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Performance of beef heifers supplemented with extruded fat on italian ryegrass pasture

Dalton Roso[1], Marta Gomes da Rocha[1], Luciana Pötter[1], Maria José de Oliveira Sichonany[1*], Aline Tatiane Nunes da Rosa[2] and Alexandre Nunes Motta de Souza[2]

*[1]Universidade Federal de Santa Maria, Avenida Roraima, 1000, 97105-900, Santa Maria, Rio Grande do Sul, Brazil. [2]Instituto Federal de Educação, Ciência e Tecnologia Farroupilha, Santa Maria, Rio Grande do Sul, Brazil. *Author for correspondence. E-mail: maria_sichonany@hotmail.com*

ABSTRACT. Productive and reproductive performance of beef heifers grazing on Italian ryegrass (*Lolium multiflorum* Lam.) were analyzed, comprising animals exclusively on pasture and supplemented animals with extruded fat (0.15 or 0.30% of body weight). The grazing method was continuous with variable stocking rate. The experimental design was completely randomized following a repeated measure arrangement. Variables related to pasture were similar when the heifers received different supplementation levels, with similar grazing conditions. Mean values of forage mass and canopy height were 1,500 kg DM ha^{-1} and 17 cm, respectively. Heifers ingested forage with a similar content of crude protein (21.90%) and neutral detergent fiber (49.30%), regardless of supplementation levels. Beef heifers supplemented with extruded fat, regardless of the level, had higher average daily gain, body weight, body condition score, body weight: height ratio than heifers fed exclusively on pasture. The use of extruded fat as a supplement caused no change in pelvic area and reproductive tract score in beef heifers. Regardless of their nutritional status, 14/15-month-old heifers were not able to conceive during the mating season.

Keywords: Angus heifers, continuous grazing, *Lolium multiflorum* Lam.

Desempenho de novilhas de corte suplementadas com gordura extrusada em pastagem de azevém

RESUMO. O desempenho produtivo e reprodutivo de novilhas de corte em pastejo de azevém (*Lolium multiflorum* Lam.) foi analisado com animais exclusivamente em pastejo ou suplementados com gordura extrusada (0,15 ou 0,30% do peso corporal). O método de pastejo foi contínuo com taxa de lotação variável. O delineamento experimental foi completamente casualisado com medidas repetidas no tempo. As variáveis relacionadas ao pasto foram semelhantes quando as novilhas receberam diferentes níveis de suplemento, assegurando similares condições a esses animais. Os valores médios de massa de forragem e altura do dossel foram 1.500 kg MS ha^{-1} e 17 cm, respectivamente. Novilhas ingeriram forragem com semelhante teor de proteína bruta (21,9%) e fibra em detergente neutro (49,3%), independente do nível de suplemento. Novilhas de corte suplementadas com gordura extrusada, independente do nível, têm maior ganho médio diário, peso corporal, escore de condição corporal, relação peso corporal: altura do que novilhas exclusivamente em pastejo. O uso de gordura extrusada não causa mudança na área pélvica e no escore de trato reprodutivo de novilhas de corte. Independente do estado nutricional imposto às novilhas, essas não são capazes de conceber durante a estação de acasalamento em 14/15 meses de idade.

Palavras-chave: Angus, pastejo contínuo, *Lolium multiflorum* Lam.

Introduction

The use of Italian ryegrass (*Lolium multiflorum* Lam.) pasture by beef heifers is a strategy so that more animals reach faster the appropriate size for the onset of the reproductive activity. There are approximately 1.6 million heifers under one year in the state of Rio Grande do Sul, Brazil (Anuário da Pecuária Brasileira [Anualpec], 2014) and they are managed during fall and winter mainly on natural pastures. Suitable nutrition is essential for the successful reproductive performance of beef heifers.

