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IMPROVING MEAT GOAT PRODUCTION IN THE SEMIARID TROPICS

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Co-editors

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PREFACE

Ten years ago, research on goats in the tropical Americas was hard to find. The little that was going on was scattered and fragmented, and scientists worked in relative isolation from each other. The establishment of the Small Ruminant Collaborative Research Support Program was a major step toward linking isolated scientists and bringing to light hidden knowledge about raising goats. 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 as the Management Entity for the Small Ruminant CRSP. This occasion brought into being a unique opportunity to increase the interaction between Brazilian and U.S. scientists, as well as to increase the opportunities for post-graduate training of young scientists from both countries.

Since then, much research has been accomplished in Northeast Brazil and in the United States. The Centro Nacional de Pesquisa de Caprinos (CNPC), or National Goat Research Center, of EMBRAPA, has been the host institute in Brazil. State research agencies in Bahía (EPABA), Ceará (EPACE) and Paraiba (EMEPA) have also participated.

Collaborating institutions from the United States were the University of California, Davis, for animal health; the University of Missouri, for sociology; North Carolina State University, for nutrition; Texas A&M University, College State 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.

The results of the collaborative research serve as the basis for the suggestions for technology improvement put forth in the present volume--a technology package, if you will. It is hoped that these ideas will prove useful for the extensionists and others who deal directly with meat goat producers, and also for teaching goat science in universities throughout the semiarid tropics. The information contained herein will be helpful for improving many facets of goat production not only in Northeast Brazil, but also for other regions with similar ecological characteristics.

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

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FOREWORD

The world goat population increased from around 465,000,000 in 1980 to about 492,000,000 in 1986, according to the Food and Agriculture Organization (FAO); about 94% of the world's goats were located in developing countries. In 1986, goats produced 2,100,000 MT of meat and 7,800,000 MT of milk. Goats in the developing countries provided about 90% of the meat and 74% of the milk of the world's production. These numbers indicated not only a sizeable but also a highly valuable contribution made by goats to the supply of high-quality proteins for human populations that have very limited access to them.

Because of the importance of goats and the many constraints on their production, the Small Ruminant Collaborative Research Support Program (SR-CRSP) initiated in 1979 a multidisciplinary research effort to improve goat utility and productivity. To address the objectives as set forth at that time, the SR-CRSP developed a series of sub-projects on range management to assess the sustainability of the feed supply while maintaining and enhancing the natural resource base; on sociology to assess the impact on the welfare of people, particularly the limited-resource goat owner; and on the economics to predict the viability of alternative systems. These approaches are in addition to the applied biological sciences usually addressed by animal and veterinary scientists. This report summarizes the accomplishments of the research, training, and demonstration team in Brazil and the United States.

We have also learned that for any research results to be effective and successful, they must be sociologically acceptable, ethically defensible, environmentally beneficial, and economically sound and relevant to the particular aims, needs and resources of the producers, their families, and their communities

These accomplishments also demonstrate the appropriateness and the effectiveness of Title XII legislation, which established the CRSP concept and laid the groundwork 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 six U.S. institutions are acknowledged with great appreciation, for without them the program would not have been possible.

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December of 1988

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INTRODUCTION

As its title implies, the focus of this publication is the improvement of meat goat production in the semiarid tropics. It is the culmination of collaborative research that was initiated in 1979 at the National Goat Research Center (Centro Nacional de Pesquisa de Caprinos, CNPC) of EMBRAPA, at Sobral, Ceará. The climate and the ecology of this region of Northeast Brazil are described in detail in Chapter 1 and can be considered typical of many semiarid tropical regions in other parts of the Americas as well as of sub-Saharan Africa and isolated regions of Asia.

The vast majority of goat producers in such regions have limited capital resources. In Chapter 2, the socioeconomic context of the limited-resource producers of Northeast Brazil is described.

The technological suggestions put forth by the authors of Chapters 3 to 12 have been formulated with the limitations of ecosystem and socioeconomic context in mind. Taken together, the recommendations from those chapters form an appropriate menu of improved technology alternatives for limited-resource producers.

As readers who have experience with technological modernization within a traditional system are fully aware, it is impossible to make one set of general recommendations that can apply to all situations. The extension worker, student, or other change agent who reads this book must pick and choose from the menu of options presented. To help in the necessary economic evaluation of proposed new technology, the basic tools for economic analysis are outlined in Chapter 13. Also, some suggestions for communication and gaining the trust of traditional farmers are presented in Chapter 14. The goal of any program of technological change should be to engage farmers in a dynamic, two-way dialogue, in such a way that both the researcher and the farmer can extract maximum advantage from each other's experience.

No package of technology can be expected to have all of the answers to all of the biological and economic questions that arise daily as the producer interacts with his animals, his feed resource, his market, and other factors of production. Recognizing that research needs still exist, we have attempted to summarize some of the immediate priorities for future research in Chapter 15.

Even the casual reader will note a lack of unanimity among different chapter authors on some recommendations. For example, several authors discuss the possibility of a controlled, limited, breeding season, but there is no consensus on the "best" time of year to breed goats in Northeast Brazil. Such differences of opinion only underline the need for careful, farm-level testing of new technology at the local level; for the exercise of prudence in adapting recommendations to individual farm circumstances; and for continued research.

Through the years of work during which research data have been generated, many people have made indispensable contributions. To list them all here would take many pages and incur the risk of unintentionally overlooking someone. Suffice it to acknowledge, through these imperfect words, the collective appreciation of the

editors and chapter authors for the selfless labors of many others: farm laborers, animal tenders, laboratory technicians, librarians, clerks, mechanics, drivers and secretaries. A special note of thanks is reserved for the dozens of students--from Brazil, from North American, and from third countries--whose hard work has generated many of the data presented and whose enthusiastic curiosity has stimulated their mentors to conduct better science.

There are several names which must be listed, for without their facilitating labors there would have been no program of collaborative research. First and foremost are the Chiefs of the National Goat Research Center (CNPC), our host institution, who have been incumbent during the lifetime of the Brazil projects: Darlan Filgueira Maciel, Dr. Elino Alves de Moraes, Dr. Luiz Carlos Lopes Freire, Francisco de Assis Vasconcelos Arruda, and Dr. Elsio Antonio Pereira de Figueiredo; the Program Directors of the Small Ruminant CRSP: Drs. David W. Robinson, William C. Weir, David W. Robertshaw and James W. Oxley; the on-site coordinators of SR-CRSP projects at the National Goat Research Center: Thomas Miller and Drs. Thomas W. Robb, Jorge Kawas and Gregory Baker. Finally, our Project Managers at AID's Bureau of Science and Technology in Washington, D.C.--Dr. Ned S. Raun, Campbell McCluskey, Dr. James W. Oxley, Dr. Charles E. Haines, Harvey Hortik and Joyce Turk--must be mentioned. As can be inferred from these lists, the Small Ruminant CRSP has outlived changes in administration in many organizations. To the credit of the founders of the program, its underlying purpose has been accepted and adhered to by all of their successors.

Special recognition is due the Presidents of the Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA) in Brasilia: Drs. José Irineu Cabral, Eliseu Roberto de Andrade Alves, Luiz Carlos Pinheiro Machado and Ormuz Freitas Rivaldo.

Two of our colleagues are no longer with us to see the fruits of their labors. Dr. David W. Robinson, Program Director through the crucial formative years of the SR-CRSP, died in Davis, California on December 26, 1986. Dr. Simon Riera, visiting IICA resident scientist at the CNPC from 1980 to 1983 and later visiting scientist for reproductive physiology at Utah State University (1983 to 1986), died in an automobile accident in his native country of Bolivia, September, 1986. Everyone who knew and worked with Drs. Robinson and Riera were inspired by their unswerving dedication to the goal of helping ease the plight of the small producer.

Finally, it is to the goat producers of semiarid tropical climates everywhere that we dedicate these pages. If any of these hardy individuals, anywhere, find their life made a little easier by adapting and adopting some of the ideas presented herein, the collective efforts of scientific collaboration will have met their ultimate success.

William L. Johnson
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Sobral, April, 1988

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Chapter 1

ECOLOGICAL CHARACTER OF THE SEMIARID TROPICS OF NORTHEAST BRAZIL

J.C. Malechek and J.S. de Queiroz

Goat production in Brazil is effectively limited to the vast sector known as "the Northeast," a region that is unique politically, sociologically and geographically. The Northeast comprises approximately 20% of Brazil's land area and includes all or parts of ten separate states. It is commonly described in terms of three macro-ecological zones: the Zona da Mata, the Agreste, and the Sertão. The Sertão, the vast inland region (Figure 1), is where most goat production is centered.

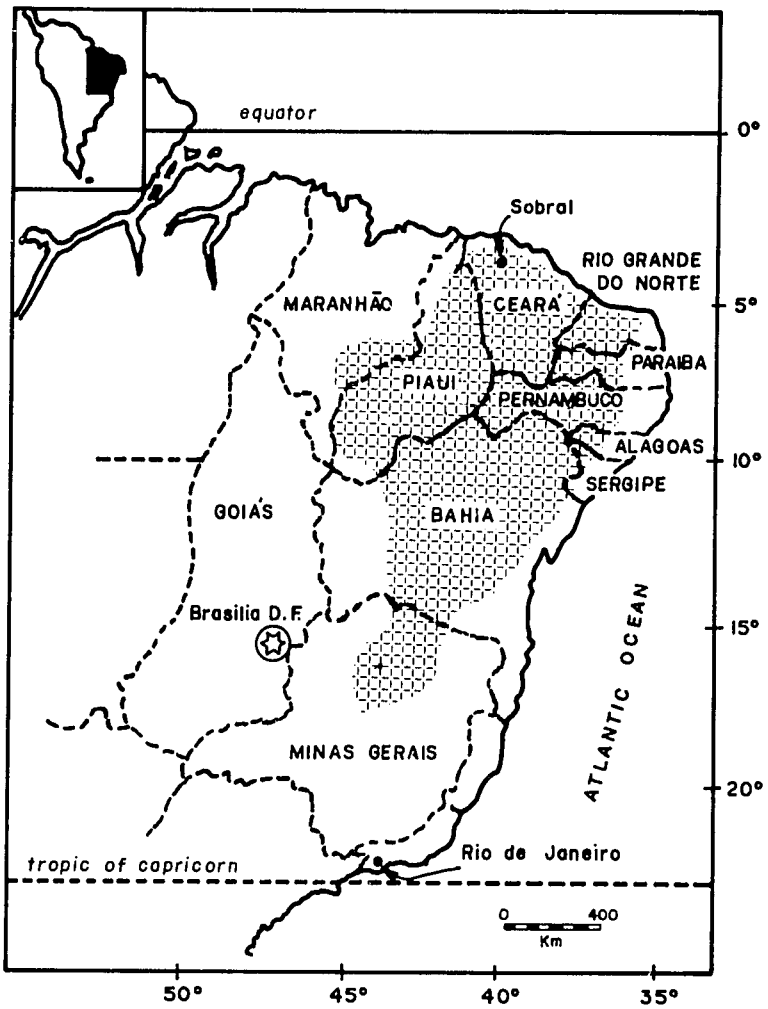

Figure 1. The Sertão of Northeastern Brazil (shaded area). Adapted from Mason (1980).

Climate

The highly variable semiarid climate exerts major control over agriculture and virtually all other aspects of life in the Sertão. This harsh climate, working in concert with soils of limited agricultural capability and a 400-year history of exploitative land use practices, has produced a vegetation that is particularly well suited to use by browsing animals, notably goats. The objective of this Chapter is to describe the environment of the Sertão in ecological terms, with particular attention to relationships that influence goat production.

Northeast Brazil is nominally situated between 1° and 18° south latitude and 35° and 48° west longitude. Its climate is generally described as semiarid tropical, with average annual precipitation ranging from 400 to 1000 mm, depending on locality. However, long-term averages do a particularly poor job of describing the climate of this area. One must speak in detail of the extremes and the variations to reach an understanding of how climate, vegetation, livestock, and man interact.

Rainy Season

The first variation to strike even the most casual observer is that of the seasonal distribution of precipitation. About 90% of the year's rainfall comes during a 5- to 7-month period, and the remainder of the year is effectively without precipitation. The rainy season begins around December or January and runs to May or June, depending on the locality and the year. Figure 2, taken from Queiroz et al. (1986) shows the average rainfall distribution for Ceará state for the years 1950 to 1983.

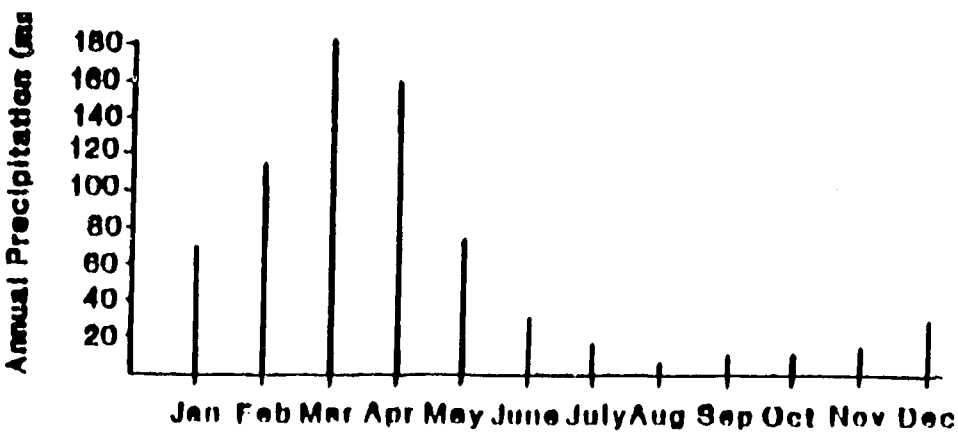

Figure 2. Monthly distribution of rainfall for Ceará state, 1950-1983. (From Queiroz et al., 1986).

Individual storms are often intense, rarely lasting longer than 45 minutes, and may be concentrated in areas of less than 2 square kilometers. Local flooding is common.

During years of above-average precipitation, soils in areas of flat or low-lying land may become thoroughly saturated and water-logged. This drastically alters movement patterns of goats grazing on native pastures, as the animals restrict their daily feeding forays to the drier portions of the landscape afforded by small elevational gradients. The net result is that the effective foraging areas for animals in a paddock are greatly reduced for extended periods of several weeks or longer. Goats avoid areas of water-saturated soils if at all possible. This factor, coupled with the attendant stresses of biting insects (matucas) and footrot that are common during such wet periods, can contribute to very poor levels of animal performance. For example, during the abnormally wet rainy season of 1985, large death losses were experienced by goat producers throughout the Sertão. On the CNPC experimental area, Schacht (1987) observed that goats only maintained bodyweights from January through May. Gains were not observed until July. This is contrary to responses during the years of average or below average rainfall, when most of the annual gains are expected during the rainy season and the transition season that immediately follows.

Dry Season

Traditionally, the dry season has been identified by producers and scientists alike as the major stress period or production bottleneck in the annual agricultural calendar. The dry season is commonly thought to begin when soil moisture stress reaches the point that the drought-deciduous trees and shrubs shed their leaves. This event typically does not occur quickly or uniformly over the whole of the Sertão, especially not during years of above-average rainfall, when the wet-to-dry transition period can last for two or more months. The transition can be especially prolonged if major rains occur late in the wet season, as was the case in 1985 when some of the normally deciduous trees never fully lost their leaves. During years such as these, animal bodyweight gains can be realized far into the dry season. For example, in 1984, Schacht (1987) observed gains by young goats in November, whereas Pfister and Malechek (1986b) found that gains had peaked by mid-September in 1981, a below-average rainfall year.

Daytime temperatures during the October-December period typically exceed 35°C. Even though rainfall is rare, humidities can remain quite high during this time. Relative humidities range from 90% in early morning to 25% in mid-afternoon at the CNPC research center. Nighttime temperatures rarely fall below 22°C during the dry season, but occasionally go as low as 14°C in the rainy season.

Recurrent Drought

Northeast Brazil is known as one of the most drought-prone areas of the world. There have been six major droughts during this century, earning the area the dubious title "drought polygon" (Mason, 1980). The most recent ended in 1984. Hargreaves (1973) studied long-term weather records for the Northeast and concluded

that, in general, dry or droughty conditions might be expected in five or six years out of every ten. Recent studies of weather records by Girairdy and Teixeira (1978) have shown that droughts in the Northeast seem to occur in regular and, perhaps, predictable cycles. Queiroz et al. (1986) used the Girairdy and Teixeira model, developed for the Fortaleza area of northern Ceará, to illustrate two major trends: a 13-year cycle of minor drought, superimposed on a 26-year cycle of major drought. This model accurately predicted the major 1980-1984 drought.

Reasons for the drought-prone character of the Northeast are not well established. The geographic location of the area places it in the transition zone between northern and southern hemisphere circulation patterns, although neither predominates. The cool Benguela ocean current, located off the northeastern coast of Brazil is thought to contribute. Cool air layers that form over this current displace warm moist air and stabilize anticyclonic circulation patterns. Thus, there is a pronounced absence of major storm fronts that could potentially carry moist maritime air during much of the year. Also, the tropical continental air mass that sits over the Northeast throughout the dry season tends to impede inland flow of moist air.

Breakdown of these dry-weather promoting conditions is generally associated with the southward migration of the Intertropical Convergence Zone (ITCZ), a large trough of atmospheric low pressure. As the ITCZ moves over the continent, warm, moist air is allowed to penetrate, and conditions for rain are established. However, movement of the ITCZ is unpredictable and subject to factors not currently understood. Thus, the threat of drought is an ever-present factor of life in the Northeast.

Livestock producers who live in such unpredictable environments often adopt risk-minimization practices, as opposed to the profit maximization approaches common to agriculture in more developed countries (Primov, 1985). Thus, climate plays a vital role not only in defining the limits of production in the biological sense, but also in determining the pattern of man's response in a managerial sense.

The Landscape

The vegetation of a particular area and the general approach to agriculture, whether it be intensive cropping or extensive livestock grazing, are largely determined by the soil resources available. Thus, to understand livestock production, an understanding of soils is needed. However, for an area as large and as geologically complex as the Sertão, general descriptions of soils can do little more than to highlight major limitations. In this context, knowledge of the geologic history is helpful.

Geology

Most of the Sertão sits atop an extensive peneplain known as the Borborema plateau. Parent rocks consist mainly of granite, schist, gneiss, quartzite, and other crystalline materials. However, limestone and sandstone were overlaid during the Cretaceous period, when much of the area was submerged. Formations were uplifted during the Tertiary period and have been dry for the

last 50 to 65 million years (Shanahan, 1953). Erosion has since carved the landscape to its present state.

The average elevation of the area varies from two to three hundred meters, but there are numerous hills and mountains of varying origin that rise as much as one thousand meters above the tableland. The eastern edge of the plateau is slightly higher than the rest, and its broken edges form a scarp that overlooks the coastal lowlands. The lower western edge dips under more recent strata that form another escarpment.

The hills and mountains include remnants of sedimentary deposits that are now characterized by broad, flat-topped "taboleiros," having steep sides. "Serras" are inselbergs which are remains of the older crystalline formations. They have a rounded-top appearance and support different soils and vegetation than do the taboleiras (Hardesty, 1986).

Cole (1960) maintains that the three major vegetational zones of the Northeast--i.e., the mata, the cerrado, and the caatinga--characterize different phases of the erosion cycle. With continued erosion of the plateau, he predicts that the caatinga vegetational zone will increase in size, because it is more adapted to soils that arise from the crystalline material that is continually being exposed.

Water

Perennial streams in the region are scarce, and ground water is very limited in distribution and is often poor in quality. The low porosity of the metamorphic rocks generally precludes the existence of large aquifers (Queiroz, 1985). The only ones of any consequence occur in the sandstone plateaus of Piaui state (Eiten and Goodland, 1979). In the larger areas underlain by crystalline bedrock, groundwater is limited to fissures and is usually salty; thus, surface reservoirs (acudes), varying in area from several hundred square meters to tens of hectares, are critically important to life in the Sertão (Queiroz et al., 1986).

Soils

Like so many features of the Sertão, soils are extremely diverse and variable. As might be expected from the above discussion of geology, greatly different types of soil are produced from the weathering of sedimentary and of crystalline parent materials. The main soil orders represented are the alfisols, the aridisols, and the entisols. Alfisols have derived from crystalline rock and are the predominant group. They are moderately shallow, are neutral to weakly acidic in reaction, and have a medium to high base saturation. There is a distinct clay accumulation in the B-horizon. Aridisols are well developed in areas where there has been little water percolation through the profile. They are typically low in organic matter and have an agrellic horizon. They can be highly productive if sufficient water is available. Entisols are developed from recently deposited materials and are without horizon development. Their surface textures are loamy to clayey, and they are generally well-drained.

Queiroz et al. (1986) found from a survey of 32 farms from throughout Ceará state that local agriculturalists used an

effective "native" soil classification scheme in which two major land types are recognized: those suitable for cultivation and those that are not. This stratification was based mainly on the features of drainage, location, fertility, and depth. Within these two main division, nine subdivisions were commonly recognized. These are summarized in Table 1, taken from Queiroz et al. (1986).

Woody Vegetation

The predominant vegetation of the Sertão is known as caatinga. Queiroz et al. (1986) point out that, because there has been no systematic classification of the caatinga vegetation type, the name, as used in the international literature, embraces a collection of substantially different sub-types. They recognized four distinct physiognomic types from their survey of Ceará goat farms:

(1) An arboreal caatinga, known locally as mata, occurs on well-drained sites and has suffered relatively few changes by man. The trees Piptadenia spp., Tabebuia spp., Aspidosperma spp., and Schinus spp. are representatives of a dense tree canopy that is typically greater than six meters in height. This vegetation is restricted to the less accessible sites.

TABLE 1. LOCAL TERMINOLOGY (APPROXIMATE ENGLISH EQUIVALENT) AND SUITABILITY RATINGS FOR THE MAJOR SOIL TYPES ENCOUNTERED IN THE 28 FARMS SURVEYED

Soil type	Description	Suitability
Barro vermelho (red clay)	Reddish loam/clay-loam subsoil	2-3
Barro vermelho com pedra (stony red clay)	Reddish loam/clay-loam subsoil with stony surface	4
Massape preto (dark cracking clay)	Poorly drained, dark cracking clays	5
Arisco (sand)	Deep soil with thick (50cm+) sandy surface and loamy subsoil	3-4
Barro de louca-carrasco (claypan soils, dense shrub layer)	Well-drained soil with a claypan underlying a sandy, often stony, surface	4
Barro de louca-tabuleiro (claypan soils, sparse shrub layer)	Poorly drained soil with a claypan underlying a sandy, often stony, nearly level, poorly drained terrain	5
Arisco com pedra-carrasco (stony sand, dense shrub layer)	Sandy, stony and mostly shallow soil	4
Coroa, baixio-liquento (alluvium, fine- and medium-textured)	Deep, fine- and medium-textured alluvial deposits	1-2
Coroa-, baixio-ariscado (alluvium, coarse-textured)	Deep and coarse-textured alluvial deposits	1

[a]Farmers' perceptions of suitability for cultivation. 1 = high; 5 = low.
Source: Queiroz et. al., 1986.

(2) A shrubby caatinga typifies the concept. This type may result from disturbance of the arboreal type, or it may be the result of poor growing conditions. Low trees or shrubs form a dense thicket between three and six meters in height. Young stands that follow abandoned croplands are called capoeira. Characteristic woody species include Combretum spp., Mimosa spp., Jatropha spp., and Croton hemiargyreus. The latter often dominates this type. It is a troublesome woody invader that spreads by sprouts from the shallow root system. It can tolerate very shallow

soils and is encouraged by fire and mechanical disturbance. Unfortunately, it is eaten little by goats or other livestock.

(3) Open woodlands are generally associated with imperfectly drained sites. The trees and shrubs form aggregations of individuals separated by wide interspaces that are covered with annual herbs and grasses shortly after the rainy season begins. The species composition is roughly the same as that of the shrubby caatinga, with the exceptions of Cnidoscolus spp. and Pilocereus spp., which are found on drier sites.

(4) Palm stands are found on deep soils subject to periodic flooding and are known locally as carnaubal. The typifying species is Copernicia cerifera, a tall palm species that produces carnauba wax. A discontinuous stratum composed of the shrubs Croton spp., Combretum spp., Mimosa spp., and Caesalpinia spp. is often associated with the palm stands.

Most woody caatinga species coppice freely from adventitious and dormant buds in the stump after cutting. Coppice shoots retain their leaves considerably longer into the dry season than do the adult trees (Hardesty, 1986). This characteristic can be beneficial in terms of providing green forage for browsing animals for a longer part of the year, or it can be viewed as a distinct disadvantage by farmers who are attempting to maintain weed-free conditions in newly cleared fields used for cultivated crops. The contribution of coppice browse to the nutrition of goats and the management of caatinga stands to optimize coppice production is discussed in Chapter 5 of this book.

Caatinga trees and shrubs are characteristically drought-deciduous and shed their leaves during the transition period between the wet and dry seasons. This typically occurs during the July-September period, depending on the year and the amount of rainfall received. Shed leaves are a critically important source of forage for goats, as well as for other forms of livestock, during the extended dry season (Pfister and Malechek, 1986a; Kirmse et al., 1987. While research has not been done to document the fact, fallen leaves are probably also vital in maintenance of nutrient cycling and protection of soil surface from the erosive forces of wet season downpours.

Leaf flush occurs within three days of an effective rainfall at the onset of the rainy season. However, this often does not occur uniformly over large regions of the Sertão, given the patchy distribution of rainfall that is typical of the area. Localized, sporadic leaf flushed can also occur during the dry season, in response to the rare showers that sometimes occur during this period. Pfister et al. (1983) documented a nutritionally important response of both goats and sheep to such an event in the dry season of 1981.

Herbaceous Vegetation

The ground layer vegetation is essentially devoid of perennial species. Annual broad-leaf herbs predominate, with such species as Hyptis spp., Bidens spp., and Melanthera spp. being common. While less common in general, some important annual graminoid species include Paspalum spp., Panicum spp., and Brachiaria mollis.

The growth of herbaceous species is stimulated remarkably by clearing or thinning of the tree overstory. Increases in biomass yields of six-fold or greater have been recorded in different years and under different site conditions by several researchers (Kirmse et al., 1987; Araújo Filho et al., 1982; and Schacht, 1987). However, this response tends to be short-lived, as the overstory canopy can regain its original cover in as few as three years after clearing, unless the coppicing shoots of the trees are re-cut or otherwise controlled.

Climbing vines, while not major components in the overall community composition, are common and can contribute importantly to the seasonal diets of goats (Pfister and Malechek, 1986a; Schacht, 1987). Two vines of documented importance on the CNPC experimental area near Sobral are Ipomoea sp. and a leguminous vine known by the local name "fava de boi."

Vegetational Change (Community Succession)

Successional pathways and rates have not been well studied in the caatinga. However, the influence of man's activities since colonial settlement some 400 years ago is strongly evident virtually everywhere. Moreover, this influence is continuing at an accelerated rate due to the increased population pressures of the past two decades. Major types of disturbance include slash and burn agriculture, land clearing for pasture improvement, clear-felling for wood harvest, and selective tree felling for wood products such as fenceposts and construction timbers. The effect of livestock grazing, although pervasive, is difficult to assess with current limited information.

Although limited in geographic scope, a recent study by Queiroz (1985) in the Acaru river valley of northern Ceará has demonstrated several aspects of caatinga succession that probably hold for broad areas. He found that, with the exception of the tree jurema preta (Mimosa acutistipula), all other major caatinga tree species in the area are shallow-rooted, suggesting the importance of surface moisture in plant growth and development. Root systems are generally confined to the upper 20 cm of the soil profile.

Early seral species (marameleiro, mufumbo, and jurema) appear more fire-tolerant than the late-seral species (pau branco, catingueira, sabiá, and imburana). Repeated disturbance, mainly in the form of slash-and-burn farming on claypan soils, leads to quick replacement of the late-seral species by early-seral species, particularly the troublesome marmeleiro. In contrast, plant communities on the well-drained red clay soils are much more tolerant and can withstand repeated disturbances without a reduction in the tree canopy that is re- established by coppice growth after the sites are abandoned by farmers.

Interviews with local inhabitants and tree ring counts indicate that the clearing cycle in the Sobral area has been roughly 20 years. However, an increasing population pressure in the face of a limited amount of land suitable for cropping is resulting in an overall shortening of this cycle. The net result seems to be an increasing presence of marmeleiro and a loss of the late seral trees. This represents a significant loss of potential revenue in the form of wood products and a reduced grazing

capacity. Marmeleiro wood is of no value for fuel or construction and its leaves are little consumed by goats or other livestock (Queiroz et al., 1986).

Land Use

Goat production is but one of the components of the typical small farm enterprise in the Northeast. Queiroz et al. (1986) found that crop and livestock activities are highly integrated and most farms that produce goats also produce cattle and sheep. Different levels of managerial and capital input are directed to the various production activities, and these shift over time, especially in relation to drought. Diversification and flexibility may be vital in the farmer's ability to survive the variable and unpredictable conditions presented by the Sertão.

Crop Production

Of the farms surveyed by Queiroz et al. (1986), the average area cropped was 23%. However, a wide range, from 1% to 70%, was observed, and there appeared to be little if any relation between farm area owned and percentage of the land in crops.

The typical crops include corn, cotton (both annual and perennial), beans, and cassava. Cashew trees, castor beans, melons, and forage crops such as Opuntia and elephantgrass (Pennisetum) were also found on some farms, depending on the locality and the land resources available. Crops are typically planted and cultivated by hand, but animal traction power is used on a smaller number of farms, especially where fields have been cleared of stumps (Queiroz et al., 1986). Planting usually begins soon after the onset of the rainy season in January. Corn and beans are often harvested by June, but cotton is not harvested until August or September. Livestock are allowed to glean fields after harvest, and crop residues represent an important source of livestock forage on many farms.

Livestock and Grazing Management

Goat production enterprises of the Sertão are described in detail in Chapter 2. However, several points deserve particular attention in this discussion, as they relate to the special way goats are viewed as part of the production system and the consequences of this viewpoint on rangeland management in the caatinga.

Primov (1985) has argued compellingly that goat producers in the Northeast own goats not for their market value as commodities for participation in the national cash economy, but rather as a source of food for family consumption, as a product for ready sale to provide money for other household needs, and as a living bank account that does not depreciate in value under the conditions of rampant inflation that Brazil has experienced in recent years. Given these economic circumstances, the way goats are managed and husbanded differs considerably from management of either cattle or sheep.

Under conditions of the Sertão, goats receive almost no capital inputs. For most producers, there would be little reason to own goats if significant levels of either labor or capital were

required (Primov, 1985). Thus, there is little incentive for programs of technology aimed at improving either animal quality or range management if the programs require an investment to implement. The strategy that most goat producers seem to follow is to maintain as many living animals as possible. Large flocks represent a growing asset with virtually no maintenance cost (goats typically get no supplemental feed during the dry season) and a form of drought insurance. The larger a producer's herd at the beginning of a drought, the greater the likelihood that enough animals will survive to rebuild a herd after a drought.

This approach to livestock management is different from that followed for either cattle or sheep. These species receive capital inputs, such as supplemental feed and health care, and are traded in the cash market typical of developed countries.

From the standpoint of land use for goat production, some of the consequences of these attitudes are predictable. Goats spend virtually all year foraging on caatinga ranges because they have the capacity to survive, if not produce at a high rate, and caatinga range is the cheapest source of forage available to the producer (Queiroz et al., 1986). This approach to land use presents formidable challenges to scientists and extension agents whose main objective is increasing livestock production in the sense of marketable commodities.

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Chapter 2

A SOCIOECONOMIC DESCRIPTION OF GOATHERDERS

J. de Souza Neto and G.A. Baker

Goats play an important role in the agricultural system of Northeast Brazil, where 89% of the goat herd is located. They are found in every state in the region, but are concentrated in several states (see Figure 1 in Chapter 1). The largest numbers are found in the states of Bahia, Pernambuco, Piaui and Ceará, representing approximately 76% of the national total (FIBGE, 1986). The concentration of goats in this region is related to the fact that 79% of the Northeast region is classified as dry forest, dense woods and caatinga, land which has few alternative uses (FIBGE, 1985). Goats are also important to the region because the range resources are renewable and goats are intimately associated with the survival of the poorest inhabitants of the Sertão, where the low consumption of animal protein presents a serious nutritional problem. Another important factor is that goats are animals which are well adapted to the harshest conditions and can be raised by small producers with very limited resources.

This chapter presents a brief description of the distribution and importance of goats in Northeast Brazil. A tentative classification of the systems of production is made in an attempt to establish guidelines that researchers may adapt to their particular conditions.

Finally, several socioeconomic studies conducted in Northeast Brazil (Neumaier, 1986a; Gutierrez et al., 1981; Souza Neto and Baker, 1986) are summarized. These studies focus on the important production characteristics and show the importance of goats in contributing to the production of a wide range of products and in offering an important source of income with low-risk investment capital.

Importance of Goats and Their Distribution in Northeast Brazil

Although the great majority of goats are located in Northeast Brazil, goats are outnumbered by cattle and contribute less than 1% of the gross domestic product of the region (Sanchez, unpublished paper). Further, goats are often consumed on the farm or traded in informal markets and are not reported in the official statistics. Consequently, the importance of goat production should be evaluated more from a social than economic perspective.

Generally, goats are raised by small producers (63% of producers have areas less than or equal to ten ha) whose lands are located in the poorest areas of the country. The production of goats by small producers helps to ameliorate the nutritional problems commonly experienced by those living in rural areas.

According to Sanford (1982), goats are especially important for developing regions. Several reasons for the importance of goats in the Northeast have been identified by studies conducted in the area:

- Goats are a subsistence product used for consumption and other domestic purposes (Gutierrez et al., 1981; Neumaier, 1986b);

- Goats graze jointly with other animals and represent a complementary use of the range resource (Gutierrez, 1987; Araújo Filho, 1987);
- Goats are used for the control of undesirable vegetation (Nascimento, 1988);
- Goats are a means of savings (Gutierrez, 1987; Souza Neto and Baker, 1987; Primov, 1984);
- Goats yield a high return while requiring a low investment and imposing a low financial risk; and
- Goats represent source of immediate liquidity for the producer (Gutierrez, 1987; Primov, 1982; Neumaier, 1986b).

Queiroz et al. (1987) studied the cattle, sheep and goat populations on 27 farms in the state of Ceará, Northeast Brazil, during the drought years of 1980 to 1983. He found that there were substantial reductions in the cattle (33%) and sheep (17%) populations during this period. During the same period the number of goats increased by 17%. These results confirm the hypothesis that producers adjust to the effects of drought by reducing the numbers of the most susceptible animals. The number of goats increased because producers believe that they are more resistent to drought and better able to utilize the scarce resources available.

Goats can effectively complement both sheep and cattle when adequate management exists (Stoin, 1970). Queiroz et al. (1987) described the strategies used in managing goats, cattle and sheep in the conditions of the caatinga of the state of Ceará, showing that goats are generally raised jointly with cattle and sheep only during certain periods of the year (January to July). After this period the management differs, with the use of cultivated fields for grazing after harvest being a common practice in the region. Initially, the cattle are put in these areas, followed by sheep. The goats remain in the caatinga during the entire year. Araújo Filho (1987) indicated that in terms of cut caatinga, the best biological and economic results were obtained with a combination of one cow per four to five goats. The yield in terms of kg/ha/year was 23.4 for cattle alone, 34.4 for goats alone, and 46.5 for the combination of cattle and goats. In the native caatinga Araújo Filho (1987) found that the best results were to allow the goats and sheep to graze together. Using this method a production of 14.5 kg/ha/year was obtained, versus 12.3 and 11.4 kg/ha/year for goats and sheep grazing alone, respectively. This supports the hypothesis that cattle and goats, and cattle and sheep, represent complementary uses of the forage resources and therefore that the maximum production from these resources may be obtained by grazing several species together. These results, although obtained under experimental conditions, are compatible with those obtained by Queiroz et al. (1987) in which he concluded that farms that had cattle, sheep and goats performed better during the drought period (1980 to 1983) than those that raised only cattle and sheep.

Gutierrez and DeBoer (1984) compared the principal production activities on a sample of farms in Ceará during 1980, which was considered a dry year. They found that the average gross margin obtained from the small ruminant activity (goats and sheep, 27%) was lower than for cattle (42%) and crops (36%). However, these percentages do not by themselves represent a measure of the efficiency of the productive resources allocated to each of the

three activities. A potentially better method of demonstrating the productivity of each of the activities is to examine the gross margin generated by each activity, divided by its respective cost of production. Using this measure, small ruminants represented the best use of the farm's resources, with a gross margin to cost of production ratio of 6.48, as compared to 1.56 and 1.68 for cattle and crops, respectively. This clearly illustrates the profitability of small ruminants under the conditions studied, despite their low gross margin.

Goat Production Systems

There are several means of classifying production systems. In this section, production systems are classified as extensive, semi-extensive, or intensive, and, according to the state of development of the production system, as either traditional or improved as well. Finally, the management characteristics typically found with each system are described (Table 2). It should be emphasized that these classifications are subject to the conditions prevalent in each region. Several studies are described below to illustrate the use of the proposed system of classification.

As a rule, in the semiarid and traditional (less developed) regions of Northeast Brazil, goats are included in the production system because of their ability to complement other production activities.

Goat Production in the State of Paraiba

This study was conducted in the micro-region of Cariri Paraibanos. Forty-three producers were surveyed in two counties (Soledade and São Jão do Cariri). The number of producers surveyed in each county was 25 and 18, respectively (Neumaier, 1986a).

Approximately 17,000 people live in these two counties; 63% live in rural areas. The principal economic activity of this area is agriculture, although it is heavily dependent on the level of precipitation (an average of 418 and 580 mm, respectively). The production systems on the surveyed farms can be characterized as mixed (crops and livestock). The principal crops were corn, beans and cotton. These products were utilized primarily for on-farm consumption, except for cotton, which was a cash crop. There were also many types of fruits and vegetables produced. Livestock production, like crop production, was diversified, but the common elements in all systems were goats.

The animal management may be characterized as extensive, with 70% of the animals grazing in the caatinga and other areas of the farm throughout the entire year. However, many medium and large producers have started to fence their properties and intensify their production.

The majority of the installations found on the survey farms were simple, typically being only a pen with no shelter from the environment. The majority of producers (56%) brought their animals into the pens at night. However, some producers left their animals in the caatinga for weeks or months at a time. Those that gathered their animals generally did so to protect them from predators (both

animal and human).

No systematic reproductive or health practices were used. This was probably because many producers believed that their goats did not need much care, and, in particular, that their goats reproduced well without any management.

TABLE 2. SOCIOECONOMIC CLASSIFICATION OF GOAT PRODUCTION SYSTEMS

System	Improved System	Traditional System
Extensive	Area Characteristics: Far from urban areas. Low soil fertility, good only for extensive grazing.	
	Management Characteristics:	
	1. Moderate use of purchased inputs.	1. Little or no use of purchased inputs.
	2. Goats graze on crop residues.	2. Subsistence oriented.
	3. Little milk production; only cheese is marketed.	3. Milk production solely for the family.
		4. Emphasis on quantity, not quality.
Semi-extensive	Area Characteristics: Far from urban areas. Several alternatives for land use.	
	Management Characteristics:	
	1. Moderate use of purchased inputs	1. Little or no use of purchased inputs.
	2. Oriented toward milk production.	2. Oriented toward the production of meat and skins as a source of income.
	3. Possible integration with processing and transportation facilities	3. Milk marketed as cheese, after the needs of the kids and family are met.
Intensive	Area Characteristics: Near large urban areas with processing facilities and characterized by high agricultural production.	
	Management Characteristics:	
	1. Extensive use of purchased inputs.	1. Moderate use of purchased inputs.
	2. Oriented toward milk production and the sale of breeding stock.	2. Oriented toward milk production and the sale of breeding stock.
	3. Possible integration with processing and transportation facilities.	3. Probably transports milk.

The majority of producers did not milk their goats. According to these producers, the does' milk was barely sufficient to feed their kids. They also thought that it was more profitable to raise

goats for meat, although the offtake was low (29%).

Among the producers surveyed, important sources of income were represented by the sale of live goats and by the sale of the skins of goats slaughtered on the farm. The criterion used for determining the timing of the sale was weight. The quantity of skins sold was small relative to the number of animals sold live.

Despite the constraints on the improvement of the productivity of goat-raising, the importance of goat-raising as a source of income and the vigor of goats make goat production an attractive enterprise. However, producers will probably not view goat production as being attractive if changes are introduced that require a large investment, because the majority of producers do not have the necessary capital.

Socioeconomic Study of Systems of Goat Production in the State of Ceará.

This study (Gutierrez et al., 1981) was conducted with producers of goats and sheep in the Sertão of Ceará. One-hundred and twenty-seven farms in nine counties (Granja, Sobral, Cratéus, Independencia, Tauá, Parambu, Quixá, Quixeramobim, and Morada Nova) were surveyed. The number of animals in these counties represented more than one-half of the small ruminants in the state. In this region goat and sheep production was only one of several production activities, which included raising crops and other animal species.

Seven types of producers of small ruminants were identified: landowners, manager-sharecroppers, sharecroppers, parceleiros (farmers settled on land under a government land settlement program), renters, communal owners, and permanent workers. In general, the owners (64% of the surveyed farms) owned land that they themselves farmed, or that was farmed by tenants or permanent or temporary workers. Tenants generally divided their time between the land that they managed for themselves and the land that they managed for the owner. Of the seven types of producers, tenants were most commonly encountered (18.9%).

The production systems may be characterized as mixed, with 88% of the producers who raised goats or sheep also raising cattle and crops. Looking only at small ruminant production, we see that 58% of the producers produced both goats and sheep, while 39% raised only sheep. The remaining 3% raised only goats.

The most common management system employed by producers was to allow the animals to graze freely during the day and to bring them into the pens at night. This management system requires very little labor. Whether the animals were gathered at night depended on the season of the year and the type of animal. The daily management of the animals was generally the responsibility of a family member or a paid worker, who usually did not receive a wage, but who was paid in kind. The in-kind payment was typically one-fourth or one-fifth of the animal production, a system called "sorte." Of the surveyed farms, 60% of the producers designated one person to be responsible for the management of the animals.

Although many producers traded their breeding males with neighbors or producers in other counties, breeding males generally remained with the females during the entire year. Only 4% of the

producers separated the males from the females to avoid undesirable matings. Sixty-six percent of the producers castrated males not to be used for reproductive purposes.

Some standard health practices were observed. For example, 93% of the producers dewormed their animals, although the process was usually conducted only once a year.

Cattle typically received first priority when it came to nutrition. During the dry season, they were the first ones to be fed crop residues and concentrates or given some other form of supplement. Sheep sometimes received supplementation, whereas goats were rarely supplemented.

The reluctance of producers to supplement goats reflects the general opinion of most producers that, relative to the other animal species, goats are best adapted to the poor environmental conditions of the Sertão. The management strategies practiced by the producers reflected the importance of the survival capacity of the region's goats.

It is generally agreed that there are two types of goat producers in Brazil: those oriented towards subsistence production, and those oriented to the market. The level of participation in the market was dependent on the type of product, and in particular on the producer's need for money (Gutierrez, 1987).

Gutierrez (1982) stated that there is a potential demand for meat from small ruminants, due to traditional consumption habits and the low price of this goat meat relative to beef. However, the use of these animals by producers is determined by nutritional necessity and by their financial situation.

Dairy Goat Production in Northeast Brazil

The objectives of the following studies were to evaluate the potential for dairy goat production in Northeast Brazil. In this region goats are milked by at least 10% of the producers in seven of the nine states: Pernambuco (16.6%), Rio Grande do Norte (16.6%), Paraíba (15.8%), Ceará (13.4%), Bahia (12.2%), Sergipe (11.7%) and Alagoas (11.5%) (FIBGE, 1984). A survey was carried out on a sample of farms in the states of Paraíba (23), Pernambuco (28) and Rio Grande do Norte (20) (Souza Neto and Baker, 1986).

In general, the production systems may be characterized as mixed, with dairy goats playing a minor role on the surveyed farms and representing only 15, 9 and 8% of the herd in terms of animal units in Paraíba, Pernambuco and Rio Grande do Norte, respectively.

The most common breed was Anglo Nubian (pure and crossbred), which is recognized in the Northeast as a dual-purpose goat (meat and milk). The Bhuj and native nondescript (SRD) breeds were also commonly encountered. The Saanen, the Toggenburg, and the German Alpine breeds were found on only a few farms.

Milk production varied considerably among states and farms. The highest production was obtained in the state of Pernambuco with an average of 1.12 liters/day and an average lactation period of 151 days and an average total production of 174 liters per lactation period. However, this is much lower than the yields

obtained from dairy goats in other tropical and subtropical areas of the world (Sands and McDowell, 1978).

As was found in other studies (Neumaier, 1986a; Primov, 1984; DeBoer et al., 1986), reproductive management was not commonly practiced. Only in Paraíba did a small number of producers restrict the use of a breeding male to a maximum of 2 years. Therefore, there was probably a high number of undesirable breedings, as is commonly found in Northeast Brazil.

The number of producers who supplemented their lactating does and the type of supplement given varied greatly by state. It is not surprising that the highest yields were obtained in Pernambuco, where the great majority of the producers supplemented their lactating does with concentrates.

The only health practice commonly followed by producers was deworming the goats, although it was usually done only twice a year, which was probably not enough to adequately control the problem. The majority of the producers milked their animals only once per day.

