



Ingestive behavior of sheep on Massai grass under different pre-grazing heights under rotational stocking

Comportamento ingestivo de ovinos em capim Massai sob diferentes alturas pré-pastejo sob lotação rotativa

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SUMMARY

This study aimed to assess the influence of three pre-grazing heights of Massai grass on the ingestive behavior of sheep under rotational stocking. Eighteen Dorper x nondescript crossbred sheep were used under rotational stocking on Massai grass at pre-grazing heights. The animal stocking was estimated to ensure a reduction of approximately 50% of the initial height. Behavior assessments were performed from 6 to 18 h at the entrance and exit of animals from paddocks. The longest activity was grazing, followed by rumination and other activities, and the period from 6 to 10 h showed the longest grazing. In the other periods, the animals in the 35-cm treatment grazed less when compared to those of the other treatments. Rumination in all treatments was more significant in the period from 14 to 18 h, but the animals in the 45-cm treatment spent more time doing this activity, which gave them a higher time of rumination of the food bolus, as well as ruminating chews. The bite rate was higher for the 25-cm treatment, followed by the 45 and 35-cm treatments, respectively.

Key words: *Megathyrus maximus*, *Panicum maximum*, ruminants

O objetivo foi avaliar a influência de três alturas pré-pastejo do capim Massai sobre o comportamento ingestivo de ovinos sob lotação rotativa. Foram utilizados 18 ovinos mestiços Dorper x sem padrão racial definido (SPRD) sob lotação rotativa em capim Massai nas alturas pré-pastejo de 45, 35 e 25 cm. A lotação animal foi estimada para garantir a redução de aproximadamente 50% da altura inicial. As avaliações de comportamento foram feitas das 6 às 18 h na entrada e na saída dos animais dos piquetes. A maior atividade de forma geral realizada foi a de pastejo, seguida de ruminação e outras atividades, sendo o período de 6 às 10 h o que apresentou maior atividade de pastejo. Nos demais períodos, os animais no tratamento com 35 cm pastejaram menos que os animais dos outros tratamentos. A ruminação, em todos os tratamentos, foi mais significativa no período das 14 às 18 h, mas os animais no tratamento com 45 cm foram os que passaram maior tempo realizando esta atividade. Os animais no tratamento com 45 cm apresentaram maior tempo de ruminação do bolo alimentar e maior número de mastigações meréricas. A taxa de bocados foi superior para o tratamento com 25 cm, seguido do com 45 e 35 cm respectivamente.

Palavras-chave: *Megathyrus maximus*, *Panicum maximum*, ruminantes

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INTRODUCTION

Massai grass is a suitable forage for livestock activity due to its productivity and structure. It also has important characteristics for its exploitation in the meat sheep, such as low size, soil fixation, high regrowth capacity, and tolerance to intense grazing (AMORIM et al., 2017; LEMPP et al., 2001; SAMPAIO et al., 2016). Besides choosing the appropriate forage, it is necessary to assess how sheep behave among pasture management possibilities by observing the animal reaction to established defoliation limits in order to assist in the adequate definition of pasture height management.

Animal behavior is modified according to the adopted defoliation strategy, resulting from the manipulation of pasture structure when pre- and post-grazing heights are established (ZANINI et al., 2012). The study of animal behavior on pasture allows a better understanding of the interaction between animal and plants and other factors that interfere with the search and feeding process (PIAZZETTA et al., 2009), which determine animal intake. It also makes possible to observe indications of improvements in pasture quality and cost reduction in order to

optimize management practices (SANTOS et al., 2011).

In this sense, this study aimed to assess the influence of three pre-grazing heights of Massai grass on the ingestive behavior of sheep under rotational stocking.

