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Original

Behavior, Performance, and Carcass Yield of Steers with Different Comfort Conditioning During the Fattening Period

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ABSTRACT

Objective. The aim of this study was to evaluate the behavior and performance of steers in two different housing areas (10 vs. 100 m^2/animal) and two feeding models (daily supply vs. self-feeding) during the fattening period. **Materials and methods:** Forty-eight Hereford steers with an initial live weight (LW) of 214.0 kg were housed under four treatments: 100DS (100 m^2/animal and daily supply), 100SF (100 m^2/animal and self-feeding), 10DS (10 m^2/animal and daily supply), 10SF (10 m^2/animal and self-feeding) until reaching a final LW of 370 – 390 kg. Their behavior was observed and recorded. Dry matter intake (DMI) and mean daily gain (MDG) were recorded to estimate feed conversion ratio (FCR). Back fat thickness (BFT) and *Longissimus* muscle area (LMA) were measured. Steers were sent to a commercial abattoir to evaluate carcass yield. **Results:** The rest and walking frequency was higher in steers in the larger housing area. Self-feeding contributed to the intake distribution during the day. No differences were detected in DMI, MDG, and FCR. However, the confined animals (10DS and 10SF) produced more BFT and less LMA. In addition, they had less carcass yield at slaughter. **Conclusions:** Therefore, a larger housing area and the self-feeding model could contribute to expressing the steers' natural behavior and improve their performance.

KEYWORDS: animal welfare, cattle, feedlot, housing area, feeding (*Source: MESH*)

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INTRODUCTION

Beef cattle are mostly fattened under intensive production systems that are generally restrictive in terms of access to valuable resources such as living space, freedom of movement, and interaction with natural substrates. In many countries, they are housed in places where muddy conditions are a major problem for animal welfare (Grandin, 2016).

Although confinement increases emerging diseases and transmission of pre-existing diseases (Rossanigo *et al.*, 2009), it is a widely used alternative for cattle fattening. However, due to the multifactorial influence, confinement may not lead to higher yields compared to grasslands or semi-confinement systems. In addition, consumers increasingly demand better quality, good production practices, animal welfare, traceability, and sustainability (Mota and Marçal, 2019).

The first method to keep cattle clean is a correct stocking density (Grandin, 2016). Mader and Colgan (2007) found that lower cattle density in feedlots resulted in lower muddy conditions. These results indicate that more space could improve animal comfort and performance.

Space influences feedlot cattle behavior and there is evidence that housing modifications could promote livestock welfare (Park *et al.,* 2020). Livestock behavior and welfare play an important role in the body development and carcass composition of beef cattle. Physical comfort and nutritional conditions integrate the five-domain model: nutrition, environment, health, behavior, and mental state (Mellor *et al.,* 2020).

Moreover, delivering feed daily is not an option for producers with limited time or equipment. Feed availability is a major limiting factor for production and animal welfare. Feeding characteristics associated with low ruminal fluid pH are high dry matter intake and ingestion of large meals. It is because of the greater amount of acid production per period, high eating rate because of lower feeding salivation, short time spent chewing while eating and ruminating because of lower daily saliva production, and large variations in feeding behavior patterns throughout the day such as less frequent meals and rumination. Adaptation of feeding behavior to diets with a greater proportion of concentrates also plays an important role, as smaller meals and a more even distribution of intake throughout the day lead to a better synchronization in time between acid production and the elimination or neutralization (González *et al.,* 2012). Many farmers feed their livestock only once a day to minimize the cost of labor. Self-feeders can be used to provide ad libitum food. Final weight and yield are indicators of animal welfare (Park *et al.,* 2020). Because of highly concentrated diets and sedentary lifestyles cattle in confinement could be more prone to manifestations of poor health (Macitelli *et al.,* 2020). Feeding behavior can also improve performance. An increase in feeding frequency during the fattening period may contribute to promoting a better rumen environment for fermentation. Likewise, more stable ruminal conditions can decrease dry matter intake (DMI) as feeding frequency increases (De Souza Teixeira *et al.,* 2018). Therefore, the aforementioned feeding model and homogeneous distribution of consumption throughout the day may contribute to expressing innate behavior of movements and rest in cattle (Oberschätzl *et al.,* 2016).