Pernambuco was the only state in which goat milk products were commonly marketed, probably due to the presence of the Companhia de Laticínios de Pernambuco (CILPE), which, at the time of the study, offered an outlet for goat milk. The majority of producers in Paraíba, Pernambuco and Rio Grande do Norte preferred to market cheese. The small production of cheese was typically consumed on the farm and offered for sale in urban areas, at fairs, or to middlemen who transported the product to supermarkets in the large cities. Contact with the marketers of goat cheese indicated that the major restrictions on marketing the product were on the supply side and not related to a lack of demand. It was noted in both local and in regional markets that a large demand for dairy goat products existed (Neumaier, 1986a).

Most producers indicated that they preferred to market cheese, rather than milk, because it was less perishable and allowed more flexibility in marketing, since it can be stored for long periods of time, is easily transported over long distances, and does not require refrigeration as milk does.

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Chapter 3

PRESENT AND IMPROVED PRODUCTION SYSTEMS FOR MEAT GOATS IN NORTHEAST BRAZIL

E.R. de Oliveira and W.L. Johnson

Goat production in the semiarid tropics of Northeast Brazil, as well as in other semiarid developing regions, is characterized by its extensive management and low offtake.

The characterization of the semiarid rangeland of the area and a socioeconomic profile of the goat producers are presented in Chapters 1 and 2. In this chapter we give a general overview of land organization in Northeast Brazil, including the major crops and animal species utilized, and of the importance of goats within this integrated production system. Finally we describe the actual status of goat keeping in this region, and, where possible, we compare some results obtained under experimental conditions with data from producers' herds.

The Importance of the Goat Within the Integrated Production System

The full understanding of goat production in lesser-developed, semiarid areas cannot be accomplished without knowledge of the socioeconomic interrelationships of the human population.

Land organization in Northeast Brazil is an intricate system in which there are farms varying from a few hectares to more than 10,000 hectares. Land ownership is also complex and Anuário Estatístico do Brasil (1986) describes the following categories: owners, renters, sharecroppers, squatters and others.

Besides being an important source of rural labor, sharecroppers play an important role in the goat production system. According to Gutierrez (1983), approximately 25 percent of the goat ownership in Ceará state is represented by sharecroppers.

Northeast Brazil is a region characterized by a coastal area, where precipitation exceeds 1,500 mm annually, and by a hinterland area, where the precipitation is low and erratic and averages 300-400 mm per year. A schematic distribution of the caatinga vegetation is shown in Figure 1 of Chapter 1.

Due to rainfall uncertainty, the producers in this area exercise a mixed production system, growing subsistence and cash crops such as corn, beans, squash, cassava and cotton. The livestock component in the system includes cattle, sheep, goats and donkeys.

The number of goats in the whole northeastern region is estimated at 8.7 million head, which represents 89 percent of the overall goat population in Brazil. The states of Bahia, Piaui, Pernambuco and Ceará together contain 84 percent of the flock in Northeast Brazil (Souza Neto, 1981; Anuário Estatístico do Brasil, 1985).

Goats play an important socioeconomic role in this intricate

and fragile production system, and their number oscillates according to the severity of the drought that commonly hits the region. Besides the recognized importance of goats as a supplier of high quality protein (in the form of meat and milk) for the poor inhabitant of the area, goats also represent an immediate source of cash that the peasants may use in order to buy other food items or clothing.

Actual Status of Goat Keeping in Northeast Brazil

Overall Management

The exploitation of goats in this semiarid region is still based on traditional methods, and only a few of the better known "improved" husbandry practices have been adapted and used on a small scale by goat producers. There are several reasons for this, the major one apparently being that producers try to minimize their investment in goats and are willing to adopt only proven technologies that do not require large investments. This is particularly true in situations where the inflation rate is extremely high and the percentage increase in the cost of production inputs surpasses the increased value of the final product.

Feeding Management

In a general way, goats, sheep and cattle are grazed together, and only a few farms are specialized by having one animal species. The animals, in the majority of cases, are allowed to graze freely in the native caatinga vegetation. Due to the diversity of plant species in caatinga, goats are able to exercise their recognized selective behavior and utilize a vast array of plant species. The different ecological sites identified in the region also contribute to the large number of plant species present in the diets of goats.

The following plant species are commonly identified as the most preferred.

Grasses: Milhã, defined as several grass genera including Paspalum sp, Panicum sp and Brachiaria sp.
Forbs: Bamburral branco Blainvillea rhomboindea), Bamburral verdadeiro (Hyptis suaveolens), Maracujá de estalo (Passiflora serrata), Feijão de rola (Phaseolus lathyroides) and Mirasol (Melanthera sp).

Vines: Jitirana (Ipomoea sp).

Shrubs: Melosa (Ruellia asperula), Mofumbo (Combretum leprosum) and Jurema preta (Mimosa nigra).

Trees: Catingueira (Caesalpinia pyramidalis), Sabiá (Mimosa caesalpiniaefolia), Mororó (Bauhinia forficata), Marmeleiro (Croton hemiargereus), Angico (Anadenanthera macrocarpa), Juazeiro (Zizyphus joazeiro), Jucazeiro (Caesalpinia ferrea) and Pau branco (Auxemma oncocalyx).

Only a few producers have adequate fencing for their goats. As a consequence, there is indiscriminate breeding and the actual stocking rate utilized by the producers cannot be evaluated. However, data from Anuário Estatístico do Brasil (1985), shown in

Table 3, indicates that, for an overall area of 88.4 million hectares, there is a herbivore livestock population of 40.2 million head. When we consider that EMBRAPA/CNPC is recommending, as a conservative stocking rate for caatinga vegetation, the value of 1.7 ha/adult goat/year (Araújo Filho, 1987; Schacht, 1987), we can conclude that many areas are grossly overstocked.

TABLE 3. TOTAL SURVEYED FARM LANDS AND LIVESTOCK POPULATION IN NORTHEAST BRAZIL

States	Area (thousands ha)	Livestock population (thousand heads)						
		Cattle	Goats	Sheep	Equines	Asinines	Mules	Water buffaloes
Maranhão	15,134	3,308	521	185	280	180	104	76
Piauí	11,162	1,589	1,741	980	149	195	44	-
Ceará	11,743	2,138	820	1,133	183	185	107	-
Rio G. do Norte	4,513	681	217	248	36	45	24	-
Paraíba	4,906	1,128	508	355	75	57	47	-
Pernambuco	6,656	1,558	1,178	497	126	77	93	1
Alagoas	2,397	880	59	123	51	12	30	-
Sergipe	1,898	663	31	143	59	14	32	-
Bahia	30,033	9,748	3,593	2,582	584	398	326	19
	88,442	21,693	8,668	6,246	1,543	1,163	807	96

Source: Anuário Estatístico do Brasil (1985).

Even with such a high grazing pressure, goats rarely receive any type of supplementation. During the dry season, farmers give supplementation preferentially to cattle, followed by sheep, and only last to those goats already showing signs of starvation. As a consequence, large losses are incurred, principally among growing kids (Figueiredo et al., 1980; Figueiredo and Pant, 1982) but also among the adult population (Oliveira et al., 1988a).

Oliveira et al. (1982) demonstrated that selective thinning of the caatinga vegetation allowed a higher stocking rate and improved the overall animal performance of SRD goats when they are compared with goats kept at a lower stocking rate under undisturbed natural caatinga vegetation. Some of the harvested wood was used for fence posts and part of it was sold for the baking of bricks and tiles.

The same authors also reported that even a simple green roughage supplementation (Napier grass) during the most critical months of the dry season (September-December) further improved animal performance. The logical conclusion is that even the recommended stocking rates may still be high and that supplementation should be used.

Breeding and Reproduction

The goats described as Sem Raça Definida (SRD) or "without defined breed" represent more than 90 percent of the total goat

population in Northeast Brazil. However, there are also some local types named Moxotó, Marota, Canindé and Repartida, which together with some exotic breeds are described in Chapter 4.

There are already some producers who raise defined breed types and commercialize them principally during livestock fairs. A few of them even have permanent exposition and sale of breeding stock.

The failure to change breeding males periodically or to control mating contributes to inbreeding and other genetic problems, such as overshot jaw, cryptorchidism and supernumerary teats. The absence of periodical culling based on production characteristics also contributes to a decreased overall flock productivity.

Reproductive Efficiency

There are several variables that measured alone or in combination may be indicative of high or low reproductive efficiency. Based on some of these variables, goats seem to be well adapted to the semiarid Northeast.

According to Simplicio (1985), goats behave as a continuous polyestric species in Northeast Brazil, and this enables them to mate and kid throughout the year. However, there is a slightly higher (47 percent) concentration of estrus in the period of January to May, which coincides with the rainy season in the region of Sobral. A histogram showing the estrus distribution throughout the year is presented in Figure 3.

The monthly distribution of parturitions reported by Alves (1986) and shown in Figure 4 agrees closely with the data on the monthly distribution of estrous cycles described by Simplicio (1985). The mean estrous cycle length reported by the latter author is 22.7 days. This means that during the first five months of the year it is possible for a breeding doe to have 6.65 estrous cycles. Animals bred in January will start kidding in May, and animals bred in May will kid in October. This coincides well with the findings of Alves (1986), which show that 70 percent of all kiddings occurred between May and October.

This seems to indicate that there is an ecophysiological adaptation by the animals to some factors that affect reproduction, such as the onset of the rainy season and the availability and quality of forage. This kind of adaptation may be responsible for the concentration of 53 percent of all kiddings between May and August. This period is dry enough to prevent chilling and respiratory problems for the newborns. Also during this period there is good forage availability and the nutritive value of the available forage is still adequate (Pfister, 1983; Kirmse, 1984; Schacht, 1987).

The number of kids born per doe kidding (prolificacy) is a good estimate of ovulation rate. Indeed, the two figures are expected to be very close, with the ovulation rate being somewhat higher.

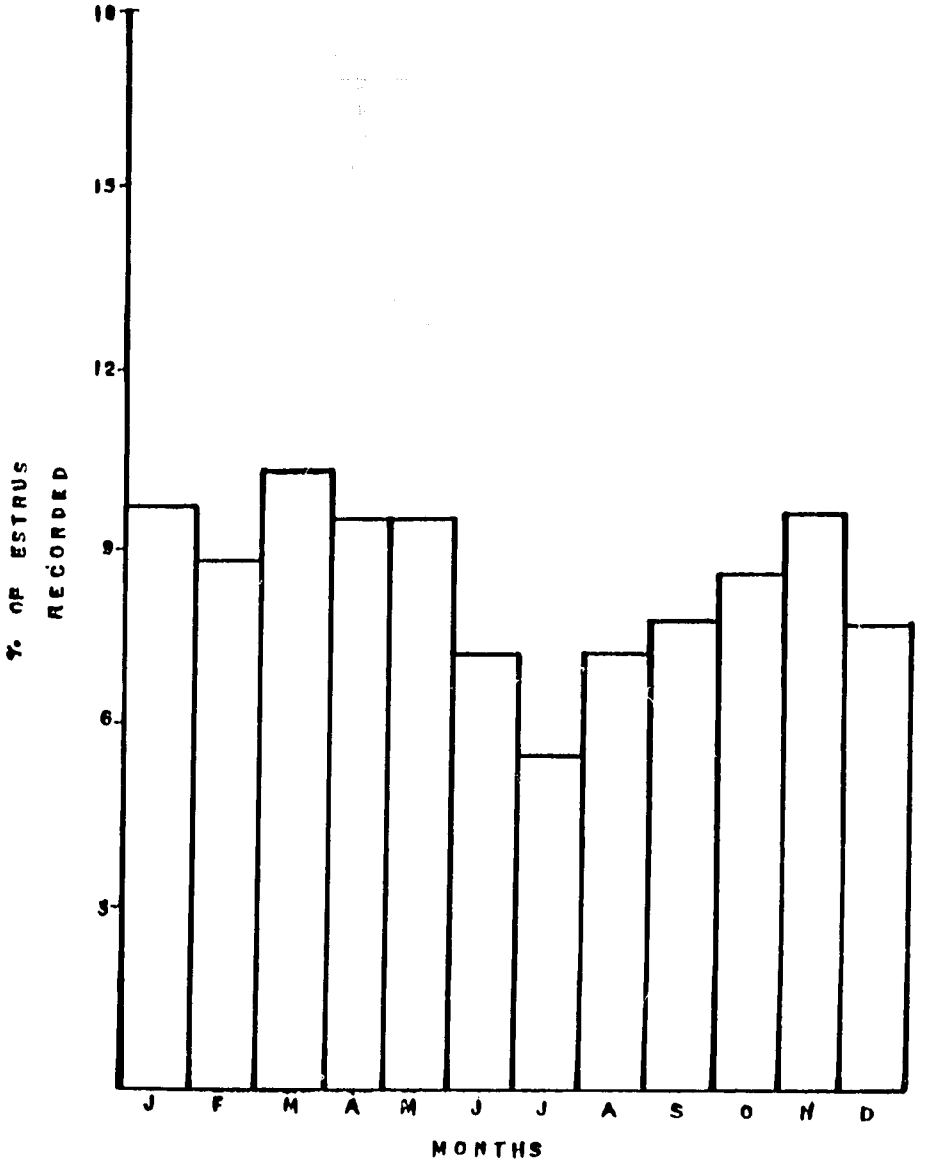

Figure 3. Monthly distribution of estrous cycles in goats in Northeast Brazil.[a]
[a]Histogram generated from data by Simplicio (1985).

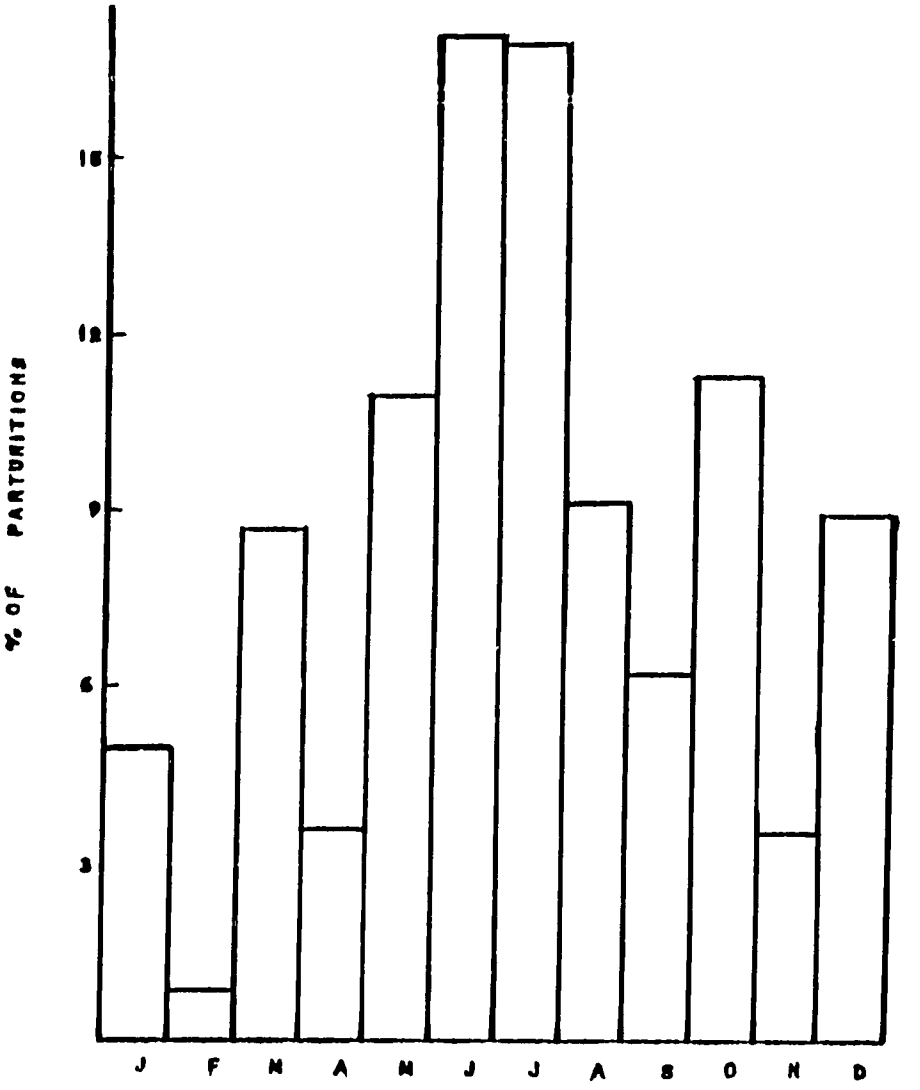

Figure 4. Monthly distribution of parturitions in goats in Northeast Brazil.
Source: Alves, 1986.

Simplício (1979) indicated prolificacy values ranging from 1.3 to 1.65 in some breeds and genotypes of goats found in Northeast Brazil.

Alves (1986), working under farm conditions, found an average of 1.3 kids born per doe kidding, lower than some other values reported in the literature (Riera, 1986; Simplício, 1979; Devendra and Burns, 1970). However, Alves' results were obtained from 1,712 parturitions on five different commercial farms during three consecutive years; the breadth of his sample adds to the reliability of his data.

Simplício (1985) reported a monthly ovulation rate of 1.5, based on 864 laparotomies performed on SRD, Marota, and Mosotó does during a two-year period.

The fertility rate reported by Alves (1986) ranged from 73.6 to 96.3 percent, with an overall mean of 84.5. This mean ranks very high when compared to some previous reports.

The onset of puberty for female goats described by Foote et al. (1986) occurred at a mean age of 363.3 days and at an average body weight of 12.5 kg. This indicates that even though the age at puberty seems to be adequate, the body mass has not attained sufficient development. The recommended weight to breed female goats is accepted to be around 60-70 percent of the animal's adult body weight. With an average adult body weight of 35 kg, recommended breeding weight would be 21 to 24 kg for the majority of the goat population in Northeast Brazil.

The kidding interval found by Alves (1986) was 298±78 days, which is well within the range reported in the literature. This interval would allow goats to have three parturitions within a two-year period.

Based on some of the variables used by reproductive physiologists and animal breeders, goats in Northeast Brazil do not show any major problem related to reproduction. The animals seem to have evolved with adapted ecological and physiological mechanisms that enable them to have a high reproductive efficiency within this type of ecological system.

Production characteristics

A high mortality rate of new born kids has been associated with low birth weights (Figueiredo and Pant, 1982; Simplício et al., 1982), which in turn are related to genetic and nutritional factors. Kid mortality rates vary greatly and figures as high as 69 percent for mortality up to one year of age have been reported (Figueiredo and Pant, 1982). Around 43 percent of the overall kid mortality in the flock happens between 0 to 15 days of age.

Some reported birth weights for goats in Northeast Brazil can be seen in Table 4. The data reported by Alves (1986) is somewhat higher than other values found in the literature. This may be due to two causes. The first is the introduction of large exotic breeds, such as Anglo-Nubian and Bujh, to breed to SRD does. The second may be related to differences in stocking rates. The farms on which Alves (1986) collected his data did not have a fixed

stocking rate, nor did they have adequate fencing. As a consequence, the animals were allowed to range freely and their selective feeding behavior was not impaired; their feeding behavior might have influenced positively their overall nutritional status. On the other hand, the value from the other sources in Table 4 were obtained under experimental conditions with fixed stocking rates, with adequate fencing, and with the does being bred by SRD bucks.

TABLE 4. BIRTH WEIGHT FOR GOATS IN THE SEMIARID TROPICS OF NORTHEAST BRAZIL

Breed or type	Weight (kg)	Type of birth	Source
SRD	2.10	Single	Oliveira et al., 1982
SRD	1.67	Multiple	Oliveira et al., 1982
SRD	2.10	Single	Lima et al., 1983
SRD	1.71	Multiple	Lima et al., 1983
Moxotó	2.15	Single	Figueiredo et al., 1984
Moxotó	1.75	Multiple	Figueiredo et al., 1984
SRD	2.62	Single	Alves, 1986
SRD	2.52	Multiple	Alves, 1986

The precocity, fertility rate and high prolificacy for goats should give them an advantage for meat production in Northeast Brazil. Unfortunately high levels of kid mortality, associated with low growth rates, prevent this potential from being realized.

Several factors contribute to this poor performance, among which are poor reproductive management and high stocking rates. Typical preweaning (up to 120 days) and postweaning growth rates for goats are presented in Table 5.

In a general way it can be observed that weaning time represents a serious stress on the growing kid. Besides the physiological stress associated with weaning, the young animals, depending on the season of the year, may also face the challenge of having a highly fibrous and lignified type of diet just when the rumen is beginning to function. In vitro organic matter digestibility values as low as 30 percent have been reported (Schacht, 1987) for goats grazing native vegetation at the end of the dry season. With such low digestibility, associated with low forage availability, high weight losses prevail. Weight losses of 25 grams daily were reported by Oliveira et al. (1988a); over time, this may represent 20-25 percent of the animal body mass, leading to a serious impairment of the animal's future development and performance.

Significant improvements in SRD kid growth performance were obtained by Oliveira et al. (1988a) by using a system of semiconfinement. The animals were allowed free grazing for twelve hours during the day, followed by confinement during the following twelve hours. During the confinement period a ration containing a maximum of 30 percent corn crop residue was offered, and the animals had an average daily gain of 73 grams with a feed conversion ratio (kg of feed per kg of gain) of 10.

TABLE 5. PRE AND POSTWEANING GROWTH RATES FOR GOATS IN NORTHEAST BRAZIL

Animal breed or type	Preweaning growth ($g.d^{-1}$)	Postweaning growth ($g.d^{-1}$)	Source
SRD	59	-	Oliveira et al., 1982
SRD	52	41[a]	Guimarães Filho et al., 1982
SRD	61	-	Lima et al., 1983
Moxotó	55	16[b]	Figueiredo et al, 1984
SRD	-	17[b]	Lima at al., 1985
SRD	-	38[c]	Fernandes et al., 1985
SRD	81	36[b]	Fernandes et al., 1985
Anglo-Nubian x SRD	85	38[b]	Fernandes et al., 1985
SRD	77	13[b]	Oliveira et al., 1988b
SRD	-	-25[d]	Oliveira et al., 1988a
SRD	-	73[e]	Oliveira et al., 1988a

[a]Up to 240 days, in caatinga vegetation.
[b]Up to 1 year, in caatinga vegetation.
[c]Up to 1 year, in buffel grass pasture.
[d]Kids 8-10 months old kept in caatinga vegetation for 112 days during the dry season.
[e]Kids 8-10 months old kept in semiconfinement for 84 days during the dry season.

Even though the major purpose of raising goats in Northeast Brazil is for meat production, the literature in the region is scanty on carcass characteristics. Some of the available data are shown in Table 6.

Dressing percentages of SRD goats kept exclusively under caatinga vegetation grazing are quite low, and yearling kids averaged only around 38 percent. Crosses with larger breeds, such as Anglo-Nubian and Bhuj, increased slaughter weight at one year of age and also showed an increase in dressing percentage. However, those crosses did not show any improvement in terms of thigh circumference, since neither Anglo-Nubian nor Bhuj can be considered to be meat-type goats.

Some improvement in slaughter weight, dressing percentage and other carcass characteristics, such as thigh circumference, of SRD goats was obtained through total confinement and feeding of rations based on corn crop residues (Oliveira et al., 1982). However, the high costs of concentrates in the region, together with the low growth potential of the local-type goats, might make this practice uneconomical.

A more promising way to improve meat production from local goats seems to be semiconfinement, with free grazing during the daytime hours and confinement, with a ration containing 30 percent corn crop residue, offered during the night time (Oliveira et al., 1988a). This approach allows the goats to exercise their recognized selective ability during the grazing hours, and the partial confinement will be less stressful than total confinement for range-adapted goats, which have a more nervous character.

TABLE 6. DRESSING PERCENTAGE AND CARCASS CHARACTERISTICS OF GOATS RAISED IN NORTHEAST BRAZIL

Breed or type	Approx. age	Slaughter wt (kg)	Dressing Percent	Carcass length (cm)	Thorax depth (cm)	Thigh circum. (cm)	Source
SRD	1 year	16.9	38.2	53.1	16.1	25.8	Bellaver et al., 1983
Anglo-Nubian crosses	1 year	22.3	42.1	54.4	16.1	26.2	Bellaver et al., 1983
Bhuj crosses	1 year	20.5	42.5	54.5	16.0	25.8	Bellaver et al., 1983
Moxotó	1 year	14.6	41.6	50.7	15.1	24.5	Figueiredo et al., 1984
SRD[a]	3-4 years	32.4	41.1	76.6	22.7	32.6	Ponce de Leon et al., 1985
SRD[b]	3-4 years	33.0	47.2	74.4	22.1	32.3	Ponce de Leon et al., 1985
SRD[c]	1 year	21.4	43.6	57.5	16.4	28.9	Oliveira et al., 1985
SRD[d]	1 year	23.1	54.4	-	-	-	Oliveira et al., 1985

[a]Female adult animals (SRD, Moxotó and Marota) kept in native pasture without being bred during two years.
[b]Female adult animals (SRD, Moxotó and Marota) kept under confinement without being bred during two years.
[c]Castrated kids kept under confinement.
[d]Castrated kids kept under semi confinement with twelve hours of grazing.

Conclusions

Even though goats in Northeast Brazil have been traditionally raised for meat production, the overall meat production from native goat types is considered small, and there is much room for improvement.

One of the cheapest ways to improve overall flock productivity in Northeast Brazil is to make use of the capacity of goats to cycle throughout the year at tropical latitudes. Thus, the breeding season can be adjusted to the cyclic pattern of forage availability and quality, as well as to environmental variables, such as precipitation. Overall herd management decisions can be

taken in such a way as to maximize the benefits from these factors.

One example is the control of mating by having a breeding season just after the first rains in the region. This environmental phenomenon naturally triggers estrus and ovulation and a higher fertility rate is expected. This would result in the kidding season occurring toward the latter part of the rainy season, when the amount and intensity of precipitation has already decreased. As a consequence, heavy kid losses due to chilling will be avoided. At the same time, the does will have their highest nutritional demands for late gestation and lactation matched with good supplies of high quality forage; this match will stimulate higher milk production and accelerate kid growth and development.

Other measures aimed at improving meat goat production involve native caatinga manipulation, which is discussed in detail in Chapter 5.

A more expensive way to effect larger improvements in meat production from native goats is to mate them to more specialized meat breeds such as Boer (Nandé and Hofmeyr, 1981) and Kiko (Batten, 1987). However, the utilization of such breeds will require a more intensive type of goat production, with the need to devise economically and biologically feasible systems of supplementation during the dry season.

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Chapter 4

GENETIC RESOURCES AND IMPROVEMENT PROGRAMS

J.M. Shelton and E.A.P. Figueiredo

The world population of goats in 1985 has been estimated at approximately 460 million (FAO), and is increasing, but at a slower rate than is the human population. This number represents a substantial biological resource for meeting mankind's needs for food and fiber. In addition to the magnitude of this resource, considerable genetic diversity exists in this world population, and this diversity should be considered as a resource independent of that represented by the number of goats. There are severe restrictions on the movement of genetic resources between countries, and problems of adaptation are encountered in the movement of genotypes between different environments and production systems.

According to Williamson and Payne (1978) and Shelton et al., (1984), a large portion of the world population of goats are found in equatorial regions. It is more correct to say that large concentrations of goats are found in the arid, semiarid and wet-dry tropics. The number of goats found in the humid tropics is small.

The preponderance of goats in tropical regions seems at variance with their origin, since the original wild type (the Ibex) prefers open habitats devoid of tall vegetation and is usually found at higher elevations, characterized by rugged, steep and rocky terrain (Valdex, 1985). Also wild goats, in general, are large animals (up to 150 kg for males), which size is at variance with domestic types found in the tropics. Wild goats are also adapted to precipitous habitats on which few other animals can find a footing. Modern domestic animals apparently still possess this trait, but it appears to make little positive contribution to their current adaptation and usefulness. On the contrary, it may present problems for fencing or control.

From the above discussion, one can see that goats have changed considerably during the thousands of years since domestication and in the probably much shorter time since their translocation into the tropics. The unique adaptation of goats to the arid tropics appears to be explained by a number of factors that are characteristic of their genetic makeup. Two of these are that goats are survivors, and that they are often the last on the scene. In a biological sense, they are efficient in the use of water, they travel well over long distances, they consume a wide variety of vegetation, and they are somewhat unusual (among domestic ruminants) in their ability to subsist largely on browse. They have little subcutaneous fat cover, which contributes to their adaptation to hot climates and militates against their suitability for cold climates.

Approximately 27 million goats are located in the tropical regions of Central and South America and the Caribbean. The largest concentrations in this area are found in Mexico (ca. 10 million) and Northeast Brazil (ca. 8.5 million). Other countries with substantial numbers include Peru and Venezuela. Several Central American countries (Costa Rica, El Salvador, Nicaragua, and Panama) actually have very few goats, but in these areas there is

both a need and a potential for expanded use of goats by small holder agriculturalists. Collectively, the Caribbean region has approximately 2.4 million goats. Although this number seems small, some of the individual islands or countries have among the highest concentrations in the world when goat numbers are expressed per unit of land area.

With respect to genotypes, goats were no doubt introduced to the American tropics (including Northeast Brazil) from Europe with the early settlers. This occurred in a relatively short period of time, compared to the time period over which the species evolved, or even to the time since domestication. Also, goats have been present in the Western hemisphere for a relatively short period of time compared to the time they have been in other parts of the world. This is an important consideration in terms of the evolution or the development of an animal that is adapted and productive in unique environments. In addition to the animals introduced at the time of settlement of the region, exotic breeding stock has been introduced from time to time, usually from temperate climates, in an attempt to improve performance. The appeal of this approach is that the animals are large and impressive in appearance, and their introduction can be a single occurrence, compared to management changes that may require seasonal or even daily inputs. Thus, in many cases the most significant factor relative to breeding programs for goats is the policy concerning the importation of exotic breeding stock. Although these introductions may at times be useful (particularly in respect to milk production), the introduction of exotic breeding stock will not solve the problems inherent in goat production in adverse environments, and, on a world basis, this practice has been overused.

Breeds

Any consideration of breed or breed resources must consider the product. It has been suggested (Shelton, 1977) that the most valuable product obtained from goats is milk; however, most of the goats of the world are used only for meat production and this is particularly true in Northeast Brazil. In any case, this chapter is concerned primarily with goats kept for meat production. It is reasonably easy to distinguish or characterize flocks maintained for commercialization of milk or fiber production from those for which meat and skins are the primary outputs. However, it is difficult to maintain a clear distinction between those maintained for meat production and those which serve a dual-purpose role, providing a household milk supply as well as meat. The latter should be encouraged, particularly in the case of the smallholder for whom family food supply is important.

The presence of an adapted, productive genotype is a primary requirement for a successful livestock industry. In the case of goats, one often finds adapted indigenous types, but their productivity is low. There is strong circumstantial evidence that adaptation to adverse environments is negatively correlated with productivity. Yet, on a world basis, there are examples of specific genotypes that survive in times of stress but can also be productive when conditions permit. The evolution of breeds that are adapted but also productive is a slow process, and there may not have been time for this to happen since goats first arrived in

the tropics. On a long-term basis, breeding programs may well be the most important factor for the development of small ruminant production in tropical environments; however, in the short term, management programs (such as nutrition and disease control) offer much greater potential. The one exception to this is where breed substitution can be used advantageously.

On a world basis, there are hundreds or perhaps thousands of breeds or genetic types of goats. There are well-established and productive breeds of goats for fiber (Angora and Cashmere) and for milk production. Unique and superior genotypes for meat production are not so easily identified. However, even with the large variety of types, most of the world's goat population is an amorphous collection that does not fit into any well-defined genetic group. These are often referred to as native or indigenous. Again, depending on how the term is defined, there may be no such thing as a "native" goat in the Western hemisphere. The original wild goats were native to the area from the Mediterranean eastward through Asia. The term "indigenous" may be more appropriate. The terms Criollo (Spanish) or Crioula (Portuguese) are commonly used, perhaps implying that these animals have been produced in a given area for many generations. Most areas have local populations of goats which are highly variable in many traits, especially color. These may be referred to by definitive terms indicating locality, i.e., the Jamaican goat. However, most of the goats found in tropical regions of Central or South America and the Caribbean are an amorphus collection without any well-defined type. In Northeast Brazil, these are designated as SRD (Sem Raça Definida, or without well-defined type). Also, within a given area there are often collections of animals that have a distinct form or appearance. These may arise from a unique genetic origin, specific selection efforts, or, in many cases, from isolation within a given geographic area over a period of time. In Brazil, some of these types are known as Moxotó, Repartida, Canindé and Marota (Shelton and Figueiredo, 1981).

Thus, in Northeast Brazil one may encounter introduced breeds (mostly dairy types), locally distinct breeds or genetic types, the SRD, and, in some cases, identifiable crosses among these types.

Some of the better known dairy breeds include the Saanen, the Alpine, the Toggenburg, the Piotevin, and the Anglo-Nubian, and all of these have been introduced to tropical environments, including Northeast Brazil. These breeds are well described in the literature, and since this discussion relates largely to meat production, they are mentioned only briefly. The Saanen, Alpine and Toggenburg breeds originated in temperate, even mountainous regions of Europe, and are sometimes collectively referred to as the Alpine breeds. The Saanen is usually considered to be the largest in size and the best milk producer. They are all white with erect ears. They generally present great problems in adaptation to adverse environments. The Toggenburg is mostly black with light or tan stripes on the face. The breed has erect ears and closely approach the Saanen in size and milk production. The Alpine may be identified by source such as British Alpine, French Alpine, German Alpine (Parda Alemã), or Rock Alpine. There is little basis for distinguishing among them, but in fact they may be different due to selection pressure or the management system in the respective areas of origin. They are similar to the Saanen and the Toggenburg in size and performance.

These European dairy breeds are not adapted to the tropics and are not recommended in pure form for meat production under smallholder conditions in any part of the tropics. They have high nutritive requirements and require a high level of management in respect to parasite and disease control. In the absence of these inputs, they are likely to have poor performance and a short life span. In addition, they offer little or no advantage over indigenous types with respect to meat production. On the other hand, if the animals are to be exploited for milk and can be provided with inputs with respect to nutrition, management and disease control, they can be produced in the tropics and do offer substantial advantages over indigenous types. Even with superior care, the established dairy types are less productive in the tropics than in temperate regions, due to heat stress and feed quality limitations. Technology might be employed to overcome some of these differences, but at considerable expense.

The Nubian or Anglo-Nubian is different from the European dairy types. This animal is better adapted to adverse tropical environments. This is probably related to the fact that the Nubian originated in a more stressful environment (Egypt) than that of Central Europe. The Nubian is a large breed with long ears and Roman nose. The color may vary from red or tan to black. The pure Nubian is not competitive with other established dairy breeds in milk production, having both a shorter lactation period and lower daily milk yields. The milk of Nubian goats has a higher butterfat content, and thus the total yield of butterfat will approach that of the other breeds. They have been extensively transported to many tropical areas, including Northeast Brazil and Mexico, as an improver breed for meat and/or milk production. They may serve well as a dual purpose animal to provide cash meat sales and a household milk supply. Several studies have shown that pure Nubians surpass local types with respect to milk production per head and that F_1 crosses derived from the use of Nubian males surpass native types with respect to meat production (Fernandes et al., 1985). Other studies suggest that pure Nubians may present problems of adaptation when managed for meat production under farm conditions.

Some of the recognizably distinct types found in Northeast Brazil are described as follows (Shelton and Figueiredo, 1981).

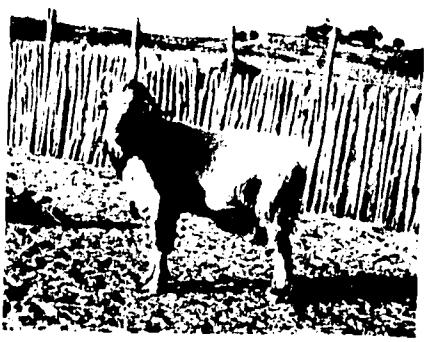
The Moxotó. The Moxotó is the most readily identifiable local type. It takes its name from the Moxotó Valley in the state of Pernambuco. The animals are uniform in color, size and type. The uniformity in color is necessary since it is this trait that makes them recognizably unique. Their uniformity in size and type suggests that they are of similar genetic origin and tend to breed true. The animals are of medium size relative to some smaller indigenous types and larger exotics. Typical weights for mature females range from 30-40 kg. Their color is light cream, almost white, with black points. Black is found as a strip or line on the dorsal surface, on the underline, and on the feet, legs and face. Most are horned, with males having relatively small horns. The ears tend to be of medium size and erect. Bettencourt (1987) pointed out the existence of a similar breed in Portugal, called Serpentina, which is supposed to have been brought to Brazil during the colonization period. In Brazil, the first published studies

NATIVE OR INDIGENOUS GOATS FOUND IN BRAZIL

Moxoto Does

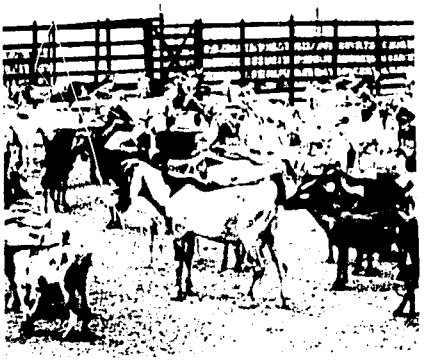
Repartida Does

Young Caninde Male



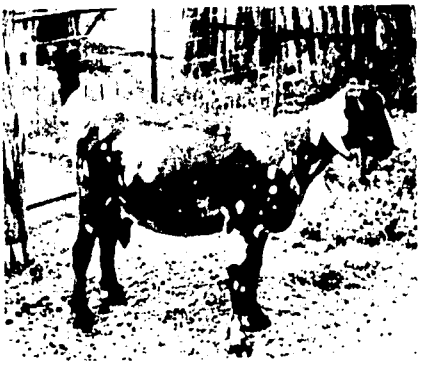
Marota Male

NATIVE OR INDIGENOUS GOATS FOUND IN BRAZIL

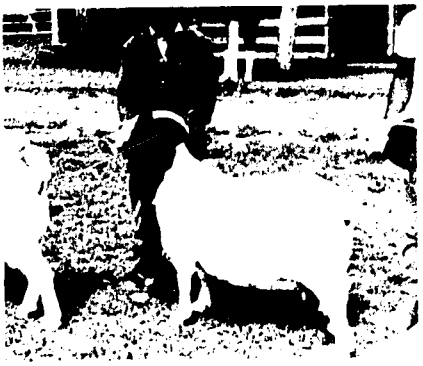


SRD Goats in Brazil
With Nubian Male in Foreground

Bhuj Male



Anglo Nubian



Boer

(Potential Improver Breeds for Meat Production)

of the Moxotó were conducted by Silva Neto (1948). More recent studies of the breed reported kidding prolificacy of 1.36 for the years 1980-82 at Sobral and 1.20 and 1.33 for the years 1984 and 1985, respectively, in Pernambuco (Araújo, 1985). The data on growth have shown averages of 9.85 and 10.91 kg for weaning weight and of 13.07 and 18.57 kg for yearling weight in Ceará and Pernambuco states, respectively (Figueiredo et al., 1987; Araújo, 1985). In Pernambuco, the average mortality rate from birth to weaning was reported as 13.1 percent and 15.9 percent from birth to yearling (Araújo, 1985).

The Repartida. The goat known as the Repartida appears to be similar in form and function to that of the Moxotó. The term Repartida refers to a unique color pattern consisting of dark forequarters and points (face and legs) with a fawn or cream color over the rest of the body. The reverse or reciprocal color pattern, where the hindquarters are dark, is almost as frequent. Most of the animals are horned with medium-sized erect ears. So far research data has revealed a prolificacy of 1.20 (Figueiredo et al., 1987), mortality from birth to weaning of 23.3% and from birth to yearling of 32.9%, and weaning and yearling weights of 9.40 and 14.96 kg, respectively (Passos, 1985).

The Canindé. The Canindé is also similar to the Moxotó and Repartida in size, form and function. In this case, the name apparently originates from or has a common origin with that of the city of the same name in the state of Ceará. As with the above types, the Canindé is distinguished largely by its color. It is usually black with a yellow belly and with a small amount of yellow or tan occasionally occurring on the face as eye stripes. The size is similar to the Moxotó and Repartida. It remains to be determined whether the Canindé is unique in production traits or whether it merely represents a color variation of animals with the same or similar genetic background as the other types identified. All three of the above types have short, fine hair and produce good quality leather. It is assumed that, since they have evolved in the region, they are well adapted to local conditions. Research reports show prolificacies of 1.38, 1.47, 1.29 and 1.43, for the Canindé in the states of Paraiba and Rio Grande do Norte and the regions Quixada and Sobral in the state of Ceará; and mortality from birth to weaning of 18.1 and 15.0 and from birth to yearling of 21.6 and 18.6 percent for Paraiba and Rio Grande do Norte, respectively. Weaning and yearling weights of 8.98 and 15.77 kg, respectively, have been reported for Quixadá (Figueiredo and Barbieri, 1988).

The Marota. This breed is also known as the Curaca, a name that derives from a city of the same name in Bahia state. The Marota or Curaca is a solid white goat that appears to be somewhat different from the other native types. Individual animals have some long, coarse hair, perhaps indicative of genes of the Saanen and/or the Angora, which are known to have been introduced to Brazil in earlier years. To the extent that this hypothesis is true, it might be assumed that they produce less desirable skins and are less well adapted to the local or tropical conditions. However, these points remain to be confirmed by more definitive studies. Research reports show kidding prolificacy figures of 1.30 and 1.53, respectively, for Piaui and Sobral, mortality from birth to weaning of 17.3 and from birth to yearling of 28.7 percent, and weaning and yearling weights of 8.52 and 16.8 kg, respectively, for

Piaui (Figueiredo and Barbieri, 1988).

The SRD (Sem Raça Definida). As stated previously, this term is an abbreviation of the Portuguese term for "without well-defined type," which means that this collection of goats cannot be classified or characterized into any specific breed or group. They are not uniform in size, in color, or in any other traits that generally describe a unique breed. This variability is likely to be traceable to their very early introduction to the region, with subsequent introduction of the genes of a variety of breeds over the years. For example, many SRD goats show Anglo-Nubian features. The end result is that the SRD is a very heterogenous group, and, because of this, they often prove to be larger in size and more productive than the smaller indigenous breeds.

Some introduced types found in Brazil, in addition to the recognized dairy breeds, are as follows:

The Mambrina. The term Mambrina is occasionally heard in Brazil in reference to goats, but this type apparently no longer exists there in pure form. It was introduced in an earlier period and has made a genetic contribution to the present goat population. The origin of the Mambrina is not clear, but it is thought to have been introduced from the Eastern Mediterranean.

The Mambrina may be related to a general type of goat that is found throughout that area, and is known as the Zarabi in Egypt, the Damascus or Shamy in Lebanon, Syria, and Jordan, and the Najdi in Iran. All tend to be large and reddish-brown in color, with long ears and a Roman nose. In the Near East they are used more as dairy animals under sedentary conditions. No research data are available on the performance of this type of goat in Brazil.

The Bhuj. The Bhuj is a goat that is unique and of some interest. The name Bhuj apparently comes from an area in the Western part of India from which goats were imported to the Brazilian island of Fernando do Noronha. They resemble a type known as Beetal in India. The animal is usually black except for white or speckled ears. Its ears are longer than other types found in the Western hemisphere. It tends to have a Roman nose and small horns. Its most noted features are its long legs and its shallow or "wasp-waisted" body. Similar long-legged, long-eared goats exist in India (Jamunapari) and Africa (West African Long-Legged). The Bhuj appears to be more exaggerated in this respect than the other types mentioned, especially the Jamunapari. Males may reach 85 cm in height, whereas others, such as the Moxotó, are more in the range of 65 cm. One could hypothesize an adaptive advantage for this stature in a browsing animal. However, available performance data (Bellaver et al., 1980) do not suggest an advantage under the conditions of Northeast Brazil. One of the problems that has been encountered is a high mortality rate. Research data showed a prolificacy of 1.51 with weaning and yearling weights of 9.81 and 12.53 kg, respectively, for conditions around Sobral (Figueiredo et al., 1987).

Breed Choices

Experimental results in Brazil have failed to show a significant and consistent difference in performance between the

four indigenous types (Moxotó, Repartida, Canindé and Marota). It is believed that to some degree these represent color variations of very similar types of goats. Indeed, color variations are the basis for assignment to various breeds or genetic types. The genes for these various colors are known to be segregating in much of the indigenous population. For these reasons, these four types have been grouped together in the evaluations and recommendations. However, this does not mean that there are no differences among them. If any of the types has been isolated and bred within the group or region for several generations, or has a different or distinct genetic origin, such a population will almost certainly be unique in some respect. The end result is that, if a producer wishes to breed the native types and has a distinct preference for one type over the others, he should feel comfortable about making such a choice. Also, improvement programs with these indigenous types should prove useful.

If improvement of both milk and meat production is the expected goal, then the breeding stock should contain some type of improved dairy breeding. Local indigenous types are likely to be low in milk production, and selection within these types is likely to provide a slow response. Genes from improved dairy breeding might be obtained from the Anglo-Nubian or the Mambrina, from crosses of indigenous types with established dairy breeds, or by selection from existing populations (SRD in Brazil) that show evidence of infusions of dairy breeding. True breeding strains may be created by selections from the above populations. It should be assumed that animals to be milked will receive some type of preferential treatment. This may apply only to the individual animals that have been selected for milking, or the same treatment may be applied on a flock basis, especially when utilizing crosses with exotic breeds such as the Alpine, the Toggenburg, etc. Extreme caution should be exercised in the introduction of genes of these breeds to flocks which are likely to receive only a low level of management or inputs. Since most of the goats in the arid regions of Latin America are used only for meat, or to a very limited degree for both meat and milk, genetic resources should be looked at from this standpoint.

