Ingestive behavior of goats under four grazing conditions

Comportamento ingestivo de caprinos sob quatro condições de pastejo

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Abstract

This study aimed to assess the sward characteristics and the ingestive behavior of mature goats grazing Aruana grass (Panicum maximum cv. Aruana) and limpograss (Hemarthria altissima cv. Florida) under low and high sward heights. The structural and morphological characteristics of the pasture were assessed, as well as the ingestive behavior of the animals for 24 hours. The animals had free access to the four sward conditions during the trial period. The forage allowance (FA) showed minimum value (P=0.0002) of 3.9% BW in DM.day^{-1} for low Aruana and maximum value of 12.5% BW in DM.day^{-1} for high limpograss. The leaf allowance (LA) showed a similar response to the FA, with a minimum (P=0.0012) of 1.7% BW in DM.day^{-1} for low Aruana and maximum of 3.1% BW in DM.day^{-1} for high limpograss. Grazing time was longer (P<0.0001) in high Aruana and high limpograss, in which the leaf mass was similar (high Aruana = 1282 kg DM.ha^{-1}) or superior (high limpograss = 1773 kg DM.ha^{-1}) to the average leaf mass of the pasture (1335 kg DM.ha^{-1}). The activities of rumination and rest occurred for prolonged periods and with higher frequency during night and late night. It was concluded that mature goats graze for longer periods in high-height swards with higher forage and leaf masses. The criteria chosen for pasture areas to be explored are based on these characteristics, under which goats sought to maximize the intake of high quality forage. Grazing activity followed a

similar pattern of other domestic herbivores (cattle, sheep and horses), but goats did not interrupt this activity during the hottest hours of the day.

Keywords: Aruana grass. Forage mass. Leaf mass. Limpograss. Sward height.

Resumo

Este estudo objetivou avaliar o comportamento ingestivo de caprinos adultos em pastagens formadas por capim Aruana (Panicum maximum cv. Aruana) e hemártria (Hemarthria altissima cv. Florida) manejadas sob diferentes alturas (baixa e alta). Foram avaliadas as características estruturais e morfológicas da pastagem, bem como o comportamento ingestivo dos animais durante 24 horas. Os animais tiveram livre acesso às quatro condições de pastejo durante o período experimental. A oferta de forragem (OF) apresentou valor mínimo (P=0,0002) de 3,9% do peso corporal (PC) em matéria seca (MS)/dia para Aruana baixa, e valor máximo de 12,5% do PC em MS/dia para hemártria alta. A oferta de lâminas foliares (OLF) apresentou resposta semelhante à OF, com valor mínimo (P=0,0012) de 1,7% do PC em MS/dia para Aruana baixa e valor máximo de 3,1% do PC em MS/dia para hemártria alta. O tempo de pastejo foi maior (P<0,0001) em Aruana e hemártria altas, onde a massa de lâminas foliares foi semelhante (Aruana alta = 1282 kg de MS/ha) ou superior (hemártria alta = 1773 kg de MS/ha) a massa de lâminas foliares média da pastagem (1335 kg de MS/ha). As atividades de ruminação e descanso ocorreram por maior tempo e com maior frequência durante a noite e a madrugada. Conclui-se que caprinos adultos permanecem por mais tempo em pastagens com maior altura e com maiores massas de forragem total e de folhas. Estes são os critérios de escolha das áreas da pastagem a serem exploradas, nas quais os caprinos buscam maximizar o consumo de forragem de elevada qualidade. A atividade de pastejo de caprinos adultos segue um padrão semelhante ao de outros herbívoros domésticos (bovinos, ovinos e cavalos), porém os caprinos não interrompem esta atividade durante as horas mais quentes do dia.

Palavras-chave: *Capim-Aruana. Massa de forragem. Massa de folhas. Hemártria. Alturas de pasto.*

Introduction

The development of a sustainable grazing system depends on the relationship between the pasture characteristics and the process of harvesting forage by the animals, as well as the effect that they have on the structure of the canopy, which cyclically affects their grazing behavior.

The ability to select is related to heterogeneity and to the sward structure. Accordingly, to consume a certain fraction of forage despite another, the animal must be able to distinguish them and harvest it. Since the heterogeneity may be perceived by the animal, the process of diet selection can occur in several levels: in feeding spots within a pasture, in species in a spot or in organs within the plant. This level of selection depends not only on the pasture characteristics, but also on the animal ability to select itself (PARSONS; DUMONT, 2003). The selection process of forage can define structural variations in different dimensions of the pasture resulting from the animal-plant relationship, which is the responsible factor for the productivity of grazing systems.

