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Seasonal Feeding Behavior and Forage Selection by Goats in Cleared and Thinned Deciduous Woodlands in Northeast Brazil

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SEASONAL FEEDING BEHAVIOR AND FORAGE SELECTION BY GOATS IN CLEARED AND THINNED DECIDUOUS WOODLANDS IN NORTHEAST BRAZIL

by

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DEDICATION

Aos responsaveis pela minha existência, durante esta passagem ...., meus pais Bibiano Veras de Mesquita e Maria Alaide Magalhães de Mesquita.

As primeiras educações básicas para o meu carater, adquiridas durante os anos de convívio, tornaram possível forjar esta minha personalidade.

O amor o qual eu lhes dedico não representa tão somente o amor paterno, mas, principalmente, o amigo de todas as horas ontem, hoje e ate quando Deus nos permitir.

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Roberto Cesar Magalhaes Mesquita

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ABBREVIATIONS

Anim.	Animal
BW	Body Weight
C	Centigrade
CPATSA	Centro de Pesquisa do Tropico Semi-Arido
CNPC	Centro Nacional de Pesquisa de Caprinos
CWC	Cell Wall Constituents
DM	Dry Matter
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuaria
ha	Hectare
hrs.	Hours
IBGE	Instituto Brasileiro de Geografia e Estatistica
kg	Kilogram
MINTER	Ministerio do Interior
mm	Millimeter
SRD	Sem Raca Definida

ABSTRACT

Seasonal Feeding Behavior and Forage Selection by Goats in Cleared and Thinned Deciduous Woodlands in Northeast Brazil.

by

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Utah State University, 1985

Major professor: Dr. John C. Malechek

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The seasonal feeding behavior, forage preferences and body weight responses of goats were studied under three densities of woodland (called caatinga), and under three stocking rates. The experiment was located in the semi-arid tropics of northeastern Brazil at 3 42' South latitude, and 40 21' West longitude at an elevation of 75 meters. Mean annual precipitation of the area is 832 mm.

Removing the shrubs and trees increased yields of herbaceous only on partially-cleared sites. Goats gained body weight (kg BW/ha) during the wet season, with the cleared treatment showing the best body weight response per unit of land. However during the dry season, animals lost weight probably due the low quality and quantity of available forage.

The botanical composition of goats' diets showed them to be mixed feeders, consuming grasses, forbs and browse in various combinations depending on the season and the array of forage species available. During the dry season standing hay from herbaceous species and regrowth of some woody evergreen species were the principal forages. Animals maintained body weight on this forage. However, leaf litter was an important component of goats' diets during the dry season, but was inadequate for weight maintenance.

Goats in all treatments spent the least time grazing during the wet season and the most time during the beginning of the dry season. They spent the most time lying ruminating during the dry season and the least time during the wet season. Forage quality was probably a limiting factor to effective animal response during the dry season.

Goats exhibited dislike for rain and wet conditions. They grazed freely when the temperatures were high (35 to 39 C). However, periods of high temperature corresponded to periods of low relative humidity, perhaps moderating the discomfort factor of combined high temperatures and high humidity.

(137 Pages)

CHAPTER I

INTRODUCTION

Statement of the Problem

The semi-arid portion of northeast Brazil is one of the biggest pockets of poverty in Latin America. Approximately thirty million people, 60 percent of the population, inhabit the rural sector of the area (MINTER-SUDENE 1980). Since the eighteenth century, oscillations in climate have triggered migration of rural people to urban centers (Guerra and Guerra 1980). However, the incapacity of the urban centers to assimilate this uneducated contingent has lead to chronic social problems (Oliveira 1980). The great majority of the rural population in northeast Brazil is landless or owns small parcels of land (Furtado 1981). According to EMBRAPA-CPATSA (1979), farms with less than 100 hectares represent 84 percent of the land in northeast Brazil, and 75 percent of these are private properties. This pattern of land ownership shows that most production comes from small, typically family operations.

The rural population of this region depends on subsistence or cash crops, such as beans, cassava, corn, perennial cotton and rice. Some of these are food crops and are often planted in mixed-crop systems but production is frequently depressed by low soil fertility, eroded soil, and the unpredictability of precipitation. Sheep, goats, and cattle are important components of the mixed-farming system of the region (Gutierrez et al. 1981). The principal

source of protein for the rural people in northeastern Brazil is from animal origin, i.e. poultry, pork, sheep, goats and cattle. Cattle and goats provide milk as well as meat and hides and serve as a cash source.

The most common use of land in northeast Brazil is for shifting cultivation and for rangeland grazing of livestock. Depending on the type of soil, two years is normally the time used by the farmer for cultivation, after which he lets the land rest about 10 to 20 years (depending on soil and precipitation). Then he comes back again for a new cycle. The farmer uses the rested areas as pasture land, principally for cattle, but also for sheep and goats. Normally this type of vegetation, commonly called caatinga, is composed of a number shrubs, trees amd some annual herbaceous species. Grasses, particularly perennial species, contribute little to the total vegetation in any of those communities.

According to Gutierrez et al. (1981), working with 27 farms in Ceara state, the traditional farm management was: 53 percent of the total area used as natural pasture or uncleared caatinga for livestock production; 36 percent, as partially cleared or improved caatinga; and only 2 percent as cultivated pasture. Finally 9 percent of the land was utilized for crop production. Perennial cotton was the principal cash crop produced, and in addition to its importance for cotton production, fields were also utilized for livestock grazing after the harvest.

It is common on a particular farm to have three different types of caatinga vegetation i. **Cleared caatinga**, a kind of vegetation

that has received a total cutting treatment and has recently been used in crop production. Normally, this type is represented by a high percentage of annual herbaceous species. ii. **Partially cleared caatinga** is a type of vegetation arising from two origins a) vegetation which was previously cleared and now regrowth partially dominates the site; b) vegetation which was partially cleared for the expressed purpose of improving pasture production. According to Gutierrez et al. (1981) partially cleared caatinga represents 36 percent of the average farm area. Typically both types of partially cleared caatinga have about 50 percent of the original overstory canopy remaining. Normally there are few large trees, but many small trees and shrubs because the wood from large trees is harvested for fence material or other cash sale production. iii. **Uncleared caatinga** is a type of caatinga that has not been manipulated for 15-20 years and has a large number of shrubs and large trees and relatively little abundance of herbaceous species.

Considering that typical farms in northeastern Brazil have mixed herds of cattle, sheep and goats, it is important to clarify the feeding behavior and dietary habits of goats under caatinga vegetation. This is a basic step towards determination of correct stocking rates and livestock combinations.

The overgrazing that is common in most caatinga areas has led to a decrease in the quantity and quality of pastures in general and in extreme cases to land degradation. The umpredictability of precipitation in the region makes the correct assessment of stocking rate very difficult. Therefore, research is needed on how various

caatinga treatments affect stocking rate.

The growing human population of northeastern Brazil is increasing pressure on the land, and it is probable that the numbers of goats are increasing relative to cattle because they produce a more rapid return in relation to large ruminants (Wilson, 1984). In addition, goats have a wider dietary range, an earlier physiological maturity, high reproductive rate (twinning is common), and a short gestation period. According to Devendra (1980), goats have high economic importance and potential for increasing food production in developing countries. Seventy nine percent of the world population of goats is found in developing countries. Devendra (1980) emphasizes the greater efficiency of energy and protein utilization in goats when compared to cattle, principally in terms of milk production. Devendra (1980) reported that goats are more efficient than other domestic ruminant species, perhaps because goats derive a higher amount of metabolizable energy from coarse feeds.

Given that most farmers of northeast Brazil own small pieces of land, and that goats can be satisfactorily produced on smaller areas than cattle, goats are favored for production. Goats are one of the most adapted herbivores to the semi-arid region; they are hardy and thrive on poor quality diets (Devendra 1978).

The Brazilian goat population is about 9 million head and about 7.4 million are in the northeast region of the country (IBGE 1980). An overhelming majority of those animals are classified as nondescript or without breed, "sem raca definida" (SRD) (Riera et al. 1982). Thus, caprine husbandry plays an important role in meat,

milk, pelt, and hair production of the region (Riera 1982).

Purpose and Objectives

This study was designed to measure the feeding habits and forage preferences of goats under three different densities of caatinga vegetation at three stocking rates during wet, transition and dry seasons and under a free grazing type of management.

The specific objectives were to:

1. Identify the influence of different densities of caatinga vegetation on animal production and feeding behavior

2. Determine the influence of stocking rate within each type of caatinga vegetation density on animal production and feeding behavior.

3. Assess the influence of season (wet, transition, and dry seasons) on animal production and feeding behavior.

The results of this research are intended to have direct management application to improve goat production in northeastern Brazil.

CHAPTER II

LITERATURE REVIEW

Among the nine domesticated ruminant herbivores, goats are the third most common species, representing 15 percent of the world total domestic ruminant population. They comprise about 400 million head as compared to 1,000 million head of cattle and sheep (Harrington 1982). However, relatively little research has been conducted on goats as compared with cattle and sheep. Even though there is a considerable amount of information regarding goats' diets, those studies were made using different approaches in ecologically distinct regions.

According to Askins and Turner (1972) studies on animal behavior have been conducted to help improve livestock production and range management. Animal behavior studies have been conducted since 1797 when a Scottish farmer described certain habits of cattle, and, as a result of his observations, suggested the adaptation of a rotation grazing system (Johnstone-Wallance and Kennedy, 1944). Considering this, Smith (1959) pointed out the importance of incorporating animal behavior studies with production data where problems of pasture management exist. Doran (1943) and Stoddart and Rasmussen (1945) showed how observation on sheep habits could help to increase management efficiency on American rangelands. Johnstone-Wallace and Kennedy (1944) have shown that improved methods of pasture management may result from information on the grazing habits of cattle.

The "activity day" of a grazing animal is divided into alternating periods of grazing, walking, resting, ruminating, standing, drinking and other activities. The duration of each activity may be influenced by several factors, including grazing management and climatic variation (Hodgson, 1982). Arnold and Dudzinski (1978) pointed out that weather conditions are an important factors needing to be know to minimize physiological stress in animals. According to Lampking et al. (1958), working with steers grazed at Muguga in Kenya's equatoral zone, only 8 percent of their grazing was at night at high altitude. But when moved to a hot humid coastal environment, 29 percent of their grazing occurred at night. Arnold and Dudzinski (1978) stated that the time spent in rumination depends on the quantity and quality of forage eaten by ruminant animals. Welch and Smith (1969) found that poor-quality roughage with high levels of fiber and cell wall constituents produced the greatest amount of rumination. However, in another study, rumination time was reduced when a large proportion of concentrate was fed (Oltjen et al., 1962).

Feeding Behavior

Anatomical differences in cattle, sheep and goats lead to different modes of food prehension. Sheep are more selective feeders because they have a smaller mouth and teeth than cattle and can take smaller bites and can eat closer to the ground (Arnold 1981). Since both goats and sheep have roughly the same mouth size, theoretically

they should be similar in dietary selectivity. However, the goat's ability to browse forage is facilitated by the presence of a mobile upper lip, a generally small body size, and great agility. They also seems to have a greater tolerance to different tastes (McCammon-Feldman, 1980).

Several authors have described differences in foraging behavior between goats and other livestock. According to French (1970) goats nibble their feed for very short periods before moving on to a new area. In Australia, Harrington (1982) working with sheep and goats noted that while sheep showed a significant aversion to grazing on shrubs, which covered 20 percent of the area, goats did not discriminate against shrubs. He also found that goats tended to choose a different grazing environment than did sheep and cattle, although considerable overlap occurred. This often resulted in different forages being available to them. According to Devendra and Coop (1982) an additional advantage of goats over sheep in some situations is their tendency to wander over longer distances in search of food. Free-grazing goats have different preferences depending on the kind of range they are grazing. Coblentz (1974) emphazised that goats under free-grazing showed a marked preference for hilly terrain or areas with a dense tree or shrub cover.

In northeastern Brazil, Araujo Filho et al. (1982) working in caatinga vegetation found that cattle grazing in common with goats gained less weight on any treatment or during any season than when grazed alone, probably due to competition for forage. However, goats did not affect sheep gains. They also stated that goat grazing on

uncleared caatinga produced the best weight gain throughout the year.

Variable results by different authors make it difficult to classify the goat as a grazer or browser. In Kenya, Edward (1948) observed that goats did not use grasses, but they ate new leaves of forbs and shrubs in the wet season and fallen leaves in the dry season. In Uganda, Wilson (1957 a.) found that goats grazed grasses but only as a small proportion of their diet as compared to shrubs and trees. In the southwestern United States, Cory (1927), and Davis et.al. (1973) reported that during most of the seasons, goats ate more browse than grass. On Texas range, Askins and Turner (1972) found that goats spent 28 percent of the day grazing grasses and weeds. This was similar to feral goats in New Zealand where 30 percent of the day was spent in feeding activities (Kilgour and Ross, 1980). In Texas, Askins and Turner (1972) found that 34.4 percent of the feeding time throughout the four seasons was spent in grazing while 65.6 percent was spent in browsing. During winter and spring the goats grazed more than they browsed. The inverse was true for fall and summer. They used the term "grazing" to include feeding upon both weeds and grasses. In Kenya, Knight (1965) reported that during the dry season, 83 percent of feeding stops by goats were on grasses, and goats preferred more grasses in their diets than forbs and shrubs. He further stated that 65, 83 and 38 percent of the goats' diets on three different sites of mixed woodland vegetation were grasses. Averaged across the study and across sites, browse made up 22 percent and forbs only 16 percent of

the goats' diets. Grasses were consumed more during the dry season when the majority of the more palatable broad-leafed foliage had been consumed. According to Malechek and Leinweber (1972), the diet selected by goats at two stocking rates did not differ greatly in their respective proportions of browse, forbs or grass. In New Zealand Riney and Caughley (1959) reported that feral goats fed mainly in areas where grasses were abundant.

In contrast, Huss (1972) indicated that goats were primarily browsers by preference, and Yocum (1967) provided similar data from Hawaiian goats slaughtered during the winter. However, during the summer, goats changed their diets and selected more grasses and forbs. According to Harrington (1978), goats eat more browse than do either sheep or cattle. He pointed out that when acceptable browse was plentiful, goats spent more than 50 percent of their time browsing. Also when browse was in short supply they spent even less time browsing.

According to Malechek (1970) forage class preference of goats was seasonal and depended on the availability and stage of growth of the plant species. In northeastern Brazil, Mesquita (1981) observed that feeding behavior of SRD goats in uncleared caatinga was seasonal, and their feed preference depended on availability of forage in the wet season. Stanley (1938) working in Arizona, concluded that grazing habits are dependent on factors that influence the condition of various plants species. Brown (1971) found that in certain areas of range, the preference by sheep for some species depended on the season. Coblentz (1977) showed that

feral goats during the Spring on Santa Catalina Island, California, ate herbaceous vegetation to the extent of 92 percent of the diet, and that annual grasses primarily Bromus sp. were the most frequently utilized food items. However, grasses were less important in winter before the new growth began. Griego (1977) working in Tunisia with goats and sheep under free-grazing conditions during spring showed that goats and sheep grazing separately were more apt to select annuals over perennials, and that goats and sheep preferred the same annual species. In Nicaragua, Pineda (1975) studied forage preferences of goats under free-grazing at the end of the dry season. He found that, although forage preference varied widely among goats, the five forage species most utilized were: a leguminous tree Pithecolobium dulce, two unidentified shrubs, a nonleguminous tree Pisonea aculeata and the dominant grass Hiparrhenia rufa. These five most-consumed species did not correlate with their availability measured on pasture.

Preferential feeding by herbivores causes changes in the floristic composition of rangelands. This change has been demonstrated under grazing by large herbivores by Vesey-Fitzgerald (1973 a, b.) and Laws et al. (1975). Even though the literature is controversial in characterizing goats as either a browser or grazer, the effect of these animals on the vegetation is complex. The season of grazing in relation to the phenological stage of the plant appears to be an important factor in causing the floristic composition to change (Hopkins, 1983).

According to Freer et al. (1962) the grazing animal uses

tactile, gustatory, and olfactory senses to determine the acceptability of plant parts. Hafez and Scott (1962) stated that goats have been shown to have a higher threshold to bitter tastes as compared with cattle, and this allows them to tolerate the bitterness of many browse species (McCammon-Feldman,1980). Bell (1959) found that goats can better distinguish between various kind of bitter tasting solutions than cattle can, but probably less than camels. He suggested that the difference between the thresholds of rejections between goats and cattle may be explained by the contrasting grazing behavior. Goats, which according to him are browsing animals, feed on shoots of shrubs which are normally bitter. However, according to Heady (1964), food selection is governed by a complex mixture of factors.

Tropical climates have dry periods which contribute to seasonally low availability of forage. There has also been shown a reduction in animal body weight principally when the moisture is not sufficient for plant production. According to Van Soest (1982), in this situation some particular adaptive features of animals may be called into play to avoid or reduce this seasonal effect. He stated that animals must rely on energy stored in adipose tissue for support in lean periods. Consequently, growth under such conditions is characterized by large variations in body weight. However, goats were not observed to lose weight during the dry winter season in Nicaragua (Van Soest 1982). Van Soest ventured that goats performed better because they consumed foliage of the deep-rooted shrubs or trees that remained green throughout the dry season. Goats were able

to use these plants even though they had thorny branches. Also, they occasionally climbed small trees utilizing the foliage in the canopy. Some of these characteristcs may be part of the reason why goats seen to be so well adapted and able to thrive in particular environments while other domestic species have problems, particularly during stress periods such as droughts.