Several studies from world-wide literature suggest that, when viewed in terms of efficiency of meat production, indigenous types are often comparable or superior to introduced types (Figueiredo et al., 1987; Rieser et al., 1985; Singh and Sengar, 1981). Therefore, caution should be exercised in extensive substitution of exotic breeds for locally adapted types. Figueiredo et al. (1987) reviewed the available performance data on goats in Brazil. The doe performance data are summarized in Figure 5 and Table 7.

Growth data tended to favor the large breeds (Anglo-Nubian and Bhuj), but reproduction and survival data tended to favor the local breeds. When kid production is expressed as a function of does exposed, and, more importantly, as a function of body weight of the doe (Figure 6), there is little or no gain from the use of exotic types.

The Bhuj gave particularly poor performance, and of the two exotic types tested, the Anglo-Nubian should hold much more promise. Also, kid mortality was not figured in these data, and the exotic types, especially the Bhuj, suffered higher kid mortality than SRD or native types. It should be realized that

these data derive from a single experiment and that exactly the same results might not be obtained under other conditions. However, the results seem so overwhelming as to suggest that further concentration of the Bhuj breeding in flocks should be discouraged.

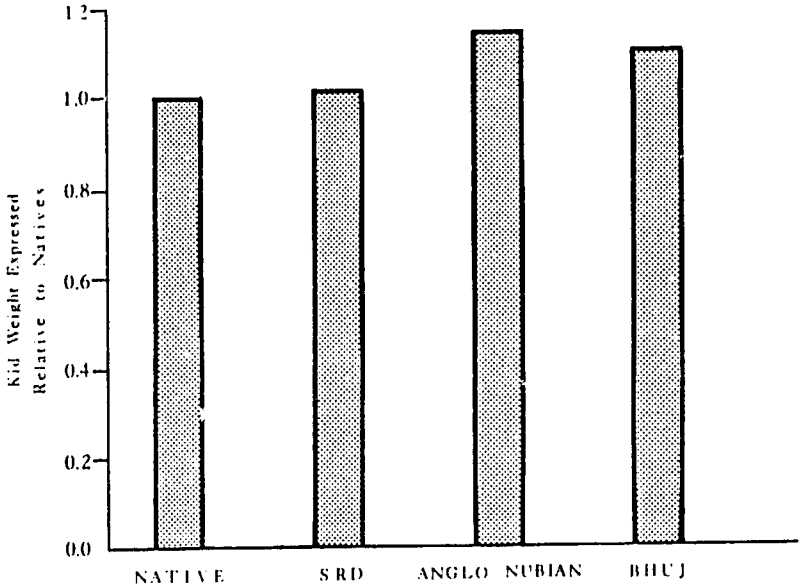


Figure 5. Kid weight at 8 months from four types of sires used on SRD does and expressed relative to natives.

The Anglo-Nubian and SRD groups performed better than the four indigenous breeds on a per head basis, but the Anglo-Nubian was not superior when performance was expressed as a function of body weight. The authors suggest caution in the substitution of pure Nubians for resident populations that are to be used largely for meat production. Such substitution will occur from repeated use of Nubian sires within a flock. Limited data, shown in Table 8 (Fernandes, 1987), suggest that even 3/4 exotics (Anglo-Nubian or Bhuj) suffer higher mortalities. Only limited data are available in Brazil on the performance of F1 females. However, as discussed above, the SRD populations are largely heterogeneous with the Anglo-Nubian as the predominant exotic contributor. This heterogeneous population performs favorably in comparison with the other indigenous types, and it seems safe to theorize that F1 females would also perform in a similar manner.

Crossbreeding

Crossbreeding offers the potential to improve performance, but a systematic crossbreeding program is difficult for small producers with limited resources to implement and maintain. However, it is unrealistic to suggest that crossbreeding not be practiced, since exotic breeds have been introduced to most areas and some crossbreeding will inevitably result. Almost without exception, the F1 offspring will show superior growth rate (Table 8) and milk

production (Table 9), and possibly superior performance as a breeding female.

Depicted in Figure 5 is the growth rate of kids sired by four different types of males bred to SRD does. The use of Anglo-Nubian and Bhuj sires, particularly, results in increased growth rate over the use of native sires. It should be pointed out that these males were used on SRD does, which are in effect a heterogenous population with some exotic (probably Nubian) breeding. A greater response might have been expected had these males been crossed to the native types. These data appear to provide an adequate basis for suggesting an advantage from crossbreeding (heterosis) in the growth rate of the kid. There is also a good basis to believe that the F1 does will be bred back to exotic breeds, resulting in an eventual grading up to the exotic breed used, which might not be desirable in the case of the Bhuj and might even be questionable with regard to the Anglo-Nubian.

TABLE 7. CHARACTERISTICS OF REPRODUCTION OF GOATS IN NORTHEAST BRAZIL (1980-1983)

	BREEDS						
	Anglo Nubian	Bhuj	Candidé	Marota	Repartida	Moxotó	SRD
No. of females available	98	102	126	129	86	276	117
Does in estrus: No.(%)	94(95.9)	69(67.7)	107(84.9)	115(89.2)	68(90.7)	244(88.4)	78(66.7)
Normal parturitions: No.(%)	48(49.0)	29(28.4)	76(60.3)	73(56.6)	46(53.5)	177(64.1)	70(59.8)
Abortions: No.(%)	29(29.6)	17(16.7)	17(13.5)	20(15.5)	14(16.3)	33(12.0)	7(6.0)
Non-pregnant does: No.(%)	16(16.3)	23(22.5)	14(11.1)	21(16.3)	8(9.3)	34(12.3)	1(0.9)
Single parturitions: No.(%)	24(24.5)	14(13.7)	43(34.1)	33(25.6)	36(41.9)	113(40.9)	34(29.1)
Twin parturitions: No.(%)	23(23.5)	15(14.7)	33(26.2)	39(30.2)	9(10.5)	61(22.1)	35(29.9)
No. kids born:	73	44	109	114	57	241	107
Prolificacy	1.5	1.5	1.4	1.5	1.2	1.4	1.5

Prolificacy indicates mean litter size over the four years.
Data on kid mortality not included.
Source: Unpublished data of CNPC/EMBRAPA.

Other Exotics

A large number of exotic (to the American tropics) breeds might be considered for introduction. The only other exotic breed in which the authors propose to take great interest is the Boer goat of African origin. These goats have now been introduced in limited numbers to Central America and to Brazil. Ideally, they should first be evaluated in experiment station herds. However, experience has shown that producers are not likely to wait for research results before proceeding with introduction to their own flocks. Thus, experimental work from other areas that involve the Boer goat should hold some interest. Experimental work in South Africa confirms that the Boer goat has good growth rates, good

carcass traits, and acceptable reproductive rates, but in such studies the Boer has seldom been compared to other types of goats. In one experiment in Tunisia (Reiser et al., 1985) the Boer was compared with a local breed and three European breeds (Alpine, Saanen, and Poitevin). In general, the Boer goat equalled or excelled in growth, litter size and kid weight. In terms of kid weight produced per doe and gross income, the Boer was superior to all other types. When these factors were expressed as a function of size or metabolic weight of the doe or as net income, the Boer was not more efficient or more profitable than the local breed.

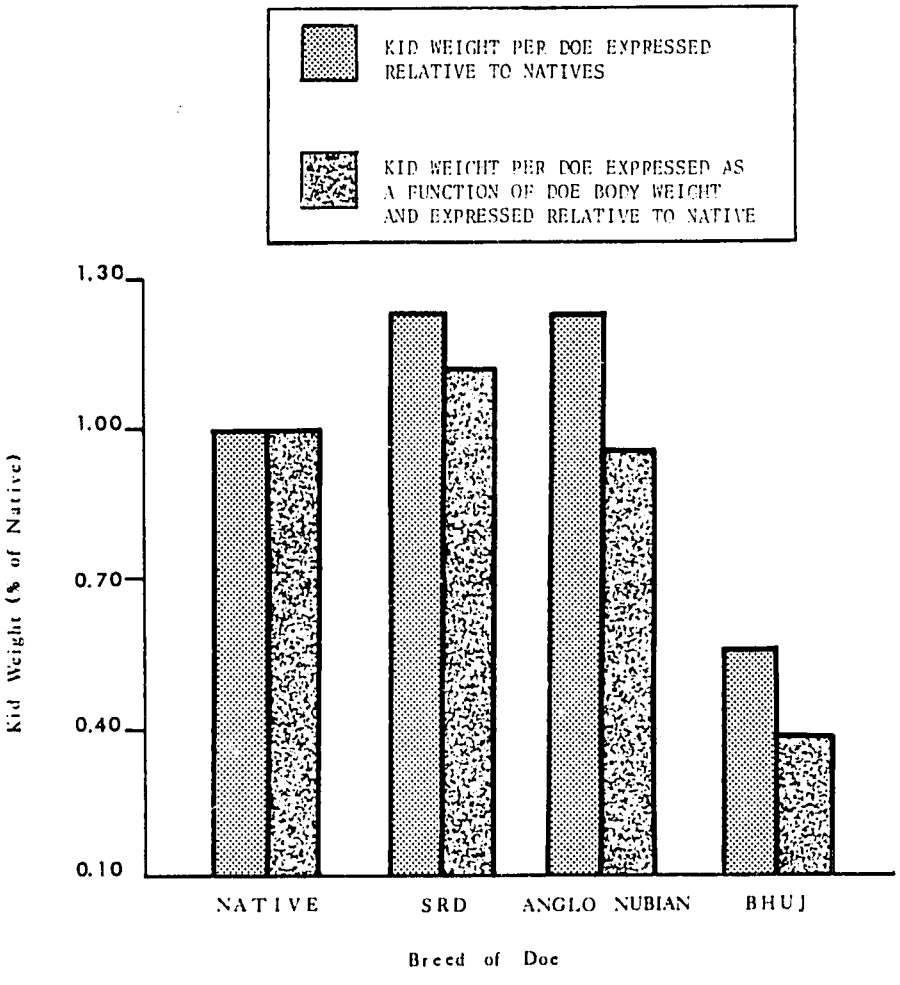


Figure 6. Kid weight at 180 days from four types of does expressed relative to native types.

These data suggest that the use of pure Boers or their crosses will be likely to add to the carcass value and the market acceptability of goat meat, but caution should be exercised in expecting this large animal, which was developed under good feeding conditions, to perform acceptably under small farmer conditions in Northeast Brazil. In summary, the Boer should probably only serve a role in crossbreeding on a commercial scale, or in providing a crossbred population for use in selection.

TABLE 8. GROWTH RATE OF CROSSBRED KIDS, TO YEARLING AGE, AT QUIXADA, CEARÁ 1986-1987

Genotype	Initial Number	Weight (kg)		
		Birth	Weaning	Yearling
SRD	59	1.98	11.63	16.70
1/2 Anglo-Nubian-1/2 SRD	199	2.23	11.68	19.50
1/2 Bhuj-1/2 SRD	207	2.27	12.02	18.94
1/2 Moxotó -1/2 SRD	46	1.96	11.99	20.64
3/4 Anglo-Nubian-1/4 SRD	38	2.42	13.09	22.93
3/4 Bhuj-1/4 SRD	13	2.37	11.49	15.75
3/4 Moxotó-1/4 SRD	14	1.64	10.39	18.67

Source: Fernandes (1987).

Selection Programs

The availability of an adapted and productive genotype is the primary requirement for an efficient livestock enterprise. At the present time, such a genotype for goats has not yet been developed or identified for the tropics, and more specifically for the conditions of Northeast Brazil. The development or evolution of

TABLE 9. PRODUCTION AND REPRODUCTION PARAMETERS OF NATIVE AND CROSSBRED GOATS IN SEMIARID VENEZUELA

	Kidding interval (days)	Days to 1st postpartum estrus	Postkidding dam weight (kg)	Milk prod. (kg)	Lactation length (days)
Native	304.7	145.8	39.3	57.2	151.0
1/2 Nubian-1/2 Native	355.8	175.0	42.1	97.7	182.4
1/2 Alpine-1/2 Native	356.8	172.4	45.9	150.5	195.0
1/2 Toggenburg-1/2 Native	360.3	171.2	38.6	115.3	191.8
3/4 Nubian-1/4 Native	403.1	222.1	42.0	95.6	183.8

Source: Garcia et al. (1981).

such an animal through natural selection under adverse conditions is likely to be a very slow process. Man's efforts can enhance this process. However, in selecting for meat production, man often interferes with the natural selection process by utilizing highly visible traits under artificial conditions rather than the important traits of reproduction, adaptability, survival, carcass merit, and disease resistance, all of which require more rigorous measurement.

Some of the major impediments to meat production from goats under adverse conditions are abortion, poor kid survival to weaning, post-weaning death losses, slow growth rates, and poor carcass yields. Some of these problems are somewhat specific to goats (i.e., abortion). At the present time, it is not known to what extent such problems as abortion or kid survival are amenable to change through selection. However, there appears to be no alternative to selection programs designed to correct some of the deficiencies enumerated above. It would appear that one anomaly of this situation is that natural selection should take care of the problem of abortion and mortality. However, there is a very real possibility that the reverse has occurred in the past. The does which carried (failed to abort) and lactated for one or more kids may have died or failed to kid during the following season, with the result that maternal selection was in the opposite direction to that desired.

In any case, selection should be practiced for net reproductive efficiency, growth rate, and carcass value under the production conditions of the target region. The appropriate production condition should be defined as that level of management that characterizes the producers who are likely to be able to make use of at least minimal levels of technological interventions.

Since they exist in much larger numbers, producers should be a major part of improvement programs. However, in adverse environments, developing countries, or small-holder conditions, it is highly desirable that research or extension agencies be an integral part of these efforts.

Selection may be made from within native types, heterogeneous populations such as SRD, or crossbred types. It is not advisable to start with exotic breeds as a selection base for meat or dual purpose production. Available information suggests that selection within native types will yield slow progress but may be important if they are to be used in crossbreeding programs, or if the development of uniquely national animal resources is a goal. It is probably desirable that milk production for household use should remain a goal even in flocks which serve primarily as meat producers. These two traits are not necessarily antagonistic.

Also, selection within heterogeneous or crossbred populations is likely to yield a faster response. Ideally, the local types would be preserved and improved, either in private or in institutional hands. This is at present being taken care of by BNB programs in Northeast Brazil. In addition, crossbreeding will occur as other breeds are introduced. If the use of sires of introduced breeds is continued, the result will be grading up to exotic types. As an alternative to this, selection programs should be initiated in producer and institutional flocks based on crossbred foundations.

It should be recalled that most of the genetic progress is obtained from selection on the male side, and thus major emphasis should be placed on selecting males. Unfortunately, many traits, such as reproduction and fitness, are expressed only in the female. In the case of the goat selected for meat production a preference should be given to male kids that grow out well, have good conformation, and are out of does that have survived and have had a good reproductive record over a period of years under typical production conditions. It is difficult for small producers to make significant genetic changes working only within his flock, due to limited genetic variation and to problems of inbreeding. To avoid inbreeding, males should be selected from outside the flock for each new generation of females, or every two years if replacement females are kept from each kid crop.

The majority of the animals in the breeds mentioned have horns. Producers should be cautioned against breeding polled (hornless) goats. Horns are due to a single pair of genes, with the polled condition being dominant. Animals which are homozygous (pure) polled have a high frequency of intersexes (improperly sexed animals), expressed as masculinized females that are infertile. This problem can be avoided by breeding only horned animals or by not mating a polled male to a polled female. If either sex in a mating pair is horned, there should not be a problem with intersexes. Other Mendelian (single gene) traits are also found in goats, but are not reviewed in this chapter. The problem of intersexes is perhaps the most important of such traits.

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Chapter 5

IMPROVING THE PRODUCTIVITY OF GRAZING LANDS IN THE SEMIARID TROPICS

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Semiarid lands offer few alternatives for achieving increased productivity. Even where improvements are biologically possible, economic or social limitations often dictate that such measures may not be practical or feasible. Thus, when agricultural experts discuss or recommend practices for improved management, caution is warranted, because the altered situation may be no better than the old one; it might even be worse.

There also seems to be an unspoken assumption among agricultural experts from developed nations that, because a particular production system is unsophisticated, it is not efficient. However, research continues to demonstrate that many traditional production systems have evolved in relation to the prevailing economic and ecological circumstances and may, indeed, be the most appropriate or optimal, despite their seemingly low level of animal offtake. Thus, it is impossible to evaluate an existing management scheme or to recommend a new one without a basic understanding of the social and economic factors governing production, as well as the biological ones.

This chapter deals principally with biological factors of production. While the main focus is the Sertão of Northeast Brazil, there are principles that apply in other regions where goats are produced under semiarid tropical savannah or woodland conditions.

Balancing Animal Requirements with Available Food

Where livestock are produced under range conditions, the first question that must be addressed--before any improvements in technology can be considered--is that of stocking rate: is the area facing difficulties because of overgrazing? If the answer is affirmative, no improvement in either animal or forage technology will bring enduring benefit; indeed, any improvements may serve only to exacerbate the problem.

Two factors must be considered in the balance between animal numbers and food supply: (1) the nutritional welfare of the animals in relation to their expected level of production, and (2) the ecological welfare of the vegetation and soil resources in terms of the sustained productivity of the plant communities present. Range managers have sometimes been accused of attending to the latter factor at the expense of the former. However, most arid and semiarid ecosystems are unforgiving of mismanagement. Millions of hectares of desert-affected lands stand in testimony to past mistakes in this regard.

The balance in forage supply and demand is especially pertinent where goats are concerned. Being highly adaptable and opportunistic, capable of extracting an existence from even the most marginal environments, they are likely to be the last

livestock species to occupy a degrading area before it is converted into unproductive, desert-affected land. Moreover, since the economic perception of the goat by most pastoral cultures is as an animal that provides cheap meat for the family, a kind of living bank account, and insurance against total livestock losses during drought, there is little incentive for conservative stocking. Primov (1985) reported that the management objective of most goat producers in Northeast Brazil was to maximize the number of live animals in the herd. There was little consideration for improving quality or performance of the individual animal.

A common research approach to understanding the land-animal balance has been the so-called "stocking rate" trial where a series of relatively large (>20 ha) replicated pastures are stocked with varying densities of animals, and both animal and plant community response are measured over a series of five or more years. This approach has proven to be very expensive and results are often limited in their applicability. Intrinsic variation in pasture productivity within an experiment is often a more important factor than treatment (stocking rate level).

Given the short time available for the SR-CRSP project in Brazil and the scarcity of land for such trials, an alternate approach was followed. This involved three phases of work: (1) ecological assessment and characterization (Chapter 1); (2) definition of ecological limits to animal nutrition at EMBRAPA-recommended stocking rates; and (3) assessment of the effects of plant community manipulation on forage production and small ruminant nutrition. This approach has provided detailed information that will aid in interpreting on-going, large-scale stocking rate trials conducted by EMBRAPA collaborators (see Araújo Filho et al., 1982), as well as giving insight into possible ways of improving production directly.

Forage Production in Mature Caatinga Stands

The discussion in Chapter 1 illustrated the fact that virtually all areas of the caatinga have been manipulated and disturbed by man, the chief manifestation being slash-and-burn clearing of vegetation for cropping. However, the woody vegetation quickly recovers and reclaims the site unless special measures (e.g., regular recutting) are taken. Thus, for the major part of the Sertão, caatinga vegetation in some stage of recovery or relative equilibrium serves as the principal year-long forage resource for goats (Queiroz et al., 1986). An understanding of the limitations to forage production under these conditions is essential before undertaking the more complex issue of animal nutrition.

Forage in the caatinga can be classified into four categories and is generally restricted to plants and plant parts within the browsing zone, extending from ground level to 1.6 m. These classes are (1) herbaceous plants, including leaves, stems, and fruits of both graminoid and dicotyledonous herbs; (2) leaves and shoots of mature trees and shrubs growing within the browsing zone; (3) leaves of coppice shoots growing from recently cut stumps; and (4) shed leaves of both mature and coppicing trees that only become available upon leaf-fall after the onset of the dry season.

Forage available for animal production is affected by three major factors: precipitation, site productivity (soil type, depth, fertility, slope), and caatinga manipulation treatment. The little data available on site productivity for the CNPC show no substantial difference in herbaceous forage yields on lithosols or non-calcic brown soils (Gobena, 1988), the two major soil types found on the station. However, personal observation and surveys by Queiroz (1985) indicate wide variability across the Sertão, with the CNPC area representing the favorable end of the scale.

Effects of precipitation and caatinga manipulation can be seen from data in Table 10, although the relationship for precipitation is not precise. Generally, total forage yields in intact caatinga woodland ranged from about 1800 kg/ha in 1981, a dry year, to about 4000 kg/ha in 1982, a year when precipitation approached the 30 year average of 756 mm. Surprisingly, yields were only intermediate during the excessively wet years of 1984 and 1985. Yield data were not collected during the exceedingly dry year of 1983.

Forage Production in Cleared and Thinned Stands

Caatinga manipulation has been shown by several researchers to have a major influence on the class of forage produced, if not on the overall amount. Data in Table 10, taken from Kirmse (1984) and Schacht (1987) illustrate 6- to 8-fold increases in yields of herbaceous forages during the first growing season after complete clearing, but total yields (including both herbaceous and woody plants) were not greatly affected. Increases in the availability of forbs and grasses during the rainy season and transition season were offset by somewhat lower amounts of tree leaves available during the dry season. However, this apparent loss in dry season forage was partly mitigated by the fact that all of the tree leaves available under complete clearing came from coppice shoots arising from the newly-cut stumps. These leaves have a delayed phenology (Hardesty, 1986) and typically remain on the stems in a green condition for one to three months after leaves of the mature trees have been shed. Thus, the period when at least some green browse is available is effectively lengthened. Leaves on the upper parts of the coppice shoots that are out of reach of browsing goats become available in November and December, when they finally fall.

Figure 7 from Schacht (1987) illustrates the seasonal shift in forage availability due to caatinga stand manipulation. It also shows that for practical purposes the response can be achieved by merely reducing the tree canopy to about half (55%) of its original coverage, as opposed to complete clearing or heavy thinning (25% cover remaining). Thinning would have the advantage of leaving selected mature trees in the stand for the continued growth of wood to optimum market size and for the production of leaves for use as dry season forage.

Animal Diets

Mature Caatinga Stands

Although the botanical composition of the diets selected by goats was studied in detail during three years, only broad generalizations are possible. Both browse and forb species were selected during the rainy season. Annual grasses were eaten avidly

when available, especially when they produced seedheads in mid-rainy season; however, grasses were never an important component of the vegetation in mature caatinga stands. Particular species of importance are listed in Table 11 taken from Pfister (1983).

TABLE 10. ANNUAL PRECIPITATION AND FORAGE BIOMASS PRODUCTION IN INTACT AND MANIPULATED CAATINGA[1]

		Forage biomass (kg/ha), peak standing crop							
		Intact caatinga			Manipulated caatinga				
Year	Annual precip. (mm)	Herb[2]	Tree leaves	Total	Treat[3]	Herb[2]	Tree leaves	Total	Ref.
1981	538	250	1530	1780	--	--	--	--	Pfister 1983
1982	705	700	3330	4030	C_1	3600	1080	4680	Kirmse 1984
1983	447	--	--	--	--	--	--	-	
1984	1005	470	2660	3130	C_3	1230	2660	3890	Schacht 1987
1985	1510	260	1890	2150[a]	$.25C_1$	1850	1200	3050	" "
"					$.55C_1$	1930	1080	3010	" "
"					C_1	1960	1130	3090	" "
"		220	2800	3020[a]	C_4	200	3350	3550	" "

[1]In some cases estimates are from different experiments on different sites on the CNPC, thus some location variability is included.

[2]Herbaceous component measured at peak standing crop (usually May) includes both grasses and broad-leaf species.

[3]Treatment designations are: C_1, cleared caatinga, first growing season post-clearing; c_3, cleared third growing season post-clearing; C_4, cleared, fourth growing season post-clearing; $.25C_1$, stand thinned to 25% canopy cover remaining, first growing season post-treatment; and $.55C_1$, stand thinned to 55% canopy, first growing season post-treatment.

[a]Data represent yields on two different research sites on CNPC in 1985.

Pau branco, the most abundant browse species at the CNPC, is known to be quite palatable during the early part of the wet season, but was one of the least palatable in the dry season. Both species Pfister (1983) and Schacht (1987) found the climbing vine jitirana to be highly sought after by goats, despite its relative scarcity in mature caatinga stands. Pfister (1983) found that fruits of this plant contained 25% crude protein.

As the rainy season waned and the dry season progressed, consumption of annual forbs tended to decline and selection of browse increased. Sabiá was uniformly an important browse species at this time because it is both palatable and relatively abundant.

TABLE 11. IMPORTANCE RANKING OF PLANT SPECIES SELECTED BY GOATS IN MATURE CAATINGA STANDS (AFTER PFISTER, 1983)

Rank	Rainy season	Early dry season	Late dry season
1	sabiá	jitirana (Ipomoea ssp.)	jitirana
2	annual grasses	mororó	mororó
3	mororó	sabiá	catingueira
4	annual forbs[1]		marmeleiro
5	other browse[2] species		sabiá

[1] Bainvillea ssp.
Commelina ssp.
Wissadula ssp.
Hyptis ssp.
Bidens ssp.
Melanthera ssp.

[2] Anadenanthera macrocarpa
Maninot glaziovii

With the onset of the dry season, fallen leaves became the major forage resource in mature stands. Pau branco contributed the most leaf biomass, but was eaten only slightly. Catingueira, a browse species that is distinctly unpalatable during most of its growing season, became quite palatable after the leaves had fallen (Table 11). Sabia was also palatable, but most of its leaves were consumed by mid-dry season.

The browse plant marmeleiro is generally considered distinctly unpalatable. However, Pfister (1983) found considerable consumption of this species after it had leafed out in response to a rare dry-season rain shower.

Manipulated Caatinga Stands

The process of clearing or thinning a caatinga stand produces large-scale changes in the available forage. In our studies the biomass of forbs increased dramatically. Browse shifted from a mature to a juvenile state in the form of coppice shoots and leaves. Seedlings of several browse species, particularly sabiá, appeared in profusion (>20,000 individuals per ha). The major and sudden input of mature leaves into the feeding zone no longer occurred at the onset of the dry season and was replaced by a gradual leaf fall of coppice leaves. Green coppice leaves of marmeleiro and pau branco remained available for browsing well into middle of the dry season.

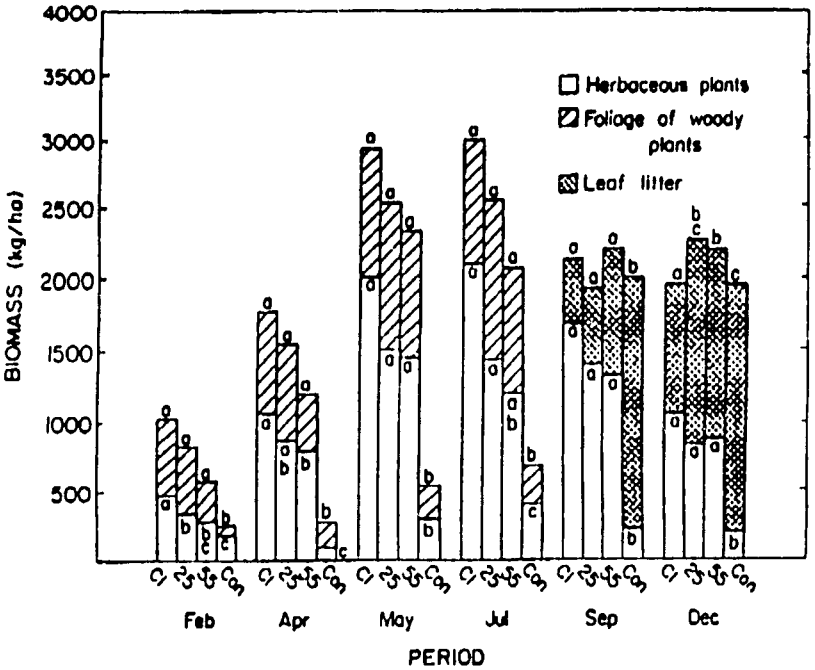

Figure 7. Available herbage biomass for six dates in 1985 on the cleared (Cl), 25% cover (25), 55% cover (55) and control (Con) pastures. Foliage of woody plants included green leaves of both coppice shoots and intact trees. Coppice foliage contributed 100%, over 97%, and 0% of the total foliage of woody plants of the cleared, thinned and control pastures, respectively. Foliar biomass of woody plants was not estimated in September and December. Bar sections with a common letter in a season and within a forage class are not significantly different (P<.1).

Despite these radical changes in food availability, dietary shifts were relatively subtle. During the rainy season, less browse but considerably more grass was consumed in treated areas as compared to untreated, mature stands. Schacht (1987) observed that grass comprised from 25 to 50% of the diet during the February-April period, compared to 7% in untreated areas.

By early dry season, diets in treated and intact stands were

generally similar. More fruits and flowers of forbs and vines were consumed in treated areas. Throughout the remainder of the dry season, the major difference was that animals in manipulated stands consumed appreciable amounts of green coppice leaves, whereas animals in untreated stands consumed only dry leaves, mainly from woody species. Kirmse (1984) noted considerable quantities of green coppice leaves in diets well into December, the usual end of the dry season.

Coppice

Given the potentially important contribution that coppice growth can make to goat nutrition, detailed studies of coppice palatability and nutrition were conducted by Gobena (1988). He found that animals preferred coppice leaves from the four most important browse species on the CNPC in the following order: sabiá, pau branco, marmeleiro and catingueira. Sabiá was ranked far above the other three, while pau branco and marmeleiro were similar. Catingueira was consistently ranked last. However, palatability was not related to condensed tannin content. Sabia had the highest tannin content and was the most palatable, whereas the poorly palatable catingieira contained very little tannin.

Seasonal Nutrition of Goats on Unmanipulated Caatinga Ranges

From a nutritional perspective, the year consists of three seasons in the Sertão: the wet season, the transition from wet to dry, and the dry season. During drought years, both the wet and transition seasons are severely truncated.

Common wisdom suggests that the dry season is the period of limitation for animal production. This is when animals either stop gaining or lose weight in normal years, or when death losses occur in drought years. Any technology aimed at increasing production or animal survivability should consider eliminating or reducing this nutritional bottleneck.

The main nutrients considered in this analysis are dietary crude protein and digestible energy. The digestibility of organic matter in the diet and neutral detergent fibre (cell wall) content are also considered, to assist in interpreting responses of protein and energy nutrition. Inattention to other nutrients, particularly the minerals that have often been shown to be a limiting factor in animal production in tropical environments (McDowell et al., 1983), should not imply their unimportance to goats in the caatinga; they were simply not investigated in the work reported here.

Crude Protein

Four years of research under differing precipitation regimes illustrated a strong seasonal trend in dietary crude protein, i.e., in protein actually consumed, as measured in dietary samples from esophageally fistulated animals. Levels quickly declined from a high of about 24% at the beginning of the rainy season to around 16% through much of the wet season and into the transition season (Figure 8). A general decline throughout the dry season (July-December) then followed. Minimum levels between 7% and 8% were observed during four years, including an average year and three wet years (1984-1986). However, dietary crude protein levels never fell below 12% during the dry season of 1981, a below-average

rainfall year. This is consistent with findings from temperate areas and may be attributable to the fact that, during droughty years, herbaceous plants do not reach full maturity; hence they remain nutritionally less differentiated. Under such circumstances, they tend to contain lower concentrations of structural components but proportionately higher levels of cell contents, nitrogenous compounds, and other easily digestible components. The same principle seems to hold for tropical caatinga conditions where much of the dry season diet is composed of fallen leaves of trees and shrubs.

When the above observations on dietary protein levels are placed in the perspective of animal requirements, limitations to growth could be expected from September through to the end of the dry season in average and wet years (Figure 8); however, protein levels probably remain adequate throughout below-average rainfall years, provided there is sufficient forage available to allow some level of selective grazing and browsing.

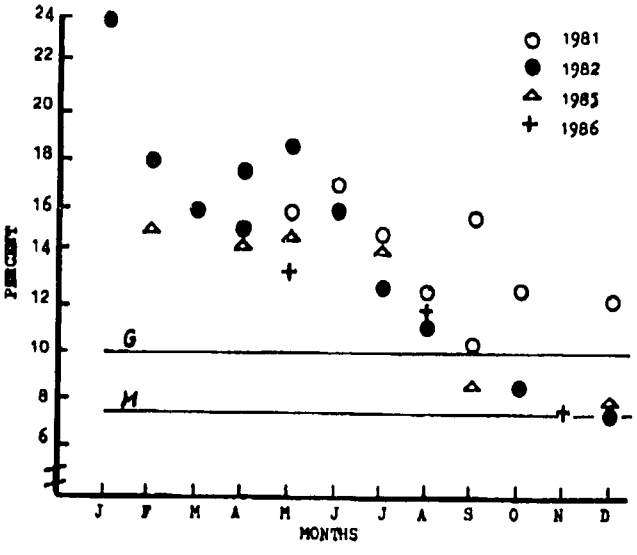

Figure 8. Seasonal trends in dietary crude protein for goats on unmanipulated caatinga ranges. Horizontal lines are NRC (1981) levels for growth (G) and maintenance (M).

In conclusion, mature caatinga range can provide dietary crude protein levels adequate for maintenance throughout the year if goats are given ample opportunity to select the most nutritious plant parts. This is probably attributable to the relatively large proportion of leguminous species in the browse fraction of the available forage. For weight gains to be sustained in young animals, supplemental protein may be required from September through December of most years.

Digestible Energy Intake

Consumption of energy by the free-ranging animal is the result of several complex interacting factors, which include the nutritional quality aspects of the forage as well as the physiological and the behavioral aspects of the animals. We have observed widely differing responses in energy consumption, both seasonally within a particular year and among years having different weather characteristics (Figure 9). Moreover, energy levels throughout most of the year, irrespective of the particular year's conditions, are shown to be deficient by NRC (1981) standards for goats. These responses and apparent anomalies are discussed below.

Considering all years, a seasonal pattern of energy consumption seems to emerge, and the pattern probably applies to goats wherever they depend on a combination of browse and

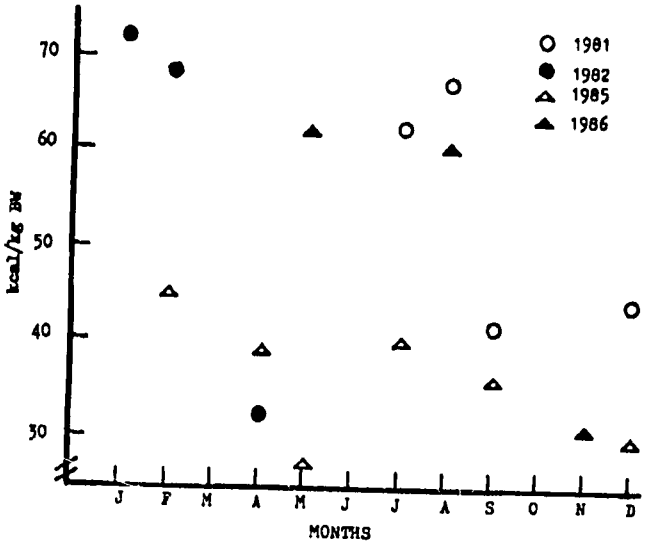

Figure 9. Seasonal trends in digestible energy intake by goats on unmanipulated caatinga ranges.

herbaceous plants as their food resource. Intake of digestible energy is at annual high levels very early in the rainy season, soon after the first flush of vegetative growth. Even though overall forage biomass is still relatively low, virtually all plants are at peak quality, so little time and effort need to be devoted to dietary selectivity. It is also at this time that animal demand is high due to recovery of weight lost during the previous dry season.

Intake of digestible energy then declines gradually over the remainder of the wet season and early dry season until about September, when it plummets (Figure 9). During the early dry season (July-August) animals have available the dry, cured remains of herbaceous plants as well as some remaining green foliage of browse plants. Then, just after leaf-fall, they suddenly have a large but overall low-quality new feed resource in the form of

newly-shed tree leaves. The palatable but relatively rare components, e.g. sabiá and catingueira, are quickly selected out of the litter, leaving behind a large (Figure 7) but generally unpalatable mass composed mainly of pau branco and marmeleiro. Leaf protein content and, presumably, digestible energy content, decline markedly upon abscission. For example, Pfister and Malechek (1986) reported that crude protein content of mororó dropped from 21% to 5% in September, when abscission occurred. Likewise, sabia declined from 20% to 10.5%. Thus, despite apparently large quantities of available biomass still remaining by mid-dry season (September) as shown in Figure 7, little of it can be considered as nutritious forage.

While the dry season presents the primary nutritional constraint to production in most years, excessively wet conditions during the rainy season can also seriously compromise energy nutrition. Biting insects and saturated soil conditions, with the attendant problems of footrot, pneumonia, and internal parasites, seem to be particularly upsetting to normal feeding behavior during years of above-average rainfall. Schacht (1987) observed that, during the entire February-April period of 1985, an excessively wet year, goats foraged in brief "frenetic" bouts interspersed by prolonged periods of lying in dense tree and shrub thickets or under low-hanging branches in an apparent attempt to escape the dense swarms of biting flies (mutucas) and mosquitos. Animals also avoided areas of the pasture where soils were saturated and free-standing water was present, or where the vegetation was tall and wet. They stopped feeding and sought shelter under trees when frequent rain showers occurred. The combination of these factors probably compromised severely both the quantity of foraging time and the use of potential foraging sites.

Generally low levels of digestible energy intake were observed throughout the wet year of 1985 (Figure 9). At no time were levels sufficient to meet NRC (1981) recommended standards. At least three factors may be responsible for this result. First, the stressful environmental conditions discussed above contributed. Secondly, stocking rates used in 1985 trials were approximately 40% heavier than those of other years (1.2 versus 1.7 ha/animal/yr). Pastures used during 1985 were relatively small (1 ha), whereas those used in 1981-32 and 1986 were larger (40 ha). Thus, limitations on selective grazing, as well as higher stocking rates, probably restricted energy intake.

The third factor relates to the reliability of published nutritional standards (especially in the case of energy) for goats. The widely used and quoted NRC standards, published in 1981, were developed at a time when nutritional data for goats were exceedingly scarce. While literature from both tropical and from temperate conditions was considered, most data came from traditional feeding trials under highly controlled conditions. Little consideration was given to the possibility that fundamental differences may exist between tropical and temperate breeds, or that certain breeds may have the capacity to reduce their maintenance energy requirements under stressful conditions. This latter point is given emphasis in view of recent work by Brosh et al. (1986). Bedouin goats, fed poor quality straw and allowed access to water only every fourth day, reduced their oxygen demand to 54% of that for animals watered daily and fed superior feed. Thus, such feeding standards as NRC (1981) should be used only as

rough approximations until more refined information becomes available, especially for tropical conditions.

In conclusion, digestible energy intake falls near or below maintenance levels from September through December in effectively all years. Excessively wet years may also result in deficiencies for production even during wet-season months.

Supplementation of Protein and Energy

In approaching the question of protein and energy requirements from a different perspective, Schacht (1987) found positive responses from growing male goats to supplemental nitrogen and energy from mid-November through December of 1984, an above-average rainfall year. Weight gains averaged about 56 grams per day for all animals from mid-October to mid-November, but from mid-November to late December, only the animals receiving supplemental nitrogen (5 g urea/da) and energy (14.0 g molasses/da) in addition to their native caatinga basal diet continued to gain (Figure 10). At the mid-November deviation, caatinga forage supplied 9.6% dietary crude protein, a level approximating maintenance only, based on animal weight responses. However, energy had also become insufficient for gain by this time, as supplemental nitrogen in the absence of supplemental energy did not sustain weight gains (Figure 10). Dietary crude protein requirements for 50 g/da of body weight gain and for maintenance are approximately 10% and 7.5%, respectively (calculated from NRC 1981 guidelines).

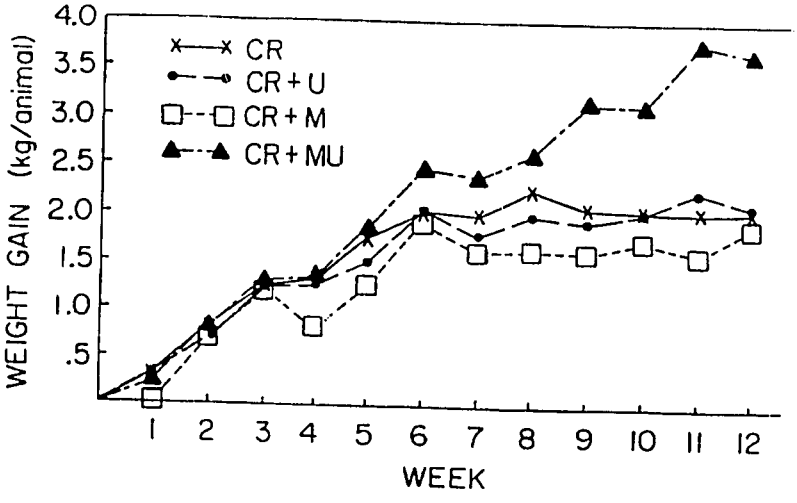

Figure 10. Cumulative weight gains by 4-month-old SRD male goats during the late dry season of 1984. Week 1 was October 10-16, week 6 was November 14-20 and week 12 was December 25-31. Treatments were CR, caatinga range only; CR+U, caatinga range plus 5 g urea/da; CR+M, caatinga range plus 140 g molasses/da; and CR+MU, caatinga range plus urea and molasses at above rates. Weight gains by the CR+MU group was significantly (P>.05) higher than for the other three groups in weeks 9-12.

Digestibility

Diet digestibility, as estimated by *in vitro* disappearance of organic matter in esophageal fistula extrusa (IVOMD), is depicted on a monthly and seasonal basis in Figure 11. Overall, a strong seasonal decline is indicated, ranging from high levels of 60-65% during the early dry season to lows of 30-45% in the late dry season. Two major factors are implicated in this trend: maturation of available forage and diminishing opportunity for selective foraging.

When data for 1981 (a dry year) and 1982 (an average year) are considered separately from that of 1985 and 1986 (both excessively wet years), two different trends seem to emerge. The average and dry years were characterized by somewhat higher levels of diet digestibility than the wet years. This pattern is the same as that discussed for dietary crude protein and relates to a lower degree of nutritional differentiation in forage in dry years.

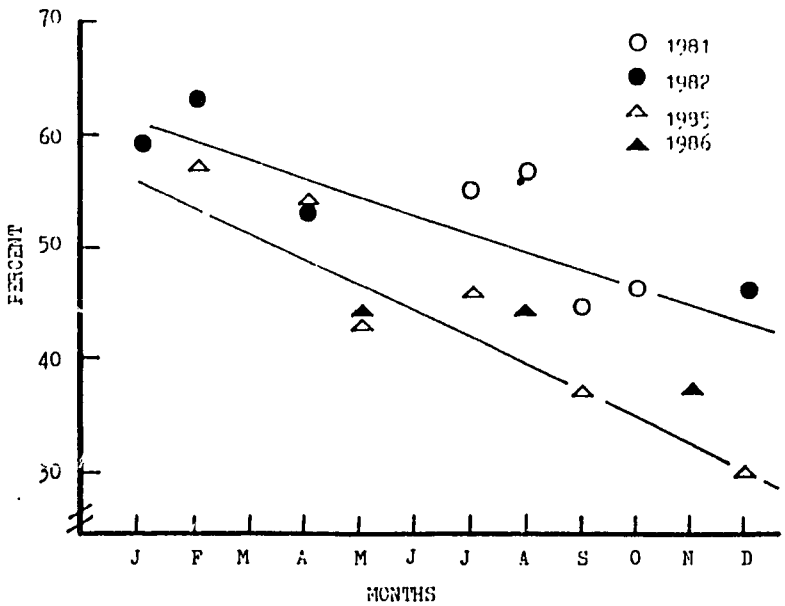

Figure 11. Seasonal trends in dietary *in vitro* digestible organic matter for goats on unmanipulated caatinga ranges. Curves fitted by eye.

Manipulating Caatinga Rangelands to Improve Animal Nutrition and Production

The foregoing section has demonstrated the nature and extent of the dry season nutritional limitation to animal production in Northeast Brazil. Research has indicated possibilities for

minimizing this limitation through caatinga stand manipulation. This is a technology currently being practiced in various forms and for various purposes within the Northeast; therefore, the potential for acceptance should be relatively high. Moreover, it is a technology that can be applied with virtually no capital outlay and with labor that is available in excess during the dry season. Properly implemented, ancillary benefits could accrue from improved management and use of the wood resources of the caatinga.

Two major forms of caatinga manipulation were considered: total clearing and selective thinning of the tree and shrub component. Both approaches made major improvements to animal nutrition, but selective thinning appeared to achieve an acceptable result with considerably less investment of labor and with less overall disturbance to the vegetation.

Effects on Forage Production and Availability

Both thinning and clearing resulted in a major increase in the production of herbaceous vegetation during the first growing season after manipulation. Increases of almost six-fold were measured in two different years by Kirmse et al. (1987) and by Schacht (1987). Figure 7, taken from Schacht (1987) demonstrates the typical response of forage production to both clearing and thinning at two levels of canopy coverage. For practical purposes, the increases achieved with the lowest level of thinning (55% canopy cover remaining) were equivalent to either complete clearing or to heavier thinning (25% canopy remaining). The only loss due to manipulation of major concern was the lowered availability of leaf litter. However, this litter consisted mainly of unpalatable material of limited nutritional value to goats. Thus, the loss of plant biomass did not necessarily translate directly into a loss of usable forage.