Although international studies on the inclusion of fats in beef cattle diet have doubled in the last decade (Hess, Moss, & Rule, 2008; Guerrero et al., 2015), in Brazil, investigations on the subject are still fledging, mostly limited to milk production systems. The importance of producing results on fat inclusion in the diet of grazing beef cattle lies in the fact that lipids have a high concentration of readily available energy and may increase the energy density of beef heifer diet. Consequently, weight gain is maximized and a successful reproductive performance is provided (Funston, 2004; Wada et al., 2008) with age reduction for first mating, since the age of puberty depends on genotype and nutrition level (Frizzo et al., 2003). The extrusion process increases the availability of nutrients in grains fed to animals (Hess et al., 2008). The extrusion process is a thermal treatment that increases the digestibility of carbohydrates. In fact, amylose and amylopectin in initially organized granules are exposed to a higher enzymatic activity when the granules are broken by heat. Extrusion also improves the digestibility of lipids in the grain by breaking the protecting cell structures (Leeson & Summers, 1997).

Information on the effects of lipid supplementation on reproduction has been a difficult process (Funston, 2004). Due to extreme differences in dry matter intake and milk production level, current research may not be directly applicable to the production of beef cattle. Thus, this study evaluates the use of different levels of supplementation consisting of extruded fat on the performance of beef heifers aged eight to twelve months and grazing on ryegrass pasture.

Material and methods

Current experiment was carried out at the Universidade Federal de Santa Maria (UFSM), Santa Maria, Rio Grande do Sul State, Brazil. According to Köppen´s classification (Köppen & Geiger, 1928), regional climate is humid subtropical. The meteorological data for the months of the experimental period were obtained from the UFSM Weather Station (Table 1). The soil is classified as Paleudalf (Empresa Brasileira de Pesquisa Agropecuária [Embrapa], 2006) and mean rates of its chemical properties in the experimental area are: pH-H_2O: 5.0; pH-SMP: 5.8; clay: 19.2%; P: 13.4 and K: 92 mg L^{-1}; OM: 2.7%; Al^{3+}: 0.2, Ca^{2+}: 4.6 and Mg^{2+}: 2.2 cmolc L^{-1}; base saturation: 56.6%; Al saturation: 3%.

The 6.0 ha experimental area was divided into eight paddocks plus an adjacent area of 2.7 ha for the put-and-take animals. The grazing method comprised a put-and-take system to maintain 1.500 kg ha^{-1} dry matter (DM) of forage mass.

The performance of beef heifers grazing exclusively on Italian ryegrass pasture (*Lolium multiflorum* Lam.) or on ryegrass pasture supplemented with 0.15 or 0.30% body weight (BW) was evaluated. Supplement consisted of a commercial feed with extruded fat, with 93.0 (DM); 29.6 neutral detergent fiber (NDF); 14.6 crude protein (CP); 14.8% ether extract (EE). Feed comprised ground corn, rice bran, whole soybean meal, limestone, dicalcium phosphate, vegetable oil, sodium chloride and mineral vitamin premix. Supplementation was provided daily at 14 hours.

Table 1. Average monthly rainfall, temperature and insolation between May and November 2008 and normal historical data, Santa Maria, Rio Grande do Sul State, Brazil.

Items	Months						
	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.
	Observed						
Average Temperature, °C	15.9	11.9	15.9	14.3	15.1	19.1	22.6
Rainfall, mm	131.7	157.7	176.8	99.8	120.8	255.3	43.9
Insolation, hour	170.4	123.3	132.9	165.2	186.0	172.5	268.7
	History						
Average Temperature, °C	16.0	12.9	13.5	14.6	16.2	18.8	21.4
Rainfall, mm	129.1	124.0	145.6	137.4	153.6	145.9	132.2
Insolation, hour	151.3	125.0	133.1	141.4	160.7	206.8	223.3

Angus heifers, with an initial age of eight months and body weight of 172 ± 11.42 kg, were adapted to supplementation and pasture for seven days before the collection of experimental data. The animals were kept on ryegrass pasture with free access to water and mineral salt and adapted gradually to supplementation.

Ryegrass pasture was seeded on May and fertilizer consisted of 200 kg ha^{-1} of the formula 05-20-20 (NPK) and 73 kg of nitrogen (N) ha^{-1} as urea, subdivided into three applications. Pasture was utilized during 112 days (18^{th} July to 4^{th} November).