Some plant characteristics related to grazing process are the height of the sward, the forage mass present per volume unit, the fibrousness of leaf laminas, the spatial arrangement of plant tissues preferred by the animals, the presence of barriers to defoliation, such as sheaths and stems, and the dry matter (DM) content (PRACHE; PEYRAUD, 1997). These characteristics are inherent to the structure of the canopy and determine the strategies and mechanisms used by animals during grazing.

The availability of DM and leaves, the sward height, the leaf:stem ratio and forage digestibility have high correlation with the forage intake in tropical pastures (GONTIJO NETO et al., 2006; BOVAL et al., 2007). Furthermore, tropical pastures composed by

species of different patterns of growth (tussock or decumbent) can affect the preference of forage selection by the grazing animals (SILVA et al., 2009). Variables associated to the structural and morphological characteristics of forage species have influence in grazing time and, therefore, in time spent on rumination, idleness, social activities, among others (PARSONS; DUMONT, 2003).

This trial aimed to assess the sward characteristics and the ingestive behavior of adult goats on pasture of Aruana grass (*Panicum maximum* cv. Aruana) and limpograss (*Hemarthria altissima* cv. Florida), both managed under different sward heights.

Material and methods

The trial was carried out at Capril Campo Largo, located in Campo Largo, Paraná (25º27'S, 49º31'W, 956m altitude). The climate of the region is Cfb, characterized as humid subtropical in the classification of Köppen. The trial period lasted 14 days.

The 672 m^2 experimental area was formed equally by two forage species with different growth patterns: Aruana grass (*Panicum maximum* Jacq cv. Aruana) with tussock growth (336 m^2) and limpograss (*Hemarthria altissima* cv. Florida) with decumbent growth (336 m^2). The soil fertility throughout the experimental area was not homogeneous due to a slope along the land. The site was, therefore, divided into three paddocks with same size (224 m^2) and different soil fertility (low, medium and high). The paddocks were composed by the two forage species, each one covering 50% of the area.

The treatments were characterized by the two forage species managed under two sward heights and kept under grazing, resulting into four combinations: low-height Aruana grass, high-height Aruana grass, low-height limpograss and high-height limpograss. Along each paddock, the sward heights were established in continuous strips composed of a single forage specie. Eight strips (2.10 m wide and 40 m long) were arranged alternately in the paddocks, being two strips for each one of the four combinations.

The strips were established by pasture regrowth after mowing management. Initially, the entire experimental area was mowed to 10 cm height. A second mowing to the same initial height was performed 14 days later on the strips marked for the lower height treatment. As a result, the age of regrowth of high- and low-height pastures corresponded to 46 and 32 days, respectively. The higher sward heights were 70 cm for Aruana grass and 50 cm for limpograss, and the lower sward heights were 20 cm for Aruana grass and 15 cm for limpograss.

Nine mature goats of undefined breed were used, being six females and three non-castrated males, aged 2.5 years and with 33 kg of average body weight (BW). In the pre-trial period, all animals were clinically examined to reassure good health status and the females were submitted to pregnancy diagnosis by ultrasonography to avoid divergent physiological conditions that could compromise the assessments. Only animals in maintenance and anestrous females were used. The goats were distributed uniformly in the treatments according to sex and BW.

During eight days before the beginning of the trial, the goats were kept from 7:00 to 22:00 hours in a 400 m^2 paddock near the experimental area, formed by the same species of grass assessed in the trial. In this period, simulations of the assessments of ingestive behavior that would be conducted during the trial were made in order to minimize the interference of the evaluators in animal behavior.

The grazing method was continuous stocking and the animals had free access to the four treatments in each paddock. Three goats were distributed in each paddock, seeking to keep the effects of natural grazing behavior in herbivore groups (PENNING et al., 1993). The stocking rate per paddock corresponded to 134 animals.ha^{-1}.

Sward height was measured using the sward stick, according to the methodology described by Barthram (1986). These assessments were performed on days 1, 3, 5, 8, 13 and 14 of the trial. The measurements were made in points randomly selected in each strip, totaling 20 points per strip and 240 points per treatment.

The forage mass and morphological composition of pasture were determined by harvesting five forage samples per treatment in each paddock, on days 1, 8 and 14 of the trial. Samples were collected using a 0.25 m^2 square (0.5 x 0.5 m) and then separated into leaf lamina, stem plus sheath and senescent/dead material. The fractions were dried in a forced air oven at 65 ºC until constant weight was achieved. The average forage mass and morphological components

mass per treatment were determined and expressed in kg DM.ha^{-1}. The forage allowance (FA) and the leaf allowance (LA) were calculated based on the method described by Soares et al. (2006), and the leaf:stem ratio was obtained dividing the mass of leaf lamina by the mass of stem plus sheath (DM basis).

