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INGESTIVE BEHAVIOR AND PHYSIOLOGICAL RESPONSES OF NELLORE IN DIFFERENT GRAZING CONDITIONS

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ABSTRACT

This study aimed to evaluate the ingestive behavior and physiological responses of steers under different grazing conditions. Five Nellore steers, weighing an average of 390.78 ± 14 kg BW, were assigned to five experimental treatments: clean pasture without concentrate supplementation (CP), dirty pasture without concentrate supplementation (DP), clean pasture with concentrate supplementation (CPWC) dirty pasture with concentrate supplementation (DPWC) and free access to pasture without concentrate supplementation (FA). The experimental design was a 5 x 5 Latin Square. The grazing behavior was measured through visual observation at the end of each trial in ten-minute intervals for 24 hours, and the physiological variables comprised rectal temperature, respiratory rate and heart rate. The physiological responses of animals were not affected by treatments. The number of steps performed by the animals kept in treatments CP (6.08 steps/min) and CPWC (5.62 steps/min) were significantly lower than those in treatments DP (16.84 steps/min) and DPWC (14.58 steps/min), showing increased activity of locomotion in animals in paddocks with invasive plants.

KEYWORDS: heart rate; locomotion; pasture; invasive plants.

COMPORTAMENTO INGESTIVO E RESPOSTAS FISIOLÓGICAS DE NOVILHOS NELORE EM DIFERENTES CONDIÇÕES DE PASTEJO

RESUMO

Este trabalho teve o objetivo de avaliar o comportamento ingestivo e respostas fisiológicas de novilhos Nelore em diferentes condições de pastejo. Foram utilizados cinco novilhos da raça Nelore pesando em média 390,78 ± 14 kg de PV, distribuídos em cinco tratamentos experimentais: pasto limpo sem fornecimento de suplemento concentrado (PLSC), pasto sujo sem fornecimento de suplemento concentrado (PSSC), pasto limpo com fornecimento de suplemento concentrado (PLCC), pasto sujo com fornecimento de suplemento concentrado (PSCC) e livre acesso aos pastos sem fornecimento de suplemento concentrado (LAPSC). Utilizou-se delineamento experimental em quadrado latino 5 x 5. O comportamento ingestivo dos animais foi mensurado por meio de observação visual no final de cada período experimental em intervalos de dez minutos, durante 24 horas, e as variáveis fisiológicas avaliadas foram temperatura retal, frequência respiratória e frequência cardíaca. As respostas fisiológicas dos animais não foram influenciadas pelos tratamentos. O número de passos realizados pelos animais mantidos nos tratamentos PLSC (6,08 passos/min) e PLCC (5,62 passos/min) foram significativamente menores que nos tratamentos PSSC (16,84 passos/min) e PSCC (14,58 passos/min), demonstrando maior atividade de locomoção nos animais nos piquetes com invasoras.

PALAVRAS-CHAVE: frequência cardíaca; invasoras; locomoção; pastagens.

INTRODUCTION

Raising cattle on pasture is a system characterized by a number of factors whose interactions may affect ingestive behavior, compromising animals´ performance and, thus, the viability of the farm (PARDO et al., 2003). According to PALHANO et al. (2007), the daily intake of forage is the central aspect to a greater understanding of the behavior of grazing animals, directly influenced by factors related to the forage plant and the animal.

The ingestive behavior of grazing ruminants can be characterized by uneven distribution of a succession of defined and discrete activity periods, commonly referred to as ingestion, rumination and rest (FISCHER et al., 2000). The animal´s ability of ingesting food depends on the action of factors which interact in different situations of feeding, animal behavior and environment.

The study of the ingestive behavior of ruminants allows the adjustment of management practices that will increase productivity, besides ensuring better health status and longevity to animals (FISCHER et al., 2002). Another relevant factor is the assistance provided by the results of studies about the feeding behavior of ruminants, regarding the understanding of how animals adjust this behavior as a function of variations in the pasture and the environment (BRÂNCIO et al., 2003).

Animal production on pasture depends on factors related to the plant and the animal; therefore, the amount and the way forage is provided to the animal determine different responses in consumption and performance. The grazing animal is under the influence of many factors that may affect forage intake, among which stands out the opportunity to select the diet, because the selective grazing compensates low quality forage, allowing the intake of more nutritious parts of the plants (SILVA et al., 2009). However, the selective behavior promotes an increase in grazing total time.

