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Diurnal ingestive behavior of Holstein calves reared in different systems: feedlot or pasture

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ABSTRACT. This study evaluated the ingestive behavior of Hostein calves kept in two husbandry systems: feedlot or pasture. We examined the ingestive behavior of 11 male non-castrated calves, with average initial age of 75 days, six of which were individually penned, consuming corn silage and concentrate-based diet at a ratio of 40:60 (on a DM basis), and the remainder, on pearl millet pasture (*Pennisetum americanum*) receiving concentrate supplementation at 1.0% body weight. Evaluations were held from November to February, from 8:00 am to 6:00 pm. Feedlot calves stay longer ($p < 0.05$) in idle, both in lying and standing positions, while animals on pasture spent more time in eating and ruminating activities. Confined animals performed a higher number of daily meals, but of shorter duration each. In both production systems, rumination activity is preferably performed in lying position, however, rumination time in standing position is about 1.4 times longer for those kept on pasture. Animals kept on pasture show a lower efficiency of DM intake, greater number of ruminated boluses, which were ruminated for less time and with fewer cud chewings.

Keywords: ingestive efficiency, idleness, rumination, calves.

Comportamento ingestivo diurno de bezerros Holandeses criados em diferentes sistemas: confinamento ou a pasto

RESUMO. Objetivou-se avaliar o comportamento ingestivo de bezerros Holandeses mantidos em dois sistemas de criação: confinamento ou a pasto. Foi observado o comportamento ingestivo de 11 bezerros machos, não castrados, com idade média inicial de 75 dias, sendo que seis foram confinados individualmente, consumindo dieta a base de silagem de milho e concentrado na proporção de 40:60 (com base na MS), e o restante, em pastagem de milheto (*Pennisetum americanum*) recebendo suplementação concentrada ao nível de 1,0% do peso vivo. As avaliações foram realizadas nos meses de novembro a fevereiro, das 8h às 18h. Bezerros confinados permanecem mais tempo ($p < 0,05$) em ócio, tanto na posição deitado, quanto em pé, enquanto que os animais a pasto permaneceram mais tempo em atividade de alimentação e ruminação. Animais confinados realizaram maior número de refeições diárias, porém de menor duração cada. Em ambos sistemas de criação, a atividade de ruminação é realizada preferencialmente na posição deitada, no entanto, o tempo de ruminação em pé é cerca de 1,4 vezes maior para os mantidos em pastagem. Animais mantidos em pastagem apresentam menor eficiência de ingestão de MS, maior número de bolos ruminados, sendo estes, ruminados em menor tempo e com menor número de mastigadas merícicas.

Palavras-chave: eficiência ingestiva, ócio, ruminação, vitelos.

Introduction

Among Brazilian regions, southwestern Paraná State is characterized by a major dairy region, which is represented largely by small and medium farms. Because of the great economic instability of this activity, some actions are currently required, which add value to dairy cattle production, for example, the use of males for meat production.

In Brazil, unlike European countries, the veal meat is still not widespread, however, studies involving the production of beef from males of dairy breeds become relevant, since these animals are still rejected by producers. This is because calves need to ingest significant amounts of milk in early development stages, which in a non-systemic view implies the reduction of gross revenue from the sale of milk. Nevertheless, the disposal of males of dairy breeds is a practice that is not consistent with the moral and rational purposes that aim the welfare of animals and may thus tarnish the sustainable image and ethics of dairy farming.

Several studies have sought techniques to improve the production of these animals (ALVES et al., 2004; SILVA et al., 2007; ZANINE et al., 2006). Based on this, it is concluded that among many factors influencing animal performance, as those related to diet, environmental and management differences, behavioral patterns, in general, serve as a basis to select the best feeding strategy of animals, whether in feedlot or pasture systems.

In animal production on pasture, there are interaction plant-animal (ZANINE et al., 2006), sward canopy structure (SOUZA et al., 2011) and food supplementation (SILVA et al., 2010) affect behavioral patterns of animals. Therefore, in feedlot systems, the greatest changes in ingestive behavior are due to differences in the proportion of concentrate in the diet (MISSIO et al., 2010), frequency of feeding the concentrate (PAZDIORA et al., 2011); feed structure (SILVA et al., 2007), among others.

