for their early nutritional and immune status, it is important that the ewe be in good health and at a good level of nutrition prior to parturition. This makes supplementation of the pregnant ewe particularly critical in times of inadequate availability of forage. It is also essential that

the lamb receive colostrum as soon after birth as possible, preferably immediately and within 12 hours at the latest. From birth, the lamb is exposed to myriads of microorganisms against which the colostral antibodies are a major defense. Should access to colostral antibodies be delayed beyond 12 hours, their absorption into the lamb's circulation will be inadequate to provide the normal level of protection during the first several months of life. As the ewe provides the lamb with immunity only to agents to which she has been exposed, birthing should take place in an environment in which she has been housed for the previous two or three weeks. Similarly, vaccinations of the ewe to protect the lamb against endemic diseases, such as contagious ecthyma, foot rot, or clostridial enterotoxemia, should be performed two or three weeks prior to the expected birth date. With some diseases, such as endemic infection of goats by mycoplasma (East et al., 1983) or caprine arthritis-encephalitis virus (Adams et al., 1983), organisms are shed in large numbers in the colostrum of infected does. The lambs are infected by ingestion of the contaminated milk, and pasteurization of the infected colostrum or replacement with colostrum from uninfected dams or cows can prevent transmission to the newborn lamb. Such a strategy--using colostrum of in-contact goats or cows when dealing with non-milking ewes--might be useful in protecting lambs from pathogens in the ewe's milk.

Since the newborn comes from the relatively sterile environment of the uterus, it is important to limit its exposure to infectious agents in its new surroundings until it develops an adequate level of active immunity. Separation of ewes with lambs from the rest of the herd and of pregnant dams several weeks prior to birthing, regular removal of manure from corrals and houses especially in the nursery area, disinfection of the nursery area prior to birthing and disinfection of the navel cords with an iodine solution immediately after birth, and removal of placental membranes from pens are procedures that alone or in combination will reduce mortality of newborn animals.

Diagnosis and Control of Infectious Diseases

The diagnosis and control of disease processes are best managed by trained veterinarians familiar with the local disease problems and regulations. Descriptions and detailed recommendations for the diagnosis, treatment, and control of various diseases which might be encountered by sheep throughout the world are available in published texts and are beyond the scope of this chapter. However, a few comments based on several disease processes experienced in Northeast Brazil that occur globally and are significant may provide some useful insights into management of infectious diseases in the rest of the semiarid tropics.

Nematodiasis

Among the diseases affecting sheep in semiarid regions of the world, such as Northeast Brazil, nematodiasis represents one of the most limiting to sheep production. Costa and Viera (1980) recorded *Haemonchus contortus* and *Trichostrongylus axei* (abomasum); *Strongyloides papillosus*, *Cooperia pectinata*, and *Bunostomum trigonocephalum* (small intestine); and *Oesophagostomum columbignum*, *Trichuris ovis*, and *Tridveris globulusa* (large intestine) as the main types of nematodes affecting sheep in Northeast Brazil.

The pathogenic effect of the above parasites depend on age, physiological condition, nutrition, immunity, and genetic resistance. Lambs and pregnant and lactating ewes are the most susceptible classes to gastrointestinal nematodiasis. Pregnancy and lactation increase the release of parasite eggs resulting in gastrointestinal nematodiasis outbreaks with higher environmental contamination, and as a consequence, causes a higher level of infection in young animals (Santiago et al., 1970).

In the acute form, the observed symptoms are weight loss, diarrhea, dehydration, and moderate anemia. In the chronic state, it may be observed as lower jaw edema, anemia, general debility, and erect, dull hair coat (hair sheep). The macroscopic lesions observed at the necropsy are anemia of all organs, fat degeneration, hydrothorax, hydropericardium, cachexia, and catarrhal gastroenteritis.

Although present throughout the year, the parasites are transmitted to a greater degree after the middle of the rainy season and the beginning of the dry season in arid and semiarid regions. The transmission occurs when animals ingest the infective larvae along with the green forage (Costa et al., 1985).

The control of these parasites may require up to three dewormings in the dry period and one in the middle of the wet period. Pregnant ewes should be dewormed 30 days prior to lambing (Costa and Vieira, 1984a). The recommended drugs are benzimidazole, ivermectin, and pro-benzimidazoles. The chemical principle should be changed yearly. Also, some precautionary measures are recommended such as avoiding overcrowding pastures, using pasture rotation, and alternate grazing with animals or species that are less susceptible to the same parasites as sheep. When introducing new animals to the flock, they should be treated for internal parasites and isolated for a few days.

Eimeriosis

This is a parasite disease also known as coccidiosis or blood curse with worldwide occurrence in ruminants, mainly in young animals (two to three months). The etiologic agent is a protozoan of the genera Eimeria. The species present in Northeast Brazil are *Eimeria minakolyakimovae*, *E. pallida*, *E. faurei*, *E. parva*, *E. intricata*, *E. ahsata*, and *E. arloingi* (Padilha et al., 1980).

The pathogenic action of this parasite is linked to its penetration in intestinal cells destroying the epithelium and causing hemorrhagic diarrhea. It causes inflamation, edema, and hypertrophy of the intestine mucosa. The infected animals show signs of anorexia, weight loss, and dehydration.

The adult animals are relatively resistent but, as they are carriers without symptoms, they are infectious to the young. The transmission of eimeriosis occurs through ingestion of sporulated oocysts with water and feed.

The control of the disease depends upon prevention of ingestion of oocysts, thus avoiding the outbreaks of the disease. Because it is self-limiting, hygienization and rigorous disinfection of the installations are of great importance in

controlling the disease.

Products such as 5% cresol, 10% sodium hypochlorite and, whenever possible, flame broom should be used. Also, as a prophylactic measure, products such as amprolium (10 mg/kg every three weeks) and monensin (13 mg/kg for five days every three or four weeks) or salinomycin (100 ppm in the feed for three weeks) may be used where their use is permitted.

Ectoparasites

Mange. Mange is caused by the mites *Psoroptes ovis*, which attack all of the animal's body, and *Sarcoptes scabiei var. ovis*, which attack the head around the ears and nose. The infected animals show intense itching and formation of reddish nodules with a serous exudate, which, after drying, forms yellow crusts.

Control may be obtained by spraying or immersion baths containing organophosphates, pyrethroids, and formamidines. Prophylactic measures consist of periodic examination of the animals for mites and taking the precaution not to introduce infested animals to the flock.

Lice. The occurrence of lice in sheep of Northeast Brazil is low. Costa and Vieira (1984b) observed 18.49% infestation in sheep by *Bovicola ovis* in one flock. They found itching and irritation of the animals' skin. The presence of lice is easily detected through examination of the animal skin and hair. Lice are found mainly in the dorsal region of the animal.

Transmission occurs through direct contact. Lice can be controlled by spraying with products containing organophosphates, formamidines, pyrethroids, etc. where they are permitted, repeating the treatment at 10-day intervals.

Myiasis. Invasion of body tissues by fly larvae is caused principally by *Cochliomyia hominivorax* (screw worm) in Latin America and *Chrysomya bezziana* in Africa and Asia, causing primary myiasis, and *Cochliomyia macellaria* and others causing secondary myiasis. Primary invasion generally occurs at the atural orifices, in the nose, gingival alveoli, or fresh wounds such as the navel of the newborn. Secondary myiasis is invasion of previously necrotic tissue. If not treated, the process will extend, causing serious mutilation and death, with the effect depending upon the site of the lesion. Insect repellents should be used when the danger of flies exists, and surgical procedures causing tissue damage, such as tail docking, castration, and dehorning should be done during periods of minimal fly populations.

Ticks. Ticks are not common in Northeast Brazil. Costa and Vieira (1984b) found, for the first time, *Boophilus microplus* infesting sheep. Only 9.65% of the sheep were affected with little loss of production.

To control the parasite, spraying or immersion baths (dipping) with products containing formamidines, organophosphates, or pyrethroids are necessary. Contaminated pastures also should be avoided when grazing.

Bronchopneumonia

Inflammation of the lungs and bronchi may occur in animals of all ages. It is a major cause of loss of weight and production, retardation of growth, and is expensive to treat. It is often the cause of death in animals that have been debilitated by malnutrition and other diseases. The primary symptoms, coughing and difficult breathing, are accompanied by nasal exudation, fever, and anorexia. Respiratory diseases may have multiple microbial etiologies including a wide variety of bacteria, viruses, parasites, mycoplasma, and rickettsia. Environmental stress, resulting from cold, dampness, draft, poor ventilation, low nutritional status, and poor sanitation, considerably influence the severity. Prevention and treatment should include maintenance and appropriate medication with specific or broad spectrum antibiotics and sulfonamides.

Foot Rot

This specific lameness of sheep and goats is caused by inflammation of the skin of the foot and may extend and involve sensitive laminae of the hoof. The disease is associated with a mixed bacterial infection by *Bacteroides nodosus* and *Fusiformis necrophorum*. It is predisposed by persistent dampness of the skin of feet exposed to a constantly wet environment. In the semiarid tropics, foot rot may become a major problem during the wet seasons. Control and treatment should include provision of dry or well-drained lounging areas. Elevated, slotted flooring in the shelters are beneficial. Other control measures include proper trimming of feet, provision and forced regular use of footbaths containing zinc sulfate or formalin, and separation and treatment or removal from the herd of chronic cases. Initiation of control measures prior to the development of a serious foot rot problem are important, especially in flocks with previous outbreaks of foot rot. Vaccines and vaccination procedures administered prior to the onset of the wet season have been of value in sheep and deserve consideration in goats.

Caseous Lymphadenitis

This insidious disease of sheep and goats is caused by *Corynebacterium pseudotuberculosis*. It is characterized by abscesses occuring predominantly in lymph nodes but also can occur in any tissue throughout the body. The disease is seen worldwide and tends to become endemic once introduced into a flock. The organism persists easily in chronically infected animals and moderately well in protected environments. This generalized disease decreases productivity and may result in debility. Abscesses may damage any tissue locally and cause varying loss of function or value depending on their location. Superficial abscesses may rupture, damaging the skin and contaminating the environment. Control is difficult but can be accomplished in part by removing chronically infected animals from the flock and avoiding contamination of the environment. With this in mind, treatment of superficial abscesses by draining and disinfection should be done outside of the flock's normal environment. Diagnostic tests to detect subclinical infection, and vaccination procedures capable of reducing the number of infected carrier animals, have been developed (Brown 1987).

Contagious Ecthyma

This viral infection causes painful debilitating sores on thinly covered areas of skin, especially around the mouth, nose, feet, and udder. Interference with eating and breathing and secondary infections may lead to severe debility, especially in young lambs. The virus persists in the environment in sloughed infected epithelium, and the incidence and mortality in young lambs in endemic flocks can approach 100% when sanitary conditions deteriorate, as can occur when lambing occurs in overcrowded shelters during the rainy season. As a prophylactic measure, a vaccine produced from the crusts may be used. The usual treatment is to remove the crusts and apply 10% iodine and glycerine, in equal parts, to the lesions.

Diarrhea

Diarrhea is a symptom of disease characterized by an increase in the volume of feces that usually are soft and fluid, may have a putrid odor, and may contain blood or excessive mucus. It often results from inflammation of the gastrointestinal tract and may be associated with signs of abdominal pain, reduced feed intake, abnormal appetite, increase or decrease in intestinal motility, reduced absorption of fluid and nutrients, dehydration, emaciation, and fever. Diarrhea may be caused by a wide variety of infectious agents, including parasites (e.g., *Eimeria*, *Cryptosporidium*, *Trichostrongylus*, etc.), bacteria (e.g., *Escherichia coli*, *Salmonella* spp., *Clostridium perfringens*, etc.), and viruses (e.g., rotavirus, adenovirus and herpesvirus). Non-infectious conditions that also may cause diarrhea include:

- Abrupt changes in feed--excessive milk, immature grass with a high moisture content.
- Chemical agents--lead, arsenic, phosphorous, mercury, molybdenum, sodium chloride, and oxalates and nitrates.
- Toxic plants.
- Mycotoxins from moldy feedstuffs.
- Nutritional deficiencies--pantothenic acid.
- Physical agents--sand and earth in the gut may be evidence of deranged appetite secondary to diarrhea rather than the cause.

In controlling diarrhea, good hygiene is of prime importance; facilities and animals must be kept clean, dry, and comfortable. Ingestion of colostrum must be assured soon after birth, and ewes should be vaccinated for enterotoxemia 30 days prior to lambing. Treatment should include removal of the cause, with specific therapy in the case of infectious agents, use of intestinal mucosal protectants and, most importantly, correction of electrolyte imbalances.

Conclusions

Disease is a major constraint on the productivity of sheep throughout the semiarid tropics. The highly variable geographic and climatic conditions result in wide variations in the type,

incidence, and severity of diseases from one location to another and from season to season in any one locale. The ability to manage these problems varies with the severity of the disease and with the interest, education, and financial resources of the veterinary health community and individual producers.

To bring a semblance of disease control to most of these regions, the development of area-wide health management systems are required. These likely would need some form of external subsidization. The need to consider the local variations in climate, available resources, and disease problems requires that the planning and implementation of specific management, treatment, and control practices be done on a local basis.

