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Effect of age and genetic group on the development of calves weaned at 63 days until one year of age

Efeito da idade e grupo genético da vaca sobre o desenvolvimento dos bezerros desmamados aos 63 dias até um ano de idade

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Abstract

The development of beef calves born of Charolais (CH), Nellore (N), and Charolais × Nellore crossbred cows with Charolais (CHP) and Nellore (NP) predominance, was evaluated from birth to 12 months of age. The cows were grouped into three age classes: primiparous, young and adult. The net energy requirements for maintenance and gain of the calves were also evaluated, as were the production and availability of energy in the milk of the evaluated cows. We used 93 pairs of contemporary cows and calves maintained in natural pasture. From birth to 21 days of age and from 21 to 42 days of age, the calves of adult cows presented the highest average daily weight gain (ADG), while the calves of young and primiparous cows had similar ADG. The highest net energy requirements for maintenance (NE_m) and gain (NE_g) were for crossbred and Charolais calves, the latter being similar to Nellore calves. The energy available in the milk of the adult cows was 33% higher than that of primiparous cows. The weight gain of calves was influenced by the age of the cow until weaning. The pre-weaning and post-weaning weights of calves were affected by the genetic group, and adult and young cows produced heavier calves in the pre-weaning period than primiparous cows.
Key words: Early weaning. Net energy for maintenance. Weight gain. Weaning weight.

Resumo

Avaliou-se o desenvolvimento de bezerros de corte, do nascimento aos 12 meses de idade, filhos de vacas Charolês (CH), Nelore (N) e mestiças com predominância Charolês e Nelore (PCH, PN), respectivamente, agrupadas em três classes de idade: primíparas, jovens e adultas. Adicionalmente, foram avaliadas as exigências de energia líquida de mantença e de ganho dos bezerros, bem como a produção e a disponibilidade de energia no leite das vacas avaliadas. Foram utilizados 93 pares de vacas e bezerros contemporâneos mantidos em pastagem natural. Do nascimento aos 21 dias de idade, e dos 21 aos 42 dias de idade, os bezerros filhos de vacas adultas apresentaram maior ganho de peso médio diário (GMD), já os bezerros filhos das vacas jovens e primíparas obtiveram GMD similar. A maior exigência de ELm e ELg foram para os bezerros cruzados e puros Charolês, sendo estes últimos semelhantes aos

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bezerros Nelore. A energia disponível no leite das vacas adultas foi 33% superior à energia disponível no leite das vacas primíparas. O ganho de peso dos bezerros foi influenciado pela idade da vaca até o desmame. Os pesos pré e pós-desmama dos bezerros são afetados pelo grupo genético das vacas. Vacas adultas e jovens produzem bezerros mais pesados no período pré-desmama do que vacas primíparas.
Palavras-chave: Desmama antecipada. Energia líquida de mantença. Ganho de peso. Peso à desmama.

Introduction

The need to produce precocious steers and heifers that reach puberty at a younger age increases the importance of producing heavier animals at weaning. Factors such as age, genetic group, and nutritional status of the cows affect pre-weaning weight gain and thus the weaning weight of calves. From 6 to 8 years of age, beef cows show higher milk yield and maternal ability than primiparous and old cows (CERDÓTES et al., 2004b), which consequently produce calves with lower weaning weights.

The genetic group of cows influences calf weaning weight, as demonstrated by Cundiff et al. (1974) and Oliveira et al. (2007), who found that the offspring of crossbred cows presented higher average daily weight gains and, therefore, higher weaning weight than purebred cows. This superiority seen in crossbred animals is due to the effects of heterosis on milk production. For example, Restle et al. (2005) found that F1 crossbred cows produced more milk throughout the lactation period, indicative of significant heterosis.

The net energy (NE) of food or feed is defined as the metabolizable energy used by an animal for maintenance and production, minus the heat increment. According to the NRC (1984), the energy content in cow milk is equivalent to the net energy for maintenance (NE_m) required for milk production and is affected by the genetic group and age of the cow. Therefore, determining the NE requirements for the maintenance and growth of calves, as well as the NE available in the milk, is crucial for producing high-weight calves at weaning since milk is the main source of nutrition in the first weeks of calf development (ROVIRA, 1996).

The aim of this study was to evaluate the effects of age and genetic group of cows on the production and available energy of milk, as well as the performance and NE requirements for maintenance and gain of calves from birth to 12 months of age.

Material and Methods

The experiment was carried out in the Laboratory of Beef Cattle Production of the Animal Science Department of the UFSM. A total of 93 pairs of contemporary cows and calves from the same experimental herd were used, with 15 pure Charolais cows and 27 crossbreeds with Charolais predominance (CHP) (11/16CH 5/16N and 21/32CH 11/32N), and 12 pure Nellore cows and 39 crossbreeds with Nellore predominance (NP) (11/16N 5/16CH and 21/32N 11/32CH). Calves were obtained by mating Charolais crossbred cows (CHP) with Nellore bulls, and Nellore crossbred cows (NP) with Charolais bulls. The age of the cows ranged from 3 to 7 years and the cows were grouped into three age classes: primiparous (3 years old), young (4-5 years old), and adult (6-7 years old). The number of animals evaluated within each class was 27, 37, and 29 for the primiparous, young and adult classes, respectively.