Individual differences in duration and allocation of feeding and rumination activities are related to appetite, anatomical differences and to meeting energy requirements or rumen repletion (FISCHER et al., 2002). In the same way as one of the major characteristics that differentiate breeding systems is the availability of food and the process of collecting and apprehension food, resulting in longer feeding time when animals are grazing (SOUZA et al., 2007). Regarding the time available for ingestive activities on pasture, the animals spend less time ruminating and more time in feeding activity (MONZANO et al., 2007; ZANINE et al., 2007), unlike the confined animals, which spend more time ruminating (MISSIO et al., 2010; SEGABINAZZI et al., 2011).

Nevertheless, in the literature, most studies involving the ingestive behavior refers to beef cattle, thereby pointing the importance of studies focusing on feeding behavior of calves of dairy breeds. In this context, the goal of this study was to evaluate the feeding behavior of Holstein calves reared on two systems: pasture or feedlot.

Material and methods

The experiment was conducted at the Universidade Tecnológica Federal do Paraná - Campus Dois Vizinhos, from October 2011 to February 2012. The region is physiographically called Third Plateau of the Paraná State, with altitude of 520 m, latitude 25°44'S and longitude 53°04' W, the climate is subtropical humid mesothermal (Cfa and Cfb), according to Köppen classification. The local soil is Haplorthox and terrain has an average slope of around 5% (EMBRAPA, 2006). Values of rainfall and minimum and maximum temperature during the experimental period, collected at the Meteorological Station of Dois Vizinhos, Paraná State, are shown in Table 1.

Table 1. Temperature, relative humidity and rainfall in the experimetnal period.

Month	Temperature (°C)			Average relative humidity (%)	Rainfall
	Minimum	Maximum	Average		
November	12.1	33	21.63	67.63	139
December	11	35.7	23.4	63.9	42.6
January	15.1	33.1	23.04	68.85	177.4
February	15.1	36.8	19.2	70.20	162

Eleven male Holstein calves, non-castrated, contemporaneous, with initial age of 75 days and 63 kg were randomly assigned to two production systems: feedlot or pasture. The feedlot system was conducted in 2 m^2 individual stalls, equipped with feeders and drinkers. The diet was provided ad libitum, twice a day (9 and 16 hours) and formulated according to the nutritional requirements established by NRC (2001) for an expected daily weight gain of 0.800 kg. The roughase used was corn silage and concentrate feed consisted of wheat bran, ground corn, soybean meal and minerals, with a forage: concentrate ratio was 40:60 (on a dry matter basis). Feed leftovers were daily measured to adjust the diet to be given on the following day, in which we considered 10% leftovers to consider intake ad libitum.

The grazing system was conducted on pearl millet (*Pennisetum americanum*) pasture, whose seeding rate was 25 kg ha^{-1} and the base fertilization followed the recommendation of soil analysis performed in the laboratory of UTFPR - Campus Pato Branco. The grazing system was continuous, where the pasture had average forage mass of 6749 kg DM ha^{-1}, and leaf: stem ratio of 0.8. The recommended supply of forage was 10%, where it was regulated every 21 days through the put-and-take technique (MOTT; LUCAS, 1952). Animals were given concentrate supplementation at 1% body weight, once a day, at 14 hours, with the same composition of the feed supplied to confined animals, beyond free access to water and mineral salt.

Samples of pasture, concentrate and corn silage used, after drying in a forced air circulation oven at 55°C, were sent to the laboratory for chemical analysis (Table 2).

Table 2. Chemical analysis of the components of the diet of Holstein calves.

	Corn silage	Concentrate	Pearl millet (hand plucking samples)
DM	22.00	84.00	84.08
CP	8.38	18.16	22.36
NDF	45.14	30.16	58.46
ADF	27.92	9.17	29.85
MM	1.58	6.90	7.40
NDF	60.51	69.88	56.16
IVDMD	57.13	79.24	55.29

Pasture dry matter (DM) was determined by indirect estimation of fecal output with the use of an external marker (Chromic Oxide) using the formula: DM = fecal output/ (1-IVDMD), in which IVDMD = in vitro dry matter digestibility, and fecal output (FO), in kg DM day^{-1}, using the following formula: FO = chromic oxide administered daily (g day^{-1})/ chromic oxide in faeces (g kg^{-1} DM) (POND et al. 1989). The results for these variables are in Table 3.

Table 3. Mean values of dry matter intake (DMI), neutral detergent fiber (NDF) intake and in percentage of body weight of Holstein calves in different systems: feedlot or pasture.

	Production system	
Variables	Feedlot	Pasture
DMI, kg DM day^{-1}	4.82	4.07
DMIBW, kg DM 100 kg^{-1} BW	3.66	3.04
NDFI, kg DM day^{-1}	1.81	2.04
NDFIBW %, kg DM 100 kg^{-1} BW	1.37	1.49

DMI = daily DM intake; DMIBW = DMI relative to body weight; NDFI = daily NDF intake; NDFIBW = NDF intake relative to body weight.