This study was conducted to evaluate changes in physiological and behavioral responses of Nellore cattle kept under different grazing conditions.

MATERIAL AND METHODS

The experiment was conducted in the city of Céu Azul, located in the western region of the State of Paraná, at latitude 24º57'21" south and longitude 53º27'19" west. The experimental area consisted of five paddocks with approximately one hectare each. In the period before the carry-out of the experiment, we performed weed control in two pasture paddocks, partial control in one paddock, allowing the infestation in half of the experimental area, and no control in the other two paddocks.

The animals were kept on native pasture, mainly *Paspalum notatum Fluegge*, maintained with the minimum canopy height of five centimeters. The main invase plants observed during the experimental period were *Mimosa Invisa* Mart, *Vernonia* sp., *Sida rhombifolia, Bidens pilosa* / *Galinsoga parviflora, Emilia sonchifolia, Asclepias bicolor Moench., Ziziphus joazeiro Mart.*

We used five Nellore steers, weighing an average of 390.78 ± 14 kg BW, divided into five experimental treatments: provision of clean pasture without concentrate supplementation (CP); dirty pasture without concentrate supplementation (DP); clean pasture with concentrate supplementation (CPWC); dirty pasture with concentrate supplementation (DPWC); and free access to pastures without concentrate supplementation (FA). The amount of concentrate fed to each animal was 0.5% BW / day, offered twice a day at 8:00 a.m. and 1:30 p.m. in covered troughs within their paddock. The animals were weighed at the beginning and end of each experimental period to adequate the diet.

We used a 5 x 5 Latin square design, each period lasting 12 days, being ten days for adaptation to diet and artificial lighting, and the two last days for data collection. The physiological variables were collected on the 11^{th} day and the ingestive behavior assessed on the 12^{th} day. We evaluated the grazing behavior by visual observation at the end of each experimental period, each ten minutes for 24 hours, to determine the time spent eating, ruminating and resting (JOOHNSON & COMBS, 1991).

The data of wind speed, dew point temperature, air temperature and relative humidity were collected by a thermo-anemometer and radiant heat was recorded using the Vernon globe (diameter 0.15 m) exposed to sun. The climatic variables were collected twice a week at one-hour intervals, during 24 hours. From the data of temperature and humidity, we calculated the temperature and humidity index (THI) by the formula by KELLY & BOND (1971):

$$THI = dbT - 0.55(1 - RH)(dbT - 58)$$

(Equation 1)

Where

dbT = dry-bulb temperature (^{o}F)

RH = relative humidity, expressed as decimal value

We interpreted THI data according to AZEVEDO et al. (2005), wherein: THI below 70 represents absence of stress; between 70 and 72, alert, reaching the critical level; between 72 and 78, above the critical level; between 78 to 82, danger; and higher than 82, emergency. Thermal radiation is an important environmental factor, whose value increases when the animals are kept in grazing. Thus we calculated the temperature and humidity index of the globe (GTHI), from data of Vernon´s globe temperature (ºC) and dew point temperature, using the formula by BUFFINGTON et al. (1981):

$$GTHI = Tg + 0.36Tdp + 41.5$$

(Equation 2)

wherein:

Tg = Vernon´s globe temperature, ºC

Tdp = dew point temperature.

Rectal temperature (RT) was measured individually by means of a digital thermometer. One single person measured the heart rate (HR) of all animals using a stethoscope, at the left side of the animal, close to xiphoid bone by counting beats for 15 seconds and multiplying the value by four. The respiratory rate (RR) was obtained by counting the movements of the flank of the animals with the aid of a timer for a period of 10 seconds, and multiplying the result by six to obtain the rate per minutes. The variables were submitted to analysis of variance and means were compared by Student Newman Keulls (SNK) at 5% probability using the program SAEG 9.1 - Analysis System Statistics and Genetics (UFV, 2007).

RESULTS AND DISCUSSION

The average air temperature during the experiment was 23.39 ºC, with a maximum of 30.5 ºC and minimum of 16.4 °C. The relative humidity of the air ranged between 88% and 35%. The minimum relative humidity coincided with the maximum black globe temperature, which may indicate an inverse relationship between the load of radiant energy of the environment and the humidity levels of the air. We observed THI values of 71 and 78, within the critical range for cattle, during most of the trial period (10:00 a.m. to 9:00 p.m.), indicating that during these critical hours the animals were subjected to heat stress. According to SILVA et al. (2008), the THI has been widely used to evaluate environments for cattle raising in tropical regions, and when the index presents critical values of the environment, the animal behavior and production is jeopardized.