Literature Cited

Adams, D.S., P. Klevjen-Anderson, J.L. Carlson, T.C. McQuire and J.R. Gorham. 1983. Transmission and control of caprine arthritis-encephalitis virus. Amer. J. Vet. Res. 44:1670.

Brown, C.C. and H.J. Olander. 1987. Caseous lymphadenitis of goats and sheep: A review. Vet. Bull. 57:1.

Costa, C.A.F. and L.S. Vieira. 1984b. Ecto parasitos permanentes de caprinos e ovinos em Sobral, CE. Pesq. agropec. bras. 19(5):639.

East, N.E., A.J. Damassa, L.L. Logan, D.L. Brooks and B. McGowan. 1983. Milkborne outbreak of mycoplasma mycoides subspecies mycoides infection in a commercial goat dairy. J. Amer. Vet. Med. Assoc. 182:1338.

Hall, M.T.B. 1977. *Diseases and Parasites of Livestock in the Tropics*. Longman, New York.

Howard, J.L., ed. 1981. *Current Veterinary Therapy - Food Animal Practice*. W.B. Sounders, Philadelphia.

Jensen, R. and B.L. Swift. 1982. *Diseases of Sheep*. Lea and Feabiger, Philadelphia.

Martin, W.B. 1983. *Diseases of Sheep*. Blackwell Scientific Publications, Oxford.

Padilha, T.N., F.A.B. de Vasconcelos and M.E.F. Lima. 1980. Eimerideos parasitos de ruminantes nos sertols de Pernambuco, Bahia, Ceará e Piauí. (EMBRAPA/CPATSA. Pesquisa em Andomento, 1.) EMBRAPA/CPATSA, Petrolina, PE.

Santiago, M., J.C. Gonzales and S. Benevenga. 1970. O Aumento subito do numero de ovos de nematodeos nas lezes das ovelhas nu epoca do parto. Med. Vet. 5(3):267.

Thedford, T.R. 1983. Sheep Health Handbook. Winrock International Technical and Informational Services, Morrilton, AR, USA.

Chapter 9

FACILITIES AND INSTALLATIONS FOR HAIR SHEEP PRODUCTION

M. Shelton and E.R. de Oliveira

Commercial scale programs for sheep production require elaborate facilities, especially if labor is a limiting factor. Smallholders or producers with limited means and those who are able to substitute labor for facilities, however, often manage to get by with a minimum of installations. This may result from small numbers of animals not warranting the expense of elaborate facilities, or from the fact that with small numbers, labor is often a substitute for facilities. Still, in some cases, facilities may be limiting.

Perhaps the most critical needs are control, containment, and (or) protection (from theft or predators). A failure to maintain proper control of animals can have both economic and social consequences. Some of the control options are fencing, herding, tethering, zero grazing (total confinement), or allowing the animals to remain free in a communal environment. The two most frequent options in Brazil and the Central American tropics are fencing (privately owned lands) or communal grazing. Tethering or confinement rearing, based on the cut-and-carry system of feeding, places an unreasonably high labor cost on any type of commercial sheep enterprise directed toward meat production.

Tethering or confinement would be a more acceptable practice if sheep, like goats, were used to produce milk for households. But sheep are rarely used for this purpose. Between the options of fencing and communal grazing, the latter is the least desirable, but it may be most widespread in developing countries. It is difficult to carry out constructive breeding programs under these conditions. Further, disease and parasite control programs become more difficult.

Perhaps the most serious constraint is the impossibility of controlling the stocking rate without some type of municipal or government involvement. The result is that the resources are over-used or abused, and animals grazing these areas are perennially undernourished. Many people who own sheep do not own land, however, and thus communal grazing is their only option. There are instances throughout the world where communal grazing, or the grazing of common lands, is managed in a manner to support an efficient production system. In those cases, grazing management, including number of animals, is under the control either of some level of government or by producer organizations.

For the most part, efficient production systems should be viewed as being based on owned land or land under private control such as various lease arrangements. Under these conditions, the animals must be controlled through herding or fencing. A large portion of the sheep population of the world is herded, but these flocks tend to be based on nomadic or transumante systems that generally do not exist in the American tropics. Fencing is the primary option.

Previous Page Blank

Fencing

Sheep, especially wool sheep, are more easily fenced than other types of farm or ranch livestock. They do not climb or jump like goats, root like pigs, or jump or damage fences like cattle. Hair sheep are not as easily fenced as wool sheep. Being smaller and lacking wool, they pass through fences more easily.

Fences may serve two roles. One of these is to restrict animals to the producer's own property to prevent them from being lost or straying to a neighbor's property, especially cropland. A second role of a fence is to divide property to permit pasture rotation and separate control of different management groups, or to protect crops. It is reasonable to assume that interior fences may be less elaborate or expensive.

The major impediments to fencing are cost, land titles, know how, or the availability of suitable materials. The cost of fencing (per animal unit protected or produced) is determined by cost per unit of fence, size of area fenced, carrying capacity of the land, and period of time over which costs can be amortized. The latter is influenced by available financing as well as the useful life of the fence. These relationships are shown in table 9.1 (Shelton et al., 1987).

Table 9.1. Influence of four factors (size of area fenced, period of amortization, and fencing costs) on cost of fencing per head of sheep (no interest or maintenance charge included).

		1 hectare (0.4 km fence)		1/4 km^2 (2 km fence)		1 km^2 (4 km fence)		4 km^2 (8 km fence)		16 km^2 (16 km fence)	
Stocking rate sheep/ km^2	Period of amortization years	$1,000/ km	$2,000/ km	$1,000/ km	$2,000/ km	$1,000/ km	$2,000/ km	$1,000/ km	$2,000/ km	$1,000/ km	$2,000/ km
100	1	400	800	80	160	40	80	20	40	10	20
100	5	80	160	16	32	8	16	4	8	2	4
100	10	40	80	8	16	4	8	2	4	1	2
100	20	20	40	4	8	2	4	1	2	.5	1
100	40	10	20	2	4	1	2	.5	1	.25	.5
200	1	200	400	40	80	20	40	10	20	5	10
200	5	40	80	8	16	4	8	2	4	1	2
200	10	20	40	4	8	2	4	1	2	.5	1
200	20	10	20	2	4	1	2	.5	1	.25	.5
200	40	5	10	1	2	0.5	1	.25	.5	.125	.25
400	1	100	200	20	40	10	20	5	10	2.5	5
400	5	20	40	4	8	2	4	1	2	.5	1
400	10	10	20	2	4	1	2	.5	1	.25	.5
400	20	5	10	1	2	0.5	1	.25	.5	.125	.25
400	40	2.5	5	0.5	1	0.25	0.5	.125	.25	.062	.125
800	1	50	100	10	20	5	10	2.5	5	1.25	2.5
800	5	10	20	2	4	1	2	.5	1	.25	.5
800	10	5	10	1	2	0.5	1	.25	.5	.125	.25
800	20	2.5	5	0.5	1	0.25	0.5	.125	.25	.062	.125
800	40	1.25	2.5	0.25	0.5	0.125	0.25	.062	.125	.031	.062

At a constant stocking rate, the amount of fencing required per animal is reduced as the size of the area to be fenced is increased. For instance, at the same stocking rate, 10 times as much fence is required per animal in fencing 1 km^2 as 16 km^2. This is little consolation to the small farmer. A similar relationship exists with stocking rate. If land can be stocked at 400 animals (sheep) per km^2, only one-fourth the fencing is required per head protected compared to a stocking rate of 100 animals per km^2.

Many of the world's sheep are concentrated in arid or semiarid environments where the carrying capacity of the land is low. This can explain why many sheep are herded instead of fenced. Tropical regions where the forage production potential is great should have an advantage in this respect. The cost of fencing would be an obvious factor, but of greater importance would be the period of time over which these costs can be amortized. Although initial financing may be a factor, the final determining factor will be the length of useful life of the fence. This may range from 5 years for wood fences in wet environments to 40 to 60 years for well-constructed wire fencing in arid environments. In the latter instance, fencing costs, expressed on an annual per head basis, can be modest (figure 9.1).

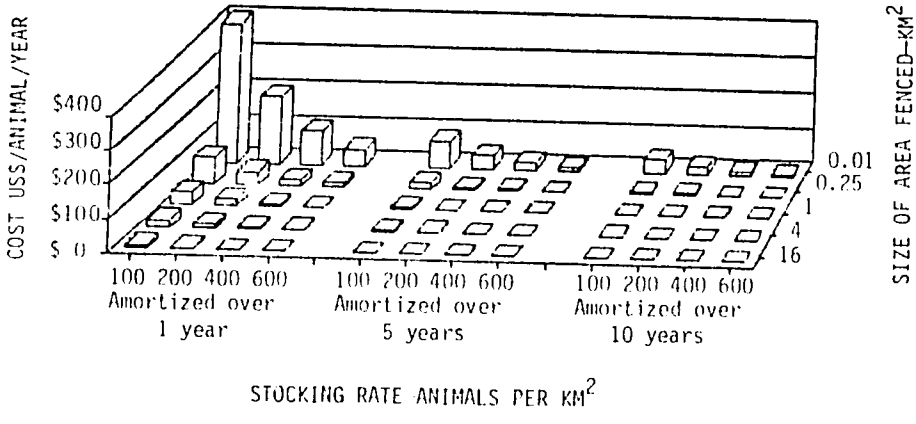


Figure 9.1. Influence of stocking rate, size of area fenced, and period of amortization of annual cost per animal protected (no maintenance of interest charged) and cost of initial fencing calculated at U.S.$1,000 per km.

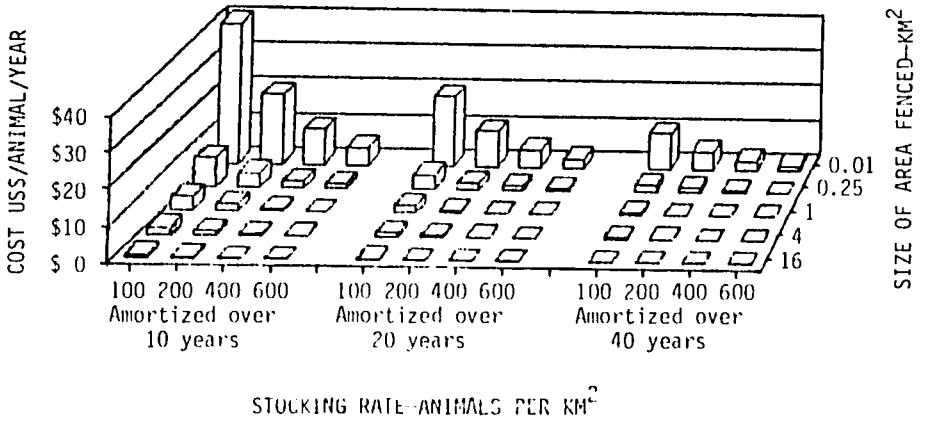


Figure 9.1. Continued.

Types of Fences

Net wire. Net wire is the most effective way to fence sheep, and its use is encouraged. For various reasons, however, it is not widely used. This may be because of the unavailability of net wire in many countries. Wool sheep often may be fenced more economically with single-strand fences. In the final analysis, however, the primary reason for the non-use of net wire fencing is initial cost. Ideally, horizontal spacing of wires would range from 10 cm at the bottom to as much as 25 cm at the top. Closer spacings near the bottom may help exclude small predators and prevent small lambs from escaping. Vertical spacings are approximately 30 cm. Typical heights are a net of approximately 1 m plus one or two barbed wires on top approximately 10 cm apart. This will provide a total height of 120 cm, more than adequate for sheep. Ideally, these fences are made of strong, heavyweight wire that will maintain tension. In an arid (non-coastal) environment, these fences may last up to 50 years, but will have a much shorter life in coastal areas where salt damages the wire.

In addition to cost, major problems with net fences are that often they are not constructed with proper tension and lack supporting posts that resist decay. Most countries have native timbers relatively resistant to decay that may be used for posts. If this is not the case, metal or treated timber can be used. Some materials commonly used for treatment are creosote or pentachlorophenol. To some extent, these treatments can be applied on the farm by simply immersing the entire post or standing one end in a solution of the preservative, but this usually will be less effective than commercial treatment.

Individual strand wire fences. Fences made of individual strands, as contrasted to net or mesh fences, are perhaps more common throughout the world. The wires may be barbed or smooth. Barbed wire fences are more effective, but are more difficult to construct than smooth wire. If wires are to be electrified at a

later date, which can often be done, the smooth wire is preferable from a safety standpoint. As few as five wires may be used with wool sheep, but a fence of this type must be well constructed.

Hair sheep are more difficult to fence because of their smaller size and absence of wool, thus a minimum of seven wires is recommended. The amount of tension and spacing on the wires is important. Suggested spacings are approximately 10 cm at the bottom graduating to 25 cm at the top. Maintenance of the wire spacing also is important. For instance, if the wires spaced at 10 cm are allowed to become loose or sag, the actual spacing may become 30 cm, and most sheep could easily pass through the strands. Spacing may be maintained by closely placed supports (posts or stays) or by tension on the wire, preferably both. Increasing the tension on the wire is the more economical approach, but it does require well constructed corners or stretch assemblies. Poorly constructed corners or stretch assemblies often are more a function of design or effort than of cost.

