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Energy supplementation in goats under a silvopastoral system of tropical grasses and leucaena[1]

Suplementação energética de caprinos em sistema silvipastoril formado por gramíneas tropicais e leucena

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ABSTRACT - The effect was evaluated of energy supplementation with ground maize grain on the performance and behaviour of Anglo-Nubian goats under a silvopastoral system of leucena and tropical grasses. The experiment was carried out in an area of Leucaena (*Leucaena leucocephala* (Lam.) De Wit.) intercropped with a herbaceous layer having a predominance of tropical grasses (Tifton 85, Andropogon and Guinea). A completely randomised design with four treatments and five replications was adopted. Growing goats were used; the control group being fed only on pasture, and the other groups supplemented with ground maize at 0.5, 0.9 and 1.3% of live weight. Supplementation reduced grazing time and increased rumination and idle time; although the goats spent approximately 85% of the time grazing on grasses, indicating a preference for this forage. Energy supplementation increased the weight gain per animal per unit area. Under a silvopastoral system of leucaena and tropical grasses, goats prefer the grasses, however, grazing on the legume results in a protein intake that justifies additional energy input. The supplementation of goats under a silvopastoral system of tropical grasses and leucaena, with maize as an energy source at a rate of up to 1.3% of live weight, influences feeding behaviour, having a favourable effect on animal performance.

Key words: Grazing behaviour. Weight gain. *Leucaena leucocephala*. Maize.

RESUMO - Foi avaliado o efeito da suplementação energética com milho em grão moído no desempenho e comportamento de caprinos da raça Anglonubiana em sistema silvipastoril formado por leucena e gramíneas tropicais. O experimento foi realizado em área formada com Leucena (*Leucaena leucocephala* (Lam.) de Wit.) consorciada com estrato herbáceo com predominância de gramíneas tropicais (capim-Tifton 85, capim-andropógon e capim-colonião). Adotou-se o delineamento inteiramente casualizado com quatro tratamentos e cinco repetições. Foram utilizados caprinos em crescimento, sendo o grupo controle alimentado apenas com pastagem e os demais grupos suplementados com milho moído a 0,5; 0,9 e 1,3% do peso vivo. A suplementação reduziu o tempo de pastejo das gramíneas e aumentou os tempos de ruminação e ócio, embora os caprinos tenham despendido aproximadamente 85% do tempo pastejando gramíneas, indicando preferência por esta forragem. A suplementação energética aumentou o ganho de peso por animal e por unidade de área. Em sistema silvipastoril formado por leucena e gramíneas tropicais os caprinos preferem as gramíneas, no entanto, o pastejo da leguminosa proporciona consumo de proteína que justifica aporte energético suplementar. A suplementação de caprinos em sistema silvipastoril formado por gramíneas tropicais e leucena com milho como fonte energética na proporção de até 1,3% do peso vivo influencia o comportamento ingestivo, com efeito favorável sobre o desempenho dos animais.

Palavras-chave: Comportamento de pastejo. Ganho de peso. *Leucaena leucocephala*. Milho.

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INTRODUCTION

Goat farming is an important socio-economic activity for farmers in the Northeast of Brazil, both in the semi-arid region and in sub-humid areas, as it is a source for generating income. A limiting factor to goat productivity on the production units of these farmers is the availability and quality of forage throughout the year, since the only source of food for the animals is usually native pasture.

Forage production is essential in feeding livestock, and the adoption of silvopastoral systems, where leguminous trees are intercropped with grasses, can help to increase, both qualitatively and quantitatively, the supply of forage in small-ruminant production systems.

One of the leguminous fodders most commonly used intercropped with grass in silvopastoral systems is leucaena. This is a promising forage species, mainly for its ability to resprout during the driest periods of the year and withstand intense grazing, as well as its high nutritional value, combining the production of fodder with a reduction in the use of external inputs (SHELTON, DALZELL, 2007).