Animal Behavior

Grazing patterns of animals may vary widely (Lynch 1974). The time of year is an important factor in grazing behavior due to seasonal effects on forage availability and animal requirements. Lynch (1974) stated that sheep can adopt behavioral strategies that satisfy their internal and external environment. Arave and Albright (1981) working with cattle found that walking time decreases as grass availability increases in the early grazing season. Cory (1927) observed that range sheep travelled 6.0 and goats 9.6 kilometers per day. He also stated that the increase in the distance travelled was associated with an increase in the total grazing time.

External environmental factors may also alter animal behavior, and according to Ruckebusch and Bueno (1978) wind, rain and heat can disrupt normal grazing activity of cattle under field conditions. Drought can also cause change in animal grazing behavior. According to Trlica (1972) drought affects the production of rangeland plants and grazing behavior. Temperature is another

important factor, especially in temperate zones. Tribe (1950) found that sheep grazing in temperate pastures walked more at night during the summer than during the winter. According to Arnold and Dudzinski (1978) the stresses of high temperature and high humidity during the day may cause discomfort to cattle of different breeds. Dudzinski and Arnold (1979) indicated that sheep could sense that it was to be a hot day and so started their grazing earlier. According to Horst (1983) the direct and indirect effects of climatic factors such as temperature and high relative humidity are the principal constraints to production in the tropics. He further stated that high temperatures may provoke a general reduction in food intake, and as consequence, an imbalance in individual energy, protein and mineral supply to the animal. Payne et al. (1951) working in a tropical climate where length of daylight varies little, found that cattle grazed predominantly at night.

Use of particular camping sites is a common behavior in sheep. Hafez and Scott (1962) found that sheep camp on high ground during cold weather and near water or under shade during hot weather. He also stated that, except during extremely hot weather, when they spent more time resting, sheep can graze more frequently at night than during the day time, and the incidence of night grazing depends on the temperature and prevalence of flies.

Observations made with sheep in Scotland indicate that grazing time in the night hours between 7 pm and 7 am is considerably longer in summer than in the winter (Tribe 1950). Hafez and Scott (1962) indicated that goats increase their eating time and their

mastication rate when the ambient temperature is decreased; however, below 10 C eating activity slows.

Little information has been scientifically developed concerning effects of management on behavior of goats under free-grazing and particularly under tropical conditions.

Observation Technique

Many methods of observation and recording activity of livestock behavior have been studied, and several investigators have compared the efficiency between continuous and intermittent methods of observation. Hull et al. (1960) compared continuous observation with instantaneous recording at 15, 30, and 60 minute intervals on four individual steers. They concluded that up to a 30-min. interval between instantaneous observations was adequate to report major activities. However, more frequent observation was required for minor activities and several animals were needed because of the variation among individuals. According to Altmann (1974) scan-sampling could provide information on the degree of synchrony among members of a group, but each individual must be scanned for the same brief period of time. Harked et al. (1954) working with 10 cattle, compared intervals of 1 to 6 minutes in recording activities of each animal using the instantaneous observation technique. After the observation was recorded, a period of 5 min. was allowed to elapse before a new observation was recorded. They found that the 4-min.

interval after a 5-min. rest gave a precise measurement of cattle behavior. Instantaneous observation on each group of animals is also refered to as a scan-sampling technique. According to Pearson and Reid (1951), making observations at 4-min. intervals gave precise and accurancy results for developing complete activity budgets. Hull et al. (1960) recommended that at least four animals per treatment must be observed individualy.

CHAPTER III

METHODOLOGY

Study Area

The 40.5-ha study area was located on the Brazilian National Goat Research Center (Centro Nacional de Pesquisa de Caprinos or CNPC) near Sobral, Ceara' state, Brazil. The municipality of Sobral is located at 3°42' South latitude, and 40°21' West longitude, at an elevation of 75 meters.

The major part of the study area is occupied by two soil-types: Solodic Planosol and Litosol (EMBRAPA-CNPC, 1980). The former is characterized by a sodium affected clay-pan with low permeability. This clay-pan restricts the effective rooting depth to the sandy surface layer. Generally this sandy surface is infertile and has low water holding capacity (Jacomine et al. 1973). Litosols are shallow soils lacking significant horizon differentiation. Thus, their physical and chemical characteristics are closely related to the underlying bedrock. In the study area, the Litosols tend to be coarse textured and seldom deeper than 50 centimeters (Ramos, personal comunication).

Climate

The climate in this part of northeastern Brazil is characterized by distinct wet and dry seasons. The dry season typically extends

from June through December, although periodic droughts may occur and this can extended the dry season to 11 months (Christiansen-Weiger, 1977). Evapotranspiration is high. For example, Figure 1 describes the relationship between monthly evaporation, mean monthly precipitation and the monthly precipitation with 60 percent probability of being equaled or exceeded for the town of Sobral. Mean monthly precipitation exceeds mean monthly evaporation only in March and April. The average precipitation in Sobral for a recent 53-year period is 832 mm (Hargreaves 1973). The 538 mm precipitation recorded in 1981 represents a dry year (Figure 2.). According to Hargreaves (1973), this amount of rainfall (538 mm) can be expected to be equaled or exceeded in 8 out of 10 years.

Table 1 shows the temperatures, relative humidities and precipitation during 1981. Data on relative humidity was recorded beginning in July of 1981. For this reason, the relative humidity values before July represent data collected in Sobral, 5 kilometers from the experimental area.

During the dry season the relative humidity is typically high, ranging from 85 to 95 percent during early morning and 30 to 40 percent in the afternoon. Temperatures in this area are generally hot, with the minimum normally occuring during the night and the maximum around 1:00 pm. Appendix Table 16 presents the day length in Fortaleza, Ceara' state (3°47' S and 38° 32' W). Sobral should show little deviation from this pattern.

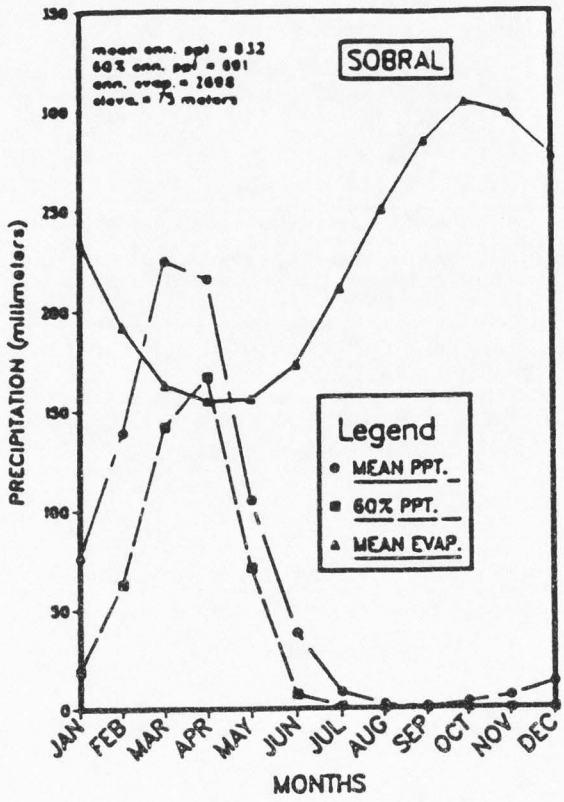

Figure 1. Mean monthly precipitation, mean monthly evaporation and the maximum monthly precipitation with 60 percent probability of occurrence.

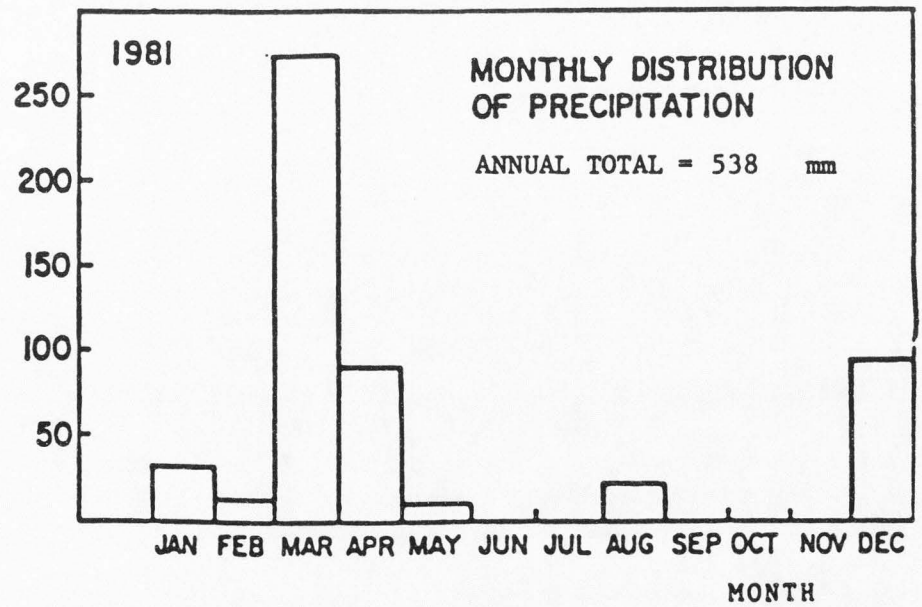

Figure 2. Monthly distribution of precipitation (mm) in study area.

Table 1. Temperature, relative humidity and precipitation in Sobral, Ceara', NE-Brazil, 1981.

Months	Mean temperature (centigrate) hours			Relative Humidity (%)					Precipit.
	9	15	21	mean	max.		min.		(mm)
January	28.0	33.0	27.3	66	-		-		45.6
February	28.6	33.9	27.7	59	-		-		18.7
March	27.2	30.4	26.0	76	-		-		270.5
April	27.5	31.3	26.1	75	-		-		67.7
May	27.6	33.3	26.3	74	-		-		41.8
June	27.9	33.5	27.2	59	-		-		0.7
July	27.8	34.5	27.0	56	81.5	7.3	31.0	4.7	0.3
August	27.7	34.3	27.0	60	85.2	5.3	33.9	4.2	12.9
September	30.0	36.5	28.7	58	81.9	6.5	33.4	5.0	0.1
October	30.3	37.3	28.4	57	85.5	7.1	29.0	3.0	0.1
November	29.5	35.4	27.4	60	86.7	5.3	33.2	3.0	2.1
December	28.8	34.0	27.8	64	90.0	6.0	37.1	9.9	77.5
Total									538.0

Experimental Lay Out

The 40.5-ha study area was divided into three major treatments based on caatinga density: uncleared, partially cleared, and cleared. The uncleared treatment represented a vegetation type typical of one that had not been cut for at least 15 to 20 years. The partially cleared treatment began with the same type of tree stand but about 70 percent of the trees were cut and removed in 1978. At the time of the clearing, there were no data available on the relative palatability of the various species to goats. Therefore, the clearing was done according to the traditional practices of local farmers, i.e. there was no selection against unpalatable species. In the cleared treatment, all species of shrubs and trees (except 2 or 3 trees per-hectare left for shade) were cut in 1978. The regrowth was cut in each subsequent year.

In each treatment three subplots of stocking rate were established: heavy, moderate, and light. However, the stocking rate was not uniform across all vegetation treatments. This was because the carrying capacity was anticipated to be different in each type of caatinga density and this adjustment was done to provide roughly the same forage-to-animal ratio in each treatment. However it is recognized that this causes problems in comparisons among caatinga treatments. Three goats were confined to each of the subplots and were grazed continously throught the year. A summary of the experimental lay-out is shown under Table 2.

Table 2. Treatment specifications.

Grazing intensity	Uncleared		Partially Cleared		Cleared	
	stocking rate (ha/anim.)	total area (ha)	stocking rate (ha/anim.)	total area (ha)	stocking rate (ha/anim.)	total area (ha)
Heavy	1.0	3.0	0.75	2.25	0.5	1.5
Moderate	2.0	6.0	1.50	4.50	1.0	3.0
Light	3.0	9.0	2.25	6.75	1.5	4.5
Total		18.0		13.50		9.0

Three seasons were studied : wet, transition, and dry season. The wet season was considered to start in February and extend through June, the transition season started in July and finished in September, and the dry season started in October and lasted through January. Data collection began in May, supposedly during the peak of primary production. The data for the transition season was collected in August when normally a large number of the deciduous species lose their leaves and also the annual herbaceous species are cured in the field as standing hay. The dry season data were collected during October and November when the animals commonly start to lose weight.

Vegetation

The research site is characterized by caatinga type of vegetation. Caatinga is an Indian word meaning "white forest" (Ferri, 1980). It is a complex mix of deciduous trees and shrubs with an annual herbaceous understory (Cole, 1960).

The specific vegetation on the area was dominated by a relatively old stand of trees, probably 15 to 20 years without disturbance. Important species included: Pau Branco (Auxemma oncocalyx), Sabia (Mimosa caesalpinifolia), Jurema preta (Mimosa acutistipula), Jurema branca (Pithecolobium dumosum), Juazeiro (Ziziphus joazeiro), Jucazeiro (Caesalpinia ferrea), Melosa (Ruellia sp.) and Mufumbo (Combretum leprosum). The herbaceous stratum was dominated by Milha (Paspalum sp. and Panicum sp.), Bamburral branco

(Blainvillea shomboindea), Bamburral verdadeiro (Hyptis suaveolens), Ervanco branco (Froelichia humboldtiana), Chanana (Turnera guianensis), Feijao de rola (Phaseolus lathyroides), Maracuja (Passifloria sp.), Mirasol (unindentified species), Matapasto (Cassia tora), Paco-paco (Wissadula amplinima) and Relogio (Waltheria sp.) (Appendix Table 17 and 18).

The dry-weight-rank method (t'Mannejete and Haysock, 1963 and Jones and Hargreaves, 1979) was used to measure the herbaceous component of the plant community. Three fixed transects were established on each soil type in each paddock. Two hundred samples were observed on each transect and botanical composition and standing biomass (on a dry matter basis) were determined. Herbaceous standing plant biomass was measured during the wet season only. During the dry season, both herbaceous standing plant biomass and litter biomass on the ground were measured. For shrubs and trees, the line interception method as described by Hyder and Sneva (1960) was used to determine density and cover.

Animals

Twenty seven native male goats of the SRD type (Sem Raca Definida or Without Definite Breed), three for each treatment, were randomly selected and blocked by age and weight from a common herd so as to minimize the effect of previous experience, as advised by Schneider and Flatt (1975), and Arnold and Maller (1977). The selected animals were castrated two months before being taken to the

study area. All experimental animals received medication to control internal and external parasites, according to Costa and Vieira (1984) and were also periodically vaccinated as recomended by the veterinary control scheme used in the CNPC animal herd. The goats were ear tagged for identification purpose and weighed every 28 days after a 16-hour fast. Mineral salt and water were offered ad libitum.

Scan-sampling, described by Altmann (1974), was used to determine animal activities. An animal was observed for ten or fewer seconds and the activity in which it was engaged was noted and recorded. The next animal in the treatment group was then observed, and so-on until all three animals' activities were recorded. Recordings were made at 5-minute intervals. This sequence was followed throughout the day, beginning at 08:00 hrs. and continuing until 17:30 hrs. This procedure was followed for a nine consecutive days until all treatments (uncleared, partially cleared and cleared), were sampled. This series of observations was made once during each of the three previously-defined seasons (wet, transition and dry season). In some cases observations were aided by the use of hand held binoculars. Activities were recorded only during daylight hours. They were divided into seven major categories: 1. grazing, 2. traveling, 3. resting, 4. standing, 5. drinking 6. licking salt, and 7. ruminating.

The following definitions were used for the seven activities:

1. **Grazing**: periods of active feeding upon grass, forbs, shrubs and tree species.

2. **Traveling**: the periods that animals were only walking without feeding.

3. **Resting**: the portion of lying time which was not occupied by rumination.

4. **Standing**: the time the animal spent standing in an immobile state but not lying.

5. **Drinking water**: the short periods of time when the animal stopped other activity to drink water.

6. **Licking salt**: the short periods of time when the animal stopped other activity to lick salt.

7. **Ruminating**: the total time (i.e. both lying and standing) spent in regurgitation, mastication and swallowing of ruminal ingesta.

When the goats were engaged in grazing activity I recorded the species and parts of plants they were eating and the amount of time spent consuming each item. This record gave the diet of animals under different treatments. The ratio between percentage of the species in the diet and percentage of that species present on the pasture gave a preference ratio as recommended by Van Dyne et al. (1980) who stated that the best way to express the dietary botanical composition for an animal is by a preference ratio.

Data Analysis

The statistical design used to analyze the data on animal behavior, standing plant biomass, and weight of animals was an

single replication of a three factor design comparing, vegetation "V", stocking rate "R" and season "S". Differences among these factors were analysed by analysis of variance procedures (AOV). Animal grazing activities were also analysed by AOV procedures. First, all activities were analysed under a single model (Appendix Table 37). For those activities where significance was indicated, further analysis was done on an individual activity basis (Appendix Table 38 to 42).

Due to problems of land availability, a second replication of this experiment was not possible. This necessitated the assumption that the three way interaction was zero, in order to perform "F" tests.

Data reduction and analysis was done using the statistical computing packages Minitab (Ryan et.al. 1981) and Rummage (Bryce, et al. 1980), respectively. A protected LSD procedure was employed to compare individual means.

Data Inference

Due to the lack of replication in either space or time, the results of this study are severely restricted in inference. However, the work was justified as a pilot study to guide the direction of subsequent research. At the time the study was initiated, there were no data in existence on how land treatments (clearing) affected animal performance and dietary behavior.

CHAPETR IV

RESULTS

Animal Performance

Caatinga Density

The average body weights of young goats when they entered in the experiment in 1980 were: 19.8, 20.0 and 20.6 kg BW/head under uncleared, partially cleared and cleared caatinga vegetation, respectively. In 1981 they were: 21.4, 21.3 and 21.2 kg BW/ha, respectively (Figure 3).