Electric. Perhaps the most important or more recent development is electric fencing. The cash costs are markedly reduced compared to other types of wire fences, and the labor required for construction is much less than for fences of native materials. While electric fencing has been in use for many years, some recent developments are worthy of note. In extremely arid environments, the animal may not be grounded sufficiently to receive an adequate electrical charge. This can be corrected by alternating charged and grounded wires with the result that an animal attempting to pass through will receive a greater shock. Further, new types of chargers or energizers with low impedance and high voltage (5000+) are available. These fences provide greater shock value and thus improved effectiveness, with reduced fire hazards. A much greater length of fence can be operated from a single energizer with reduced problems of grounding. A third development has been solar panels for charging batteries; these permit the use of electric fencing in areas where electric power is not available (Zometa et al., 1985).

Electric fences are less suitable for periphery or boundary fences, because the animals may escape if they pass through the fence. They are more commonly used for internal division fences including temporary fences used for pasture rotation. As few as two wires are used routinely for temporary fences for short-term pasture rotation. For more permanent fences, four or five strands are commonly used. Electric fences work better where the resident animal population is somewhat stable. A period of training is necessary for the sheep to learn to respect the fence. They may have to pass through the fence before learning to fear or respect it. If the animal population is changing constantly or frequently, there may be a continual problem.

Maintenance of electric fencing is essential. This means maintaining a charge on the wire (5000+ volts) and maintaining tension and spacing of the wires so that the animals are not able to pass through without receiving a shock. A type of wire must be used that can withstand considerable tension. In the case of the five-wire fence, suggested spacings for the wire would start at 15 cm at the ground level graduating to 25 cm at the top.

Electrical fencing is clearly the most economical means of

fencing, and its use is rapidly increasing. Still, this type of fence will present problems for small farmers or for developing countries because of cash costs or the technology required.

Living. Living fences have been used for various types of livestock. Sheep and especially goats are relatively difficult to contain with a living fence. They are much more likely to eat the living fence than would be the case with cattle or other species. They are also smaller and more active, making it more difficult to fence them in by any means.

In addition to true living fences, living posts can be used in conjunction with wire fences to reduce the need to replace supporting posts. Living posts may be planted at desired locations; some species will sprout roots and grow when cut and put in the ground. One plant, Erythreme sp., is used in Central America as a living post. Some species (Leucaena sp.) also could serve as posts and produce forage if branches above the fence line were cut.

Native Materials. In areas with extensive woody vegetation, it often is possible to construct fences of local materials with little or no cash cost. Fences made of wood require considerable maintenance, particularly in tropical environments because of decay of the existing materials. Limitations on the availability of wood no doubt present problems in heavily grazed areas.

The large amount of wood in the caatinga in Brazil encourages the use of these materials for fencing. Under these conditions, the cost of materials may be low, but labor requirements are high. The number of possible designs can be near infinite, but at least two are generally recognized and identified by name. These are Faxina and Estacote. These fences all serve the same purpose, and when in good repair are equally or more effective than seven-strand wire fencing. In this area, where there is a rainy season, these wooden fences decay. They also may be destroyed by fire. Some repair usually is required after 5 years, with extensive replacement within 10 years. Wood for initial construction may be obtained while clearing the land. When the fence is replaced, adequate wood may not be available, and there is often a tendency to shift to wire.

Other types of native or local materials that can be used are rocks or stones when they are abundant in the area. Cash costs of this type of fence would be low, but if a value is put on labor, the costs will be prohibitive. Thus, these may be more commonly used for corrals or night lots. Fences made of stones resist decay. As a matter of economy, the lower part of the fence may be made of stone to resist decay, with wire or wood at the top. Few rock fences are being constructed at present because of the labor required.

Corrals and Shelters

The actual or potential losses associated with predators or theft make it imperative to have a place to hold animals at night. It is not unusual, however, for these types of installations to be built without considering some important guidelines. This may increase rather than lower mortality rates.

Hair sheep, principally young animals, are susceptible to

chilling, and high losses because of respiratory-related problems are reported in the literature. Thus the corrals and holding pens should be located in elevated areas and on soils with good drainage capacities. Divisions should be provided for management, such as separation of young males and females, late gestating animals, etc.

The shelters should be located at the higher end of the holding pen. These can be simple but efficient, and the materials should come, as much as possible, from the farm. The location requires good ventilation, and the direction and intensity of the sun and wind must be considered to avoid heat overload and to keep animals from getting wet from rain.

One way of protecting animals is to plant trees around the shelter area, as well as planting them in the maternity and exercise paddocks. This measure facilitates air movement, gives extra protection against rain penetration in the sheltered areas, and provides shade to reduce the heat load for a grazing animal in paddocks close to the management center during the day. Clay tiles make a good covering material in tropical regions. Galvanized steel and aluminum are not advised as metallic covering may increase considerably the inside temperature. If the cost of clay tiles is too expensive for the small producer, an alternative covering might be palm tree leaves. This material, when conveniently braided, provides effective protection against rain and sun. The major inconvenience of using such leaves is that the covering must be replaced or repaired periodically.

The sheltered area should have a separate fenced area to hold newborn lambs to prevent accidental losses while the animals are still too young to follow their mothers while grazing.

In the hot dry tropics, the slatted floor type of housing may not show any advantage over ground level housing (Oliveira et al., 1982; Costa et al., 1988). Slatted floor housing may be more desirable in the hot and humid tropics. In such conditions, a higher amount of precipitation associated with high temperature and humidity facilitate gastrointestinal parasites as well as other pathogenic microorganisms.

Special care should be exercised when building slatted floor housing in the hot humid tropics. As the animals are going to stay a longer time together, the construction should allow adequate space for sufficient ventilation and ease of cleaning. The minimum recommended space for each ewe is 1.2 m^2, young lambs 0.4 m^2, and replacement young ewes and castrated lambs 1.0 m^2. The open yard should provide at least twice as much space for the animals. The elevation from the floor should be at least 1.0 m to facilitate cleaning and collection of manure. The recommended distance between the slats is 1.5 cm for the space reserved for adult animals and 1.0 cm for the young lambs to facilitate the dropping of fecal pellets.

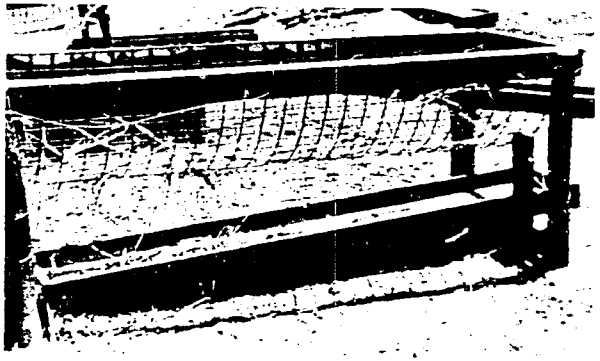
Other Installations and Facilities

Feeding devices to be used during periods of low forage availability or to supplement late gestating or lactating animals should be placed in the holding pens. To facilitate feeding during wet weather, it may be desirable to leave space for feeders under the shelter. Therefore, when planning the building of shelters,

additional space should be provided. The feeding containers can be made in different ways such as mangers, racks, bunks, etc., depending on the type of supplement to be used. Where possible, use of native materials reduces cost. As supplemental feed is expensive, feeding devices that minimize feed loss should be built. Unless individually controlled, supplemental feed intake is desired, it is recommended that two-sided feeders be used for a better utilization of space. Minimum linear space on those feeders should allow 20 cm for young animals and 30 cm for adults.

Waterers, built in any form or shape, are to be placed outside the sheltered area. The producer can choose to have only one large water point or several smaller waterers depending on the size of the herd. In either case, waterers should be easy to clean and be constructed to prevent fecal droppings from contaminating the water.

Mineral supplements can be fed either as licks, blocks, or in a loose form. Licks or blocks are preferred to prevent wastage. If only looser mineral supplements are available, even old half tires can be used with good results. The device should be well-protected from rain and deep enough to avoid wastage.



Some types of feed troughs which might be considered. Ideally, they would be constructed of locally available materials, and the design should prevent the animals from climbing into the trough.

Some type of housing is desirable in the tropics, but may not be critical. The raised floor type (above) has many advantages, but may not always justify the cost. The other type (below) is more widely used in Brazil.

Literature Cited

Costa, C.A.F., L. Veira and M.E.A. Berne. 1988. Influência das instalaçoes de penoite, do tipo de pastagem e da suplementação volumosa sobre o parasitismo por nematodeos em caprinos, pesquisa agropecuaria, bras. (In press)

Oliveira, E.R. de, F.A.M. Lima and K.P. Pant. 1982. Effect of housing, pasture management and roughage supplementation on the pre-weaning growth of goats in the tropical Northeast Brazil. Pesquisa agropecuaria, bras. 17(9):1389.

Shelton, M., A.A.O. Fernandes and E.A.P. Figueiredo. 1987. Fencing for goats. In: *Proceedings of the IV International Conference on Goats*. pp. 809-820. Brasilia, Brazil.

Zometa, C.A., W. da Silva Correia and M. Shelton. 1985. Cercas eletricas com utilização de energia solar. Empresa Estadual de Pesquisa Agropecuaria da Paraiba Doc. No. 7.

Chapter 10

PRODUCTS AND MARKETING

E.A.P. de Figueiredo and J. de Souza Neto

In various parts of the world, sheep are raised to provide meat, fiber, milk, skins, and manure, and also as a means of weed control and for sport or leisure (hunting or fighting). In tropical regions of the Americas, sheep are raised primarily for meat and skins. Other products are considered secondary (or by-products).

The meat often is consumed at the place of production by the family and hired labor. Skins of animals slaughtered on the farm along with the skins of animals that have died are sold and can be an important source of cash. Surplus animals also are sold; in a commercial scale enterprise, this represents the primary source of income.

This chapter will attempt to describe the way meat and skins are obtained and their importance to the producer and to the national economics of the countries involved. Marketing channels and some suggestions to improve the income through strategic marketing also will receive attention.

Production Conditions

Sheep raised in the tropical or subtropical regions of the Americas are generally part of a complete farm production system. Animals are slaughtered periodically for home consumption and either are consumed directly or preserved as salted or dried meat. Some families slaughter the animal, keep the offals for their use, and sell the meat and the skin at the village market. This type of operation is more characteristic of poorer families with limited resources, essentially subsistence farmers. Sheep production is the only enterprise that generates cash, with other enterprises directed to household use. In this case, the producers generally use a controlled breeding season as well as other improved management practices. Sales primarily include male lambs along with surplus ewe lambs and culled, aged females. Even so, the offtake in terms of numbers and weight is low. The meat production on a per head basis is shown in table 10.1. The data were obtained from the slaughtering of a sample of 39 adult females bought at the market in Northeast Brazil (Bellver et al., 1983). Eight of these were pregnant, but this is believed to only have influenced directly the low dressing percentage (ca. 42%).

Slaughter lambs raised on rangeland, slaughtered at about 25 kg live weight, had higher dressing percentages than mature ewes. These data (table 10.2) illustrate the amount of meat production on a per head basis during a given period of time (Figueiredo et al., 1982). The total amount of meat produced on a per head basis was low if compared to the potential for these sheep as indicated in table 10.3. For example, in these data some estimates compare the meat production per ewe per day in improved and unimproved production systems. The improved system considered here contains

Table 10.1. Least square means for characteristics of adult ewes of three breeds in northeast Brazil.

Breeds	Pre-slaughtr weight (kg)	Hot carcass weight (kg)	Dressed head weight (kg)	Pluck weight (kg)	Wet skin weight (kg)
Santa Inês	44.70	15.30	1.35	1.11	2.93
Morada Nova	28.29	12.54	1.25	0.84	2.63
Crioula	25.81	12.38	1.11	0.94	2.99

Source: Adapted from Bellaver et al., 1980.

Table 10.2. Least square means for characteristics of lambs of two kinds of hair sheep in Brazil.

Breed	Age at slaughter (days)	Weight at slaughter (kg)	Hot carcass (kg)	Wet skin weight (kg)
Santa Inês	163.7	25.18	11.80	1.95
Morada Nova	213.5	22.85	10.98	1.58

Source: Adapted from Figueiredo et al., 1982.

Table 10.3. Actual meat production estimated for improved and unimproved sheep production systems.

Parameters	Improved[1]	Unimproved[2]
Weaning %	124.0	84.3[a]
Slaughter weight (kg)	46.3	25.2[b]
Carcass weight (kg)	23.9	11.8[b]
Slaughter age (days)	226.0	163.0[b]
Live weight per day per ewe in the flock (kg)	0.254	0.130
Carcass weight per day per ewe in the flock (kg)	0.131	0.061

Source: 1 Boyd, 1983.
2a Adapted from Sousa, 1987.
2b Figueiredo et al., 1983.

crossbred Dorset x Barbados Blackbelly ewes bred to Suffolk rams, with lambs confined after weaning (Boyd, 1983). The unimproved system is based on Santa Inês ewes on the range of Northeast Brazil, with lambs weaned at 112 days and raised under range conditions up to slaughter weight of 25 kg (Figueiredo et al., 1983; Souza, 1987). However, the difference between improved and unimproved systems also reflects feed and location differences.