Although legumes in the pasture improve the quality of the diet fed to animals, supplementation with high-energy food can increase the usage efficiency of dietary protein, improving the use of nitrogen for microbial protein synthesis and consequently improving animal performance (MARQUES *et al*., 2014).

Energy supplementation in grazing goats can also influence the behavioral habits of the animals and inhibit or stimulate forage intake (ADAMI *et al*., 2013). This research was therefore developed with the aim of evaluating behavioral change and performance in goats supplemented with high-energy food under a silvopastoral system of tropical grasses and leucaena.

MATERIAL AND METHODS

The experiment was carried out from December 2013 to February 2014 in the Sector for Goat Farming of the Department of Animal Science at the Center for Agricultural Sciences (CCA) of the Federal University of Piauí (UFPI), in Teresina, in the State of Piauí, Brazil. Located at 05º05'21" S and 42º48'07" W, at an altitude of 74.4 m. According to the Köppen classification, the climate in the region is type Aw' - tropical rainy savannah, with dry winters (June to November) and rainy summers (December to May), with the greatest rainfall concentrated from January to April.

The accumulated rainfall during the experimental period was 482 mm (Figure 1). The experiment began at the end of the dry season, with a rainfall of 38.2 mm, when the pasture was irrigated at night by sprinkler every two days. From January to March, the rainfall was 444 mm, characterizing the rainy season. There was a fall in average temperature from 28.9 to 26.4 °C, with the relative humidity increasing from 67.9 to 86.8% from the dry to the rainy season.

The soil in the area is a Red-Yellow Latosol. At the start of the experiment, soil samples were collected, with the following chemical characteristics being obtained at a depth of 0-20 cm: pH (H_2O) = 7.15, Ca = 2.02 ($cmol_c\ dm^{-3}$), Mg = 0.51 ($cmol_c\ dm^{-3}$), K = 0.14 ($cmol_c\ dm^{-3}$), Al = 0.00 ($cmol_c$ dm-3), P - Mehlich-1 = 3 ($mg\ dm^{-3}$) and organic matter = 8.88 ($mg\ kg^{-1}$).

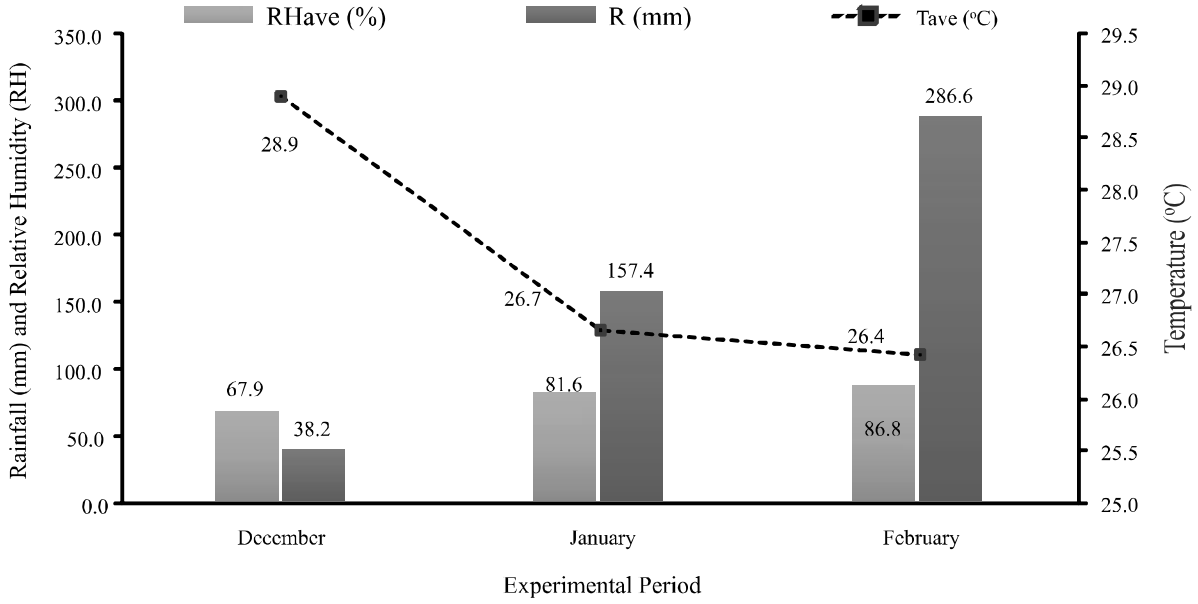
The area comprised 2,655 m², containing leucaena (*Leucaena leucocephala* (Lam.) De Wit.) established in 2000, at a spacing of 1.90 by 0.70 m between the rows and plants respectively, and a density of 1,996 plants ha^{-1}. Under this area of leucaena, a herbaceous layer developed naturally. This was composed of grasses: Andropogon grass (*Andropogon gayanus* Kunth.), Guinea grass (*Panicum maximum* Jacq cv Colonião), Tifton-85 grass (*Cynodon* spp.), and Alexander grass (*Brachiaria plantaginea* (Link) Hitchc); of legumes, *Stylosanthes* spp. and *Mimosa pudica* L.; as well as plants from other families, *Marsypianthes chamaedrys* (Vahl) Kuntze), *Borreria verticillata* (L.) G. Mey, *Turnera subulata* Sm. and *Alternan theratenella* Colla.

