PERFORMANCE OF HEIFERS SUPPLEMENTED WITH DIFFERENT LEVELS OF CORN ON PASTURE[1]

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ABSTRACT: In southern Brazil, production systems are typically extensive and rely on grazing that often results in limited forage quantity and quality, decreasing efficiency and compromising reproductive tract development. The aim of this study was to evaluate the productive performance and reproductive tract development of heifers supplemented with different levels of corn on pasture. The following supplemental treatments were evaluated: T0 [40 g trace-mineralized salt per heifer per day (80 g phosphorus/kg product)]; T1 [0.5% of body weight (BW) cracked corn + 40 g trace-mineralized salt per heifer per day]; T2 [1% of BW cracked corn + 40 g trace-mineralized salt per heifer per day], and T3 [1.5% of BW cracked corn + 40 g trace-mineralized salt per heifer per day]. Thirty-nine phenotypically homogeneous Brangus heifers (average BW = 184±17 kg, average age = 269±27 days) raised on winter pasture (*Lolium multiflorum* Lam.) were randomized to 13 paddocks (one hectare each), with three heifers/paddock, to evaluate the effect of feeding different energy levels. Body condition score, average daily gain, frame score, dry matter availability, reproductive tract score, and stocking density were evaluated. The body condition score, average daily gain, reproductive tract score and stocking density increased ($P<0.05$) with increasing level of corn supplementation. Daily supplementation levels lower than 1.0% on *Lolium multiflorum* Lam. pasture can compromise the target breeding weight at 13 months of age. Therefore, daily supplementation at 1.0% of BW after weaning is a strategy to improve the economic and biological efficiency of livestock production systems, allowing to increase stocking density and to anticipate the age of heifers at first breeding.

Keywords: benefit-cost analysis, grazing, supplementation.

DESEMPENHO DE NOVILHAS EM PASTOREIO SUPLEMENTADAS COM DIFERENTES NÍVEIS DE MILHO

RESUMO: No sul do Brasil os sistemas de produção na sua maioria são extensivos, sendo que a principal fonte de alimento são as pastagens. Isto em muitos casos resulta em limitada quantidade e qualidade da pastagem, o que impacta negativamente a eficiência produtiva e o desenvolvimento do trato reprodutivo das fêmeas. O objetivo desta pesquisa foi avaliar o desempenho produtivo e o desenvolvimento do trato reprodutivo de novilhas suplementadas com diferentes níveis de milho em condições de pastejo. Os tratamentos avaliados foram: T0 [40 g de sal mineralizado por novilha por dia (80 g de fósforo/kg de produto)]; T1 [0,5% do peso vivo (PV) de milho quebrado + 40g de sal mineralizado por novilha por dia]; T2 (1% do PV de milho quebrado + 40g de sal mineralizado por novilha por dia); e T3 (1,5% do PV de milho + 40g de sal mineralizado por novilha por dia). Foram avaliadas 39 novilhas Brangus com características fenotípicas homogêneas, com PV e idade ao inicio do experimento de 184±17 kg e 269±27 dias, respectivamente. O estudo foi realizado na época de inverno em pastagem de *Lolium multiflorum* Lam. As novilhas foram distribuídas aleatoriamente em 13 piquetes (de um hectare cada) com três novilhas por piquete. As variáveis avaliadas foram escore de condição corporal, ganho médio diário, escore de *frame,* oferta de massa de forragem, escore de trato reprodutivo e carga animal. O escore de condição corporal, ganho médio diário, escore de trato reprodutivo e a carga animal aumentaram (P<0,05) com o aumento dos níveis de suplementação de milho. Níveis de suplementação diária inferiores a 1,0% em pastagem de *Lolium multiflorum* Lam. podem comprometer o PV alvo de acasalamento aos 13 meses de idade. Portanto, a suplementação diária de 1,0% do PV após o desmame pode ser uma ferramenta que melhora a eficiência econômica e biológica dos sistemas de produção de bovinos de corte, permitindo alocar mais animais por área e antecipar a idade de novilhas ao primeiro acasalamento.