At a constant stocking rate, the amount of fencing required per animal is reduced as the size of the area to be fenced is increased. For instance, at the same stocking rate, 10 times as much fence is required per animal in fencing 1 km^2 as 16 km^2. This is little consolation to the small farmer. A similar relationship exists with stocking rate. If land can be stocked at 400 animals (sheep) per km^2, only one-fourth the fencing is required per head protected compared to a stocking rate of 100 animals per km^2.

Many of the world's sheep are concentrated in arid or semiarid environments where the carrying capacity of the land is low. This can explain why many sheep are herded instead of fenced. Tropical regions where the forage production potential is great should have an advantage in this respect. The cost of fencing would be an obvious factor, but of greater importance would be the period of time over which these costs can be amortized. Although initial financing may be a factor, the final determining factor will be the length of useful life of the fence. This may range from 5 years for wood fences in wet environments to up to 40-60 years for well-constructed wire fencing in arid environments. In the latter instance, fencing costs, expressed on an annual per head basis, can be modest (figure 9.1).

Table 10.3 shows that a theoretical improvement of 215% still can be achieved in the tropical sheep industry, and this figure likely does not represent the maximum possible. Also, the unimproved system considered here is not the least improved system, as the flocks involved were produced with a number of practices recommended for the intermediary level of management for the sheep producers of Ceará state in Brazil.

Limited information is available about meat production from sheep in the tropical areas of Central and South America and the Caribbean. Some data have been summarized in table 10.4. This data confirms statements made earlier that sheep presently are of limited importance in tropical regions, and that an opportunity exists for great improvement.

The primary product obtained at slaughter is the carcass. Carcass yields are low compared to that obtained from market lambs in temperate regions. This can be explained largely by a limited amount of fat cover and large rumen capacity relative to body weight. Both of these conditions result indirectly from lower forage quantity and (or) quality in tropical regions. Breeding may also be a factor. The limited fat cover and small carcass weight results in small cuts of high lean content. This might be construed as an advantage in respect to the home meat supply for the small farmer, the primary outlet in developing countries. The protein obtained from lean meat likely has greater nutritional significance for the family, and the smaller carcass will present less problems in respect to preservation. Quality variations are less important to the family.

Table 10.4. Contributions of sheep to regional supplies of meat.

Region	Total meat 1000 MT[a]	Sheep Population[b]	Sheep Meat 1000 MT	Sheep Meat % of total
Central America	2,806	8,779	22	0.8
South America, Trop.	7,512	47,469	92	1.3
South America, Temperate	4,587	58,761	170	3.7

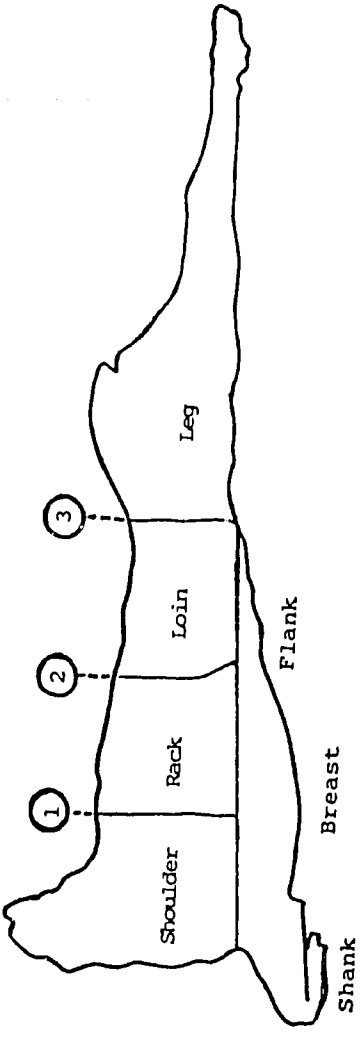
[a] Carcass weight expressed as a percentage of total carcass weight production from cattle, buffalo, sheep, goats, poultry, and swine.
[b] Population in thousands.
Source: Adapted from Winrock Internationa, 1983.

There are a number of ways to prepare meat when it is consumed fresh. The main ways of cooking are baking as barbecue, also known as assado or churrasco. It also can be done by boiling the meat, called cozido. Dishes made of viscera or offal include tongue, liver, heart, intestines, blood, etc. Besides the meat, other products are extracted from the sheep. Some of these are listed in table 10.5, classified as edible and inedible.

Table 10.5. Sheep and lamb by-products and major uses.

Edible By-Products	Inedible By-Products
1. Heart	1. Pelt-skin
2. Liver	1.1 Robes, rugs, shoe polishers
3. Sweetbreads	1.2 Wool
4. Kidneys	1.3 Gloves, shoes, costs, chamois leather, hat sweatbands, belts, etc.
5. Fries	2. Tallow
6. Tongue	2.1 Soap, cosmetics, glycerine, etc.
7. Brains	3. Bone and connective tissue
8. Cheek and head meats	3.1 Glue
9. Casings	3.2 Animal feeds
10. Gelatin	3.3 Fertilizer
11. Tallow	4. Blood
	4.1 Pharmaceutics
	5. Casing and associated tissue
	5.1 Ligatures, string, etc.
	6. Glands

Source: Scott, 1983.



1 Cut between the 5th and 6th ribs

2 Cut between the 12th and 13th ribs

3 Cut between the last two lumbar vertebrae

Figure 10.1. Retail cuts of a lamb carcass.

Source: Adapted from Smith et al. (1978).

There is relatively little commercialization of sheep meat from local production in the tropics. This is true especially in tropical regions of Central and South America and the Caribbean. As a result, much of the area is a net importer of sheep meat. To the extent that commercialization results in a movement to the more affluent elements of society (including hotel and restaurant trade), some concern about meat quality must be involved. Larger carcasses or cuts along with at least a limited fat cover may be required.

Most of the meat intended for this trade is merchandised as fresh meat on a bone-in basis, with imported products more commonly being frozen. Retail cuts of lamb are similar to those of other species (figure 10.1). In developed countries, the legs and shoulders have been used largely as roasts; the loin and rack, as chops; and the thin cuts such as shanks, breasts, and flanks have been boned for stewing or ground lamb. There also is an increasing interest in boneless cuts. For example, boneless leg and shoulder represent products of greater convenience than the corresponding bone-in cuts. The use of frozen meats also is increasing, including those from sheep. Freezing facilitates transportation and merchandizing and evens out the supply over the year.

Meat Quality

Meat quality may be discussed in terms of hygiene (cleanliness or the absence of disease), carcass composition (lean, bone, and fat), and palatability. From the standpoint of hygiene, one must be concerned with the health status of the animal at slaughter, cleanliness and sanitation during slaughter, processing, marketing, and proper refrigeration. Hygiene may be important in respect to the health of consumers or for aesthetic reasons. The latter may be of equal importance in attempts to commercialize lamb meat production. If it does not exist presently, government or industry should look to some type of inspection service to ensure hygienic conditions, at least at central slaughter facilities involved in merchandising meat to the public.

The eating quality of meat (taste, tenderness, etc.) depends mainly on the age, sex, nutrition, and condition (amount of fat) of the animal at slaughter and also treatment after slaughter. In general, younger animals and those with at least a limited amount of carcass fat will be more tender. Depending on how they are used and the customs of the society, male animals may be considered undesirable. Quick chilling after slaughter can result in increased toughness, whereas aging the carcass will make the meat more tender. Aging of unrefrigerated carcasses under tropical conditions is not desirable. Quick chilling may present more of a problem with small carcasses with limited fat cover which are often obtained from tropical sheep.

Not only are carcass items important for home consumption in most Latin American countries, but also the dress-off items. In table 10.5, all parts that might be considered digestible by man are listed as edible, and those which consist largely of keratinized protein are listed as inedible. Whether or not they are actually consumed by man would be influenced by the customs of the society involved and the degree of need for food of animal origin. Carcass conformation traditionally has been regarded as important by the sheep meat trade in many countries, and carcasses

short and plump in the leg and back are believed to contain more high-priced cuts, more meat, and less bone than carcasses longer in the leg.

Nutritional Value of Carcass Components and Dress-off Items

The carcasses of the breeds of sheep raised in tropical areas generally are leaner than those of sheep from temperate areas. The tropical sheep carcasses are more similar to goat carcasses. The energy value of sheep is intermediate (3.1 Mcal/kg) (McDowell and Bove, 1977). The protein content of sheep meat is similar to that of other livestock species.

Assuming the nutrient value of the offals and dress-off items of sheep carcasses is similar to those from other species, the dietary value of these products is significant. For example, the liver is not only a good source of protein, but also of precursors of vitamin A and D, folic acid, and poly-unsaturated fatty acids.

Palatability or Acceptability of Sheep Meat

According to Shelton et al. (1985), the degree of emphasis to be placed on quality or palatability of meat in developing countries may be subject to considerable question. The importance to be attached to palatability traits is a function of the eating habits of the society involved and how the meat is prepared and used. Palatability can be influenced greatly by cooking methods and the addition of flavoring ingredients. For instance, people who historically have consumed meat of one particular species will react positively to any practice that enhances the distinctive flavor of that species, whereas people who had not previously consumed that particular type of meat might react negatively. Likewise, for meats served in a highly processed form, tenderness would be of little concern, whereas for meats served as chops, steaks, or roasts it might be particularly important. Workers in Nigeria (Obanu, 1975) recorded that goat was preferred over chicken, beef, mutton, wildlife, pork, guinea fowl, snail, and water fowl. There also is considerable variability in the degree to which people look with disfavor on tough meat. In the case of domestic or home consumption in developing countries, quality traits are likely to be of limited importance, but in marketing sheep meat to hotels, restaurants, or more affluent households, quality traits are important.

A reason often given for the lack of popularity of sheep meat in countries where it is not commonly eaten is the presence of an unpleasant smell given off when the meat is cooking, or a stronger, less pleasant flavor in the cooked meat. This mutton flavor is more noticeable in meat from sheep over 2 years of age than in lamb (Sink and Caporaso, 1977).

It generally is agreed that the main contributors to mutton flavor are found in the lipids. Hircinoic acid (4-methiyloctanoic acid) also has been indicated as contributing to the sweaty-sour odor present in mutton, in addition to sulphur-containing components of the lipid fraction. Mutton flavor, however, has not been a problem for countries where sheep meat is eaten regularly.

Meat Marketing

The marketing of sheep meat products in developing countries is labor intensive. Relatively little capital is invested in equipment for distribution or marketing as most animals are slaughtered on farms and the products sold at the local market.

The characteristics of supply and demand for sheep and sheep products in developing countries are influenced by cultural aspects, climatic conditions, urban migration, and characteristics of the production system. Figure 10.2 shows some of the factors that influence the marketing of sheep in developing countries.

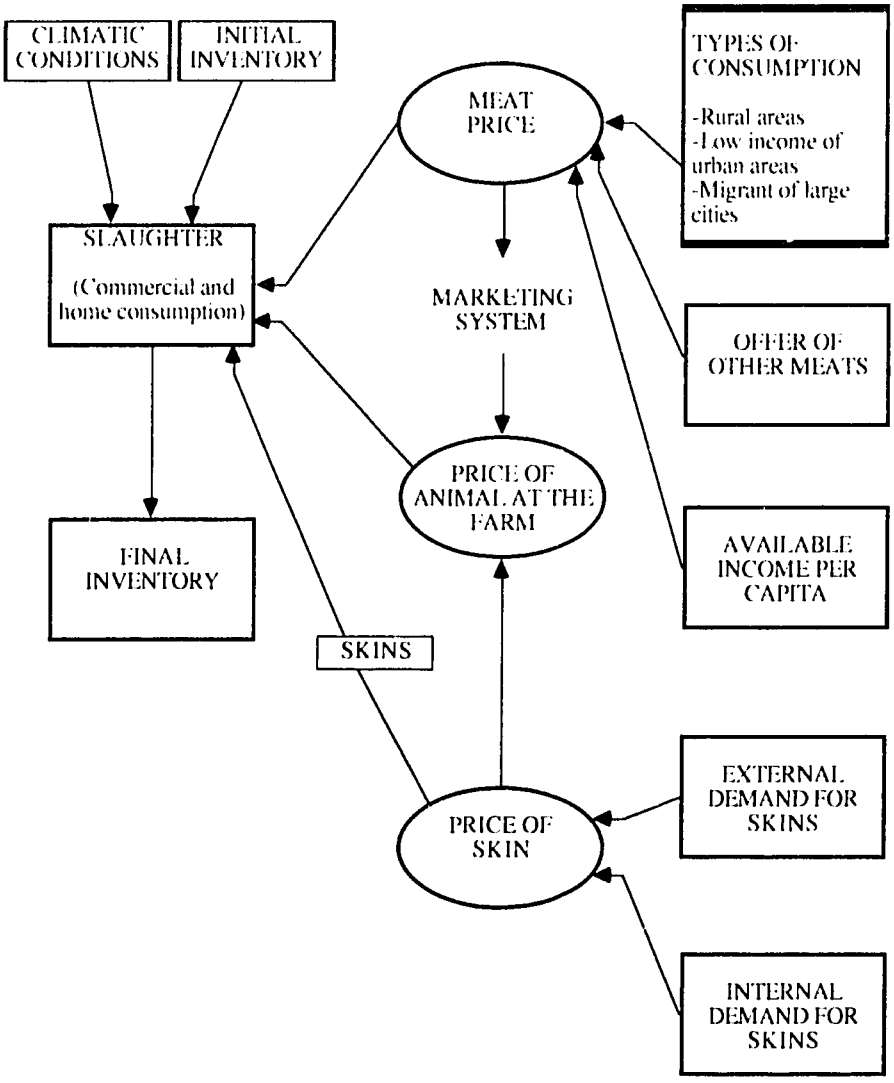


Figure 10.2. Structure of offer and demand of meat and skins of tropical sheep and goats in Northeast Brazil.