Since cultivation of the leucaena, the area had not been fertilized and was used for hay production, later being used for grazing with the natural development of the herbaceous layer. The area was divided into six equal-sized paddocks of 299 m², with an extra area of 559 m² having the same conditions as the other paddocks and used to help maintain the post-grazing height of the herbaceous stubble at 20 cm.

Twenty healthy Anglo-Nubian goats in the growth phase were used, with an initial weight of 16.74 ± 1.95 kg. A completely randomized statistical design was adopted, with four treatments, grazing with no supplements (control group), and supplemented with ground maize grain at ratios of 0.5, 0.9 and 1.3% of body weight, with five replications. Goats submitted to all the treatments were allocated to the same paddock at the same time, and received mineral supplements and water *ad libitum*.

A grazing system of rotational grazing and fixed loads was adopted, with a 6 day occupancy period and 30 days of rest, enough for the pasture to reach a height of 55 cm. The experimental period was 75 days, with two grazing cycles,

Figure 1 - Rainfall and maximum and minimum temperatures during the experimental period



the first 15 days for the animals to adapt, and 60 days for evaluation of pasture characteristics and goat behavior.

To evaluate forage production and the morphological characteristics of the leucaena, the leucaena was cut back to a uniform height of 1.0 m and the herbaceous layer to 20 cm. To evaluate the leucaena, five samples were collected from each paddock using a 0.5 x 1.0 m frame, and the plants counted and cut to a length of 1.0 m. The samples were weighed and divided into two subsamples, one the forage fraction (branches with a diameter of less than or equal to 6 mm) and the other the non-forage fraction (RAMOS *et al*., 1997). The forage fractions were weighed, and further subdivided into two subsamples, separating the stems from the leaves.

To evaluate the weight of the herbaceous forage, five samples were collected per paddock at a height of 5.0 cm from the ground, using 0.5 x 1.0 m frames at points that represented the average conditions in the pasture. After weighing, the botanical composition of the samples was determined, and they were separated into three groups: exotic grasses, native grasses and other herbs (herbaceous legumes and others). All samples were subjected to preliminary drying for 72 hours at 65 °C in a forced air circulation oven.

The pre- and post-grazing height of the grass and leucaena was measured at ten different points, and the amount of forage offered was calculated from Equation 1:

$$FO = (AVAIL/(LW/100)/TIME \quad (1)$$

where: FO = forage offered in kg DM/100 kg LW/day; AVAIL = forage availability in kg DM/ha; LW = live weight of the goats; TIME = duration of occupation, 6 days (ALLEN *et al*., 2011).