Farmers must provide adequate conditions to meet the physiological and behavioral needs of livestock (Fernandez-Novo *et al.*, 2020). It is necessary to promote a more sustainable and efficient production system than the current farming systems. Thus, livestock conditions have to improve animal welfare and reduce environmental problems. Based on this information, this study aimed to evaluate steer behavior and performance in two separate housing areas (10 vs. 100 m^2/animal) and two feeding models (daily supply vs. self-feeding) during the fattening period.

MATERIALS AND METHODS

This research was carried out at the INTA Agricultural Experimental Station, located in the city of Concepción del Uruguay, Entre Ríos, Argentina (32°48’ S, 58°34W). Forty-eight Hereford steers with an initial age of 9 months and live weight (LW) of 214,0 ± 23,7 kg were housed using four treatments: 100DS (100 m^2/animal and daily supply), 100SF (100 m^2/animal and self-feeding), 10DS (10 m^2/animal and daily supply) and 10SF (10 m^2/animal and self-feeding).

Before the experiment, the animals went through a 35-day adaptation period. The fattening period diet consisted of 77% whole corn, 20% ground corn, 2% slow-released urea (43% N), and 1% mineral supplement. Animals were fed according to the assigned treatment. The daily supply treatments meant that 3.2% of LW animals were fed every day, whereas the feeders were filled every four days in the self-feeding treatment.

Steers were labeled with numbers written on both sides of their bodies, and their behavioral data were recorded during the first 7 days of the study. The animals were observed for one hour three times a day (09:00= morning, 13:00= noon and 17:00=afternoon). The times the animals had their feed intake (access to the feeder) and movements (resting, walking, static standing) were recorded.

LW was recorded at 14-day intervals to estimate the mean daily gain (MDG). Intake was determined as the difference between the amount of food provided and residual food, divided by the number of animals in each treatment. Feed conversion (FC) was determined by the ratio intake/MDG. DMI and MDG were recorded individually to determine the feed conversion ratio (FCR).

Back fat thickness (BFT) and *Longissimus* muscle area (LMA) were measured in steers at 28-day intervals until slaughter. A real-time ultrasound scanner (FALCOVET 100, PieMedical, Holland) was used to measure LMA and BFT between the 12th and 13th rib, and plant oil was used as a coupling agent.

Steers were fattened to 370 – 390 kg LW and sent to a commercial abattoir. The hot carcass weight was obtained after pelvic fat removal. Carcass yield was calculated by dividing hot carcass weight by final body weight (7% dressing).

Statistical analysis was performed using PROC GLM (4). The model includes the effect of two housing areas (HA), two feeding (F) models, and the interactions between these effects (HA*F). The model also included the effect of time on data collection. The steers were considered as experimental units (n=12). When interaction or principal factors were significant ($p<0.05$), the means were compared using the Tukey test.

RESULTS AND DISCUSSION

A difference in the frequency of food intake was found among different feeding models along the day ($p<0.0001$, Figure 1). The animals with daily supply (100DS and 10DS) presented higher intake frequency in the morning than at noon and afternoon ($p<0.05$). These treatments also showed higher intake frequency regarding 100SF and 10SF in the morning, similar at noon, and lower in the afternoon. Self-feeding resulted in a homogeneous feeding pattern along the day ($p>0.05$). The higher feeding activity in the morning in 100DS and 10DS was associated with the conditioned reflex caused by the food supply.