Forage mass (FM; kg DM ha^{-1}) was evaluated every 14 days by direct visual estimation with double sampling and canopy height (cm) was measured at the same time with a ruler, with 20 readings in each paddock. Forage was cut at ground level and the samples collected were split into two sub-samples to determine DM content. Botanical and structural components were separated manually into: leaf (blade), stem (leaf sheath + stem), dead material, inflorescence of ryegrass and other species. The samples were dried in a forced air circulation oven at 55°C, until constant weight.

Forage accumulation rate (FAR; kg ha^{-1} day^{-1} DM) was determined with three exclusion cages in each paddock in 28-day periods. Total DM production (kg ha^{-1} DM) per paddock was calculated by the sum of production at each period (FAR × number of days of period) plus forage mass at the beginning of grazing. Stocking rate (SR; kg ha^{-1} BW) was calculated by measuring the sum of the mean body weights of test animals plus the average weight of animals used for adjustments of stocking rate, multiplied by the number of days that the animals remained in each paddock and divided by the number of days in the trial period.

Forage allowance (FA; kg forage DM 100 kg BW^{-1} day^{-1}) was calculated by the equation: (FM/number of days in the period) + FAR)/SR of period, where: FM – forage mass; FAR – forage accumulation rate; SR – stocking rate. The green leaf blade allowance (GLBA) was obtained by multiplying FA by the average percentage of green leaf blades in FM.

Heifers were weighed after a 12 hours fast from solids and liquids. On these occasions, the animals were subjectively evaluated for body condition score, ranging between 1.0 (very thin) to 5.0 (very fat) (Lowman, Scott, & Somerville, 1973).

Average daily weight gain (kg $animal^{-1}$ day^{-1}) of the test heifers in each experimental period was calculated as the difference of weight between two consecutive dates and divided by the number of days in the period. By multiplying this rate by the average daily weight gain of test heifers, the weight gain per unit of area (WGA), in kg ha BW^{-1}, was estimated.

CP and NDF contents were determined for forage as grazed. The samples were dried in a forced air oven at 55°C until constant weight. Dry samples were ground in a Willey mill and analyzed according to methodology by Association of Official Analytical Chemists (AOAC, 2005).

Dry matter intake (DMI), according the agronomic method, was calculated as the difference between the dry matter´s total production and the final forage mass, subtracting forage losses during the grazing period. The value obtained was divided by stocking rate and multiplied by 100 (Rosa et al., 2010). The forage transformation efficiency (kg forage in kg BW) was obtained by the ratio between DMI and WGA. The supplement transformation efficiency (kg supplement in kg BW) was obtained by the ratio between the total supplementation provided to the animals and the difference between the WGA of the supplemented animals and the GPA of the animals fed exclusively on pasture.

Hip height, body weight: height ratio, pelvic area and reproductive tract score were the factors taken into account to evaluate the heifers´ body and reproductive developments. The pelvic area was determined by a pelvimeter, via transrectal. The reproductive tract score (1-5) was determined at the beginning and end of pasture utilization period, with heifers sorted by scores: infant (1 or 2); pre-pubertal (3) and pubescent (4 or 5; Anderson, LeFever, Brinks, & Odde, 1991).

The experimental design was completely randomized with repeated measurements over time, with three supplement levels (0; 0.15 and 0.30% BW), three replications of area and three animals per replication. Normally distributed variables were evaluated taking into consideration supplementation levels, evaluation periods and their interactions as fixed effects, and the residual and heifers or paddocks nested in the supplemented levels as random effects.

Statistical analyses were performed by Mixed procedure of SAS 9.2. Selection test structure was performed using Bayesian information criterion (BIC) to determine the model that best represented the data. The interaction between supplementation levels and evaluation periods was split when significant at 5% probability. Whenever significant differences were detected, mean rates of the supplement levels and evaluation periods of assessment were compared by *lsmeans* at 5% probability. When there were no differences between the supplementation levels, a study of contrasts was conducted to compare the variables related to supplemented and non-supplemented animals. A chi-square test evaluated the reproductive tract score. Polynomial regression was performed with PROC GLM, considering the period (x = days) variable.