Assessments of daily ingestive behavior were performed three times (on days 2, 9 and 13), according to the method described by Jamieson and Hodgson (1979). The procedure consisted on the observation, identification and recording of the activities performed by the goats every 10 minutes, like grazing, idleness, rumination and water and mineral intake. Grazing activities were recorded by identifying in which treatment they were performed. The animals were monitored for 24 hours, and this period was divided into four shifts: morning (6:00 to 12:00), afternoon (12:00 to 18:00), night (18:00 to 00:00) and late night (0:00 to 6:00 am). In these shifts, the average temperatures were 16.6, 21.6, 16.5 and 14.9 ºC, respectively (Sistema Meteorológico do Paraná, 2005).

Data from pasture were analyzed according to a randomized blocks design with four treatments and three replicates (blocks/paddocks). Data from ingestive behavior were analyzed in a completely randomized design with four treatments and nine replicates. The analysis were performed by ANOVA using the general linear model (GLM) procedure, and the means that showed statistical difference among treatments (P<0.05) were compared by Tukey test. Analyses were performed using the *Statistical Analysis System*, Version 9.0 (SAS, 2002).

Results

The expected difference through the mowing handling was achieved, which was evidenced by the superiority in sward height and forage mass observed for the higher management sward heights in both species (Table 1).

The forage mass available for the animals was 4611 kg DM.d^{-1}, which is the average value calculated from the forage masses of the two species associated with the two sward heights (Table 1). The FA calculated under this condition was 8% BW in DM.d^{-1} on average, with a minimum value (P=0.0002) of 3.9% BW in DM.d^{-1} for low Aruana grass and maximum of 12.5% BW in DM.d^{-1} for high limpograss.

The leaf mass was 1335 kg DM.ha^{-1} on average and corresponded to 32% of forage mass. The LA followed the results observed for FA and showed 2.3% BW in DM.d^{-1} on average, with minimum value (P=0.0012) of 1.7% BW in DM.d^{-1} for low Aruana grass and maximum of 3.1% BW in DM.d^{-1} for high limpograss.

The animals grazed for 8.9 hours.day^{-1}, meaning that they have dedicated approximately one third of their days to this activity. However, differences (P<0.0001) were noted in time spent on grazing in the four sward conditions (Figure 1).

Table 1 – Means for the structural and morphological characteristics of Aruana grass (*Panicum maximum* Jacq cv. Aruana) and limpograss (*Hemarthria altissima* cv. Florida) pastures with different sward heights

Sward characteristics[I]	Treatments				P
	Aruana grass		Limpograss		
	Low	High	Low	High	
Sward height (cm)	20.9 (1.0) b	51.0 (4.6) a	14.2 (0.9) b	40.0 (6.9) a	0.0005
Forage mass (kg DM.ha^{-1})	2211 (96) c	4313 (176) b	4725 (412) b	7193 (340) a	0.0002
Leaf mass (kg DM.ha^{-1})	963 (23) c	1282 (76) bc	1323 (92) b	1773 (70) a	0.0011
SS mass (kg DM.ha^{-1})	674 (14) c	1981 (115) b	2489 (322) b	4595 (308) a	0.0002
SDM mass (kg DM.ha^{-1})	575 (98) b	1050 (12) a	913 (19) a	826 (42) ab	0.0041
L:S ratio	1.43 (0.02) a	0.64 (0.01) b	0.54 (0.05) b	0.39 (0.01) c	<0.0001

[I]Subtitles: SS = stem plus sheath; SDM = senescent/dead material; L:S = leaf:stem

Note: Numbers inside parentheses indicate the standard error of the mean. Different lowercase letter in the same rows differ (P<0.05) by the Tukey test.

Source: Research data.

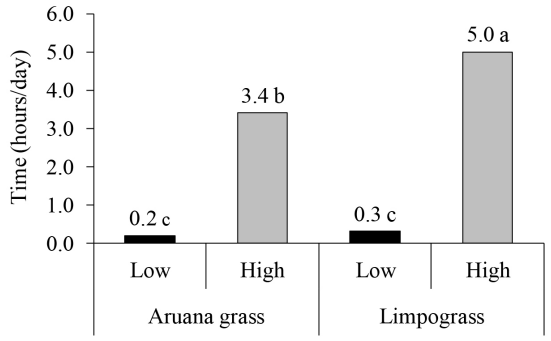

Figure 1 – Grazing time of adult goats in Aruana grass (*Panicum maximum* Jacq cv. Aruana) and limpograss (*Hemarthria altissima* cv. Florida) pastures with different sward heights

Source: Research data.