Statistical analysis for body weight gain was done only for the data collected during 1981, because this year corresponded to the data collected for vegetation and animal behavior. There were statistical differences among vegetation density categories ($P<0.05$). Goats tended to gain the most weight under cleared and least under uncleared caatinga vegetation (16.9 vs 5.4 kg BW/ha). Partially cleared vegetation was intermediate with 10.3 kg BW/ha. While the above values represent yearly averages, there were periods during wet and dry seasons, when animals did not respond uniformly. For example during the wet season, weight gains were the highest of all periods (Table 3) due to greater availability of forage. Complete body weigh data are found in Appendix Tables 19, 20 and 21).

Stocking Rates

There were also significant differences among stocking rates

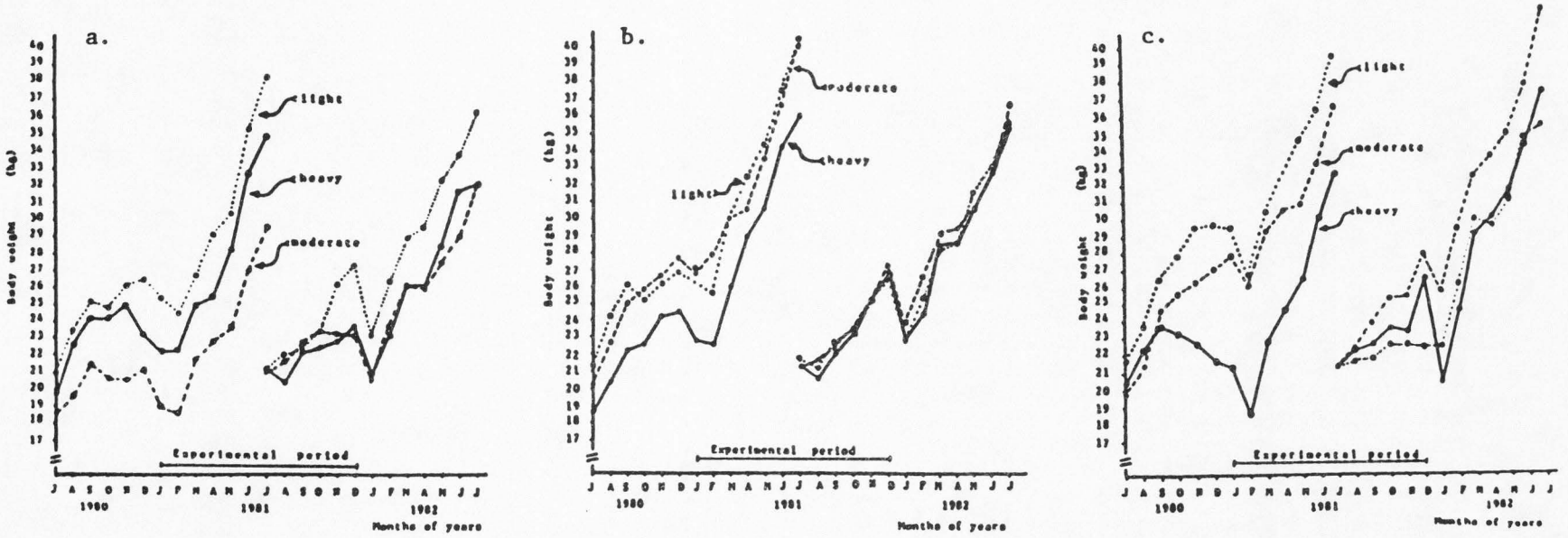

Figure 3 . Seasonal body weights (kg/head) of goats on uncleared (a), partially cleared (b) and totally cleared caatinga (c), each at three stocking rates.

Table 3. Weight gain (kg/ha) by goats during three seasons under three different densities of caatinga vegetation, 1981.

Season	Uncleared	Partially Cleared	Cleared	Seasonal mean
Wet	7.6 cp	10.0 bp	16.0 ap	11.2
Transition	0.7 am	1.1 am	1.1 am	1.0
Dry	(2.9) bn	(0.8) an	(0.2) an	(1.3)
Total	5.4	10.3	16.9	

Values with common superscripts in rows (a,b and c) and columns (m, n and p) are not significantly different ($P < 0.05$).
Value in parentheses are negative (weight losses).

($P<0.01$). Averaged over all caatinga densities, goat production per unit land was highest under the heavy grazing treatment (Table 4). However, goats from the light grazing treatment gained more weight per head. Moderate stocking under partially cleared and cleared vegetation was the most effective in minimizing weight loss during the dry season studied in 1981.

Season of Year

There were also significant differences among seasons ($P<0.01$). All animals tended to gain more weight (kg BW/ha) during the wet season. However, they tended to lose weight during the final months of the dry season, and also at the begining of the wet season. They recovered this weight loss as the wet season progressed and the availability of forage increased. This phenomenon is typically termed "compensatory growth" (Wilson and Osbourn, 1960).

During the transition season in all treatments studied, goats did not lose weight; however, they gained very little body weight in relation to the wet season.

A forage bottleneck exists for goats during the dry season, because normally they tend to lose weight during this season. During the wet season in all treatments the goats gained weight; however, goats in cleared caatinga gained the most body weight.

Table 4. Weight gains (kg/ha) by goats under three densities of caatinga vegetation during three seasons and under three stocking rates, 1981.

Season	Stocking Rates: Heavy	Moderate	light
Uncleared			
Wet	12.83 ap	5.48 bp	4.56 bp
Transition	1.54 am	0.55 am	0.11 am
Dry	(1.47) an	(1.34) a,m	(0.06) am
Total	12.90	4.69	4.60
Partially Cleared			
Wet	17.68 ap	8.89 bp	6.41 bp
Transition	1.64 am	0.64 am	0.68 am
Dry	(0.84) an	0.29 am	(0.22) am
Total	18.48	9.82	6.87
Cleared			
Wet	29.12 ap	10.50 bp	8.47 bp
Transition	1.34 am	1.67 am	0.13 am
Dry	(0.60) am	0.47 am	(0.09) am
Total	30.36	12.64	8.69

Values with common superscripts in rows (a,b and c) and columns (m,n, and p) are not significantly different ($P < 0.05$).
Values in parentheses are negative (weight losses).

Vegetation

Caatinga Density

Partially cleared caatinga yielded the highest amount of standing biomass (4,507 kg DM/ha) and cleared caatinga the least (3,179 kg DM/ha). The uncleared treatment was intermediate at 4,095 kg DM/ha (Table 5). However, this must be viewed with caution because a particular stocking rate was not uniform across all treatments (Table 2) and biomass present at any given moment was a function of removal due to grazing as well as production. For example, heavy grazing under uncleared and moderate grazing under cleared caatinga vegetation had the same stocking rates (1.0 ha/anim./year) (Table 3). The standing biomass estimates for these two respective treatments were 2,812 and 2,901 kg DM/ha during the wet season, and 860 and 510 kg DM/ha during the dry season. Also, moderate grazing under partially cleared and light grazing under cleared caatinga had the same stocking rates (1.5 ha/anim./year). The respective biomass estimates were 4,623 and 2,907 kg DM/ha during the wet season, and 1,221 and 717 kg DM/ha during the dry season, (Appendix Table 22, 23 and 24).

Important forb species under uncleared caatinga (at all stocking rates) were mirasol[1], bamburral branco and ervanco branco. Grasses were also important contributors to the botanical composition. Milha, (*Brachiaria sp.* and *Paspalum sp.*), two annual grasses very

[1] A complete list of plants showing both local and scientific nomenclature is presented in Appendix Table 18.

Table 5. Biomass yields (kg DM/ha) during the wet and dry season under three different densities of caatinga, 1981.

Season	Uncleared	Partially Cleared	Cleared
Wet	2,977 b,p	3,508 a,p	2,583 c,p
Dry	1,118 a,m	1,000 a,m	597 b,m
Total	4,095	4,507	3,179

Value with common superscripts in rows (a, b and c) and columns (m, n, and p) are not significantly different ($P<0.05$) and ($P<0.01$), respectively.

common in the region, had a higher percentage than other grasses, such as capim barba de bode (Andropogon virginium), capim panasco do Ceara' (Aristida sp.) and capim rabo de raposa (Andropogon sp) (Table 6).

The biomass of shrubs and trees on the pastures were not measured during the wet season. However, cover was measured for browse species. Under uncleared caatinga, cover values of 75, 74 and 74 percent were recorded on heavy, moderate and light stocking rates, respectively. Aroeira, jurema preta, mufumbo, pau branco and sabia were the species which contributed most of the cover under all stocking rates. Leaf litter biomass was measured during the dry season (Appendix Table 25).

Partially cleared caatinga supported a greater biomass of herbaceous species during the wet season than did uncleared caatinga. Also, the number of species present increased due to the partial clearing (Appendix Table 24 and 22). However, this number increased to five (Table 7) under partially cleared vegetation. The three species cited previously under uncleared vegetation and two other species, chanana and relogio, were important. Cover values under the partially cleared treatment were 32, 35 and 32 percent for heavy, moderate and light grazing, respectively. Jurema preta, pau branco and sabia were the tree species which ranked high in cover under this treatment (Appendix Table 26).

In cleared caatinga all shrubs and trees were removed in 1978 and the regrowth (coppice material) was re-cut each year. Two trees per hectare were retained as shade for goats. Theoretically,

Table 6. Percentage botanical composition of vegetation during wet and dry seasons under three different stocking rates in uncleared caatinga, 1981.

Species	Wet Season Stocking Rate heavy	moderate	light	Dry Season Stocking Rate heavy	moderate	ligh
Forbs						
Amendoim bravo	T	T	1	-	-	-
Azulao	6	1	T	-	-	-
Bamburral branco	8	9	12	10	11	8
Bamburral verd.	3	5	5	6	4	5
Canafistula lagoa	1	T	3	T	T	3
Carrapicho de agulha	1	T	1	T	T	1
Chanana	T	T	T	T	T	T
Cidreira brava	1	T	T	-	-	-
Engana bobo	40	52	15	-	-	-
Erva mijona	-	11	16	-	2	4
Ervanco branco	16	5	12	7	3	5
Feijao de rola	T	T	T	T	T	T
Jitirana	T	2	8	3	1	2
Lingua de vaca	T	8	1	-	-	T
Maracuja	T	T	T	T	-	T
Maria preta	-	T	4	-	-	-
Marmelada de cavalo	T	T	T	-	-	T
Matapasto	-	T	-	T	-	T
Mato leitoso	-	5	5	-	-	-
Mirasol	23	32	7	9	5	8
Paco-paco	3	2	3	2	2	2
Pega-pega	T	1	T	-	T	-
Relogio	T	T	3	T	T	2
Others	T	1	2	-	T	2
Total Forbs	71	90	86	86	98	95
Grasses						
Capim barba bode	6	1	2	10	1	2
Milha	22	8	8	4	T	3
Panasco do Ceara	T	T	1	-	-	-
Rabo de raposa	1	T	3	-	-	-
Total Grasses	29	10	14	14	2	5
Leaf litter	-	-	-	47	67	50

T: values less than 1.0 percent
Specific names of plant species are shown in Appendix Table 5.

Table 7. Botanical composition (%) of vegetation during the wet and dry seasons under three stocking rates in partially cleared caatinga, 1981.

Species	Wet Season Stocking Rate			Dry Season Stocking Rate		
	heavy	moder.	light	heavy	moder.	light
Forbs						
Amendoim bravo	T	6	T	-	T	-
Anil bravo	T	-	T	-	-	-
Azedinho	-	T	T	-	T	-
Azulao	10	T	3	4	T	1
Bamburral branco	5	-	6	5	-	9
Bamburral verda.	4	4	1	4	1	2
Canafistula lagoa	T	3	2	-	8	3
Centrosema	T	T	T	-	-	T
Chanana	7	10	5	3	2	2
Engana bobo	T	T	T	-	-	-
Erva mijona	4	5	12	2	2	T
Ervanco branco	7	9	12	5	4	16
Feijao de rola	T	10	5	2	2	5
Jitirana	3	5	8	T	T	7
Lingua de vaca	T	T	T	T	-	T
Malva relogio	T	1	T	-	3	T
Maracuja	T	5	3	-	-	4
Marmelada cavalo	T	T	1	-	-	T
Matapasto	2	6	2	2	7	2
Mirasol	21	11	14	17	32	8
Paco-paco	3	2	4	2	T	2
Pega-pega	T	T	T	T	T	-
Pescoco de ganco	2	T	T	-	T	T
Relogio	5	10	4	5	3	4
Others	2	2	6	2	2	2
Total Forbs	77	94	92	88	88	98
Grasses						
Capim barba bode	T	T	T	T	T	T
Milha	19	5	7	9	11	1
Panasco do Ceara	2	-	T	3	T	-
Rabo de raposa	T	2	-	-	4	-
Total Grasses	23	6	8	12	12	2
Leaf litter	-	-	-	35	16	25

T: values less than 1.0 percent
Scientific names of plant species are shown Appendix Table 5.

herbaceous species should have shown high production when compared to other vegetation treatments. However, this did not occur. For example, 2,813, 3,529 and 2,590 kg/ha were produced in uncleared and 1,942, 2,901 and 2,907 kg/ha were produced in cleared treatments, respectively under heavy, moderate and light stocking. However, the diversity of forbs species was greater under the cleared treatment. Azulao, bamburral branco, bamburral verdadeiro, ervanco branco, feijao de rola, maracuja and milha were the species that ranked high in the botanical composition of cleared caatinga (Table 8).

Stocking Rates

There were statistical differences among stocking rates ($P<0.05$). Total herbaceous biomass on uncleared caatinga was highest ($P<0.05$) under moderate grazing (4,891 kg DM/ha), least under heavy grazing (3,672 kg DM/ha), and intermediate (3,723 kg DM/ha) for the light stocking rate. No difference was found between heavy and light grazing (Table 9).

Under partially cleared caatinga, total standing biomass was highest under moderate and least under light grazing (5,845 and 3,575 kg DM/ha, respectively). Heavy grazing was intermediate with 4,101 kg DM/ha (Table 9).

Under cleared caatinga total standing biomass was highest ($P<0.05$) under light and least under heavy stocking (3,624 and 2,453 kg DM/ha, respectively). The moderate stocking rate was intermediate with 3,464 kg DM/ha. However, no statistical difference was found between light and moderate grazing, but there was a statistical

Table 8. Botanical composition (%) during the wet and dry seasons under three stocking rates in cleared caatinga, 1981.

Species	Wet Season Stocking Rate			Dry Season Stocking Rate		
	heavy	moderate	light	heavy	moderate	light
Forbs						
Amendoim bravo	T	T	T	-	-	-
Azulao	9	5	7	7	3	3
Bamburral branco	1	7	4	2	8	2
Bamburral verdadeiro	15	1	1	1	3	2
Canafistula de lagoa	-	T	T	-	-	-
Chanana	T	3	2	-	-	-
Engana bobo	2	T	3	1	1	4
Erva mijona	T	15	T	-	3	-
Erva de ovelha	T	T	2	-	-	-
Ervanco branco	17	6	10	16	10	12
Feijao de rola	8	14	8	12	9	2
Girao	T	T	2	-	T	-
Jitirana	3	9	2	-	T	1
Lingua de vaca	5	1	1	4	3	3
Malicia	T	T	6	-	2	T
Malva relogio	2	2	3	3	5	1
Maracuja	8	15	T	9	16	13
Marmelada de cavalo	T	T	T	T	-	-
Matapasto	5	3	3	4	3	4
Mirasol	1	-	2	T	-	T
Relogio	T	3	2	3	2	3
Salsa	-	-	8	-	-	5
Others	4	T	2	1	1	T
Total Forbs	82	87	71	76	69	61
Grasses						
Capim barba de bode	2	T	3	3	2	4
Milha	16	12	26	20	29	31
Panasco do Ceara	T	T	T	T	T	4
Total Grasses	18	13	29	24	31	39

T: values less than 1.0 percent.
See Appendix Table 5 for scientific names of plants.

Table 9. Biomass yield (kg DM/ha) during the wet and dry seasons under three stocking rates for three caatinga densities, 1981.

Season	Stocking Rates		
	Heavy	Moderate	Light
	Uncleared		
Wet	2,812 b,p	3,530 a,p	2,590 b,p
Dry	861 b,m	1,362 a,m	1,135 ab,m
Total	3,673	4,892	3,725
	Partially Cleared		
Wet	3,240 b,p	4,623 a,p	2,659 c,p
Dry	861 b,m	1,221 a,m	917 ab,m
Total	4,101	5,844	3,575
	Cleared		
Wet	1,942 b,p	2,901 a,p	2,907 a,p
Dry	511 a,m	563 a,m	717 a,m
Total	2,453	3,464	3,724

Values with common superscripts in rows (a ,b and c) and columns (m, and p) are not significantly different ($P<0.05$) and ($P<0.01$), respectively.

difference ($P<0.05$) between the moderate and heavy stocking rates (Table 9).

Season of the Year

Vegetation biomass was measured only during the wet and dry seasons. In all caatinga densities and under all stocking rates, the wet season was more ($P<0.01$) productive than the dry season. In general, species that were common during the wet season tended to show the same dry season pattern. However, a few exceptions were found (Appendix Table 22,23 and 24). For example, maracuja in cleared caatinga under light stocking showed 21.6 and 89.6 kg DM/ha during wet and dry seasons, respectively (Appendix Table 23).

During the dry season, both the standing biomass and leaf litter were measured. Leaf litter was an important component in the pasture under uncleared and partially cleared vegetation. Leaf litter on the uncleared treatment was clearly the dominant component of available biomass with 47, 67 and 50 percent of the total biomass for heavy, moderate and light grazing, respectively. However, during the dry season the total biomass decreased drastically with 30, 39 and 44 percent of the amount found during the wet season. Many of the plants were annuals and when the dry season began they lost their leaves. Pau branco and mofumbo were the two most important species contributing to leaf litter yields, with 227, 685 and 339 kg DM/ha for pau branco and 102, 130 and 54 kg DM/ha for mofumbo under heavy moderate and light grazing, respectively. These two species also had high values for cover (Appendix Table 25).

