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Ingestive behavior of crossbred heifers in four seasons related to the structure of stargrass pasture

Ludmila Lacerda Campana[1*], Elisa Cristina Modesto[1], Ana Carolina Carvalho de Barros[1], Pablo Gilliardi Zanella[2], Carlos Augusto Brandão de Carvalho[2] and Sérgio Traballi Camargo Filho[3]

*[1]Departamento de Produção Animal, Universidade Federal Rural do Rio de Janeiro, Instituto de Zootecnia. Rodovia BR-465, Km 7, 23890-000, Seropédica, Rio de Janeiro, Brazil. [2]Departamento de Nutrição Animal e Pastagem, Universidade Federal Rural do Rio de Janeiro, Seropédica, Rio de Janeiro, Brazil. [3]Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro, Rio de Janeiro, Rio de Janeiro, Brazil. *Author for correspondence. E-mail: lacerda.campana@gmail.com*

ABSTRACT. The ingestive behavior of crossbred heifers grazing on stargrass pasture was managed at two levels of light interception and two levels of post-grazing residual height. The experiment was conducted at Pesagro (Seropédica, Rio de Janeiro State) between April 2012 and January 2013. The grazing (GT), rumination (RT) and idling (IT) times were evaluated every 10 minutes throughout a 24-hour period. Forage samples were collected for the analysis of chemical composition and for leaf:stem ratio determination. Dry bulb, wet bulb and black globe temperatures were evaluated every hour along with the relative humidity, during grazing to characterize the environment and calculate the Black Globe Humidity Index (BGHI). The mean grazing time (6 hours) was inversely related to sward height. The rumination time was associated with lignin content, in autumn and spring. The mean idle time (9 hours) was related to the grazing time. Animals became tolerant to climatic variations, as GT, RT and IT showed no temporal variations. On the other hand, the sward structure and its chemical characteristics showed greater influence on the ingestive activities of cattle grazing on pasture.

Keywords: BGHI, *Cynodon nlemfuensis*, grazing, idling, morphological composition, rumination.

Comportamento ingestivo de novilhas mestiças nas quatro estações do ano e sua relação com a estrutura da pastagem de capim-estrela

RESUMO. Avaliou-se o comportamento ingestivo de novilhas mestiças em pastagem de capim-estrela manejada sob dois níveis de interceptação luminosa e duas alturas de resíduo pós-pastejo. O experimento foi conduzido na Pesagro (Seropédica, Rio de Janeiro State) entre abril/2012 a janeiro/2013. Os tempos de pastejo (P), ruminação (R) e ócio (O) foram avaliados a cada 10 min. durante um período de 24h. Amostras da forragem foram colhidas para análise da composição químico-bromatológica, e para determinação da relação folha:colmo. Temperaturas de bulbo seco, bulbo úmido, globo negro e a umidade relativa do ar foram medidas a cada hora durante o pastejo para caracterização do ambiente e cálculo do ITGU. O tempo médio de pastejo (6h) apresentou inversamente relacionado à altura do dossel. O tempo de ruminação esteve associado ao teor de lignina, no outono e na primavera. O tempo médio de ócio (9h) apresentou relação com o tempo de pastejo. Os animais mostraram-se tolerantes às variações climáticas, uma vez que os tempos de P, R e O não variaram com as estações do ano. Por outro lado, a estrutura da pastagem e suas características bromatológicas exerceram maior influência sobre as atividades ingestivas dos bovinos em pastejo.

Palavras-chave: ITGU, *Cynodon nlemfuensis*, pastejo, ócio, composição morfológica, ruminação

Introduction

Animal behavior can be defined as any and all types of action of an animal, whether perceptible or not, to the human sensory system (Lawrence, 2008), that occurs as a voluntary or involuntary pattern of action (Maggioni et al., 2009).

Throughout grazing behavior the animal shows characteristics of its pastoral environment. The knowledge of this behavior should be considered when searching increases in productivity and to ensure the health and longevity of animals (Fischer et al., 2002).