MATERIAL AND METHODS

The experiment was conducted at the Escola de Medicina Veterinária e Zootecnia (EMVZ) of the Federal University of Tocantins (UFT), campus of Araguaína, Tocantins, between February and April 2017, during the rainy season. The procedures used in this experiment were approved by the Ethics Committee on Animal Use of the Federal University of Tocantins (CEUA-UFT) under process nº 23101.002369/2014-28. The municipality of Araguaína is located in the northern region of the state of Tocantins, at the geographical coordinates 7°10'31" S and 48°20'28" W and 236 m of altitude. According to Köppen (1948), the regional climate is classified as Aw (warm and humid), with a mean temperature of 28 °C and mean annual precipitation of 1800 mm. The meteorological data during the experimental period are shown in Figure 1.

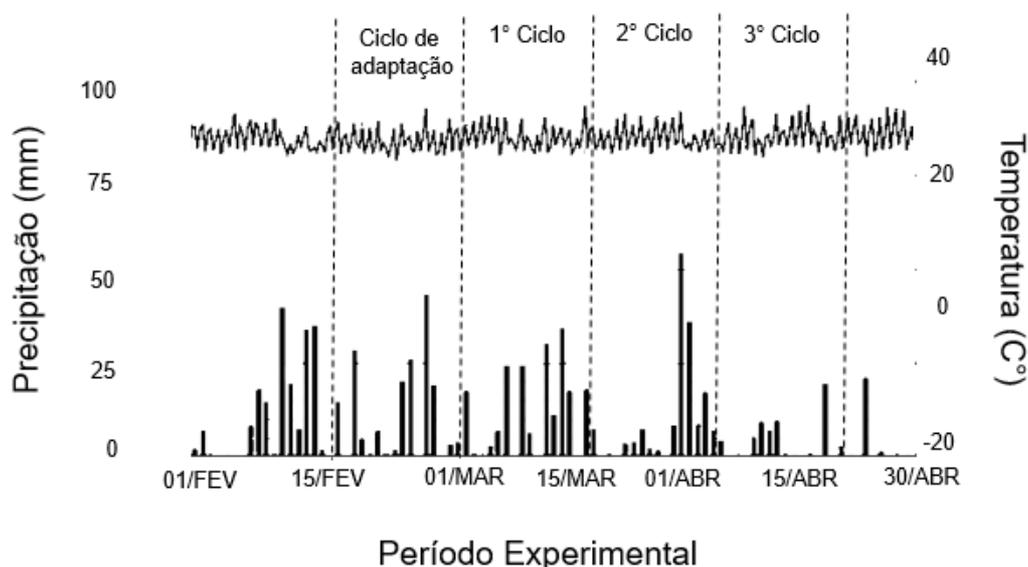


Figure 1. Daily data of precipitation (mm) and temperature (°C) in Araguaína, Tocantins, Brazil, during the experimental period, obtained from the Araguaína-A021 meteorological station (INMET, 2018).

Precipitation (mm); Temperature (°C); Experimental period. Adaptation cycle; 1st cycle; 2nd cycle; 3rd cycle. Feb.; Mar.; Apr.

The experiment was installed in an area of 4,816 m² already formed of Massai grass on a Typic Orthic Quartzarenic Neosol (EMBRAPA, 2013), located in the sheep sector of EMVZ/UFT.

The area was divided into 16 paddocks of 301 m². Four paddocks were used for each of the three treatments, where the rotational stocking method of animals was applied. Each paddock was fenced with screens for sheep to make sure the animals were maintained in the area until the post-grazing height was reached. Twelve paddocks were used to carry out four grazing cycles, the first of them being the adaptation cycle. Four paddocks were reserved and maintained at heights of 45 and 35 cm (two paddocks for each height) to be used if the experimental paddocks did not return to their initial

heights after the rest period. A reserve paddock was not used for the 25cm height because the adaptation cycle showed that the rest period was sufficient to return to the initial height. Each cycle was finished as soon as the sheep returned to the first paddock.

Initially, a standardization cut was carried out at 15 cm from the soil with a brushcutter at the first paddocks of each treatment. For the other paddocks, it was carried out every four days to avoid that all of them reached the defined heights at the same moment.