Palavras-chave: análise de custo-benefício, pastoreio, suplementação.

INTRODUCTION

Beef cattle are produced mainly on natural pastures in the State of Rio Grande do Sul, a region characterized by a subtropical climate. Due to the limited forage quantity and quality during the autumn and winter months, species such as *Lolium multiflorum* Lam. have been introduced to improve natural pastures (Ferreira *et al*., 2011).

The autumn and winter periods exert a negative influence on forage availability and on the quality of natural pastures, limiting the consumption of energy and protein by animals (Berretta *et al*., 2000). This can reduce the growth of animals (Horn *et al*., 2005; Viñoles *et al*., 2009) and delay the age at first breeding. In this respect, postweaning nutritional regimens providing high-quality diets are positively associated with improved metabolic state, stimulating a high growth rate of bone, muscle and fat deposition (Hopper *et al*., 1993; Hall *et al*., 1995), and consequently influence the subsequent reproductive performance of females (Gunn *et al*., 1995).

In the United States, 90% of heifers are bred at 13 to 15 months of age (Dome, 1992). However, this does not occur in southern Brazil because of the low body weight (BW) gain in typical subtropical grazing systems. Nevertheless, some studies indicate that energy supplementation on winter pasture in subtropical Brazilian systems could improve productive (Medeiros *et al*., 2010) and reproductive traits (Randel and Welsh, 2013).

Pre-breeding energy supplementation may anticipate the age of development of the reproductive tract and increase average daily gain, body condition score (Rosa *et al*., 2010) and stocking density (Abdelhadi *et al*., 2005). However, feed costs are a major input in almost any animal production system. Although feed costs for grazing animals are difficult to quantify in extensive grazing systems, feed is the major expense in beef production (Herd *et al*., 2003) and detailed assessment of supplementation costs should be carried out to develop feeding management strategies for the production system.

Therefore, the objective of this study was to evaluate the productive performance, reproductive tract development of heifers supplemented with different levels of corn on pasture, as well as to perform a benefit–cost analysis.

MATERIALS AND METHODS

The experimental protocol was reviewed and approved by the Institutional Animal Care and Use Committee of the Universidade Federal do Rio Grande do Sul (Approval number: 27478).

The experiment was carried out from June to September 2014. Thirty-nine phenotypically homogeneous Brangus heifers (average BW = 184±17 kg, average age = 269±27 days) were randomized to 13 paddocks to evaluate the effect of feeding different energy levels in a continuous grazing system. Each paddock consisted of winter pasture (*Lolium multiflorum* Lam.) (one hectare each), with 3 heifers/paddock. The following supplemental treatments were evaluated: T0 [40 g trace-mineralized salt per heifer per day (80 g phosphorus/kg product)]; T1 [0.5% of BW cracked corn + 40 g trace-mineralized salt per heifer per day]; T2 [1% of BW cracked corn + 40 g trace-mineralized salt per heifer per day], and T3 [1.5% of BW cracked corn + 40 g trace-mineralized salt per heifer per day]. Treatments T0, T1 and T2 consisted of 3 paddocks each, while T3 treatment comprised 4 paddocks. The data were analyzed in a completely randomized design with four treatments. Heifers were supplemented once a day at 8 am for 112 days and were weighed every 28 days to adjust the amount of supplement according to BW.

The chemical composition of the pasture (whole plant) and corn (Table 1) was determined by near-infrared spectroscopy. Pasture samples were collected at the beginning and at the end of the experimental period for each treatment. Total digestive nutrients were determined using the equation described by Weiss (1992).