Ingestive activities of cattle are concentrated in discrete periods during the day, heterogeneously distributed over the circadian period (Fischer et al., 2002; Silva et al., 2008), and climate and feeding are some of the factors that affect the behavior of these animals (Grant & Albright, 1995). Another determining factor in the ingestive behavior of ruminants while grazing is the structure of the forage canopy, given the selectivity of these animals that prefer younger parts of the plants, such as the leaves, thereby making the ingestion process dependent on the forage characteristics (Maggioni et al., 2009).

The study of ingestion behavior in cattle while grazing is therefore necessary, as the knowledge of feeding habits enables the development of more adequate management to provide greater comfort to the animal to express its maximum potential and thereby increase production.

This study aimed to evaluate the ingestion behavior (grazing, rumination and idling times) of crossbred heifers on stargrass pasture managed at two levels of light interception and two levels of post-grazing residual height during the autumn, winter and spring of 2012 and summer 2013, in Baixada Fluminense, Rio de Janeiro State.

Material and methods

The experiment was conducted in the State Agricultural Research Center of Rio de Janeiro (Centro de Pesquisa da Empresa de Pesquisa Agropecuária do Estado do Rio de Janeiro/PESAGRO-RIO), in Seropédica, Rio de Janeiro State, from April 2012 through January 2013, covering all four seasons of the year. The climate in the region is the Aw type (Köppen & Geiger, 1928), with the dry season occurring from April to September and the hot and wet season from October to March. Geographical coordinates are 22°45' latitude South and 43°40' longitude West. Data of air temperature (°C), maximum temperature (T°, Max.), minimum temperature (T°, Min.) and rainfall (mm - Precip.) were collected during the experimental period in the Meteorological Station of Agrobiology Embrapa (Seropédica, Rio de Janeiro State), and are illustrated in Figure 1.

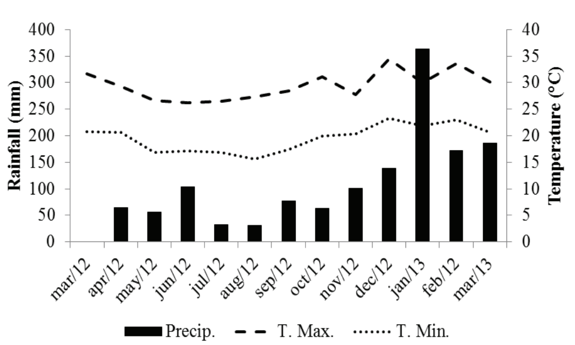

Figure 1. Annual rainfall (mm), annual maximum and minimum temperatures (°C) during the period from March 2012 to March 2013.

The experimental area consisted of 16 paddocks of 300 m² each, containing stargrass (*Cynodon nlemfuensis* cv. Florico) pasture, and a drinking fountain. No shade was provided in the paddocks. Grazing intervals corresponded to the period of time necessary for the forage canopy to reach 90 to 95% of incident light interception (LI) during regrowth.

Grazing intensity corresponded to residual heights from 20 to 30 cm, with treatments composed by the combination of both frequencies (90 and 95% of light interception in pre grazing) and two defoliation intensities (20 and 30 cm of height after grazing – residual height), arranged in a completely randomized block design in factorial arrangements (2 x 2) with four replications. In this way, the treatments were 90/20; 90/30; 95/20 and 95/30.

The lowering of paddock vegetation to the recommended residual was performed via direct grazing using Holstein *vs.* Gir crossbred heifers, with mean ages of 2.5 years and mean weight of 440 kg, simulating rotational grazing. The stocking rate for one day of lowering (24 hours) varied from 4 to 6 animals per paddock.