The chemical composition of the pasture was obtained from samples that simulated grazing by the goats. The levels of dry matter (DM), crude protein (CP) and lignin were determined following a methodology proposed by the AOAC (2012). The NDF and ADF content was determined using a method of Van Soest, Robertson and Lewis (1991).

The animals were weighed at the beginning and end of the experiment and every 7 days, to obtain information on the variation in daily weight and the total gain per area, and to adjust the supplementation. The concentrated energy supplement was always offered at 7 a.m., in individual stalls in the sheep-pen. Weight gain per animal (g day^{-1}) and gain per area (kg ha^{-1}) were calculated following the proposal of Adami *et al*. (2013).

To monitor the level of infection by endoparasites, feces were collected every week directly from the rectum vault of the goats. The number of eggs per gram of feces (EPG) was determined as per the Gordon-Whitlock technique modified by Ueno and Gonçalves (1998), administering levamisole hydrochloride in a single dose of 2 mL/10 kg LW to those animals with an EPG equal to or greater than 1,000 (COSTA; SIMÕES; RIET-CORREA, 2011).

To evaluate feeding behavior, five goats were used per treatment, with the time spent by the animals on grazing, movement, rumination and idleness recorded as proposed by Jamieson and Hodgson (1979). At the same time, ingested plants were identified to calculate the frequency of species in the diet. The evaluations were carried out during the first and third day of occupation of the paddocks, from 8 a.m. to 5 p.m. at intervals of 10 minutes, by previously trained observers.

The biting rate (bites/minute) was determined by observing each animal and taking note of the time taken to achieve 20 bites (FORBES; HODGSON, 1985). The observations were made at 9 a.m., 11 a.m., 1 p.m., 3 p.m. and 5 p.m. The number of bites was divided by the time in seconds, and the result multiplied by 60, to obtain the rate of bites per minute.

The results were submitted to analysis of variance and regression using the GLM and REG procedures of the SAS v 9.0 statistical software. The statistical model used to analyze the data is shown in Equation 2:

$$Yij = \mu + \alpha i + \varepsilon ij \quad (2)$$

where: Yij = observation for animal j at supplementation level i; μ = general mean; ai = effect of supplementation level i (i = 1, 2, 3, 4); random error associated with each observation (j = 1, 2, 3, 4, 5).

RESULTS AND DISCUSSION

Total forage production was 4,087.81 kg DM ha^{-1}, allowing forage to be offered at 7.0 kg DM/100 kg live weight. The pasture from the herbaceous layer was composed of 70.6% exotic grasses (Tifton-85, Andropogon and Guinea grass), followed by native grasses (11.6%) and other herbs (7.5%). Considering that forage intake by grazing adult goats is about 3% of LW (RODRIGUES *et al.*, 2013; RUFINO *et al.*, 2012), the offer of forage in this study was twice that value, demonstrating the favorable conditions of a pasture in a silvopastoral system with leucaena for growing goats.

The pre- and post-grazing height of the herbaceous layer was 42.3 and 19.2 cm respectively; for the leucaena it was 145.7 and 115.5 cm respectively (Table 1). As there is a positive relationship between the height of the forage canopy and forage availability, these values indicate the capacity for regrowth of both the herbaceous layer and the leucaena, even at a high stock density (83 goats ha^{-1}) and under intensive grazing.

The production of herbaceous forage (3,160.65 kg DM ha^{-1}) proved to be greater than that obtained for different monocrops of grasses in the Mid-Northern sub-region, managed under similar regrowth intervals and submitted to chemical fertilizers. This shows that intercropping with leucaena did not compromise the dry matter production of the herbaceous layer, which could have reduced plant growth through competition for nutrients and water, and through shading. Araújo *et al.* (2008) obtained a production of 1,227; 1,805 and 2,776 kg DM ha^{-1} for Tifton-85, Marandu and Tanzania grass respectively after 32 days of regrowth.