Effects on Diet Quality Components

Diet quality, as measured by crude protein and IVDOM content, was generally unaffected by stand manipulation (Table 12). Apparently, within the range of stocking rates of 1.7 to 1.2 ha/animal/year, forage was sufficiently available, even in untreated caatinga stands, to allow for selective grazing to the extent that animals could maintain forage quality within seasonally-imposed limits.

The presence of coppice material in manipulated stands contributed positively to nutritional quality at particular times, even though it was not measured in terms of year-long averages, such as those presented in Table 12. For example, during September of 1985, crude protein was appreciably higher for animals in manipulated caatinga than in unmanipulated caatinga (11% vs 8.5%). Likewise, during 1982, December crude protein levels were significantly higher for cleared than for uncleared caatinga (9% vs 7%).

Effects on Intake

Caatinga manipulation promoted forage conditions that allowed higher rates of intake of both organic matter and of digestible energy (Table 12). Even so, treated pastures provided adequate levels of digestible energy for weight gain only during the

June-September transition period. Other months saw digestible energy at or slightly below maintenance levels.

TABLE 12. EFFECTS OF CAATINGA MANIPULATION ON DIET QUALITY AND INTAKE. VALUES SHOWN ARE YEAR-LONG TREATMENT MEANS

Nutritional entity	Cleared	Treatments: 25% canopy cover	55% canopy cover	Control
Crude prot.(%)				
1982[a]	12.3	--	--	12.4
1985	12.9	13.0	12.9	12.5
IVDOM (%)				
1982	58.9	--	--	56.2
1985	47.5	46.7	46.9	44.5
Digestible energy intake (kcal/kg/BW)				
1985	50.1	46.5	45.3	36.0
Organic matter intake (% of BW)				
1985	2.3	2.2	2.1	1.8

[a]Data for 1982 from Kirmse (1984); for 1985 from Schacht (1987).

Goats responded positively to caatinga manipulation because much more forage biomass was present in the feeding zone during the part of the year when weight gains are most likely to occur, which is the period from late wet season to soon after leaf-fall. During 1985, this increase in available forage ranged from 1,200 to 2,400 kg per ha (Figure 7). After leaf-fall, total forage biomass available did not differ appreciably on treated versus untreated areas (Figure 7), but by then forage quality became limiting (Figures 8 and 11) because of the generally low nutritive value of leaf litter. The delayed abscission of coppice leaves provided a margin of improved nutritional quality in treated areas.

An important result of Schacht's (1987) research on caatinga manipulation was that positive responses in organic matter and energy intake were achieved with every level of canopy reduction. From a statistical point of view, the lowest level of canopy reduction (55% canopy remaining) was just as effective as complete clearing, i.e. none of the manipulation treatments differed significantly ($P<.05$) among themselves, but all were greater than the untreated control. Greater responses to treatments might have been observed, had the lower EMBRAPA- recommended stocking rate of 1.7 ha/animal been used instead of the 1.2 ha/animal level. However, Schacht (1987) argued that the heavier rate more closely approximates those used by producers in the Sobral area.

These responses of animals to caatinga manipulation could be expected to diminish in successive years after treatment. By the third year, coppice shoots will have grown out of reach of browsing animals and the tree canopy will have re-closed (Schacht et al., 1986). This shading effect, along with competition for water and

nutrients by trees, will greatly reduce yields of herbaceous plants in the understory. By year 4, treated coppice stands can effectively be considered as "mature" from a physiognomic point of view (Hardesty, 1986) and probably also from a nutritional point of view.

Recommendations for Improved Technology

Caatinga manipulation, in conjunction with proper livestock grazing management, offers feasible alternatives for improving goat production in Northeast Brazil. While total clearing gives substantial increases in livestock production per unit of land area (Araújo Filho et al., 1982), similar results can potentially be achieved with stand thinning. With the thinning of a stand, an added benefit of 1500 to 2700 kg/ha of wood production by intact trees also may be realized during the initial treatment year (Schacht, 1987).

The following recommendations for a coppice-based system of caatinga stand management have been taken largely from Hardesty (1986) and Schacht (1987). The four species discussed are the major components of the caatinga in the Sobral area.

Pau branco produces valuable wood as a mature tree and its coppice leaves are relatively palatable. However, mature leaves from this species are of little value as dry season feed. Trees with marketable timber potential should be retained, but those with poor form should be eliminated. Coppice resulting from cut trees should be <u>re-cut annually</u> to maintain them in a juvenile state.

Sabiá produces excellent wood and its foliage is highly palatable as fresh browse or as leaf litter. Its coppice withstands heavy browsing and it reproduces well from seed in cleared areas. This species should be encouraged and increased where possible. In areas where seedling regeneration is required, protection from grazing for at least one growing season may be required.

Catingueira produces palatable, browsing-resistant coppice and leaf litter, but low-value wood. It is unpalatable as browse in the mature-tree form. It should be cut and maintained as coppice where possible. Marmeleiro is a potentially troublesome species because of its invasive tendencies. Its wood is of little value and its leaves are unpalatable except as dry-season coppice. This species should be reduced where possible and its invasion into new areas controlled by keeping community disturbance to minimal levels. Some steps toward this latter objective include keeping the cutting cycle on desirable species (e.g. sabiá, mororó) to <u>ten or more years</u> and maintaining thinning levels at 50% or less (Schacht, 1987).

While this approach to caatinga stand harvesting and management is more complex and detailed than those currently used (i.e. complete clearing and opportunistic harvesting of valuable specimen trees for timber), no new technology is called for. However, before it can be applied on a practical basis, land owners must be made aware of the potential value residing in wood products and the benefits to livestock production that are possible from stand manipulation.

Tree stand management alone will not overcome current limitations on goat production on caatinga rangelands. Careful grazing management is also required. Goat production appears highly sensitive to stocking rate (Kirmse, 1984; Schacht, 1987). The currently-recommended stocking rate of 1.7 ha/35-kg animal/year should not be exceeded until further research indicates otherwise, and should be reduced in areas of lower range productivity, i.e., where soils are poorer or where less precipitation occurs. This level seems, from informal observation, to be sufficiently conservative that soil and vegetational resources will not be placed at risk.

The above recommendations will not be sufficient to meet animals' nutritional needs during severe droughts. Some form of supplemental feeding of conserved forages will probably be required to prevent mortality in severely dry years. Kirmse (1984) found that caatinga vegetation deferred from use during the growing season could be used effectively during the dry season as a kind of natural hay. This worked best where newly cleared areas were deferred. However, fencing or some form of animal control is required, and, given current fencing costs, this practice stands little chance for adoption by goat producers.

Occasionally, negative recommendations can be as valuable as positive ones. In this regard, we specifically recommend against the energy- and capital-intensive intervention of land clearing and seeding of buffelgrass (Cenchrus ciliaris) for goat production. Unless greatly subsidized, small-holder goat producers could never afford the investment. Moreover, the biological risk of failure is high, the superiority of buffelgrass over well-managed native caatinga has not been demonstrated, and buffelgrass is often not palatable for goats.

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Chapter 6

NUTRIENT NEEDS AND IMPROVED FEEDING SYSTEMS

W.L. Johnson and E.R. de Oliveira

To be economically viable and biologically effective, improved feeding strategies for goats must meet three basic criteria. They must match the inherent capacity and needs of the animals; they must make effective use of available feed resources; and, above all, they must be consistent with the goals of the producer.

In the semiarid region of Northeast Brazil the traditional strategy for feeding goats is a low-input, low-risk strategy. Goats serve as insurance against severe drought conditions when other crop and livestock enterprises fail. Goats also serve as a banking mechanism; they can easily be converted to cash if an emergency need arises. Being a low-input enterprise, goat production as traditionally managed also yields low levels of output.

More than other ruminants, native goats in the semiarid tropics have become adapted to the harsh conditions of climate and feed availability. The fact that they are able to survive under these conditions, plus the reluctance of most producers to spend scarce cash on their goats, leads to the tendency to let goats gather what nourishment they can from grazing, with little or no supplemental feed provided.

The feed-related factors that limit productivity in the traditional system will vary at different times of the year. As the dry season progresses, for example, first feed quality deteriorates, and finally feed quantity becomes limiting as well. Feed supply and feed quality are both limiting at times of severe drought and during the latter months of the dry season even in a normal year. At any time of the year, if the area is overstocked all animals will suffer from reduced nutrient intake.

In the early months of the dry season, while "standing hay" and fallen leaf litter of palatable species are still available, both forage availability and quality are adequate for meat goats, provided there is no overstocking. The leaves of shrub species, plentiful at that time of year, maintain their nutritive value longer than grasses, which rapidly become lignified in the semiarid tropics.

A not-so-obvious problem is the case of underfed goats in the rainy season, when forage is abundant. The reason is clear to the observer of behavior in grazing goats: they do not like to get wet and will avoid exposure to rain and wet herbage. Also, this is the season of the eclosion of the biting flies known in Northeast Brazil as "mutucas," which can disturb animals to the point of reducing their grazing time. Reductions in feeding time due to these factors may lead to insufficient nutrient intake, or "famine in the midst of plenty." Feeding time may be restricted by conscious decision of the farmer, as well, if he elects not to give his animals access to the rangeland for the full day.

Without an adequate plane of nutrition the herd will suffer from poor resistance to disease and parasites, low fertility, high kid mortality and poor growth. Each of these factors will affect

offtake, the net result being a very low or nonexistent cash income. The producer whose herd has low offtake because of nutritional problems can benefit from changes in his feeding strategy, especially if improvements can be made at relatively low cost.

Under extreme conditions all animals will suffer, and the undernourishment will be obvious. More insidious, however, is the marginal situation when nutrient intake is almost sufficient. In the latter case, high risk animals will suffer: the pregnant doe, the lactating doe and her young kid, and the weaned kid at the age when it should be growing rapidly. These are the animals which must have an adequate daily intake of a high quality diet if fetal growth, milk production, and kid growth are to proceed at optimum rates.

It is commonly believed that goats use low quality feeds more efficiently than other ruminant species. However, there is little convincing scientific evidence to support this belief. Goats do have the ability to be more selective in their feeding habits, and therefore may consume a better quality diet than other species, when forage availability is not limiting and equal access is allowed to the forage on offer. Since they are browsers as well as grazers, the range of preferred species may be broader for goats. Also, their vertical reach is greater than that of sheep; they often stand on their hind legs to reach browse above them, and have even been known to climb low trees that have angular limbs to reach leaves on upper branches.

There is some evidence that a goat will pass undigested fiber through its system faster than a sheep or a cow, thus allowing for higher intake levels. Such evidence is stronger for diets of medium to high fiber concentration. However, this phenomenon may simply be a reflection of smaller size (and smaller gastrointestinal fill capacity) for the goats than the sheep in the experiments where this effect was observed. Also, the grazing goat in caatinga vegetation may be more limited by access to forage and the time available for foraging than by physical fill of the digestive tract (Burstein, 1988).

What Are the Nutrient Requirements for Native Goats in the Semiarid Tropics?

No tables of nutrient requirements have yet been published that deal specifically with the small body-size goat breeds of the tropics, in their native habitat. Because of differences in mature weight, tables developed for the larger South Asian and European breeds are difficult to adapt for use with the small tropical breeds of African origin. Differences in exercise patterns and exposure to heat stress, as well as the stress of other elements of the environment, also contribute to the inaccuracy of applying data from temperate countries to tropical animals, especially under grazing conditions.

Even if reliable numeric estimates of nutrient requirements were available, they would be of limited use for balancing a diet when the exact intake of grazed or browsed feed is unknown.

In spite of these problems many producers and technicians do use published nutrient requirement tables, such as those from NRC (1981) or others, as a basis for planning improved diets. When using this classical approach the following points should be remembered:

1. Breeds of smaller mature body size will have a higher energy requirement for maintenance per unit of body weight or per unit of metabolic size (weight raised to the .75 power) than larger breeds. This is true because a smaller body can store less heat (loses heat faster) than a large body.

2. Animals of smaller body size require a diet that is more digestible than larger-bodied animals. Animals of smaller breeds have a smaller gastro-intestinal tract in proportion to their maintenance energy requirement; this size limitation means that ingested feed can stay in the tract for a shorter time and must therefore be digested more rapidly in order for the animal to obtain sufficient energy for its needs.

3. Animals that must walk or climb great distances, or are exposed to environmental stress, will have higher maintenance energy requirements than animals which are kept in confinement.

4. When animals are under heat stress they will reduce their exercise and also reduce their intake as strategies for minimizing heat production from muscular activity and digestion. Because of a reduced intake, the diet which is consumed must be more highly concentrated in energy and protein in order for the animal to meet its requirements.

5. During the final four to six weeks of gestation and the first eight to ten weeks of lactation, the mature doe will need to double her energy and protein intake compared to other periods of her productive cycle. This can be accomplished only with a high quality diet. If a doe is nursing twins, she will need an extra daily allotment of energy and protein to support the additional milk yield.

6. The nutritive value of forage consumed while grazing will vary at different times of the year. To balance intake with requirements, the supplement should be adjusted accordingly. In general, energy may be more limiting than protein throughout the rainy season and during the early part of the dry season while ample leaf litter is available. During the last part of the dry season, the protein in grazed forage may become as limiting as energy.

A Pragmatic Approach to Improved Feeding

Since exact data on nutrient requirements and sufficient information about nutrient intake by the grazing goat are lacking, a pragmatic approach to supplementation can be taken. One suggestion is that the producer experiment with a modest level of low-cost energy and/or protein supplement, according to the suggestions below, and observe the results. If he is satisfied that animal productivity (growth and offtake) improves enough to offset the costs of the additional feed, then he should continue with the supplementation. If, on the other hand, he finds that his costs are

greater than added income, then he will need to try a different strategy. Meanwhile, researchers should accelerate the gathering of more precise information on nutrient intake, requirements, and sources, and on the response to levels of supplementation for free-ranging goats.

Some rules of thumb can be helpful:

1. Intake of pasture and range forage should be maximized by avoiding overstocking and by not unduly restricting hours of grazing.

2. In periods of very low forage availability (severe drought) a substitute roughage can be fed. Possibilities include maize crop residue, napier grass, and sorghum forage, all of which will need an additional energy and protein supplement. Such forages should be offered at levels 50-100% above the amount consumed, in order to maximize the opportunity for selectivity. They should not be fed when rangeland or pasture forage is abundant, because they will only cause the animal to reduce its grazing intake. They will substitute for part of the grazed portion of the diet, rather than supplement it.

3. Higher quality forages such as "cunha" and "matapasto" can be fed as hay supplements with low-quality range, pasture, or substitute roughage. These and other legumes should not be fed as the sole diet except to growing kids or does with high requirements; feeding them to low- requirement animals in unlimited amounts is wasteful. At controlled, low, daily levels (up to 0.5% of body weight per day), these forages will cause a minimal substitution effect.

4. High energy (and high cost) supplements, such as maize or sorghum grain, cassava meal, and molasses, should be fed very sparingly. A suggested amount would be 150 to 300 grams per animal per day. Fed at these levels, the animal's intake of the basal forage diet will not decline significantly, and utilization of the forage may improve due to a positive effect on rumen microbial growth.

5. When feeding a protein supplement, the quality of the protein must be taken into account. Urea can be beneficial only if fed at very low levels (up to 5 grams per animal per day) and only if accompanied by a readily available carbohydrate source such as a starchy supplement (maize, sorghum, cassava meal) or molasses. Urea, or any other source of nitrogen that is highly soluble in the rumen, will be wasted if fed with lush green forage; such forage also provides rumen-soluble nitrogen, probably already sufficient to meet the requirements of the rumen microbes. (An overdose of urea, as is well known, can cause severe intoxication and death, if the rate of rumen ammonia accumulation is more rapid than the microbial system can assimilate.)

6. Some minerals may be necessary, particularly salt and iodine. For animal performance to be improved by mineral supplements, it is necessary that energy and protein not be limited. The necessity for specific minerals, other than iodized salt, will depend on soil conditions and other local factors. In certain situations an animal response may be obtained with one or more of the following: calcium, phosphorus, copper, cobalt,

selenium, zinc and sulfur. Advice should be sought from a nutritionist or a veterinarian who is familiar with local conditions.

The well-designed strategy for supplemental feeding will take into account the genetic ability of the animals to respond, as well as the economic goals of the producer. A range of strategies can be envisioned, from minimum to maximum input:

1. The simplest low-input strategy is to offer only a basic mineral mixture as supplement, plus emergency supplementation of energy and protein during severe drought.

2. A forage supplement, or a mixture of urea with molasses or another readily available source of soluble carbohydrate, can help prevent severe animal weight losses during the latter part of the dry season.

3. For does known to be prolific (having high probability for bearing twins) a medium energy, medium protein supplement fed during the last 6 weeks before and the first 2 months after kidding can help assure adequate birth and weaning weight of the kids.

4. When breeding is desired during the dry season, a high-energy supplement fed for 3-4 weeks before, and during, exposure to the buck will help increase ovulation rates and fertility. This strategy, called "flushing," is beneficial only for does that are slightly lean (neither too fat nor too under-conditioned). Maize or equivalent fed at 100 grams per animal per day will help the does to be in slightly positive energy balance (gaining weight at a modest rate), which will improve breeding results.

5. Only for does with a high potential for milk production, and intended to be used for that purpose, will full supplementation be profitable (see Chapter 12).

Nutritive Value of Feeds

Many of the feeds available as potential supplements for goats in the semiarid tropics have not been well studied. However, for most common feeds, at least limited information is available and can allow a general assessment of their nutritive value.

Two chemical analyses, both of which are simple and not very expensive, can give a good general impression of the potential value of a given feed material. These are **crude protein** (CP) and **total cell-wall fiber**, also called neutral-detergent fiber (NDF).

The CP content of a feed is useful as a broad indicator of its potential contribution to the protein needs of the animal. In very general terms, the diet dry matter must contain at least 7% CP to maintain normal rumen function, about 10% CP to meet the maintenance requirement of the mature doe, and 12-14% CP during late pregnancy and lactation. However, knowing only the CP content of a feed tells us nothing about the **quality** of the protein fraction. Some tropical feeds contain protein that is unavailable to the animal (bound to the cell-wall fiber) or susceptible to a reduction in digestibility due to the presence of tannins. More detailed laboratory and animal performance studies of such feeds

are necessary.

The NDF content is a useful negative indicator of nutritive value. Cell-wall fiber is only partly digestible, and the time required for complete breakdown of the digestible portion exceeds the normal residence time of forage in the rumen. Meanwhile, the fibrous material is occupying space in the rumen, preventing the animal from further intake. Therefore, for medium to high fiber diets, a high negative correlation exists between %NDF and the potential intake of the diet. Furthermore, feeds high in NDF will be lower in digestibility and therefore of lower energy value than low-NDF feeds.

Precise estimates of energy value are difficult and expensive to obtain. Therefore, NDF is used as a general indicator of energy value. Forages and crop residues very high in NDF (above 70%) will have limited energy value and will require an energy supplement if weight loss is to be prevented. Feeds within the range of 55-70% NDF can be expected to meet only the maintenance requirement of the animal consuming them. Feeds or complete diets in the 45-55% NDF range will permit modest growth of kids and adequate reproductive and lactation performance of does. Feeds with less than 45% NDF are generally excellent sources of energy.

The nutritive value of almost all tropical feeds will vary greatly from one lot to the next. The maturity of plants is known to influence protein and energy content; as plant parts grow more mature, their feeding value decreases rapidly. Climate and soil conditions can also influence nutritional value, as can processing and storage. For these reasons, tabular data on nutritive composition are not totally reliable. To be sure about any particular batch of feed, a representative sample should be analyzed.

The leaves of plants are usually higher in protein and lower in NDF than the stems; this distinction is one reason why it is desirable to allow goats ample chance to select their own diet. Goats have a natural preference for the more nutritious parts of a plant.

Alternative Strategies for Increasing Productivity of Meat Goats

Balancing the diet with supplements, to insure that nutrient intake meets estimated nutrient requirements, is but one of the ways a producer can adjust his management to improve productivity. Hand in hand with better feeding is the opportunity to practice selection of better animals. Selection can be made from within the herd, keeping only those animals that respond to better feeding with faster growth rates or higher twinning percent or heavier weights of their kids at weaning. Also, over the long run the herd can be upgraded with genetically improved breeding stock purchased from outside.

Some techniques are available to manipulate the native rangeland so that the forage on offer will be of higher nutritional value. Some of these techniques are discussed in Chapter 5. Likewise, it is possible to manage the grazing animals in such a way as to maximize their ability to take advantage of available herbage.

Yet another management alternative is to adjust the production calendar to the feed supply. The goal would be to have the period of maximum animal requirements (late gestation, lactation, rapid growth) coincide with the period when maximum nutrition can be obtained from grazed or browsed herbage (during the rainy season and early part of the dry season). In parts of Northeast Brazil, this would mean breeding the does in the middle of the dry season (October) for kidding to occur after the rains have started. Disadvantages of managing the breeding herd for dry-season mating are the need for an energy supplement during the breeding season, the risk that late arrival of the rains will leave the producer with does in advanced pregnancy with no feed, and the problems associated with maintaining healthy newborn kids during the height of the rainy season. Some alternative mating calendars are discussed in other chapters.

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Chapter 7

SOME FACTORS AFFECTING THE REPRODUCTION OF GOATS IN THE SEMIARID TROPICS

W.C. Foote and A.A. Simplicio

Reproduction is a contributing part of every aspect of animal production. In fact, without reproduction there can be no production. The level and efficiency of reproduction in many cases establish the limits of level and efficiency of production. Reproduction, particularly as it contributes to generation interval and selection differential, also contributes directly to the rate at which genetic improvement can be made.

In this paper various aspects of reproduction are considered as reproduction occurs in goats under the conditions of the arid and semiarid subtropics.

The Influence of Environment on Reproduction

The seasonal patterns of reproduction in goats that are caused by changes in photoperiod at northern and southern latitudes are minimal or non-existent at tropical and subtropical latitudes. Prevailing precipitation and temperature patterns, however, may influence reproduction. In addition to their direct affect, these latter factors act indirectly through their influence on the availability of quantity and quality of food.

Reproduction in the Female

Puberty

Puberty is associated with the occurrence of two events, ovulation and estrus. Typically the first estrus, which marks the attainment of puberty, is preceded by one or more periods of ovulation in the absence of estrus. The actual incidence or proportion of puberal does that ovulate without estrus before the occurrence of ovulation with estrus has not been determined, but estimates of at least 40% have been obtained with the native breeds of goats in Northeast Brazil.

The average age at puberty in the native genotypes of goats in Northeast Brazil, managed on native pasture, was observed to be 364 days, or about one year. Although the Canindé breed tended to be younger at puberty (330 days), this age was not significantly affected by genotype or by whether the does were born as singles or twins. The average body weight at puberty for all genotypes was 12.6 kg. The ovulation rate at puberty was essentially 1.0 and did not vary among genotypes.

The Occurrence and Lengths of Estrous Cycles and Periods

The average length of all estrous cycles in goats is about 21 days. However, estrous cycles of short and long duration occur and are usually associated with reduced fertility. When estrous cycle lengths were measured at the CNPC and classified according to short (less than 17 days), normal (17-24 days), and long (longer than 24

days) the incidence and average length of each were 11.0% and 8.3 days, 76.5% and 21.0 days, and 12.5% and 33.6 days, respectively. This shows that approximately one-fourth of the estrous periods were outside the range in length considered to be normal and, therefore, would not provide the best opportunity for conception and successful gestation. These proportions and average lengths were not found to be different in the wet or dry seasons.

The average length of the estrous period measured in goats in Northeast Brazil was 57 hours. This is longer than that generally reported for goats in other regions (36-42 hours). The length during the wet season was longer (62 hours) than during the dry season (51 hours).

All native genotypes of goats in Northeast Brazil cycled throughout the year, with 8.3% of the total estrous periods occurring each month. This proportion did not vary significantly from month to month (7.6 to 9.8%) or between the wet and dry seasons. This indicates that breeding and therefore kidding can occur throughout the year.

Ovulation Rate

Ovulation rate in all native genotypes was found to be approximately 1.0 at puberty. Breed differences were noted as the does matured. In one study the average ovulation rate was 1.4 for the Marota and Moxotó and 1.7 for the SRD. The ovulation rate was not influenced by the wet or dry season (1.5 and 1.4). Ovulation rate is an important consideration in estimating reproductive performance because it is the major contributor to prolificacy.

Reproductive Performance

Reproductive performance is a measure of reproductive level or efficiency during a particular period of time or reproductive cycle.

The following information on reproductive performance is from producer flocks of SRD goats (varying in number from 100 to 600) managed on native pastures over a three-year period. The proportion of kids born during each month of the year varied from 1% in February to 17% in June. During the five-month wet season, 58% of the does kidded, with an average of 11.6% per month. May through August represented the period of highest kidding. This means that the period of highest mating (conception), which would have occurred five months earlier, was during December through March, or near the end of the dry season and the early part of the wet season. Although breeding can occur during any month of the year there is some reason, due to the environment or preference by producers, to favor these periods.

The interval between successive kiddings was 292 days or approximately 9.75 months, varying from 279 to 317 days among the farms studied. This interval allows an average of 1.25 kiddings per year, with an average period from kidding to the subsequent conception of 142 days. The males were generally allowed to be with the females continuously, which suggests a long interval following parturition before the does become potentially fertile (re-establishment of estrus and ovulation). These estimates also include does that failed to kid for extended periods of time. The

postpartum interval (the period from kidding to first estrus) in another group of animals averaged 176 days.

Fertility, the percent of does exposed for breeding that kidded during the period of one year, was 92% in one flock. The kidding rate or prolificacy over all farms monitored was 1.29, the range being 1.13 to 1.51. The mean birth weight of kids for all farms was 2.6 kg and did not vary between the wet and dry seasons. Birth weights in one flock varied for different genotypes of native goats, from 1.7 kg for the Moxotó, Repartida, and SRD, to 1.8 kg for the Canindé and 1.9 kg for the Morota. Birth weight of the exotic Nubian was 2.5 kg. The body weight at parturition of does of native breeds was 29.9 kg.

The average kid loss during the first year of life was 21.6%. Of this 8.2% died between 0 and 7 days. 19.9% died between 8 and 30 days, 8.4 died between 31 and 180 days, and 3.1% died between 181 and 365 days. The total loss among farms varied from 9.8 to 36.5%, suggesting differences in management.

The interval from birth to first suckling varied from 30 to 45 minutes. There was no relationship between birth weight or weaning weight and the interval from birth to first suckling.

The Influence of Management on Reproductive Performance

Some evidence has already been presented to indicate the role of management on reproduction. Changes in traditional management to measure the influence of the change of a single management practice indicated that, while important improvements can be made through changes in management, caution and judgement should be exercised and the value of each new practice should be carefully evaluated.

In one producer flock the breeding period was restricted to two months (October-November) rather than the traditional continuous breeding exposure. The restricted breeding season required additional management. Fertility was higher in the traditionally managed or control flock than in the flock with a restricted breeding period (92.2 vs 82.9%), but this difference was reduced by abortion rates of 5.9 and 1.1%, respectively. Early kid mortality was 3.2% for the restricted breeding and 25.7% for the control flock. Fifty-three percent of the control flock produced multiple births compared to 60 percent of the flock with restricted breeding. The overall affect showed an advantage to using the restricted breeding period.

Trimming and disinfection of the navel at birth significantly reduced kid mortality. The value of forced weaning of kids depends on the level of milk production at the time of weaning. In does still producing relatively high levels of milk, problems with mastitis occurred. Milk production was higher in does showing evidence of crossing with imported dairy breeds and during the wet season, when better feed was available.

The supplementation with concentrate of does on native pasture for 45 days before and/or after kidding improved reproductive performance in terms of doe weight and of the birth and weaning weight of kids. The greatest benefits appeared to come from supplementation before parturition. Kid mortality rates and

postpartum intervals were not affected by supplementation before or after kidding. Supplementation after birth favorably influenced weaning weight.

Pregnancy can be determined between 60 and 120 days after conception with accuracy greater than 90% by using an ultra-sound device developed for sheep. Other methods of pregnancy diagnosis are also available, such as the use of painted teaser bucks to check for estrus, abdominal palpation, and the determination of blood serum progesterone.

Supplementation of young does on a caatinga range with grain sorghum during their first year increased the body weight, the fertility, and the prolificacy of the does and the birth and weaning weights and survival rates of their offspring.

Reproduction in the Male

Puberty

The age of puberty in Moxotó bucks (using an artificial vagina to detect the first ejaculation that contains motile sperm) was about 129 days. Their body weight at puberty was 12.8 kg and scrotal circumference was 16.0 cm. This does not represent the age or stage of development at which they could be used even for limited breeding, but does represent a point in development at which they become potentially fertile. The age at which the penis became detached from the sheath was about 125 days. Penis detachment is visible and easily measured, and, because it occurs just preceding or by the time of first ejaculation of motile sperm, it represents a useful method of estimating puberty (fertility) in bucks and can be used to determine when young males must be separated from their dams and other females to avoid fertile mating.

Annual Variations in Semen Production and Quality

Moxotó bucks were shown to be fertile throughout the year, as measured by sperm production and the ability to serve the artificial vagina. The volume of semen was lower (0.66 ml) but the concentration of sperm was higher (3.12×10^9) during the dry season compared to the wet season (0.78 ml and 2.59×10^9 sperm, respectively). This resulted in a larger number of sperm per ejaculation during the dry than the wet season (2.06×10^9 vs 1.86×10^9). However, the percent of abnormal sperm was higher in the dry than the wet season (19 vs 12%) and the percent of motile sperm after incubation for 120 minutes at 37°C was lower during the dry compared to the wet season (24.5 vs 39.7%).

There was no difference in sperm motility after incubation for five minutes. It must be noted that due to the six to eight weeks required for spermatogenesis, sperm ejaculated in one period classification (wet or dry) has undergone some stages of development during the previous season.

The Relationship of Scrotal Morphology to Semen Characteristics

The scrotum of 25-30% of the male goats in Northeast Brazil

has some degree of division in which each testicle tends to occupy a separate scrotal pouch. It has been suggested that fertility is greater in bucks with a divided scrotum. There is no clear cut evidence that this is true based on comparison of semen characteristics. Ejaculate volume was significantly higher (0.8 vs 0.6 ml) and the percent abnormal sperm was lower (7.7 vs 23.2%) in bucks with divided rather than non-divided scrotums.

General Conclusions

1. Some differences occur among genotypes, primarily related to body size and ovulation rate.

2. Both male and female goats are fertile and breed throughout the year. There is no appreciable change in fertility or in ovulation rate during the year.

3. Seasonal differences in reproduction appear to be due to changes in the availability of quantity and quality of feed rather than on the direct effects of climate; therefore, increased reproductive performance could likely be achieved by changing management to best adapt reproduction and production cycles to feed production cycles.

4. Native pasture, under the conditions in which our studies were conducted, appeared to provide at least minimal nutrient requirements for reproduction. Improved nutrition, through supplementation or access to better pasture, could increase reproductive performance in some ways, such as increased growth rate to produce better developed, heavier animals at puberty; improved fetal development during late gestation, accompanied by decreased abortion and increased early offspring survival; and improved milk production by the dam during early lactation.

5. Improved nutrition can increase the weight at puberty of males and females, with a probable reduction in breeding age and improvements in birth weights and weaning weights.

6. High reproduction potential exists in producer flocks measured under conditions of traditional management (flock size of 100 to 600). This potential is not always achieved, perhaps because of inadequate management. Lack of resources often limits the ability of producers to improve management. Specifically:

- Reproduction and production losses occur due to infertility, high abortion rates, high kid loss (both neonatal losses and postnatal losses that are probably associated with feed availability), and poor growth rate of kids.

- Reproduction rates in producer flocks can probably be increased by introducing such management practices as early weaning (care must be taken to avoid mastitis in higher lactating dams), restricted breeding season, navel disinfection, culling of nonproductive breeding stock, and selection of breeding males from other flocks.

- Certain traits observed in producer flocks with a high incidence (supernumerary teats) or moderate incidence

(polledness) might be related to decreased reproductive performance, although specific relationships have not been established. However, the high observed incidence of divided scrotum might be beneficial to fertility if associated with improved semen quality.

- Producers respond to practices that they can apply and that they observe to be beneficial.

7. Major factors that limit reproduction performance include low body weight, delayed age at puberty, low fertility, and a long postpartum interval.

8. Major factors that might help increase reproductive performance are the possibility of year-round breeding by both males and females and a reasonably high prolificacy.

9. The average kidding interval measured in some producer flocks is less than a year, but the period from parturition to conception is long under conditions of continuous breeding, indicating reduced fertility.

10. As a management tool to improve reproductive performance, ultrasound provides an accurate, simple procedure for pregnancy diagnosis. Other methods of pregnancy diagnosis such as the use of painted teaser bucks and abdominal palpation (ballottement) should also be considered.

11. Important differences occurred among years for all traits measured. The causes for these differences have not been identified but are assumed to be related to variation in climate and to the availability of quantity and quality of feed.

12. The same technology (management practices) cannot apply to all producers. Management practices must be selected to meet the needs and resources of individual producers.

Recommended Alternative Management Practices to Increase Reproductive Performance in Goats in Northeast Brazil

The uses of these practices depend on the available resources and production constraints to the producer.

1. Develop and adopt some form of record-keeping system commensurate with the resources of the producer. If written records are not possible, then marking high, low and nonproducing animals can be used as a practical recording system.

2. Restrict the breeding season to about 60 days to provide a shorter and better managed parturition period.

3. Breed to kid at an estimated two to three months after the beginning of the rainy season, in order to take advantage of increased feed for improved nutrition during late pregnancy, increased milk production of the dam, and faster growth of offspring.

4. Wean offspring prior to puberty, and select replacement females and place them on the best feed available so they will be

larger and better developed for breeding.

5. Separate male offspring from dams, or sterilize them, to avoid unplanned matings. Use penis detachment to estimate the time to separate the males.

6. Obtain breeding males from an outside flock. This will encourage the selection of better quality males and eliminate inbreeding.

7. Trim and disinfect the navel. The use of 10% iodine at birth can significantly reduce early post-natal loss, especially if kids are kept under conditions of poor sanitation.

8. Evaluate each animal in the breeding flock each year and remove unhealthy, non-reproducing animals.

9. Check the testicles and penis as well as the general health of the breeding males just before the breeding period, to detect potential problems with fertility and ensure that the buck(s) will be able to breed.

10. Place pregnant females on the best pasture available or on supplement during the final 6-8 weeks of pregnancy and during early lactation.

11. Diagnose for pregnancy. Non-pregnant females can be identified for culling at the most economical time or placed on lower quality pasture. Pregnancy diagnosis can be made using painted teaser males from the end of the breeding season (or painted fertile males during the breeding season) or by using ultrasound equipment (i.e. as a service by the extension service) at no less than 60 days after the end of the breeding period.

12. If the production of offspring more frequently than once a year is profitable, planned periods of breeding should be established to shorten the parturition interval and to take advantage of the annual feed production cycles.

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Chapter 8

HERD HEALTH MANAGEMENT OF GOATS IN THE SEMIARID TROPICS

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This chapter is not intended to cover all aspects of herd health management of goats in the semiarid tropics. Published texts are available that describe the specific diseases and health problems of goats and provide the necessary practical information on methods for their control, treatment and management more fully than is possible here (Guss, 1977; Hall, 1977; Thedford, 1983). What is presented here is a distillation of some perceptions of herd health problems in the semiarid Brazilian northeast, together with considerations of how they might be managed and how they relate to those of other semiarid regions.

The ultimate objective of maintaining animals in a relatively normal state of health, in order to attain normal productivity and use, involves the same goals in the semiarid tropics as elsewhere. However, the extremes of climate, of availability of feed stuffs, and of economies that often characterize the semiarid tropics may require approaches that are unique to a specific locale.

Perhaps no other factors are as important in the control of disease as the design and management of the husbandry system. Disease or the potential for disease is ever present; it represents a disequilibrium between those factors that enhance an animal's function and those that disturb it. Disease is a natural part of existence; it is a reflection of the balance between productive and destructive processes; it is the mirror image of the healthy state. There is no such thing as a disease-free goat herd. The normal herd is one in which the many disease potentials are kept in check by proper management.

Noninfectious diseases often result directly from mismanagement, and correction of the management factors, such as nutritional or environmental aberrations, also represent the cure. Goat herds are also often predisposed to infectious diseases by management factors that undermine the balance between an animal's resistance and the challenge by 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. Success in preventing losses due to infectious disease will generally reflect the extent to which the manager is willing to control those factors. The managerial choices that have to be made are usually influenced by economic considerations, including a balance between the financial losses due to disease and the cost of their prevention.

The severity of a challenge by a disease agent is determined by its virulence and numbers, which can be largely controlled by several theoretically simple management practices that should be followed in establishing a herd health program.

Acquisition of Animals

Only healthy animals should be brought into the herd. This requires knowing the herd in which new animals have originated and

its management, including disease control practices. Prophylactic antibiotic treatments and vaccinations in the source herd may mask the presence of disease agents. The number of sources of animals should be as small as possible. A single source is best, and sales where goats from a number of sources are mixed should be avoided. When animals of various origins are mixed, even if they appear healthy, there is likely to be an exposure of susceptible animals from one herd 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.

The importation of animals from foreign countries 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 established to protect the commercial trade and animal industries of the countries involved.

Isolation

Healthy animals in any one herd environment have established an equilibrium between their resistance and any potential agents of disease with which they live. Their resistance to newly introduced agents is unpredictable, and such exposure should be avoided. For optimum protection, the goat herd should be kept as free as possible from contact, direct or indirect, with other goats or sheep. This requires an isolated location and the control of all traffic. A closed herd without additions of new animals from other sources is desirable, but if and when new animals are added, this addition should be done carefully and in a controlled fashion.

Quarantine

When it is necessary to add animals, as it is for the addition 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 herd. In large herds with a high potential for loss, placing young, susceptible animals from the herd with the animals in quarantine and testing the new animals for potentially dangerous diseases, e.g., caprine arthritis-encephalitis virus and bluetongue, would be reasonable further precautions.

Controlled Introduction

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

Environment

When possible new herds should be established in environments in which sheep or goats have never 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. The cleaning and sanitizing, painting, or even burning of contaminated facilities and repeated cultivation and prolonged drying and exposure to sunlight of corrals and pastures will further lessen the risks. Such methods may not always be practical, but the level of health in the herd will usually 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 fencing out the animals. The same procedures can be used after the removal of a diseased herd during an eradication and repopulation procedure.

Hygiene

Cleanliness is the major means by which the number of pathogens in the environment can be minimized. If 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, especially if cleanliness is coupled with the rapid identification and removal of diseased animals from the herd.

Effect of Environment on Herd Health

The main constraints on animal health in the semiarid tropics are the closely interrelated factors of climate, nutrition and disease. The general seasonal variation from wet to dry and the corresponding variation in available forage can have marked effects on the nutritional status of the animals. During periods of drought, the major cause of ill health is poor nutrition, involving both inadequate caloric intake and specific nutritional deficiencies and imbalances. Some infectious diseases may actually 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 can suppress those microbes which 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 one animal to another may become extremely virulent in the late dry or early wet seasons, when animals are weakened by malnutrition or dehydration.

Poisoning by the 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 for young animals that have not established definite habits of forage selection. As starvation becomes more imminent, an abnormal appetite may cause even adults to sample plants that they would normally reject. Access to poisonous plants is a common problem in pasturing goats on depleted, unimproved, or poorly accessible rangeland, but intoxications by other substances are also likely in such circumstances; for example, botulism can occur when animals in need of calcium and phosphorus ingest carrion contaminated with *Clostridium botulinum*.

Prevention of toxicoses is best accomplished by avoiding the need for such abnormal foraging through maintenance of adequate levels of nutrition. Diagnosis and control require the recognition of locally available toxic plants and materials and making them inaccessible to the animals.

As the dry season progresses, forage becomes scarce, and unless supplemental feed is given, animals will be poorly prepared for the stresses of the wet season. With the onset of rains regrowth of forage will occur, but nutrient intake may actually decrease. This occurs in part because the animals may forage less in wet weather, because they have a tendency to stay closer to sheltered areas.

The tendency to gather in confined places, whether voluntary or enforced, creates sanitary problems that potentially endanger the health of the herd. During the warm wet seasons of the tropics, environmental control becomes both more difficult and more critical than in the dry seasons. Not only are many disease agents able to survive and multiply more readily, but animals are apt to be gathered for protection from the weather, increasing their access to one another and to the correspondingly more contaminated environment.

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

Elevated slotted flooring provides added ventilation, which may help in reducing heat stress in the hot dry seasons. However, such construction is also conducive to drafts, which may be especially stressful during the wet season. Facing the open side of houses away from the prevailing storms and providing windbreaks can help reduce the chilling of animals, decreasing their susceptibility to respiratory diseases. Good ventilation is especially important in controlling respiratory diseases. The normal mechanisms of resistance in the lung are usually sufficient to protect animals from infection by common microbial contaminants, such as Mycoplasma, Pasteurella and Hemophilus, 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 varies with local tradition and the nature of the ecology. An extensive system of management, that is, spreading the animals over a wide area, is preferable to an intensive system, to prevent buildup of environmental contaminants. Sanitation and health can be improved by using methods which encourage animals to forage widely. Such measures might include distributing shelters and sources of supplemental feed 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 be helpful in encouraging wider foraging in wet seasons. Feed and water containers should usually be elevated, placed and protected so as to prevent fecal contamination.

In summary, the object of sanitation is to keep the level of harmful microorganisms in the environment low enough to allow the animal's defense mechanisms to resist disease. During the dry season, 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 season sanitation may be more difficult to maintain, but reducing the level of contamination and avoiding excessive moisture are the main elements of control.

Use of Medications in Maintaining Herd Health

Given normal resistance and consistently low exposure to usual environmental infectious agents, animals can be reared with little or no prophylactic medication or immunization. However, in most commercial situations animals are raised in large groups and are stressed in a variety of ways which alter their resistance. Also, animals with different environmental and disease backgrounds are often mixed together. Under such conditions, it is likely that medication and vaccination for treatment and control of locally endemic diseases will be necessary. The need and choice for specific procedures will be dependent 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 the several published texts mentioned previously.

Use of anthelminthics is a virtual necessity in rearing groups of animals. The identity of the predominant parasite must be determined locally, and specific prophylaxis or therapy should be chosen accordingly. As indicated below, the seasonal timing of prophylactic medications may be critical to success.

Whenever possible, medications, when used, should be directed against the specific causative agent or the specific symptoms of the disease being treated. This will reduce the possibility of developing antibiotic-resistant microorganisms or untoward reactions in the animal being treated. However, it is often impractical to determine the specific causative agent, 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, with the use of the full dosage and course of treatment recommended by the manufacturer to give the medication the greatest possible chance of controlling or eliminating the causative organism. However, the course of antibiotic treatment should not be excessively prolonged, as this can allow the overgrowth of other environmental organisms, such as fungi, which are unaffected by the antibiotic. For this reason, especially in hot and humid conditions, it is preferable to treat surface wounds with suitable antiseptic chemotherapeutic agents rather than antibiotics.

Health Management for the Newborn

Since kids are dependent on their dams for their early nutritional and immune status, it is important that the doe be in good health and have a good level of nutrition prior to parturition. This makes supplementation of the pregnant doe particularly critical in times of inadequate availability of forage. It is also critical that the kid receive colostrum as soon after birth as possible, preferably immediately. The newborn kid 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 kid's circulation will be inadequate to provide the normal level of protection during the first several months of life. Since the dam provides the kid 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 at least the previous 2 or 3 weeks. Similarly, vaccinations of the doe to provide the kid with passive colostral immunity against endemic diseases, such as contagious ecthyma, foot rot or clostridial enterotoxemia, should be performed 2 or 3 weeks prior to the expected birth date. In some diseases, such as endemic infection of goats by mycoplasma (East, 1983) or caprine arthritis-encephalitis virus (Adams, 1983), organisms are shed in large numbers in the colostrum of infected dams. The kids are infected by ingestion of the contaminated milk, and pasteurization of the infected colostrum or replacement with colostrum from uninfected dams can prevent transmission to the newborn kid.

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

Diagnosis and Control of Infectious Diseases

The diagnosis and the control of disease processes are best managed by trained veterinarians familiar with the local disease problems and regulations. Below are comments on several diseases experienced in Northeast Brazil that are also of worldwide occurrence and significance; these comments may provide useful insights into the management of infectious diseases throughout the semiarid tropics. More detailed descriptions and recommendations for the diagnosis, treatment and control of these various other diseases that might be encountered by goats are available in previously cited references.

Gastrointestinal Helminthiasis

The most important gastrointestinal parasitisms of goats in the semiarid Northeast Brazil are *Haemonchus contortus*, *Trichostrongylus colubriformis*, *T. axei*, *Strongyloides papillosus* and *Oesophagostomum columbianum* (Costa et al., 1987; see Table 13).

These parasites were found to be present throughout the year, but their transmission was limited to the latter part of the rainy season through the early dry season. Santa Rosa et al. (1986) found that gastrointestinal helminths were the principal cause of death (24.9%) in 726 necropsies performed at Sobral from 1981 to 1985. In another study (Costa, 1983), pregnant and lactating animals were more susceptible; very young kids are also at high risk. Elevated pens with slatted floors did not control gastrointestinal parasites better than pens with earthen floors and good sanitation (Costa and Vieira, 1984); however, the test period was one of severe drought.