According to BAETA & SOUZA (2010), GTHI values up to 74 indicate a thermal comfort condition for Nellore cattle; values between 75 and 78 indicate an alert situation; values between 79 and 84 represent danger, and above that, emergency. GTHI values were observed over the range of danger (emergency), between 08:00 a.m. and 5:00 p.m., reaching a maximum value of 94.40. However, similarly to ITU results, the animals showed thermal discomfort in times of emergency, seeking shade to avoid direct sunlight. At subsequent moments, GTHI values remained below alert levels.

The mean rectal temperature (RT), heart rate (HR) and respiratory rate (RR) of animals are described in Table 1.

The increase in respiratory rate and panting are important physiological mechanisms for heat dissipation in this species. However, these mechanisms require energy, resulting in the increase in daily maintenance of bovine animals from 7 to 25%, which also results in heat production (COLUMBIANO, 2007). As a defense against thermal discomfort, bovine animals use physiological adaptive mechanisms of body heat loss to try to avoid hyperthermia. Thus, they increase the respiratory rate presenting tachypnea, in addition to the increase in sweating rate, constituting both important means of body heat loss by evaporation. Under normal temperature conditions, crossbred cows exhibit respiratory rate about 18-28 movements per minute, from 26 °C on, the movements increase. At temperatures of 31 ºC, they present an average of 68 movements per minute. Up to 60 movements, the animals do not show signs of stress yet. When respiratory rate exceeds 120 movements, it shows excessive heat load, and above 160 it is necessary to adopt emergency measures (BACCARI, 2001).

TABLE 1 - Mean values of rectal temperature (RT), heart rate (HR) and respiratory rate (RR)

Treatments	RT (ºC)	HR (bat/min)	RR (mov./min)
CP	37.80	122.00	47.50
DP	38.10	124.00	48.40
CPWC	37.90	130.00	42.00
DPWC	38.10	131.00	43.50
FA	37.90	126.00	45.40
CV (%)	0.58	7.84	22.40

CP - clean pasture without concentrate supplementation
DP - dirty pasture without concentrate supplementation
CPWC - clean pasture with concentrate supplementation
DPWC - dirty pasture with concentrate supplementation
FA - free access to pastures without concentrate supplementation

The average values of heart and respiratory rate (126 beats/minute and 45.36 movements/minute, respectively) were not affected by treatments. Table 2 shows the data about feeding time (FT), rumination time (RumT), resting time (ResT), water ingestion

time (WT), rumination time in standing and lying positions, resting time in standing and lying positions, number of daily meals (Nm) and number of rumination periods (Nrp), with the respective coefficients of variation for the different treatments.

No significant differences were observed for feeding, resting and water times, with averages of 9.03; 6.17 and 0.50 hours/day, respectively. Despite the time spent in resting did not vary within treatments, animals kept in grazing without weed control showed a numerically smaller value of resting, probably because of the increase in time spent searching for food. Resting time with the animal in standing and lying positions occurred, respectively, mostly during the day and in the evening.

TABLE 2. Behavioral variables relative to different treatments

Variables	Treatments					VC (%)
	PC	DP	CPWC	DPWC	FA	
FT (h/day)	9.2	9.1	9.1	8.7	9.03	7.21
RumT (h/day)	7.60^{b}	8.60^{a}	7.80^{b}	8.90^{a}	8.39^{ab}	5.52
ResT (h/day)	6.8	5.6	6.6	5.7	6.14	11.24
WT (h/day)	0.5	0.49	0.51	0.5	0.51	1.32
RumT standing (h/day)	0.82	1.01	0.8	1.03	0.91	22.12
RumT lying (h/day)	6.81^{c}	7.84^{a}	7.09^{bc}	7.95^{a}	7.46^{ab}	5.21
ResT standing (h/day)	2.56^{a}	1.12^{c}	1.99^{b}	1.09^{c}	2.33^{a}	26.76
ResT lying (h/day)	4.38^{b}	4.63^{b}	4.71^{a}	4.49^{b}	3.78^{c}	20.85
Nrp (n./day)	8.75	8.5	11.5	8.25	9.24	20.37
Nrp (n./day)	15.25	13.75	13.75	12.52	13.63	10.91