At two days after standardization cut, the area was fertilized using 250 kg Nha⁻¹ year⁻¹, 50 kg P₂O₅ ha⁻¹ year⁻¹, and 100 kg K₂O ha⁻¹ year⁻¹, considering seven months of rainy season in the year and using as sources urea, single

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superphosphate, and potassium chloride, respectively. N was divided into four parts and applied at the beginning of each grazing cycle (adaptation and experimental). Fertilizer doses were defined according to a previous experiment of nitrogen and potassium fertilization carried out in the area to ensure a mean yield of 5500.00 kg DMha⁻¹ of Massai grass (SILVA et al., 2017).

Eighteen Dorper x nondescript crossbred sheep (six females and twelve intact males), with a mean weight of 24 kg ± (4) and six months of age were tested. Sheep were previously identified with numbered earrings, weighted, dewormed, divided into groups with the same number of males and females to remove the effect of sex, and distributed in three treatments. The rotational stocking method with a fixed rest period of 12 days and 4 days of occupation was adopted. Before the entry of animals into the area, animal stocking was estimated to ensure a reduction of approximately 50% of the initial forage height. The rest time to be fixed was considered in this period, being enough for height recovery. It was possible because the experimental time was not long enough for great climate changes. Regulating animals, intact sheep, were used at plots of treatments that needed to remove more mass (45 and 35 cm) to standardize grazing periods. The stocking rate was defined during the adaptation period by considering the number of animals needed for each treatment.

Sheep were maintained on pasture during the day (between 6 and 18 h). After this period, the animals were taken to stalls separate by treatment to avoid predator attacks during the night, during which time no food was available. Whether on pasture or in stalls, animals had free

access to water and mineral mix (135 to 150 g kg⁻¹ Ca, 65 g kg⁻¹ P, 107 g kg⁻¹ Na, 12 g kg⁻¹ S, 30 g kg⁻¹ CP, 100 g kg⁻¹ TDN).

Forage canopy height was controlled during grazing and after the animals left the area until the beginning of the next cycle. The control was performed every two days by taking 20 measurements at random points at each paddock with a ruler in centimeters from the tiller base, close to the ground, to the midpoint of the highest canopy leaves.

Animal behavior was performed during the second and third assessment cycles at the entrance and exit of animals from paddocks, totaling four days of observation. Four trained observers carried out observations during 12 hours (6 to 18h), the time in which the animals were on pasture. The animals were painted with yellow and black spray paint depending on the animal color to facilitate visualization by evaluators. The variables were individually measured in the animals every ten minutes by recording the grazing, rumination, and other activities. Observations were extrapolated to minutes day⁻¹ and grouped into three periods of the day (6 to 10 h, 10 to 14h, and 14 to 18 h). The time spent for rumination of each food bolus, the time required to make ten bites, the bite rate (bites min⁻¹), and the number of ruminating chews (chews needed for rumination of each food bolus) were counted with a digital timer. Eight observations were carried out for each variable, i.e., four in the morning and four in the afternoon. The bite rate was considered as the time spent by the animals to perform 20 bites (PENNING & RUTTER, 2004).

The meteorological data were obtained in the assessment periods and overall mean

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at each day of behavior assessment (Table 1).

Table 1. Temperature, air humidity, radiation, and precipitation of behavior assessment days obtained from Araguaína-A021 meteorological station in Araguaína, TO (INMET, 2018)

Day	Temperature (°C)			Daily mean	Radiation (kJ m ⁻²)	Precipitation (mm)
	Mean	Minimum	Maximum			
03/16/17				25.9	815.1	11.0
6–10 h	23.1	22.9	23.4			
10–14 h	25.0	22.8	27.4			
14–18 h	29.5	26.9	31.3			
03/20/17				26.4	765.5	18.0
6–10 h	22.1	21.6	22.7			
10–14 h	27.9	22.1	31.7			
14–18 h	29.3	26.7	31.1			
04/17/17				25.9	527.3	0.4
6–10 h	22.5	22.1	23.1			
10–14 h	27.9	22.7	32.1			
14–18 h	27.2	26.9	28.0			
04/20/17				25.7	691.7	0.0
6–10 h	21.9	21.7	22.3			
10–14 h	24.7	22.1	27.3			
14–18 h	30.5	29.3	31.6			
Mean	22.4	26.4	29.1	25.9	699.9	
Total precipitation						29.4

The experimental design was a completely randomized design with six replications (animals) per treatment, repeated over time within the periods of the day. Statistical analyses were performed using the Statistical Analysis System (SAS, 1999), initially analyzing the normality (Shapiro-Wilk) and homoscedasticity (Levene) assumptions. The data were then submitted to analysis of variance and the Tukey's test, being considered significant values of probability lower than 5% ($P < 0.05$).