Results

There was no interaction ($p > 0.05$) between supplementation levels × evaluation period for the variables: forage mass (FM), forage accumulation rate (FAR), forage allowance (FA), green leaf blades allowance (GLBA), leaf:stem ratio (LSR), canopy height (CH), crude protein (CP) and neutral detergent fiber (NDF).

Variables related to pasture were similar ($p > 0.05$) when the heifers received different levels of supplementation, assuring similar grazing conditions to the animals. Mean values of FAR, FM and CH were respectively 55.9 kg ha^{-1} day^{-1} DM, 1.500 kg DM ha^{-1} and 17 cm.

Stocking rate (SR) was similar among supplementation levels, averaging 1603.7 kg ha BW^{-1}. The above management provided the pastures with similar values of LSR (0.64), GLBA (847.2 kg ha DM^{-1}), stem mass (1326.4 kg ha DM^{-1}), dead material mass (525.4 kg ha DM^{-1}), inflorescence mass (42.9 kg ha DM^{-1}) and leaf blades allowance (2.70 kg DM 100 kg BW^{-1}). The mass of leaf blades, stems, dead material and inflorescences represented 31.3, 48.3, 18.8 and 1.6% of forage mass, respectively.

Forage mass fitted into a linear regression model ($\hat{Y}$ = 1055.43 + 6.32x; $p < 0.0001$; $r^2 = 0.4027$; CV = 16.61), with an increase of 6.32 kg DM to each day of pasture use. Leaf blades allowance fitted into a polynomial model ($\hat{Y}$ = 1.401 + 0.1251x – 0.0015x^2; P = 0.0002; $r^2 = 0.7125$), with the highest rate (4 kg DM 100 kg BW^{-1}) on day 42 of pasture usage. The average FA was 11.45 kg DM 100 kg BW^{-1}.

Heifers ingested forage with similar content ($p > 0.05$) of CP (21.9%) and NDF (49.3%), regardless of the supplementation levels. There was no interaction between supplementation levels x evaluation period for average daily gain. Regardless of supplementation levels, heifers achieved a similar ($p > 0.05$) daily weight gain. The analysis of contrasts indicated that supplemented heifers had a higher average daily gain (Table 2), with an increase of 29% (228 grams) when compared to animals fed exclusively on pasture.

Differences ($p < 0.05$) were detected among supplementation levels for weight gain per area (WGA), forage transformation efficiency (FTE) and supplementation transformation efficiency (STE). WGA was 424.2 kg for the exclusive use of pasture, and an increase of 33.4 (141.7 kg) and 15.50% (65.7 kg) for 0.15 and 0.30% BW supplement levels, respectively. Supplementation to animals provided a better forage transformation efficiency ($p < 0.05$) with 14.5 and 10.5 kg rates for each kg BW for animals fed exclusively on pasture and for supplemented animals, respectively. In STE, for each kg of body weight increase, 1.3 and 5.3 kg supplementation were necessary at levels 0.15 and 0.30% BW supplementation, respectively. By the end of the use of ryegrass pasture, the analysis of contrasts pointed out supplemented heifers with 10.2 (26.0 kg) of body weight and 6.7% (0.21 kg) of body condition score higher than those fed exclusively on pasture (Table 2).

Table 2. Average daily gain, final body weight, body condition score final, final height, weight:height ratio, pelvic area and reproductive tract score of beef heifers fed on ryegrass pasture plus supplementation with extruded fat.

Itens	Ryegrass[1]	Supplementation[2]	p*
Average daily gain, kg	0.78	1.1	0.0226
Final body weight, kg	255	281	0.0371
Final body condition score	3.12	3.33	0.0480
Final height, cm	115	119	0.0002
Weight:height ratio, kg cm^{-1}	2.21	2.39	0.0035
Pelvic area, cm^2	152	166	0.0852
Reproductive tract score	2.08	2.81	0.1351

*Probability; [1]Beef heifer grazing exclusively on Italian ryegrass; [2]Beef heifer grazing on Italian ryegrass pasture plus 0.15 or 0.30% BW of supplementation with extruded fat.