The complexity of the marketing process is related to the distance between producers and consumers. For example, in the state of Ceará in Northeast Brazil, the marketing of live animals generally is done through traders or middlemen at the farm level or directly in the central markets of the villages or small towns.

The marketing of sheep skins in the local market is done by producers or butchers who collect raw skins to sell to atravessadores who acquire small packs of skins from each source until they accumulate a large quantity. Then they resell to the atacadista. The atacadista then resells to a large merchant in the urban zone, or they may even sell directly to tanneries. In figure 10.3, an attempt has been made to summarize the marketing channels for live animals and skins in the state of Ceará.

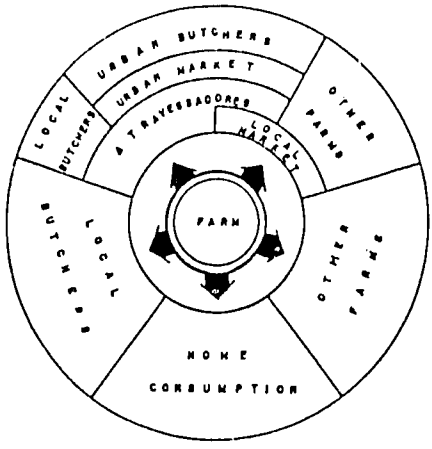


Figure 10.3. Sheep and goat marketing channels for live animals in State of Ceará, Northeast Brazil.

Source: Adapted from Gutierrez, 1982.

In the relatively few slaughtering plants in the meat exporting countries, frozen carcasses or cuts are the primary export product. The process involves holding the carcasses for a period of time after slaughter in a cool atmosphere to reduce the internal temperature. After that, they are transferred as full carcasses to a blast freezing unit. This rapidly reduces the temperature to between -10° and -20°C. Alternatively, the cooled carcasses are moved to specialized cutting rooms where they are cut, boned, and packaged for freezing. It also is possible to process the frozen carcasses into primal cuts. The cuts are then wrapped in shrink film to protect exposed surfaces during transit to the final destination.

In organized sheep producing countries, the most common form of marketing carcasses and meat of lambs and other sheep is based on the operation of a wholesale meat market. This relieves retailers of the task of buying livestock for slaughter. The market is a central point for retailers to purchase different types

of meat and meat products in the same place at the same time. It has the advantage that generally the buyer can choose portions of carcasses (rather than the whole carcass) to balance the preferences of his clients. The central market is the most common type in those countries where grading or classification is not developed, or in some cases not accepted, as it provides a venue for the butcher to select those carcasses that meet his requirements in terms of yield and value of saleable meat. These markets also have an important role in the wholesale procurement and distribution of imported meat supplies that, if frozen, require specialized storage, handling, and cutting facilities.

The determination of prices is mainly on the basis of private treaty negotiations between buyer and seller, who are generally well-versed in the operations of the market, the status of supply, and the relative prices of the day.

Retailing of lamb and mutton in developing countries in the most basic form is carried out in small shops operated by one butcher handling relatively small quantities of meat with only a modest investment in equipment. In underdeveloped countries, a lack of refrigeration facilities makes rapid distribution of the product essential. Most smaller shops open early in the morning and sell the majority of the meat before mid-day.

A significant point about retailing sheep meat in Northeast Brazil and other arts of the Americas is the lack of emphasis on differentiation between the various cuts or parts of the carcasses. The main criterion of value is the degree of leanness.

Product quality, differentiation of cuts, and attractive presentation of meat of all types are features of larger butcher shops servicing more affluent customers in the developed countries, as well as in larger cities in the developing countries. The labor costs involved in the carcass-cutting operation on an individual shop basis are high, and there is a tendency towards more centralized cutting and preparation of product prior to distribution. In addition, increasing quantities of meat are being sold through self-service outlets, e.g., supermarkets. In these operations, the meat is prepackaged, either in cutting rooms in the store or in centralized wholesalers and packing plants. Sheep meat, particularly lamb, usually is presented as bone-in primal or consumer cuts, shrink-wrapped with plastic film either individually or on trays.

Imported frozen lamb cuts also are a feature in self-service outlets, particularly in those countries where there is little prejudice against frozen meat products.

Chilled lamb cuts, vacuum-packed in polythene bags, also are beginning to be supplied by exporters, and techniques are being developed to ensure that the exacting temperature and handling requirements are met during transportation and distribution. An adaptation of the self-service outlet in some countries has been the establishment of home-freezer centers where consumers can buy meat in bulk to stock their own deep-freezers.

Skin Production

Most of the world sheep population produces wool; however, a

large portion of the sheep in the tropics do not have wool. The skin of these animals is more valuable for leather than is the skin of wool sheep; thus in tropical areas the skin of sheep is valuable.

In developing countries the export of skins in raw or processed form is an important source of foreign exchange. In areas of low cost labor, the skins also may be an important raw material for handicrafts, therefore increasing the aggregated value of the skins and providing a resource for local industry.

The skins are obtained from animals slaughtered on the property, from the animals which die, and from animals slaughtered at slaughterhouses. In developing countries, a large proportion of small ruminants (sheep) are slaughtered on the farm or in small abbatoirs, and this leads to problems of quality control in removing or preserving the skins. The result may be many skin defects. The main defects are cuts by knife, scars from barbed wire, defects of preservation, overdrying, grease spots, and damage by insects. These defects reduce skin quality in about 40% of the skins (Barret, 1982).

With few exceptions (as in the case of Karakul pelts), skins are by-products of the slaughter of animals for meat. However, skins are valuable by-products that deserve careful attention. Bellaver (1980) has shown that in Northeast Brazil, skins may represent as much as 30% of the value of an individual sheep. In some cases, sheep skins may be even more important to the producer or the national economy in countries where they are produced. In the case of animals slaughtered for household use, only the skins are available for converting to cash.

Literature Cited

Barrett, J. C. 1982. Hides and Skins Advisory Visit to the Federal University of Paraiba, Brazil. Report to Tropical Development and Research Institute, London.

Bellaver, C. 1980. As Peles. EMBRAPA-CNPA Circular Tecnica, 03. EMBRAPA-CNPC, Sobral.

Bellaver, C., E.A.P. Figueiredo, E.R. Oliveira and K.P. Pant. 1983. Characteristics of goats and sheep in Northeast Brazil. Pesq. Agrop. Bras. 18(3):301-9.

Boyd, L.H. 1983. Barbados blackbelly sheep in Mississippi. In: H.A. Fitzhugh and G.E. Bradford (Ed.) *Hair Sheep of Western Africa and the Americas*. pp. 199-304. Westview Press, Boulder, Colorado.

Figueiredo, E.A.P.; M. Shelton and K.P. Pant. 1982. Goat skins. In: *International Conference of Goat Production and Disease, 3. Proceedings*. p. 488-90. Tucson, Arizona.

Figueiredo, E.A.P.; A.A. Simplicio; C. Bellaver and K.P. Pant. 1982. Evaluation of goat breeds in the tropical Northeast Brazil. Pesq. Agropec. Bras. 17(4):643.

Figueiredo, E.A.P.; E.R. Oliveira, C. Bellaver and A.A. Simplicio. 1983. Hair sheep performance in Brazil. In: H.A. Fitzhugh and

G.E. Bradford (Ed.) *Hair Sheep of Western Africa and the Americas*. pp. 125-40. Westview Press, Boulder, Colorado.

Gutierrez-A., N.; J. DeBoer and J.U Alves. 1981. *Interacoes de Recursos e Caracteristicas dos Criadores de Ovinos e Caprinos no Sertao do Ceará, Nordeste do Brasil*. EMBRAPA-CNPC Boletim de Pesquisa, 3. EMBRAPA-CNPC, Sobral, CE.

Gutierrez, N. F. and J. DeBoer. 1982. Marketing and price formation for meat goats, hair sheep and their products in Ceará state, Northeast Brazil. In: *International Conference on Goat Production and Disease, 3. Proceedings*. pp. 50-62. Tucson, Arizona.

Kirmse, R.D.; J.A. Pfister, L.V. Vale and J.S. de Queiroz. 1983. *Woody Plants of the Northeast Ceará Caatinga*. Small Ruminant CRSP Technical Report Series No. 14. EMBRAPA-CNPC, Sobral, CE and Utah State University, Logan, Utah.

McDowell, R.E. and L. Bove. 1977. The goat as a producer of meat. Cornell International Agriculture, Department of Animal Science, Mimiograph, 56. Ithaca, New York.

Obanu, Z.A. 1975. A survey of the meat preferences of the Ibos of East Central State, Nigeria. J. Sci. Food Agr. 16903.

Pfister, J.A. 1982. Final Report: Range Management Project, EMBRAPA-CNCP, Sobral, CE and Utah State University, Logan, Utah.

Scott, G.E. 1983. *The Sheepman's Production Handbook*. Sheep Industry Development Program, Inc. Abegg Printing Co., Inc., Denver, Colorado.

Shelton, M.; G. Snowder and E.A.P. Figueiredo. 1985. *Meat Production and Carcass Characteristics of the Goat*. Small Ruminant Collaborative Research Support Program Technical Report Series, 45.

Smith, G.G.; G.T. King and Z.L. Carpenter. 1978. *Laboratory Manual for Meat Science*. American Press, Boston, Massachusetts.

Sink, J. D. and F. Caproaso. 1977. Lamb and mutton flavour; contributing factors and chemical aspects. Meat Sci. 1:119.

Sousa, W.H. de. 1987. Genetic and environmental factors affecting growth and reproductive performance of Santa Inês sheep in the semiarid region of Brazil. Texas A&M University, San Angelo, Texas.

Winrock International. 1983. *Sheep and Goats in Developing Countries. Their Present and Potential Role*. Winrock International, Morrilton, Arkansas.

Chapter 11

TROPICAL SHEEP PRODUCTION SYSTEMS

J. de S. Neto and E.A.P. Figueiredo

Sheep were among the first livestock species to be domesticated by man. The domestication occurred as early as 8,000 to 10,000 B.C., probably in the area known today as Iraq and Iran (Mason, 1977). Sheep served an important role in the transformation of man from a hunter to one who managed the resources to his benefit. Sheep are still important to mankind with large numbers of people living mostly on products obtained from sheep.

Sheep are adapted to and perform well in a variety of environments throughout the world.

Although they are economically less important than wool sheep on a world wide basis, tropical hair sheep serve an important role as a source of human food in developing areas of the tropics. According to Fitzhugh (1983), tropical sheep generally are found in areas of low altitude and latitude. In the Caribbean there are about 2 million head. In Brazil there are approximately 6 million head of hair sheep in the Northeast.

The type of vegetation found in various regions producing tropical sheep is related directly to the rainfall pattern, temperature, humidity, and other environmental factors, which, along with the social and economic aspects, determine the characteristics of the animal production systems.

This chapter attempts to describe the general form of the tropical sheep production systems where this species, together with others (cattle, goats, horses, donkeys, etc.), are the main components of the animal production system.

Finally, based on the information presented, strategic research is proposed to improve the production system, especially that concerned with improving productivity of tropical hair sheep.

Principal Factors Influencing the Production System

Resources Available

This is the main factor influencing the production system. For example, more fertile soils are used more commonly for cultivated agriculture. As a result, areas with poor soils or lower productive potential are available for animal production. One example of this is the caatinga region of Northeast Brazil, which has been used for sheep and goat production because alternative uses are limited. Similar situations exist in other areas. The alternative of using the more productive resources for sheep production should be considered an option, but is not likely to find favor in developing countries where the human population places pressure on the available resources, requiring their use for cropping to produce human food.

Complementariety of Production

Tropical sheep are used, and needed, to provide additional income and high quality supplement to the human diet (Gutierrez, 1987; Primov, 1982). In general, they contribute meat, milk, skin, and wool, depending on the breed. Manure (fertilizer or fuel) may be an important by-product in some areas. Arújo Filho (1987) reported that in the caatinga region of Northeast Brazil, the best results were obtained with combined grazing involving both sheep and goats, which produced 14.5 kg Bw/ha/year versus 12.3 and 11.4 kg Bw/ha/year, goat and sheep respectively, when grazed singly.

Tradition, Social Conditions, and Development

Tradition and social organization of animal producers in many parts of the world are influenced strongly by the land resource available and patterns of its use. In Northeast Brazil, the most common activity on poor farms with limited resources is sheep and goat production. However, because of tradition and the status that cattle provide, many producers pay more attention to cattle and crops. This fact may be justified by the labor supply available in large families and by a possibly larger gross income from cattle and crops in good years than from small ruminants only.