On partially cleared vegetation, the biomass values during the wet season tended to be higher on all stocking rates when compared with uncleared treatments. Again this observation requires caution because the stocking rates were not uniform, and biomass present at any given moment was a function of removal due to grazing as well as production.

Leaf litter was lower on partially cleared than on uncleared caatinga. Obviously the number of shrubs and trees was less in this treatment due to cutting. In this treatment the leaf litter contributed 35, 16 and 25 percent of the biomass production for heavy, moderate and light stocking rates, respectively (Appendix Table 24).

During the dry season, biomass yields were low compared with those of the wet season. Dry season amounts were 27, 26 and 34 percent of the wet season for heavy, moderate and light grazing, respectively (Appendix Table 24).

Cleared caatinga vegetation during the dry season had available only the standing biomass from herbaceous species. For this reason, biomass during the dry season was very low and represented only 26, 19 and 25 percent of the total production found during the wet season for the heavy, moderate and light grazing treatments, respectively (Appendix Table 23).

In summary, the standing biomass was drastically reduced on all treatments during the dry season. However, under the partially cleared treatment the standing biomass was greater than on the other two densities of caatinga. Also, partially cleared vegetation had

the three principal sources of food during dry season: standing biomass, leaf litter and regrowth of shrubs. This probably was an important factor contributing to the result that goats did not lose weight on this treatment during the dry season.

Animal Behavior

Botanical Compositon of Diet

The botanical composition of goats' diets was analyzed on the basis of three principal components: forbs, grasses, and browse.

Vegetation treatment. There were statistical differences ($P<0.01$) in diet composition as a result of caatinga vegetation treatment. Goats selected more forbs under cleared than under either uncleared or partially cleared vegetation (61, 30 and 39 percent of the diet, respectively). No difference was found in forb consumption between uncleared and partially cleared vegetation. The other major difference noted was a much lower content of browse in the diets on the completely cleared treatment as compared to either partially cleared or intact treatments (Table 10).

Under partially cleared vegetation, goats selected more ($P<0.01$) forbs than grasses, 39 and 29 percent, respectively, with browse being intermediate at 32 percent. However, no difference was found between grasses and browse nor between forbs and browse.

Goats in the uncleared treatment selected more ($P<0.01$) browse than forbs, 38 and 30 percent, respectively, with grasses being intermediate at 32 percent. No differences were found between forbs and grasses or between grasses and browse.

Stocking rates and seasons of year. The data showed statistical differences among stocking rates ($P<0.10$) and among seasons ($P<0.05$)

Table 10. Percentage botanical composition of goats' diets under three densities of caatinga vegetation, 1981.

Species	Uncleared	Partially Cleared	Cleared
Forbs	30 ^{bm}	39 ^{bp}	61 ^{am}
Grasses	32 ^{apm}	29 ^{am}	28 ^{am}
Browses	38 ^{am}	32 ^{apm}	11 ^{bn}

Values in the same rows (a and b) and columns (p,m and n), with different superscripts are statistical different ($P<0.01$).

only for grasses. Under uncleared caatinga goats selected more ($P<0.10$) grasses under light grazing than under moderate grazing during both the wet and dry seasons. However, this pattern changed during the transition season when goats selected more ($P<0.10$) grasses under heavy and less under light grazing (Table 11). In general under this treatment goats selected more ($P<0.05$) grasses during the transition and wet seasons than during the dry season.

Under partially cleared vegetation goats selected more ($P<0.10$) grasses under light than under moderate stocking during the wet season. This pattern changed during the transition season when they selected more ($P<0.10$) grasses under moderate and less under heavy grazing. During the dry season goats selected more ($P<0.05$) grasses under heavy and less under moderate grazing. In all stocking rates goats tended to select the most ($P<0.05$) grasses during the wet and transition seasons.

Under cleared vegetation goats selected more ($P<0.10$) grasses under heavy than moderate and light grazing in all three seasons. However, under different stocking rates goats tended to eat grasses more ($P<0.05$) during the wet and transition seasons. An exception was under heavy grazing where the animals ate grasses during the dry season.

Preference

Goats under uncleared caatinga vegetation during the wet season preferred milha, maracuja, jitirana and bamburral verdadeiro, with preference ratios being 22.4 and 2.1, 19.5, 4.0 and 2.8,

Table 11. Percentage of grasses in diets selected by goats under three different stocking rates, and during three seasons, 1981.

Season	Stocking Rate: Heavy	Moderate	Light
Uncleared			
Wet	33 bm	28 bm	45 ap
Transition	48 ap	39 bp	28 cn
Dry	35 am	9 bc	38 am
Partially Cleared			
Wet	29 apm	23 bm	30 am
Transition	32 bp	43 ap	39 ap
Wet	26 am	19 bn	23 abn
Cleared			
Wet	36 apm	28 bp	25 bp
Transition	33 am	28 bp	28 bp
Dry	40 ap	17 bm	20 bm

Values with common superscripts in rows (a, b and c) and columns (m, n and p) are not significantly different ($P<0.05$).

respectively (ratio = percentage of species in diet divided by the percentage of forage available). During the dry season, preference ratios changed slightly and they prefered juazeiro, jurema, milha, jitirana and ervanco branco (ratios of 163.3, 32.5 and 3.2, 7.2 and 3.3 and 3.3, respectively (Table 12).

Normally browse was preferred during the dry season; however, this must be viewed with caution because during the wet season no data was collected on browse availability. Overall, goats had high preference during the wet season for sabia, mororo, jurema and juazeiro in all types of vegetation.

Under partially cleared vegetation goats prefered maracuja, bamburral verdadeiro and milha (ratios of 15.0, 6.1 and 4.0 and 3.8, respectively during the wet season). However, during the dry season goats prefered jurema, milha, bamburral verdadeiro, maracuja and bamburral branco, with ratios of 38.7 and 19.0, 12.8 and 2.2, 2.4, 2.1 and 2.0, respectively (Table 12).

Under cleared vegetation goats prefered jitirana, maracuja, bamburral branco, malva relogio and milha, (ratios of 23.5 and 5.4, 11.0 and 2.2, 5.6, 4.6, 3.3 and 2.0 and 2.1, respectively during the wet season). However, during the dry season the pattern changed a little and goats prefered malva relogio, bamburral branco, jitirana and matapasto with ratios of 8.5, 8.0 6.5 and 2.5, 7.8 and 2.1, respectively (Table 12).

In general species such as milha, ervanco branco, jitirana, bamburral verdadeiro and bamburral branco had high preferences in all treatments studied during two seasons (wet and dry seasons).

Table 12. Ratios between percentage of forage available on-pasture and species in goats diets under different caatinga densities, 1981.

Species	Stocking Rate					
	Heavy		Moderate		Light	
	wet	dry	wet	dry	wet	dry
Uncleared						
Forbs:						
Bamburral branco	1.4	0.9	-	1.8	0.1	1.6
Bamburral verdadeiro	2.8	0.2	1.1	0.2	1.8	-
Ervanco branco	0.4	0.5	-	0.6	0.5	3.1
Jitirana	4.0	-	0.7	-	0.3	3.3
Maracuja	-	-	-	-	19.5	-
Malva relogio	-	-	-	-	0.7	-
Grasses	1.1	3.3	2.1	0.6	22.4	7.2
Browse:						
Juazeiro	-	163.0	-	-	-	-
Jurema	-	3.2	-	32.5	-	-
Pau branco	-	-	-	0.1	-	-
Sabia	-	-	-	1.5	-	-
Partially Cleared						
Forbs:						
Bamburral branco	1.2	1.8	-	-	1.0	1.8
Bamburral verdadeiro	-	2.4	3.0	-	6.1	0.7
Ervanco branco	0.2	2.0	1.4	1.9	0.6	0.2
Jitirana	1.4	-	0.9	-	1.3	-
Maracuja	15.0	-	1.9	-	1.6	2.1
Grasses	1.3	2.2	4.0	1.5	3.8	12.8
Browse:						
Jurema	-	-	-	19.0	-	38.7
Cleared						
Forbs:						
Bamburral branco	4.6	6.4	0.2	2.5	0.3	8.0
Bamburral verdadeiro	-	0.1	5.6	1.3	-	0.6
Ervanco branco	1.4	1.5	1.2	1.3	0.3	0.5
Jitirana	5.4	-	0.8	7.8	23.5	-
Malva relogio	-	0.7	3.3	0.2	2.0	8.5
Maracuja	1.6	0.5	2.2	0.5	11.0	1.0
Matapasto	0.5	2.1	0.6	0.4	0.9	1.9
Grasses	1.9	1.7	2.1	0.5	0.8	0.5

Also, the short stature of some of the woody evergreen species such as jurema, which had high preferences during the dry season, probably aided goats in preventing weight lose. This was principally under the partially cleared and cleared treatments.

A summary of the percentages of forage available on-pasture, that was consumed by goats, and the ratios between them are found in Appendix Table 27, 28 and 29.

Activity Budgets

Grazing

There were statistical differences only among seasons. Overall, goats spent the most ($P<0.01$) time grazing during the transition season and the least time during the wet season. With the exception of the partially cleared treatment, there were no specific differences between the dry and transition seasons with respect to time spent grazing (Table 13).

Traveling

As with grazing, there were statistical differences only among seasons for time spent traveling. Goats spent the most ($P<0.05$) time in traveling during wet season, and the least time during the transition season in all caatinga densities, except for the partially cleared treatment where there were no seasonal differences (Table 13). Individual animals that spent more time walking tended to graze less ($r= -0.83$).

Lying idle

Again there were statistical differences only among seasons ($P<0.01$). Goats spent more time lying idle during the wet season and less time during the transition season (Table 13).

In general, when the animals spent more time lying idle they also spent less time grazing. However, his relationship was rather weak ($r= -0.76$).

Table 13. Percentage of time spent by goats, in three different activities, during daylight hours in three seasons and under three densities of caatinga, 1981.

Season	Uncleared	Partially Cleared	Cleared	Seasonal means
		Grazing		
Wet	48 a,m	42 a,n	38 a,m	43
Transition	62 b,p	71 b,p	61 b,p	65
Dry	55 c,pm	60 c,m	59 c,p	58
Annual means	55	58	53	
		Traveling		
Wet	26 a,p	20 a,p	28 a,p	25
Transition	14 b,m	14 b,p	14 b,m	14
Dry	21 c,pm	19 c,p	18 c,p	19
Annual means	20	18	20	
		Lying Idle		
Wet	16 b,p	25 a,p	17 b,p	19
Transition	12 a,m	4 b,n	10 b,n	9
Dry	14 a,pm	10 b,m	10 b,m	11
Annual means	14	13	12	

Value with common superscripts in rows (a, b and c) and columns (m, n and p) are not significantly different.

Lying ruminating

There were statistical differences among stocking rates ($P<0.05$) and seasons ($P<0.01$) for this activity. In general goats tended to lie ruminating more under light grazing than under heavy grazing principally in the uncleared and partially cleared vegetation (Table 14). Seasonally, goats spent the most time lying ruminating during the dry season, and the least time during the wet season in all stocking rates and in all vegetation treatments studied. Additionally the data showed a weak positive relationship ($r = 0.34$) between time lying ruminating and time in grazing activity. this was most obvious during the dry season.

Standing idle

There were statistical differences among both vegetation treatments and seasons ($P<0.01$). Goats spent the most ($P<0.01$) time standing idle in cleared vegetation. However, no difference was found between the uncleared and partially cleared treatments.

During the wet and transition seasons goats spent the most time standing idle. However, under partially cleared vegetation no difference was found among the three seasons (Table 15). A weak negative correlation ($r= -0.60$) was found between standing idle and grazing time.

Average activity budgets are shown graphically in Figures 4, 5 and 6. Additionally a complete data set for activities is summarized in Appendix Table 30. Data records for standing ruminating and

Table 14. Percentage of time spent by goats in lying ruminating activity under three densities caatinga, during three seasons and under three stocking rates, 1981.

Season	Stocking Rates			Seasonal
	Heavy	Moderate	Light	means
Uncleared				
Wet	5 b,n	7 a,n	7 a,n	6
Transition	6 c,m	7 b,m	9 a,m	7
Dry	7 c,p	9 b,p	10 a,p	9
Annual means	6	8	8	
Partially Cleared				
Wet	6 a,n	9 a,p	8 b,m	8
Transition	8 a,m	7 b,m	8 a,m	8
Dry	9 a,p	9 a,p	9 a,p	9
Annual means	8	8	8	
Cleared				
Wet	6 a,n	3 b,m	6 a,m	5
Transition	9 b,m	9 b,p	10 a,p	9
Dry	10 a,p	9 b,p	10 a,p	10
Annual means	8	7	9	

Value with common superscripts in rows (a, b and c) and columns (m, n and p) are not statisticaly different, ($P<0.01$) and ($P<0.05$), respectively.

Table15. Percentage of time spent by goats standing idle during daylight hours during three seasons and under three densities of caatinga, 1981.

Seasos	Uncleared	Partially Cleared	Cleared	Seasonal means
Wet	4 b,p	4 b,p	11 a,p	6
Transition	4 b,p	2 b,p	11 a,p	6
Dry	0 a,m	2 a,p	2 a,m	1
Annual means	3	3	8	

Value with common superscripts in rows (a and b) and columns (m and p) are not significantly different, ($P<0.01$).

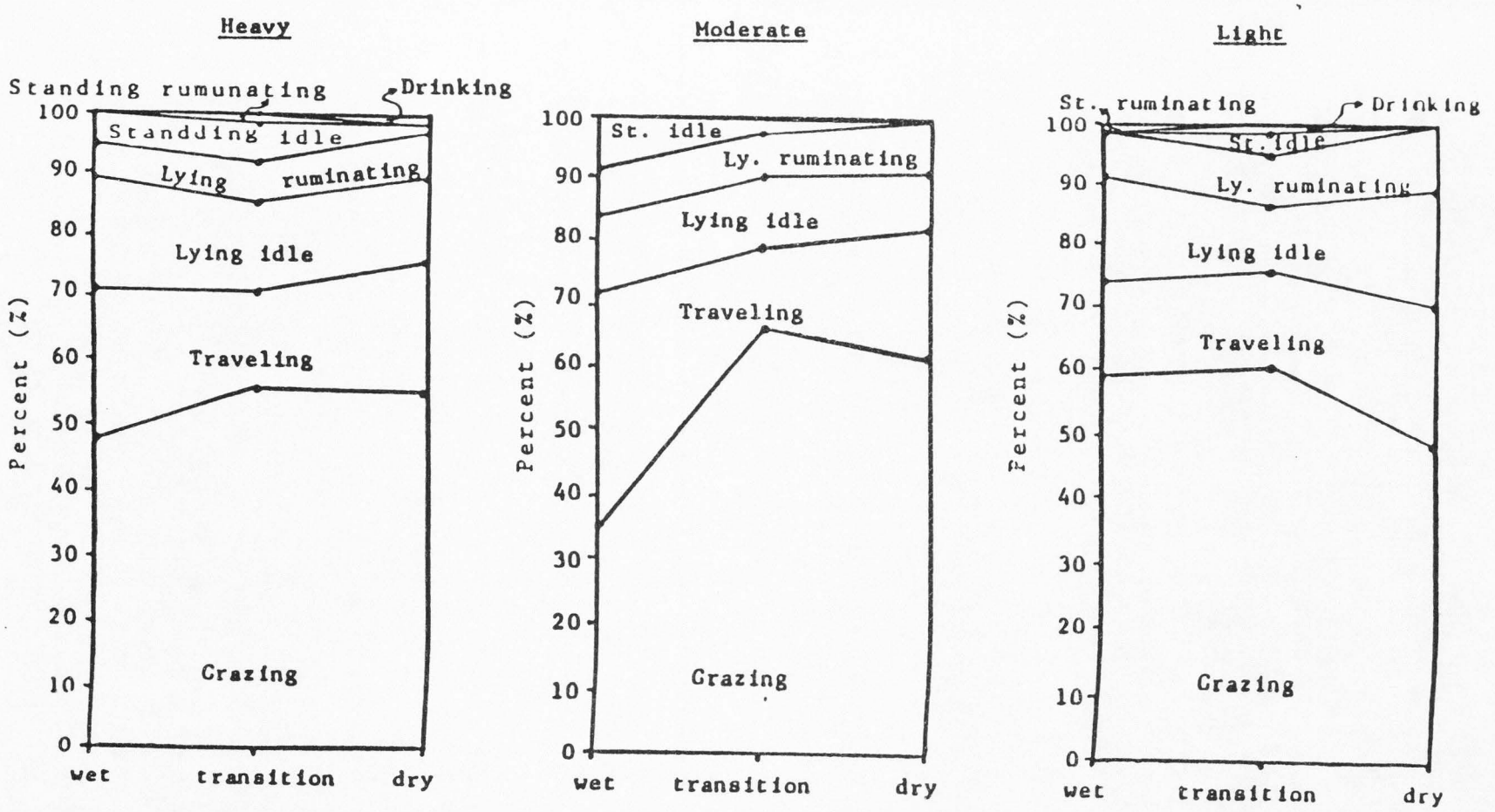

Figure 4. Percentage of time spent by goats in different activities, between 8:00 am and 5:30 pm at three stocking rates, during three different seasons in uncleared caatinga vegetation, 1981.