The estimation of the nutritive value of the pasture was performed by collecting samples through a hand plucking technique (Euclides et al., 1992) on the day of the animal entrance in the paddock, in all four treatments and simultaneously in their respective repetitions. The procedure was conducted in each season of the year totaling 64 samples: 16 per season (autumn, winter, spring and summer). From all collected samples, around 50% was taken for chemical composition analysis regarding the content of dry matter (DM), mineral matter (MM), crude protein (CP), indigestible neutral detergent fiber (NDF), indigestible acid detergent fiber (ADF), lignin and cellulose according to Silva & Queiroz (2002). The analysis was performed in the Animal Nutrition Laboratory of the Rural Federal University of Rio de Janeiro (Universidade Federal Rural do Rio de Janeiro).

To evaluate the ingestive behavior of animals, an evaluation by treatment (90/20, 90/30, 95/20 and 95/30) was made in each season of the year, with four repetitions for each treatment evaluated simultaneously, and two animals evaluated in each repetition (paddock), totaling 64 evaluations (16 per season). The observations of behavioral activities were made by trained observers through instantaneous sample collection or Scan, every 10 minutes over a 24-hour continuous period, as animals entered the paddock (Silva et al., 2006); each treatment (with 4 repetitions) therefore had a 24 hour evaluation period in each season. During the nocturnal period, artificial lighting was used to assist in the visualization of animals.

The mean grazing (G), ruminating (R), idling (I) and diverse activity (DA) times were evaluated for each paddock. Grazing time was considered as the period in which the animal was actively grasping or selecting forage. Rumination time was considered as the period in which the animal was not grazing, but re-chewing the cud (observed by the lateral movement of the mouth and the flow of food bolus via the esophagus). Idling time represented the period in which the animal did not make any activity. Times when water ingestion, walking and socialization, among others, occurred, were considered as diverse activities.

Bite rate (bites per minute) was also determined for one of these two animals, randomly chosen, at the time when the animal accessed the pasture for grazing and just before the animal was removed from the paddock (after 24 of occupation).

Data referring to the mean grazing, ruminating and idling times and the bite rate was subjected to analysis of variance and the means were compared by probability of difference ('PDIFF'), at a level of 5%. The analyses were run using SAS (2004) 9.0 software (Statistical Analysis System).

During the behavior evaluation period (24 hours), the environment was monitored by dry bulb (air temperatures - °C) (DBT), black globe (BBT - °C), and wet bulb (°C) temperatures, and the relative humidity of the air (RH - %), which were measured each hour using a portable WBGT (Wet Bulb Globe Temperature) Thermal Stress Measure – Model HT30, obtaining a mean value. The Black Globe-Humidity Index (BGHI) was also calculated using the formula $BGHI = Tg + 0.36\ Tpo + 41.5$ (Buffington et al., 1981), where Tg represents the black globe temperature in °C and Tpo the dew point temperature in °C to characterize the environment (Table 1).

Table 1. Mean dry bulb temperature (DBT), black globe temperature (BGT), relative humidity (RH) and Black Globe Humidity Index (BGHI) over 24 hours on the respective evaluation dates, from four treatments during the study period.

Season	Treatment	Date	DBT (°C)	BGT (°C)	RH (%)	BGHI
Autumn	90/20	8/5/2012	22.3	28.5	67.4	70.8
	90/30	24/4/2012	25.3	30.4	72.1	72.5
	95/20	18/5/2012	22.0	31.9	62.1	74.4
	95/30	18/5/2012	22.0	31.9	62.1	74.4
Winter	90/20	3/7/2012	24.1	30.6	62.8	73.3
	90/30	31/7/2012	22.6	31.9	69.4	73.7
	95/20	18/7/2012	18.1	18.8	79.8	60.6
	95/30	18/7/2012	18.1	18.8	79.8	60.6
Spring	90/20	12/12/2012	32.4	36.7	57.5	80.0
	90/30	22/11/2012	25.7	34.9	63.3	77.3
	95/20	6/12/2012	30.8	35.7	62.2	78.6
	95/30	13/12/2012	30.6	39.9	63.7	82.6
Summer	90/20	15/1/2013	26.8	32.8	73.5	75.0
	90/30	23/1/2013	31.4	51.5	68.7	79.6
	95/20	17/1/2013	28.1	35.0	71.2	77.2
	95/30	21/1/2013	24.1	28.2	77.6	70.2

Results and discussion

Data referring to the nutritive value of the forage, sward height and leaf:stem ratio during autumn, winter and spring of 2012 and summer 2013 are presented in Tables 2 to 5.