The production of leucaena forage was 927.2 kg DM ha^{-1} after 30 days of regrowth, a value close to that obtained by Sales *et al.* (2013) for twice the regrowth period (60 days), of 1,194 kg DM ha^{-1}. It can be inferred from this that the system has the potential for an increase in productivity with an increase in the post-regrowth cutting period. Bacab, Solorio and Solorio (2012), evaluating leucaena intercropped with *Panicum maximum* cv. Tanzania, obtained 881.28 kg DM ha^{-1} of forage material at regrowth intervals of 45 days and a cutting height of 60 cm, which suggests the high regrowth

Table 1 - Forage weight, structural characteristics and botanical composition of the herbaceous layer and the leucaena

Parameter	Herbaceous layer	Leucaena
Forage weight (kg MS/ha^{-1})	3,160.65 ± 1,003.02	927.16 ± 405.08
Dead material (%)	10.21 ± 7.78	
Leaves (%)		75.94 ± 6.46
Stems (%)		24.05 ± 6.46
Exotic grasses (%)	70.63 ± 25.13	
Native grasses (%)	11.6 ± 24.20	
Other herbs (%)	7.54 ± 10.57	
Pre-grazing height (cm)	42.31 ± 11.84	145.75 ± 21.10
Post-grazing height (cm)	19.25 ± 5.91	115.53 ± 20.06

capacity of leucaena under the system of rotational stocking at grazing intervals of 30 days adopted in this study.

The forage from leucaena represented 22.7% of the total forage produced in the system, comprising 75.9% leaves and 24.1% stems. The proportion of leaves is superior to that obtained by Costa *et al*. (2015) in leucaena harvested at 45 days of regrowth (68.8%) under similar conditions of soil and climate. The grazing frequency used favored the production of leaves and consequently of better quality forage, considering that the lower the age of the plant, the greater the leaf to stem ratio and crude protein content of the forage (MOURA *et al*., 2011).

The DM content of the herbaceous layer and the leucaena was 22.6 and 24.2%, respectively (Table 2). The CP content of the herbaceous layer of 14.1% was considered high compared with other tropical cespitose grasses grown in different regions of Brazil, including the Mid-Northern sub-region, with values equivalent to Tifton-85 grass, irrigated and fertilized with 300 kg N ha^{-1}, with a CP of 14.2% (RODRIGUES; LOPES; MAGALHÃES, 2005).

The CP content of the leucaena was 33.0%, considered high even for legumes, and probably resulted from the short regrowth interval. This value was higher than that obtained by Retama-Flores *et al*. (2011), of 26.9% CP for leucaena in a silvopastoral system when intercropped with star grass (*Cynodon nlemfuensis*). These results demonstrate the importance of leucaena in raising the CP content of forage offered to animals in mixed pasture, given that legumes provide more protein than grasses under such conditions.

The NDF and ADF content of the herbaceous layer was 66.1 and 36.2% respectively; values lower than those obtained by Araújo *et al*. (2008) for Tanzania, Marandu and Tifton-85 grass, after 32 days of regrowth and when fertilized, of 71.4 to 81.7% NDF and 40.0 to 43.1% FDA respectively. The NDF and FDA content of the leucaena was 40.1 and 25.3% respectively, equivalent to that obtained by Costa *et al*. (2015) of 37.5 to 41.4% NDF and 26.8 to 31.5% ADF for leucaena intercropped with exotic and native grasses at regrowth intervals of 30 to 75 days. The lower proportion of cell wall (NDF) and lignocellulosic complex (ADF) of the leucaena in relation to the tropical grasses favors both the intake and digestibility of forage intercropped with this legume in a non-fertilized silvopastoral system.