Means followed by different letters in the row differ ($p < .05$) by the Student-Newman-Keuls test.
CP - clean pasture without concentrate supplementation
DP - dirty pasture without concentrate supplementation
CPWC - clean pasture with concentrate supplementation
DPWC - dirty pasture with concentrate supplementation
FA - free access to pastures without concentrate supplementation

BRÂNCIO et al. (2003) evaluated the ingestive behavior of Nellore calves with 150 kg of body weight, on Tanzania grass pasture, with and without fertilizer, and reported cattle grazing times, on average, between 8.3 and 11.3 hours per day. ZANINE et al. (2007) observed that calves grazed longer in the early morning and late afternoon, on *Brachiaria brizantha* pasture

Rumination time was significantly greater for animals kept in paddocks with the presence of invasive plants with and without concentrate supplementation, with values of 8.60 and 8.90 hours/day, respectively, when compared with animals in clean paddocks (7.60 and 7.80 hours/day, respectively). MENDONÇA et al. (2004) reported similar values, with an average of 7.71 hours/day. Rumination occurred mainly with the animal lying in all treatments, with longer times for DPWC and DP treatments, with values of 7.95 and 7.84 hours/day, respectively, and the shortest time for the CP treatment, with an average of 6.81 hours/day.

The number (N.) of meals and number of rumination periods were not affected by treatments, with average values of 9.25 and 13.78 N./day, respectively. BURGUER et al. (2000), working with diets with increasing levels of concentrate, observed a greater number of meals, with an average of 14.80. The highest time spent for food consumption (83.42% of the total consumption of food daily) was recorded between 8:00 a.m. and 8:00 p.m. (FIGURE 1). A meal is defined by a long grazing sequence. When it is interrupted for several minutes, the earlier meal is established, and the next one starts as soon as the animal begins a new grazing sequence.

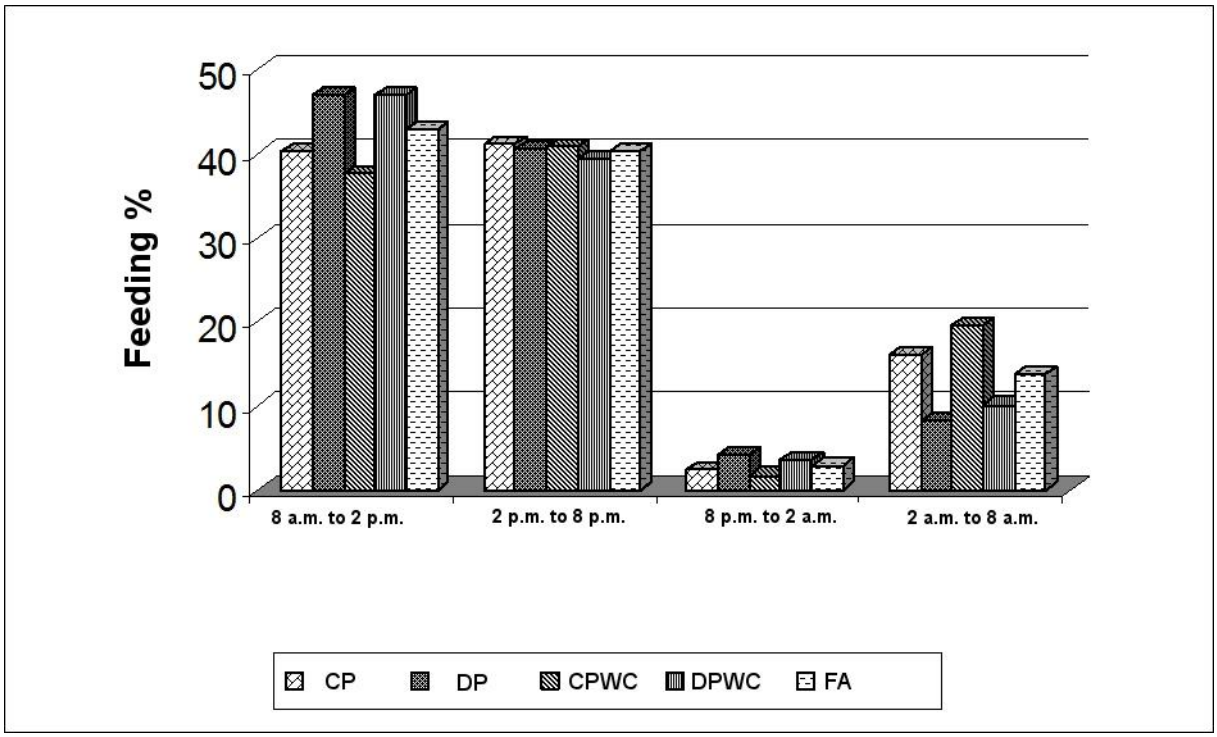

FIGURE 1. Ingestive behavior pattern of daily feeding time, for each treatment, relative to four periods of 6 hours.