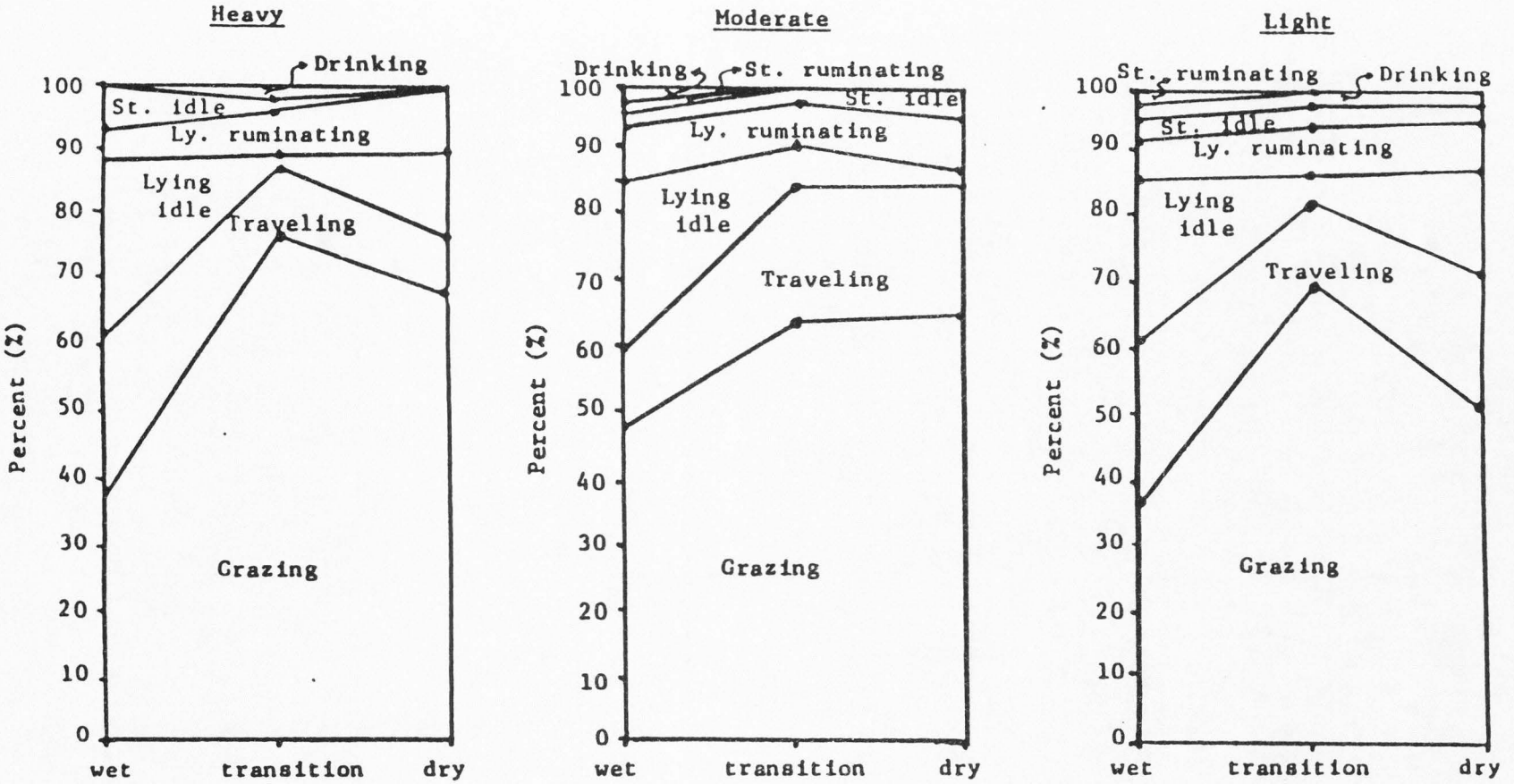

Figure 5. Percentage of time spent by goats in different activities, between 8:00 am and 5:30 pm, at three stocking rates, in three different seasons in partially cleared caatinga vegetation, 1981.

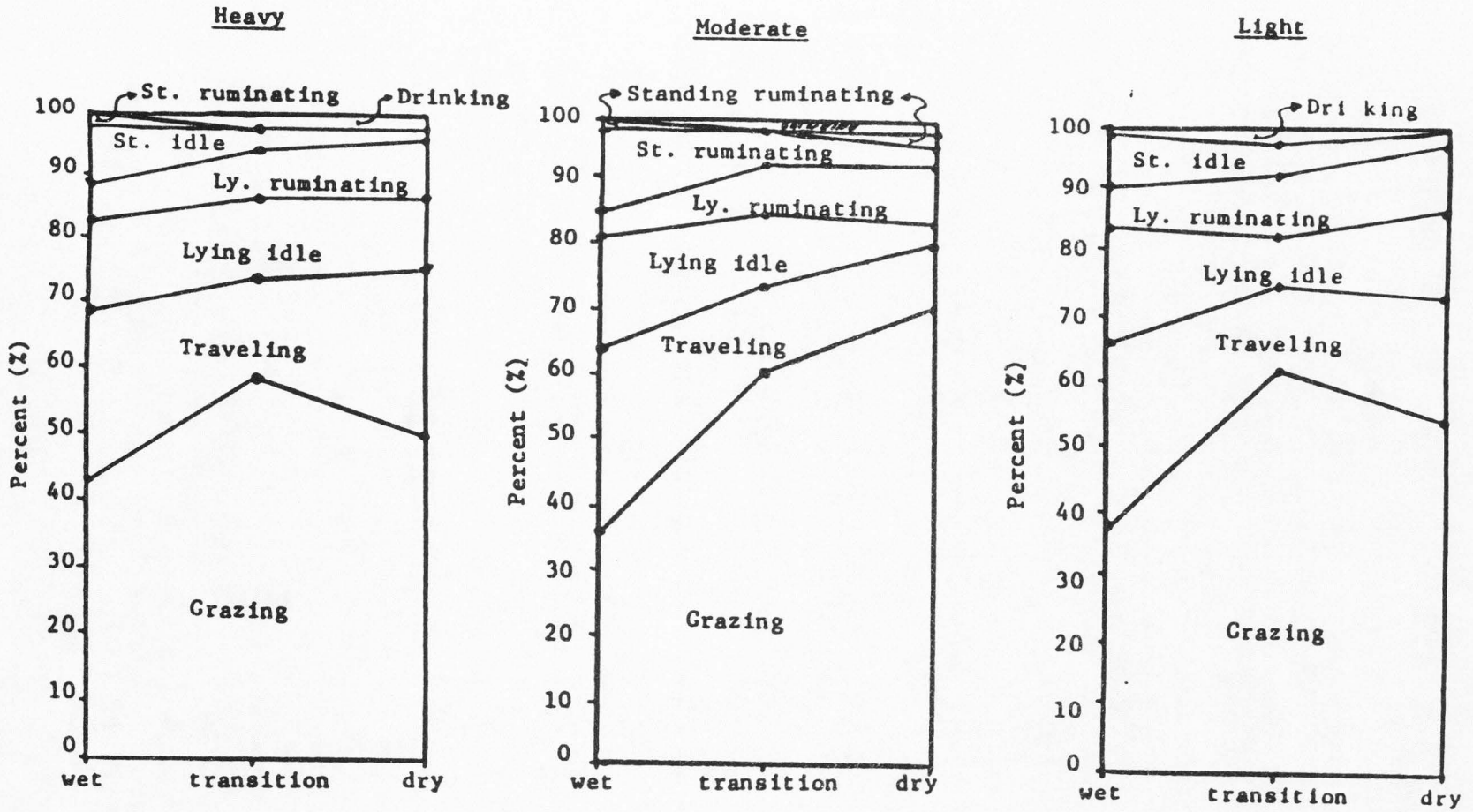

Figure 6. Percentage of time spent by goats in different activities, between 8:00 am and 5:30 pm, at three stocking rates, during three different seasons in cleared caatinga vegetation, 1981.

drinking water are included in Appendix Table 30 but are not discussed because they were minor activities, rarely occupying more than 2% of the time. The data on licking salt was considered in conjunction with that on drinking water.

CHAPTER IV

DISCUSSION

Vegetation

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

The largest standing biomass was found in the partially cleared treatment during the wet season, which can be attributed to the partial removal of the woody canopy and the related increased in standing herbaceous vegetation (Appendix Tables 22, 23 and 24). Cleared vegetation was the least productive.

The most important difference between partially cleared and uncleared vegetation was in standing biomass from herbaceous species during the wet season. During the dry season, standing biomass of herbaceous species and leaf litter was similar among treatments. However, it is important to remember that during this study the

standing biomass estimates reflect both production and consumption because the goats were in the study area all year, and no measurements were taken in areas excluded from grazing. Also the limitation imposed by lack of replication must always be kept in mind.

Standing biomass estimates in cleared vegetation were low and were not in agreement with those of Kirmse (1984) and Araujo Filho et al. (1982). The former, working near my experiment, found that removal of the tree canopy resulted in a sixfold increase in standing herbaceous vegetation during the first year of the experiment. The latter found that removal of the woody canopy resulted in a fivefold increase over the uncleared vegetation. However, this study was done in another type of caatinga vegetation and a direct comparison is not valid.

The large difference between my findings and Kirmse' work is related to the time between when the clearing treatment was applied and when the biomass was measured. In my work the woody species were cut during the dry season of 1978 and goats were introduced in July 1979. In Kirmse's work clearing was done in the dry season of 1981 and animals were put in the experimental area during the dry season of 1982. His biomass measurements were taken during the wet season of 1982 under conditions of no grazing. Another point related to the comparison with Kirmse's work was that of soil and precipitation differences. For example, in 1981 the precipitation in the experimental area was 538 mm. However in 1982, coinciding with Krimse's data colection, the precipitation was 705 mm. Both studies

were located in the Brazilian National Goat Research Center and the type of caatinga in the two experimental areas was not very different. However, both were different principally in terms of vegetation of the study reported by Araujo Filho et al. (1982).

The partially cleared treatment was the best option for goat husbandry under the conditions of the study, principally under the moderate stocking rate because the goats did not lose weight during the dry season. However, the cleared treatment produced the best body weight response per unit of land. These differences must be resolved by considering long-term production. Indiscriminate clearing of caatinga together with heavy grazing, commonly practiced in northeast Brazil, may lead to environmental degradation in the long term. Kelley (1977), pointed out that in South African woodlands, there is evidence that indiscriminate clearing leads to environmental degradation. This work was probably done in a savanna ecosystem, which is different from caatinga vegetation, wherein the woody species regenerate rapidly by copping following cutting.

This regeneration varies according to precipitation and type of soil. However, Ramos and Marinho (1980) showed that areas of uncleared caatinga vegetation in the Sobral area lose less top soil than cleared areas. This is attributed to the protective cover of the leaf litter which can help avoid extreme effects of the intense seasonal rains, common in northeast Brazil. Also trees and shrubs can extract nutrients from deep layers of the soil profile and deposit them on the surface though leaf litter (Charley 1972 and Kirmse and Norton 1984).

In summary, even though partially cleared caatinga appeared to be the best option for goat production, this vegetation treatment needs to be better understood in relation to the mechanism of soil and plant relationships according to precipitation. No work has been done in caatinga vegetation on the shoot density of woody plants after a cutting treatment and the amount of nutrients this might make available to animals and what happens to soil conditions under such a treatment.

In some cases, tropical areas may get several times as much rain as land used for crop production in temperate climates. However, due to the higher **evapotranspiration** (for example in Figure 1), tropical areas are used most for grazing. This is a common picture of caatinga vegetation in northeast Brazil.

Animal Performance

Understanding how different densities of caatinga vegetation and different grazing intensities affect livestock production is critical to the advancement of effective range management under caatinga vegetation. One may approach these questions from two different points of view, depending on whether the objective is to increase profits from livestock production (not considering land as more important), or to integrate livestock use to maintain a stable ecosystem. The first view holds that through manipulation of stocking rates improved levels of livestock production can be realized, while the second assumes that manipulation of grazing practices is done to minimize livestock's impact on the environment. This probably will affect animal production levels, but it will maintain a higher level of stability in the ecosystem. Probably the second view is the best option for caatinga vegetation in that the constant threat of drought should lead to a lower optimum stocking rates than the maximum sustained yield level often recommended by the biologist. This involves less risk of resource degradation. However, according to Workman (1984) the economic optimum stocking rates is always less than that recomended by the biologist.

According to Dahl (1982) an animal's performance is most commonly measured as weight change. This is a reflection of both quantity and quality of forage ingested (t'Mannetje et al. 1976). Weight gain on an area basis combines effects of stocking level and individual gain into a single measure considered to be the most

important criterion for evaluating grazing response. Herbel (1974) stated that animal performance per unit area is more important than performance of individual animals.

Under semi-arid conditions, precipitation needs to be considered from two aspects: amount and distribution. Precipitation is one of the most important factors controlling the nature of caatinga vegetation, because primary production is entirely dependent upon rainfall. The seasonality of rainfall not only affects the amount of biomass available to herbivores, but also influences the quality of the available food.

Clearing

When the different densities of caatinga vegetation were compared, the data showed that animals grazing cleared caatinga gained the most weight on a per-area basis. However, this must be viewed with caution because the different vegetation treatment also had different stocking rates. This confounding of stocking rate with vegetation treatment makes a strict biological interpretation of either effect impossible, even though results of the statistical analysis showed significance. It can not be clearly concluded whether the response was due to stocking rates or vegetation treatment or both.

Stocking Rate

The relation between stocking rate and liveweight gain is the subject of lively controversy. However, the slope of the curve in this experiment is in agreement with that of Jones and Sandland (1974) who stated that animal gain and stocking rate (animal/ha) remained linear over a wide range of stocking rates.

The best body weight response was found under the moderate stocking rate in cleared and partially cleared caatinga. Goats gained 12.0 and 9.8 (kg BW/ha) in the two respective treatments. Also goats did not lose body weight under either treatment at any time during the year. Animals in both stocking rates had access to jurema, an evergreen leguminous species, during the dry season. This represented an important component of the goats' diet during the dry season.

This study indicates that correct stocking rate is a important factor needing to be considered. Range nutritionists need to determine the best stocking rate, according to the amount of the current years precipitation and pasture availability during the dry season. Swift et al. (1979), stated that only 10-15 percent of the net primary production in tropical grassland is consumed by herbivores. The moderate stocking rate seemed to be best for goats when considering body weight response and pasture standing biomass.

Unquantified field observation indicated that under moderate and light stocking rates in uncleared and partially cleared vegetation, not all areas of the pasture were visited with equal frequence by

animals during the wet season. This probably resulted in leaving a quantity of standing forage available for use during the following dry season.

Season

The results showed that in all three treatments (uncleared, partially cleared and cleared caatinga vegetation) goats gained more weight (kg BW/ha) during the wet season than during the other two seasons. Also animals under heavy grazing gained more weight (kg BW/ha) than those in the other two grazing intensities. During the wet season the availability of forage is at its maximum, both in quantity and quality. During this season, heavy grazing probably does not pose any constraints to animal production.

Herbaceous species made a reasonable contribuition to animals' diets during both the wet and dry seasons. However, the availability of leaves and stems from shrub species probably was the key factor determining that goats did not lose weight during the dry season on certain treatment. Probably the best way to get more available and higher quality food is through cutting treatments which improve the herbaceous species and the shrubs through regrowth. This may be seen as an alternative to having tall trees which only have their fallen leaves available for consumption. The nutrient content of the animals' diets was not studied. For this reason, it is difficult to explain precisely the differences in weight gain by the goats.

The dietary data in this study showed clearly that leaf litter

made a major contribution to goats' diet during the dry season. The same finding was also reported by Pfister (1983) and Kirmse (1984). However, in the current experiment, leaf litter by itself was not enough to maintain body weight, and some other factors may have been involved. Pfister (1983) pointed out that dietary protein levels remained at or above about 12 percent from October to December (the peak of the dry season), resulting mainly from consumption of leaf litter. He used the conventional factor of 6.25 to calculate crude protein content from Kjeldahl nitrogen analysis of esophageal fistula extrusa. The possibility exists that recycling urea in saliva during the dry season may have contaminated his samples and led to an over-estimate of nitrogen content. In the partially cleared and cleared treatments persistence of green foliage in the canopy of woody plants may have provided enough nitrogen to render microbial digestion of the low-quality roughages in the diet more efficient during the dry season. Also, green browse could potentially provide a valuable source of digestible energy. The nutritional value and accessibility of browse from juvenile regrowth has been recognized in other parts of the world as an imporatnt component of animal diets (Powell and Box 1979). However, there have been few studies of this under caatinga vegetation.

Goats tended to lose weight during the final months of the dry season and also at the beginning of the wet season. However, in some treatments, e.g. under uncleared and partially cleared caatinga, goats showed some weight loss at the start of the dry season (August) when a large number of the trees lost their leaves. This

weight loss, however, may be correlated with animal experience. According to the experimental design the animals were put in pastures each year in July commonly when the rainy season stopped and the dry season started. Even though the animals were previously grazing under caatinga vegetation, they were brought from another place, and the specific environment was new for them. Probably their preferred species were absent or available only in small amounts and the animals had to adjust themselves to a new diet. This may have caused more searching for preferred species, and probably a higher energy expenditure. This phenomenon was more common under the heavy grazing treatment where, perhaps due to the small area, the animals did not find enough of their previously preferred species (Figure 3 and 4).

In support of this contention, the data on animal activities showed that goats spent more time searching for food during August (transition season). According to Arnold and Dudzinski (1978), the experience of animals on pasture is an important factor which needs to be considered when animals are changed to new pasture. Also prior experience with vegetation may influence animals' diets (Arnold 1964 and Arnold and Maller 1977).

The seasonal effects on weight loss by goats in northeast Brazil is clear (Riera et al. 1982; Oliveira et al. 1982 and Melo Lima et al. 1983). Also, body weight loss during the dry season is significant for other tropical regions (Ali et al. 1975 and ILCA 1979).