Theoretically, the policy of agricultural development aims to reach all strata of producers. However, the requirements needed (land tenure, installations, facilities, etc.) to obtain the benefits of technology and development programs often make it difficult to affect producers of small ruminants. In this way, the ability to respond often is restricted by the social and cultural conditions.

It is clear that these problems, added to other cultural factors, have influenced small ruminant production systems in tropical areas. Studies in Brazil (Neumaier, 1984) show that producers are receptive to technology and desire to improve the level of productivity of their flocks, but they often are limited in their ability to respond. Government policies often influence significantly the development potential of an area, and small ruminants often are ignored or receive low priority in developing these policies.

Demand and Prices

The level of demand combined with political constraints of movement of animal products across boundaries may limit the potential production increase in some countries. The per capita consumption of meat often is low because the majority of people do not have funds necessary to buy more animal products. Another reason is that the meat production from tropical sheep may be restricted to certain limits because of nonexistence of effective market infrastructure for live animals or their products. This is the situation in Northeast Brazil where the animals are sold at the property to neighbors and abattoirs of the neighboring village.

The resources in tropical regions certainly could support a higher level of production of sheep if the choice is made to use the resources for this purpose. Although there are production problems to overcome, the technological constraints often are less

serious than socioeconomic ones (including price).

In general, livestock production in the developed countries is more intensive in the use of capital as meat prices are relatively competitive with prices of other products required in the production system. In the developing countries, mainly in South America, high interest rates, high inflation, lack of capital, low prices of the products, and generally low wages make small ruminant exploitation much more intensive in the use of labor (Valdez and Nores, 1979).

Government Policy

The role of the state in the development of agricultural production is very important for the evolution of animal production systems. In many countries, government policy interferes in some way with the free market for animal products. In general, the direct impact of price control policies on tropical sheep has not been of large importance, since it is very difficult to control the marketing and consumption of the small volume involved because of the diffuse nature of the industry.

A more important factor is the impact that the elevated prices of the inputs have on the buying power of the rural population, limiting the possibilities of producers to make the necessary investments to improve the production system.

Because tropical sheep are produced under smallholder conditions, government programs to provide assistance or credit to small producers may be much more difficult and expensive to administer. Credit often is viewed as the principal constraint (Winrock International, 1983).

Production Systems

Tropical sheep contribute to several production systems (Fitzhugh, 1983) that largely are dependent on natural resources and socioeconomic constraints. Categorization of agricultural and livestock production systems is difficult, and the approach often is influenced by the background of the investigator. Kolors and Bell (1979) combined geography, environment, and people. Whitless (1976) classified the systems by region. McDowell and Hildebrand (1980) focused on the small producer with integrated crops and animal production systems. It is difficult to separate tropical sheep from other animal species and crops in production systems.

The tropical sheep production system may be characterized as (a) extensive; (b) dual or multiple purpose, involving many products and functions; and (c) market-oriented to satisfy the products necessary for subsistence in combination with other animal species with or without crops.

Tropical sheep are important components of the production systems of the Northeast region of Brazil, and are exploited by small producers with areas less than 10 ha. Sheep raised in this manner constitute more than 50% of the sheep population of the region. To these producers, the main reason for producing tropical sheep is to supply meat to low income rural people.

Skin production appears to be the second reason, and skins are

sold to tanneries. In such a region, the native caatinga is the basic source of feed, but because of its seasonality, forage restricts animal performance. The lack of an adequate diet during a long period of the year probably is responsible for fluctuation in body weight, high slaughter age, and low milk production, the latter contributing to high lamb mortality.

In these systems, cattle generally have priority in the use of feed resources of the ranch. But producers are conscious of the necessity to adopt management practices that may alleviate the nutritional deficiency associated with seasonal variation in feed supply. In this respect, Queiroz et al. (1987) showed a common characteristic of the production systems, in that tropical sheep, together with cattle, were the most important livestock activities. Cattle and sheep grazed together during the dry season (systems 1 to 3); in system 4, however, they introduced only cattle in the cotton field grazing (figure 11.1).

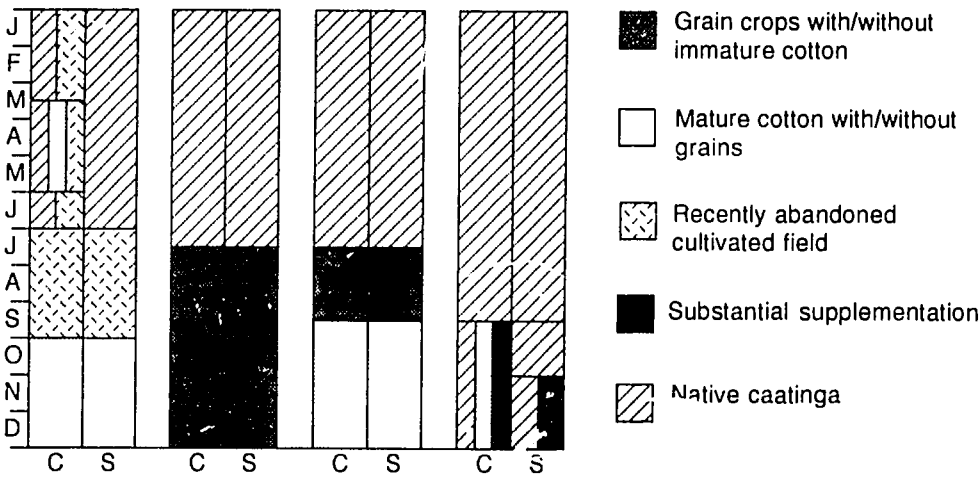


Figure 11.1. Diagrammatic representation of grazing systems of cattle (C) and sheep (S) used in farms, Northeast Brazil.

Adapted from Queiroz et al., 1987.

The tropical sheep production systems in Northeast Brazil are characterized by a low level of supplementation. The objective of this practice is to ensure survival and not to put on weight. As a result, sheep often receive a supplemental feed only when they already are in poor condition. Studies conducted in Northeast Brazil, however, have shown that when confined, such animals had weight gains of approximately 172 g/day (Oliviera et al., 1986). The performance of animals fed in tropical environments seldom approaches that of animals in temperate regions. This may be in part genetic, but likely represents the suppressing effect of high temperatures on feed intake and utilization.

Reproduction management is somewhat limited. The majority of properties do not have a controlled breeding season; lambings occur year-round. Gutierrez et al. (unpublished data), in farm level studies in Northeast Brazil, showed a positive correlation between rainfall and the birth of lambs 5 months later (figure 11.2).

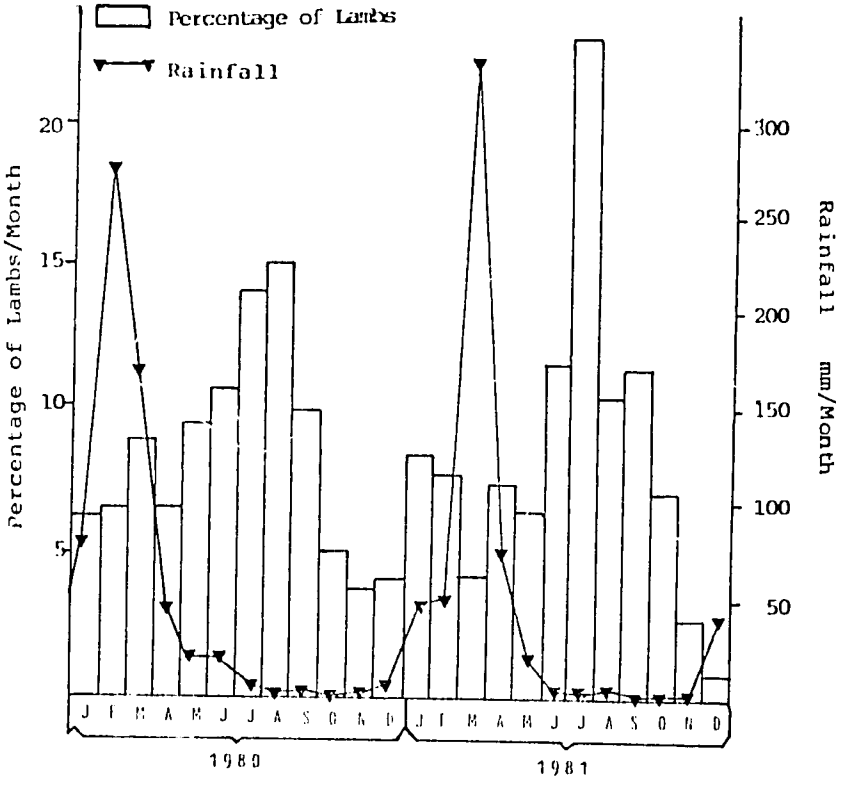


Figure 11.2. Lambing and rainfall distribution 1980-81 in Ceará State, Northeast Brazil.

Many producers do not use rams born in their own flock; this reduces inbreeding. Ewes on the range generally lamb unassisted and the newborn are subject to death because of mismothering or predation. Deworming, the only therapeutic practice widely used, is not universally practiced.

To the small producers who own the majority of tropical sheep, sheep are a renewable resource that periodically may be sold to obtain cash to meet family needs (Primov, 1982). Sheep are sold in small groups. The price of the animal is determined by weight on the basis of visual estimate. The ages at which animals are sold range upward from 12 months, with most being sold between 12 to 18 months. Sheep meat consumption is concentrated in the cities in the interior states. There is no well-established structure for marketing sheep meat. This often results in a lower price for sheep or goat meat. Conversely, the structured skin market is represented by the network of tanneries and skin traders in large cities.

The best approach to improve the sheep production systems of the small farmer would be:

- To stimulate the development of introduced forage with the objective of supplying the nutritional needs of animals without prejudice or reduction of the cropping areas. Good options that may contribute to this objective would be the use of crop residues and the use of legumes in the form of protein banks.

- To implement the use of hay or silage along with conserved forage in certain areas as a way of preventing feed scarcity in critical times.

- To develop programs of minimal cost for producers related to treatment and control of internal parasites.

- To consider greater use of fat tail or fat rump sheep in regions where feed supplementation in critical times is not possible, to encourage the use of more prolific sheep in areas where forage resources can support a higher level of production, and to develop large breeds for high forage producing areas or in confinement or to restrict their use to that of a sire breed.

Literature Cited

Araújo Filho, J.A. de. 1987. Combined species grazing in extensive caatinga conditions. In: *International Conference on Goats, 4, Brasilia, DF., Proceedings*. Vol. II. p 947-54. EMBRAPA-DDT, Brasilia, DF.

Fitzhugh, H.A. and G.E. Bradford. 1983. *Hair Sheep of Western Africa and the Americas: A genetic resource for the tropics*. Westview Press, Inc., Boulder, Colorado, U.S.A.

Gutierrez-A, N. 1987. How and why goats are produced in Northeast Brazil. In: *International Conference on Goats, 4. Brasilia, DF. Proceedings*. Vol. II. p. 321-26. EMBRAPA-DDT, Brasilia, DF.

Kolors, J.F. and D. Bell. 1975. *Physical Geography-Environment and Man*. McGraw-Hill, New York.

Mason, I.L. 1977. Sheep breeds of the Arab countries. Paper presented at training course in sheep production in arid zones, Tripoli, Lybyan Arab Jamahiriya.

McDowell, R.E. and P.E. Hildebrand, 1980. *Integrated Crop and Animal Production: Making the most of Resources Available to Small Farms in Developing Countries*. The Rockefeller Foundation, New York.

Neumaier, M.C. 1984. The Social Organization of Peasant Goat Production in Northeast Brazil. University of Missouri, Columbia, Missouri. Master's Thesis.

Oliviera, E.R., N.N. Barros, W.T. Robb, W.L. Johnson and K.P. Pant. 1986. Substituçãoo de tora de algodão por feno e leguminosas. Pesq. Agropec. Bras. 21:555. Brasilia.

Primov, G. 1982. Small ruminant production in the Sertão of Ceará, Brazil: A Sociological analysis. University of Missouri, Department of Rural Sociology Small Ruminant CRSP. Sociology Technical Report Series Publication, 6.

Quieroz, J., N. Gutierrez-A. and F.A. Ponce DeLeon. 1987. The ecology and management of small ruminant production systems in the Sertão of Ceará, in the Northeast of Brazil. Agricultural System 22:259.

Valdez, A. and G. Nores. 1979. *Growth Potential of the Sector in Latin America--Survey of Issues and Policies*. International Food Policy Institute, Washington, D.C.

Whittlesey, D. 1976. The Major Agricultural Regions of the World. Ann. Assoc. Amer. Geographers 26(1436:199-240).

Winrock International. 1973. *Sheep and Goats in Developing Countries: Their present and potential role*. Winrock International, Morrilton, Arkansas.

Chapter 12

SOME SUGGESTIONS FOR IMPROVED PRODUCTIVITY THROUGH MANAGEMENT

M. Shelton and E.A.P. Figueiredo

On a world basis, a large amount of research has been conducted with sheep, but most of this relates to wool sheep or those produced in temperate regions. Also, sheep frequently are used as an experimental animal in research. Information derived from these types of research have limited applicability to tropical hair sheep, and the amount of sheep research in tropical regions is limited. A relatively recent initiative in research with sheep and goats has been the establishment by EMBRAPA of a research center in Northeast Brazil and the initiation of the Small Ruminant Collaborative Research Support Program funded by USAID. The early and often preliminary results of research by these groups, combined with results from other areas, should provide the basis for recommendations contributing to improved productivity. But research results or technology do not directly result in change or improvement. To have an impact, technological developments must result in changes that can be implemented through management.