Table 2. Mean content of dry matter (DM), mineral matter (MM), crude protein (CP), insoluble neutral detergent fiber (NDF), insoluble acid detergent fiber (ADF), lignin and cellulose; leaf:stem ratio and height (cm) pasture average pre-grazing by the treatments during the fall of 2012.

Mean Content	Treatment				CV (%)
(%DM)	90/20	90/30	95/20	95/30	
DM	23.5c	27.8a	25.2b	26.5ab	18.2
MM	9.6ab	8.9b	9.8a	9.3ab	12.1
CP	13.9ab	13.4ab	14.9a	12.6b	25.1
NDF	73.9a	73.4a	73.9a	73.1a	5.3
ADF	34.7ab	33,8b	34.0b	35.4a	6.1
LIGNIN	4.6a	4.2ab	3.7b	4.3a	21.7
CELLULOSE	24.9a	24.5a	23.7b	24.5a	6.0
Height (cm)	53ab	51b	55a	55a	16.9
Leaf:Stem	1.2a	1.3a	1.1a	1.1a	456

Means followed by the same letter are not significantly different by the PDIFF at 5% probability.

Table 3. Mean content of dry matter (DM), mineral matter (MM), crude protein (CP), insoluble neutral detergent fiber (NDF), insoluble acid detergent fiber (ADF), lignin and cellulose; leaf:stem ratio and height (cm) pasture average pre-grazing by the treatments during the winter 2012.

Mean Content	Treatment				CV (%)
(%DM)	90/20	90/30	95/20	95/30	
DM	29.2b	34.6a	27.2c	28.3bc	18.2
MM	9.5c	10.3b	10.5ab	11.2a	12.1
CP	12.2a	9.8b	11.2ab	11.2ab	25.1
NDF	73.3b	73.7ab	74.9a	74.1ab	5.3
ADF	36.5a	35.4b	35.7b	35.3b	6.1
LIGNIN	5.0a	5.3a	4.8a	4.2b	21.7
CELLULOSE	26.2a	24.2b	24.6b	24.4b	6.0
Height (cm)	42b	37c	45a	43b	16.9
Leaf:Stem	1.3a	1.1ab	1.0b	1.2ab	45.6

Means followed by the same letter are not significantly different by the PDIFF at 5% probability.

Table 4. Mean content of dry matter (DM), mineral matter (MM), crude protein (CP), insoluble neutral detergent fiber (NDF), insoluble acid detergent fiber (ADF), lignin and cellulose; leaf:stem ratio and height (cm) pasture average pre-grazing by the treatments during the spring 2012.

Mean Content	Treatment				CV (%)
(%DM)	90/20	90/30	95/20	95/30	
DM	37,9a	30,6c	33,2b	37,3a	18,2
MM	9,0a	9,2a	9,5a	8,9a	12,1
CP	8,8b	11,0a	9,3b	8,7b	25,1
NDF	78,2a	76,6a	77,8a	78,4a	5,3
ADF	34,8a	33,4a	34,5a	35,1a	6,1
LIGNIN	5,3a	4,4b	4,6b	4,7b	21,7
CELLULOSE	25,4a	24,1a	24,6a	25,1a	6,0
Height (cm)	47b	41d	51a	44c	16,9
Leaf:Stem	0,9ab	1,2a	0,8b	0,8b	45,6

Means followed by the same letter are not significantly different by the PDIFF at 5% probability.

The grazing time (in minutes) varied according to the interaction between light interception and season ($p < 0.05$), with longer times occurring in the autumn and the winter (LI 90%). At 90% LI, the grazing time did not differ between the spring and the summer ($p > 0.05$). At 95% LI, the grazing time in the spring did not differ from any other season ($p > 0.05$; Table 6).