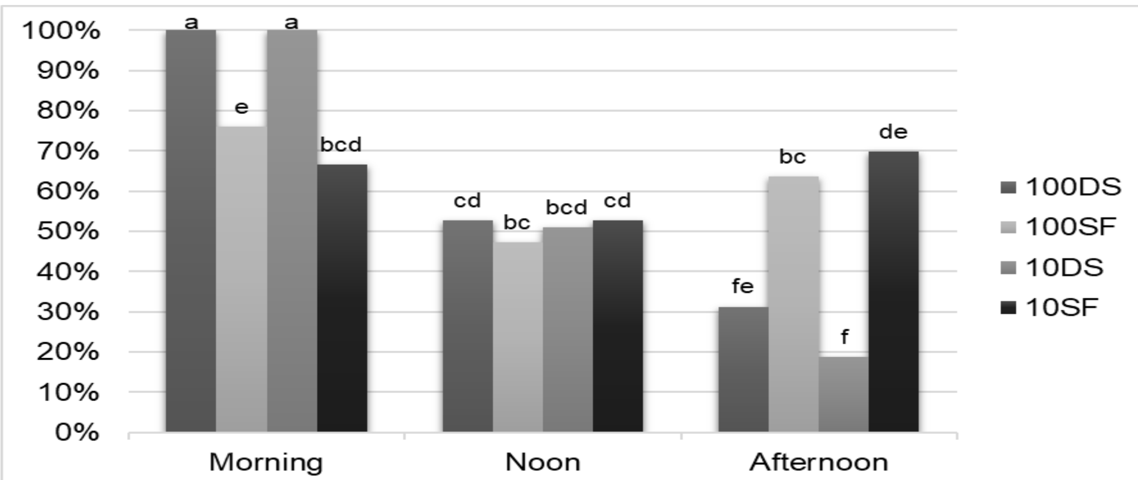

Figure 1. Food intake throughout the day in steers with different conditions during the fattening period. 100DS: 100 m^2/animal and daily supply, 100SF: 100 m^2/animal and self-feeding, 10DS: 10 m^2/animal and daily supply, 10SF: 10 m^2/animal and self-feeding.

a, b: Mean values represented by unequal scripts in the rows indicate statistical differences detected by the Tukey test (p<0.05).

The experimental conditions (housing area and feeding model) affected ster movements during the fattening period (Figure 2). The treatments with larger housing areas (100DS and 100SF) presented a higher animal walking frequency. Only 1% of confined animals (10DS and 10SF) walked and also had a lower resting frequency due to the smaller space ($p<0.05$).