Possibility of Increasing Numbers

The relatively small numbers of sheep in tropical regions in general, and especially the Caribbean and Central America, indicate that the greatest opportunity for increased production from this species would be through an increase in numbers. In Northeast Brazil, numbers can be increased primarily through raised stocking rates brought about through improved caatinga management or caatinga modification. In other areas, numbers may come from introducing sheep to properties where there presently are no sheep. This might occur in three ways: (1) through establishment of new producing units in areas not currently used for productive agriculture or animal agriculture; (2) through substitution for other ruminant species, such as cattle or goats (in many cases this should be recommended only with caution); and (3) through placing sheep on properties currently used only by a single livestock species such as cattle or goats. This should benefit the overall productivity because of the complementary grazing behavior, and in some cases, an improved economic situation as the point of diversification. Taken collectively, these approaches offer the potential for numbers several multiples of those currently existing in the American tropics. Sheep production in these areas does present challenges, however, and major shifts in species or increases in numbers should be approached cautiously.

Improved Offtake

The offtake or extraction rate from sheep flocks in much of the tropics is low. By contrast, the potential exists for this to be a strong point for tropical sheep flocks. There is little seasonality (seasonal restriction to mating) in tropical regions. Many of the breeds (such as Barbados Blackbelly) in tropical regions are more prolific than those in temperate regions. Additionally, many tropical regions lack a well-defined seasonal

Previous Page Blank

pattern of forage production. These factors combine to indicate a potential for good lambing rates at more frequent intervals in tropical regions as contrasted to temperate regions; or an overall higher reproductive rate than that realized at present. A large litter size or multiple births may not always be desirable. If feed conditions (quantity or quality) are not adequate to support larger litters, a single lamb may be more desirable. Specifically, if the feed supply is reasonably continuous, but of low quality, then a single lamb at frequent intervals may be preferred.

To realize the potential for increased productivity in tropical regions, producers must treat sheep production as an industry or an enterprise and provide the necessary management inputs. An impediment to doing this is the perception of the flock as serving a subsistence role or as a cash reserve in lieu of using the banking system or as a hedge against inflation. These perceptions tend to maximize numbers; increased numbers adversely affect offtake expressed as a percentage of the flock. Technology may have limited impact under conditions in which productivity is not a priority goal.

The approaches to improving offtake from sheep may be outlined as follows:

- Increase the proportion of total numbers in the flock that is represented by breeding age females,

- Improve or increase net reproductive rate (frequency of lambing and/or lambing rate),

- Reduce death losses.

Death losses because of disease are discussed in Chapter 8, but other factors such as nutrition influence death losses as well. Reproduction is the subject of Chapter 7. But net reproduction, defined as the number of lambs raised or marketed per ewe, is important to the concept of offtake. Physiological infertility is rare and is not a primary source of problems. General undernutrition is a major source of delayed breeding, low lambing rates or poor lamb survival, and reduced growth rates.

A key ingredient to improving offtake is to develop a system that permits marketing of lambs at less than one year of age, thus increasing the proportion of breeding age females in the flock.

In flocks kept for meat production, the primary saleable animals would be male lambs (all except an occasional male kept for breeding), surplus ewe lambs (all except those required for replacements), and cull mature ewes. Thus the saleable animals within a given year should equal the net lamb crop raised (defining the net lamb crop as those raised to market age) minus the death losses of the adult ewes throughout their productive lives. Under reasonable conditions, death losses of adult animals should not exceed 4-5% annually, and thus over a 5-year productive life might represent 25% of the replacement females added to the flock. Thus if one assumes that only breeding age animals are maintained for the entire 12 months (97% females and 3% males) and that all females raise one offspring per year, the projected offtake rate would be more than 90% (i.e., 97 less the death losses in the breeding flock). To the extent that multiple births are obtained

and the lambs are reared or that parturition occurs more often than once per year, the production potential is greater than indicated. By contrast, extraction rates in tropical environments often are in the range of 10% to 20% (Oscarberro et al., 1985; DeBoer and Fitzhugh, 1983; and Souza Neto, 1987).

In order for a high percentage of the flock to be made up of breeding age animals, some or all of the following conditions need to be met.

- Surplus animals must be marketed before one year of age or within the year they are born.

- Replacement females must be bred to lamb at an early age, preferably one year.

- Death rates and culling of mature females should be at a low rate.

While all of these conditions can be met, this may not be easy to realize. Marketing lambs at less than one year of age may require they be fed for continuous growth or that they be sold to another party capable of managing them to maximize market value. Most hair sheep in the tropics will reach sexual maturity prior to one year of age and thus be able to lamb before two years (Johnson et al., 1988). The advantages of a low death rate in mature ewes is obvious. In commercial programs, however, culling of mature ewes perhaps should be minimized except for unsoundness or some other problem that will interfere with their ability to produce and raise lambs. In purely commercial programs, culling of sound ewes for genetic reasons is difficult to justify.

Matching Animal Numbers with Feed Resources

No concept is as important in animal agriculture as proper matching of the animal and feed resources; on a world basis, this is perhaps the area where the greatest mistakes are made. One often sees considerable disparity in which many areas have no sheep or other small ruminants although resources are well-suited for them, while in other areas or on individual properties the numbers are excessive in relation to feed resources available. Resources may refer to the type (quality) and the amount (quantity) of feed available; both may be critical. In contrast to the earlier discussion of areas where numbers may be increased, there are many current situations on individual properties or on communally grazed areas where overstocking is the major problem.

Once animal numbers and feed resources are balanced properly quantitatively, the concept of forage quality comes into play. In respect to optimizing performance, sheep benefit from somewhat higher quality feed than other species, particularly cattle.

The approximate priority of nutrient use (from <u>bottom</u> to <u>top</u>) in animal production is outlined below:

Breeding female	Breeding male	Market Animal
Fattening	Fattening	Fattening
Breeding	Breeding	
Growth		
Lactation	Growth	Growth
Fetal development		
Maintenance*	Maintenance*	Maintenance*

*including disease and parasite burden.

Although this outline is somewhat theoretical, and the indicated physiological functions are not totally independent, the principles are applicable. Maintenance is the first necessary function for survival. If only maintenance needs are provided, however, no production will occur. Situations like this occur in many subsistence or communally grazed flocks. Growth, reproduction, and fattening, which are necessary for production, require a higher level of nutrient intake above maintenance. To maximize performance, neither quantity nor quality should be limited for any extended period of time throughout the production cycle.

Fattening is shown as last on the list of metabolic priorities. Some readers might question the need for fattening. In most societies a certain level of fat in the carcass is considered desirable or necessary to command the best price. More importantly, some fat reserve on the breeding animal is important to support reproduction and lactation. In a grazing or foraging environment, it is difficult to conduct a productive animal enterprise unless the breeding animal is able to develop fat at some time during the year or production cycle, to be used as a reserve energy source at times of nutritional stress.

A closely related concept is efficiency. Only the nutrients supplied above maintenance can be used for production. Thus, theoretically it is possible to feed a group of animals at maintenance and produce essentially nothing, and this is in fact what happens for much of the year in low producing systems. If a group of animals is fed, on an annual basis, at 10% above maintenance then only 9% of the nutrients actually are available for production. By contrast if these animals are fed, on an annual basis, at 50% above maintenance, then approximately one-third of the total nutrients can be used for production. If the animal is fed double maintenance levels approximately one-half of the nutrients can be available for productivity. Thus it often will be possible to maintain fewer animals and have greater productivity. This concept should be stressed in relation to low producing systems.

As applied to the grazing animal, efficiency generally resolves itself to the appropriate stocking rate. Overstocking of the arid rangelands is one of the world's major tragedies. If a producer is using owned or privately controlled grazing land, the choice of the appropriate number and kind of livestock may well be one of the most important decisions he makes. Communal grazing lands present a different problem. Maximizing the number of livestock on communally grazed lands creates many serious problems, but there may be little an individual producer can do. In this

case, the number of animals a producer should attempt to own may be adjusted to those he can provide effectively and economically with supplemental nutrition at critical times. However, in communally grazed systems some type of control over numbers should be considered. This might occur as a voluntary initiative on the part of producers or might be imposed by some level of government.

In the case of the caatinga region of Northeast Brazil, stocking rates may require special consideration. Forage may be adequate during the rainy season, but numbers may need to be adjusted to those that can be provided adequate nutrition in the extended dry season.

Castration

Male lambs are the primary sale product. One question to address is, should these animals be castrated? Under most conditions, castration will reduce the rate of growth and thus body weight. This difference may not be evident in animals that are growing slowly because of nutritional constraints. There also is the risk that castration can result in infection or death. This is more likely with surgery. In any case, surgery will result in some blood loss and a temporary depression of growth. Castration is not automatically a desirable practice and is not universally recommended.

One of the reasons for castration is to reduce the rutting or mating activity. This practice also will eliminate development of secondary sex characteristics and thus may improve market acceptability. The castrated animal will fatten more readily. Thus castration may improve genetic progress or reduce management difficulties by removing the threat of young males breeding selected females in the flock. This may be a minor benefit among animals kept in communally grazed flocks as ewes often become pregnant by outside males. Perhaps most important is the influence of castration on carcass value or market acceptability. If the market does not pay a premium for wether animals, then there is little reason to castrate. In some societies, males sell to advantage. If there is a desire to access higher priced market outlets, however, such as hotel and restaurant trade, castration will almost certainly will be required.

The methods of castration include surgery, emasculation (severing nerve and blood circulation to testes), or the use of rubber bands early in life. Use of chemical castration have not produced encouraging results (Willingham et al., 1988). Some procedures require equipment that may not be available to the small producer, but many experienced producers are able to castrate the animal by manual procedures that do not require invasive surgery. Assistance in castration of surplus males may provide a mechanism for extension agents to help producers and thus advise on other aspects of production.

Grazing Time

Most livestock producers in developing countries confine their animals at night. This is usually for protection from theft, straying, or predation and may well be necessary. Confinement reduces grazing time, and animals spend more time in unsanitary pens or lots. If it is possible for the animals to remain in the

open, they should be more productive because of increased feed intake and improved sanitation. Reduced grazing time is more critical under conditions of high temperature stress, because the animal may not forage efficiently during the hottest period of the day. If animals are confined at night, longer grazing periods during the cooler part of the day (early and/or late) should be desirable.

Choice of Breeding Season

The choice of breeding season or mating schedule represents one of the more important decisions a producer will make, but it is difficult to provide highly definitive recommendations because of highly variable conditions. Some factors to consider are the potential of the sheep to breed more often than once a year, seasonality of feed supply, availability of markets throughout the year, and in some cases, seasonality of labor. It is important to exploit, where possible, the potential of the animal to reproduce on an accelerated schedule (at less than 12-month intervals). This is more successful at lower latitudes, which by definition includes most of the tropical regions, where photoperiod is less limiting. This approach also is more successful where feed supply (likely forage) is relatively constant year-round and nutritional level is adequate to maintain the breeding females in good condition even on an accelerated production schedule. If the nutritional level is low and forage or feed supplies are highly seasonal, it might be desirable to control the reproductive cycle so that breeding ewes have a chance to improve their condition and (or) periods of greater nutrient demands coincide with periods of greater forage availability. Although theoretically and technically correct, it may not be possible to follow the principle entirely. Three options with respect to the breeding season should be considered, as follows:

1. Continuous mating or accelerated lambing.

By default rather than design this is likely the most frequently used mating system for animals kept for meat production in developing countries in tropical regions. Farmers with communally grazed flocks usually will follow this system because control of mating may not be possible. Also, low labor input systems of production usually will follow this practice because the producer is unable or unwilling to manage males independently. Two situations in which continuous mating probably is desirable are when sheep are raised in the wet tropics where feed supply is relatively constant, and for intensely managed flocks in which the nutrient requirements are provided as needed. A third condition in which continuous mating often is practiced and possibly can be condoned is in areas where it is not possible to predict forage availability or to provide the management inputs necessary to exploit a well-designed system. This latter approach usually will be characterized by low levels of production and high mortality, but may be the only option for certain groups of producers.

Under these conditions, permitting ewes to lamb at the less opportune time may be preferable to having no lambs at all, which could happen with a single controlled breeding period that coincides with periods of nutritional or climatic stress. It has been shown (Figueiredo et al., 1983 and Silva et al., 1987) in the wet-dry regions of Brazil that ewes frequently mate at the start

of the wet season because of their improved nutritional status at this time. As they lamb near the start of the dry season, this results in high lamb mortality, slow growth rate, and delayed marketing.

Although in the above discussion the terms continuous mating or continuous lambing have been used, it is likely that some version of intermittent exposure to males (such as alternate months) would be more desirable as this would permit and require some organization of management. Also, intermittent exposure to males may stimulate a higher level of reproductive activity.