Outward signs of infection include anemia, diarrhea, dehydration and weight loss; chronicity leads to edema and general weakness. Histological observations show mucosal,

TABLE 13. PREVALENCE AND INCIDENCE OF GASTROINTESTINAL HELMINTHS IN GOATS IN THE SERTÃO REGION OF INHAMUNS, COYERA, NORTHEAST BRAZIL, IN 1982 TO 1985

Helminths	Prevalence (%)	Incidence (%)
Haemonchus contortus	97.6	47.6
Trichostrongylus colubriformis	94.5	47.6
Strongyloides papillosus	87.4	34.7
Oesophagostomum columbianum	78.0	22.6
Trichostrongylus axei	58.3	16.1
Cooperia pectinata	1.6	2.4
Cooperia punctata	1.6	4.0
Cooperia sp	3.9	2.4
Skrjabinema sp	19.7	0.8
Trichuris sp	46.4	2.4

submucosal and serosal edema, degeneration of epithelial cells, ulcerations, and leucocyte infiltration (Berne et al., 1986).

Recommended treatment to control gastrointestinal parasites involves three medications during the dry season and one in the middle of the rainy season. In addition, pregnant does should be treated 4 weeks before expected parturition. Broad spectrum products such as netobimin, ivermectin, and triclorfon are recommended; these work on both adult and immature parasites. To prevent buildup of immunity, the drugs should be rotated annually. Vieira et al. (1987a and b) showed that several benzimidazoles were not effective in control of Haemonchus or Oesophagostomum species; thiabendazole was effective, however, in treating Strongyloides.

Eimeriosis

This is a worldwide infection, also known as coccidiosis, which principally affects young animals and animals in confinement. At least seven species of the Eimeria genus have been identified in goats in Northeast Brazil (Padilha et al., 1980). CNPC scientists have observed infection in up to 100% of kids, with a mortality of 17% when the kids were kept in semiconfinement with inadequate sanitation. The crowding of kids in the rainy season can lead to high infection rates, especially if they ingest feed or water that has fecal contamination. Adult goats can be permanent carriers and contaminators of the environment with sporulated oocysts.

Infection leads to lesions in the small intestine, with mucosal hemorrhaging, hypertrophy of the intestinal wall, and the formation of small whitish nodules on the mucous and serous tissues (Santa Rosa et al., 1986). The animal's capacity to absorb nutrients is impaired, with consequent reduced growth and possible permanent stunting. Outward symptoms include loss of appetite, anemia, diarrhea, dehydration and loss of weight. Respiratory system complications are often observed that can lead to death.

Curative treatment can be by amprolium at 100 mg/kg of body weight and sulfadimidine at 140 mg/kg, orally, every day for five days. A recommended preventative treatment is amprolium at 50 mg/kg for three weeks. Good sanitation of feeders, waterers, and the general premises is of the utmost importance; creosol (5%) and chlorine compounds can be used, or if fire is not a risk, the area can be torched. The crowding of animals and excessive humidity should both be avoided.

Miiasis

In Latin America, the invasion of body tissues is caused principally by Cochliomyia hominovorax, while in Africa and Asia, Chrysomyia bezziana is the organism responsible. Both cause primary miiasis. Cochliomyia macellaria causes secondary miiasis. Primary invasion occurs generally at the natural orifices, in the nose, or gingival alveoli, or in fresh wounds, such as the navel of the newborn. Secondary miiasis is the invasion of previously necrotic tissue. If the invasion is not treated, the process will extend, causing serious mutilation and death, the effect depending upon the site of the lesion. Insect repellents should be used when fly danger exists, and those practices that cause tissue damage, such as tail docking, castration, and dehorning, should be done during seasons when the fly population is at a minimum.

Caseous Lymphadenitis

Caseous lymphadenitis (CLA) of goats and sheep is a chronic disease caused by the bacterium Corynebacterium pseudotuberculosis. Characterized by abscessation of one or more lymph nodes, CLA causes considerable economic loss to both goat and sheep industries worldwide. An incidence of 27.7% in goats was reported in Northeast Brazil by Unanian et al. (1985).

Clinical disease takes the form of a recurring disorder, with abscesses appearing sporadically in various lymph nodes in infected animals. Usually it is the large superficial nodes that are

affected. Less commonly, deep lymph nodes and viscera (especially lungs and liver) can be affected in a more debilitating internal form of the disease. Santa Rosa et al., 1986) found that 58.9% of liver abscesses and 8.7% of pneumonias in goats were associated with the presence of C. pseudotuberculosis. Unanian et al. (1985) and Brown et al. (1987) reported 11.5 and 13.9%, respectively, incidence of visceral abscesses in slaughterhouse studies of goats in Northeast Brazil.

Transmission of the disease has been the focus of numerous studies. Although experimentally the disease can be produced through inoculation by a variety of routes (Nagy, 1976; Silva and Silva, 1982; Unanian et al., 1985), in nature C. pseudotuberculosis probably enters the animal by contaminated soil contacting abraded skin. Once established in subcutaneous tissue, it is able to disseminate to lymph nodes and viscera. There it can remain quiescent and protected for weeks, months, or years, until the organisms incite the formation of an abscess.

Control of CLA has been of major concern to the goat and sheep industries. Although C. pseudotuberculosis is sensitive to many antibiotics, they are useless for treatment because they cannot penetrate the thick wall of the abscess. A single ruptured abscess can liberate billions of organisms, which can survive for as long as eight months in dry soil and up to several weeks on fomites. The presence of several infected animals in a herd can ensure continuing environmental contamination and persistence of the problem.

A serologic test to distinguish between clinically normal infected and noninfected animals would be helpful in identifying animals that may develop abscesses. Several serologic tests for CLA have been developed (Brown and Olander, 1987). One such test, the synergistic hemolysis inhibition (SHI) test, utilizes the complementary actions of exotoxins from C. pseudotuberculosis and Corynebacterium equi to cause hemolysis synergistically. In experimentally infected goats, the SHI test was positive in all animals which developed lesions of CLA (Brown et al., 1985). In a field trial in which the SHI test was applied to animals with the natural disease, sensitivity was 98% for goats and 96% for sheep. Titers remained positive even in the subclinical stage of the disease, indicating the SHI test could be used to detect infected carriers (Brown et al., 1986b). In addition, an enzyme-linked immunosorbent assay utilizing exotoxin as antigen has been developed, with good sensitivity (Maki et al., 1985).

Control of CLA requires a multi-faceted approach. Since it is so difficult to eradicate once established, the best and most cost effective measure is prevention of its introduction into the herd. This can be achieved through consistent serologic testing of any new animal additions. Once established in a herd, eradication can only be achieved through a long-term rigorous program involving environmental decontamination, frequent animal examinations, serologic testing, and vaccination. The most critical step is to break the recurring cycle of abscess rupture and environmental contamination. Premises, including animal pens, fences, flooring, etc., should be thoroughly disinfected, and if animals are enclosed for part or all of the day in small corrals, the uppermost layer of earth from this area should be removed. Animals should be examined weekly for the presence of any enlarged

superficial nodes. Any animals with abscesses should be segregated from the herd and, when the abscesses are mature, they should be surgically lanced and all purulent material thoroughly removed and burned. These animals should be kept segregated until the evacuated abscess cavity is healed and no longer exuding liquid. If possible, all animals in the herd should be tested serologically. If only a small proportion are positive, it is recommended that these animals be culled, or, at the very least, monitored closely to prevent abscess rupture in group quarters. Any animal with a positive serologic titer should be watched for the development of abscesses. A very high titer is usually indicative of internal abscesses, and it may be advisable to cull these animals, since internal CLA is often associated with wasting, death, and carcass condemnation.

The last line of defense is vaccination. A formalinized exotoxin has been shown experimentally to protect kids against challenge with live organisms. This toxoid works by decreasing the ability of C. pseudotuberculosis to spread throughout the body, thereby protecting animals against dissemination of the organism from a primary site of infection. It may be of limited usefulness for adult animals already harboring the organism in multiple lymph nodes. Preparation of the toxoid vaccine is straightforward and involves the addition of 3% formaldehyde to the filtered supernatant of a broth culture of C. pseudotuberculosis (Brown et al., 1986a). The vaccine, which is mixed with Freund's incomplete adjuvant, is administered subcutaneously twice at three week intervals. A commercially available vaccine including the C. pseudotuberculosis toxoid as well as several Clostridium spp. toxoids is available in some parts of the world ("Glandvac," Commonwealth Serum Laboratories, Melbourne, Australia).

Bronchopneumonia

This is probably the most important respiratory disease of goats, causing weight loss, reduced growth, general weakness and reduced productivity (Hordagoda et al, 1981; Abubark et al, 1980). It is characterized by the inflammation of the pulmonary and bronchial parenchyma in goats of all ages, although the young are more susceptible (Chawla et al, 1982; Sarmah et al., 1981).

It is often the cause of death in animals that have been debilitated by malnutrition and other diseases. The primary symptoms of cough and difficult breathing are accompanied by nasal exudation, fever and anorexia. There are often multiple microbial etiologies, including a wide variety of bacteria, viruses, parasites, mycoplasma and rickettsia. Environmental stresses, especially cold, dampness, draft, poor ventilation, low nutritional status, and poor sanitation, have considerable influence on the severity of the problem.

Santa Rosa et al. (1986) showed an incidence of 23.1% of bronchopneumonia in a sample of goats in Coyerà; the types most frequently found were suppurative (exuding pus) and fibrinogenic (forming blood clots). In this project a dozen different bacterial species were isolated from goats with active bronchopneumonia; of these Pasteurella haemolytica was by far the most common, found in one-third of the cases. Other bacteria were found in 2-13% of the cases.

Prevention and treatment should include maintenance of good nutrition, sanitation and environmental comfort and medication with specific or broad spectrum antibiotics and sulfonamides.

Contagious Ecthyma

This viral infection causes painful debilitating purulent sores (poxes) on thinly covered areas of skin, especially about the mouth, nose, feet and udder. Interference with eating and breathing and secondary infections may lead to severe debility, especially in young kids. The virus spreads very rapidly by animal to animal contact, and persists for a long time in the environment in sloughed infected epithelium. The incidence and mortality in young kids in endemic herds can approach 100% when sanitary conditions deteriorate, as with kidding in overcrowded shelters during the rainy season.

In Northeast Brazil, incidence rates of 90% have been reported (Santa Rosa et al., 1986), but the mortality is low if treatment is timely, before secondary infections develop in the lungs and the gastrointestinal tract.

There is no permanent cure. Infected animals should be treated by removing the scabs and applying a 7% iodine solution and glycerine (Silva and Silva, 1987). Autovaccination can be practiced, applying a preparation made from dry scabs to a scarified area on the inside of the thigh. Vaccinated animals should remain isolated until the site of application is healed. Vaccination of does prior to kidding has proven effective in reducing the spread of the disease.

Footrot

This specific lameness of goats and sheep is caused by the highly contagious bacteria Bacteroides nodusus or Fusiformis necrophorus. Infection leads to inflammation of the skin of the foot and extends into the sensitive laminae of the hoof. It is most often observed in the wet season (Silva and Silva, 1987) with incidences as high as 30 to 40% recorded in Northeast Brazil (Santa Rosa et al., 1986).

Transmission is by means of secretions from the feet of infected animals. Spontaneous cure is possible, but in such cases the organism can persist up to several years without clinical symptoms.

Overt symptoms of an active case start with a localized dermatitis, with later necrosis and a fetid odor. Animals then become weak and lame, severely impairing their grazing ability.

Control and treatment should include provision of dry or well-drained areas in which the animals can loaf. Elevated, slotted flooring in the shelters are beneficial in this respect. Other helpful procedures are proper trimming of the feet; provision and forced regular use of footbaths containing zinc sulfate, formalin, 50% copper sulfate, or 10% tincture of iodine; and separation and treatment or removal of chronic cases from the herd. In severe cases, antibiotics (penicillin and streptomycin) can be used (Silva and Silva, 1987). Planning and initiation of control measures prior to the development of a serious problem is important,

especially in herds in which the disease has occurred previously. Vaccines and vaccination procedures administered prior to the onset of the wet season have been of value in sheep and deserve consideration in goats.

Conclusion

Disease is a major constraint on the productivity of goats 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 extremes of these variations but also with the interest, education and financial resources of the veterinary health community and the individual producers.

To bring a semblance of disease control to most of these regions requires the development of area-wide health management systems, which would likely need some form of external subsidization. The need to consider local variations in climate, available resources, and disease problems requires that the planning and implementation of specific practices be done on the local level.

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Chapter 9

SOME SUGGESTIONS FOR IMPROVED PRODUCTIVITY THROUGH MANAGEMENT

M.S. Shelton and E.A.P. Figueiredo

A large volume of information characterizing the goat industry and its production systems has been generated by workers within the various scientific disciplines of the CNPC and the SR-CRSP during the past decade to add to previously available information and experience. However, information will not in itself bring about changes or improve productivity. The implementation of practices that are likely to bring about improvements must be accomplished through changes in the management system. A decision to implement or to recommend the adoption of a given practice should come only after careful consideration is given to the overall needs of or goals for the producer and his family.

Possibility for Increasing Numbers

The potential exists for more fully exploiting the unique place held by goats in the region covered by the "caatinga" in Northeast Brazil. This is due to the ability of the goat to utilize browse, plus the fact that the caatinga has few alternative uses other than the production of wood for fuel and construction. At the present time, the potential for goat production is not being fully realized. This is due in part to low productivity in many flocks in the region, but also to the fact that much of the area is not currently being utilized by goats to the extent that it could be. There are an estimated 83 million hectares of caatinga (Kirmse et al., 1983). Based on the hypothesis that goats are the preferred users of caatinga and on a proposed stocking rate of one goat per two hectares, a total of over 40 million goats can be projected, compared to the current population of approximately 8 million. Even a modest level of production from such numbers would require some new initiatives in marketing, but on a world-wide basis there is a shortage of low-cost red meats.

The potential for increasing these numbers is even more evident with respect to the United States and several countries of Central America. Within Central America, Honduras, Panama and Nicaragua have very few goats at present, even though they possess land, resources well suited to utilization by goats. Also, several individual islands of the Caribbean have browse resources not currently being fully utilized. There are over 300 million hectares in the United States in which brush encroachment is a problem, mostly in the South and Southwest. Only a very small part of this area (ca. 10 million hectares in the Edwards Plateau of Texas) is currently utilized by goats.

On a worldwide basis, goats are found primarily where browse is the predominant feed resource, or in arid environments where mobility, water restriction, survival--or all of these--constitute limitations. Deviations from this occur only for high value products (not meat), such as unique milk products or, in recent years, fiber.

In some areas the presence of goats in the grazing system can

improve overall productivity even when they are being utilized by other species. A study conducted by the Car State Agricultural Research Agency at Quixadà (Fernandes et al., 1987) over a period of several years indicates that goats kept for meat production offer an advantage over cattle and sheep where native or lowered caatinga browse constitutes the basic feed resource. A unique research opportunity exists to develop further production systems for efficient production involving goats that more fully exploit the vast areas of caatinga in Brazil and other areas where browse is the dominant vegetation. This task has not been completed. Much of the present publication is devoted to improving productivity from current flocks, but consideration should also be given to the potential and desirability of increasing numbers. For the most part, an increase in numbers of goats will be brought about by establishing new flocks; this will not directly benefit current producers but would benefit the overall economy of the areas involved.

It is not thought to be feasible, at least by the authors, to produce goats efficiently from the caatinga without some additional inputs. To make such inputs economically feasible, it will be necessary to manage the flock as a commercial enterprise. The major limitations are not biological, but may be related to land ownership and the costs of fencing, labor and supplemental feed. In extensive grazing systems, it is seldom possible to justify land ownership costs on animal productivity alone; instead, other forces come into play, such as the appreciation in land value or simply the fact that there is no good alternative use of the land. In extensive, semiarid regions, such as Northeast Brazil, fencing costs may be the major constraint to more efficient utilization of the vast pasture resource.

Maximizing Offtake

Producer surveys and socio-economic studies indicate that a major reason for raising goats in arid or stressing environments is their ability to survive and the sense of security that this provides to the producer (Primov, 1984). Statistics confirm that in times of extended droughts (Zometa et al., 1987) the total number of goats may decrease, but their numbers as a percent of the total animal population may increase. A close corollary to this stated reason for keeping goats is the view of them as a hedge against inflation and as a potential cash reserve in lieu of using the banking system. Maintaining livestock, as contrasted to currency, as a hedge against inflation is a difficult matter to deal with in the development of efficient production systems. All of these factors may have as cumulative effects that goat keeping is not viewed as a productive enterprise and that numbers are maximized. Under these conditions the "offtake" or extraction rate is usually low. The extraction rate reflects the number of animals sold or used for domestic consumption, expressed as a percent of the total number in the flock. Under northeast Brazil conditions, offtake rates as low as 10% are not unusual. Primov (1984) reported an average of 22.2% and Figueiredo (chapter 11) reported a mean value of 15.34% for the period 1950-1970, whereas the potential is many multiples of this. A shift in the way the goat enterprise is viewed is almost indispensable to making the flock more productive. Technology will have limited impact unless productivity becomes a goal. In fact, technologies, such as

disease and parasite control, which permit the survival of a larger number of animals, can have a negative impact on offtake if it is expressed in percent or on a per head basis.

Flock productivity or potential offtake is largely a function of the following factors:

- The percent of the total numbers represented by does of breeding age,
- Reproductive rates, and
- Death losses.

Death losses due to disease are discussed in Chapter 8, but other factors, such as nutrition, impact death losses as well. The important factor of reproduction is considered in Chapter 7. However, net reproduction, defined as the number of kids raised per doe, is important to the concept of offtake, and there are some unique problems in respect to reproduction in goats. Physiological infertility in goats is rare and is not a primary source of problems. General undernutrition is a major source of delayed breeding. Also, abortion and heavy newborn death loss are somewhat restricted to goats and are correctable through adequate energy nutrition and intense management during kidding.

A key ingredient in improving offtake is to develop a system that permits the marketing of kids at less than one year of age, thus increasing the proportion of breeding age females in the flock.

In herds kept for meat production the primary saleable animals would be male kids (all except an occasional male kept for breeding), surplus female kids (all except those required for replacements) and cull mature does. Thus the saleable animals within a given year should equal the net kid crop raised (defining the net kid crop as those raised to market age) minus the death losses of the adult goats throughout their productive life. 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 does 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 1 kid per year, the projected offtake would be 88%. Under the conditions of Northeast Brazil this may be unrealistic, but it could be considered as a goal.

Matching Animal Numbers with Feed Resources

No concept is an important in animal agriculture as the proper matching of the animal and the feed resources, and on a world-wide basis this is perhaps the area where the greatest mistakes are made. One often sees considerable disparity in goat production in which many areas have no goats although resources are well suited for them, while in other areas or on individual properties goats are produced in numbers that are excessive with respect to feed resources. Resources may refer to both the type (quality) and the amount of feed available, and both may be critical for goats. In contrast to the earlier discussion of areas where numbers may be

increased, there are many current situations in which overstocking is a problem.

Once animal numbers and feed resources are properly balanced, the concept of forage quality may be the limiting factor. Only with high-quality forage will goats be able to grow and reproduce at rates that allow high offtake rates.

The approximate priority of nutrient use (from bottom to top) in animal production is outlined below:

Breeding female	Breeding male	Market animal
Fattening	Fattening	Fattening
Breeding	Breeding	
Growth	Growth	Growth
Lactation		
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 apparent. Maintenance is the first necessary function for survival. However, if only maintenance needs are provided no production will occur. Growth, reproduction and fattening, all of which are necessary for any production to occur, require a higher level of nutrient intake.

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 receive the best price for the product. 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 animal is able to lay on 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 that of 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 level and produce essentially nothing. If a group of animals are fed, on an annual basis, at 10% above maintenance, only 9% of the nutrients are actually 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 utilized for production. If the animal is fed at twice the maintenance requirement, approximately one-half of the nutrients can be available for production. In the latter case, it may be possible to maintain fewer animals but still have greater productivity. This principle is illustrated in Figure 12.

As applied to the grazing animal, the concept generally resolves itself into determining the appropriate stocking rate. The overstocking of the arid rangelands is one of the world's major tragedies. If a producer is utilizing privately controlled rangeland the choice of the appropriate number and kind of

livestock may well be the most important decision 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 about the situation. In this case, the number of animals a producer should attempt to own may be adjusted to those he can effectively and economically provide with supplemental nutrition at critical times.

In the case of the caatinga region of Northeast Brazil and areas of similar climate elsewhere, forage may be adequate for goats during the rainy season and early dry season, but herd size should be adjusted to a number that can be provided with adequate feed during the extended dry season.

Reducing Abortion

Abortion has long been a problem with goats. It is most serious with Angora goats, and much of the research has been conducted with this breed. However, research results and observations in Brazil and other locations confirm that abortion losses occur with other types of goats as well (Unanian and Feliciano-Silva, 1984). The susceptibility of the goat to abortion is apparently explained by the dependence of the goat on the presence of a corpus luteum; thus, any situation which interferes with the function of the corpus luteum results in abortion. This problem is more commonly observed in Angora goats, in which the burden of fiber production results in a greater degree of nutritional stress. Research with the Angora (Wentzel et al., 1974; Reeh, et al., 1987) has shown that abortion results from

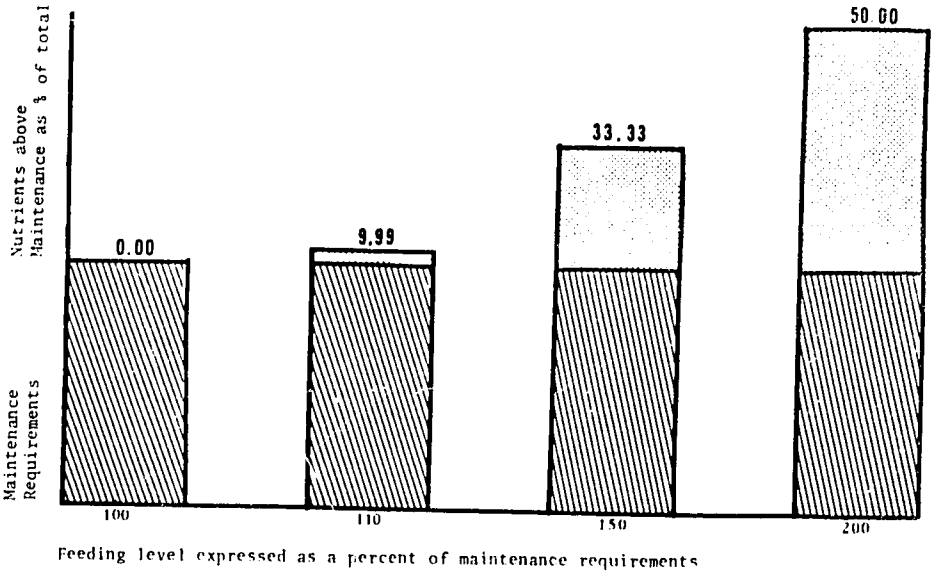

Figure 12. Influence of level of feeding above maintenance on percent of nutrients utilized for production.

nutritional stress (primarily energy) during gestation. General undernutrition may predispose an animal to abortion, but there is an apparent requirement of the fetus for blood glucose. Glucose may be obtained from the diet, but it cannot be obtained efficiently from the breakdown of body fat. Thus, there is a dietary requirement for energy precursors to prevent abortion. It has been shown that a few days without feed can precipitate abortion in otherwise healthy animals, and that the problem is made more acute by an overall low level of nutrition.

Meat-type goats apparently abort from the same mechanism as the Angora, but, without the burden of fiber production, conditions must be more extreme in order for them to abort. Thus, abortion can be prevented by even a modest level of nutrition during gestation.

While most cases of abortion are nutritional in origin, there are, of course, a number of infectious diseases which can also cause abortion.

Improving Kid Survival

Numerous references have been made to the fact that kid mortality is a major limitation to the productivity of goats in the tropics. Few detailed studies of this problem have been reported from Northeast Brazil. It is known that a high percent of these losses occur in the first week following parturition and that death losses are greater in kids with low birth weights (Figueiredo and Pant, 1982). The same study showed a breed difference in which exotic breeds suffered significantly greater losses. In addition to the death losses following parturition, a second peak occurred around weaning, which is characteristic of stressing environments such as Northeast Brazil. Losses at this time are likely due to a combination of nutrition and internal parasites, subjects covered in other chapters.

A 10% death loss during the first week postpartum is a practical minimum, except in cases of intense supervision with artificial feeding. The cause of these losses will vary, but can usually be determined by the flock manager. Some of the major causes of losses are abnormalities causing death at or before birth, starvation (does have no milk or kids are too weak to nurse), chilling, low birth weights (particularly among multiple births), and pneumonia or coccidiosis following periods of stress. Losses from the latter two causes do not usually occur during the first few days. Normally a small percent of kids are dead at birth from various abnormalities, or dystocia (difficult birth, which is rare in goats), or failure to break out of the birth membrane in order to breathe. Some of these losses can be prevented if a producer is in attendance. Normally, losses at birth are low (i.e., 1-2%), but can be higher with low birth-weight kids. Starvation or chilling (hypothermia) after birth are more important causes of loss. Starvation may be due to abandonment by the doe if kidding occurs on the range, to the kid's being too weak to nurse, to the doe's not having sufficient milk, to the kid's being unable to reach the teats, or to the teats' being too large for the kid to nurse. Many of these losses can be prevented or reduced with managerial assistance. Chilling in the tropics comes mainly as an effect of rainfall. The kid may be lost in the first few

hours after birth or before they are cleaned off and able to nurse. If a kid is weak with very little milk intake and continues to be wet, hypothermia may cause loss in kids up to several days of age.

It should be possible to keep kid losses down to an acceptable level by taking a few precautions. The first is to cull does with bad udders (those from which kids are unable to nurse), although it may be desirable to keep a doe for milking even if her udder is poorly shaped for kid rearing. A second recommendation would be to ensure that the does receive a sufficient level of nutrition to ensure an adequate milk supply and to produce healthy kids. Third, it is usually recommended that the navel cord be disinfected shortly after birth. This is of little importance unless the kid is born in a dirty barn or pen, as may often be the case. Fourth, it is very important that the kid receives milk, including colostrum, shortly after birth, to receive passive immunity protection from the dam. In the first few weeks of life the kid needs to receive adequate milk and to remain dry. Occasionally getting wet should not be dangerous for healthy kids, but remaining wet for an extended period will increase losses, particularly for weak and undernourished kids.

Other causes of loss that may present problems are infection or predation, which should be dealt with as they arise. If does are kept for milk production it may be desirable to wean the kid at a very early age. In this case, correct feeding of the kid is very critical (see Chapter 12).

Castration

Male kids make up the primary sale product. One question to be addressed is whether these kids should be castrated. Under most conditions castration will reduce the rate of growth and body weight by as much as 10%. This difference may not be evident in animals that are growing slowly due to nutritional constraints (Figueiredo et al., 1984). There is also the risk that castration could result in infection or death losses. This is more likely to be true if surgery is used. In any case, surgery will result in some degree of blood loss and a temporary depression of growth. Thus, castration is not automatically a desirable practice and should not be universally recommended. One of the reasons for castration is to reduce rutting or mating activity. Castration will also eliminate the characteristic odor of sexually mature males and thus may improve market acceptability. The castrated animal will fatten more readily. Also, castration can improve genetic progress and reduce management difficulties by removing the possibility of non-selected young males' breeding does in the flock. This may be a minor benefit if does are kept in communally grazed flocks.

Perhaps most important is the influence of castration on carcass value and market acceptability. If the market does not pay a premium for wether animals, then there is little reason to suggest castration, and there are some societies in which males sell to advantage. However, if there is a desire to access higher-priced market outlets, such as the hotel and restaurant trade, castration will almost certainly be required.

Methods of castration include surgery, emasculation (severing

nerve and blood circulation to testes), and the use of rubber bands. Attempts to use chemical castration have not given encouraging results (Thompson and Shelton, 1986). Some procedures require equipment which 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 surgery. Assistance in the castration of surplus males may provide a mechanism for extension agents to be of assistance and thus provide an opening for giving advice 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. However, confinement has the effect that grazing time is reduced, and the animals spend more time in potentially unsanitary pens or lots. Thus, if it is possible for the animals to remain in the open, they will probably be more productive as a consequence of the increased feed intake resulting from increased grazing time and from improved sanitation. Reduced grazing time is even more critical under conditions of high temperature, because the goats may not forage efficiently during the hottest period of the day. If animals must be confined at night, longer grazing periods during the cooler part of the day would be desirable.

Choice of Breeding Season

The choice of the breeding season or mating schedule represents one of the more important decisions a producer will make, but it is difficult to provide definitive recommendations due to highly variable conditions. Some factors that should be considered are the potential of the goat to kid more often than once per year, the seasonality of feed supply, the availability of markets throughout the year and, in some cases, the seasonality of labor. It is important to exploit, where possible, the potential of the animal to reproduce on an accelerated schedule (less than 12 months). This is more successful in areas of lower latitudes, which by definition include most of the tropical regions, where photoperiod is not a limiting factor. This approach is also more successful where feed supply (probably forage) is relatively constant year round and the nutritional level is adequate to maintain breeding females in good condition even on an accelerated production schedule. On the other hand, if the nutritional level is low and forage or feed supplies are highly seasonal, it may be desirable to control the reproductive cycle so that periods of greater nutrient demand 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 are discussed below.

I. Continuous mating or accelerated kidding.

By default rather than by design, this is likely to be the most frequently used mating system for goats kept for meat production. Communally grazed flocks will usually follow this system, because control of mating may not be possible. Also, low labor-input systems of goat production usually follow this system because the producer is unable or unwilling to manage males

independently. When goats are raised in the wet tropics, where the feed supply is relatively constant, or when goats are in intensely managed herds, where nutrient needs are provided as needed, continuous mating is desirable. A third condition in which continuous mating is often practiced and can possibly 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 last approach will usually be characterized by low levels of production and high mortality, but may be the only option for certain producers. Under these conditions, permitting does to kid at a less opportune time may be preferable to the risk of having no kid at all, which could happen with a single controlled breeding period.

Although in the above discussion the terms "continuous mating" and "continuous kidding" have been used, it is likely that some version of intermittent exposure to males (such as alternate months) would be more desirable since this would permit some organization of management. Also, intermittent exposure to males may stimulate a higher level of reproductive activity.

II. Controlled matings whereby period of greatest nutrient requirements (lactation of dams and growth of the kids) will coincide with the period of greatest forage availability.

This is the natural scheme of things in temperate regions, where matings are controlled for lambing or kidding to occur in 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. However, in the wet/dry tropics and other areas of highly seasonal (and hopefully predictable) forage production, the synchronization of breeding season with forage availability is almost certainly the most productive alternative. In the case of a six-month wet and six-month dry seasons, matings can be made shortly after the end of the wet season in order for kidding to occur shortly before the start of the wet season. In this system, the period of lactation and kid growth will coincide with that of highest forage availability. Kids would be weaned at five to six months of age and, it is to be hoped, sold. However, there are some critical components in order for this to work. One is that the does need to be in adequate condition to breed at the time the kids are weaned. Also, abortion may be a problem with nutritionally stressed does in the late dry season. Thus, for the system to work, producers must be in a position to provide for the needs of the doe gestating during the latter part of the dry season. Also, kids from undernourished does that are dropped during a period of unexpected early heavy rains may suffer extremely heavy mortality. Thus, the producer needs to insure by various means that this does not happen. The important interventions would be nutrition of the doe and protection and good sanitation for the kids.

An added risk of this system is the possibly late arrival of rains and the consequent shortage of feed just when it is most needed.

III. A modified scheme in which kidding occurs after the start of the rainy season.

The wet/dry seasons, as mentioned above, describe the situation of Northeast Brazil, although the period of rainfall may not be exactly six months in duration and its beginning and ending dates are not highly predictable. Several studies have been conducted in this region that provide information on a kidding season, but the results have not been definitive. Although system II, described above, is preferred by the authors, it has been found that in practice producers, and sometimes even researchers, cannot predict events and may have economic difficulty in providing the inputs necessary to make the system work. An alternative system has evolved, in which does are bred later in the dry season with the kids dropped after the heavier part of the rainy season. This may largely eliminate the problem of abortion and will, in any case, reduce the problem of kid mortality. The does will often need some additional feed at mating (flushing), but this will be minor compared to the needs of the pregnant or early lactating does. A correlated disadvantage of this scheme is that kids will go into the dry season at a younger age and a lighter weight. Mortality may be higher, and there is little hope of selling them for slaughter until after the following rainy season unless they are heavily supplemented.

In the above discussion, exact dates have not been provided. Producers in different locations will need to adapt the system to local conditions of climate and feed availability.

Once a controlled mating system is adopted, does 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 does, especially if they are aged or unsound, or to provide a later second mating period. In most cases, out-of-season kids will be preferable to no kids at all.

Size of Flock

Extensive experience has shown that goats perform better in flocks of small or modest size as compared to large flocks. This is not likely to be a serious problem under small-farmer conditions, but may be more important in commercial herds. It is not implied that large scale production is impossible, but rather that large flocks should preferably be split into smaller groups (possibly no more than 100 head) for management. Some of the problems encountered in large herds are kid survival due to crowding and the unsuccessful competition for feed by less aggressive animals, a factor which may result in reduced productivity.

Supplemental Feeding

Several chapters in this publication call attention to nutrition as a constraint to production in Northeast Brazil. 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 the Northeast 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 technological information may be serious constraints. Possible supplemental feeds include (a) crop aftermath (i.e., corn, beans, etc.) (b) cultivated forages (i.e., cunha, 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 (i.e., matapasto and panasco). Animals needing such supplements include females at mating, or does gestating or lactating late in the dry season, or weaned kids intended for market.

Use of Protein Bank

The first limiting nutrients for livestock production on a range are usually protein and energy. High protein forages, popularly 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 small-holder conditions and also provides no supplemental energy. The most effective way to provide protein is through the use of high-protein concentrates (such as oil meals), which are also good energy sources, but this supplementation will often present problems to producers of limited means, due to cash cost or transportation. A third approach is to use high-protein forages in the form of annual leguminous crops, such as cunhã, or shrubs or trees such as leucaena and algaroba. In the humid tropics, kudzu or other legumes are often used for this purpose.

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 as the animal can benefit over several days from a single feeding (Calhoun et al., 1988). Animals with low requirements, such as dry does, may, therefore, be fed the supplemental forage as infrequently as once or twice a week, but animals with higher requirements, such as growing kids or lactating does, 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.

Cutting Browse for Feeding Goats

The unique contribution of goats is in their utilization of browse or woody types of forage. In the more arid regions, most of the browse species are within the feeding zone (reach) of the goat. In commercial forests in temperate regions, there is little forage within reach of the goat and grazing by goats may be detrimental to the regeneration of cut-over forests. For this reason, goats are not commonly grazed in commercial forests.

BROWSE LINE AND FALLEN FORAGE

The presence of a distinct browse line indicates that goats have exhausted the forage (from browse) in their feeding range. This may be corrected by cutting the forage that is out of their reach.

The goats may be allowed to feed on the forage as it falls, or it may be carried to confinement lots. Goats prefer to feed above the ground.

Between these two extremes there are large areas covered by woody species that are not suitable for specialized timber production, but where much of the biomass is above the feeding zone for the goat. The caatinga in Northeast Brazil is an example of this, as are other areas, particularly in the Caribbean. The shortage of forage is more critical because as stocking rates are increased, the forage within the feeding zone of the goat is fully utilized. This is easily discernable by the existence of a browse line. In chapter 5, selected lowering of the caatinga, with the resultant regrowth of the plant (coppicing) within the feeding zone, is suggested as a management practice that yields good results. The practice of cutting the upper limbs to allow the goats immediate access to forage is also a widely used practice, which has the effect of providing an immediate source of feed as well as a reduction of the canopy. In as little as thirty minutes per day, one man with a machete can provide feed for as many as 50 mature goats. Some of the most successful goat producers in tropical environments have been observed to use this practice.

This practice should be carried out with a knowledge of the browse species involved. Only palatable, nutritious and nontoxic species should be used as a feed. Desirable plant species which do not sprout back from the base (coppice) should not be cut back to the extent that the plant is killed. It may be desirable to remove undesirable forage species periodically, to prevent their domination of the stand and to improve the productivity of the desirable forage species.

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Chapter 10

FACILITIES FOR GOAT KEEPING

M.S.Shelton, E.A.P. Figueiredo and A.A.O. Fernandes

Since most goats are kept by producers with limited resources and/or in unfavorable environments, it is often necessary that investment in facilities be kept to a minimum. Nevertheless, lack of proper facilities, particularly fencing, can present a serious problem or limitation. The facilities required for goat keeping (for meat or household milk supply) may be thought of as pasture fencing, confinement lots, shelter, and feeding or watering facilities. The facilities required for commercial milk production from goats are not addressed in this chapter and would be much more elaborate than those required for meat production.

Control or containment and protection (from theft or predation) represent major problems with respect to goats. These two problems are interrelated, and can have sociological as well as economic implication. For control, some of the options are fencing, herding, or allowing the animals to roam free in communal flocks. Other options, not commonly found in Northeast Brazil, may include tethering or zero grazing (total confinement), such as cut and carry systems of production. Fencing and communal grazing are the primary options in Northeast Brazil. Fencing is expensive for any type of livestock, but perhaps more so for goats, since they are more difficult to fence and represent a lower per-head value. Other options may require lower capital investment than fencing but present serious labor or management constraints. In many societies goats have been traditionally tended by children, and as more children enter school, goat-keeping may be disrupted. Communal grazing leads to the overuse of grazing resources and makes it difficult for an individual producer to manage his flocks to best advantage.

Fencing

Fencing should be considered the preferred option but may not always be feasible. Two types of fences should be considered. The first is a boundary fence to prevent animals from being lost through straying or to keep them out of neighbors' crops. The second is internal fencing within the producer's property to permit the rotation of pastures, or to allow differential management for various age or sex subgroups, or to protect cropland. The requirements for boundary fencing would be more elaborate than for internal fencing.

Some impediments to fencing are cost, nomadism, land ownership, and, in some cases, knowledge. The cost of fencing (per animal unit protected) is determined by the cost per unit of the fence, the size of the area fenced, the carrying capacity of the land and the period of time over which costs can be amortized (Shelton et al., 1987). 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. The same is true with increased stocking rates. However, under the best of conditions, fencing costs are prohibitive unless they can be amortized over a period of years. Any type of fence should be expected to last several years, but this may range from only 5 years for fences made of wood

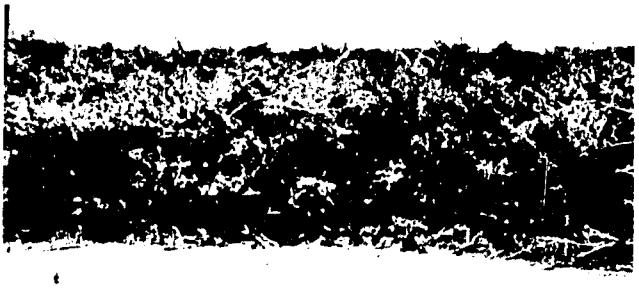
to as long as 50 years for well-maintained wire fences in arid environments.

Some Types of Fences

Net wire. Net wire is the most effective way to fence goats, and its use should be encouraged. However, for various reasons it is not widely used throughout the world. Certain types of net wire fences can cause problems if the goats feed through the wire spacing and become trapped by their horns. This problem can be reduced by using a net with smaller openings. Except for the entrapment problems, a horizontal and vertical spacing of approximately 15 cm is common and acceptable, but closer spacings near the bottom may assist in excluding small predators, preventing small kids from escaping and reducing the tendency for goats to become trapped by their horns. A typical height is a net of approximately 1 meter plus one or two barbed wires on top at approximately 10 cm spacing. This will provide a total height of 120 cm; this will usually be adequate. Individual goats may be able to jump this fence, making a higher fence desirable. However, it may be more economical to cull and sell individual animals than to fence for problem animals. Ideally, these fences should be made of a strong, heavy-weight wire that will maintain tension. In an arid, non-coastal environment, such fences may be expected to last for up to 50 years. Wire fences have a much shorter life in coastal areas, where salt causes damage to the wire.

In addition to cost, major problems with net fences are that they are not constructed with proper tension or with supporting posts that resist decay. In most countries, there are native tree species that are relatively resistant to decay and 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. These treatments can be applied on the farm by simply standing the end or immersing the entire post in a solution of the preservative, but this will usually be less effective than commercial pressure treatment.

Individual strand wire fences. Fences made of individual strands, as contrasted to net or mesh fences, are perhaps more common throughout the world, but an elaborate fence of this nature is required for goats. The wires may be barbed or smooth wire. Barbed wires are somewhat more effective, but less pleasant to use in construction than smooth wire. If there is a potential interest in electrifying the wires at a later date, which can often be done, the smooth wire is preferable from a safety standpoint. With single strand wire fences, generally seven or even up to ten wires are used for goats. Even with the larger number of wires, kids may pass through. The amount of tension and spacing on the wires are very important to contain even adult goats. Suggested spacings are approximately 10 cm at the bottom, graduating to 25 cm at the top. The maintenance of spacing on the wire is important. For example, if wires spaced at 10 cm are allowed to become loose or sag, the effective spacing may become 30 cm, with the result that most goats could easily pass through. Spacing may be maintained by closely placed supports (posts or stays), by tension on the wire, or, preferably, by both of these methods at the same time. Increasing tension is the more economical approach, but requires well-constructed corners and stretch assemblies, which may present limitations.

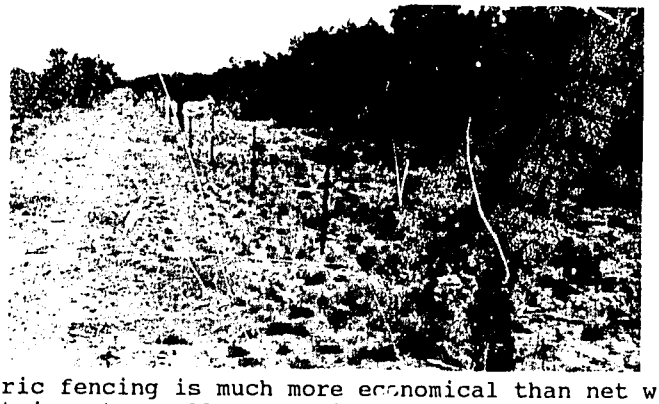


One type of fence made of native materials. This type is more commonly used for night lots in many regions of the world.

A fence of native materials and wire used in Brazil. There are many variations of fences made of wood in the caatinga region. These would vastly benefit from some treatment of the wood to retard decay.

A fence of stone and wood. This fence should have a much longer life span, but it is difficult to construct and the climbing ability of the goat will present problems.

Net wire is the most effective way to fence goats, but to be cost effective, it should be amortized over long periods of time. This fence has been in use for over 60 years.



Electric fencing is much more economical than net wire, but it is not equally effective.

The use of solar panels permits using electric fencing where electricity is not available.

Electric fencing. Perhaps the most important recent development in the fencing of goats is the use of electric fencing. The cash costs of this type of fence are markedly reduced over other types of wire fences, and the labor required for construction is much less than for fences made of native materials. Electric fencing has been in use for many years, but there have been some relatively recent developments that are worthy of note. One of these is the realization that in extremely arid environments, the animal may not be sufficiently well grounded to receive an adequate charge from traditional electric fences. This can be corrected by alternating charged and grounded wires, with the result that an animal attempting to pass through will receive a charge. The second is the development of new types of chargers or energizers with low impedance and high voltage (5000+), which provide greater shock value (and thus improved effectiveness with reduced fire hazards) and permit much greater lengths of fences to be charged from a single energizer, with reduced problems of grounding. A third development has been the use of solar panels for charging batteries, permitting the use of electric fencing in areas where traditional electric power is not available.

Although electric fencing is having a great impact on animal industries throughout the world, this is less true for goats because they are more difficult to fence in and they are often raised by small holders, or in nomadic systems, or in developing countries, situations in which these more modern types of fences are less readily available. However, electric fencing is clearly the most economical means of fencing and its use is rapidly increasing.

Electric fencing is not suggested for periphery or boundary fences, because the animals can still escape if they pass through the fence. They are more appropriate for internal division fences, including temporary fences for pasture rotation. Four- or five-wire electric fences are successfully used in the U.S. for the containment of goats, but in other areas more elaborate fencing has worked better.

There seem to be two explanations for these contrasting experiences. One is the stability and training of the animal population. Goats can readily pass through a four- or five-wire fence; thus, they must learn to respect or fear the charged fence. Therefore, this fence would not work well if the animal population changes frequently. The second factor is that the fence must be maintained in good repair. This means maintaining a charge on the wire (5000+ volts) and maintaining the tension and spacing of the wires so that the animal can not pass through without receiving a shock. A type of wire must be used which 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.

Living fences. Living fences are sometimes used for various types of livestock. They are less satisfactory for goats than for other animal species, because goats are more likely to eat the living fence than are cattle or sheep; and goats, smaller and more active, are more difficult to fence in by any means, including living fences. The end result is that living fences are not generally recommended for goats.

In addition to true living fences, living posts can be used with wire fences to reduce the need to replace the supporting posts. Living posts may be planted at the desired locations, or some species will sprout roots and grow when cut and put in the ground. Erythrema sp. has been used for living posts in Central America. Leucaena sp. could also be used to serve the dual role of post and of forage producer by lopping branches above the fence line. One caution is that highly palatable tree species may be killed by the goats' eating their bark, especially in the cases of high stock densities.