The high CP content and lower levels of NDF and ADF were a result of the sample having included only leaves from the upper part of the leucaena and herbaceous layer which comprise the forage pasture. It should also be considered that 30 days of regrowth did not allow the leucaena branches over 1.0 m in height to reach a thickness of more than 6 mm and be characterized as non-forage pasture (RAMOS *et al*., 1997).

The lignin content of the herbaceous layer was 8.3% and of the leucaena 13.2%, values lower than those obtained by Detmann *et al*. (2014) for different grasses and tropical legumes, among these Tifton-85 grass and leucaena, of 15.1 and 22.5% respectively. The lignin in legumes is generally found in larger quantities than in grasses. Even with a low NDF content, the greater the proportion of lignin, the lower the digestibility of the forage (BARBERO *et al*., 2010), however, the ADF content of the leucaena in the silvopastoral system was only 25.3%, demonstrating the low proportion of this constituent directly related to digestibility.

A level of supplementation up to 1.3% of LW influenced ($p<0.05$) grazing behavior, with a reduction in grazing time and increases in rumination and idle time (Table 3). This reduction in grazing time with supplementation shows the effect of substituting pasture in the animals' diet, agreeing with the result obtained by Biezus *et al*. (2012), where grazing time for goats was less when supplementated with concentrate.

The greater intake of nutrients with energy supplementation promotes a reduction in grazing time and can result in a lower energy expenditure associated with this activity, thereby favoring the goats' performance. Supplementation for grazing ruminants involves maintaining the rate of ingestion and consumption of forage DM per unit of time, with a reduction in grazing time (COSGROVE; EDWARDS, 2007).

The positive relationship between supplementation and idle and rumination time may be associated with the intake of nutrients provided by the supplement, and the

Table 2 - Chemical composition of leucaena and the herbaceous layer grown under a silvopastoral system

Component	DM (%)	CP (%)	NDF (%)	ADF (%)	Lignin (%)
Herbaceous layer	22.68 ± 1.26	14.10 ± 1.23	66.13 ± 2.60	36.22 ± 2.94	8.30 ± 1.53
Leucaena	24.24 ± 2.11	33.04 ± 2.59	40.13 ± 6.67	25.27 ± 4.25	13.16 ± 2.51

DM= Dry matter; CP= Crude protein; NDF= Neutral detergent fiber; ADF= Acid detergente fiber

Table 3 - Grazing behavior and bite rate in Anglo-Nubian goats supplemented with maize under a silvopastoral system

Variable	Level of supplementation (% LW)				Regression equation	R^2	SEM
	0.0	0.5	0.9	1.3			
Grazing time (h)	7.71	7.58	6.73	7.12	$\hat{y} = 7.69 - 0.61x$	0.57	0.11
Rumination time (h)	0.60	0.58	0.74	0.82	$\hat{y} = 0.55 + 0.18x$	0.81	0.04
Idle time (h)	0.47	0.58	1.12	0.77	$\hat{y} = 0.50 + 0.33x$	0.46	0.08
Movement time(h)	0.21	0.24	0.38	0.26	$\hat{y} = 0.27 \pm 0.12$	-	0.02
Bite rate	21.56	20.1	21.03	20.56	$\hat{y} = 20.81 \pm 3.24$	-	0.72

R^2= Coefficient of determination; SEM= Standard error of the mean

consumption and digestion of the supplement in the early hours of the day, which might have discouraged grazing, thereby increasing the idle and rumination time of the animals.

With maize-based supplementation, the goats were supplied with an energy source of rapid degradation, favoring rumination and idleness. Moreover, the presence of leucaena in the pasture may have created a microclimate that favored idle behavior. According to Young and Corbet (1972), when environmental conditions favor idle behavior, there is a saving of energy, which can be used for production.

Movement time and bite rate remained stable ($p>0.05$) with energy supplementation. The paddock area was small (299 m²) and fairly uniform, with a good distribution of the herbaceous and shrubby (leucaena) layers, and a positive impact on movement time due to the proximity of the grazing sites. In addition, all the goats grazed at the same time in the same paddock, with access to the same sward structure and forage resources, which resulted in a stable bite rate.