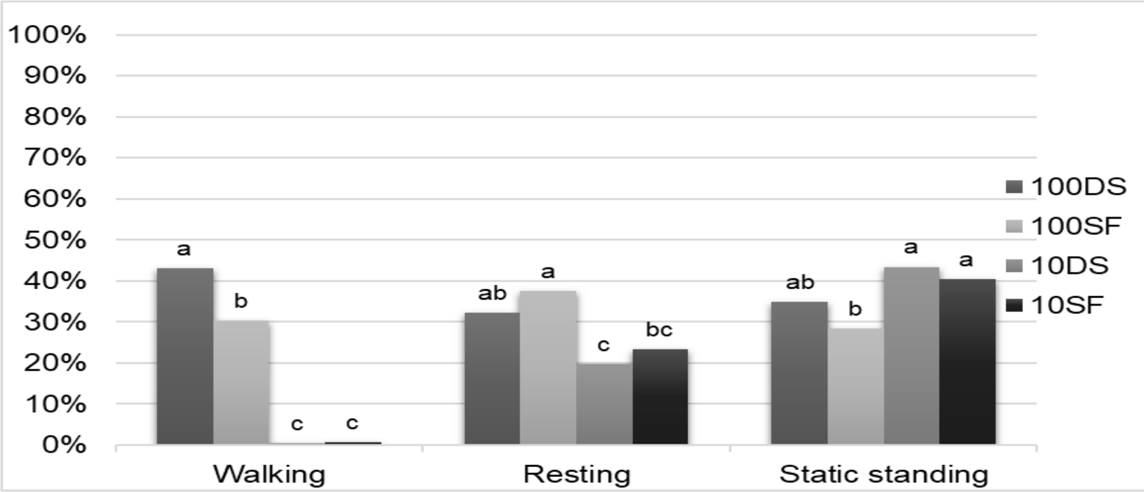

Figure. 2. Steer movement with different conditions during the fattening period. 100DS: 100 m²/animal and daily supply, 100SF: 100 m²/animal and self-feeding, 10DS: 10 m²/animal and daily supply, 10SF: 10 m²/animal and self-feeding.

a, b: Mean values represented by unequal scripts in the rows indicate statistical differences detected by the Tukey test (p<0.05).

Patterns of food intake match the findings of Mattachini *et al.* (2011) who reported that the frequency of feed delivery affected the pattern of lying down behavior throughout the day and the lying down time following feed supply.

Under natural conditions, cattle display a need to expand their feeding behavior over the whole day (Schneider *et al.*, 2019). The results of this paper show better intake behavior along the day in animals on the self-feeding system. The outcomes of movement behavior were similar to Schütz *et al.* (2019), who found that cows on manure-contaminated surfaces had a reduced lying time in comparison with those on dry soil. They suggested that the reduction in lying down time was predominantly due to the surface moisture content. Muddy surfaces have negative effects on the health and welfare of dairy cattle, and if possible, cows will avoid this surface.

Final weight, MDG, TWG, DMI, and FCR were similar, regardless of the housing conditions during the fattening period (Table 1).

Table 1. Mean values for weight evolution, dry matter intake, and feed conversion ratio in steers with different comfort conditions during the fattening period.

	100DS	100SF	10DS	10SF	SEM	*p*		
						HA	F	HA*F
IW[1] (kg)	214.9	212.8	220.0	208.3	3.42	0.97	0.32	0.49
FW[2] (kg)	369.9	371.8	384.2	376.8	2.98	0.11	0.65	0.44
MDG[3] (kg)	1.3	1.3	1.3	1.4	0.02	0.13	0.33	0.97
TWG[4] (kg)	155.0	159.1	164.2	168.5	3.91	0.41	0.70	0.99
DMI[5] (kg)	1103.8	1095.3	1106.4	1139.4	25.43	0.41	0.70	0.99
FCR[6] (kg)	7.2	6.9	6.8	6.8	0.16	0.58	> 0.99	0.73

100DS: 100 m²/animal and daily supply, 100SF: 100 m²/animal and self-feeding, 10DS: 10 m²/animal and daily supply, 10SF: 10 m²/animal and self-feeding, HA: housing area, F: feeding models.

[1]Initial weight, [2]Final weight, [3]Average daily gain, [4]Total Weight gain, [5]Dry matter intake, [6]Feed conversion ratio.

Ultrasound measurement and carcass yield were affected by the housing conditions (Table 2). A significant difference in final and total gain BFT ($p<0.05$) according to housing areas was observed. At the end of the fattening period, the 10DS treatment showed BFT higher than 100SF. Conversely, LMA final and total gain was higher for 100SF than 10SD. The housing areas also affected carcass yield. Animals with more housing space presented higher values ($p=0.0010$).

Table 2. Mean values for ultrasound measurement and carcass yield in steers with different conditions during the fattening period.