CP - clean pasture without concentrate supplementation

DP - dirty pasture without concentrate supplementation

CPWC - clean pasture with concentrate supplementation

DPWC - dirty pasture with concentrate supplementation

FA - free access to pastures without concentrate supplementation

Food intake time from 8:00 p.m. to 8:00 a.m. was only 16.58%, and rumination occurred mainly at night, when temperature was cooler, around 19.9 °C, with 80.86% of rumination occurring between 8:00 p.m. to 8:00 a.m. BALOCCHI et al. (2002) used 12 bovine animals to evaluate supplementation with two types of concentrate (beet pulp and cereal) on grazing time, rumination time and time for other activities, besides pasture intake and total dry matter intake. Supplementation altered grazing behavior, reducing total and daytime grazing; increased daytime and decreased nighttime rumination, and decreased the number of bites. There was no difference among types of concentrate. Total dry matter intake increased and pasture intake decreased with supplementation, without differences between concentrates.

The daily pattern of rumination activity (FIGURE 2) showed high levels 10 hours after the feeding supply (8:00 p.m. to 2:00 a.m.), and remained fully active for 12 hours thereafter.

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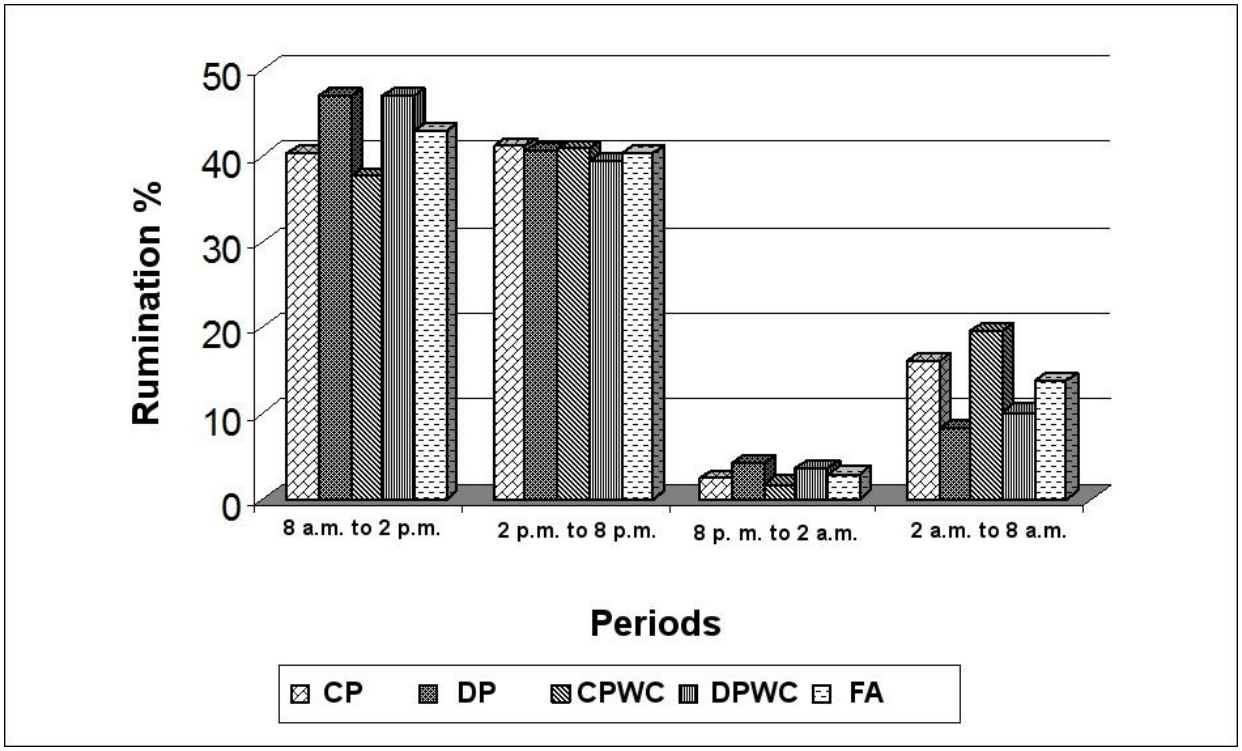