The variables evaluated were body condition score (BCS), average daily gain (ADG), frame score, initial dry matter availability, final dry matter availability, stocking density, and reproductive tract score (RTS). Frame score, RTS, final dry matter availability and BCS were measured at the end of the supplementation period. Body condition score was evaluated visually on a scale from 1 to 5 (1 = very lean and 5 = very fat) (Lowman *et al*., 1973). Average daily gain was calculated considering final BW minus starting BW, divided by the period of 112 days. The same starting point was used and the heifers had restricted access to forage and water for 12 hours before weighing. The frame score was determined by measuring hip height using the method proposed by the Bif(2010).

Dry matter availability was determined using the sward stick method (Hodgson, 1990). Pasture height was measured at 40 sites/ha at the beginning and at the end of the experimental period. The average value of the measurements was used as an independent variable in linear regression equations using the height measurements and actual forage mass measurements determined on the same date in each paddock using a square of 0.25 m^2. Five forage samples were cut per hectare close to the ground. Stocking density was calculated using the average BW/ha for each treatment over the period.

The RTS was determined by rectal palpation, applying a score of 1-5 to uterine horn diameter, ovary length, height and width, and ovarian follicle diameter as described by Andersen *et al*. (1991). The heifers were classified as follows: RTS 1 and 2 = prepubertal, RTS 3 = peripubertal, and RTS 4 and 5 = pubertal. Reproductive tract scoring is a repeatable and accurate method for assessing pubertal status and a high level of agreement (72%) between the RTS system and ultrasonography-progesterone concentrations in differentiating prepubertal from pubertal status has been reported (Rosenkrans and Hardin, 2003).

In this study, a benefit-cost analysis (Table 3) of supplementation was performed based on the final BW results (Table 2). For the calculation of supplementation costs, the cost per kg of corn was US$ 0.16 and the sale price per kg of heifer live weight was US$ 2.01 (Table 3) (Notícias Agrícolas, 2014).

Data were analyzed using the MIXED procedure of the SAS program (SAS Institute, Inc., Cary, NC, USA). The animal was the experimental unit since feed intake was controlled for each heifer over time and the paddock was used as a fixed effect. Contrast statements were used to test for linear and quadratic effects of supplementation level. Initial age and initial BW were used as covariates to adjust the models for RTS, stocking density, ADG, BCS, final BW and frame score since the P-value for initial age (P=0.06) and initial BW (P=0.08) tended to be significantly different.

RESULTS

No differences (P>0.05) were observed in initial age or initial BW (Table 2). There was also no difference in frame score (P=0.98), while BCS, ADG, stocking density, and RTS increased (P<0.05) with increasing level of supplementation (Table 2). The mature weight percentage of heifers at 13 months

Table 1. Initial and final chemical composition of the pasture for each treatment (T0, T1, T2, T3) and composition of the corn supplement

[1]Variable	Pasture								Supplement
	Initial				Final				
	[2]T0	T1	T2	T3	T0	T1	T2	T3	
ADF (% DM)	25.20	28.22	21.70	19.48	37.92	35.73	33.93	40.75	8.00
NDF (% DM)	53.29	56.05	55.20	54.12	68.61	68.36	69.53	70.60	14.39
TDN (%DM)	70.20	68.09	72.65	74.20	61.30	62.83	64.09	59.31	81.93
CP (% DM)	15.32	15.49	17.02	15.10	8.70	9.78	7.81	6.60	0.94

[1]ADF: acid detergent fiber; NDF: neutral detergent fiber; TDN: total digestible nutrient; CP: crude protein; DM: dry matter. [2]T0: corn supplementation, 0% of body weight; T1: corn supplementation, 0.5% of body weight; T2: corn supplementation, 1% of body weight; T3: corn supplementation, 1.5% of body weight.