The reason goats tended to lose weight during the beginning of

the wet season may be related with decomposition of pasture. As was shown previously, leaf litter was a important component of goats' diets during the dry season. However, when the rainy season begins these leaves, which are on the ground, rapidly start to decompose due principaly to the high humidity of the soil and high ambient temperatures. Swift et al. (1979), found that moisture was highly correlated with decomposition rates when temperature was not a limiting factor.

However, the animals tended to recuperate as the wet season progressed. Rapid recuperation of weight by animals in regions where seasonal drought occurs is very common. Rate of gain can be abnormally high. This phenomenon is known as "**compensatory growth**".

Many factors influence the animal's ability to recover from the effects of weight loss. Among the factors governing an animal's ability to recover, the most important are: a) the nature of undernutrition, b) the severity of undernutrition, c) the duration of the period of undernutrition and d) the stage of development of the animal at the commencement of undernutrition.

Under caatinga vegetation no work was found with goats which can explain the most important factors influencing weight loss and subsequent compensatory growth. However, it is no easy task to prove which one is more important, because they can not be easily separated, the nature of undernutrition may be a important point which helps to explain part this phenomenon in caatinga vegetation.

According to Wilson (1957 b.), Wilson and Osbourn (1960), and Keenan and McManus (1969), an animal's growth can be retarded by

restraining any one of the many nutritional components of its diet. The animal's ability to recover may, in certain instances, depend on whether the energy or the protein content of the diet has been the limiting factor.

Pfister (1983), working with goats under uncleared caatinga vegetation, speculated that animals lost weight during the dry season because they were not able to meet their maintenance requirements for energy. The largest weight losses occurred from October to December, when the animals were apparently not getting enough energy. According to the same author, during late dry season animals lost 15-20 percent of their body weight from October to December. Figueiredo et al. (1980) found that body weight loss of SRD-does under uncleared caatinga vegetation varied according to the season. It usually started in August, two months after the rainy season had finished. He stated also that not only was undernutrition responsible for weight lost but also that the does were influenced by their parturition cycles during the year.

In summary, if we assume that goats eat around 2.5 percent of their body weight (for maintenance) all stocking rates under the different treatments furnished enough food (vegetation biomass), for the animals during the dry season. While the quantity and quality of the pasture were enough during the wet season for all stocking rates studied, this was not true during the dry season because the animals lost weight during this season. Probably the quality of food was an important factor causing goats to lose weight during the dry season.

Supplementation

Few studies have been done on supplementation of goats in caatinga vegetation. Oliveira et al. (1982), worked with goats under partially cleared caatinga vegetation using two treatments: i. partially cleared caatinga and ii. partially cleared caatinga plus supplementation with Napier grass (Penisetum purpureum). The supplement was fed from September to December (dry season). Their results showed that goats receiving the supplement performed better. They concluded that goats under caatinga vegetation during the dry season had some nutritional deficiencies. Schacht et al. (1985), working in caatinga with young goats, found that during the dry season animals which received molasses (source of energy) and urea (source of nitrogen) gained an average 47 grams per day, compared to only 25 grams per day for the control group. They concluded that native caatinga range forage is deficient in available protein and energy during the dry season, even under an abundance of available forage.

Another feasible option for minimizing weight loss during the dry season is conservation of standing range forage by some form of grazing deferrment during the wet season or growth period as suggested by (Stobbs and Minson 1980; Malechek 1982 and Kirmse, 1984). However, this may not entirely resolve the forage quality problem unless there are highly nutritious plants, such as forage legumes, present in the deferred vegetation.

Dietary Selection

Normally goats selected grasses during the wet and transition seasons. Under cleared caatinga grasses were selected more during the dry season. This probably happened because grass leaves were green during the wet season and they retained some green tissue during the transition season. Also seedheads from grasses were available during the transition season. Grasses and grass parts ranked high in preference by goats.

Pfister (1983), working near my experimental area, found that shifts in diet selection by goats were motivated by selection for nutritious foods. However, caution must be used in this interpretation because ruminants are thought to be essentially hedyphagic, and normally select food according to pleasing tastes and not necessarily because of superior nutritional value (Arnold and Dudzinski 1978).

During the wet season, green leaves, flowers, and seedheads from different species formed an important component of goats' diets. This observation is in agreement with those of Nge'The and Box (1976), Bryant et al. (1979) and Pfister (1983). Based on my data it is difficult to classify goats as grazers (consumers of grasses or forbs) or browsers. This is in agreement with findings of Edward (1948), Wilson (1957 a), Yocum (1967), Huss (1972), Harrington (1978) and Pfister (1983).

The precipitation during 1981 was 583 mm, making it a relatively dry year. Probably this limited biomass production in the

experimental pastures. In general the data showed that forbs were selected more than grasses and browse. However this does not agree with Merrill and Taylor (1982) who reported that grass consumption is influenced by the availability of forbs and browse. They stated also that when rainfall is short, preventing forb growth, grasses might be heavily used during certain periods of the year. Probably the precipitation in 1981 was not low enough to trigger this phenomenon. Another factor may be that perennial grasses are a major component of the vegetation in Texas where the Merrill and Taylor (1982) study was done, while only annual grasses are found in the caatinga.

The statistical analysis showed no difference for dietary forbs and browse in relation to stocking rates and seasons. This probably resulted because of high variability in the dietary data. Means and standard deviations for forbs and browse were 42.7 $\pm$ 18.4 and 26.8 $\pm$ 17.6 respectively.

Species Consumed and Preferred

The diets of goats showed a seasonal variation among grasses, forbs and browse. However, only for grasses were there statistical differences.

The preference ratios showed that species such as the grass milha, and the forbs jitirana, bamburral verdadeiro, maracuja and malva relogio all had high preference ratings during the wet season in all stocking rates and under different caatinga densities.

Probably for forbs this high preference was due to low availability during the dry season, since all are annual species that lose their leaves as soon as moisture diminishes.

Bamburral branco, ervanco branco, jurema and regrowth of pau branco were more preferred during the dry season. For the forbs, bamburral branco and ervanco branco, this preference was more associated with availability of flowers than with leaf material. Fruits and flowers were seasonally important in goats' diets. These food items may help animals survive at times of nutritional stress (Malechek 1982 and Malechek and Provenza 1983). The two shrubs had high preferences due to their green leaves, which were present throughout the dry season for jurema and occasionally on the regrowth of pau branco.

In general goats tended to consume large amounts of shrub regrowth including that from species generally considered unpalatable. This indicates that on caatinga range goats have potential use in controlling undesirable species. This was more clear under heavy grazing treatments.

Some species were consumed during both wet and dry seasons including the grass milha an the forbs jitirana and malva relogio. The latter was consumed mainly as plant stems. These data agree with those of Pfister (1983) who stated that goats seasonally shifted their diet selection, but selected jitirana during both the wet and dry seasons.

One interpretation of these dietary shifts is selection for the most nutritious food. However, a counter argument is that ruminants

are essentially hedyphagic (Arnold and Dudzinski 1978). What ever the driving force might be, goats showed interesting behaviors in food selection. For example, during the transition and dry seasons, jucazeiro dropped its seed pods on the ground when there was sufficient wind to shake the trees. Goats were attentive to strong winds, and when they occurred, the animals looked for jucazeiro pods and avidly ate this protein-rich material. Malechek and Provenza (1983) stated that selection for nutritionally-superior forage may be a result of the correlation between animal preference for available material, and the higher nutritional quality of such material.

My data agree with those of Cory (1927), Knight (1965), Malechek and Leinweber(1972), Brown (1971), Davis et al. (1973) and Lopes (1982) who stated that goats' preferences are seasonal.

Leaf litter was an important component of the available biomass under uncleared and partially cleared treatments during the dry season under the various stocking rates. The major part of the available leaf litter was pau branco. Pfister (1983) showed that goats under caatinga vegetation disciminated against leaf litter of pau branco.

In summary, even though goats had a large number of species available in the pasture (>40) they selected less than ten species for the major part of their diets. However, they nibbled many others but in very low proportions which were too small to quantify accurately. Goats changed their diets according to availability of preferred species. Many other unidentifiable factors were thought to

influence goats forage preferences.

Animal Behavior

Grazing is a complex activity which includes the period of walking, searching for suitable herbage, and the time spent in association with manipulating the food in the mouth. These components can be highly variable. The results showed that grazing time was statistically different only among seasons. In all treatments, goats spent less time grazing during the wet season, more time during the start of the dry season, and again diminished grazing activity during the end of the dry season (Appendix Table 30).

Probably during the wet season less grazing time was required because of the high availability and quality of the vegetation. However, animals spent more time traveling when grazing time was low. During the wet season goats had abundant feed and they walked more apparently searching for their preferred species of plants and plant parts. By the end of the dry season, when the feed supply had decreased to low levels, goats walked less. This may have been due to the relatively large amount of time invested in rumination at this period. There is a well established relationship between rumination time and the amount of fiber in the diet (Welch and Smith 1969). Poor quality, highly fibrous diets typical of dry season conditions require large investiments in rumination activity.

The time spent ruminating by goats under caatinga vegetation showed that there were statistical differences among season ($P<0.01$) and among stocking rates ($P<0.05$). Normally in all treatments more

rumination time occurred during the dry season. Also under the light stocking rate or in those treatments where higher biomass was available during the dry season, goats spent more time ruminating.

The quantity and low quality of pasture are two important factors which need to be considered in terms of ruminating time. For example, ingestive behavior is characterized by a long eating time which in this experiment varied with season from 3 hrs. and 21 min. to 7 hrs and 22 min. per day. After ingestion, food stays in the reticulo-rumen and this material can only escape thought the reticulo-omasal orifice after being reduced into fine particules by microbial digestion combined with mechanical break down by mastication during rumination. McCammon-Feldman (1980), stated that the only effective means the animal has of reducing the size of the cell walls is through rumination.

When plants become older their content of cell-wall constituents (CWC) increases, and their ingestibility and eating rate decreases. The cell walls of older plants are more resistent to microbial digestion and mastication (Dulphy et al. 1980). Pfister (1983), working with goats near the experiment in Sobral, found a correlation between dietary cell wall and rumination time. When CWC increased, rumination time also increased.

During the dry season clearly both quantity and quality of forage decrease drastically. Freer et al. (1962) and Suzuki et al. (1979), stated that limitation of access to food induces as previously seen, an increase in eating rate and a reduction of ruminating efficiency.

Normally the time goats spent ruminating during daylight hours varied from 5.2 to 10.3 percent of the their activity, depending on the kind of vegetation (Appendix Table 30). This suggest that most rumination occured during the night. Wilson and Flynn (1974), Metz (1975) and Ruckebusch and Bueno (1978), all found that the largest part of ruminating occurs during the night.

In summary goats spent more time ruminating during the dry season and there appeared to be a relation with those paddocks having high biomass available during the dry season. Also the temperature during the dry season was very high at mid-day and normally during the 11 am to 3 pm period, goats stayed under shade and did not forage. Whether they were lying in shade to escape the heat or to fulfill an obligation to ruminate is not clear.

During the transition season, goats spent the most time walking, probably in an attempt to mantain dietary quality for as long as possible. However this is complicated by the fact that at this time new animals had been introduced to the pastures and due to lack of experience, may have spent additional effort walking and searching for prefered species.

This study is in disagreement with that of Atkenson et al. (1942), who pointed out that cows spent more time grazing under poor pasture conditions than on good pasture. Probably in my experiment, the heavy grazing treatment was not of a sufficient intensity to elicit a similar response.

Feed intake is influenced by a complex set of interactions of climate, forage composition and availability, animal feeding habits

and animal requirements. Incidental observations suggested that the weather was an important factor influencing goat behavior and was more important during the wet season than during the dry season. Goats apparently do not like wetness, and during the rainy season the dew on the vegetation in the morning normally was high. In this condition goats started grazing after 8:00 or 9:00 am. They apparently waited until the dew on the leaves had evaporated or diminished to a low level. This delay was not generally perceived to be a large problem because during the wet period, goats had abundant pasture (quantity and quality), and they could compensate easily by feeding more during other more comfortable times of the day.

The data suggested that neither temperature nor relative humidity were serious factors to goats under caatinga vegetation during either the transition or dry seasons (Appendix Table 31). Data on weather variables were not available for the wet season of this study.

Another factor which disturbed feeding by goats was rain. They were often observed running to shelter when rain occurred. Ruckebusch and Bueno (1978), also reported that rain disrupted normal grazing activity in goats.

Field observations indicated that when the sward was wet, the goats tended to feed more with their heads up or in the bipedal position. The partially cleared and cleared treatments were more open and seemed to be more accomodating of goats' behavior. During the wet season the dense understory of forbs beneath the shrubs and trees impeded animal movement. Therefore in uncleared vegetation the

penetration by sunlight was suppressed. Consequently the understory remained wet for a longer period in the day than did the other two kinds of vegetation. Taylor (1953) found that grazing animals change their dietary preferences according to wetness of foliage.

There was no evidence that sunset and sunrise influenced goats' behavior in this study. During the wet season goats normally started to graze after 8:00 am and stoped before 6:00 pm. However, during the transition and principally during the dry season, both the start and end times changed, so that animals started feeding before 8:00 am and continued grazing during the afternoon until dark. Probably, this behavior was more influenced by the availability of feed than by daylight conditions.

No statistical difference was found under different treatments with respect to the time at which goats drank water. During the wet season the animals drank less than during the dry season. Field observations indicated that goats drank water every day during the dry season , but not every day during the wet season. Apparently the high level of the water in forage satisfied much of the animals' water needs during the wet season.

The literature generally shows that goats are more resistent to water deprivation than are cattle and sheep, but less so than camels. Duerison (1974), found that goats in arid conditions can mantain their water balance without drinking if their feed plants contain at least 52 to 67 percent water.

CHAPTER VI

SUMMARY, CONCLUSION AND RECOMENDATIONS

General Considerations

The body weight responses, feeding behavior, and forage selectivity of goats were examined in three different densities of caatinga, under three stocking rates, and during three seasons.

Removing shrubs and trees has been hypothesized to increase herbaceous forage production. However, in this study this happened only on the partially cleared treatment.

In all caatinga densities and under all stocking rates, the wet season was the most productive. During the dry season the standing biomass declined drastically.

Goats gained up to 90 percent of their body weight (kg BW/ha) during the wet season. During the dry season, all animals except those in moderate stocking in partially cleared and cleared caatinga lost weight, principally during latter part of the season. The cleared treatment showed the best body weight response per unit of land, with 10 kg more than in uncleared and 6.0 kg more than in partially cleared caatinga. However, caution needs to be exercised because undiscriminate clearing of the caatinga may lead to soil erosion and environmental degradation. During the dry season all stocking rates in the cleared treatment were judged to do not have enough top soil protection (unpublished data on file at CNPC). According to Ramos and Marinho (1980), uncleared areas of northeastern Brazil lose less top soil than do cleared areas.

Forage quantity and quality (or probably both) were the limiting factors. The botanical composition of diets did not clearly show if the goats should be considered as grazing or browsing animals because the diet they selected constantly showed overlap among forbs, browse, and grasses during the different seasons studied. Herbaceous species such as milha, ervanco branco, jitirana, bamburral branco and bamburral verdadeiro were preferred in all treatments. Normally, when available, species with high preferences during the wet season tended to show the same pattern during the dry season. Leaves from shrubs and trees such as sabia, jurema, juazeiro, jucazeiro had high preferences during both wet and dry seasons. During the dry season leaf litter was an important source of forage. However, leaf litter alone was not enough to mantain body weight, and some other factors may have been involved. A high proportion of the leaf litter was not consumed by goats due the presence of many leaves from pau branco, the dominant woody species which is unpalatable to goats.

This study suggest that unpalatable species such as pau branco, mufumbo and marmeleiro could be replaced by other species with immediate potential benefits to livestock production. Also, tall trees of sabia and jurema and other palatable forage species should be cut periodicaly. The objective of this treatment would be to offer accessible regrowth for animals. Jurema an evergreen species with high occurrance in goats' diets, is also valuable as salable wood. This treatment might also provide enough dietary nitrogen through green browse to render microbial digestion of the low

quality roughages in the diet more efficient during this time of year. A partial clearing scheme with 30 to 50 percent of the cover remaining should be feasible. However, this clearing scheme should be flexible depending on the type of soil present. In land soil it will not be justifiable use the same scheme with more fertile soil.

Removing the woody species may not entirely resolve the forage quality problem unless highly nutritious plants, such as forage legumes are present. In caatinga vegetation there is potential for developing additional forage from drought-resistent native species such as Centrosema, Styloshantes, Desmodium, Glycine, and Galactia. Also native woody species such as Capparis, Pithecolobium and the introduced species of Leucaena, and Ziziphus need to be tested in caatinga under different types of soil with the objective of improving pasture quality.

Precipitation is an overriding factor controlling the nature of caatinga vegetation because the production of annual species will vary greatly according to yearly rainfall. However, the woody species can be viewed as a factor minimizing the year-to-year variation, because they are capable of producing new leaves when little rain occurs.

Goats in all treatments spent the least time grazing during the wet season and the most time during the beginning of the dry season (transition season). During the wet season, the high quality and quantity of forage probably facilitated high passage rates and forage intake. During the start of the dry season goats spent more time grazing and walking, probably searching for preferred species

in an attempt to maintain diet quality for as long as possible. Goats spent the most time lying ruminating during the dry season and the least time during the wet season in all stocking rates and in all vegetation treatments. Quantity and quality of pasture are two important factors known xto influence rumination time.

Goats showed dislike for rain and wet conditions. However, they grazed freely when the temperatures were high (35 to 39 C). When the vegetation was wet goats tended to feed more in the heads-up and bipedal positions. Partially cleared and cleared treatments were more open and seemed to be more accomodating of goats' behavior, because during the wet season the lower density of shrubs, trees and herbage species did not impede animal movement.