FIGURE 2. Ingestive behavior pattern of time daily rumination, for each treatment, relative to four periods of 6 hours.
CP - clean pasture without concentrate supplementation
DP - dirty pasture without concentrate supplementation
CPWC - clean pasture with concentrate supplementation
DPWC - dirty pasture with concentrate supplementation
FA - free access to pastures without concentrate supplementation

We noticed a variation in rumination position of animals during day and night. Overnight, animals are in lying position during 87.69% of rumination, which may be related to the greater thermal comfort during the period. During the day, 74.17% of rumination occurs on standing position, probably due to the higher ambient temperature and increased social activities of animals. Resting was defined by the time when the animals were not consuming food, drinking water or chewing. The time spent in resting was similar for all treatments, without statistical differences. However, we observed a behavioral pattern for all these treatments, in which resting was similar between 8 p.m. to 2 a.m. and the longest time spent in resting (41.24%) in the period from 2 a.m. to 8 a.m. This behavioral pattern may be due to the fact that animals rest mainly at this time of day. In the period from 2 a.m. to 8 a.m. the animals remained 46.68% of the time lying. During the day, resting occurred mostly with the animals standing, probably due to evolutionary factors, because the animals remain on alert against predators while searching for food.

Bovines tend to minimize grazing time as a strategy for forage intake, and this may be an evolutionary heritage, since that would also work as a strategy to escape predation (RUTTER et al., 2002). ZANINE et al. (2007) studied calves and verified that the longest rumination time occurred at the beginning and end of the night.

Water consumption occurred during the day, the period of greatest food intake and higher ambient temperature. Any water intake was observed during the night. The number of sites per minute and the number of steps per minute (TABLE 3) were affected ($P < 0.05$) by the presence of invasive plants.

TABLE 3 - Mean values of the number of grazing sites (N. site/min), number of bites (N. bites /min) and number of steps (N. steps/min) for each treatment

Treatment	N. site/min	N. bites /min	N. steps/min
CP	2.84[a]	27.36	6.08[a]
DP	4.24[b]	23.52	16.84[b]
CPWC	2.76[a]	24.23	5.62[a]
DPWC	5.32[b]	23.44	14.58[b]
FR	2.57[a]	24.11	7.89[a]
VC (%)	15.13	6.84	16.21

Means followed by different letters in column differ ($p < 0.05$) by Tukey test.
CP - clean pasture without concentrate supplementation
DP - dirty pasture without concentrate supplementation
CPWC - clean pasture with concentrate supplementation
DPWC - dirty pasture with concentrate supplementation
FA - free access to pastures without concentrate supplementation

In treatments in which the animals were kept on clean pasture (without invasive plants), CP and CPWC, the number of grazing per minute was 2.84 and 2.76, respectively, lower values than those observed for animals kept on dirty pasture (with invasive plants), DP (4.24) and DPWC (5.32). Animals kept in paddocks with invasive plants move around more often in search of food than animals kept in clean paddocks, probably due to the high pasture contamination by invasive plants that hindered grazing. This greater mobility for feed intake in dirty paddock is observed when comparing the number of steps per minute.

In clean paddocks, CP and CPWC, the number of steps per minute was 6.08 and 5.62, respectively; while for treatments DP and DPWV presented values of 16.84 and 14.58, respectively. These results show that animals kept in paddocks with invasive plants need to move around more often than animals kept in clean paddocks, which can require more energy for moving, reducing animal productivity.

CONCLUSION

No significant differences were observed for feeding, resting and water intake times. Rumination occurred mostly with the animal lying in all treatments, with longer times for treatments and DPWC and DP.

Resting time during the day and at night occurred mainly with the animals in standing and lying positions, respectively. The time spent in resting was similar for all treatments, without statistical differences, but there was a behavior pattern in which the resting activity was similar for the periods between 8 a.m. and 2p.m. and longer for the period between 2 a.m. to 8 a.m.

During the day, resting occurred mostly with the animal standing, probably due to evolutionary factors, since the animals remain on alert against predators while searching for food.

Animals kept in clean paddocks, CP and CPWC, showed less number of steps per minute compared with animals in treatments DP and DPWC. These results demonstrate that animals kept in paddocks with invasive plants need to move around more often than animals kept in clean paddocks, which can lead to a higher energy request, reducing animal productivity.

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