The adopted statistical model was:

$$Y_{ijk} = \mu + T_i + \gamma_i + P_j + (T \times P)_{ij} + \varepsilon_{ij}$$

where μ is the overall mean, T_i is the effect of the treatment i ($i = 45, 35, \text{ and } 25$ cm), P_j is the effect of period of day j ($j = 1, 2, \text{ and } 3$), $(T \times P)_{ij}$ is the effect of the treatment \times period interaction, and ε_{ij} is the random error corresponding to the observation Y_{ijk} .

RESULTS AND DISCUSSION

An interaction was observed between treatments and periods of the day for grazing and rumination times. For the other activities, a significant difference was observed for treatments and period of the day, separately (Table 2).



Table 2. Times of grazing, rumination, and other activities of sheep on Massai grass pasture as a function of pre-grazing heights. Mean of four days

Grazing (min)								
Pre-grazing height	Period			Mean	Pr> F			CV (%)
	6–10 h	10–14 h	14–18 h		T ¹	P ²	T × P ³	
45 cm	240Aa	240Aa	123Ab	201				
35 cm	240Aa	217Cb	90Bc	182	0.0003	<.0001	0.0026	16.92
25 cm	235Aa	230Ba	112Ab	192				
Mean	238	229	104					
Rumination (min)								
Pre-grazing height	Period			Mean	Pr> F			CV (%)
	6–10 h	10–14 h	14–18 h		T	P	T × P	
45 cm	0Ab	0Bb	65Aa	22				
35 cm	0Ab	17Aa	22Ba	13	0.0414	<.0001	<.0001	22.34
25 cm	3Ab	5Bb	15Ba	8				
Mean	1	8	31					
Other activities (min)								
Pre-grazing height	Period			Mean	Pr> F			CV (%)
	6–10 h	10–14 h	14–18 h		T	P	T × P	
45 cm	0	0	52	17B				
35 cm	0	7	127	45A	0.0119	<.0001	0.3630	21.25
25 cm	3	5	112	40A				
Mean	1c	3b	97a					

CV = coefficient of variation. ¹Treatments; ²Period of the day; ³Interaction between treatments and periods of the day. Means followed by different lowercase letters in the rows and uppercase letters in the columns differ from each other by the Tukey's test at 5% probability level.

Grazing was the predominant activity from 6 to 10 h and 10 to 14 h at the three canopy heights, which corresponded to 93% of the activities performed by the animals. In fact, most of sheep grazing activity occurs during the day (SIQUEIRA & FERNANDES, 2014) due to the diurnal management adopted during its evolutionary period to avoid predator attacks (POMPEU et al., 2009). Also, animals remained at rest and rumination at night, returning to grazing during the day, which would explain the predominance of this activity by the animals until 14 h.

Between 6 and 10 h, the grazing period was similar for the canopy heights of 25 to 45 cm. According to Lima et al. (2014), the main grazing moments begin

at dawn and, according to Pompeu et al. (2009), the behavior of ruminants on pasture is characterized by long periods of feeding, mainly in the early morning and late afternoon, decreasing other activities, such as rumination, in these periods. This behavior resembles that observed in this study since rumination was lower in the early morning, regardless of the treatment.

Grazing period varied between the three treatments from 10 to 14 h. Although still as a predominant activity, the longer time at the height of 45 cm may be associated with the beginning of selectivity. The intermediate time at the height of 25 cm is associated with the higher bite rate required for the food bolus formation (Table 3).