During the wet season goats started to graze after 8:00 am and stopped before 6:00 pm. However during the transition and dry seasons goats began grazing before 6:00 am and did not stop until after 6:00 pm. In general goats spent more time grazing when the quality of the pasture decreased; however, rumination time also increased it. It is not clear if it was the disappearance of preferred forage species which provoked the increase in grazing time or if it was the low quality of pasture which provoked the increase in rumination time as consequence of reduced passage rate.

This experiment suggests that during drought periods, goats need to have continuous access to pasture so they can feed at times most consistent with their particular needs. The traditional approach to animal management where animals are penned in the corral early (5:00 pm) every day, may not be easily justified.

Research Limitations and Recommendations

Several flaws in the design of this experiment severely restrict any inferences that can be made from it. While these deficiencies were largely out of the control of the investigator, they are important to be recognized and avoided in future grazing studies. Specifically, the major limitations were as follows:

1. Lack of replication of treatments precluded separation of responses. There is no way to state with certainty that observed responses were due to caatinga cutting treatments or to inherient site (soil, vegetation) differences. A minimum of two replications must be included in future studies. Three or more replications would be even more suitable.

2. Small sample size (only three animals per treatment block) restricted interpretations on animal responses. Components of variance from this study should be analyzed and used in determining minimum animal numbers in future studies. Generally, 6-10 animals per treatment should be considered as an absolute minimum number.

3. Animal behavioral observations taken only during daylight hours limited interpretations on animal activity budgets, particularly with respect to rumination. Future studies must include 24hour observation periods if daily activity budgets are to be determined.

4. Nonuniform stocking rates across various caatinga treatments limited inference on both animal and vegetation responses to treatments. Future grazing studies should be designed so that a

particular stocking rate is uniformly represented over all treatments and replications.

5. Lack of "exclosures" or areas of vegetation from which grazing animals were excluded limited information on vegetation production in response to treatment. Future studies should include replicated, entire treatment block with zero grazing.

These limitation not withstanding, the study accomplished some valuable purposes in terms of research training and pilot information that can be used in the design of future definitive grazing and caatinga-treatment studies. They are critically needed to underestand livestock production and rangeland ecology of northeastern Brazil.

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APPENDIX

Table 16. Lengh of day and mean monthly time of sunrise and sunset in Fortaleza, Ceara' State (3°47'S and 38°32"W), 1981.

Months	Sun rizer	Sun set	Hours of sunlight (hrs:min)
January	5:33	17:50	12:17
February	5:42	17:54	12:12
March	5:40	17:48	12:08
April	5:35	17:35	12:01
May	5:33	17:29	11:54
June	5:38	17:30	11:52
July	5:43	17:36	11:53
August	5:41	17:37	11:56
September	5:29	17:32	12:03
October	5:17	17:26	12:09
November	5:12	17:26	12:14
December	5:19	17:37	12:18

Source: Ministerio da Aeronautica, 1981.

Table 17. Major shrubs and trees species in uncleared, partially cleared and cleared caatinga vegatation. 1981

Common name	Family	Genus	Uncleared		Partially cleared		Cleared	
			Wet	Dry	Wet	Dry	Wet	Dry
Aroeira	Anacardiacea	Astronium	+	-	+	-	-	-
Catingueira	Leguminosae	Caesalpinia	+	+	-	-	-	-
Juazeiro	Ranaceas	Zezyphus	+	+	-	-	-	-
Jucazeiro	Leguminosae	Caesalpinia	+	+	-	-	-	-
Jurema Branca	Leguminosae	Pithecolobium	+	+	+	+	-	-
Jurema Preta	Leguminosae	Mimosa	+	+	+	+	+	+
Marmeleiro	Euforbiacea	Croton	+	-	+	-	+	-
Melosa	Acantacea	Ruellia	-	-	+	-	-	-
Mofumbo	Combretacea	Combratum	+	+	+	+	-	-
Mororo	Leguminosae	Bauhinia	+	+	+	+	-	-
Pau branco	Borraginacea	Auxemma	+	-	+	-	+	-
Pereiro	Apocinacea	Arpidosperma	+	-	+	-	-	-
Pinhao bravo	Euforbiacea	Jatrophes	+	-	+	-	-	-
Sabia	Leguminosae	Minosa	+	-	+	-	-	-

(+) present
(-) absent

Table 18. Major herbaceous species found in uncleared, partially cleared and cleared caatinga vegetation. 1981

Common name	Family	Genus	Uncleared		Partially cleared		Cleared	
			Wet	Dry	Wet	Dry	Wet	Dry
Amendoim bravo	Leguminosae	Arachis	+	-	+	-	+	-
Anil bravo	Leguminosae	Indigofera	-	-	+	-	+	-
Azedinho	Oxalidacea	Oxalis	-	-	+	-	+	-
Bamburral ver.	Compositae	Blainvillea	+	+	+	+	+	+
Bamburral bra.	Labiatae	Labiatae	+	+	+	+	+	+
Can. de lagoa	Leguminosae	Pithicellobium	+	+	+	+	+	-
Capim B. Bode	Graminea	Andropogon	+	+	+	+	+	+
Car. de agulha	Compositae	Bideus	+	+	-	-	-	-
Chanana	Turneracea	Turnera	+	+	+	+	+	-
Centrosema	Leguminosae	Centrosema	-	-	+	+	-	-
Cidreira Brava	Euphorbiacea	(**)	+	-	+	-	-	-
Erva mijona	Comeliacea	Commelina	+	+	+	+	+	+
Erva de ovelha	Leguminosae	Stylosanthes	-	-	-	-	+	-
Ervanco branco	Rubiaceae	Borrenia	+	+	+	+	+	+
Feijao de rola	Leguminosae	Phaseolus	+	+	+	+	+	+
Jitirana	Concolvulaceae	Ipomoea	+	+	+	+	+	+
Lingua de vaca	Compositae	Chaptalia	+	-	+	+	+	+
Malva relogio	Malvaceae	Sides	-	-	+	+	+	+
Maracuja	Passifloraceae	Passiflora	+	+	+	+	+	+
Mar. de cavalo	Leguminosae	Desmodium	+	-	+	-	+	-
Matapasto	Leguminosae	Cassia	-	-	+	+	+	+
Milha	Graminea	(*)	+	+	+	+	+	+
Mirasol	Compopsitae	(**)	+	+	+	+	+	+
Paco-paco	Malvacea	Wissadula	+	+	+	+	-	-
Pan. do Ceara	Graminea	Aristida	+	-	+	+	+	+
Pega-pega	Loasaceae	Mentxelia	+	-	+	+	-	-
Rabo de raposa	Graminea	Andropogon	+	-	+	+	-	-
Relogio	Sterculiacea	Waltheria	+	-	+	+	+	+
Salsa	Convolvulacea	Ipomoea	-	-	-	-	+	+

(*) two Genus Paspalum and Panicum
(**) species not identified
(+) present
(-) absent

Table 19. Body weight (kg-per head) of goats in uncleared caatinga vegetation.

Months	Stocking Rate															
	Heavy						Moderate						Light			
	1980		1981		1982		1980		1981		1982		1980		1981		1982	
January	-		22.1	2.1*	21.0	2.7	-		19.0	0.1	20.7	1.7	-		25.5	1.9	23.2	0.2
February	-		22.2	2.7	23.2	3.5	-		18.7	0.9	23.9	2.6	-		24.6	1.6	26.5	1.0
March	-		25.0	3.0	26.2	3.1	-		21.9	2.1	26.2	3.1	-		27.9	1.8	29.0	1.9
Abril	-		25.7	2.6	26.2	3.9	-		22.9	1.4	26.1	3.4	-		29.1	2.8	29.8	2.3
May	-		28.3	2.8	28.7	4.3	-		23.6	2.2	27.6	3.8	-		30.4	1.8	32.5	2.9
June	-		32.3	3.7	31.9	4.5	-		27.0	3.1	29.1	4.4	-		35.3	3.4	35.0	2.8
July	19.9	2.8	35.0	3.8	32.1	4.7	18.5	0.5	29.7	3.4	32.1	1.9	21.0	0.7	38.3	3.9	37.4	2.2
August	22.6	3.7	20.5	3.0	-		19.8	1.0	21.8	1.5	-		23.4	1.0	22.0	0.7	-	
September	24.1	3.0	22.1	2.4	-		21.4	1.7	22.9	1.4	-		25.1	1.3	22.4	0.9	-	
October	24.1	3.2	22.5	2.9	-		20.6	0.9	23.4	2.0	-		24.9	1.1	23.4	0.6	-	
November	25.0	3.6	22.9	2.7	-		20.6	1.1	23.2	1.8	-		26.1	1.2	26.2	0.6	-	
December	23.1	3.7	23.8	3.5	-		21.1	0.9	23.2	1.8	-		26.5	1.6	27.4	1.0	-	

* Mean Std. Dev. n = 3

Table 20. Body weight (kg-per head) of goats in partially cleared caatinga vegetation.

Months	Stocking Rate															
	Heavy						Moderate						Light			
	1980		1981		1982		1980		1981		1982		1980		1981		1982	
January	-		22.9	0.4*	23.0	1.6	-		25.9	0.9	23.9	0.2	-		27.0	1.9	22.9	3.2
February	-		22.8	0.6	25.3	1.7	-		26.9	1.1	26.8	0.4	-		25.7	1.6	24.2	4.8
March	-		26.0	0.0	28.2	2.3	-		30.0	0.5	29.1	0.8	-		30.0	1.0	28.0	4.7
April	-		29.0	0.8	28.6	2.5	-		31.3	1.2	29.3	1.1	-		32.3	1.1	28.5	5.4
May	-		30.6	1.3	30.6	3.1	-		33.4	1.3	30.8	1.7	-		34.2	1.1	31.5	5.1
June	-		34.3	1.3	32.9	2.9	-		36.7	1.7	33.7	1.9	-		37.4	1.3	33.2	5.2
July	18.7	1.0	36.0	1.9	35.2	3.8	20.2	1.0	40.0	0.8	36.8	2.7	21.2	0.2	40.3	2.4	35.6	6.1
August	20.4	0.9	20.8	0.8	-		22.6	0.8	21.2	2.3	-		24.1	1.2	21.0	1.7	-	
Septenber	22.1	1.3	22.0	1.1	-		25.1	0.2	22.1	2.5	-		26.0	3.0	22.6	1.9	-	
October	22.6	1.3	23.1	1.6	-		25.9	0.3	23.5	1.2	-		25.2	1.0	23.4	3.0	-	
November	24.1	1.5	25.2	1.6	-		26.7	0.7	25.2	0.7	-		26.2	1.1	25.1	2.9	-	
December	24.5	0.8	26.7	2.1	-		27.7	0.7	27.1	1.0	-		26.9	1.9	26.2	3.4	-	

* Mean Std. Dev. n = 3

Table 21. Body weight (kg-per head) of goats in cleared caatinga vegetation.

Months	Stocking Rate															
	Heavy						Moderate						Light			
	1980		1981		1982		1980		1981		1982		1980		1981		1982	
January	-		21.2	0.7*	20.4	4.4	-		27.7	1.6	25.6	3.7	-		29.4	5.5	22.3	2.1
February	-		18.6	1.7	24.6	5.2	-		26.0	1.4	29.3	3.4	-		26.7	5.1	26.0	3.4
March	-		22.9	2.1	29.0	5.5	-		29.2	1.5	32.4	3.7	-		30.4	4.9	29.9	4.6
April	-		24.8	1.3	30.0	6.7	-		30.6	0.9	33.8	4.3	-		30.1	1.5	29.5	4.7
May	-		26.4	1.2	31.6	6.8	-		30.9	1.0	36.0	5.6	-		34.6	4.6	31.0	5.0
June	-		30.0	1.6	34.1	6.4	-		34.1	0.8	37.8	6.4	-		36.2	5.2	35.7	4.5
July	20.4	1.2	32.6	1.9	37.2	7.5	19.8	2.0	36.5	1.5	42.0	6.2	21.7	3.0	39.4	4.9	36.2	6.9
August	22.2	1.0	22.1	3.1	-		21.3	1.9	22.2	2.8	-		23.7	3.7	21.7	2.0	-	
September	23.7	1.4	22.8	3.4	-		24.7	2.3	23.9	3.0	-		26.5	5.2	21.9	1.8	-	
October	23.1	0.4	23.4	4.0	-		25.6	2.3	25.1	2.5	-		27.9	5.7	22.4	1.9	-	
November	22.7	0.6	23.2	4.45	-		26.2	2.1	25.3	2.8	-		29.4	5.5	22.4	2.0	-	
December	21.7	0.4	26.3	2.9	-		27.0	2.0	27.9	3.3	-		29.6	5.6	22.3	1.3	-	

* Mean Std. Dev. n = 3

Table 22. Biomass by species (kg DM/ha) during the wet and dry seasons under three different stocking rates in uncleared caatinga, 1981.

Species	Wet Season Stocking rate heavy	moderate	light	Dry Season Stocking rate heavy	moderate	light
Forbs						
Amendoim bravo	16.4	30.3	25.2	-	-	-
Azulao	160.0	39.4	11.1	-	-	-
Bamburral branco	232.0	315.9	306.3	85.8	153.6	93.8
Bamburral verd.	94.0	159.2	124.3	53.7	55.5	50.7
Canafistula lagoa	40.0	22.1	69.3	4.1	2.3	38.3
Carrapicho agulha	40.0	16.7	32.0	6.1	3.2	13.8
Chanana	2.4	17.4	22.1	0.3	0.9	8.3
Cidreira brava	31.0	22.6	9.6	-	-	-
Engana bobo	44.6	52.0	14.9	-	-	-
Erva mijona	-	387.9	413.7	-	28.5	40.4
Ervanco branco	462.4	186.7	320.9	57.7	42.2	61.1
Feijao de rola	23.5	29.5	15.5	1.0	10.9	6.5
Jitirana	9.4	82.2	197.3	20.4	18.7	25.1
Lingua de vaca	23.8	296.4	35.3	-	-	2.3
Maracuja	14.2	9.9	4.5	3.8	-	0.7
Maria preta	-	13.4	106.5	-	-	-
Marmelada cavalo	21.1	6.5	16.6	-	-	2.7
Matapasto	-	5.6	-	3.6	-	3.9
Mata leitoso	-	127.4	117.5	-	-	-
Mirasol	652.5	1,126.4	173.3	79.9	69.7	94.1
Paco-paco	94.9	71.9	79.1	20.0	29.2	26.7
Pega-pega	1.0	33.7	17.5	-	2.6	-
Relogio	25.6	18.5	68.9	3.6	8.9	19.7
Others	13.8	44.5	41.8	-	1.0	18.4
Total Forbs	2,002.6	3,160.9	2,233.2	739.9	1,335.2	1,074.2
Grasses						
Capim barba bode	168.6	50.1	43.5	83.7	18.6	25.0
Milha	606.8	287.7	202.2	37.3	7.7	35.3
Panasco do Ceara	1.0	8.9	34.8	-	-	-
Rabo de raposa	33.3	21.7	76.1	-	-	-
Total Grasses	809.7	368.4	356.6	121.0	26.3	60.3
Leaves litter	-	-	-	399.9	908.0	567.7
Total	2,812.3	3,529.3	2,589.8	860.9	1,361.5	1,134.5

Table 23. Biomass by species (kg DM/ha) during the wet and dry seasons under three stocking rates in cleared caatinga, 1981.

Species	Wet Season Stocking Rate			Dry Season Stocking Rate		
	heavy	moderate	light	heavy	moderate	light
Forbs						
Amendoim bravo	12.1	14.6	26.9	-	-	-
Azulao	176.2	135.2	198.7	36.5	16.3	17.7
Bamburral branco	22.7	209.3	128.5	11.8	43.9	15.5
Bamburral verda.	218.9	35.2	35.5	66.0	16.9	13.2
Canafistula lagoa	-	1.9	20.6	-	-	-
Chanana	16.8	77.1	64.7	-	-	-
Engana bobo	30.9	26.0	88.8	5.3	8.0	30.2
Erva mijona	9.4	407.9	12.5	-	15.2	-
Erva de ovelha	5.2	13.8	47.1	-	-	-
Ervanco branco	324.7	167.5	297.5	82.1	54.2	87.7
Feijao de rola	154.1	401.3	240.0	60.5	51.2	15.5
Girao	3.4	6.8	511.5	-	1.1	-
Jitirana	54.6	245.4	56.5	-	3.6	7.4
Lingua de vaca	91.4	35.4	28.9	20.9	16.3	17.6
Malicia	14.4	25.7	181.2	-	9.2	1.6
Malva relogio	44.7	71.7	90.9	16.6	30.1	47.1
Maracuja	145.2	446.4	21.6	46.0	87.1	89.5
Marmelada cavalo	0.3	3.1	8.7	0.2	-	-
Matapasto	97.7	85.4	99.5	22.5	14.1	26.9
Mirasol	27.4	-	51.4	3.2	-	5.1
Relogio	3.8	87.8	42.7	15.7	13.6	22.8
Salsa	-	-	227.6	-	-	-
Total Forbs	1,588.0	2,517.7	2,065.7	393.1	386.5	438.8
Grasses						
Capim barba bode	46.6	21.8	89.2	17.3	10.5	25.0
Milha	300.1	344.2	740.5	98.0	164.1	222.2
Panasco do Ceara	6.9	17.6	11.6	2.5	1.5	31.0
Total grasses	353.6	383.6	841.3	117.8	176.1	278.2
Total	1,941.6	2,901.3	2,907.0	510.9	562.6	717.0

Table 24. Biomass by species (kg DM/ha) during the wet and dry seasons under three different stocking rates in partially cleared caatinga, 1981.