	100DS	100SF	10DS	10SF	SEM	*P*		
						HA	F	HA*F
Initial BFT[1] (mm)	6.3	6.2	6.4	6.4	0.12	0.46	0.71	0.76
Final BFT (mm)	10.7 ab	10.4 a	11.6 b	11.0 ab	0.18	0.03	0.21	0.73
Total gain BFT (mm)	4.4 ab	4.2 a	5.2 b	4.6 ab	0.16	0.04	0.29	0.54
Initial LMA[2] (cm^2)	40.3	39.6	43.3	40.1	0.98	0.38	0.34	0.53
Final LMA (cm^2)	76.8 ab	80.6 a	74.2 b	75.0 ab	1.12	0.004	0.29	0.48
Total gain LMA (cm^2)	36.5 ab	41.0 a	30.9 b	34.8 ab	1.50	0.03	0.15	0.93
Hot carcass weight (kg)	212.5	213.4	214.5	211.7	1.87	0.72	0.57	0.42
Carcass yield (%)	61.7 a	61.7 a	60.1 b	60.4 b	0.00	<0.001	0.93	0.92

[1]Back fat thickness, [2]Longissimus muscle area.
100DS: 100 m^2/animal and daily supply, 100SF: 100 m^2/animal and self-feeding, 10DS: 10 m^2/animal and daily supply, 10SF: 10 m^2/animal and self-feeding.
a, b: Mean values represented by different letters in the rows indicate statistical differences detected by the Tukey test ($p<0.05$).

According to Park *et al.* (2020), space conditions influence cattle behavior and performance, which are indicators of a positive welfare state. Exposure to mud also has implications for cattle hygiene and health. In this research, a smaller housing area produced muddy conditions which resulted in poor animal hygiene (Photo 1). With more space, animals remained clean during all the fattening periods (Photo 2). Previous rains and pooling surface water were useful measures to determine less lying down time, thus compromising animal welfare (Neave *et al.*, 2022).

Chen *et al.* (2015) suggest that poor hygiene could present an increased risk of infection and immunosuppression. In addition, Macitelli *et al.* (2020) found that a reduced space allowance for beef cattle in outdoor feedlots degrades the feedlot environment and affects animal welfare.

Photos 1 and 2. Steers with different housing areas (left: 10 m^2/animal, right: 100 m^2/animal) during the fattening period.

Accordingly, Pordomingo *et al.* (2022) reported similar live weight evolution and feed efficiency in feedlot cattle. However, Grandin (2022) and Mader and Griffin (2015) found efficiency problems with confinement and muddy conditions.

According to De Souza Teixeira *et al.* (2018), intake, MDG, and FCR were not impacted by behavior (food intake along the day and movements). However, in this work, behavior affected fat deposition, LMA growth, and carcass yield. A high correlation between LMA and carcass yield ($p<0.05$) was found. Carcass yield underwent a significant positive correlation ($p<0.05$) with walking ($r= 0.44$) and resting (0.43). A positive canonical correlation ($p=0.03$) was also determined between behavior associated with animal welfare (walking and resting) and carcass yield. On the other hand, Dunston-Clarke *et al.* (2020) showed that sedentary cattle had lower carcass yield. In this work, similar results about behavior and its effects on fattening and carcass yield were observed.

CONCLUSIONS

More space allowance on the feedlot pens provides a better environment for the animals, offering them more choices on where to stay or lay down, and reducing the risk of diseases spreading. Animals with more space, walk and rest for longer periods, and improved comfort associated with self-feeding contribute to the natural cattle movements during the fattening period. Self-feeding contributes to meal frequency throughout the day without affecting the animal's performance.

Nevertheless, confinement increases fattening and reduces the *Longissimus* muscle area, with lower carcass yield. Larger housing areas and self-feeding under the Ecological Feedlot system are alternatives to intensive fattening systems. This study is valuable for farmers to improve animal welfare and carcass yield in cattle. Further exploration to develop a suitable system that is repeatable is recommended.

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AUTHOR CONTRIBUTION STATEMENT

Research conception and design: MEM, JSV, AB, SAR, GAT; data analysis and interpretation: MEM, JSV, AB, SAR, GAT; redaction of the manuscript: MEM, JSV, AB, SAR, GAT.

CONFLICT OF INTEREST STATEMENT

The authors state there are no conflicts of interest whatsoever.