At the end of the evaluation period, supplemented heifers presented an increase of 0.21 points in body condition score gain when compared to heifers fed exclusively on pasture (Table 2). Heifers fed exclusively on pasture had lower height and weight:height ratio ($p < 0.05$) when compared with supplemented heifers. At the end of the experiment period, the supplemented animals were 4 cm taller than heifers fed exclusively on pasture. There was no difference ($p > 0.05$) for the pelvic area (159 cm^2) and reproductive tract score (2.44) for supplemented or non-supplemented heifers grazing on ryegrass (Table 2).

Discussion

Climatic data recorded in this study (Table 1) showed that monthly averages of rainfall, air temperature and insolation were close to the historical average, characterizing the evaluation period as normal.

Forage mass was within the forage availability range required for maximum performance of cattle fed on forage species of temperate climate (Hodgson, 1990), with canopy height at a level to optimize the biomass flow of this species (Pontes, Carvalho, Nabinger, & Soares, 2004). Consequently, forage intake cannot be restricted.

The forage accumulation rate (FAR) is controlled by environmental factors, such as temperature, light, nutrient supply, soil water conditions (Lemaire & Chapman, 1996) and the grazing management imposed (Silva et al., 2005; Roman et al., 2007). According to the literature, there is a range of values for FAR of ryegrass between 37.2 kg ha^{-1} day^{-1} DM (Silva et al., 2005) and approximately 67.5 kg ha^{-1} day^{-1} DM (Barbosa et al., 2007). Rate in current study (55.9 kg ha^{-1} day^{-1} DM) has been expected.

The supplementation was not enough to promote alterations in stocking rate (SR), caused by the replacement of forage by supplement. Pilau et al. (2004) observed that only supplementation levels higher than 1.50 kg DM 100 kg BW^{-1} may keep stable the stocking rate, regardless of forage accumulation rate. According to Aguinaga et al. (2008), for adequate animal performance, special attention should be given to the contribution of leaf blades in forage mass in annual forages. This management allows a more stable amount of green leaves available to grazing animals, beside the ryegrass cycle.

Increasing forage maturity influences its quality due to changes in the leaf:stem ratio, because both the percentage of crude protein and the organic matter *in vitro* digestibility are higher in the upper canopy, composed mainly of leaf blades, than in the lower layers, mainly composed of stems and senescent leaves (Hodgson, 1990). The forage allowance of 11.45 kg DM 100 kg BW^{-1} probably did not limit the heifers´ forage intake, since forage allowance should be at least three times the estimated forage intake of the animal (Gibb & Treacher, 1976), which is approximately 2.76% BW day^{-1}, according to National Research Council (NRC, 2001) for heifers in this category.

Crude protein (CP) contents of forage as grazed was 80% higher than that recommended by NRC (2001) to meet the requirements of the category (12.1% DM). The energy derived from fat has little synergy with the protein degraded in the rumen, since fat is mainly absorbed in the intestine. Thus, excess of CP in the diet consumed causes nutritional imbalance, with reduced energy efficiency, since part of CP is transformed into energy and the remaining N is excreted, with a reduction in animal performance (Van Soest, 1994).

Metabolizable energy from forage and supplement was 2.2 and 3.1 mcal kg^{-1}, respectively. Thus, the best performance of animals receiving supplementat may be related to increased energy intake due to its consumption. In fact, total metabolizable energy intake of animals exclusively on pasture accounted for 23.92 mcal day^{-1}, with an average increase of 7.5%, with supplementation. Without exceeding the maximum level of fat inclusion, probably the elimination of gas formed by microbial fermentation processes was not impaired and did not decrease the digestibility of forage. According to Hess, Moss, and Rule (2008), these effects may occur with high levels of dietary fat. Further, the metabolizable energy intake is taken as the main limiting to productive performance of ruminant animals fed on pasture, since inadequate intake of dietary energy and loss of body condition may adversely affect the reproductive function (Rahbar, Safdar, & Kor, 2014).