2. *Controlled matings whereby the period of greatest nutrient requirements (lactation of dams and growth of the offspring) will coincide with the period of greatest forage availability.*

This is the natural scheme of things in temperate regions where matings are controlled so that lambing occurs in the late winter or early spring. This is almost certainly the explanation for the evolutionary development resulting in photoperiod as a synchronizing agent in reproduction for many species. In tropical regions, both temperature and photoperiod-induced seasonality of production are less evident. In the wet-dry tropics or other areas of highly seasonal and usually predictable forage production, however, synchronization of production systems and forage availability is almost certainly the most productive. In the case of a six-month wet and six-month dry season, matings can be made shortly after the end of the wet season in order for lambing to occur just before the wet season begins. In this system, lactation and lamb growth will coincide with forage availability. Lambs would be weaned at five to six months and, it is hoped, sold.

There are some critical components for this to work. Ewes need to be in adequate condition to breed at the time or shortly after the lambs are weaned. Thus, for the system to work, producers must be able to provide for the needs of the gestating ewe during the latter part of the dry season. Also, lambs from under-nourished ewes that are dropped during a period of unexpected early heavy rains may suffer heavy mortality. Thus, the producer needs to ensure by various means that this does not happen. The most important interventions would be nutrition of the ewe, protection, and good sanitation for the lambs.

An added risk of this system is the possible late arrival of rains, and the consequent shortage of feed just when it is most needed.

3. *A modified scheme in which lambing occurs after the start of the rainy season.*

The wet-dry season, as mentioned above, describes the situation of Northeast Brazil, although the period of rainfall may not be exactly six months, and its beginning and ending dates are not highly predictable. Although system 2, described above, is preferred by the authors, in practice producers, or even researchers, cannot predict events and may have difficulty in providing the inputs necessary to make the indicated system work.

An alternative system has evolved in which ewes are bred later in the dry season with lambs being dropped after the heavier part

of the rainy season. This may reduce lamb mortality compared with that likely to occur if a thin ewe drops lambs at the peak of the early rainy season. The ewes often will need some additional feed at mating (flushing), but this will be minor compared to that of the pregnant or early lactating ewes. A correlated disadvantage of this scheme is that lambs will go into the dry season at a younger age and lighter weight. Mortality may be higher at this time, and there is little hope of selling them for slaughter until after the following rainy season unless they are heavily supplemented or transferred to an alternative management system such as a feed lot or irrigated pasture.

In the above discussion, dates have not been provided. Producers will need to adapt the system to local conditions of climate and feed availability.

Once a controlled mating system is adopted, ewes that fail to conceive on the chosen schedule should not be allowed to remain open for a full year. The options are to sell these ewes, especially if they are aged or unsound, or to provide a later second mating period. In most cases, out-of-season lambs are preferred to no lambs at all.

Supplemental Feeding

Several chapters in this publication cite nutrition as a constraint to production. In more favorable years, the period of serious nutritional deficiency may be as little as 30-60 days late in the dry season. Throughout most of Northern Brazil, there is adequate land area and moisture during the rainy season to grow forage or feeds to fill this need. The cash costs of doing this may be low or nonexistent. However, labor, initiative, and know how may be serious constraints. Possible supplemental feeds may be (a) crop aftermath (i.e., corn, beans, etc.), (b) cultivated forages (i.e., cunhá, napier grass, etc.), (c) leguminous trees or shrubs (i.e., leucaena or algaroba, etc.), or (d) unpalatable native forages that may be preserved and fed as hay or silage (matapasto and panasco, etc.). Several of these are acceptable to animals as preserved forage. Animals needing such supplements include females at mating, or ewes gestating or lactating late in the dry season, or weaned lambs intended for market.

Use of Protein Bank

The most frequently limiting nutrients for livestock production in a range environment are protein and energy. High protein forages, commonly called a protein bank, are an effective means of providing both energy and protein as supplements to late dry season caatinga, which has been shown to be marginal or deficient in protein as well as energy.

Other ways to meet protein requirements include the use of non-protein nitrogen (NPN), but this is difficult to use safely under smallholder conditions; also, it provides no supplemental energy. The most effective way to provide protein is through feeding high protein concentrates such as oilmeals, which are also good energy sources, but this often will present problems to producers of limited means because of cash cost or transportation. A third approach is to use high protein forages in the form of annual leguminous crops such as cunhá or shrubs or trees such as

leucaena or algaroba. In the humid tropics, kudzu or other legumes can be used.

On a dry matter basis, most of these forages contain more than 20% crude protein. The principle of using these as a protein bank is that they would be used in limited amounts as a supplement to the range diet. They may be offered in the form of short-term grazing or as cut-and-carry forage. For maintenance alone, it is not necessary to feed them every day (Calhoun et al., 1988). Animals with low requirements, such as dry ewes, may be fed the supplemental forage as infrequently as once or twice a week, but animals with higher requirements, such as growing lambs or lactating ewes, should preferably be offered the high protein forage daily. Producers with small numbers of animals (30 or less) may be able to produce sufficient supplemental forage for the latter part of the dry season on an area as small as 0.1 ha. If irrigation is not available, it will be necessary to produce the forage in the wet season and store it as hay or silage for use in the dry season.

Literature Cited

Calhoun, M.C., J.M. Shelton, C.J. Lupton, B.C. Baldwin and S.W. Kuhlman. 1988. Effect of frequency of feeding a protein supplement on production of Angora goats. Paper presented at American Society of Animal Scientists. Rutgers, N.J.

DeBoer, A.J. and H.A. Fitzhugh. 1983. Sheep and Goats in Developing Countries - their present and potential role. World Bank Technical Paper.

Figueiredo, E.A.P., E.R. De Oliveira, C. Bellaver and A.A. Simplicio. 1983. Hair Sheep Performance in Brazil. In: *Hair Sheep of Western Africa and the Americas: A Genetic Resource for the Tropics*. pp. 124-40. Westview Press, Boulder, Co.

Johnson, W.L., N.N. Barros, E.R. De Oliveira, A.A. Simplicio and G.S. Riera. 1988. Dietary energy levels and age and weight at puberty in Morada Nova ewe-lambs in Northeast Brazil. Small Ruminant Research 1:67.

Oscarberro, R., S. Fernandez and L. Tovar. 1982. La Produccion Ovino en la Zona de Rio Frio, Edoide Mexico. In: *Memorias del Primer Seminario Nacional Sobre Sistems de Produccion Pecauria*. pp. 269-286. Universidad Autonoma Chapingo, Chapingo, Mexico.

Silva, A.E., J.F. Nunes, G.S. Riera, N.N. Barros, E.A. Lopes and W.C. Foote. 1984. Influence de nutricáo nu atividade ovariana e apos a puberdade em ovinos das racas deslavdas. In: *Simposio Naconal de Reproducáo Animal, S. Anais*. Colegio Brasileiro de Reproduc, áo Animal. Belo Horizonte, Brazil.

Souza Neto, J. 1987. Demanda potencial de carne ofde caprinos e ovinos e perspectivas de oterta. 1985-90. EMBRAPA/CNPC, Documentos 2. Sobral, Ce., Brazil.

Willingham, T.D., P.V. Thompson and M. Shelton. 1988. Chemical castration in Angora Goats. Texas Agricultural Experiment Station. PR 4577.

Chapter 13

RECOMMENDATIONS FOR FURTHER RESEARCH

M. Shelton and E.A.P. Figueiredo

Improved Forage Production

Forage production and utilization are basic concerns in any industry based on ruminant species, and thus research in this area should be an ongoing process. The exact nature of the work to be undertaken will vary depending on conditions or resources. Information reported in Chapter 5 indicated a marked improvement in forage (herbage) production from lowering, or especially thinning, of caatinga vegetation in Northeast Brazil. These practices possibly benefit sheep more than other species in this unique resource area.

The research involving lowering or thinning as a means to improve forage production is relatively recent in origin. Appropriate management of fragile resources must be followed over time. Thus, research on the alternative types of caatinga management needs to be continued over many years. In some cases, it will prove desirable to follow individual plant species and their response to various types of utilization or management.

At present, the practice of caatinga manipulation as a means of improving grazing is limited. Caatinga clearing is used widely as a part of the shifting agriculture of the region. This likely will continue to be the primary reason for altering the caatinga. Thus, equally or more important than caatinga management, research should be conducted on grazing management following a period of cultivation. This may have more effect on the long-term productivity and conservation of soil, water, and forage resources of the region.

Forage production research, including that of introduced or cultivated forages, should have a high priority for research at any location in the tropics. Nutritional value of tropical forage, especially tropical grasses, generally is lower than that produced in temperate regions, and this often represents a constraint to small ruminant production. Thus, forage quality should be a focus of these investigations.

Genetic Improvement

As pointed out in Chapters 2 and 3, sheep, like goats, are comparatively recent occupants of the tropics. Tropical environments are likely to prove stressful to any animal that has not had a long period of adaptation or selection under these conditions. To serve as the basis of a successful industry, the animal must adapt to the environment, or the environment must be altered to fit the animal. Although there may be limited opportunities to modify the environment, there can be little question that the animal must be adapted to the prevailing environmental and production conditions. There also is the added requirement that for commercial exploitation, the animal must

Previous Page Blank

produce in reasonable quantity a product or products useful to mankind. The presence of an adapted and productive genotype is likely the most important requirement for exploitation of a given species in a specific environment. Such a sheep does not presently exist in the humid or wet-dry tropics. The development or generation of this genetic resource should command high priority. Over time, natural selection will generate an adapted genotype, but most evidence suggests that this will be at the expense of productivity. The development of a productive and adapted genotype will require a great amount of time and resources. These are not likely to be available to smallholder farmers or research agencies in developing countries with limited resources or limited interest in sheep. Thus international agencies or programs, including the SR-CRSP, can be faulted for not having adequately funded a regional program with the continuity necessary to accomplish this task.

For discussion purposes, tropical regions might be viewed as consisting of three types, although natural variables cannot be so easily or accurately categorized. One of these is the humid or wet tropics, the second is the wet-dry tropics such as exist in Northeast Brazil, and the arid regions of the tropics or subtropics. For the most part, the Americas do not possess large land areas in the arid tropics. Only North Mexico and a small part of the southwestern United States fit this description. Most of the United States is above the arbitrary line of 30°N latitude. The two most prevalent or widespread genotypes of sheep on a world basis (the Merino and the fat-tail or fat-rump and carpet wool types), are reasonably well-adapted to arid regions. In general, the only requirements to exploit these genotypes is that land resources be adequate (not overly stocked) and that producers be in a position to provide the necessary nutritional inputs to maintain the animals in times of stress.

The humid or wet tropics present some special challenges. An adapted animal must be able to deal with the problem of heat stress, parasites and diseases, and the generally lower quality of available forage. In addition to meeting these requirements, the animal must be a reasonably good producer of meat, milk, or fiber. It seems a safe conclusion that no such animal presently exists.

The wet-dry tropics also present different challenges. It is the writers' opinion that animals adapted to the humid tropics generally can function successfully in an arid environment, at least from the standpoint of climatic constraints. Management practices must be developed, however, to provide for their nutritional requirements during the dry period. In the more extreme cases, where aridity or feed scarcity presents the dominant picture, the approach may be reversed with the fat-rump or fat-tail genotypes providing the starting base. It is recognized generally that the fat-rump types, such as the Somali or Blackhead Persian, possess superior adaptation to arid environments. However, most research which is conducted under controlled conditions with the results expressed on a per head basis will reflect unfavorably on these types. This type of research must be conducted under conditions comparable to producers' experience.

Disease and Parasite Control

Diseases and parasites are constraints to sheep production in the tropics. In some cases, the technology is available to deal

with specific disease and parasite problems; in others, further work is needed. However, economic forces as well as communication or education may limit the ability to implement the high technology involved in preventing or treating disease and parasite problems. Thus, breeding of animals with resistance to disease and parasites should continue as a major goal. This approach will require time, and in the interim other approaches must be taken. Although good anthelmintics are available, resistance to specific anthelmintics occurs at a reasonably rapid rate with most products. There is a need to develop and evaluate new drugs on a continuing basis. Also total dependence on drugs under tropical conditions does not seem advisable. Thus, there is a need to monitor genetic resistance and to develop recommendations for a combined approach involving genetic resistance, management practices, and the strategic use of anthelmintics.

Research workers with EMBRAPA and SR-CRSP have made significant progress with respect to one disease condition known as caseous lymphadenitis, and this work needs to be continued until results can be implemented under producer conditions.

Nutrition

Poor nutrition is a major factor contributing to low production of small ruminants in the tropics. It is unlikely that there are major gaps in the knowledge of nutrition that are likely to be resolved by attempting to study the principles of nutrition in developing countries or tropical regions. However, there is a need for adaptive research, combined with forage production research, to develop and demonstrate management practices to overcome nutritional constraints.

Socioeconomic Constraints

Socioeconomic constraints frequently are the major impediments to improved production. After having made this observation, however, there is relatively little that a production oriented researcher can do to modify the forces that bring about these situations. On the other hand, such research can have a negative influence through fostering a defeatist attitude relative to the difficulty of helping the small farmer. Rather than to ignore research in these areas, the approach taken should focus on how the producers can be influenced or benefitted. Descriptions of the status quo has little value unless the research sheds light upon the reasons (or perceptions) farmers have for sustaining it.

Primary among the lines of investigation should be economic feasibility studies concerning the implementation of specific production practices or new approaches in marketing.