Table 2. Least squares mean ± standard error for productive performance and reproductive tract development of heifers supplemented with different levels of corn on pasture

Variable	[1]Treatment T0	T1	T2	T3	[2]Ln	[2]Qu	[3]LRE	[4]R^2
Initial age (days)	248±8.00	279±8.00	275±8.00	270±7.00				
Initial BW (kg)	173±5.63	181±5.63	187±5.63	197±4.22				
Final BW (kg)	263±7.18 b	279±7.18 ab	285±7.18 a	292±6.22 a				
Body condition score (1-5)	3.00±0.03	3.01±0.03	3.08±0.03	3.11±0.03	0.02	0.63		
Average daily gain (kg/day)	0.790±0.10	0.864±0.18	0.889±0.07	0.927±0.12	0.002	0.53	y=0.091+0.09x	0.05
Frame score	4.85±0.30	4.55±0.29	4.87±0.29	4.73±0.26	0.98	0.78		
Initial dry matter availability (kg/ha)	2510±35	2490±45	2486±32	2490±29	0.61	0.80		
Final dry matter availability (kg/ha)	2358±105	2771±98.0	2870±100	3028±87	0.0001	0.18		
Initial forage allowance (kg DM/kg BW/ha)	4.85	4.58	4.44	4.21				
Final forage allowance (kg DM/kg BW/ha)	2.98	3.32	3.35	3.46				
Stocking density (kg/ha)	733±14.8	767±12.4	774±12.8	794±11.6	0.009	0.53	y=529+37.1x	0.80
Stocking density (AU/ha)	1.63±0.03	1.71±0.03	1.72±0.03	1.76±0.03	0.009	0.53	y=1.17+0.08x	0.80
Reproductive tract score	2.16±0.12	2.45±0.13	2.54±0.11	2.56±0.10	0.01	0.30	y=0.16+0.24x	0.26

[1]T0: corn supplementation, 0% of body weight; T1: corn supplementation, 0.5% of body weight; T2: corn supplementation, 1% of body weight; T3: corn supplementation, 1.5% of body weight. [2]P-value for a linear (Ln) or quadratic (Qu) effect of treatment on each variable. [3]LRE: linear regression equation. [4]R^2: coefficient of determination. Means in the same row followed by different letters differ from one another ($P<0.05$).

of age was 60, 63 65 and 66% in T0, T1, T2 and T3, respectively.

The costs of supplementation per heifer per day increased with increasing supplementation level and were US$ 0.18, 0.38 and 0.59 for T1, T2 and T3, respectively. Thus, supplementation costs per heifer over the period of 112 days were US$ 20.16, 42.56 and 66.08 for T1, T2 and T3, respectively. On the other hand, net income per hectare over the 112 days was US$ 29.38, 5.76 and -27.29 for T1, T2 and T3, respectively (Table 3).

Table 3. Benefit–cost analysis of corn supplementation of heifers in the grazing system

[2]Variable	[1]Treatment			
	T0	T1	T2	T3
Corn intake (kg/heifer/day)	-	1.15	2.36	3.67
AGSFLW (kg/heifer/day)	-	0.14	0.20	0.25
CS (US$/heifer/day)	-	0.18	0.38	0.59
GI (US$/heifer/day)	-	0.27	0.39	0.5
NI (US$/heifer/day)	-	0.09	0.02	-0.08
NI (US$/heifer/period)	-	9.79	1.92	-9.3
NI (US$/ha/day)	-	0.26	0.05	-0.25
NI (US$/ha/period)	-	29.38	5.76	-27.89

[1]T0: corn supplementation, 0% of body weight; T1: corn supplementation, 0.5% of body weight; T2: corn supplementation, 1% of body weight; T3: corn supplementation, 1.5% of body weight. [2]AGSFLW: average gain by the effect of supplementation in relation to final live weight; CS: costs of supplementation (US$ 0.16/kg corn); GI = gross income (the sale price of the kg BW was US$ 2.01); NI: net income (period of 112 days).