Table 3. Ingestive behavior of sheep on Massai grasspasture as a function of pre-grazing height. Mean of four days

Time to perform 10 bites (sec)							
Pre-grazing height	Period		Mean	Pr> F			CV (%)
	Entrance	Exit		T ¹	P ²	T x P ³	
45 cm	20.87	19.75	20.31B				
35 cm	25.62	24.37	25.99A	<.0001	0.1194	0.9742	11.35
25 cm	17.50	16.62	17.06C				
Mean	21.33	20.24					
Rumination of food bolus (sec)							
Pre-grazing height	Period		Mean	Pr> F			CV (%)
	Entrance	Exit		T	P	T x P	
45 cm	38.00	38.08	38.4A				
35 cm	23.62	22.98	23.28B	<.0001	1.0000	1.0000	21.12
25 cm	28.62	29.05	28.83B				
Mean	30.08	30.03					
Number of ruminating chews							
Pre-grazing height	Period		Mean	Pr> F			CV (%)
	Entrance	Exit		T	P	T x P	
45 cm	53.21	53.65	53.43A				
35 cm	36.25	36.76	36.50B	0.0002	1.0000	1.0000	23.55
25 cm	43.54	43.02	43.28B				
Mean	44.33	44.46					
Bite rates (bites min ⁻¹)							
Pre-grazing height	Period		Mean	Pr> F			CV (%)
	Entrance	Exit		T	P	T x P	
45 cm	29.25	30.87	30.06B				
35 cm	23.52	24.89	24.20C	<.0001	0.1676	0.9949	12.14
25 cm	34.85	36.28	35.55A				
Mean	29.20	30.68					

CV = coefficient of variation. ¹Treatments; ²Period of the grazing cycle; ³Interaction between treatments and periods of the grazing cycle. Means followed by different lowercase letters in the rows and uppercase letters in the columns differ from each other by the Tukey's test at 5% probability level.

In the period from 14 to 18 h, the animals in all treatments had a lower time of grazing. It is due to the satiation of animals at the end of the day, which is not associated with the mean, minimum, and maximum temperatures at this time, not exceeding the upper critical temperature of thermal comfort of animals (Table 1). According to Baêta and Souza (1997), the upper critical temperature of thermal comfort is up to 35 °C, corroborating with Oliveira et al. (2011), who assessed sheep on pasture in the semi-arid and observed

heat stress in animals when temperatures were close to 40 °C. Calviello et al. (2013) did not observe a reduction in sheep grazing activity even during the warmest time of the day when the thermal amplitude was from 21.88 to 34.60 °C. Animals from the treatment with a pre-grazing height of 35 cm showed a lower time of grazing in relation to the other treatments in the period from 10 to 18 h. It demonstrates that a lower time was required to meet the nutritional requirements of animals probably because



this height had lower fibrous material when compared to the height of 45 cm and higher mass availability when compared to the height of 25 cm, causing the animals of these treatments to graze for a longer time, even at warmer times.

The best structure and quality of the 35 cm treatment in relation to the 45 cm treatment allowed the animals to increase energy intake more quickly due to a lower rumen filling, using this time for rumination and other activities. Ruminants adapt to different feeding conditions by modifying their ingestion parameters to reach the level of intake needed to meet their requirements (HODGSON, 1990). In plants with higher heights, protein content is reduced because there is an increase in cell wall thickness and in the quantity of lignin with an increase of stem production, which is more difficult to be digested and used by animals (VALENTE et al. 2010). Macedo et al. (2015) observed an increased grazing time of goats as the height Marandu grass pasture increased. However, Dias et al. (2014) observed no correlation between feed digestibility and grazing times in steers. This modification in plant structure reported by the mentioned authors is related to the longer grazing time in the 45 cm treatment since there is a smaller apprehension of mass in the bite due to lower participation of leaves in plant composition, requiring that animals spend more time grazing.