Table 5. Mean content of dry matter (DM), mineral matter (MM), crude protein (CP), insoluble neutral detergent fiber (NDF), insoluble acid detergent fiber (ADF), lignin and cellulose; leaf:stem ratio and height (cm) pasture average pre-grazing by the treatments during the summer 2013.

Mean Content (%DM)	Treatment				CV (%)
	90/20	90/30	95/20	95/30	
DM	23.4a	24.7a	24.3a	20.1b	18.2
MM	8.4a	7.6a	8.3a	7.9a	12.1
CP	18.3a	15.5c	16.3bc	17.3ab	25.1
NDF	63.8c	69.3b	71.5b	76.3a	5.3
ADF	28.7d	30.4c	34.9a	32.2b	6.1
LIGNIN	2.9bc	3.6a	3.2ab	2.5c	21.7
CELLULOSE	21.2c	22.0bc	24.6a	22.9b	6.0
Height (cm)	57c	62b	65a	64ab	16.9
Leaf:Stem	2.1b	1.9b	1.8b	3.0a	45.6

Means followed by the same letter are not significantly different by the PDIFF at 5% probability.

Table 6. Grazing time (minutes) according to light interception during the study period.

Season	Interception (%)	
	90	95
Autumn	434 aA	318 bB
Winter	424 aA	306 bB
Spring	360 aB	347 aAB
Summer	386 aAB	370 aA

Means followed by the same letter (lower case in rows and upper case in columns) are not significantly different by the PDIFF at 5% probability.

Pasture management at lower LI levels resulted in a lower pre-grazing height of the pasture (Tables 2 and 3). While 90% LI resulted in median pre-grazing pasture heights of 52 and 40 cm, 95% LI generated heights of 55 and 44 cm in the autumn and winter, respectively. Similar results were found by Gontijo Neto et al. (2006), where the grazing time (in hours) was negatively correlated with the canopy height.

Comparing the two LI levels (90 and 95%), grazing time presented an inverse trend with the longer times occurring in autumn, winter and summer at LI levels of 90%, and in spring and summer at 90% LI (Table 6). The longer grazing time for 90% LI in autumn can be related to the lower bite rate found for this interception compared with 95% (17 and 21 bites per minute, respectively); the same occurred in spring, where 95% LI presented a lower bite rate (19 bites per minute) compared to the 90% LI (24 bites per minute). In winter, taking into consideration that the activities of the animals are mutually exclusive (Costa et al., 2003), this result can be related to the shorter time spent in rumination for the 90% LI treatment compared to the 95% LI treatment (416 and 455 minutes, respectively; Table 8).

Longer grazing times were also registered for the 30 cm residual height in autumn and winter (427 and 414 minutes, respectively), when compared to the 20 cm residual height (Table 7).

Table 7. Grazing time (minutes) according to the residual height during the study period.

Season	Residual (cm)	
	20	30
Autumn	325 bA	427 aA
Winter	316 bA	414 aAB
Spring	339 aA	368 aB
Summer	360 aA	396 aAB

Means followed by the same letter (lower case in rows and upper case in columns) are not significantly different by the PDIFF at 5% probability.

A similar situation was observed by Manzano et al. (2007), in which the grazing time was inversely related to the grazing intensity. According to Crowder & Chheda (1982), the grazing time reflects the ease of grasping and taking the forage, and in situations where the animal is forced to graze strata where stem and senescent material is dominant, a reduction in the feeding time (Chacon & Stobbs, 1976) and the bite rate (Trindade, Silva & Carvalho et al., 2009) is generally observed. In autumn, the bite rate did not differ between the two residual heights ($p < 0.05$), while in winter, the 30 cm residual presented a greater number of bites per minute compared to the 20 cm residual height (22 and 15 bites per minute, respectively).

In addition, the 90/30 treatment in winter led to a lower pre-grazing height than the other treatments (Table 3). According to Trevisan et al. (2004), the animals are obliged to increase the number of bites under low biomass situations in order to optimize the consumption of forage, thus increasing the grazing time (Olivo et al., 2006).