The average grazing time was 3.6 hours.day^{-1} for Aruana grass and 5.3 hours.day^{-1} for limpograss. It was also observed that the grazing time was longer on the areas with higher forage mass, with grazing times of 3.4 and 5 hours.day^{-1} for high Aruana grass and high limpograss, and 0.2 and 0.3 hours.day^{-1} for low Aruana grass and low limpograss, respectively (Figure 1). Thence, the animals grazed for longer periods in the taller pasture with higher forage mass and more leaves, but lower leaf:stem ratio (Table 1).

The peaks of grazing activity occurred in the morning, between 9:00 and 11:00, and in the afternoon, between 15:00 and 17:00 (Figure 2). There were discrete occurrences for this activity during night and dawn with peaks between 20:00 and 22:00, and between 0:00 and 2:00, respectively.

Even with the peaks of grazing activity occurring in the early morning and late afternoon, the animals did not interrupt the grazing activity throughout the day (Figure 2). In contrast, the time spent for other activities was higher during the night and the dawn.

Discussion

The potential feed intake (DM.d^{-1}) of a 33 kg BW adult goat in maintenance is around 2.5% of BW.d^{-1} (National Research Council, 2007), and the forage intake is maximized under FA from 10% to 12% BW in DM.d^{-1} (HODGSON; BROOKES, 1999). There was high heterogeneity in the pasture offered to the animals, which had simultaneous access to limited (low Aruana grass, FA=3.9% BW in DM.d^{-1}) and suitable (high limpograss, FA=12.5% BW in DM.d^{-1}) grazing conditions to achieve the potential forage intake in maintenance.

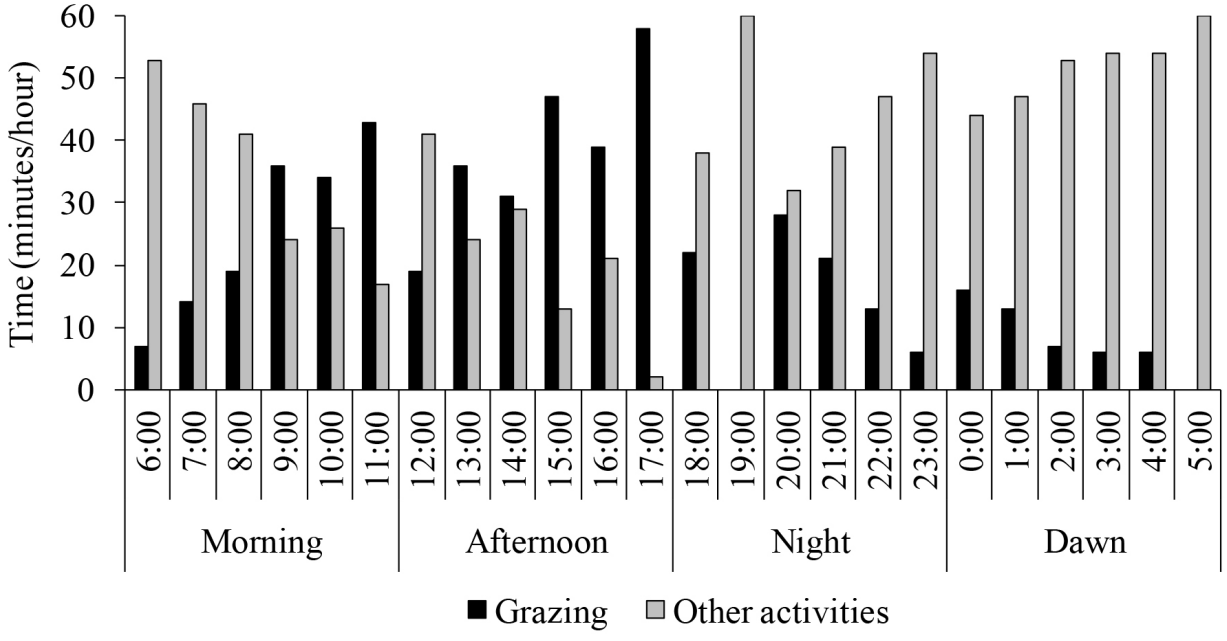

Figure 2 – Time spent by adult goats on grazing and other activities for each hour of day

Source: Research data.