Ingestive behavior data were recorded for six alternate days, during 10 hours a day (8 to 18 hours), using the focal method with 10min. sampling interval, as proposed by Martín and Bateson (1986). During the 10 hours of observation, every 5 min. the animal was classified into the following activities: food (TAL), rumination (TRU), idleness (TO) or drinking water (B). Behavioral activities were regarded as mutually exclusive, i.e. at each record, each animal was classified into only one activity. For animals on pasture, the feeding activity included the time spent in the selection of sites for grazing, grasping and handling of the food bolus. Brief displacements with low head in search of pastures were considered as grazing time. For confined animals, the presence of the animal at the feeder was considered as feeding activity. Idleness considered the time the animals showed no mandibular movements. The rumination activity considered the time spent in regurgitation and cud-chewing of boluses and the time elapsed between swallowing and regurgitation.

The number of daily meals (NM) was recorded after the permanence of the animal at the feeder for a minimum time of 10 min. Behavioral data were interpreted following the methodology of Polli et al. (1996) and Bürger et al. (2000) where: EA_{DM} = DMI/FT; RUE_{DM} = DMI/TRT; NBO = TRT/TMB; TIT = TSI+TLI and TRT = TLR+TSR, in which: DMI (g DM day^{-1}) is the DM intake; RUE_{DM} (g DM h^{-1}) is the DM rumination efficiency; EA_{DM} is DM intake efficiency; FT (h day^{-1}) is the feeding time; TRT (h day^{-1}) is the total rumination time; NBO (number day^{-1}) is the number of bolus chewed daily; TMB (s bolus^{-1}) is the time of cud chewing per ruminal bolus; TLI (h day^{-1}) is the time lying idle; TSI (h day^{-1}) is the time standing idle; TSR (h day^{-1}) is the standing rumination time; TLR (h day^{-1}) is the lying rumination time; TIT (h day^{-1}) is the total idle time.

The experiment was a completely randomized design with two treatments, with six confined animals and five animals on pastures targeted for observations for six alternate days. Data were tested for normality using the Shapiro-Wilk test, and further compared by the PROC MIXED procedure with repeated measures over time, and the covariance structure Compound Symmetry (CS) was the most appropriate model. Means were compared by DMS test at 5% level and the mathematical model used was as follows:

$$\gamma_{ijk} = \mu + \tau_i + \alpha_j + \varepsilon_{ijk},$$

where:
γ_{ijk} = dependent variables,
μ = overall mean of all observations;
τ_i = effect of the i-th production system;
α_j = effect of the j-th evaluation period;
ε_{ijk} = random residual error, NID (0, σ^2).

The analyses were run with the aid of Statistical Analysis System 9.1.3 (SAS, 2001).

Results and discussion

The evaluation period had no effect on the ingestive behavior of the animals. Therefore, only the effects of the feeding system are discussed henceforward.

The time spent in rumination, idle, feeding and drinking water were influenced ($p < 0.05$) by the production system (Table 4).

Table 4. Mean and standard error of behavioral activities of Holstein calves in different systems: feedlot or pasture.

Variable	Production system		p
	Feedlot	Pasture	
TSR (min.)	10.47±1.30	25.37±2.24	0.0001
TLR (min.)	130.80±3.61	136.37±6.35	0.4535
TRT (min.)	141.25±3.54	161.75±6.25	0.0085
TSI (min.)	112.41±3.94	81.62±6.63	0.0004
TLI (min.)	165.93±4.72	110.25±8.26	0.0001
TOT (min.)	278.08±5.27	191.88±9.01	0.0001
FT (min.)	171.39±4.56	240.13±7.86	0.0001
TBE (min.)	9.89±0.82	5.12±1.39	0.0056

TSR = standing ruminating; TLR = lying ruminating; TRT = total rumination; TSI = standing idle; TLI – lying idle, TOT – total idle; FT - feeding, TBE – drinking water.

Animals on pasture remained approximately 14.2% more time on rumination activity than confined animals. Factors related to diet as the level and type of fiber can directly influence the ruminal parameters and rumination activity (MISSIO et al., 2010). However, the increased level of concentrate in the diet seems to have been more relevant on these results, once the confined animals consumed a diet containing more concentrate (2.2% BW) compared with those on pasture (1.0% BW). The increase of dietary concentrate improves the digestibility of the diet (PINTO et al., 2010), in this way, food stays less time in the gastrointestinal tract, thereby increasing the rate of passage and consequently the intake of dry matter (KONONOFF et al., 2003). The smaller particle size also contributes to increase DMI, since it facilitates the grasping and chewing, but reduces the activity of rumination.