Supplementation resulted in a lower ($p<0.05$) grazing time on grass but did not affect ($p>0.05$) the time grazing on leucaena (Table 4). The lesser grazing time on leucaena may be associated with the presence in the forage of phenolic compounds, mainly tannins, which can form complexes with salivary glycoproteins and compromise the taste, reducing intake and digestibility (REED, 1995). According to Otero and Hidalgo (2004), a tannin concentration greater than 5% of the DM affects voluntary intake and the digestibility of the forage.

The animals spent around 85% (6.23 h) of the grazing time on grass, demonstrating a preference for this forage, with a greater preference for leucaena at the beginning and end of the day (Figure 2). This greater preference for the legume at the beginning and end of the day is associated with their needs being met and their being more selective of diet at these times, since those animals that received the supplement early in the day and in the evening had a full gastrointestinal tract.

Energy supplementation resulted in a greater weight gain ($p<0.05$) per animal per unit area (Table 5), showing that maize supplement as an energy source giving high carbohydrate degradability in the rumen should favor the ruminal environment by facilitating synchronization of leguminous nitrogen use with greater microbial synthesis and a greater supply of amino acids to the ruminant (MARQUES *et al.*, 2014).

The average daily gain and the gain per area obtained at the highest level of supplementation (1.3% LW), proved greater than those obtained by Araújo *et al.* (2015), of 41g day^{-1} and 124 kg ha^{-1}, for goats grazing on Andropogon grass, with 15% forage offered during the rainy season, justifying energy supplementation under silvopastoral systems with leucaena.

Table 4 - Grazing time on grass and leucaena in a silvopastoral system in Anglo-Nubian goats supplemented with maize

Parameter	Level of supplementation (% LW)				Mean	Regression equation	R^2	SEM
	0.0	0.5	0.9	1.3				
Grazing on grass (h)	6.96	6.45	5.40	6.11	6.23a*	$\hat{y} = 6.81 - 0.84$ x	0.48	1.64
Grazing on leucaena (h)	0.75	1.13	1.33	1.01	1.05b	$\hat{y} = 0.75 \pm 0.51$	-	1.64

*Mean values followed by different lowercase letters in a column differ by SNK test ($p<0.05$); R^2= Coefficient of determination; SEM= Standard error of the mean

Figure 2 - Percentage of goats grazing on grasses and leucaena under a silvopastoral system