There is a correlation between the increased grazing activity not only with a reduction in quality caused by excessive heights but also with a reduction in forage availability. Pacheco et al. (2013) observed an increased grazing time by cows on pasture when there was a reduction in both the quality and the quantity of supplied pasture. In the

present study, a longer grazing time was observed in the 25 cm treatment when compared to the 35 cm treatment in the periods from 10 to 14 h and 14 to 18h, as there was a higher competition for animals to preferentially select leaves, which are more nutritious. According to Sampaio et al. (2016), there is no correlation between grazing activity and intake since it is believed that this activity is associated with forage conditions. These authors, however, correlated the increase in this activity with a reduction in forage availability. According to them, animals can better select the most nutritious plant part when there is a higher forage availability, meeting their requirements more quickly.

Animals had a more significant rumination in the period from 14 to 18 h, especially those submitted to the 45cm treatment. According to Pacheco et al. (2013), this activity associated with grazing time implies a higher energy expenditure and, therefore, its increase is not desired. In a forage with higher height, i.e., with a higher amount of stem, animals need to spend more time ruminating the food due to a lower protein content and higher fiber content since the purpose of this activity is to reduce the particles of the consumed food (SAMPAIO et al., 2016) and favor the best use of the diet by buffering the rumen (DIAS et al., 2014).

As expected, the animals submitted to treatment with a pre-grazing height of 45 cm had less time for other activities since most of their time was used for food search. There is a correlation between foods with lower digestibility and lower nutritional contribution with a reduction in the time used for other activities (DIAS et al., 2014). In plants with higher heights, as in the 45cm treatment, higher

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production of structural material is observed and, therefore, more lignified material, which can also explain this result. Macedo et al. (2015) observed a reduction in the time of other activities in goats as pasture height increased.

The time to perform bites, rumination of food bolus, the number of ruminating chews, and the bite rate were modified according to canopy height ($P < 0.05$), with no interaction with the different periods of the day (Table 3).

The time required to perform the bites was lower in the pre-grazing height of 25 cm, followed by 45 cm. This value is inversely proportional to the bite rate and is associated with the lower forage mass available for food bolus formation.

Animals maintained on pasture with a height of 45 cm took more time to ruminate each food bolus and, consequently, increased the number of chews. Pastures with higher heights show a higher stem production due to a higher shading in the internal part of clumps (MACEDO et al., 2015), as previously mentioned. The lower amount of leaf mass in relation to the amount of stem mass damages pasture structure and causes effects on the ingestive behavior and grazing efficiency of the animal (DIM et al., 2015). In this sense, defoliations that maintain plants at heights higher to those of the suitable levels for the forage species are harmful to mass production and forage density, impairing food intake (FONTES et al., 2014).

The bite rate was higher for the 25 cm treatment, evidencing the lower mass density, forage availability, and bite depth at the lower height, increasing grazing time and decreasing intake. Roman et al. (2007) studied sheep on ryegrass pasture with different availabilities and observed

that the increased bite rate was the main strategy to increase the intake in relation to forage availability variation. For this treatment, the bite rate was higher when compared to that found by Pompeu et al. (2009), who observed a mean of 28 bites min^{-1} in sheep exclusively on Tanzania grass pasture, and Poliet et al. (2009), who verified 27.43 and 27.30 bites min^{-1} for lambs weaned and not weaned on Tifton 85 pasture, respectively.

An increased canopy height rises forage capture efficiency (MACEDO et al., 2015) and the bite rate is reduced with a higher forage availability since the animal manages to increase the bite depth and capture more mass (TEIXEIRA et al., 2011). It was observed in the pre-grazing height of 35 cm, which presented the lowest bite rate, while in the 45 cm treatment this rate was intermediate probably due to a higher stem quantity, which hinders the animal from achieving a higher bite depth when grazing. Pacheco et al. (2013) verified an increase in the bite rate of cows on pasture with higher participation of stems in the supplied forage and attributed this increase to a reduction in the bite depth by this structural plant part.

Among the tested pre-grazing heights, 35 cm pastures tended to interfere positively with sheep behavior, which had shorter grazing and rumination times, besides a reduced bite rate, with a possible reduction in the energy expenditure to carry out the activities. Managing pastures with heights higher or lower than 35 cm leads to energy losses and, consequently, a negative change in the grazing behavior of sheep.



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