Another factor that influences the rumination time is the intake of NDF. Nevertheless, it seems not to have been so important to the results, since the NDF intake in relation to the percentage of body weight did not vary widely (Table 3). Animals that were on pasture of pearl millet, probably grasped larger leaf particles, which can be reflected in changes in digestibility of dietary DM, due to longer ruminal retention time, and consequently in the reduction of DMI. This was verified in the present study, in which confined animals showed higher DMI in relation to the percentage of body weight (3.66 vs 3.04 kg DM 100 kg^{-1} BW).

The reduction in the DMI may be minimized as processes of chewing and ruminating are intensified, because they reduce the particle surface, enhancing bacterial action on food, increasing the digestibility of the diet and, consequently, the rate of passage of digesta. Moreover, the greatest chewing stimulation promotes increased saliva production, which improves the conditions of ruminal pH, increasing the development of microbe responsible for greater digestion of fiber. Souza et al. (2007) reported that confined animals spend less time in the consumption activity and increase the rumination time.

Of total rumination time, approximately 88.45% of this activity were performed in lying position, regardless of the system, as this position facilitates the rumination, by increasing abdominal pressure. Meantime, during the evaluation period, the animals on pasture remained 1.4 times more time standing ruminating than the confined animals (25.37 vs 10.47 min.).

As for idle activity, confined animals spent more time in this activity (278.08 vs. 191.88 min.). These results are consistent with those presented by Souza et al (2007), who found that during daytime, the idle time of confined animals was longer than of animals on pasture. Considering the position, confined animals remain 50% more time standing idle and 37% more time lying idle than animals on pasture.

With regard to feeding time, this activity represented, respectively, 28.53 and 40.09% of the total daytime, for the animals confined and on pasture. The animals kept on pasture remain 40.1% more time in this activity than confined ones. In this case, the displacement time, ease of search, collection and selection of pasture may affect the time of daily feeding, making these animals to spend more time in grasping and ingesting food. Furthermore, cattle are diurnal animals, and feeding activity is more frequent during the day, but this behavior may vary in case of high temperatures, which was not observed in the present study (Table 1).

The time spent drinking water was 91.8% higher for the confined animals (Table 4). Water intake is influenced by several factors, including the dry matter intake, the composition of the food and ambient temperature. The fact that confined animals are in an ambient restrictive to movements may have forced these calves to stay longer in the sun, since the confinement was semi-covered and the pasture has various shaded sites. This may have led the confined animals to a higher thermal stress, and a consequent, to higher water consumption.

Figures 1 and 2 show that cattle change their behavior according to feeding management adopted.

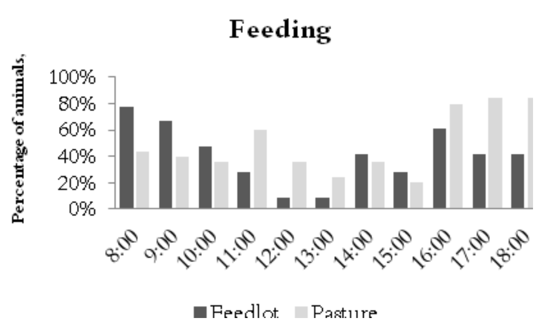

Figure 1. Percentage of Holstein calves in feeding activity according to the production system.

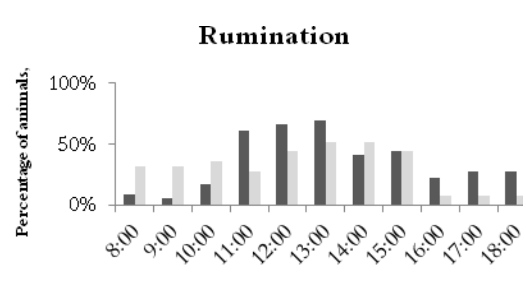

Figure 2. Percentage of Holstein calves in rumination activity according to the production system.