Fences of native materials. In areas with extensive woody vegetation, it is often possible to construct fences of local materials with little or no cash cost. Fences made of wood require considerable maintenance as the existing materials decay. Limitations on the availability of wood would 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 such conditions the cost of materials may be low, but labor requirements are great. The number of possible designs are almost infinite, but at least two, Faxina and Estacote, are identified by name. These fences all serve the same purpose, and when in good repair are at least as effective as seven- to nine-strand wire fencing. The decay of wooden fences, due to prolonged exposure to humidity during the rainy season, is a problem. They may also be destroyed by fire. Some repair is usually required in five years, with extensive replacement in ten years. Wood for initial construction may be obtained from land clearing. When the fence must later be replaced, adequate wood may not be available, and there is often a tendency to shift to wire.

Other local materials that can be used for fencing are rocks or stones when they are abundant in the area. Cash costs of this type of fence are low, but if a value is put on labor the costs will be prohibitive. Rock fences are more commonly used for corrals or night lots. Fences made of stones would have the advantage that they would resist decay. A clear disadvantage is that it is almost impossible to control goats with a fence made entirely of stone, since goats love to climb. However, the lower part of the fence may be made of stone to resist decay and to contain small kids, with a standard wire fence at the top to contain the adults. Few rock fences are being constructed at the present time because of the large amount of labor required.

A Corral or Night Lot (Chiqueiros)

Many producers find it necessary to confine their animals at night. This may be for shelter, for protection from theft and predation, to prevent straying, or to provide extra management care, such as supplemental feeding, suckling kids, or collecting milk for domestic use. Night confinement pens should contain at least two divisions to permit separation of males and females, or does with young kids, etc. Unless space is a premium, a minimum of two square meters per doe is recommended for the night pen. Construction materials would be the same as for pasture fencing, but expense would be of less concern. The fencing used for night lots should be well constructed to provide the desired security.

Since a large percent of the goat population is located in the tropics and arid subtropics, one would assume that shelter is not a critical requirement. In the tropics goats might be exposed to intense sunlight or rain but generally not to cold stress. Goats do not suffer greatly from high temperature stress (Arruda et al., 1986; Pant et al., 1985) in Northeast Brazil. Shade will be beneficial, but not critical. In areas where natural shade is present, goats will use whatever is available. It is doubtful that constructing shade specifically for free-ranging goats can be justified, except possibly for intensively managed dairy herds.

Protection from rain may be more important. Goats produced for meat in temperate regions are seldom provided protection. However, even in the tropics, when given a chance, goats will seek shelter from rain. The mere fact that they seek shelter does not mean that there is a need, since it could be a habit learned from their mothers. However, the authors have on several occasions observed mature goats dying in Northeast Brazil from chilling or from the stress associated with prolonged rain. One can ask why goats seem to survive in temperate regions but die in the tropics from stress associated with rain. One explanation is that goats in the tropics have a very limited hair coat, while those in temperate regions generally have much more extensive coats. Also, the animals in tropical regions that have been observed to die from weather-related causes were usually thin and apparently undernourished. Poor nutrition or poor condition (little body fat) can contribute to chilling in many ways. Size or body mass represents a reservoir of body heat and helps to protect the internal organs from lowered temperatures. Also, fat on the body provides some degree of insulation for the internal organs. A higher level of nutrition adds protection from chilling by providing readily available energy for maintaining body temperature. Also, heat is a by-product of digestion, particularly of fibrous feeds, and an animal with a full gut suffers much less from chilling. Lastly, rain in Northeast Brazil may continue for several days; animals suffering from chill will often refuse to forage in wet caatinga pastures during this period, even when it is not raining, because they would become as wet as if they were in the rain. Under these conditions the animal will not only be undernourished but will often suffer from other stress-related phenomena.

Thus, the necessity for sheltering adult animals probably relates largely to the expected weather patterns in the area and the nutritional level of the flock.

The above comments apply to adult animals, and although losses do at times occur, this is certainly not one of the major problems for the industry. However, the death loss of kids is a major problem, perhaps even more so in the tropics. The authors have observed and heard reports of kid losses approaching 75%. One published study (Simplicio et al., 1982) reported kid death losses as high as 68.1%. This problem is not restricted to Brazil, as similar mortality rates (up to 60%) have been reported from Africa (Oppong and Yebuah, 1981). By contrast, intensively managed flocks under favorable conditions may experience kid losses under 10%. Most losses occur within the first few days after birth.

Thus, some type of shelter appears to be desirable, though perhaps not always necessary. A shelter facility in which the

animals are kept on an elevated floor is widely used throughout Northeast Brazil (see photograph). This type of house is theoretically good in design since it provides shade and protection from rain, permits air movement to reduce heat stress, and improves sanitation by allowing urine and fecal material to pass through the floor. Although this is theoretically an excellent type of facility, one study (Oliveira et al., 1982) failed to show that this elaborate facility can be justified, and in the case of cold stress, animals on the ground may in fact be warmer and have a better survival rate. Also, since the facility is elevated the animals are more likely to become wet from blowing rain. Thus, a ground level structure may be preferable both from the standpoint of cost and for protection from chilling.

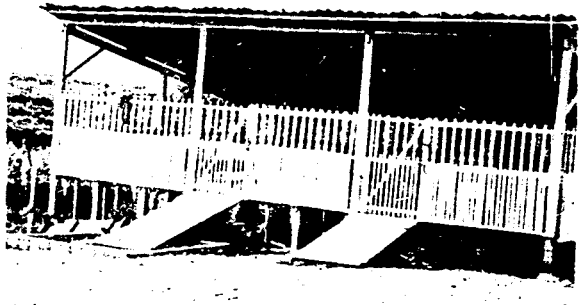
In conclusion, some minimal type of shelter (any type that protects from the rain) should be provided. It is assumed that this would be placed in the night lot, near the producer's household. The animals should have access to the shelter during daytime as well. If space under the shelter is limited, a low roof height will provide better protection from blowing rain. On the other hand, if the roof is made of metal, a low roof structure will add to the animals' heat load. If the prevailing wind is from one direction during the rainy season, a temporary or permanent wall on the side of the prevailing wind would be desirable. The shelter should also be placed in a well-drained area to reduce the accumulation of mud.

Feeding Facilities

Feeding facilities need to be simple and inexpensive, and, therefore, should be made from locally available materials. Some examples are shown in the attached figures. It is important to remember that goats are often competitive, and some animals may not feed unless space is adequate for all animals to feed at the same time. It is also important to remember that goats are highly active and many will spend time in the feeding troughs, a fact that can contribute to poor sanitation and the spread of diseases such as coccidiosis. Feeding facilities should be designed to prevent the animals from standing or lying in the feed trough. A third important factor to remember is that goats are often finicky eaters and may refuse to eat soiled feed or to drink dirty water.

Provision of Water

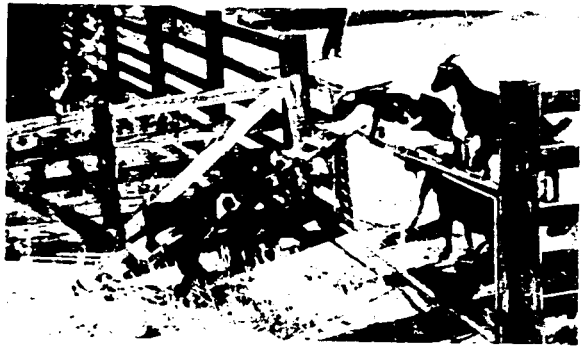
One of the reasons that goats are found in arid environments is their greater tolerance for water deprivation. When animals are consuming lush green forage they can perform well without drinking free water, but this is not recommended, especially for lactating does. However, it is possible to run goats on green and growing forage without free water, and there are occasions when this can be important. During a dry period, water is required for satisfactory performance, although goats may not die if deprived of water for several days. Goats have been known to persist on some islands for extended periods of time without standing water. The preferred practice is to provide access to water at all times, day and night. If this is not feasible they should be allowed to water at least once and preferably twice per day. Free ranging animals grazing under extensive conditions will go to water at



This type of shelter is widely used in Brazil and is good from the standpoint of sanitation and cooling, but research suggests that the costs may not be justified, and that it provides poor protection from blowing rain.

A good type of feed trough of native materials. It is preferable that goats not be able to stand or lay in troughs.

This type of structure at ground level may be more economical and equally effective. Note the example of a type of fence used for night lots.



Gathering may be a problem for goats run under extensive conditions. It is possible to trap them with reasonable success. In the example, remove the ramp leading out of the lot where feed, water, or salt are provided.

least once per day. Some genetic differences exist in the ability of goats to tolerate water deprivation (Shkolnik et al., 1987), but it is preferable to provide water rather than to attempt selection for this trait. The water provided should be kept clean, to reduce disease transmission and to encourage intake.

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Chapter 11

PRODUCT QUALITY AND MARKETING

E.A.P. Figueiredo

This chapter discusses alternatives for improving the quality of goat products, as well as some of the more appropriate marketing practices and strategies for them.

Data on the quality of goat products and on marketing strategies in the Americas has been very scarce. The total goat population of the Americas amounts to approximately thirty-four million, of which more than half are found in Brazil and Mexico together (Table 1).

The majority of goats in Latin America are raised for meat and skin production. Meat is used for home consumption and the surplus is sold; skins are produced only for sale. Milk and other dairy products are produced mainly for home consumption and rarely for marketing. Manure is also considered as a valuable by-product of the goat industry. Hair production is limited specifically to the South of Argentina and the state of Texas (USA); all of it is destined for sale.

A small goat population in certain countries does not necessarily mean that goats are less important than in others of larger population. In the Americas, goats are raised in every country, and mostly by people of similar social status. In general, they are people who inhabit the warmer, semiarid regions, although there are also people in humid, tropical areas who raise goats. In the hot and dry areas there are some similarities in production systems across countries, including the types of animals and products.

The production systems, as seen in previous chapters, are extensive, with animals feeding on shrubs and trees and subject to wide annual fluctuation of vegetation growth while receiving little feed supplementation, parasite treatment, or other management, such as controlled breeding, weaning, or castration.

The animals are a criollo type with marked introductions of Anglo-Nubian blood, and in some regions there are also introductions of Alpine and Angora breeds.

Meat Production and Quality

Meat Production

The majority of the goat population shown in Table 14 is represented by nondescript mixed types, which for convenience are called "sem raça definida" (SRD) in Brazil (Figueiredo et al., 1982), criollo or "Spanish" in Spanish-speaking countries (Garcia, 1981), and "Spanish" in the USA (Shelton, 1978). Producers often cross these types with Anglo-Nubian, Bhuj, Mambrima, Jamunapari, and other breeds in an attempt to improve their meat-producing characteristics. There is also some crossbreeding with dairy breeds to improve milk production, and in a few specific cases there is introduction of Angora blood to improve hair production.

Average carcass weight reaches 13 kg (Table 14), which is a low value for adult animals. Offtakes of 22 percent are also low if one considers that a doe may be able to produce two kids per year, which number represents 200 percent offtake (not corrected for replacement breeding animals).

TABLE 14. MAJOR GOAT PRODUCING COUNTRIES IN THE AMERICAS AND PRODUCTION OF MEAT, MILK, AND SKINS (1976)

Country	Goat Population	Number of Animals Slaughtered*	Production** Meat	of Milk	Fresh Skin	Offtake (%)
Brazil	9,800	2,193	24,123	101	6,579	22.4
Mexico	9,331	1,410	15,510	204	4,230	15.1
Argentina	3,100	1,575	11,025	-	3,937	50.8
Bolivia	2,848	560	6,160	13	1,400	19.7
Peru	1,720	850	11,050	19	2,125	49.4
U.S.A.	1,567	-	-	-	-	-
Haiti	1,384	521	4,168	25	938	37.6
Venezuela	1,340	430	8,170	-	516	32.1
Columbia	860	289	3,468	-	723	33.6
Chile	800	310	5,580	10	775	38.7
Dominican Rep.	335	26	416	-	51	7.3
Jamaica	350	79	869	-	158	22.6
Ecuador	200	62	620	2	124	31.0
Paraguay	100	18	180	-	36	18.0
Cuba	106	28	336	-	55	26.4
Guatemala	76	26	390	-	65	34.2
Honduras	58	-	-	-	-	-
Others	411	-	-	-	45	-
Total	34,272					

*thousand heads
**metric tons .cw12

The worldwide meat production from goats is estimated at 1.97 million metric tons, of which 97 percent is from developing countries (FAO, 1977). This figure was no doubt roughly estimated in most countries, since the majority of goat meat is not marketed through organized channels but consumed at or near the point of origin. Gall (1982) states that actual production is probably higher than the official estimates. Although goats produce only a small percent of the total world supply of red meat, their contribution is much more important in developing countries (Raun, 1982). Goat meat is not subject to religious taboos as is sometimes the case with beef or pork.

The demand for meat exceeds the supply in many parts of the world. In Brazil, goat meat is sold in the Northeast at prices similar to or lower than other meats. However, in the southern states, there are some specialized markets for kids, which are sold at a premium price.

Meat Quality

Research data in Northeast Brazil (Bellaver et al., 1983) has shown breed group differences in pre-slaughter weight, hot carcass weight, carcass length, hind-leg length, thorax depth, wet skin weight, and dressing percentages. Hot carcass weights for yearling male goats ranged from 7.5 to 8.1 kg and did not differ for

recognized local breeds, Anglo-Nubian crosses, Bhuj crosses, and SRD goats. These weights were inferior to hot carcass weights of 14.8 kg for adult does (Ponce de Leon et al., 1985); however, the estimate given by the Anuario Estatastico do Brasil (11 to 14 kg) fall between these two values.

Not only are carcass items important for home consumption in most Latin American countries, but the dress-off items are also used (Shelton et al., 1985; Ponce de Leon et al., 1985). Shown in Table 15 are some of the products that may be obtained at slaughter, arranged into edible groups. The classification of edible vs inedible is not exact. Essentially all parts that might be considered digestible by man are listed as edible, and those that consist largely of keratinized protein are listed as inedible. Whether or not they are actually consumed by man would be highly influenced by the customs of the society involved and by the degree of need for food of animal origin. Table 16 shows the proportion of each part of the animal's body from the total, corrected for empty body weight.

TABLE 15. A PARTIAL LIST OF PRODUCTS OBTAINED AT SLAUGHTER

Edible	Inedible
Carcass	Feet
Head	Hair
Blood	Skin
Kidneys	Horns
Heart	Hooves
Liver	
Lungs	
Fat Trim	
Tongue	
Stomach	
Intestines	
Testicles	

Nutritional Value of Carcass Components and Dress-off Items

The goat carcass generally has more lean meat and less fat than carcasses of other species, which factors influence the protein and energy content of the meat (Shelton et al., 1985). The energy value of goat meat (2.3 Mcal/kg) is lower than that of beef and sheep (3.6 and 3.1 Mcal/kg, respectively) (McDowell and Bove, 1977). There is some indication that goat meat may have a higher content of some essential amino acids such as arginine, leucine, and isoleucine (Shelton et al., 1985).

Assuming that the nutrient value of the offals or dress-off items of the goat carcass is similar to that 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 the precursors of vitamins A and D, folic acid, and poly-unsaturated fatty acids.

TABLE 16. WEIGHT AND PERCENT OF DRESS-OFF ITEMS AND BY-PRODUCTS (CORRECTED FOR EMPTY BODY WEIGHT) FROM NATIVE BRAZILIAN SRD GOATS

Carcass and/or dress-off items	Average weight (kg)	Percent of empty body weight
Corrected live weight	27.7	100.0
Carcass weight	14.8	54.0
Dress-off weight of products for human consumption		
Tongue	0.099	0.3
Heart	0.130	0.4
Liver	0.491	1.7
Kidneys	0.095	0.3
Empty abomasum	1.028	3.8
Empty small intestine	0.475	1.5
Empty large intestine	0.875	3.2
Subtotal		11.2
Weight of inedible by-products		
Wet skin	2.5	9.3
Head	1.2	4.5
Metacarpus	0.34	1.2
Metatarsus	0.31	1.1
Horns	0.13	0.5
Subtotal		11.6
Weight of blood + loss		6.9

Source: Santa Rosa et al. (1985).

Palatability or Acceptability of Goat Meat

According to Shelton et al. (1985) the degree of emphasis to be placed on the quality or the palatability of meat in developing countries may be subject to considerable question. Questions might be asked about the relative preference for goat meat as compared to that of other species, or the importance of quality traits, such as tenderness, within species. Some studies (Smith et al., 1974) have suggested that goat meat is significantly less tender than that of sheep. However, subsequent developments suggest that this may have been an artifact of the interaction between quick chilling and cold shortening of the carcasses. Since goat carcasses were smaller and had less fat cover, it is felt that they chilled much more quickly, thus affecting tenderness.

The importance to be attached to palatability traits is a function of the eating habits of the society involved and of the use of the meats. For instance, people who have historically consumed goat meat will react positively to any distinctive flavor, whereas people who had not previously consumed goat 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. There is also 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 attempts to market goat meat to hotels, restaurants, or more affluent households, quality traits should be of concern.

Griffin et al. (1983) evaluated loin chops and leg steaks from sheep and goats, using U.S. and non-U.S. panelists. The foreign panel consistently gave higher ratings in all comparisons. However, the differences tended to be small and were statistically significant only in the case of flavor, tenderness, and overall palatability of the leg steaks. The meat of sheep consistently received more favorable ratings than goat meat, and for the most part these differences were significant. The only trait in which goats rated as high as sheep was flavor. These results suggest a possible problem for commercial sales of goat meat. Exceptions may be with populations who have traditionally consumed goat meat, or for methods of preparation in which quality traits such as tenderness would be of little concern. There was little difference in the ratings given for meat from young males or from aged females. However, neither of the animal types used in this study necessarily represent the most desirable slaughter animal. It has already been suggested that, in those markets which have been tested, castrated animals received a higher price. Except for localized situations, it appears that most consumers choose goat because it is cheaper, or because they expect it to be cheaper, and not because they prefer it. It has been suggested (Primov, 1984) that this is the case in Northeast Brazil.

The palatability of goat meat also seems to be associated with fatty acid composition, as is the case for mutton, lamb and beef (Melton et al., 1982; Dryden and Marchello, 1970). According to Campion et al. (1976), the lower melting points of unsaturated fatty acids are associated with soft fat, which has a less desirable flavor.

Fatty acid composition varies with age, with breed (Congiu and Argiolas, 1977) and, to a smaller extent, with sex and with weight (Kemp et al., 1981). Wu et al. (1982) studied the fat composition of 120 young intact males and aged females of three breeds of sheep (Karakul, Rambouillet, and Barbados Blackbelly) and two breeds of goats (Angora and Spanish). The major fatty acids, comprising up to 85% of the total in the subcutaneous fat, were oleic (C18:0) and palmitic (C16:0). The composition of unsaturated fatty acids in ovine and caprine fat (38-49%) was smaller than that reported for ovine fat (54.5-63.6%) by Field et al. (1978).

According to Wu et al. (1982), among the five breed/species groups, fat from Karakul sheep had the highest percentages of pentadecanoic (C15:0), margaric (C17:0), heptadecanoic (C17:1) and total unsaturated fatty acids, while fat from Angora goats had the highest percentages of palmitic (C16:0) but the lowest percentages of oleic (C18:1) and total unsaturated fatty acids. There were significant differences in percentages of most of the fatty acids in subcutaneous fat from goats vs sheep. Percentages of myristic (C14:0), C16:0, palmitolic (C16:1) and total saturated fatty acids were higher in subcutaneous fat from goats. However, sheep had higher percentages of C17:1, C18:1, linoleic (C18:2) and total unsaturated fatty acids. Analysis of subcutaneous fat from aged females revealed that goats had higher percentages of C14:0, C16:0 and C16:1 but lower percentages of C18:1 than did sheep. Both

young intact male and aged female goats had lower percentages of C18:1 than young male and aged female sheep. The lower proportion of unsaturated fatty acids may enhance flavor in goat meat as compared to sheep meat (Griffin et al., 1983).

Meat Uses

In general there are three types of dishes prepared with goat meat. The first two are baked and boiled meat; the third is cooked viscera. The local nomenclatures are primarily variations of these three basic types.

The common uses of goat meat in several countries of the Americas are for feasts, occasions for which kid is often preferred. The main dishes known to be prepared with kid meat are "cabrito al pastor" in Mexico, and "cabrito al asador," "a la parrilla," "a la calabresa," "al horno," "a la portuguesa," "al champignon," and "con arrijas saltados" in Argentina.

Meat from adult animals is generally consumed as an everyday dish such as "bode assado," "cozido," "guizado de carne de bode," and "buchada" in Brazil; "barbacoa", "birria", and "mixiotes" in Mexico; and "a la parrilla," "a la cacerola," and "al horno" in Argentina.

In rural areas, meat may be preserved by air drying and salting, or by baking. In villages and cities the consumer usually purchases a piece that can be consumed in the same day, and, therefore, needs no preservation.

Very rare are the cases where there is a well-organized industry for exploiting goat meat. Argentina and the U.S. are exceptions, with their networks of slaughterhouses that distribute cooled kid meat and goat sausages.

Milk Production and Uses

Goats are capable of high milk yields that can be compared to cattle or buffalos on a body-weight basis. The goats raised in the semiarid environments of the Americas are exploited mainly for meat and skins, and rarely for milk, although their contribution of protein to rural families would be greater through milk. National productions of goat milk in Brazil and other Latin American countries are shown in Table 14.

Apart from the milk that is produced in a few specialized dairies, most of the production is from non-selected animals, commonly called "criollo" or "Sem Raça Definida," which may contain some genes from Alpine or Anglo-nubian breeds. The milk production of these goats will average less than one kilogram per day up to five months of lactation (Figueiredo et al., 1987).

Milk is generally consumed in fluid form, unpasteurized, or as soft fresh cheese; however, in Mexico "cajeta" is popular; this is a dehydrated milk-based candy. "Cajeta" can be in several flavors, such as vanilla or strawberry, and contains about 30% moisture, 26% milk solids (including 10% lactose, 7% protein, 7.5% fat and 2.0% ash), 44% sucrose and 1.5% buffer substances (Arbiza, 1986).

There are a few dairy plants that specialize in milk in Mexico, Brazil and the United States. All are of small size and with few exceptions have not managed to grow (Sousa Neto, 1987, Arbiza, 1986 and Kapture, 1982). The main limiting factors are the high initial investments and the difficulty of obtaining a milk supply at a constant rate throughout the year.

It is very difficult to deal with the problem of marketing goat milk, but it is very easy to produce dairy products at the home level for use in the family, selling the excess to neighbors. There would be a tremendous impact in the health status of the young and the poor if every home in rural semiarid environments could have one or two does to produce one or two liters of milk each day. Perhaps the benefit from that social action would be greater than if that milk were to enter marketing channels.

Skin Production

Importance of the Skin to the Production System

Along with meat, skins or hides were among the earliest animal products used by man. As late as the nineteenth century, American Indians used animal skins for housing, clothing, and protection from the environment. Leather is used for a variety of purposes. Leather, or the hides or skins from which it is made, is an important commodity in international trade.

The terms "hides" and "skins" are often used interchangeably, resulting in some confusion. However, the tendency is to use the term "hide" for large animals and "skin" for small animals. In this chapter, therefore, we have used the term "skins" to represent the commodity obtained from small animals, such as goats, following slaughter or natural death. The term "leather" relates to the skin after it is treated to resist decay while it retains its wearing properties.

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, deserving careful attention. Bellaver (1980) has shown that skins may represent as much as 30% of the value of an individual goat. In some cases goat skins may be even more important to the producer or to the national economy in countries where they are produced. In the case of animals that are slaughtered for household use, only the skins are available for conversion to cash. At the village level they may be used as water containers, tents, mats or leather (Josserand and Ariza-Nivarro, 1982), or they may simply be wasted. Some skins, particularly those from fine, short-haired breeds, are retained on the carcass, singed, cooked and eaten (Holst, 1987).

As a large portion of the world's goat population is concentrated in tropical regions (Shelton, 1978), and more especially in the semiarid tropics, where many of the developing countries are located, the export of goat skins is a potentially important source of foreign exchange. Efforts should be made to maximize their value.

According to the FAO, annual world goat-skin production amounts to 345 thousand metric tons. In the Americas, Brazil is the most

important goat skin producer. Its production is concentrated in the Northeastern part of the country, covering particularly the states of Bahia, Piam, Pernambuco, Cear and Paraiba. The total goat skin production in Latin America is shown in Table 14.

Unique Qualities and Uses of Goat Skins

When properly cured and tanned, goat skins produce a fine leather that has a wide variety of uses. Tropical goat skins have unique qualities that yield some of the finest leathers, such as velours, suede, and chamois for clothing, shoes (glazed kid), and ladies' gloves (Gall, 1981). Some of the finest leather is reportedly produced by the Red Sokoto goat of Niger.

Holst (1987) commented that leather processors recognize season of the year, sex, age, body condition, and breed of goat as contributors to variation in skin quality. There is a premium for fine-grained leather with satisfactory physical properties. A goat, with its fixed complement of primary follicles, will have a fine grain when young and small, and coarse-haired goats will produce a grain appearance different from that of fine-haired goats. This is why old buck skins are less valuable in the market. The liveweight at slaughter and the area of skin are factors that influence primary follicle density and thus grain fineness (Holst, 1982).

For good quality skin, a minimum size is necessary. For SRD and Brazilian native goats, that size has been estimated (Bellaver, 1980) to be attained at approximately 21 kg of liveweight at slaughter. Holst (1987) mentioned that skin from Australian goats less than 21 kg liveweight were generally fine-grained and that goat breeds renowned for the quality of their skins (e.g. Red Sokoto, Black Bengal) are essentially dwarf-sized goats and have low mature liveweight. Holst (1987) stated that nutrition in the weeks pre-slaughter influences liveweight and skin structure, concluding that the quality of leather produced from goat skins is dependent upon management factors, genetic factors and environment. Since goat skins are a by-product, it is unlikely that improvement can be made through genetic means. More likely, improvement in quality will come about through changes in management.

Quality of Skins Produced in Northeast Brazil

According to Barret (1982), the mean dried weight for goatskins produced in Paraiba, Northeast Brazil is estimated at 600g, yielding 4.75 sq ft (0.4m^2) of finished leather. Almost all finished leathers show some grain defects of preslaughter origin, and 40% of raw skins are downgraded because of obvious damage. The quality of flay is generally good; less than 10% of raw skins are downgraded because of flay damage. Approximately 90% of the goat and sheepskins produced in Paraiba are preserved by simple air drying and the remaining 10% are salted. The main problems reported with dried skins are overdrying and grease spots. Improved practices can be recommended to reduce or eliminate these problems.

For Paraiba, Barret (1982) also reported that there was virtually no interstate movement of small stock for slaughter, so that skin supply is determined by offtake from the local animals. Offtake can be calculated on the basis of national skin production

in relation to national smallstock population. This is consistent with theoretical offtakes calculated using livestock models. Offtake rates are thus estimated at 45% for the goat populations of Paraíba and the Northeast. These figures are well above those calculated in Table 1, showing that there is not an accurate recording of animals slaughtered.

Barret (1982) also pointed out that the current loss in potential commercial value of the hides and skins produced in Paraíba is about 17%, a figure that can safely be extrapolated to the entire Northeast. This loss is almost entirely attributable to raw material defects, poor preparation practices, and rehydration due to poor drying. In Paraíba, losses in potential value due to poor raw material quality are estimated to amount to US$2.37 million per annum, representing approximately 57% of the potential gross volume from sales of finished leather.

There is a need for considerable research related to this problem. At the simplest level, experiments could be carried out to discover how to avoid the problem. For example, the relative desirability of skins that are dried in the sun vs. skins that are dried in the shade could be studied, as could the effects of a minimal salt treatment (i.e., 1% of the green weight) to retain a minimum moisture content in the skin. At a more sophisticated level, it would be possible under more controlled drying conditions to identify whether the critical parameter that results in overdrying is temperature, humidity, moisture content or exposure to intense sunlight. At the most academic level, studies on the effect of different drying conditions on the various chemical constituents of the skin could be undertaken and related to the degree of difficulty in rehydrating after drying.

Other Products and Utilization of Goats

Among other products from goats are hair and manure. Goats are also mentioned as being used for draft, pets, game, and brush control.

Mohair and cashmere are valuable products from goats. However, in most of the Americas there is some incompatibility in producing both meat and fiber, since animals need to remain in the flock to produce fiber, lowering the meat offtake. Also, when they are culled their meat value is very low. Mohair is a very important industry in Texas and also has some value in Argentina, although there is potential for larger production.

Brush control is an important task that goats can do at no cost or even with profit. This type of goat use is largely done in the U.S., where goats browse infested pastures to clear or maintain the infestation at a low level so that grasses can grow to feed cattle.

Goat manure is largely used as a fertilizer in the vegetable gardens and the coffee plantations of Brazil, the vineyards of Argentina and Chile, and in other countries as an input to horticulture as well.

There are few records of goats being used for draft; however, in some places they are used to pull carts, as in parts of Rio de

Janeiro state. In some other places they have been used as leaders to work sheep in the sales barn.

Goats are also used for leisure; this includes their use as pets, game animals, circus performers, and pullers of children's carts.

Most of these use of goats are of minor value in the Americas compared to the meat, milk, and skin production industries.

General Marketing Practices for Meat, Milk and Skins

Meat

The demand for goat meat in the Americas is mainly domestic, with prices set by internal markets. According to Gutierrez and De Boer (1982), demand in Brazil is concentrated among three major groups: (a) rural areas of the Northeast including rural farm and non-farm population; (b) urban areas of the Northeast that have a large population of rural migrants and other low-income groups, and (c) Northeast migrant populations in the large cities of the South. High consumption levels of goat meat in all three markets is due to a combination of traditional habits and low prices for goat meat relative to other meats. Meat is characterized by high cross-price elasticities of substitution, so higher supplies of goat meat on the market during a prolonged drought, for example, would lead to a less-than-proportional decrease in price as consumers switch to relatively cheaper meat. Market prices for meat are thus determined endogenously by supply and demand in Brazil and are responsive to the usual factors that shift the demand schedule, such as tastes and preferences, prices of substitute products, and consumer income growth.

Goats generally are disposed of through home consumption and commercial sales. Commercial sales in Brazil are largely composed of surplus males (12-18 months old), old females, and cull male breeding stock.

The small size and regular availability of goats from rural areas are important convenience factors leading to a regular consumption of their meat and a well-developed market for the skins from the goats consumed for meat.

According to Gutierrez and De Boer (1982), the small carcass size of goats is more important in the rural areas, since refrigeration is seldom available. Commercial sales are usually to middlemen at the farm gate, or directly to rural market centers. A few sporadic sales directly to urban markets have also been observed. Local butchers (merchants) are usually also the owners of the small village stores where the meat is sold. The merchants buy live animals from the farmers as well as from middlemen operating in the local markets.

The marketing of live animals to the urban markets is more complex. A group of middlemen ("atravessadores") collect truckloads of sheep and goats at the farm gate or at rural market centers. In both markets, the atravessador is in direct competition with the small town butcher. These middlemen transport the animals to the large, open-air urban markets. Those markets

selling large numbers of sheep and goats are generally located in the urban fringe areas, where large numbers of rural migrants from the "sertão" live. The atravessador sells directly to a group of market middlemen, called "compradores," who buy the ownership of the animal and resell it to urban butchers. The animals may be held for a few hours or a few days. Most of the urban butchers slaughter in their shops and relatively few small ruminants go through the large municipal slaughterhouses.

Given the general aggregate market conditions described above, price-making is a result of a fairly flexible supply of sheep and goats (except in severe drought situations), interacting with a responsive demand situation characterized by a large number of consumers in the low-income group. As a result, large price fluctuations for sheep and goat meat are rare and small ruminant meat prices, at least in Northeast Brazil, are somewhat less than for the major substitute products. Skin prices have a minor influence in setting live animal prices.

Milk

De Boer (1982) pointed out that, in developing countries, goat milk seldom enters commercial channels in sufficient quantity or with sufficient regularity to be in direct price competition with cow or water buffalo milk. He also states that cow's milk will generally place the upper and lower limits on the price farmers can expect from goat milk. It is very important to have in mind that there is a world surplus of dairy products, particularly nonfat dry milk and butter in the high income regions of the world. That surplus will tend to keep down the price of nonfat dry milk. Therefore, the dairy industry in most developing countries will require some degree of subsidization, which may favor goat milk production.

The costs of setting up a dairy to produce Grade A pasteurized goat milk vary greatly, depending on how much labor the dairyman can do himself and whether he can find real bargains on used equipment. The costs reported by operating goat dairies in the United States (Kapture, 1982) varied from $20,000 to $85,000 for the dairy buildings alone, not including farm buildings and producing stock. It is obvious that for other countries, less exigent in health control, the cost will be considerably lower but still very heavy for goat producers. It is very difficult to justify an initial investment of about $20,000 in order to sell 200 liters of milk a day.

To transform goat milk into cheese presents more problems than meet the eye. Cheesemaking is an art and the proper marketing of cheese requires much expertise. In the United States, for example, goat cheese has not, for the most part, been produced and marketed by professional cheese manufacturers. It has been handled by amateur goat raisers who become involved with cheese production as a method of marketing their milk. Table 17 shows the classification of French goat cheeses, which gives an idea of the potential degree of sophistication of cheesemaking.

According to Kapture (1982), producers interested in cheesemaking must overcome problems of the small volume of milk supply, the need to use milk not more than three days old for the best flavored cheese, the need for Grade A equivalent cleanliness

in milking facilities for the best quality cheese, and the desirability of year-round milk supply, especially for cheeses that do not have a long storage life.

Fluid goat milk dairies may solve the problems of custom processing by constructing their own on-farm processing facilities. However, this solution is less feasible for goat cheese. Cheesemaking is much more complex than pasteurizing and bottling milk, and it requires a great degree of skill and expertise. Cheesemaking is also much more time-consuming than simply processing milk.

In France, for example, the farmstead cheese producer is the more common type of goat farming operation. In theory, farmstead cheese production appears to be a reasonable way to market goat milk. It is particularly attractive because it does not require a nearby large population to provide a market, as is the case with fluid milk. However, the cost of meeting state licensing requirements is very high.

There are other products that could be marketed from goat milk, such as yogurt, ice cream, kefir, sour cream, soft cheese, carob-flavored milk, and non-fat dried milk powder. However, to date, no dairy has found the demand for any particular product to be high enough to make specialization in that product an attractive alternative to fluid milk.

TABLE 17. CLASSIFICATION OF FRENCH GOAT CHEESE

	Fresh Cheeses	Aged Cheeses		Fermented Cheeses	
		Dried	With Ash	External	Internal
Slow Coagulation	All the cheeses with herbs, garlic, etc., Jonchee Niortaise Trio-Cornes	Bannon Maconnais Briques du Forez Cabecou Cabrion Beaujuloais Cachat Pigouille Rigottes Saint Marcellin Crottin de Chauvignol	Selles sur Cher Valencay	Chabichou Charolais Couhé Verac Gien Lusignan Pavé de Touraine Pelardon Picodon Pouligny St. Pierre Rogeret St. Maixent St. Maure Valencae Vézelay	
Fast Coagulation	Broccio Brousse Serac	St. Félicien Tommes de montagne	Bougon Chevreton Mont d'or		Bleu de chevre Persillés des Aravis Persillés du Mont Cenis

Source: Le Jaouen (1977).

Skins

Fresh goat skins are air dried and seldom receive further treatment. Collection in the rural areas starts in the local market, where the farmers and butchers bring the raw skins for sale to the local skin traders called "corretores." The traders

purchase small lots of skins until they have enough to resell to the wholesaler ("ambulante"). The ambulante then sells to a large urban-based middleman or directly to the tanneries or exporters.

Brazilian industry has a capacity for tanning over 14 million skins, of which 5.0 million are goat skins, and for producing over 500 million pairs of footwear, ranking Brazil among the major leather product manufacturing countries of the world.

The skin market in Brazil has several peculiar economic characteristics that tend to make it unstable because of a lack of self-correcting mechanisms:

(a) The supply is a function of the demand for meat, not the demand for skins, since skins are a by-product of the slaughtering process.

(b) The demand for skins is a derived demand, based on the requirements of the various end products, such as footwear, garments, and accessories.

(c) The possibilities for stockpiling skins are very limited, as arbitration to match supplies with market requirements is not possible.

(d) Brazil is basically a price taker in the international market for goat skins, having little market power to influence world prices.

As a consequence, the large fluctuations in goat sales have little influence on the prices received for skins, since these prices are set by world market, and increased supplies from Brazil would not be of sufficient magnitude to depress international prices. As a consequence, the prices received by goat producers and marketing agents are influenced primarily by domestic meat demand.

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Chapter 12

SPECIAL REQUIREMENTS FOR DAIRY GOAT PRODUCTION IN THE SEMIARID TROPICS

W.L. Johnson and H.J. Burstein

Goats in Northeast Brazil traditionally have produced meat and hides but very little milk, either for family use or for sale to the public. In recent years, interest in dairy goat production has increased, although not rapidly. The purpose of this chapter is to highlight some of the special management factors to consider if a shift from meat to milk production is planned.

The producer contemplating this shift must first carefully define his goals. Does he wish only to take the milk from a few does for use in his household? Does he wish to sell fresh milk to his neighbors? Or are his goals more ambitious, with the desire to provide cheese or fresh milk to a wider market? Does he already have an established herd for meat production, as a starting point? Or will he start from the beginning with a specialized dairy herd? His needs for capital and new management skills will increase proportionally with the complexity of his goals.

Environmental Limitations

Goats, like other ruminants, are affected by the physical environment in which they are raised. Indigenous breeds become adapted to their environment by natural selection across many generations.

Native goats in Northeast Brazil have adapted to the heat and seasonality of feed supply by reducing body size; this simultaneously reduces the total maintenance requirement and metabolic heat load and increases the efficiency of heat loss. They have also evolved with very low levels of milk production. Milk yields of indigenous breeds and SRD goats grazing in the caatinga with only a mineral supplement were reported to be in the range of 400-500 g/day (Bellaver et al., 1980). Burstein (1988) reported an average daily milk yield of 600 g for does of these same breeds during the first month after an early wet season kidding, declining gradually to less than 400 g six months later.

Breeds that evolved in Europe or South Asia and that have been highly selected for milk yield can produce up to 4 or 5 kg per day when maintained in a cool climate with adequate nutrition. However, their milk yields are greatly reduced when translocated to a tropical environment. As their milk yield decreases, their economic efficiency will also decline, especially if high levels of costly feed supplements are necessary.

In one experiment conducted in Paraiba (Northeast Brazil), German Fawn and Anglo-Nubian goats, kept in confinement with ad libitum forage and 650 g of concentrate, produced only 1.2 and 0.9 kg of milk, respectively (see Table 5; Johnson et al., 1986). Goats not adapted to tropical conditions decrease their feed intake and suffer a continual stress due to the difficulty of dissipating metabolic heat from their body. Under these conditions it is impossible for their genetic potential for milk production to be

fully expressed.

The milk production of 12 goats each of three breeds (36 goats in all) was compared by Rodrigues et al. (1982) at the Pendencia Experimental Farm in Paraíba. The goats grazed buffelgrass (Cenchrus ciliaris) pastures during the day and received 500 g of concentrate for milk yields up to 400 g per day, then 200 g of additional concentrate for each 400 g increment in milk yield. From 45 to 157 days post-partum the average daily yield of German Fawn does was 2.2 kg, while Anglo-Nubian does produced 1.5 kg and SRD does produced 0.8 kg.

It is evident from these and other experiences that the environment will impose severe limitations on the development of dairying with goats. Producers who are located in the interior lowlands of Northeast Brazil and similar harsh environments elsewhere must keep these limitations in mind when considering commercial dairy goat production. They can milk a few goats as a backyard operation, to provide milk and/or cheese for their families and neighbors, but they will be at a great economic disadvantage for full-scale commercial production, compared with producers in more favorable locations.

There are isolated and peripheral microclimates within or near larger semiarid tropical regions where commercial dairy goat production may be feasible. In Northeast Brazil, for example, some isolated regions with higher elevations could be considered, as could the zone near the coast where the climate is tempered by proximity to the ocean.

Two recent studies of 43 dairy goat producers in the states of Paraíba and Rio Grande do Norte, Northeast Brazil, revealed a mixture of native and exotic breeds being used. The average milk yield per doe reported from these studies was 700-900 g per day, over a lactation period of about 4.5 months (Baker and Souza Neto, 1987; Souza Neto and Gutierrez, 1987).

Installations and Facilities for Dairy Goats

If a meat goat producer plans to make a modest commitment to a new dairy enterprise, the additional facilities required will be minimal and will consist of the following:

1. A milking stall or platform, protected from rain and mud, equipped with a stanchion for securing the doe and a feed box for offering supplemental feed during milking, elevated for the comfort of the milker.

2. Holding pens for separating the milking does and their kids from the rest of the herd and from each other.

3. A safe, dry place for storing feed, medicines and other supplies.

4. Clean, safe containers for collecting and holding the milk.

5. Bottles or a bucket with nipples for feeding milk to kids.

6. A source of clean water for the animals to drink and for washing utensils.

7. Separate pasture and holding pen for the buck(s) during the period of the year outside the breeding season.

Separate pens for isolating sick animals and for maternity are especially important for the dairy herd. Also, it is even more important to provide a roof (for protection from rain and sun) for dairy than for meat animals.

If the producer has as a long-term goal the possible expansion of his dairy operation, he will want to locate his initial facilities in a place where such expansion will be convenient.

Additional Nutrient Requirements for Milking Does

The traditional meat goat production system in the semiarid tropics uses grazing on natural pastures as the feed base, with a minimum of additional feed input. Goats survive under this system but have low levels of productivity. If the producer wishes to guarantee an output of milk for his own use or for sale, he will have to ensure that his does are well fed; without an adequate nutrient intake, they will not produce much milk. This means that attention must be paid to the provision of high-quality forage.

The nutrient requirements of a milking doe will be in direct proportion to her level of production. The U.S. National Research Council (NRC, 1981) estimates the daily requirement for each liter of milk produced by a goat to be 1.20 to 1.25 megacalories of metabolizable energy (ME) and 60 to 75 grams of crude protein (CP). The lower figures refer to milk with about 3% fat, and the higher figures refer to milk with 4% fat or more. These nutrient requirements are in addition to the maintenance requirement of a mature doe or the maintenance plus growth requirements of a young (first lactation) doe, and do not take into account additional maintenance energy requirements related to heat stress and heat dissipation. The practical implication of these requirements is that for the production of one liter of milk per day (a good target for average yield of goats on farms in Northeast Brazil) the daily ME requirement for a 30-kg mature doe increases by 100%, while her daily protein (CP) requirement increases by about 140%, compared to her maintenance needs. Put another way, she will have to double her energy intake and more than double her CP intake in order to maintain a milk yield of one liter per day.

It happens that the requirements for one liter of milk almost coincide with the requirements published by the NRC for the last 4 to 6 weeks of pregnancy (above maintenance). Thus an adequate feeding program for late pregnancy, carried forward into the immediate postpartum period, should support the production of one liter of milk per day.

For the more modest milk yield of 750 grams per day, energy intake will have to increase by 75% and CP intake by about 100% over the maintenance requirement. And for the minimal milk yield of 1/2 liter per day, energy and protein intake will have to increase by 50 and 70%, respectively, over the maintenance requirement. These calculations are based on the NRC estimate of

1.30 Mcal ME and 50 grams CP as the maintenance requirement of a 30-kg mature doe.

The first parity doe (kidding for the first time) is not likely to have achieved her mature weight. To produce milk and to continue growth at the same time she will need to have 0.36 Mcal ME and 14 grams of protein, or about 25% of the maintenance requirement, added to her daily intake to support the growth requirement.

In addition to energy and protein, the requirements for minerals and water will have to be met if milk production is to remain at a desirable level. Clean water should be available continuously. The minimum provision of minerals should include salt and iodine; other minerals may be necessary as well, depending on local soil and plant deficiencies. Calcium (Ca) and phosphorus (P) are especially important for gestation and milk production. The NRC (1981) suggests a minimum allowance of 2 g of Ca and 1.4 g of P per day during the last weeks of pregnancy and the same amounts for each liter of milk produced. As with energy, this means a 100% increase over the requirement for maintenance alone for a 30-40 kg goat. Further, the ratio of Ca to P must be kept in proper balance; the NRC suggestion is at least 6 parts of Ca for each 5 parts of P (ratio 1.2 to 1.0).

Other minerals that may occasionally need to be supplemented are sulfur (for maximum rumen microbial growth), cobalt, copper, zinc and selenium. Local soils and vegetation should be analyzed for these minerals to determine whether or not a problem exists.

During the months when the caatinga is green, grazing goats have little likelihood of encountering problems of mineral deficiency. For goats fed harvested forages in complete confinement, and for all goats during the late dry season, some minerals may be marginal or deficient.

Feeding Milking Does in Normal Years

Data presented in Chapter 5 suggests that the digestible energy (DE) intake of non-lactating goats grazing caatinga can be as high as 65 kcal per kg of body weight during the rainy and early dry seasons. This level of intake is sufficient to meet the energy requirement for maintenance and allow for milk yields up to 300-400 g per day. Crude protein (CP) intake will also be sufficient for this level of milk yield.

Sheep (Smith et al., 1986) and dairy cows (Johnson et al., 1966) are known to increase their forage intake when lactating, and dairy goats can be expected to do the same. A conservative conclusion would be that additional concentrate is needed to support milk yields above 500 g per day. Data presented by Bellaver et al. (1980) support this conclusion; in their study, average milk yield of unsupplemented goats and hair sheep of several breeds was 532 g per day in the rainy season, dropping to only 262 g per day in the dry season.