DISCUSSION

Each percent increase in corn supplementation level (% BW) resulted in a linear increase in ADG of 90 g/day (P=0.002) and in RTS of 0.24 units (P=0.01) over the period studied. These results may be explained by the fact that corn is a source of rumen-degradable carbohydrates, increasing the production of volatile fatty acids and propionic acid (Noviandi *et al*., 2014) and thus the availability of glucose for uterine, muscle and fat tissue deposition. This, in turn, could accelerate development of the reproductive tract, which influences the age or weight at puberty (Eborn *et al*., 2013, Gutierrez *et al*., 2014). Moriel *et al*. (2012) showed that reproductive tract development of beef replacement heifers fed diets based on low and medium quality forages is enhanced when low-starch energy supplements are offered daily. In addition, this induction of precocious puberty is preceded by an increased luteinizing hormone pulse frequency (Gasser *et al*., 2006).

Each percent increase in corn supplementation level (% BW) increased stocking density by 37.1 kg/ha, corresponding to an increase of 4.7, 5.7 and 8.4% in T1, T2 and T3, respectively, compared to T0 (Table 2). Abdelhadi *et al*. (2005) supplemented beef heifers on temperate pastures and increased stocking density from 4.2 heifers/ha for grazing to 7 heifers/ha for feeding 40% corn silage (dry matter basis).

We observed a substitutive effect of forage by the supplement with increasing supplementation level (Table 2). This finding might be explained by the higher forage allowance of 16% (3.46 kg DM/kg BW/ha), 12% (3.35 kg DM/kg BW/ha) and 11% (3.32 kg DM/kg BW/ha) in T3, T2 and T1, respectively, compared to T0 (2.98 kg DM/kg BW/ha).

The age of beef cattle at first breeding is an important parameter that has an economic impact on the efficiency of production systems (Kluyts *et al*., 2003; Hugh *et al*., 2011). The net income per hectare of T1 was apparently greater (US$ 29.38) than that of T3 (US$ -27.89) and T2 (US$ 5.76). However, these heifers (T3 and T2; Table 3) reached the required BW for breeding (286 kg) at 13 months of age, corresponding to 65% of mature cow weight (440 kg) in this livestock production system (Rovira, 1996). The aim of breeding heifers at 14–15 months of age is to reduce the requirements for animal replacement, to eliminate unproductive categories, and to decrease the generation interval (Nogueira, 2004). Thus, reducing the age at first breeding has advantages such as increasing the amount and velocity of rotation of capital in the production system, as demonstrated by Pilau and Lobato (2009). However, maximizing the biological and economic efficiency is important to determine the balance between nutrient inflow, their costs, and product generation (Endecott *et al*., 2013; Santana *et al*., 2013).

The BW of heifers of T0 and T1 at 13 months of age was 263 kg (60% of mature weight) and 278 kg (63% of mature weight), respectively. Nevertheless, it is unlikely that these heifers conceive early in the breeding season. Beef heifers that conceive early in the breeding season are more likely to get pregnant in the next period, to maintain short calving intervals, and to produce heavier calves at weaning (Monteiro *et al*., 2013).

Energy supplementation on winter pasture (*Lolium multiflorum* Lam.) can improve stocking density and anticipate the age at puberty, consequently reducing the breeding age and shortening the cow-calf production cycle. This supplementation may therefore be a strategy to improve the profitability of cattle production systems. The supplemental treatments T2 and T3 permitted to achieve the minimum weight (286 kg) for breeding at 13 months of age. However, the supplementation costs of T2 heifers were 36% lower (US$ 42.56) than those of T3 heifers (US$ 66.08) over the same period.

CONCLUSION

Increasing the level of corn supplementation on *Lolium multiflorum* Lam. increases ADG and anticipates development of the reproductive tract of heifers to 13 months of age, allowing to increase stocking density on pastures. Daily supplementation levels lower than 1.0% on *Lolium multiflorum* Lam. pasture can compromise the target breeding weight at 13 months of age. Therefore, daily supplementation at 1.0% of BW after weaning is a strategy to improve the economic and biological efficiency of livestock production systems, allowing to increase stocking rates and to anticipate the age of heifers at first breeding.

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