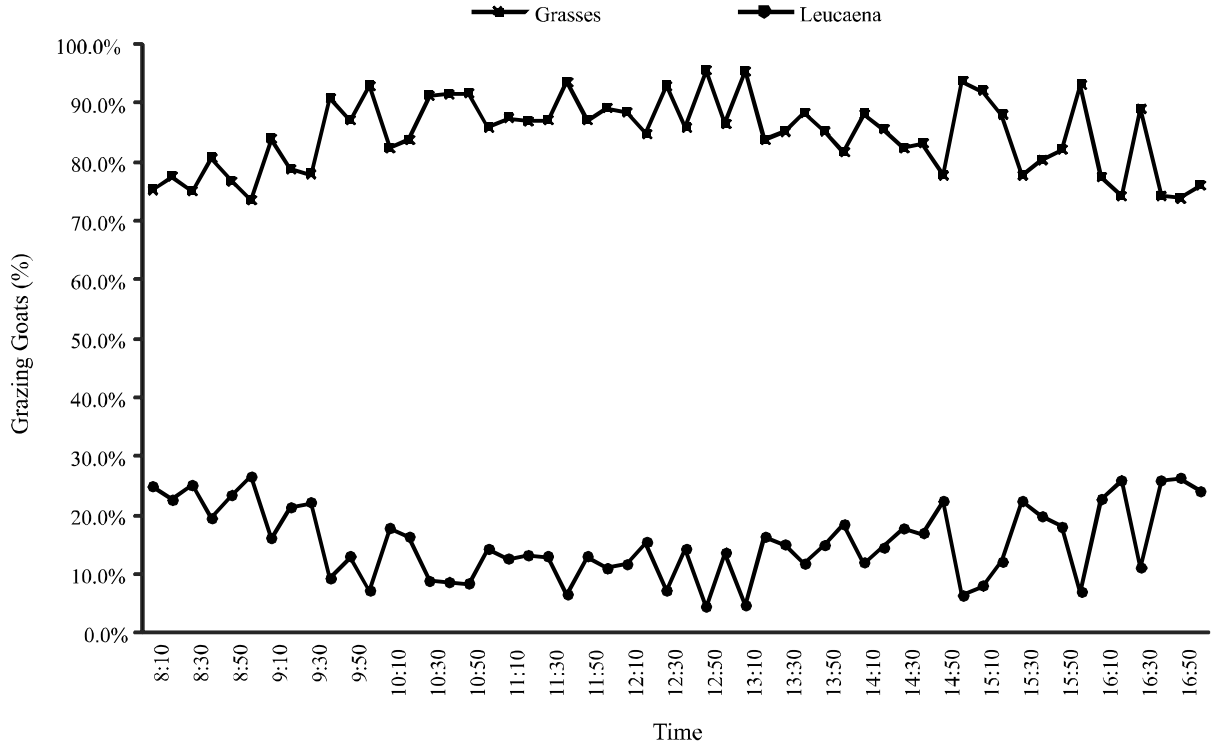


Table 5 - Average daily gain and gain per area in Anglon-Nubian goats supplemented with maize under a silvopastoral system

Parameter	Level of supplementation (% LW)				Regression equation	R^2	SEM
	0.0	0.5	0.9	1.3			
ADG (g/day)	17.87	37.26	32.26	67.26	$\hat{y} = 16.31 + 33.11x$	0.78	5.72
Gain per área (kg/ha)	43.89	93.47	80.93	168.72	$\hat{y} = 40.22 + 83.74x$	0.79	14.40
EPG (n)	910	1077.5	900	1120	$\hat{y} = 1001.88 \pm 646.12$	-	0.07*

ADG = Average daily gain; SEM= Standard error of the mean; EPG = Eggs per gram of feces; R^2= Coefficient of determination; * Log^{10} transformed data

The results are similar to those obtained by Cavalcante, Bomfim and Leite (2006) in Boer goats supplemented with maize, grazing on irrigated and fertilized Tanzania grass, with an estimated value of 66.48 g day^{-1} for supplementation based on 1.3% of LW. This shows that a silvopastoral system with leucaena provided equivalent gains even at a higher stock density, 83 animals ha^{-1} in this study, compared to the 60 animals ha^{-1} adopted by those authors.

Energy supplementation with ground corn grain in goats under a silvopastoral system with leucaena, has the notable result of high weight gain per area. Even adopting a high stock density (83 animals ha^{-1}), the animals produced 168 kg ha^{-1} in 60 days; a considerable value in the case of a tropical area of the Mid-Northern sub-region, and for Anglo-Nubian goats of mixed capacity.

Infection with nematodes was not affected by supplementation ($p>0.05$), with an average EPG value of 1,001 eggs per gram of feces, equal to the recommended level for deworming (COSTA; SIMÕES; RIET-CORREA, 2011). It should be noted that there were peaks of contamination during the experiment, when treatment was carried out with anthelmintics.

CONCLUSIONS

1. Anglo-Nubian goats under a silvopastoral system of tropical grasses and leucaena preferentially graze on the grasses; however, grazing on the legume provides a protein intake that justifies additional energy input;

2. The supplementation of goats under a silvopastoral system of tropical grasses and leucaena, with maize as an energy source at a ratio of up to 1.3% of live weight, has an influence on feeding behavior, with increased grazing time and less rumination and idle time, and a favorable effect on animal performance.

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