The supplement should contain at least 3.0 Mcal DE (2.45 Mcal metabolizable energy) and 130 to 140 g CP in each kg of dry matter. For each 100 g of milk above 500 g per day, an allotment of 50 g

of such a concentrate will be necessary.

Once the intake of supplement goes above 250-300 g per day, there will be a substitution effect for intake of caatinga herbage. Thus, for goats with milk yields above 1.0 kg per day the additional increment of concentrate will need to be in progressively higher proportion to increments of milk yield.

These recommendations are summarized in the first column of Table 18.

Feeding Milking Does in Very Dry or Very Wet Years

There is evidence, as reported in Chapter 5, that the non-lactating goat decreases its DE intake to about 40 Kcal per kg body weight in poor years. In abnormally dry years, forage availability will be limiting, as will be the opportunity for selectivity. In very wet years, caatinga herbage intake may be limited by behavioral factors, particularly the unwillingness of goats to expose themselves to rain, soggy ground, wet foliage, and biting flies. The reported level of energy intake is below the maintenance requirement, and supplemental feed will be required to prevent weight loss at any level of milk yield. The suggested allowances in Table 18, column 2, take these factors into account.

Feeding Milking Does During the Late Dry Season

Perhaps the best advice for the most severe months of the dry season, when the best leaf litter and browse in the caatinga have been exhausted, is to dry off all does and not attempt to produce milk. Feed limitations and heat stress are both at their most severe state during these months.

However, if the producer does wish to continue milking some animals he will need to provide most of their energy and protein in the form of forage and concentrate in confinement. The suggested allowances in Table 18 (third column) for dry season feeding assume that a good quality forage is provided. Examples of such forages would be young napier grass (mostly leaves), forage sorghum, and cunhã hay (Clitoria ternatea). If a doe is expected to consume 500 g of dry matter from any of these forages, she must be offered a higher amount, to allow selection of the more nutritious and appetizing portions (mainly leaves) and refusal of the highly lignified, poorly digestible stems. A practical suggestion is to offer 750 g per animal and expect refusals of 250 g. The refused feed can be used for mulch or compost or fed to dry cows.

Total Confinement Diets for Lactating Goats

There has been limited research on complete diets for lactating goats kept in total confinement in Northeast Brazil. Two experiments which were conducted at the Pendencia Experimental Farm in Paraíba were reported by Johnson et al. (1986). In these experiments the goats received forage, water and trace-mineralized salt ad libitum, along with the diets described in Tables 19 and 20. Milk yield, milk composition, feed intake and doe weight changes were observed for 90 days, starting 2 days after

parturition in Exp. 1 and 3 months after parturition in Exp. 2. The results are shown in Tables 21 and 22.

Milk yields were higher than 1.1 kg per day for German Fawn goats, but only 600-900 g per day for the Anglo-Nubians. In Exp. 1, goats fed sorghum hay out-produced the buffelgrass hay groups (with or without maize supplementation) and the goats receiving only forage plus cottonseed cake. In Exp. 2 there was a tendency for milk yield to decrease as jackbean meal (Cornavalia ensiformis) replaced cottonseed cake as the major protein supplement.

In Exp. 1, conducted early in the lactation period of the goats, milk yield was closely related to dry matter intake (Table 4). Sorghum hay was consumed at higher levels than buffelgrass. However, does lost weight (5.5 to 7.7 kg over 90 days) on all diets except treatment 4, which included sorghum hay plus 250 g cottonseed cake and 400 g maize. Total feed dry matter intake was less than 3% of body weight on the diets, which resulted in significant weight loss. On treatment 4, intake reached 3.6% of body weight.

In Exp. 2 feed dry matter intake was above 4% of body weight on all treatments, and does essentially maintained a constant body weight throughout the 90 days. As more jackbean meal was added to the diet, total feed intake increased; but due to a parallel decrease from 70 to 61% in dry matter digestibility (Johnson et al, 1986), the milk yield declined.

TABLE 18. SUGGESTED ALLOWANCES FOR CONCENTRATE FOR LACTATING GOATS WHICH GRAZE FREELY IN CAATINGA VEGETATION

	Concentrate allowance (g per head per day)[a]		
Milk yield (kg/day)	Rainy and early dry seasons		Late dry season[b]
	Normal years	Very wet or very dry seasons	
0.5	0	250	300
0.6	50	300	360
0.7	100	360	425
0.8	150	425	500
0.9	200	500	575
1.0	250	575	650
1.1	325	650	725
1.2	400	725	800
1.3	475	800	900
1.4	550	900	1,000
1.5	625	1,000	1,100
1.6	700	1,100	1,200
1.7	800	1,200	
1.8	900	(Higher concentrate levels	
1.9	1,000	are not recommended)	
2.0	1,100		

[a]The concentrate is assumed to contain 3.0 Mcal digestible energy per kg of dry matter, and 13-14% crude protein.
[b]Supplemental good quality forage should also be provided at a level to allow intake of 500 g per day.

TABLE 19. COMPONENTS OF THE FOUR DIETARY TREATMENTS FOR LACTATING DAIRY GOATS (EXP. I), WITH DAILY AMOUNTS FED AND CHEMICAL COMPOSITION (JOHNSON ET AL., 1986)

	Dietary ingredients			
	Buffel-grass hay	Sorghum hay	Cotton-seed cake	Ground maize
Diet no.			g/day	
1	Ad lib.	-	250	-
2	Ad lib.	-	250	400
3	-	Ad lib.	250	-
4	-	Ad lib.	250	400
Composition (% of DM)				
Crude protein	6.5	6.3	25.2	9.3
Neutral-detergent fiber	69.0	72.4	30.9	22.2
Hemicellulose	28.3	32.4	8.0	17.6
Cellulose	36.9	35.5	13.7	5.0
Acid-detergent lignin	3.7	4.1	9.6	.8

TABLE 20. COMPONENTS OF THE FOUR DIETARY TREATMENTS FOR LACTATING DAIRY GOATS (EXP. 2), WITH DAILY AMOUNTS FED AND CHEMICAL COMPOSITION (JOHNSON, ET AL., 1986)

	Dietary ingredients			
	Sorghum green chop	Ground maize	Cotton-seed cake	Jack-bean meal
Treatment no.			g/day	
1	Ad lib.	500	300	-
2	Ad lib.	500	200	175
3	Ad lib.	500	100	350
4	Ad lib.	500	-	530

Composition (% of DM)

		Concentrate mixtures			
Chemical fraction	Sorghum green-chop	Trmt. 1	Trmt. 2	Trmt. 3	Trmt. 4
Crude protein	17.9	23.4	23.1	23.1	19.9
Neutral-detergent fiber	64.0	46.0	48.0	52.0	58.4
Hemicellulose	31.9	27.7	29.2	32.4	34.3
Cellulose	27.2	11.7	14.4	15.5	18.8
Acid-detergent lignin	2.9	5.0	4.6	4.9	5.1

TABLE 21. DIETARY TREATMENT EFFECTS ON MILK YIELD AND COMPOSITION, AND DOE WEIGHT CHANGES, (EXP. 1 AND 2) (JOHNSON ET AL., 1986)

Diet[a]	Milk yield g/day	Fat %	Dry matter intake g/day	Dry matter intake % of body weight	Doe wt. change kg/90 da.
		Experiment I			
B, CS	848b	3.7bc	874	2.0	-5.6bc
B, CS, M	1042c	3.6b	1221	2.8	-7.7c
S, CS	990bc	4.0b	1242	2.8	-5.5bc
S, CS, M	1351d	3.7bc	1579	3.6	- .3b
		Experiment II			
0:100	1028c	2.3	1688	4.0	.8
33:67	871c	2.4	1724	4.1	- .5
67:33	789bc	2.7	1821	4.3	.2
100:0	763b	2.7	1886	4.4	- .6

[a]Exp. I - B = buffelgrass, S = sorghum hay, CS = cottonseed cake, M = ground maize.
Exp. II - proportions of crude protein from cottonseed cake and jackbean meal (Canavalia ensiformis).
bcd-Means within a column, followed by different letters, are significantly different (P<.05); each experiment is independent from the other.

TABLE 22. BREED EFFECTS ON MILK YIELD AND COMPOSITION, AND DOE WEIGHT CHANGES, EXP. 1 AND 2. (JOHNSON ET AL., 1986)[a]

Breed	Milk yield g/day	Fat %	Total solids %	Solids not-fat %	Doe wt. change kg/90 da.
		Experiment I			
German Fawn	1220	3.0	10.8	7.8	-2.3
Anglo-Nubian	912	4.4	13.0	8.6	-6.9
		Experiment II			
German Fawn	1112	1.9	9.8	7.9	.4
Anglo-Nubian	614	3.2	11.9	8.7	- .4

[a]All breed differences within each experiment are significant at P<.01, except doe weight change, for which P<.05 for exp. I and n.s. for exp. II.

A conclusion from these experiments is that a minimum intake of 3.5 to 4.0% of body weight is necessary to maintain reasonable levels of milk yield while preventing undue weight losses. A high quality diet will be necessary to achieve this intake goal. Unless cell-wall fiber is kept at levels below 55% of the total diet, one can expect intake and therefore milk production to be lower than the levels achieved in those two experiments.

Selection of Does for Milking

Which does should be chosen for milking? The best criterion is actual milk yield, but only after having milked a doe is this information available. The producer who milks some of his goats daily will soon learn which does produce the most milk and which produce the least. The first group are good candidates for special attention in the breeding herd. On the other hand, does producing less than one-half liter of milk per day are good candidates for culling, because they will not even produce kids with desirable weaning weights.

As the dairy enterprise develops, accurate milk records will be vitally important as the basis for culling and selection.

The producer who milks his does every day will quickly get an impression of their relative docility and ease of milking. Both physical and personality traits are important. Size and shape of the teats and the tightness of the teat sphincter will regulate the ease of actual physical withdrawal of the milk, while the animal's disposition will determine whether the milking process is a pleasant experience or a struggle. Does that present difficulties in physical or in personality traits might best be relegated to the meat-producing herd, especially if their milk yield is only average or lower.

The selection of does without previous milk records is difficult. Conformation traits can be helpful, and are described in other publications (Considine and Trimberger, 1978; Gall, 1980; Zometa et al., 1985). One useful indicator would be to look for does that have previously weaned twins with an average or better growth rate, because these does will be average or better milk producers.

Procedures for Milking and Milk Handling to Maintain Milk Quality

Good hygienic practices are important at all stages of milking and milk handling to maintain a safe and pleasing product for human consumption. Hygiene starts with the milker, who should wash his (her) hands well, with soap, before starting milking. Loose dirt and other material which might fall into the milk pail should be brushed away from the animal, and the teats washed with a mild disinfectant solution. All containers for milk should be clean and dry.

The recommended practice is to pasteurize the milk immediately. This can be accomplished in the kitchen of the producer's home over any heat source. If a thermometer is available, heat the milk to 75°C and then remove it immediately from the heat. Without a thermometer the pasteurization temperature can be approximated by removing the milk from the heat source before boiling, just as foam is beginning to form on the surface. In either case the milk should be stirred continuously while heating. After pasteurizing, immediately cool the milk by placing the container of milk in a larger container of cool (preferably running) water, while continuing to stir. Properly pasteurized and cooled milk can be kept for several days if refrigerated and at least overnight without refrigeration, or the

milk can be processed for cheese or yogurt.

How to Feed and Manage the Kids of Does Selected for Milking

The producer who wishes to milk his does from the first week postpartum must be prepared to pay special attention to their kids. Kid mortality may increase if he does not feed and care for them properly.

For less intensive milk production, two options exist whereby kids can continue to suckle their mothers directly. The first is to milk the does only after the kids are weaned, which process could occur at 60 days if the doe is a good milk producer, if the kid has grown normally and is healthy, and if a high quality post-weaning diet is available. The second is to milk the does only once a day after several hours of separating them from their kids during the preweaning period. For the first two weeks of life the kids should not be separated for longer than six hours at a time. Thereafter, if the kid is healthy and growing normally, the separation can be increased up to twelve hours. For the remaining twelve hours the kids should remain with the does.

Does which have borne twins should not be milked on the once-a-day schedule, since the remaining milk will not be sufficient for the needs of the twin kids.

If a more intensive production of milk is desired, the kids must be removed completely from their mothers after about 3 days of colostrum ingestion. From the very first day these kids must start to be trained to bottle feeding. The same type of bottle and nipple that is used for human babies is effective for hand-nursing kids. Special buckets with nipples for nursing several kids at a time can be purchased commercially, or can be made by a local metalsmith.

The amount of milk to be provided to each kid will increase during the first three to four weeks or until the kid is eating forage (and perhaps also concentrate; see below) well. During the first week each kid should be allowed to drink as much milk as it wills; milk should be offered three or four times per day. The upper limit for milk intake is about 20% of the kid's weight each day for the first two months of life. If the kid's appetite for forage is good and it is otherwise healthy, it can be weaned at sixty days of age, at a minimum of 6 kg, the normal body weight range for SRD kids in this age group (Melo Lima et al., 1983). However, if the kid's growth has been retarded due to diarrhea or other disease, weaning should be postponed. A recommended weaning system is to simply remove 1/4 of the daily milk allotment each day over a four-day period, and thereafter offer no milk at all.

In order to hasten the development of their rumen, kids should be offered a good quality forage starting at two to three days of age. The forage can be hand cut from the caatinga (palatable species) or, in the dry season, a good quality hay (cunhã, matapasto, forage sorghum or immature napier grass) can be offered.

For maximum growth rates, or for early weaning, kids will also need to consume a high quality concentrate, equivalent to a mixture of corn (2 parts) and cottonseed cake (1 part). This will be especially important if the only available forage is of poor

quality (dry season caatinga, or a cultivated forage harvested beyond the immature state). The concentrate can be first offered at seven to ten days of age, and ad libitum intake allowed until each kid is consuming up to 100 g (small breeds) or 150 g (large breeds) per day. As the kid grows, and if the forage continues to be of high quality, the concentrate can gradually be withdrawn at about three months of age. Access to iodized salt and clean drinking water is important, especially after weaning.

Other management practices for dairy kids (disinfecting the navel, dehorning, castration, vaccinations, and drenchings) should follow the same recommendations as for goats raised exclusively for meat.

Upgrading the Dairy Herd by Selective Breeding

The serious producer of goat milk will want to improve gradually the dairy qualities of his herd. Some suggestions for the initial selection of does were presented earlier in this chapter. Culling of the initial herd may be dictated by low milk yield, breeding difficulty, poor udder or teat conformation, lameness, or poor disposition for hand milking. The precise weight to be given to each of these factors will vary among farms, depending on the number of does available, their individual milk yields, and the specific combinations of traits observed in individual animals.

Milk yields should be measured, not guessed at. If a set of dairy scales is available, the daily milk yield can be weighed, recorded, and later compared among does. Alternatively, a volume measurement will serve just as well. Soft-drink bottles or any small bottles or jars of uniform size can serve as the unit of measurement.

The best criterion for the selection of replacement females is their mothers' demonstrated performance. Selection criteria for a doe kid will include her mother's measured milk yield, and, of lesser importance, her mother's udder and teat conformation, reproduction performance, and disposition.

Perhaps the most important decision the dairy goat producer will make is his choice of a buck to which to breed his dairy does. One half of the genetic contribution to the milk-producing capacity of the kids will come from the buck. The best measure of a young buck's dairy value is the milk yield of his closest relatives: first his own mother and full sisters and then his half sisters. A producer will be undertaking a large risk in purchasing a buck, regardless of its breed and physical appearance, if this information is not known.

The producer may wish to acquire a buck with specialized dairy breeding and thus upgrade his herd. Rapid genetic improvement can be attained by this method. However, feeding and management improvements must occur at the same time, or the investment in improved genetic capacity will be wasted. Worse, by selecting a buck of exotic breeds, adaptation to local climate and resistance to local diseases may be sacrificed, making improved feeding and management all the more crucial to success.

Selection of a buck from within the herd is an alternative

only if the herd is large enough to avoid inbreeding. Very likely it will be necessary in this case to keep at least two breeding bucks and to separate the does into two breeding herds so that neither buck will breed any does closely related to him. The producer with a small herd should always obtain his buck from outside, still using the known milk production of the buck's close relatives as the most important selection criterion.

Managing the Reproduction of Does in the Dairy Herd

Because milk production is physiologically linked to reproduction, the management of reproduction will directly influence the timing of the milk supply, as well as the coordination of the doe's nutritional requirements with the annual calendar of feed supply.

The backyard producer who wants just a few liters of milk for his family can exercise maximum flexibility in his reproductive management. As long as he has several does bred to kid at various times of the year, he will be able to select a few of them for milking at any time. He will need to adjust his feeding practices to the season, as discussed earlier.

The producer with the greater ambition of producing milk for sale or of making cheese will probably find it most economical to control and limit the season for milking does. The Brazilian National Goat Research Center in Sobral, Ceará has chosen a November breeding season, with kidding in April, for its Anglo-Nubian dairy herd. By the time the does enter advanced gestation (late February) the caatinga vegetation is in full production, following the onset of rains in late January. With kidding occurring in April, some of the worst problems of kid management and diseases that occur during the early part of the rainy season are avoided. And, for the milking does, a full five months of adequate caatinga forage can be expected, consisting of green herbage until June or July, then dried standing hay, and finally the first fall of palatable tree leaves for August and September. A minimum of year-round supplemental feed is required under this system, assuming that does will be dried off as soon as the dry season caatinga forage starts to depreciate rapidly.

Other breeding calendars could be followed. However, the producer must be prepared with advance planning for his feed requirements under any calendar.

If ample year-round good quality forage is available, an accelerated breeding calendar could be considered (three kiddings and three lactation periods in two years). However, the expected costs and returns of such a system should be carefully budgeted before it is undertaken.

Other aspects of breeding management of particular importance for dairy production include the protection of does from exposure to non-selected bucks, the castration or the early removal of young bucks not desired for breeding purposes, and the supplemental feeding of replacement doe kids to maintain an adequate growth rate (50 g per day), especially through the dry season, to ensure that they reach breeding age in minimum time and in adequate condition.

Special Disease Problems and How to Prevent Them

Chapter 8 discusses specific diseases of importance to Northeast Brazil and various ways of guarding against serious disease problems. The transmission of diseases is perhaps easier in a dairy flock, due to closer contact among individual animals on a daily basis. Avoiding muddy conditions and flies around the milking facility is especially important, as is the immediate isolation of any sick animals.

Mastitis is a disease that may present special problems in the dairy herd. Fortunately, low incidences of mastitis have been detected in Northeast Brazil (Paulo et al., 1985). Most forms of mastitis are highly contagious. Should overt symptoms of mastitis be noted (abnormal udder swelling and caking, bloody and/or curdled milk) immediate steps should be taken to avoid its transmittal to other does. The infected doe should be milked last, and her teats and udder carefully washed before and after milking. The milking platform should then be thoroughly cleaned. Due to the high cost of treatment, and the high probability of mastitis organisms remaining viable in the dry udder until the next parturition if no treatment is given, the best course may be to cull the doe immediately.

Mastitis prevention should be on the mind of the milker and herd manager during every phase of goat management. The pens and holding areas should be kept as dry as possible and free of mud. Dehorning is important in reducing udder injuries inflicted by fighting. Animals with draining abscesses should be isolated. The milking routine should start with clean hands and the washing of the teats and the udder floor with a mild disinfectant. Dipping the teats in a recommended iodophor solution after milking is also recommended.

Conclusions

The back yard milking of two or three does for family use is to be encouraged because of the positive contribution this will have on the nutritional well-being of the family members who consume the milk. The energy, protein, and minerals (especially calcium) are important for young children, especially as they are weaned from their mother's breast. Calcium from milk is important for people of all ages, and most especially for aging women. The potential contribution of goats to family nutrition in rural semiarid areas has only begun to be tapped.

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Chapter 13

MEASURING THE ECONOMIC FEASIBILITY OF NEW SMALL RUMINANT TECHNOLOGIES IN BRAZIL

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This chapter briefly describes and illustrates the economic analysis of on-farm animal research. In the analysis of the components of a technology, techniques such as partial-budget, gross-margin, break-even, and benefit-cost analyses are useful. These analytical tools require only limited data, are easy to use, and can be applied to farms of all sizes, from small subsistence to large commercial units. However, they only indicate the profitability of a technology and do not reveal its interactions with other components. When a technology that affects more than one farm enterprise is considered, or when a reorganization of the farm is required, whole-farm budgets should be prepared. In this chapter, the above techniques are explained, along with their strengths and weaknesses and the situations where their use is appropriate. With the information presented in this chapter, the reader should be able to

- choose the appropriate analytic technique, depending on the technology being evaluated
- use partial-budget, gross-margin, break-even, benefit-cost, and whole-farm budget analyses with data from experiment station or on-farm animal research.

Techniques for Economic Analysis

There are numerous forms of evaluation for new farming technologies/methods/systems. The most frequently used and least expensive is intuition, often in association with discussions between researchers and farmers. A more detailed and structured form of evaluation is budgeting. Budgeting is the tabulation of gains and losses of a (farm) operation. Gains and losses can be measured using any units. Most commonly, monetary units are used since this allows for the easy computation of total gains and total losses. However, nutritional budgets for households, measured in calories or crude protein, may also be used, as may energy budgets measured in energy units for whole farms. The budgeting analysis offers an organized listing of the quantities of resources used (inputs) and products produced (outputs). Once these technical input-output relations have been specified, socioeconomic values can be applied to these inputs and outputs. The return to individual resources or to the total resources of the farm are then calculated.

Partial budgeting is the simplest and most commonly used of the budgeting techniques. It is used to evaluate a technological change that affects only part of the farm operation. A technique similar to partial-budget analysis is gross margin analysis. Gross margin analysis is used for comparing several technologies or enterprises for inclusion in the total farm plan. As in partial budget analysis, it is assumed that there is no change in fixed resources. When a change is considered that would require different fixed resources or a total reorganization of the farm,

whole-farm budgets should be constructed.

Two other techniques provide additional information to decision makers and may be used in conjunction with the methods discussed above. Break-even analysis provides for the calculation of the level at which returns and losses are equal. For example, the price at which a certain technology pays off can be calculated. Benefit-cost analysis is similar to gross-margin analysis, the difference being that costs and returns are separated into cash and noncash categories. Various measures are then calculated to be used in evaluating the technologies.

Budgeting

Budgeting is perhaps the simplest tool available for deriving preliminary estimates of the profitability of single interventions. Bradford and Johnson (1953) define a budget as the sum of all expected products (or increased inventories) times their respective prices, less the costs of all items used in production. Budgeting allows one to compare different plans and provides a rationale for choosing one plan over another.

The following assumptions are made in budgeting:

Divisibility: All factor are perfectly divisible, that is, labor can be used for a fraction of an hour and draft power can be used in fractional units.

Linearity or additivity: All inputs have a linear relationship with a constant marginal physical product. This means that each additional unit of input to the production process results in the same contribution to the output as the previous unit.

Perfect knowledge: The decision-maker has perfect foresight of the inputs and outputs required to produce a given activity, and all coefficients are known with certainty.

Nonnegativity: None of the activities can be produced in negative amounts nor can resources be used in negative quantities.

Partial-budget Analysis

Among the general types of budgeting (such as gross margin, parametric, and enterprise) partial budgeting has special significance. It is widely used to determine the profitability of a single intervention. Because of its widespread applicability in analyzing innovations, a major portion of this chapter is devoted to describing, discussing, and interpreting partial budget analysis.

According to Dillon and Hardaker (1984) a partial-profit budget (partial budget for short) is an estimate of the effect on some measure of farm profit of a proposed change in the farm plan. Partial budgeting is used in two ways. In the evaluation of new technologies during the period that scientists are still working on the design of the technology, it is used to provide a measure of how attractive this new technology might be for the target

farmers. During the validation and extension phase of the technology, partial budgeting can be used by Farming Systems Research and Extension (FSR/E) workers and farmers to estimate whether it will pay for a farmer to adopt this innovation.

A partial budget is the tabulation of expected gains and losses due to a relatively minor change in farming method, e.g., the replacement of one goat breed with a new one, the introduction of a new forage, or the use of a new vaccine. It is a method of balancing and examining the total gains (benefits) and losses (costs) that will result if a change is made in a part of the farming system. The term "partial" indicates that the change occurs in only one component of the farm and implies that no major change in the farmer's resources or overall farming plan will occur.

The partial budget requires minimal information about changes in variable costs and benefits; however, production and price information must clearly reflect farm conditions. (The general tendency is to overestimate benefits and underestimate costs.) Since partial-budget analysis is relevant only for component technology, it is not suitable for answering questions in which several factors determine the contribution of a treatment. In the case of livestock, the true effect of the treatment on milk yield, reproduction, changes in animal weight, or other variables should be estimated carefully. Erroneous production coefficients may result in misleading conclusions. At times, it is more appropriate to develop partial budgets for a whole herd than for a single animal.

Partial budgets may involve from one to four elements including

- added costs
- added returns
- reduced costs
- reduced returns.

These four elements give direction to the specific items to be estimated. They can be grouped according to their effects on net returns. The added returns and/or reduced costs constitute the gains from which to deduct the losses--added costs and/or reduced returns--to arrive at the difference, which is the profit or loss resulting from the technology.

Added returns plus Reduced costs	minus	Added costs plus Reduced returns	equals	Profit or Loss

The above equation may be set into a form that allows detailed itemization, as follows:

Gains (A)	Losses (B)
Added returns Reduced costs	Added costs Reduced returns
Total A	Total B

Change (A - B) = Profit or Loss

The element of costs (including their magnitudes) is the bulk of budgeting. The following example shows how the format above can be used to solve a problem.

Suppose one wants to compare the profitability of raising native nondescript goats (SRD) with that of raising the Anglo-Nubian breed. The research has produced the data for a 100 ha goat farm entered in Table 23.

Therefore, one can compile the partial budget shown in Table 24 that shows the gains and losses associated with raising Anglo-Nubian goats rather than SRD goats.

The net differential benefits per 100 ha farm per year of substituting the traditional system of raising native SRD goats for one of raising Anglo-Nubian goats was US$3.83. Such results would suggest that it would be profitable for farmers to shift from producing SRD to Anglo-Nubian goats. However, additional cash costs would be incurred for medication and additional labor, which were priced at the market rate.

As shown in the above example, four types of data are required:

- physical input and output data
- price data--prices of inputs and outputs
- resource input requirements--labor, land, and capital
- resource basis of farm.

TABLE 23. ANNUAL GAINS AND LOSSES ASSOCIATED WITH INTRODUCING THE ANGLO-NUBIAN BREED TO A TRADITIONAL 100 HA, 40-GOAT FARM, WITH THE SRD BREED[a]

Gain-loss components	Quantity	Price
Additional weight of Anglo-Nubian goats[b]	64 kg	US$0.38/kg
Additional manure produced by Anglo-Nubian goats	192 kg	US$.006/kg
Additional labor required for Anglo-Nubian goats	52 hours	US$0.27/hr
Additional medication required for Anglo-Nubian goats		US$0.19/goat
US$1.00 = Cz$104.7 (March, 1988)		

[a]Hypothetical example.
[b]For the purposes of this example, it is assumed that the cost of SRD and Anglo-Nubian goats is the same.

TABLE 24. PARTIAL BUDGET FOR INTRODUCING THE ANGLO-NUBIAN BREED ON A TRADITIONAL 100 HA, 40-GOAT FARM, WITH THE BRD BREED, FOR ONE YEAR

Gains (A)		Losses (B)	
Added returns		Added costs	
Weight gain	US$24.32	Labor	US$14.04
Manure	1.15	Medication	7.60
Subtotal	US$25.47	Subtotal	US$21.64
Reduced costs	--	Reduced returns	--
Total A	US$25.47	Total B	US$21.64

Change (A - B) = US$3.83 profit

Advantages and Disadvantages

Partial budget analysis has the following advantages:

- It is simple and can be performed with a hand calculator. It can readily be taught to extension workers and to farmers who have some education.

- It is effective for assessing the economic viability of single-intervention technologies since it examines only the net changes in costs and benefits.

- It implies a minor change in the farmer's whole farm operation. Generally, this is the way farmers adopt new technologies: stepwise-and-partial rather than by shocks or revolutions.

- It requires less data than whole-farm budgeting since aspects of the operation that remain constant are not examined. Nearly any other form of economic analysis involves collecting at least the same information as that needed for conducting a partial budget analysis. In many cases, firm conclusions about the adaptability of new technologies can be drawn after only a partial analysis without going into the more cumbersome details of the components of the farming system that will not be affected. It is, therefore, a time-efficient method.

- The major advantage of partial-budget analysis, its simplicity, also leads to several drawbacks, including the possibility of overlooking or underestimating important factors. The impact of these drawbacks can be lessened, however, by exercising care in the determination of the factors to be included in the analysis, as well as their magnitudes, and by presenting other information that may not directly affect the partial budget analysis but that may be relevant to the technical implementation of the technology.

Partial budget analysis has the following disadvantages:

- The greatest danger in using partial budgeting is the possibility of neglecting the limitation of the resource basis of the farmers, i.e., technologies that have a substantial effect on the farmer's resource basis are analyzed without the economist's realizing this effect. Two mistakes are common. Nearly all new technologies involve an increase in purchased inputs. The availability of cash, however, is a constraint to smallholders. Similarly, technologies are often promoted that intensify the use of land. Generally, these technologies also require a higher labor input per land unit. It is too easily assumed that labor is available or can be diverted from other tasks (farming, household, and off-farm activities) to the farming system component under consideration without accounting for the value of the labor.

- Another danger is in not understanding the farmers' objectives. Farmers do behave rationally; however, this does not necessarily mean that they are concerned with maximizing the returns of one given enterprise. For example, one can demonstrate to farmers the increase in benefits to be obtained by the drenching of their goats. They can even be provided credit for the purchase of the treatment. Nevertheless, they may apply it to their cattle because this species is more important to them or sell it to their neighbors to buy medicine for their families. The key point is that the partial view of a farming system might obscure the secondary character of a given farm component.

- A third drawback is the danger of omitting time from the analysis. During the process of tabulation, all factors are arranged as occurring during the same time period. Timeliness of farm activities, however, is an important aspect. In order to realize how a change resulting from the adoption of a new technology affects other farm operations, it is important to know if the labor required (e.g., 50 person-hours) will occur during one peak period (e.g. one week) or be spread out over a three-month period when there is plenty of slack time.

- Similarly, the time for various farming activities (planting, weeding, and harvesting) is limited. It is therefore necessary to know at what time and for what duration resources are required.

- By the same token, the problem of cash flow tends to be overlooked. The longer the period between cash expenses and cash returns, the less likely that farmers will be attracted to a new technology. This may be handled by explicitly incorporating the time value of money into the analysis.

- If the introduction of a new technology implies keeping animals on a larger scale, the use of small-scale input/output data may be erroneous. Such use assumes linearity of the factors involved, e.g., the assumption

that farmers can raise three times more goats on 3 ha as they can raise on 1 ha. These kinds of assumptions are often invalid because of differences in timing, in the quality of land, in the increased risk of diseases, or in problems in marketing the products. The assumption that an expansion of a unit of resource (e.g., an animal) will increase the profit proportionally may, therefore, be questionable. Similarly, the increase in management skill that many new technologies imply may not be defined.

- Although a partial budget gives an indication of what "better" is, it does not answer the question what "best" is. For example, the daily feeding of 500 g of supplement to a goat will be better (more profitable) than feeding no supplement at all. However, the question remains: at what rate of feeding (250, 500, 750, 1000, etc., g/goat/day) are farmers maximizing their profits, i.e., what daily rate of feeding is the best?

Partial-budget analysis is therefore useful for the following types of trials:

- where a single component must be analyzed (for example, a feed supplement, forage, or medication)
- where the component being analyzed does not involve complex interactions between several other inputs and/or outputs
- where inputs and outputs are measurable and easy to value
- where the animals' performance varies little between farms (for example, when farms use the same species and similar breeds and have equal access to the market)
- where profitability is the major concern rather than issues such as equity and income distribution
- where fixed costs do not change.

In the above case, the new technology affects only one component of the farming system and the anticipated change is minor. In many such cases, a number of factors (resource basis, resource requirement) can be assumed to be fixed and, therefore, omitted from the analysis. Thus, partial budget analysis is most appropriate for cases where only those practices requiring similar noncash resources and similar capital (investment) resources are compared.

Partial budgeting is also appropriate for conducting an economic evaluation of new technologies that are not yet well developed if only a general notion about the feasibility of such a technology is needed. In this case, the merit of the partial budget lies in the tabulation of the factors affected by the technology, rather than in the values (prices) attached to these factors.

How to Conduct a Partial-Budget Analysis

A good start for any economic analysis of new technologies is a statement of farmers' objectives, especially as they relate to

a given farm enterprise. For example, farming households might raise several types of livestock mainly for home consumption. In this case, the farmer might have a target for meat production in mind, and he will try to reach that target with minimal cost. His objective might be to reach this target production and keep the maximum quantity of resources available for other farm operations (or off-farm jobs). Another example is the keeping of small ruminants. It has been argued that many farmers keep a few sheep and goats as a buffer (insurance) against bad times. Just as insurance owners try to keep the premium (price of insurance) low, farmers might try to keep the costs of their animals low by providing minimal inputs (e.g., scavenging). In both of the above cases, the partial analysis of a new technology might lead to the wrong conclusions. A statement of farmers' goals is thus a good beginning.

The second step is a detailed description of the change (new technology) proposed. Based on this description, a determination should be made of which factors will remain the same and which factors are expected to change. The difficulty of determining these factors depends on the stage of technology development. If the technology is in the development state, it may be hard to determine the factors which are likely to change as a result of the technology. "Brainstorming" by the researchers, extensionists, and possibly a select group of farmers is a useful technique for identifying possibilities. After the technology has been tested, either at the research station or on farms, the users will be better able to indicate the factors affected by the technology.

At this point the resource basis should be determined. This must be done early in the analysis because the intensity with which the technology may be applied will be limited by the fixed resources. For example, in Northeast Brazil the carrying capacity of the land is a limiting resource; therefore, the number of animals that can be raised will be limited by how much land is available. Other common limiting resources are water, buildings, equipment, and cash. From this point on, all assumptions are based on the chosen resource basis. In choosing the resource basis, it is advisable to choose the smallest practical unit so that the results of the analysis can be extrapolated to farms of different sizes on the same ecological site. When the linearity condition does not hold, or more than one combination of resources or intensity of resources is common, a partial budget for each scenario is appropriate.

After the list of "changes" is made, these are tabulated by "gains" and "losses." Each of these two columns is subdivided into two categories. Gains consist of any additional income that is expected and any costs that are saved. Losses are any additional expenses or costs, and any foregone revenues (opportunity costs). The difference between gains and losses constitutes the net benefit (or loss) resulting from the change under consideration.

Several methods are available for estimating the gain and loss coefficients. When the research is conducted at a research station, the experimental results may be used. However, station results often represent the ideal conditions obtained with a high level of management, conditions which are not likely to be repeated on a peasant's farm. On the other hand, they represent a highly controlled environment that aids in isolating the experimental

factors. Data from on-farm trials may be more realistic, although there will likely be a higher variability, and the opportunity for uncontrolled variables influencing the results is greater. Ultimately, it is usually a progression from ideas that are tested and screened first on paper, then at the research station, followed by limited on-farm trials, and finally, by large numbers of farmers. Therefore, the researcher must use his or her judgement as to which source of data represents the effect of the technology at each stage.

The last step should be a listing of all important noncash considerations that are relevant to the farmer's choice. For example, if a change in cash input requirements is large, a special note on cash-flow should be added. In the case of herbicide application, a note about the risk of hazards to family members in case of careless use or storage is necessary. Other examples are a change involving farm inputs that are not always available, a technology involving high management skills, a technology involving subsidized prices, etc.

Gross Margin Analysis

Traditionally, farmers make management decisions by intuition and crude calculations. However, as the rate of technological innovation accelerates, intuition will not be enough. For their farms to survive, the farmers must formulate plans that are technically feasible and economically efficient. Gross margin analysis is one technique that can help farm managers calculate the profitability of alternative plans or different enterprises.

The "gross margin" is the difference between the gross revenue of a farm activity and its variable costs; that is, it is the returns above variable costs for that activity. "Total gross margin" is the sum of the gross margins of all of the farm's activities. Gross margins are expressed in units of some common resource; for example, gross margin per head is used to measure the efficiency of animal-production activities (Figure 13) and gross margin per acre is used for cropping activities.

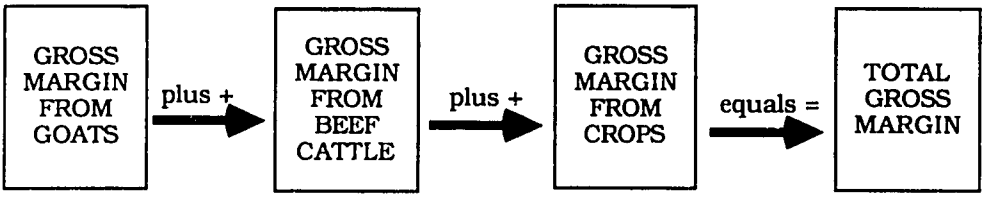
In calculating gross revenues, all income produced from an activity is included. For livestock this will include the sale of the entire animal or any of its products or by-products, such as milk, meat, manure, and the hide. Products consumed on the farm are also included. Both crop and livestock products are often used for on-farm consumption and should be valued at their market prices.

Variable costs include all costs which vary with the volume of production. For livestock activities, variable costs include feed and other supplements, medication, transportation costs, and repair and maintenance costs of buildings and equipment. Typical variable costs for cropping activities include those for seed, labor, fertilizer and other chemicals, transportation costs, and equipment repair and maintenance. All products, such as seed, that were produced on the farm should be included as a variable cost and priced at their market values. An example of a gross margin analysis is presented in Table 25.

FIGURE 13

The gross margin is the farm's returns above variable costs:

If the farm has more than one activity:



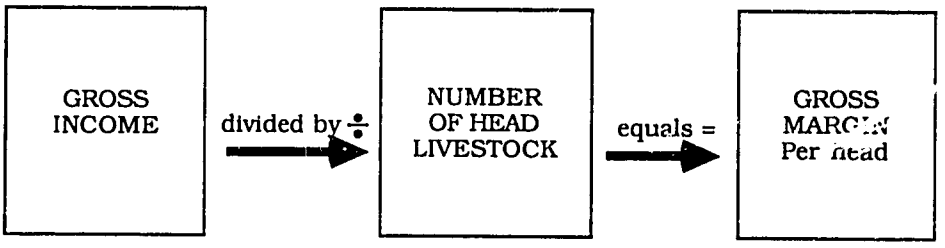
Gross margins are usually expressed in units of a common resource. For example, gross margin per head is used to measure the efficiency of animal production activities

continued

FIGURE 13

Steps in gross margin analysis

The gross margin for an activity divided by the units of that activity gives the per unit gross margin:



To get Net Farm Income, Fixed or 'overhead' costs are subtracted from Total Gross Margin:

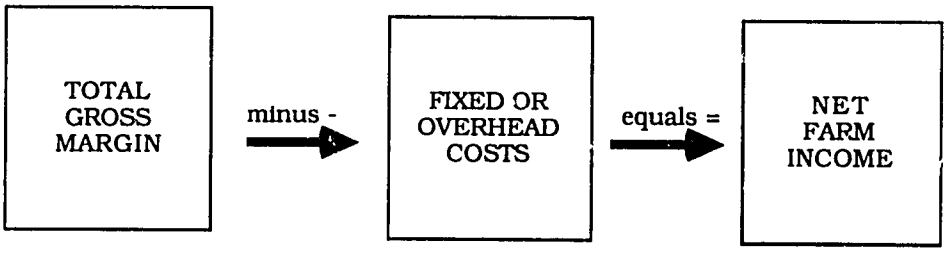


TABLE 25. GROSS MARGIN OF A TYPICAL MIXED PRODUCTION SYSTEM (GOAT, BEEF CATTLE, AND CROPS) IN NORTHEAST BRAZIL[a]

	Activity			
Revenue/expense	Goats	cattle	Crops	Total
Gross revenue (US$/ha)				
Sales	US$408	US$1,462	US$ 655	US$2,525
Consumption	220	0	402	622
Total	628	1,462	1,057	3,147
Variable costs (US$/ha)				
Hired labor	42	95	301	438
Feed and supplements	31	445	0	476
Medication	11	32	0	43
Seeds	0	0	62	62
Other	0	0	31	31
Total	84	572	394	1,050
Gross margin (US$/ha)	544	890	663	2,097

Source: Gutierrez A. and De Boer.
US$1.00 = Cz$64.00 (December, 1980).

Gross margin analysis is particularly useful for analyzing new technologies in two situations: when the technology impacts many of the operation's activities, or when several technologies are being compared. The calculation of the gross margin is conducted as described above. All gross revenues and variable costs are listed, with their values reflecting the technology with which they are associated.

Table 26 presents a gross margin analysis of five different feeding systems. The goats receive the following diets: I - 50% corn stover (S), 5% molasses (M), 45% concentrate (C); II - 40% S, 5% M, 55% C; III - 30% S, 5% M, 65% C; IV - 30% S, 70% C; V - daytime free grazing in native "caatinga" vegetation plus nighttime confinement with "ad libitum" access to 30% S, 5% M, 65% C.

Comparing the five technologies, it can be seen that the highest gross revenue is generated by system V, the traditional management system with a nighttime supplement. The additional costs (principally for pasture) were more than offset by the increased revenue. The gross margin of US$86.2 for system V was substantially higher for this treatment than for any of the other four treatments.

Advantages and Limitations of Gross Margin Analysis

The main advantage of the gross margin technique is that it can be easily used in the ranking of more than one technology. It therefore lends itself to analyzing the results of different treatments applied in trials. By a comparison of the gross margin for each treatment, the most promising treatments can be selected, i.e., the treatments (technologies) with the highest gross margin.

The limitations of gross margin analysis are basically the same as those of partial budgeting. However, the danger of inappropriate use is greater. Because gross-margin analysis is

such an easy method of giving an economic meaning to experimental

TABLE 26. GROSS MARGIN ANALYSIS OF FIVE DIFFERENT FEEDING SYSTEMS[a]

Item	Feeding Systems I	II	III	IV	V
Gross revenue					
Goat meat[b]	US$119.1	US$121.8	US$129.8	US$118.1	US$172.4
Total	119.1	121.8	129.8	118.1	172.4
Variable costs (US$/kg)					
Supplemental feed	55.4	57.6	53.1	47.0	59.2
Salt	0.4	0.4	0.3	0.3	0.3
Hired labor	16.7	16.7	16.7	16.7	16.7
Pasture (rent)	-	-	-	-	-
Total	72.5	74.7	70.1	64.0	86.2
Gross margin	46.6	47.1	59.7	54.1	86.2

Source: Base data from Oliveira et al., 1988.
[a]US$1.00 = Cz$104.7 (March, 1988)
[b]Based on dressing percentages of 42.4, 41.6, 42.4, 43.1 and 54.4 percent of live weight for systems I, II, III, IV and V, respectively.

results, it is most often used without an understanding of the farmer's perspective, i.e., without reference to the farmer's objectives or resources. Generally, using experimental input/output data will result in the anticipation of inflated production levels, i.e., the estimated benefits are unrealistically high.

Cautions

In using gross-margin analysis, it is tempting to conclude that farm profit can always be increased by expanding the enterprises that have the highest gross margins per unit at the expense of those that have lower returns. This may not be true because of resource and other constraints. If the number of animals with high per-unit gross margins is increased substantially without regard to the constraints, fixed expenses would probably have to be increased, perhaps to the point that the increase in total gross margin is more than offset.

Another way to look at the problem is to ask why, based on the results of Table 25, producers in Northeast Brazil produce both cattle and goats as opposed to only cattle, which have a much higher gross margin per hectare. The answer lies in their complementarity. If only cattle were produced, more cattle could undoubtedly be raised, and the gross margin per hectare increased above US$890/ha to, say, US$1,200/ha. However, by adding the complementary activity of raising goats, the total gross margin from livestock activities is increased to US$1,434/ha (US$890 + US$544), above the US$1,200 from raising only cattle. This is because while the cattle and goats use some of the same range resources, goats feed largely on resources that would be unused by the cattle.

It is also important to guard against assuming linearity in gross income and variable expenses when the relationships are in fact nonlinear. The format set does not lend itself well to nonlinearities.

Benefit-cost Analysis

Animal experiments generate data concerning the relationships between inputs and outputs, especially for inputs such as feed, medicine, labor, and equipment. Animal-feeding experiments often generate data relating feed inputs or stocking rates to animal output. Complex methods exist for the analysis of input-output relationships, such as estimating production functions; however, in most cases less elaborate techniques, such as input-output budget analysis, are sufficient. The aim of input-output budget analysis is to derive farm recommendations that are consistent with the farmers' desires to increase income, avoid undue risk, and make the best possible use of scarce investment funds. Several input-output budget analysis techniques exist. One of these techniques, benefit-cost analysis, is described here.

Benefit-cost analysis is a form of input-output analysis that is useful for evaluating on-farm trials. It is very similar to gross-margin analysis, the primary difference being that cash and noncash costs and benefits are separated and then used to derive the appropriate ratios (Figure 14).