Greater efficiency in nutrient use in response to supplementation may be due to changes in feeding behavior, displacement patterns and energy demand associated with this activity (Glienke et al., 2010). Energy supplementation extends the availability of metabolizable protein, increasing the absorbed protein: energy ratio and energy retention, reducing the metabolic heat production and favoring higher consumption and, consequently, increasing gain rates (Poppi & McLennan, 1995).

According to NRC (2001), suitable weight for mating in British-breed heifers is 65% of adult BW (450 kg), or 293 kg. On November 4th, heifers had a body weight equivalent to 56.7 and 62.4% adult BW for heifers grazing exclusively and on pasture plus energy supplement, respectively. The maintenance of individual gains at 0.78 and 1.0 kg daily would take non-supplemented and supplemented heifers to the weight at first mating in 49 and 12 days beyond the pasture utilization period, respectively. Thus, heifers should start the pasture utilization period weighing 210 and 184 kg, when kept exclusively on pasture or on pasture plus supplementation, respectively. Growth rate during rearing is related to weaning weight (Pilau & Lobato, 2006). Weight gain: time period ratio for heifers with initial weight of 172 kg would make unfeasible their mating at 14 months of age for non-supplemented heifers when November 15th is taken for the initiation of mating.

The supply of energy supplements for animals on pasture with high content of crude protein (average 21.9% DM) accumulates fat in the animals very early. The above fact is attributed to the high ratios of protein and energy in the nutrients consumed (Poppi & McLennan, 1995). In fact, increased energy intake may influence the early onset of puberty (Gasser et al., 2006).

In addition, the heifers showed, regardless of the feeding system, an appropriate body condition score, according to rate suggested by Rocha and Lobato (2002), or rather, more than 3 on a 1-5 scale, as a determinant for the start of reproductive functions in cows. According to Funston (2004), body condition score is associated with the reproductive function of beef heifers.

Energy intake by supplementation was able to provide greater body development of heifers since the forage consumed by both groups showed the same chemical composition. Observed height increase was 38% more than that reported by Pötter et al. (2010), namely 2.9 cm, in experiments with beef heifers on cool season pasture with or without supplementation.

The weight increase of heifers was 10.9 and 11.4 kg for each centimeter increase in height when exclusively grazing or on pature plus supplementation, respectively. The use of the body weight:height ratio is considered an efficient parameter to estimate body growth and nutritional status of beef heifers, being composed of easily measured objective variables. The effect of body weight on puberty must always be related to the height of heifers. A ratio of 2.5 kg cm^{-1} height at 426 days of age is considered appropriate, regardless of animal size (Fox, Sniffen, & O'Connor, 1988). Heifers showed 87 and 94% of this rate at 390 days of age, exclusively on pasture or with supplementation, respectively. Therefore, heifers of the same herd, when subjected to a higher intake of nutrients, may reach puberty and conceive before their contemporaries with lower nutritional status.

In current study, the animals had a pelvic area (159 cm^2) within a range considered appropriate by Brinks (1990), or rather, 140 and 170 cm^2 for one-year-old heifers. Regardless of nutritional status imposed on heifers, they had lower than 3 scores of reproductive tract, considered by Anderson, LeFever, Brinks, and Odde (1991) as prepubescent, and thus incapable of conceiving during the mating season at 14/15 months old. Therefore, even with adequate weight gain, the heifers failed to reach adequate body structure to initiate the reproductive activity, regardless of supplementation. However, supplementation enabled heifers to reach a body structure next to that expected.

Conclusion

The use of fat supplement at 0.15 or 0.30% of body weight increased forage transformation efficiency, better individual performance, heavier and higher, coupled to a higher body condition score and body weight: height ratio compared to heifers fed exclusively on Italian ryegrass pasture. The supply of fat is not enough to cause differences in the pelvic area and reproductive tract score. Independent of nutritional status imposed, 14/15-month-old heifers are not able to conceive during the mating season.

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