Feedlot animals showed peaks of food intake close to the periods when food was supplied (9 and 16 hours), with a peak of rumination about 3 hours after the first daily meal, with minimum 60% of animals in this activity, and so for approximately 3 hours (Figure 2). In the case of animals on pasture, feeding activity was characterized by oscillations throughout the day, and was more intense from 16 hours, two hours after the supply of the supplement, when more than 80% of the animals remained in grazing activity. Moreover, rumination occurred more significantly in the interval from 13 to 14 hours, when more than 50% of the animals were observed in this activity. These results reflect that there are adaptive differences between animals on pasture or in feedlot considering activities of feeding and rumination, especially during the hottest hours of the day.

In relation to the number and time of feeding and rumination periods (Table 5), confined animals showed a greater number of daily meals (4.91 vs 3.50), but performed in a shorter time (36.16 vs 57.67min.) than animals on pasture. In agreement with Fraser and Broom (2002), the ease of obtaining food is a factor that the ruminant takes into consideration when deciding when and what to eat. Similarly, Huzzey et al. (2005) explains that the feeding frequency may also increase in environments that limit competitive meetings, non-existent in the case of the present study, because animals were confined individually.

Table 5. Mean and standard error for the number and time of meals and rumination periods of Hostein calves in different systems: feedlot or pasture.

Activities	Production system		p
	Feedlot	Pasture	
Feeding period			
Number (unit)	4.91±0.18	3.50±0.25	0.0010
Time (min.)	36.16±1.92	57.67±2.37	0.0001
Rumination period			
Number (unit)	4.19±0.20	3.40±0.22	0.0437
Time (min.)	28.21±0.80	29.73±0.91	0.6825

Feedlot animals performed more rumination periods (4.91 vs 3.40), but the time spent in these rumination sessions was similar ($p > 0.05$), with average time of 28.97min. each (Table 5). The number of rumination periods may increase with increasing content of dietary fiber, but the DM rumination efficiency seems also to influence those results.

In Table 6, it can be seen that feedlot animals were 29.6% more efficient in rumination (2279.05 vs 1758.5 kg DM h^{-1} rumination), which may explain the greater number of rumination periods of these animals compared to those on pasture. Still in Table 6, feedlot animals were more efficient in the food intake process (1714.0 vs 1017.0), which could reflect increased formation of ruminated boluses per day. In this study though, the results showed the opposite, that is, animals on pasture had fewer ruminated boluses daily. This result may be explained by the greater need of maceration the leaf blades from grazing. In this case, defoliation can promote the intake of larger particles, which act in the process of stimulating the mechano-receptors of the rumen-reticulum epithelium that indicate the need to process the digesta, inducing rumination, increasing the formation of ruminal boluses.

The chewing time per bolus was longer ($p < 0.05$) for the confined animals (47.27 s $bolus^{-1}$) compared with animals on pasture (39.31 s $bolus^{-1}$).

Table 6. Mean values of behavioral activities of Holstein calves in different systems: feedlot or pasture.

Variables	Production system		Probability
	Feedlot	Pasture	
EA_{DM} (g DM h^{-1})	1714.00±117.39	1017.00±77.58	0.0009
RUE_{DM} (g DM h^{-1})	2279.05±114.77	1758.50±206.10	0.0346
NCB (number day^{-1})	368.89±8.67	535.25±14.56	0.0001
TMB (s $bolus^{-1}$)	47.27±1.03	39.31±1.74	0.0004
NBO (number $bolus^{-1}$)	63.39±1.49	50.55±2.43	0.0001

EA_{DM} = intake efficiency (g DM h^{-1} feeding) RUE_{DM} = rumination efficiency (g DM h^{-1} rumination); NCB = number of chews per bolus; NBO = number of ruminal boluses per day; TMB = chewing time per bolus.

The number (NBO) and time (TMB) of chewings per bolus was higher ($p < 0.05$) in feedlot animals in relation to those on pasture. Although DM intake was higher for those animals, the animals act adaptively, and the fewest ruminated boluses during the day may have generated the need to produce more saliva, which neutralizes the ruminal pH, preventing possible digestive disorders resulting from the sharp drop in ruminal pH. On the other hand, Missio et al. (2010) worked with different levels of concentrate for cattle (22, 40, 59 or 79%) and registered a decline in NBO (59.56, 57.58, 54.95 and 53.19 chews per bolus, respectively), with increasing concentrate levels in the diet, but in their study, intake efficiency (g DM h^{-1}) also increased linearly with the addition of concentrate, which was evidenced in the present study.

Conclusion

Holstein calves kept on pasture remain longer in eating and ruminating activities, and present lower ingestive efficiency of DM consumed.

Feedlot animals spent more time idle and show more daily ruminal boluses, which require more time and cud chewings to be ruminated.

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