Species	Wet Season Stocking Rate heavy	moder.	light	Dry Season Stocking Rate heavy	moder.	light
Forbs						
Amendoim bravo	4.7	260.8	24.1	-	3.6	-
Anil bravo	1.9	-	7.7	-	-	-
Azedinho	-	1.6	1.3	-	0.7	-
Azulao	318.8	42.5	88.1	33.3	2.7	9.9
Bamburral branco	165.0	-	163.5	41.7	-	83.0
Bamburral verda.	136.9	181.3	27.9	31.4	14.3	14.7
Canafistula lagoa	14.4	133.0	47.3	-	98.0	23.9
Centrosema	1.2	4.2	31.2	-	-	4.8
Chanana	217.0	452.8	126.5	25.7	19.8	17.8
Engana bobo	5.3	17.5	2.3	-	-	-
Erva mijona	123.9	254.7	329.4	13.5	21.3	5.8
Ervanco branco	293.0	415.1	315.2	41.5	45.6	142.5
Feijao de rola	10.0	480.9	123.8	19.3	19.1	48.9
Jitirana	105.3	238.5	216.0	7.3	9.9	62.4
Lingua de vaca	18.4	4.1	18.6	2.2	-	3.9
Malva relogio	18.7	63.6	14.3	-	33.8	3.9
Maracuja	2.2	252.4	74.5	-	-	37.9
Marmelada de cavalo	11.9	8.5	36.9	-	-	1.1
Matapasto	57.6	269.5	48.6	18.0	81.8	19.0
Mirasol	690.1	515.1	375.9	142.5	391.4	72.0
Paco-paco	86.3	74.8	118.3	20.0	9.3	19.3
Pega-pega	18.1	34.8	8.2	4.8	24.1	-
Pescoco de ganco	54.7	8.3	4.7	-	0.7	5.0
Relogio	176.8	444.7	93.2	38.4	30.1	33.9
Others	71.9	100.2	153.9	14.5	23.6	16.6
Total Forbs	2,550.0	4,261.9	2,451.4	454.3	829.8	626.3
Grasses						
Capim barba de dode	5.4	24.9	14.4	3.6	6.6	1.6
Milha	614.6	234.6	188.8	73.8	138.8	55.9
Panasco do Ceara	55.7	-	4.1	25.9	5.7	-
Rabo de raposa	14.8	102.0	-	-	42.6	-
Total Grasses	690.5	361.5	207.3	103.3	193.7	57.5
Leaves litter	-	-	-	303.8	197.8	233.0
Total	3,240.6	4,623.4	2,658.7	861.4	1,221.3	916.8

Table 25. Leaf litter biomass (kg DM/ha) during the dry season and cover (%) during the wet season of shrubs and trees under uncleared caatinga, 1981.

Species	Stocking Rate					
	Heavy		Moderate		Light	
	kg/ha	(%)	kg/a	(%)	kg/ha	(%)
Aroeira	13	3	8	2	5	T
Catingueira	2	1	T	2	-	2
Juazeiro	T	-	-	-	12	-
Jucazeiro	T	-	-	-	-	T
Jurema branca	-	T	-	2	-	T
Jurama preta	13	23	2	14	-	23
Melosa	-	-	-	-	-	T
Mofumbo	102	14	130	10	54	10
Mororo	-	T	3	T	-	-
Pau branco	227	18	685	32	339	21
Pereiro	8	-	-	-	-	3
Pinhao bravo	33	-	-	-	-	-
Sabia	-	14	80	11	159	14
Umburana	-	T	-	T	-	-
Total	400	75	907	74	569	74

T: values less than 1.0 percent

Table 26. Leaf litter biomass (kg DM/ha) during dry season and cover (%) during the wet season of shrubs and trees under partially cleared caatinga, 1981.

Species	Stocking Rate					
	Heavy		Moderate		Light	
	kg DM/ha	(%)	kg DM/ha	(%)	kg DM/ha	(%)
Aroeira	-	T	-	-	-	-
Carnaubeira	-	T	-	-	-	-
Ciume	-	-	-	1	-	-
Jurema branca	-	T	-	-	-	-
Jurema preta	-	11	1	19	T	14
Melosa	-	2	-	-	-	-
Mufumbo	83	4	6	4	-	-
Mororo	-	-	T	-	T	2
Pau branco	66	6	48	3	107	8
Pereiro	-	T	-	-	-	-
Pinhao bravo	4	-	-	-	-	-
Sabia	149	7	83	8	125	8
Marmeleiro	2	-	-	-	-	-
Total	304	32	198	35	233	32

T: values less than 1.0 percent

Table 27. Percentage of forage avaiable on-pasture, species present in goats' diets and the ratio between them, under three stocking rates during two seasons under uncleared caatinga vegetation, 1981.

Species	Percentage avaiable on-pasture						Percentage consumed by goats						R A T I O					
	Heavy *		Moderate		Light		Heavy		Moderate		Light		Heavy		Moderate		Light	
	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry
Forbs																		
B.branco	8.2	10.0	9.0	11.3	11.8	8.3	11.8	9.4	-	20.7	1.0	13.1	1.4	0.9	-	1.8	0.1	1.6
B. verda.	3.3	6.2	4.5	4.1	4.8	4.5	9.4	1.1	5.0	1.0	8.7	-	2.8	0.2	1.1	0.2	1.8	-
E. branco	16.4	6.7	5.3	3.1	12.4	5.4	5.9	3.1	-	1.8	5.8	16.6	0.4	0.5	-	0.6	0.5	3.1
Jitirana	0.3	2.4	2.3	1.4	7.6	2.2	1.2	-	1.7	-	1.9	7.3	4.0	-	0.7	-	0.3	3.3
Maracuja	0.5	0.4	0.3	-	0.2	0.1	-	-	-	-	3.9	-	-	-	-	-	19.5	-
Mal.Relog.	0.9	0.4	0.5	0.7	2.7	1.7	-	-	-	-	1.9	-	-	-	-	-	0.7	-
Grasses	29.2	10.5	13.7	14.0	2.0	5.3	32.9	35.1	28.3	8.5	44.7	38.2	1.1	3.3	2.1	0.6	22.4	7.2
Browse																		
Juazeiro	-	0.1	-	-	-	2.1	-	19.6	-	1.8	-	-	-	163.3	-	-	-	-
Jucazeiro	-	0.1	-	-	-	-	3.5	-	-	-	-	-	-	-	-	-	-	-
Jurema	-	3.2	-	0.2	-	-	3.5	10.3	1.7	6.5	1.0	4.8	-	3.2	-	32.5	-	-
Melosa	-	-	-	-	-	-	-	-	30.0	25.3	8.7	16.6	-	-	-	-	-	-
Pau branco	-	56.8	-	75.5	-	59.6	10.6	-	21.7	5.5	4.8	-	-	-	-	0.1	-	-
Sabia	-	-	-	8.8	-	28-0	8.2	15.5	10.0	13.1	10.7	-	-	-	-	1.5	-	-

* Heavy, moderate and light refer to stocking rates. Wet and dry designate seasons.

Table 28. Percentage of forage avaiable on-pasture, species present in goats' diets and the ratio beteen them, under three stocking rates during two seasons under partially cleared caatinga vegetation, 1981.

Species	Percentage avaiable on pasture						Percentage consumed by goats						R A T I O					
	Heavy*		Moderate		Light		Heavy		Moderate		Light		Heavy		Moderate		Light	
	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry
Forbs																		
B. branco	5.1	4.8	-	-	6.2	9.1	5.9	8.5	5.8	21.0	6.1	16.1	1.2	1.8	-	-	1.0	1.8
B. verda.	4.2	3.6	3.9	1.2	1.0	1.6	-	8.5	11.6	-	6.1	1.1	-	2.4	3.0	-	6.1	0.7
E. branco	7.4	4.8	9.0	3.7	11.9	15.5	1.5	9.4	12.8	7.0	7.6	3.3	0.2	2.0	1.4	1.9	0.6	0.2
Jitirana	3.2	0.8	5.2	0.8	8.1	6.8	4.4	-	4.7	-	10.6	-	1.4	-	0.9	-	1.3	-
Maracuja	0.1	-	5.5	-	2.8	4.1	1.5	-	10.5	16.7	4.5	8.8	15.0	-	1.9	-	1.6	2.1
Malva rel.	0.6	-	1.4	2.8	0.5	0.4	-	7.5	-	-	-	-	-	-	-	-	-	-
Grasses	22.6	12.0	5.8	12.5	8.0	1.8	29.4	26.4	23.3	19.3	30.3	23.1	1.3	2.2	4.0	1.5	3.8	12.8
Browses																		
Juazeiro	-	-	-	-	-	-	2.9	2.8	-	4.4	-	16.5	-	-	-	-	-	-
Jucazeiro	-	-	-	-	-	-	-	-	-	-	3.3	-	-	-	-	-	-	-
Jurema	-	-	-	0.6	-	0.3	25.0	11.3	5.8	11.4	4.5	17.6	-	-	-	19.0	-	38.7

* Heavy, moderate and light refer to stocking rates. Wet and dry designate seasons.

Table 29. Percentage of forage avaiable on-pasture, species present in goats' diets and the ratio between them under three stocking rates during two seasons under cleared caatinga vegetation,1981.

Species	Percentage avaiable on-pasture						Percentade consumed by goats						R A T I O					
	Heavy *		Moderate		Light		Heavy		Moderate		Light		Heavy		Moderate		Light	
	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry	wet	dry
Forbs																		
B. branco	1.2	2.3	7.2	7.8	4.4	2.2	5.5	14.8	1.7	19.8	1.5	17.7	4.6	6.4	0.2	2.5	0.3	8.0
B. verda.	14.5	12.9	1.2	3.0	1.2	1.8	-	1.1	6.7	3.8	-	1.0	-	0.1	5.6	1.3	-	0.5
E. branco	16.7	16.1	5.8	9.6	10.2	12.2	23.3	23.9	6.7	12.3	3.1	6.3	1.4	1.5	1.2	1.3	0.3	0.5
Jitirana	2.8	-	8.5	0.6	1.9	1.0	15.1	4.5	6.7	4.7	44.6	-	5.4	-	0.8	7.8	23.5	-
Malva rel.	2.3	3.2	2.5	5.4	3.1	1.1	-	2.3	8.3	0.9	6.1	9.4	-	0.7	3.3	0.2	2.0	8.5
Maracuja	7.5	9.0	15.4	15.5	0.7	12.5	12.3	4.5	33.3	8.5	7.7	12.5	1.6	0.5	2.2	0.5	11.0	1.0
Matapasto	5.0	4.4	2.9	2.5	3.4	3.8	2.7	9.1	1.7	0.9	3.1	7.3	0.5	2.1	0.6	0.4	0.9	1.9
Grasses	18.3	23.8	13.3	31.4	29.0	38.8	35.6	39.8	28.3	17.0	24.6	19.8	1.9	1.7	2.1	0.5	0.8	0.5

* Heavy, moderate and light refer to stocking rates. Wet and dry designate seasons

Table 30. Percentage of time spent in different activities by goats under three densities of caatinga, during three seasons and under three stocking rates, 1981.

Activity	Stocking Rates								
	Heavy			Moderate			Light		
	wet	tran.	dry	wet	tran.	dry	wet	tran.	dry
Uncleared									
Grazing	48.9	57.5	55.7	34.5	66.7	61.5	59.2	60.9	48.3
Traveling	23.6	14.9	20.1	37.9	12.1	21.3	15.5	15.5	22.4
Lying idle	19.0	14.4	13.8	12.1	12.1	8.6	17.2	10.3	19.0
Ly. ruminat.	5.2	6.3	6.9	6.9	6.9	8.6	6.9	8.6	10.3
Standing idle	3.4	6.3	-	8.6	2.3	-	-	3.4	-
St. ruminating	-	0.6	1.7	-	-	-	1.1	-	-
Drinking	-	-	1.7	-	-	-	-	1.1	-
Partially Cleared									
Grazing	39.1	77.6	60.9	49.1	64.4	65.5	37.9	71.3	52.3
Traveling	23.6	10.3	16.7	11.5	20.7	20.1	24.1	11.5	20.1
Lying idle	24.6	1.7	13.8	25.9	6.9	1.7	24.1	4.6	15.5
Ly. ruminat.	5.7	7.5	8.6	8.6	6.9	9.2	7.5	8.0	8.6
Standing idle	5.2	0.6	-	2.3	1.1	3.4	2.9	2.9	2.3
St. ruminating	-	-	-	0.6	-	-	1.7	-	-
Drinking	-	2.3	-	1.7	-	-	1.7	1.7	1.1
Cleared									
Grazing	42.0	58.6	50.0	34.5	60.9	71.3	37.4	62.2	55.2
Traveling	26.4	16.1	25.3	29.9	13.1	9.2	27.6	12.6	19.0
Lying idle	13.8	12.1	11.5	17.8	12.1	4.0	19.0	8.6	13.8
Ly. ruminat.	5.7	8.6	9.8	3.4	8.6	8.6	6.3	9.8	10.3
Standing id.	11.5	2.9	1.7	12.6	3.4	3.4	9.2	4.6	1.7
St. ruminat.	0.6	-	-	1.7	-	1.7	-	-	-
Drinking	-	1.7	1.7	-	1.7	1.7	0.6	1.7	-

Table 31. Simple correlation coefficients relating goats' activities to temperature and humidity.

	Activities				
	Grazing	Traveling	Lying	Ruminating	Standing
Temperature	0.20	0.20	0.01	0.14	0.12
Relative Humidity	0.27	0.22	0.02	0.15	0.14

Table 32. Analysis of variance for weight gain (kg/ha) by goats in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	23.4810	6.11*
Stocking rate (R)	2	57.9994	15.10**
VR	4	4.0066	
Season (S)	2	364.3662	94.85**
VS	4	13.8578	
RS	4	46.7204	12.16**
Error (VRS)	8	3.8414	

Table 33. Analysis of variance for biomass production (kg DM/ha) in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	72.4717	6.54 *
Stocking rate (R)	2	76.0216	6.86 *
VR	4	19.2351	
Season (S)	1	1,975.6060	178.26 **
VS	2	13.7180	
RV	2	33.1951	
Error (VRS)	4	11.0826	

Table 34. Analysis of variance for diet preference of goats for forbs, grasses and browse in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation	2	0.0114	
Stocking Rate	2	0.0053	
VR	4	0.0065	
Season (S)	2	0.0047	
VS	4	0.0086	
RS	4	0.0035	
VRS	8	0.0132	
Diat (D)	2	1,869.9794	5.16 *
VD	4	2,173.5694	5.98 *
RD	4	153.2764	
SD	4	189.3109	
VRD	8	241.2206	
VSD	8	60.1934	
RSD	8	85.2868	
Error (VRSD)	16	363.3301	

Table 35. Analysis of variance for diet preference of goats for grasses in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	72.3826	
Stocking Rate (R)	2	168.2292	
VR	4	71.1220	3.34
Season (S)	2	228.8993	
VS	4	30.3020	4.55 *
RS	4	89.1504	
Error (VRS)	8	50.3056	

Table 36. Analysis of variance for diet preference of goats for forbs in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation	2	2,462.6144	7.40 **
Stocking rate	2	97.7200	
VR	4	110.6044	
Season (S)	2	137.3811	
VS	4	32.4622	
RS	4	38.6811	
Error(VRS)	8	332.7706	

Table 37. Analysis of variance for diet preference of goats for browse in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	1,812.1478	5.27 *
Stocking Rate	2	40.6044	
VR	4	300.7156	
Season (S)	2	12.3433	
VS	4	57.6444	
RS	4	42.7428	
Error (VRS)	8	343.5856	

Table 38. Analysis of variance for activity budget of goats in three densities of caatinga, 1981.

Source	df	MS	F
Vegetation (V)	2	0.0121	
Stocking Rate (R)	2	0.0017	
VR	4	0.0035	
Season (S)	2	0.0040	
VS	4	0.0079	
RS	4	0.0027	
VRS	8	0.0121	
Activity (T)	6	29,032.1658	550.92 **
VT	12	109.2901	2.07 *
RT	12	28.5309	
ST	12	703.1605	13.34 **
VRT	24	26.5401	
VST	24	64.9198	
RST	24	50.5772	
Error (VRST)	48	52.6975	

Table 39. Analysis of variance for grazing time spent by goats in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	178.3704	
Stocking rate (R)	2	51.5926	
VR	4	63.7593	
Season (S)	2	3458.3704	17.49**
VS	4	189.0370	
RS	4	256.0926	
Error (VRS)	8	198.7593	

Table 40. Analysis of variance for traveling time spent by goats in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	59.1481	
Stocking rate (R)	2	7.3704	
VR	4	72.7038	
Season (S)	2	729.3070	4.47*
VS	4	66.5370	
RS	4	41.2570	
Error (VRS)	8	162.9259	

Table 41. Analysis of variance for lying idle time spent by goats in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	16.1481	
Stocking rate (R)	2	91.7037	
VR	4	7.7593	
Season (S)	2	803.5926	33.70**
VS	4	216.9815	9.10**
RS	4	119.3704	5.00*
Error (VRS)	8	23.8426	

Table 42. Analysis of variance for lying ruminating time spent by goats in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	2.1111	
Stocking rate (R)	2	13.0000	5.85*
VR	4	5.9444	
Season (S)	2	52.1111	23.45**
VS	4	9.2222	4.15*
RS	4	0.4444	
Error(VRS)	8	2.2222	

Table 43. Analysis of variance for standing idle time spent by goats in caatinga vegetation, 1981.

Source	df	MS	F
Vegetation (V)	2	93.5926	8.19*
Stocking rate (R)	2	9.0370	
VR	4	6.7037	
Season (S)	2	161.1481	14.10**
VS	4	50.9815	4.46*
RS	4	18.5926	
Error (VRS)	8	11.4259	

VITA

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Thesis: Seasonal Feeding Behavior and Forage Selection by goats in Cleared and Thinned Deciduous Woodlands in Northest Brazil

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