The forage mass for high limpograss (7193 kg DM.ha^{-1}, Table 1) was 56% higher than the average forage mass in the pasture throughout the trial period. At intermediate levels of forage mass (1500 to 2500 kg DM.ha^{-1}), the forage mass in those selected grazing sites can be 65% higher (1000 to 1600 kg DM.ha^{-1}) than the average forage mass in the pasture (LACA; DEMMENT, 1991). Hence, the grazing periods recorded during 24 hours for the four conditions of pasture were influenced by the structural characteristics of the canopy, since the goats grazed for longer periods in areas with forage mass higher than the average of the pasture. These effects were verified for high-height limpograss and justify the longer grazing period observed on this forage specie.

It is noteworthy that the mean LA (2.3% BW in DM.d^{-1}) in the pasture was close to the potential feed intake of an adult goat (2.5% BW in DM.d^{-1}) (National Research Council, 2007). Therefore, the animals had the opportunity to select and compose a high-quality diet, characterized by high proportion of leaves. This is the morphological component preferably consumed under grazing conditions (BRÂNCIO et al., 2003; GONTIJO NETO et al., 2006).

The higher grazing time observed in limpograss (5 hours.d^{-1}) when compared to Aruana grass (3.4 hours.d^{-1}) was related to the maintenance of higher forage and leaf mass in high-height limpograss pasture in the middle of the trial period. Higher grazing time and, consequently, the preference by the adult goats for this sward condition were reported in other studies with tropical grasses (SILVA et al., 2009) and temperate annual grasses (BRATTI et al., 2009).

The preference for taller plants expresses the search for higher forage intake by the goats, in the sense that higher sward heights enhance the bite depth and thereby the bite mass (GONÇALVES et al., 2009a). Several studies showed the influence of pasture height on the ingestive behavior of cattle (BAGGIO et al., 2008; GIBB et al., 2008), sheep (BAUMONT et al., 2004; GONÇALVES et al., 2009b) and horses (NAUJECK; HILL; GIBB, 2005; FLEURANCE et al., 2009). According to these studies, animals maximize forage intake by selecting sites for grazing in which the pasture is taller than the average sward height. The results observed in this study demonstrate that goats follow the same sense in choosing grasses.

The preference of goats by the high-height Aruana or limpograss is related to the leaf mass observed in these treatments, which remained near (1281 kg and 1773 kg DM.ha^{-1}, respectively) the average leaf mass of the pasture (1335 kg DM.ha^{-1}). This fact can be explained by the increase in forage intake by ruminants in response to the increase of leaf mass on pasture (GONTIJO NETO et al., 2006), indicating that there was higher accessibility to the material of higher nutritional value (BRÂNCIO et al., 2003). The longest grazing time recorded in areas with higher forage mass and, consequently, with higher LA confirms that goats followed the same pattern of search, selection and intake of better quality forage under grazing conditions.

The animals remained for a greater period at taller pastures, with more forage and leaf masses but lower leaf:stem ratio (Table 1). This indicates that goats preferred areas with higher forage mass in order to maximize nutrient intake, which suggests that characteristics such as density and proportion of leaves and leaf:stem ratio had less relevance in the choice of areas to be grazed. According to Bazely (1990), animals grazing in such conditions would maximize their forage intake by selecting taller plants and keeping the nitrogen intake at appropriate levels when selecting darker plants. Those are indicatives of higher levels of nitrogen and soluble carbohydrates.

The distribution of the goats grazing activity within 24 hours followed the same pattern observed on other herbivores (cattle, sheep and horses) and it is characterized by intensive periods of grazing immediately after sunrise and before sunset, with short periods of nocturnal grazing (SILVA, 2006). This behavior was also described by Roda et al. (1995), who reported that goats graze more frequently in the morning until 11:00 and in the afternoon from 15:00 until dusk, and not showing interruptions during the hottest periods of the day, unlike sheep and cattle. Parente et al. (2005) evaluated the feeding behavior of Saanen goats grazing Tifton-85 pasture between 6:00 and 18:00 during the summer and observed well-defined peaks of grazing in the early morning and late afternoon, with intermediary periods during the hottest hours of the day, corroborating with the findings of this study.

The time spent by the goats on other activities (rest and rumination) were mainly carried out during night and late night. In fact, ruminating is a subsequent assignment to the most intensive periods of grazing, but it is performed more frequently during the night (SILVA, 2006).

Conclusion

Mature goats graze for longer periods in high--height swards with higher forage and leaf mass. The criteria of choice for pasture areas to be explored are based on these characteristics, under which goats sought to maximize the intake of high quality forage.

Grazing activity followed a similar pattern of other domestic herbivores (cattle, sheep and horses), but goats did not interrupt intake activity during the hottest hours of the day. The activities of rumination and rest occur for prolonged periods and with higher frequency during night and dawn.

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