Benefit-cost analysis uses four measures of profitability:

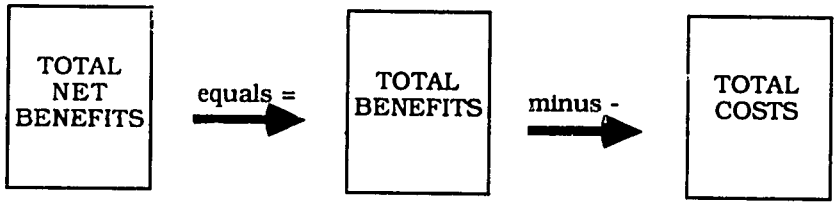
- total net benefits--overall farm profit
- net cash benefits--cash returns minus cash costs
- benefit-cost ratio--overall benefits derived per unit of overall cost
- return to capital--ratio of cash returns to cash costs.

Benefit-cost analysis may be used at different levels of sophistication, allowing the researcher or extension worker to incorporate the subjective judgments of the farmer. In quantifying the benefit or cost of a technology, values must be assigned to marginal improvements in income and the change in welfare. An important criterion is the farmer's willingness to pay for the technology. Often it is difficult for the farmer to respond directly to this question. First, he usually does not know about the market price or availability of the technology. Second, it is difficult to attribute marginal changes in productivity to a single factor when a number of interventions are being tested simultaneously. However, when a single intervention is tested, the farmer can often provide insight into the value of that intervention to the overall resource allocation and value system.

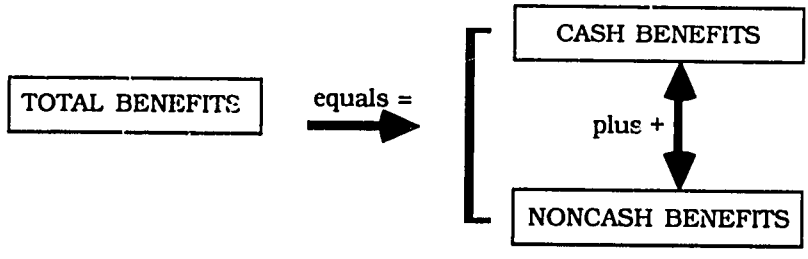
FIGURE 14. BENEFIT-COST ANALYSIS

BENEFIT-COST ANALYSIS USED FOR MEASURES OF PROFITABILITY

TOTAL NET BENEFITS:



WHERE:



AND

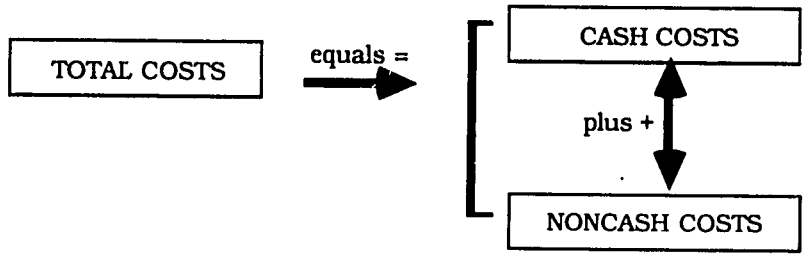
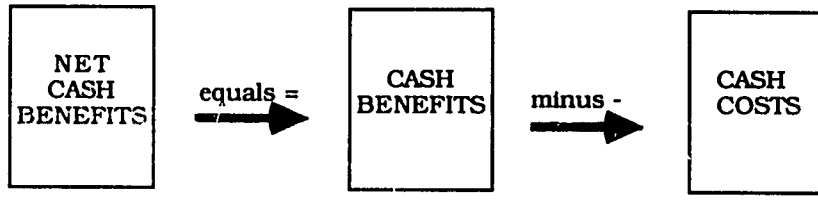
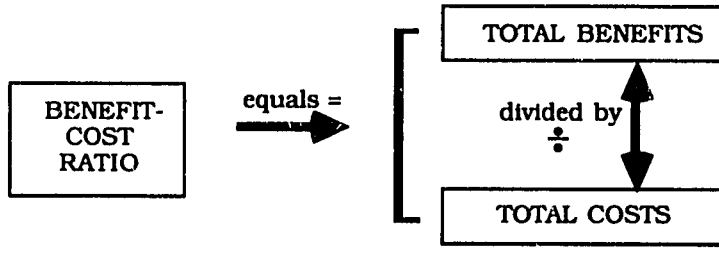


FIGURE 14. BENEFIT-COST ANALYSIS

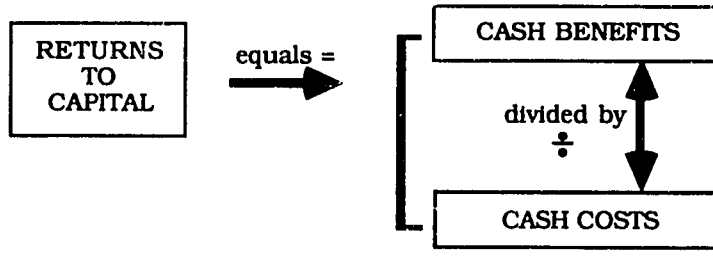
NET CASH BENEFITS:



BENEFIT-COST RATIO:



RETURNS TO CAPITAL:



The following example illustrates the use of benefit-cost analysis. Suppose a researcher wants to compare the results of two feeding systems for fattening native goats during the dry season in Northeast Brazil. The technologies used for comparison were the feeding of goats in confinement with a complete ration of corn crop residue and a semi-confinement system in which the goats graze as well as receive corn stover (Oliveira et al., 1988), (Tables 27 and 28).

Therefore, the following analysis of benefits and costs in Table 28 may be conducted.

The example in Table 27 is a typical case in Northeast Brazil. Total returns, total net benefits, the benefit-cost ration and the return to capital all increase under the new technology. In addition, there is a very high mortality rate for the animals raised under the traditional system. However, given the scarcity of cash, farmers will probably not adopt the new technology.

TABLE 27. TECHNICAL AND ECONOMIC DATA FOR TWO FEEDING SYSTEMS IN NORTHEAST BRAZIL[a]

	Farmer's practice	New technology
Technical Data		
Breed type	SRD(nondescript breed)	SRD
Feed system	Extensive	Semi-confinement
Feeds	Grazing(native caatinga)	Grazing + corn stover + concentrates
Feed quantity	-	485 kg[b]
No. of head	10/yr	10/yr
Labor requirement	70 days	70 days
Live weight gain	-25g/head/day	73g/head/day
Fattened live weight	15.2 kg/head	22.1 kg/head
Mortality (%)	0.3	-
Economic Data		
Price stock (SRD)	US$8.12/head	
Price corn stover + concentrates	US$0.12/kg	
Pasture rent	US$0.48/head/mo	
Wage rate	US$0.24/day	
Price/kg meat goat	US$1.43/kg	

Source: Base data from Oliveira et al., 1988.
[a]US$1.00 = Cz$104.7 (March, 1988).
[b]Value expressed in dry matter.

TABLE 28. BENEFIT-COST ANALYSIS OF TWO FEEDING SYSTEMS IN NORTHEAST BRAZIL[a]

Item	Farmers' practice Quantity	Farmers' practice Price	New technology Quantity	New technology Price
Benefits				
Cash				
Goat meat[b]	43.5kg		121kg	
Total benefits		US$62.30		US$172.40
Costs				
Cash				
Stock (SRD)	10 hd	81.20	10 hd	81.20
Corn stover concentrates	-	-	485kg	59.50
Noncash				
Grazing (rent)	-	11.20	-	11.20
Labor	70 days	16.70	70 days	16.70
Losses (Mortality)	3 head	24.40	-	-
Total cost		133.50		168.60
Total net benefits[c]		US$71.20		US$ 3.80
Net cash benefits[d]		US$18.90		US$31.70
Benefit-cost ratio[e]		0.46		1.02
Return to capital[f]		0.76		1.23

Source: Base data from Oliveira et al., 1988.
[a]US$1.00 = Cz$104.7 (March, 1988)
[b]Dressing percentage of 40.8% and 54.4% of live weight for farmers' practice and new technology, respectively.
[c]Total net benefits = total benefits minus total costs.
[d]Net cost benefits = cash benefits minus cash costs.
[e]Benefit-cost ratio = total benefits divided by total costs.
[f]Return to capital = cash benefits divided by cash costs.

Break-even Analysis

In most budgets there will be a few key factors that affect the balance of gains and losses. For these factors, it is useful to know at what level (what value and/or quantity) gains and losses are equal (the break-even point). Generally this analysis is done by manipulating the most uncertain key factor or factors.

The simplest application of break-even analysis is with partial budget analysis in which it is used to trace the effect of a change in assumptions. If a relatively small change in the price or yield of a product as a result of a new technology results in a zero balance between added benefits and losses, the traditional and new technologies can be considered nearly equal in profitability. When one considers the added risk of adopting a new technology for little or no gain, it is very likely that the farmer will maintain his existing operation.

Break-even analysis may also be used as an indication of the amount of risk involved. The result is the minimum or maximum value of a critical factor at which a new technology is expected to become or to stop being beneficial to farmers. Therefore, the more sensitive the results are to changes in these critical factors, the higher the risk.

Break-even analysis may be used in conjunction with other types of analysis. In general, when one compares the results of a new technology to the traditional practice, the variables of interest are manipulated to find their values at the point when the returns (or losses) of the new technology exactly equal those of the traditional technology.

A break-even analysis of the data in Tables 1 and 2 would be calculated as follows. The level to which price or yields could fall before gains are offset by the losses would be the net cost of production divided by the price of yield. The net cost of production is calculated by subtracting any gains that do not vary with the price or yield changes from the losses. In this example, it is assumed that the price and quantity of manure produced is constant. The net cost of production is equal to US$20.49 (US$21.64 - US$1.15). To find the break-even price, the net cost of production is divided by the yield.

$$\text{Break-even Price} = \frac{\text{Net Cost of Production}}{\text{Yield}} = \frac{\text{US\$20.49}}{64\ \text{kg}} = \text{US\$0.32/kg}$$

Therefore, the price of goat meat can fall from US$0.38 to almost US$0.32 before the new technology becomes unprofitable. Alternatively, the net cost of production may be divided by the price to determine how far the yield may fall before the break-even point is reached.

$$\text{Break-even Output} = \frac{\text{Net Cost of Production}}{\text{Yield}} = \frac{\text{US\$20.49}}{\text{US\$0.38}} = \text{US\$53.92 kg}$$

The additional yield could fall from 64 kg (1.6 kg/head) to below 54 (1.35 kg/head) before the technology would be unprofitable.

The advantages of break-even analysis are as follows:

Instead of calculating a fixed value, one can assess the results of a budget analysis in terms of probabilities, i.e., the probability that the actual value will be above or below the established break-even level. Thus, one can assess the chances that the proposed change will be profitable (assuming that all other budget components can be fairly well predicted).

- It is usually easier to assess the probability of an uncertain coefficient exceeding or falling below a specified value than it is to assess an expected value for that coefficient. If the break-even value is very high or very low, conclusions can be drawn about the profitability of the change with a high degree of confidence.

- In small crop-livestock farming systems, farmers want as much information as possible about the profitability of various farm activities or enterprises. Break-even analysis offers two types of information: break-even price and break-even output. The break-even price is the price at which the farm's given level of output, if sold, would enable the farmer to recover costs at least. Alternatively, the break-even output is the level of production that would enable the farmer to recover costs if the products were sold at the given or prevailing price.

- Since break-even analysis is used in conjunction with other types of analysis, such as gross margin or partial budgeting analysis, the same set of data is required. However, for the break-even analysis, historical data on the variability of prices and/or yields of crops or farm products are useful. These changes may be compared with the changes in yield and/or prices resulting from the break-even analysis.

Because basically the same data is used as in partial budget or gross margin analysis, the same limitations apply.

Whole-farm Budget Analysis

Whole-farm economic analysis and planning is used to examine the implications of reallocating farm resources. The analyst is concerned with the consequences of changes in the farm's methods of production or its organization. Sometimes the changes are minor--for example, using a new pasture type or purchasing a new piece of equipment. However, the changes can be radical, as when land of little or no agricultural value is brought into intensive production (Dillon and Hardaker, 1984). In whole-farm economic analysis, the farm is considered as a complete entity. The whole crop-and-animal production program is reviewed, and the overall use of farm resources is considered. If profit budgets are prepared, they take into account all farm income and expense items, including fixed expenses. (In partial-farm analysis, some aspects of the production system are taken as given and the budget analysis considers only the aspects of the operation that are directly affected by the proposed change.) The costs-and-returns table is a common approach to constructing a whole-farm budget.

In Table 29 a hypothetical example is used to compare the traditional management system to a farm on which foot baths have been added. Foot baths are used to reduce the problem of foot infections in goats in Northeast Brazil. It was assumed that they cost US$36, and are depreciated over a three-year period. The other costs that were affected as a result of the new technology were medication, which declined by US$2, while other costs (in which lime is included) rose by US$3. Total costs rose by US$13 per year. Total returns rose by only US$10 (0.5 kg per each of the 20 head sold at US$31/kg). This was less than the increase in costs and caused the profits to decrease from US$8 to US$5 per year.

TABLE 29. ANNUAL COSTS AND RETURNS OF THE TRADITIONAL MANAGEMENT SYSTEM AS COMPARED TO THE ADDITION OF FOOT BATHS FOR A 20-GOAT FARM

Item	Treatment	
	Traditional	Footbaths
Fixed costs		
Fences	US$190	US$190
Pens	38	50
Animals	25	125
Total fixed costs	353	365
Variable cash costs		
Medication	21	19
Other	7	10
Total variable cash costs	28	29
Noncash costs		
Labor	51	51
Total costs	432	445
Total returns	440	450
Profit(loss)	8	5

[a]Hypothetical example.
[b]US$1.00 - Cz$104.7 (March, 1988).

Although it has been noted before, it should be stressed again that a factor that is generally omitted from budgets is time--both the timing of activities and the timing of costs and returns. The real cost of borrowing, or the opportunity cost (that is, the alternative uses of money invested) should be incorporated into the analysis. The timing of costs and returns is particularly important during periods of high inflation. At the time of this writing, the inflation rate in Brazil was in the neighborhood of 20 percent per month. Not accounting for the effects of inflation would lead to serious errors in the evaluation of a technology. For a detailed treatment of how this may be incorporated into the analysis for a full-cost budget see Brown (1979) or Calkins and DiPietre (1983).

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Chapter 14

EFFECTIVE COMMUNICATION WITH THE SMALL PRODUCER

G.A. Baker and M.C. Neumaier

The focus of this chapter is on enhancing communication among researchers, extensionists, and small producers. It is directed at practicing researchers and extensionists, as well as their administrators.

The authors have drawn heavily on their research in Northeast Brazil as part of the economics and sociology projects of the Small Ruminant Collaborative Research Support Program, in collaboration with the Centro Nacional de Pesquisa de Caprinos (CNPC) and the Empresa Estadual de Pesquisa Agropecuária de Paraíba (EMEPA).

The collaborative research focused on three principal areas: (1) description of small ruminant production systems, (2) the development of an understanding of the role of the small ruminant sub-system within the total production system, and (3) the development and testing of new technologies. The development of these research programs reflects an evolutionary process, whereby the research component evolved from being operated in isolation from the extension and producer components to being fully integrated with them.

To understand the role of communication in development, it is first necessary to clarify what is meant by the term "communication." Communication, as it relates to the relationship among researchers, extensionists and producers, has traditionally been looked upon as a transfer of knowledge, with the transfer being from researcher to extensionist to producer. This approach has come into question in recent decades, as an increasing number of development specialists have acknowledged that the great majority of efforts to transfer knowledge to small producers have been in vain. Research programs, on the one hand, will have little impact on small producers if they involve inputs not affordable to them or do not address the major production problems of small producers. Extension programs, likewise, will remain limited in their ability to improve the welfare of small producers as long as the underlying reasons for rural poverty remain unchanged. Additionally, extension programs are often underfunded, limiting their impact and their ability to develop new initiatives. Given these limitations, it is all the more important that extension institutions be effective as agents of change.

The noted Brazilian educator, Paulo Freire, argued that the traditional approach to development is "conditioned historically and socially," and that "peasants' knowledge gained from experience ... is equally conditioned" (Freire, 1977). He proposed a new approach to development in which the target audience both defines the problem and searches for solutions. The role of the change agent then becomes that of a facilitator. In fact, some of the most successful examples of technology transfer have occurred when the technology has been sought after by the user.

Such a complete reversal of roles is probably neither practical nor acceptable at most institutions in the short-run. However, incorporating two principles, which are essential to the

success of the Freire approach, will lead to more critical research and extension programs and to better communication with producers.

The first principle is that interaction with the intended beneficiary is essential. Researchers typically suffer more from the "ivory tower syndrome" than do extensionists and, therefore, stand to benefit the most. It is an elementary rule of science that a proper understanding of the problem is necessary to the development of relevant solutions.

Several studies were carried out at the CNPC that have led to a better understanding of the small ruminant production system. The most comprehensive of these studies was carried out in the State of Ceará and described land usage, cropping systems, animal numbers, practices relating to the management of installations, pasture, reproduction, health, nutrition, and labor (Gutierrez et al., 1981). Other studies led to a better understanding of the dynamics of the production system (Gutierrez and Ponce de Leon, 1986a,b) and grazing systems (Queiroz et al., 1982). A summary of the results of these studies is found in De Boer et al. (1986). These studies provided important baseline data on small ruminant production systems in Northeast Brazil. A beneficial byproduct was that many researchers at the CNPC had the opportunity to visit small ruminant farms by participating in the surveys.

Research conducted by Primov (1982 and 1984) contributed to developing an understanding of the role of small ruminants in the total farm system and helped to explain producer behavior. His research revealed that the primary objective of most producers was survival, and that their production strategies had developed in response to this objective. These studies provided direction for research and extension programs by clearly defining the problems faced by small producers and the types of solutions that were most likely to be adopted.

The second principle is that producers should be allowed to participate in the research and extension process, as opposed to being the subjects of it. Because researchers and extensionists are better educated and hold higher positions in society, they are typically viewed by farmers as teachers, while farmers are viewed as students by the researchers and extensionists. This narrow definition of roles inhibits the flow of communication, since the researcher or extensionist cannot learn directly from producers but must do so indirectly by observation or by the analysis of a survey. Overcoming these barriers by allowing producers to participate in the definition of problems and in potential solutions will lead to more eclectic and innovative approaches to difficult problems, with each group contributing to a solution based on its own experience and knowledge.

A study conducted at the Fazenda Saco do Belém agrarian reform site (Baker et al., 1988) represented one of the earliest attempts at technology validation and transfer for the CNPC and the SR-CRSP in Brazil. Producers participated in defining the problem and in the search for solutions, a participation that had a significant impact on the success of the technologies tested.

The following sections focus on information that may be helpful to researchers and extensionists in their communications with small producers. The first section, "Understanding the Small

Producer" addresses some of the important differences between researchers or extensionists and small producers and suggests how to establish a common ground for communication between them. The following section, "Developing a Rapport with the Small Producer," focuses on building mutual trust and understanding. "Learning from the Small Producer" describes some of the contributions that producers have to offer. The last section, "Farmer Participation in Farming Systems Research and Extension: A Case Study," describes a research project in which farmers participated in the problem definition and the identification of technologies to be tested and in the evaluation of the technologies.

Understanding the Small Producer

The importance of understanding the small producer cannot be overemphasized. Programs and projects have traditionally been developed to solve problems based on the researchers' and extensionists' perceptions of those problems. In practice, researchers, extensionists and producers often identify many of the same problems; however, perceptions of their relative importance may differ.

The type of research conducted and the resulting recommendations are usually based on the assumptions of the researchers. Primov (1984) pointed out that survival is one of the most important goals of the small producer and that failure to realize this will lead to recommendations that would actually make the producer worse off. He states that "producers cannot adopt recommendations which may lead to substantial improvements in their goat production, ... if it lessens their flexibility to shift production strategies in order to optimize survival under varying conditions."

Because small producers often have very different backgrounds from those of the researchers and the extensionists, it is important to consider how these differences affect their behavior. Some of the most important considerations affecting producer behavior are social structure, customs, religious beliefs, resources, educational level and motivation.

Social Structure

One of the most interesting aspects of working with small producers is observing the interrelationships between people. Because researchers and extensionists will often be from a different social class from the farmer, it may also be a challenge to create open two-way communication. Within a family unit it is important to determine who is responsible for the various tasks, such as taking care of the animals, milking the animals, and working the fields. The father, the mother, and the children often have specific jobs assigned to them. For extensionists it is essential to determine who the decision makers are and who influences the decisions. This is true both within a family unit and within a community. Most communities have formal leaders, who may have attained their position by election or by virtue of seniority. There may also be informal leaders of smaller groups within the community. Identifying and working with these leaders, to whom others in the community look for guidance, is a key to gaining widespread acceptance of new ideas.

"Custom" is defined to mean the common or usual practice. Different customs may be confusing and seem irrational to newcomers to the area, and they may feel uncomfortable because they must conform to a behavior that is alien to them. It is of utmost importance, however, that researchers and extensionists understand and respect the customs of the people with whom they are working. In order to influence producers, a newcomer must gain their trust and respect. It is therefore important to be sensitive to their behavior expectations.

Customs concerning interpersonal relations can be learned either by asking persons familiar with the area or by careful observation. This will help the newcomer to know how to address the producer and his family members, whether it is more appropriate to make small talk initially or to get right down to business, or whether it is considered impolite to turn down an offer for food or drink.

Customs and beliefs that are directly affected by adopting new technologies represent a more difficult obstacle, particularly if accepting the technology means doing away with or altering the custom. In this situation it is important to understand the basis of the custom, since it will give the researcher or extensionist an insight into how to encourage change. If the practice represents local wisdom, an attempt should be made to understand the reasoning. Practices that at first appear illogical often make good sense when all of the facts are considered. If the facts indicate that the producers could benefit by doing away with a custom and adopting new practices, the alternatives should be presented to them, along with the advantages and disadvantages of adopting the new practices. However, their choice should be accepted by the researchers and extensionists, with the realization that not all choices are based on maximizing economic benefit.

Some examples of local customs and beliefs are documented by Neumaier (1986). One producer stated that he did not treat his goats for diseases because "goats are strong by nature." This belief is fairly common in Northeast Brazil and presents a difficult challenge to researchers seeking to improve the production system. It is believed that goats withstand the frequent droughts better than other animals. That they need so little care and cash investment is one of their primary advantages. The challenge to researchers is to improve goat production without substantially increasing the cash costs or labor required.

Religious Beliefs

In some respects religious customs and beliefs are more easily handled than those not based on religion. They are usually well defined, and, although many religious beliefs cannot be understood on the basis of logic, neither can they be easily changed. Therefore, in most cases they should simply be accepted as a constraint. Technologies are then developed that are consistent with the religious beliefs of the people. Some examples of religious beliefs that may affect production practices are what times are allotted for prayer, when work is allowed, and how the animals are treated. One producer reported to Neumaier (1986) that he would rather take sick goats to a healer than give them

medicines.

Resources

By definition, small producers have limited access to resources. This severely restricts the economic choices open to them. They typically have little or no land, few animals, and very little cash. Often their animals represent a form of savings, particularly in countries with a high rate of inflation.

The access of small producers to resources provided by the government may also be limited, even for programs that are intended primarily for them. There are many reasons for this, and even well-intentioned programs may miss their targets. Producers may never hear of the programs, or if they do, they may not understand that they are eligible for them or how to go about fulfilling the requirements. Poor transportation may mean that it is difficult and costly to travel to the city to apply for the programs. Further, "research and extension efforts tend to favor those producers who, due to their privileged social and economic conditions, are most able to quickly adopt new technologies" (Neumaier, 1984).

Education

The educational level of the small producer and his family depends greatly on the government's commitment to education. Rural areas are usually the last to receive adequate funding for education. Even when adequate funding is available, the lack of qualified teachers may preclude schooling. Necessity and traditional values toward education may determine who gets the education. In the rural communities of Northeast Brazil, it is common for most children to attend school, although the male children typically do so only until they are able to work in the fields, and after that only when they are not needed for field work.

A low level of education makes communication more difficult. There is no doubt that the lack of basic knowledge, a smaller vocabulary, and fewer reasoning skills on the part of the small producer can be a significant barrier to communication. However, an even greater danger is that the researcher or extensionist will stop trying to communicate because he or she thinks that the farmer understands what has been said. Because many people, even educated people, will say they understand to avoid showing their ignorance, the responsibility lies with the teacher to ensure that learning has occurred.

Motivation

Motivation is the most complex of the factors that have been discussed so far. It involves the previously discussed factors and interactions among them. It is a key to understanding why small producers make the choices they make. Assuming that the role of the researcher and the extensionist is to help the small producer become better off, understanding his motivation is essential in assessing what constitutes "better off" for him and in learning how to develop and present alternatives in a manner consistent with his motivation.

Understanding producer motivation can be especially difficult for the researcher or the extensionist from another culture. For example, in most developed countries hard work is rewarded and there is general agreement that more is better. This belief does not necessarily hold true for small producers in developing countries, possibly because of a system in which their experience has shown them that no matter how hard they work, it is impossible to make themselves better off.

Some of the differences in motivation may be traced to the economic situation of the producers. Their everyday concern with survival impacts heavily on the economic choices that they may make. Most small producers tend to be adverse to risk. Given a choice between their current technology and a new technology, which compared to the current technology gives higher returns with a higher variation, they will choose the current technology, the reason being that the higher potential returns of a new technology are meaningless when the producer is faced with a potential low-return year that threatens their survival. The research problem must therefore be understood within the "framework of the nature and survival strategies of peasant producers" (Neumaier, 1984). Producers also tend to be cash poor, a factor which severely limits their ability to participate in the cash economy. Therefore, any recommendation that requires a cash commitment will be heavily scrutinized. Using their scarce cash reduces their flexibility to purchase such essential items as food or medicine in the short run.

In such a situation, the options for technology recommendations appear to be very limited. Primov stated that "the most effective means of helping these producers is to strive to provide a broad range of very modest solutions" (Primov, 1984). Small changes or variations of current practices are less likely to be perceived as risky.

As a motivation for producers, it is important not to overlook the impact of information. Much of the perceived risk of adopting new technologies may be due to a lack of complete information about the performance of the technologies. Education programs and on-farm demonstrations are two means of increasing the producers' knowledge and reducing their perceptions of risk.

Developing a Rapport With the Small Producer

Developing effective two-way communication with the small producer involves more than simply understanding him or her. It involves developing a mutual trust and respect between the farmer and the researcher or extensionist.

Initially, farmers may be suspicious of the outsider. After all, it is not often that someone offers him or her something for nothing. And while it is the farmer who has the most to gain, it is also the farmer who has the most to lose, especially if his or her farm or animals will be used in an experiment. Producers must know that they can trust the information given to them by researchers and extensionists and that agreements will be honored. In some cases researchers or extensionists may have to establish their credibility. Depending on the reputation of the institution, it may be necessary for the researcher or the extensionist to prove that he or she is qualified before the farmers are willing to risk

their crops or animals on their advice.

An example of the effectiveness of building rapport occurred during the Saco do Belém technology-validation trial. All sheep, goats and cattle were dewormed, to prevent the spread of parasites from one species to another. One producer was at first reluctant to allow the researchers to deworm his cattle. However, after working with them for several months and seeing the results of their work, he later asked that his cattle also be treated.

Whenever the farmer is asked to participate in any type of experiment, the researcher or the extensionist should be very clear about what the objectives are, about what is expected of the farmer, about what the researcher and/or the extensionist will provide, and about what risks are involved. In particular, the following items should be discussed with each producer:

a. The reasons for selecting his or her farm;

b. The objectives of the experiment, specifically
   - the expected technological advances,
   - the potential benefits for the participating producers, and
   - the potential impact for the region under study;

c. The obligations of the farmer and the researcher and/or extensionist, as regards the following:
   - the inputs, labor, cash and management to be provided by each party,
   - any restrictions, particularly regarding management decisions such as planting or harvest time,
   - the recipient of the crop or livestock produced; and

d. The risks involved for the producer and the terms of any compensation to be provided.

A written agreement is a useful tool to ensure that both parties understand their obligations. However, the researcher or extensionist should go over the agreement thoroughly with the producer via oral communication, to guarantee that it is clearly understood.

Developing a rapport with the farmer is also important for the researcher or extensionist. Often a great deal of time and money are invested in setting up an experimental unit. Researchers must know that they can trust the farmer to carry out his or her part of the agreement. For example, if feed is provided by the research institution for an experiment with goats, the validity of the results depends on the farmer feeding the goats according to the researcher's instructions. It is not uncommon for producers to divert resources provided by the researcher or extensionist to a use that the farmer perceives as being more valuable.

It is often beneficial to start with a group meeting. Prior contact will have been made with one of the community leaders and someone who is well respected in the community should introduce the researcher or extensionist. In this way an instant credibility will be established with a large group of people. It is also an efficient means of learning about problems that are common to farmers in the area and for explaining the objectives of the work

planned in the community.

To establish a rapport effectively with individual farmers requires one-on-one interaction. Individual problems not applicable to the large group are best dealt with in such a setting. The farmer is also more likely to talk openly with one other person than in a large group.

Working with farmers in the fields or with his or her animals can be a powerful mechanism for reinforcing what is said orally. It is also an opportunity for the researcher or extensionist to demonstrate his skill and to learn by first-hand experience the problems that the farmer faces.

Rapport with the small producer is developed over time. Because of the many differences in social status, educational levels, etc., a certain amount of distrust and uneasiness is natural, more than would normally exist between people with a common background. Developing open, honest communication requires that both parties try to break down these barriers through continued interaction.

Learning From the Small Producer

Not only are researchers and extensionists guilty of viewing themselves as teachers, but they fall into this role much too easily. It is an understandable pitfall. They are higher in social status almost without exception, better educated, and wealthier than the small producers with whom they work. The role of the researcher or extensionist as a teacher is one with which both parties feel comfortable. Unfortunately, it is all too easy to overlook the fact that researchers and extensionists can learn something from the farmer.

Researchers and extensionists should not allow themselves to be misled into thinking that simply because the small producers are poor, they are also stupid or they have chosen to be poor. Given the same constraints, researchers or the extensionists would probably find that the small farmers would out-perform either the researchers or the extensionists, even with their superior education. The farmers' talents lie in their ability to produce anything at all, given minimal resources. Researchers and extensionists rarely have the opportunity of offering substantially more resources. More often, they can provide small innovations. The maximum benefit lies in combining these marginal improvements offered by researchers and extensionists with the ability of the small producers to exploit these innovations to the fullest. In the following paragraphs some of the specific ways in which researchers and extensionists can learn from small producers are addressed.

Small farmers know their own problems better than anyone else does, and they are usually happy to talk about them. They may be able to relate only the symptoms of the problems, but, nonetheless, these are helpful in identifying the principal production constraints and the areas where the highest potential benefit from research and extension might be attained. This information should be incorporated at the beginning of the research process and continual feedback should be received all the way through to the stage of diffusion of technology.

In addition to knowing what their problems are, farmers are often able to offer practical solutions. Solutions generated by producers most often have the advantage of being simple and inexpensive, two criteria which are important for widespread adoption. Their suggestions may serve as a starting point for researchers, who may improve on the ideas.

An example of this occurred during the Saco do Belém technology-validation trial. During the course of regular meetings with the producers, the producers identified foot rot as a major problem during the rainy season. However, the second part of the solution required building concrete foot baths that would have required a substantial investment on the part of the producers. After discussing this with the producers, a means of constructing the foot baths with inexpensive materials, readily available at the project site, was devised.

Unlike researchers, who typically have a narrow focus in a single discipline, farmers view the production system as a whole. They are very good at pointing out interactions that may be overlooked by researchers and extensionists. They can force the researchers and extensionists to broaden their perspective and to take a more realistic approach to technology development and diffusion.

Once a positive result has been achieved at the experiment station, there is a tendency to believe that the innovation is ready for diffusion. At best it is probably ready for testing. Seldom can a technology that was developed under specific controlled conditions be applied in blanket fashion to a wide array of farms. Producers can be helpful in adapting innovations to their local situations. Their knowledge of their farms, together with the researcher's knowledge of the technology, provide the necessary elements to fine-tune the technology.

Farmer Participation in Farming Systems Research and Extension: A Case Study

The Farming Systems Research and Extension (FSR/E) approach emphasizes the value of experimentation with farmers for technology development. Nonetheless, most research conducted to date has followed the traditional approach of developing the technology at the research station and subsequently testing it in the farmers' fields. Farmers are usually excluded from the design process, and their research potential is largely ignored (Okali and Knipscheer, 1985). The SR-CRSP/CNPC project at the Fazenda Saco do Belém was an attempt to integrate farmers into the research and extension process, by exploiting the relative strengths of each group.

FSR/E is generally carried out in four phases: (1) site description and problem diagnosis; (2) technology design; (3) technology testing and evaluation; and (4) technology extension (Harwood, 1979). It is typically directed at one or several homogeneous geographic areas. The objective is then to develop technology packages for the target areas.

The results of the Saco do Belém technology validation trial that follow are taken from Baker et al. (1988).

In the Saco do Belém study, the target area was very narrowly

defined because the emphasis of the study, in addition to developing technology recommendations, was to test the effectiveness of farmer participation in the research and extension process. The Saco do Belém site was chosen because the experimental units were fairly homogeneous. Saco do Belém is the site of an agrarian reform resettlement project. Each farmer had 25.5 ha of private land and 62.5 ha of community pasture. The land quality was similar. The farmers had all occupied their land for approximately 3 years and usually raised the same crops and types of animals. A complete description of the project is given by Baker and Souza Neto (1986).

A multi-disciplinary advisory team was formed of researchers and extensionists from the National Goat Research Center. The field researchers relied heavily on this team in the design and early stages of the research, particularly for the site description, problem diagnosis, and technology design.

The site description was carried out through multiple visits to the site and meetings with individual farmers. A detailed description was performed by administering a questionnaire to 51 of the 198 farmers (26%). Based on this survey, 30 producers who met certain minimum criteria for time residing at the project and for number of animals were chosen to participate in the experiment. The farmers were randomly divided into three groups. Group A, the control group, received no technology and used traditional management practices. Group B received the technology package. Group C received the same technology package as Group B, but additionally participated in regular meetings with the researchers and extensionists.

In order to determine the principal production constraints a series of meetings with members of the research team and farmers from Group C were held. Based on these constraints, which were determined by a consensus of the researchers, extensionists and farmers, a set of potential technologies was suggested by the researchers and extensionists. These were discussed with farmers in Group C, who made suggestions concerning these and other potential technologies. The final technology package represented a consensus of the researchers', extensionists', and farmers' opinions.

The technology package administered to farmers in Groups B and C consisted of the following components:

- drenching the animals four times a year;
- vaccinating against foot-and-mouth disease;
- cutting the umbilical cord of newborn animals and treating the navel with an iodine solution;
- castrating male animals not to be used for reproductive purposes; and
- regular visits by a veterinarian.

In addition to receiving the technologies, farmers in Group C participated in Regular Research Field Hearings (RRFH), which were previously used in Indonesia (Knipscheer and Suradisastra,

1986). The principal objectives of these meetings were

a. to create a dialogue among the farmers, researchers and extensionists, to encourage mutual trust and respect;

b. to increase the researchers' and extensionists' understanding of the production system;

c. to increase the producers' understanding of the technology, to insure its correct application and to stimulate motivation; and

d. to contribute to the farmers' knowledge of livestock production.

The format of the meetings varied throughout the year in which they were held. In the first several meetings, the topic concerned the description of the production system, the principal constraints, and the potential technologies. The next several meetings focused on the application of the technologies. It was felt that increasing the producers' understanding of the technologies was critical for their support. This is especially true for livestock production, since farmers are reluctant to risk their animals on technologies with which they are not familiar. The farmers' understanding is also important for technologies that are managed by them.

Training sessions were incorporated into these meetings. Researchers or extensionists usually covered one or two topics from the areas of animal health, breeding, management, or reproduction.

The results of the study were encouraging (Table 30). The performance of Group B, which received the technologies but did not participate in the experiment, was closer to that of the control group than to that of Group C, which received the technologies and actively participated in the experiment. There was a significant difference between animal weight gains between farmers in Groups B and C, as well as a significant difference between the farmers' perceptions of their animals performance. Although the farmers in Group C were willing to pay more for the technologies than farmers in Group B the difference was not statistically significant.

TABLE 30. PERFORMANCE MEASURES BY GROUP

	A Control	B Tech. Pkg.	C Tech. Pkg. + RRFH
Avg. daily weight gain[a]	0.051	0.055	0.068
Farmers' perception of animal performance[b]	3.33	3.67	4.50
Willingness to pay[c]	N/A	55.56	75.50

[a] Average for animals with a weight of four kilograms or less at the start of the experiment (A:n=5, B:n=8, C:n=5).
[b] Farmers' ratings of performance/satisfaction on a scale of 1 to 5 with 1 representing very poor and 5 representing excellent.
[c] Average total willingness to pay for all technologies, in cruzados (Cz$40 = US$1.00).

Because the project terminated at the end of the first year, it was not possible to carry it to its conclusion. Ideally, in the second year the technologies would have been modified and tested on a broader scale with a heavier involvement of extension personnel and a gradual withdrawal of the research team. Follow-ups of farmers in Groups B and C would have been conducted to measure the adoption rates and the underlying reasons for adoption. This information could then be used in the broader extension of the technology.

A much heavier involvement of extensionists would also be necessary in the following years. In the first year the researchers took the lead, and although the extensionists participated, their role was secondary. As the project moves closer to the extension stage, the roles should be reversed, with extensionists playing the primary role and researchers having a more advisory role.

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Chapter 15

RECOMMENDATIONS FOR FURTHER RESEARCH

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Many ideas have been presented in the previous pages: some are ready for farmers to use widely, others are ready only for on-farm validation, and still others remain in the realm of speculation, awaiting further testing before they can be accepted or rejected. We reemphasize that each producer must evaluate his or her unique situation before adopting new technology, choosing only those ideas that are relevant for the physical and economic environment in which he or she operates.

Technology transformation of animal agriculture (any agriculture, in fact) is a dynamic process. As ideas are developed and tested, new questions are constantly raised. Also, as basic understanding of the biological systems (plants, animals, and their interaction) advances, new approaches become available for solving practical problems. In a true sense, by the time a "Technology Package" is published it is already out of date.

An important aspect of the process of technology transformation in agriculture is a concurrent transformation in the process of research evaluation and planning. "Top-down" diffusion of new technologies should give way to a participatory process in which farmers and extensionists communicate freely with scientists. As the concerns and priorities of producers become better understood by the scientists who profess to serve them, priorities for further research will become more relevant to producers' needs. Unfortunately, there has not yet been enough time for the research evaluation and planning process for small ruminants to mature to this point in Northeast Brazil, nor in most other semiarid tropical regions.

The fact that some of the ideas presented by authors of previous chapters have not yet been adequately validated at the farm level is one reason why there is equivocation about some points. For example, several authors have discussed a controlled breeding season for meat goats, but there is not yet a perfect consensus about when this should be. Under the existing system, breeding is allowed to occur year-round on the majority of farms. Could producers benefit from a controlled breeding season? What is the best time of year for kiddings to occur, a factor that would determine when the breeding season should occur? The truth probably is that there is no one breeding season that will be "best" for all producers. Only further research, coupled with increasingly closer communication with farmers--including the evaluation of controlled breeding seasons as adopted by farmers--will resolve this issue.

For these reasons (incomplete on-farm testing and a lack of producer participation in research evaluation and planning) the ideas presented in the pages that follow must be taken as preliminary. However, we present them with the hope that they stimulate a dialogue among scientists and other readers, who can then perfect the list and establish their own priorities, adjusted to local realities.

For convenience, our suggestions are grouped by discipline. However, the need for a multidisciplinary team approach to the planning and the evaluation of research cannot be overemphasized. For example, teh reproductive performance of native breeds and SRD genotypes has been reported to be adequate in normal years with good access to caatinga forage. As genotypes are upgraded by crossbreeding, will reproductive performance still remain at satisfactory levels? As another example, can resistance to helminthic parasites be improved through better feeding? Finally, the opinions of economists and sociologists during the planning stage of biological research, and their active participation during the validation phase, can help anticipate later problems that producers might have at the application phase; and, conversely, biological scientists can help the socioeconomic researchers ask the right questions when they attempt to evaluate the interactions of new technologies within the integrated farm system and farm-family context.

Range Management

In Chapter 5 it was shown that thinning the native caatinga can result in six- to eight-fold increases in the yields of herbaceous vegetation and that coppice foliage sprouting from stumps of newly cut trees will remain green for a longer period into the dry season than other caatinga foliage. Still needed are long-term ecological studies of successional changes caused by management and of the efficacy of alternatives, such as strip clearing. Animal management variables should be incorporated into these studies, since the ultimate objective is to improve animal productivity without jeopardizing the equilibrium of the caatinga forage resource.

Another area worthy of study is a comparison of the presently recommended controlled continuous grazing system with alternatives such as delayed, deferred, and rotational systems. Since grazing studies are long-term and expensive, they must be carefully planned and executed in order to maximize the information from them.

Animal Nutrition

It is axiomatic that only with adequate nutrition will the production potential of native, upgraded, or exotic genotypes be realized. Goats have been shown to use unique behavioral and selective traits to enhance their survival in harsh environments.

The major caatinga species making up the diet of goats free grazing one caatinga type during the wet, early dry, and advanced dry seasons have been recorded. Continuing studies should expand this data base to all important caatinga types, and for all critical periods of the year, to identify exactly when, what and for how long specific nutrients (energy, protein, and major minerals) are adequate, marginal, or grossly deficient if supplementation is not offered. Behavioral studies should examine further the effect of environmental variables such as rain, humidity, temperature, and biting insects, as well as caatinga manipulation treatments, on grazing time and nutrient intake.

Finally, studies on nutrient requirements of free-grazing goats are needed, so that a more appropriate standard can be used to assess the adequacy of caatinga intake.

For more intensive management systems there is a need for further nutritive evaluation of introduced forages, crop residues, and agro-industrial byproducts. Preservation methods for forages to be used in the dry season need further refinement. Animal preference studies of agronomically proven forage cultivars can be used to select the few new accessions to enter in vivo evaluation. For some forages, studies of anti-quality factors such as tannins are needed.

For specialized dairy goat production, emphasis should be placed on diet formulation using minimum-cost ingredients, such as leaf meals from low-fiber native or introduced forage legumes. The overall nutritional management of artificially reared kids, as adapted to the semiarid environment, also needs attention, including formulas for milk substitutes.

Reproduction

An area previously mentioned is the evaluation of alternative controlled breeding seasons, in terms of their effect on improving milk production of the doe and consequent kid survival, as well as the overall economics of such systems. Multidisciplinary teams need to evaluate the implications for animal health, nutrition, and range management in alternative systems.

The reproductive efficiency of crossbred and introduced genotypes will need continuous evaluation. Both male and female reproductive traits need attention. As more intensive production (dairy) is adopted, artificial insemination may become economically viable, in which case more studies will be needed on semen quality, processing, and storage, as well as estrous cycle control in the female.

Breeding and Genetics

Even though the native breeds do not show significant differences in growth traits (Chapter 4), their growth performance and carcass yields remain low. Insofar as variability can be shown among individual animals, there is room for improvement of these traits by selection. The relative merits of selection versus crossbreeding and/or upgrading need to be evaluated.

Two exotic breeds with apparent potential for use in crossbreeding and upgrading schemes, the Boer from South Africa and the Anglo-Nubian (which has already been introduced to Northeast Brazil), need further evaluation and comparison with local smaller breeds in terms of overall production efficiency.

Animal Health

Due to the heavy reported losses associated with gastrointestinal helminths, more studies of their population dynamics are indicated, which studies can lead to more effective

(and, one hopes, more economical) control strategies. There may be some local plants, the extracts of which can serve as effective vermifuges. In vitro screening of such substances, followed by field evaluation of more promising materials, should be carried out.

Other diseases needing further study include coccidiosis and pneumonias for kids, and contagious ecthyma and footrot for goats of all ages. The pathogenicity, prophylaxis, and treatment of these diseases should be looked at.

Finally, due to the economic losses it causes to the skin industry, caseous lymphadenitis needs continued priority, particularly for the efforts to develop an effective vaccine.

Meat, Skin and Milk Products

Goat meat and meat products have been neglected, worldwide, in terms of studies of composition, quality, and processing techniques. If more sophisticated urban markets are to be developed for goat meat, such studies will be important.

A large incidence of damaged skins has been reported by tanneries in Northeast Brazil, not only due to caseous lymphadenitis lesions but also from external parasites and improper processing and storage. Improved processing, drying and storage techniques need to be studied in relation to wet and dry season conditions.

As interest in dairy production grows, so should studies on milk products. An attractive alternative for Northeast Brazil and other similar areas would be the incorporation of native fruits into yogurt making. Suitable formulas for flavored yogurt should enhance the acceptance of this product in regional markets.

The manufacture of fine cheeses may have a place, particularly for access to large urban markets that may be some distance away.

Studies of potential market acceptability of such products should accompany the laboratory studies on product development.

Sociology and Economics

As technology alternatives emerge from other disciplines, economists can help evaluate their cost/benefit parameters, and both sociologists and economists can help evaluate their appropriateness for existing farming systems.

Socioeconomic studies can help identify the most limiting factors (social, economic, or biological) for the adoption of new technologies at the farm level. Constraints of labor, capital, motivation and goals need to be identified and continually monitored. Costs of production, including interactions with other enterprises in mixed farming systems, should also be monitored.

Of overriding importance are continued studies on the methodologies of effective technology validation and transfer. Practical suggestions on how to improve this process are urgently

needed.

It is encouraging to note the acceptance of socioeconomic research as an integral part of livestock production research at institutes such as the National Goat Research Center of EMBRAPA. This acceptance is a symbol of the increasing attention to the final criteria by which technology improvements should be judged: their potential contributions toward the improvement of the family income of producers and to the improvement of rural welfare generally.