In spring and summer, the time destined for grazing did not differ between the two frequencies (90 and 95% LI) and the two grazing intensities (20 and 30 cm residual heights) ($p > 0.05$). There was no isolate effect of season on grazing time ($p > 0.05$), which presented a mean of 368 minutes (6.08 hours); this value is within the expected range for cattle kept on pasture, which spend 359 to 720 minutes per day in feeding (Hodgson, 1990; Krysl & Hess, 1993).

An effect was detected for the interaction between LI, residual height and season on the rumination time (minutes) ($p < 0.05$), with the highest values occurring in the 90/20, 90/30 and 95/30 treatments in autumn and spring (Table 8).

According to Van Soest (1994), rumination time is influenced by the nature of the diet and is probably proportional to the level of cell wall in the diet mass. In autumn, the NDF levels did not differ between the treatments. The 95/20 treatment was however among those that presented low ADF and lignin values, as well as presented a low cellulose value (Table 2), which probably resulted in a lower time spent ruminating. In spring, although the NDF and ADF levels did not differ between the treatments, the 95/20 treatment was among those that presented lower contents of lignin (Table 4).

Table 8. Rumination time (minutes) according to the light interception and residual height during the study period.

Season	LI 90%		LI 95%	
	20 cm	30 cm	20 cm	30 cm
Autumn	471a	434ab	408b	436ab
Winter	409a	424a	468a	443a
Spring	425a	453a	379b	465a
Summer	393a	453a	461a	456a

Means followed by the same letter are not significantly different by the PDIFF at 5% probability.

The mean time spent ruminating did not differ between the seasons, presenting a mean of 436 minutes or 7.16 hours. Rumination activity in adult animals takes around 8 hours per day with variations from 4 to 9 hours (Van Soest, 1994), divided into periods which can take minutes or less than one hour (Damasceno, Baccari Júnior & Targa, 1999).

Idling time did not vary between seasons ($p > 0.05$), presenting a mean of 567 minutes or 9.45 hours. There was, however, an effect of LI on the idling time ($p < 0.05$), with 95% LI yielding longer times than 90% LI (595 and 539 minutes, respectively); there was also an effect of residual height ($p < 0.05$), with idling time longer with 20 cm residuals than with 30 cm residuals (610 and 525 minutes, respectively).

Time destined for idling varies according to the circadian cycle of the species and is related to the grazing and rumination behavior (Ortêncio Filho et al., 2001). According to Costa et al. (2003), the behavioral activities of animals are mutually exclusive, and one activity compensates another. Rumination time did not differ between the two light interceptions (IL) and the two residual heights ($p < 0.05$); grazing time meanwhile was longer at 90% LI (Table 6) and at a residual height of 30 cm (Table 7), leading to a shorter idling time in these situations.

The time destined for diverse activities (DA) was not affected by the treatments ($p < 0.05$), with a mean of 68.5 minutes.

Although the temperatures and the BGHI were observed to vary over the seasons (Figure 1 and Table 1), the times destined for grazing, rumination and idling did not vary between the seasons. It is believed that the animals evaluated in the experiment had a certain degree of acclimation, as they had originated from herds originally introduced to the region in 1949, so that a standard distribution of activities could be maintained regardless of the high temperatures, low rainfall and conditions that did not favor animal comfort.

According to Galina et al. (2001), animals maintained in tropical environments for a long time almost always develop sufficient adaptation, so that their reactions to environmental variation are different from before. In addition, crossbred cows are more adapted to tropical conditions, presenting critical values of air temperature and BGHI, more so than those animals from temperate climates (Azevedo et al., 2005).

Conclusion

The ingestion behavior of cows was shown to be more influenced by the pasture management of stargrass and, consequently, its structure and bromatology, than by the climatic characteristics, especially ambient temperature and Black Globe-Humidity Index (BGHI), due to the tolerance of the animals to environmental characteristics found in the area.

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