The experimental site had an area of 88 ha, divided into three paddocks of 29.3 ha, with native pasture composed mostly of annoni-2 grass (*Eragrostis plana* Nees), cespitosa grass, African summer season perennial grass, and warm season species like *Andropogon lateralis* Nees, *Paspalum notatum*, and *Axonopus affinis*, with an average forage mass of 5006.56 kg DM ha^{-1}, 78.7 g kg^{-1} neutral detergent insoluble fiber (NDF), 4.4 g kg^{-1}

crude protein (CP), and 47.02 g kg^{-1} total digestible nutrients (TDN). Animals were rotated every 14 days to minimize the effect of the paddock. The average stocking rate was 0.6 AU ha^{-1}. The calving period was from September to November. The weight of the calves at birth was determined within the first 24 hours after calving, and then at intervals of 21 days until 63 days postpartum when they were weaned. Subsequently, the animals were weighed at 5, 7, and 12 months of age. All weights were measured using a digital electronic scale. The design was completely randomized in a 4 × 3 factorial arrangement, with four genetic groups and three age groups with variable numbers of replicates. In the post-weaning period, the management and feeding regime were the same for all the calves. In the first seven days after weaning, the calves were kept in the cattle shed and were fed commercial concentrate containing 20 g kg^{-1} CP. After this period, they were kept on Tifton pasture (*Cynodon* spp.) containing 12.7 g kg^{-1} CP, 75.4 g kg^{-1} NDF, and 54.3 g kg^{-1} TDN, and concentrate equivalent to 1% of live weight, with 20 g kg^{-1} CP and consisting of corn, soybean meal, and wheat bran. The calves were kept in this management system until 5 months of age. From 5 to 12 months of age, they were kept on native pasture composed mostly of annoni-2 grass (*Eragrostis plana* Nees) and warm season species like *Andropogon lateralis* Nees, *Paspalum notatum*, and *Axonopus affinis*. During this period, the calves did not receive any type of supplementation. Milk production and composition were also determined as described in Silveira et al. (2014), and the values were used to calculate the energy in the milk. Estimates of calf energy requirements (NE_m and NE_g) were calculated in Mcal day^{-1} using the equations proposed by the NRC (1984), where: NE_m=0.077*live weight$^{0.75}$; NE_g=0.0437*live weight$^{0.75}$*daily weight gain$^{1.097}$ for each age group. The energy available in the milk was calculated according to the NRC (1996), where: Milk energy (Mcal kg^{-1})=0.097 × (% milk fat) + 0.361, and multiplied by the milk produced by the cows.

The analyses were performed using the statistical program SAS (2001). The data were submitted to analysis of variance at the 5% significance level, using the MIXED procedure in SAS. When differences between the means were detected, they were compared by Tukey's test. The interaction between the genetic group and the age of the cow was tested. The calving order was used as covariable, and the statistical model used was: $Y_{jk}=\mu+GG_j+IV_k+(GG*IV)_{jk}+e_{jk}$, where: Y_{jk}=dependent variables; μ=mean of all observations; GG_j=effect of the genetic group of the cow of order "j", which is 1 for Charolais, 2 for Nellore, 3 for CHP crossbreeds, and 4 for NP crossbreeds; IV_k=effect of the age of the cow of order "k", which is 1 for primiparous, 2 for young, and 3 for adult; (GG*IV) = interaction between the j^{th} genetic group of the cow and the k^{th} age group of the cow; e_{jk}=residual random error.

Results and Discussion

The evaluated effects did not show a significant interaction and are presented separately. The age group of the cow influenced the daily average weight gain (ADG) of calves until 63 days of age ($P<0.05$) (Table 1). From birth until 21 days of age, calves born to adult cows presented a higher ADG ($P<0.05$) compared to calves of young and primiparous cows, which showed similar ADG values. From 21 to 42 days of age, calves born to adult cows were the heaviest, calves born to primiparous cows the lightest, and calves from young cows showed intermediate values ($P<0.05$). From 42 to 63 days of age, the ADG was similar for calves from adult and young cows, which presented 31 and 27% higher ADG values, respectively, than calves from primiparous cows. According to Cerdótes et al. (2004a), the reduced performance seen in calves born to primiparous cows reflects their low milk production. This is a consequence of their growth since primiparous cows also require nutrients to complete their development, in addition to maintenance and lactation. This is different than that observed for calves from young and adult cows, which present better physiological conditions as a result of higher milk yields.

Table 1. Means for the average daily weight gain (ADG), in grams, of calves according to the age group of the cows.

Variable[s]*	Age group of the cows			CV (%)**
	Primiparous	Young	Adult	
ADGbirth-21d	814b	863b	1024a	12.24
ADG21-42d	614b	682ab	777a	11.33
ADG42-63d	547b	752a	797a	8.22
ADG63d-5m	744a	590a	679a	18.86
ADG5-7m	327a	261a	374a	19.10
ADG7-12m	99a	76a	90a	49.95

* ADGbirth-21d: average daily weight gain from birth to 21 days of age; ADG21-42d: average daily weight gain from 21 to 42 days of age; ADG42-63d: average daily weight gain from 42 to 63 days of age; ADG63d-5m: average daily weight gain from 63 days to 5 months of age; ADG5-7m: average daily weight gain from 5 to 7 months of age; ADG7-12m: average daily weight gain from 7 to 12 months of age; **CV: coefficient of variation of the data; [a,b]Means in the same row, followed by different letters, differ (P<0.05) by Tukey's test.

The ADG was similar (P>0.05) for all calves after weaning (63 days of age), indicating that the age of the cow significantly affected the ADG during the lactation period; subsequently, however, the weight gain rate of the calves was dependent on the individual intake of forage or feed. Table 1 also shows that calves maintained an ADG above 500 g until five months of age, likely due to the supplementation with 10 g kg^{-1} wheat bran. After five months of age, the calves consumed only native pasture, which lacked sufficient nutritional quality (44 g kg^{-1} CP, 787 g kg^{-1} NDF, and 470 g kg^{-1} TDN) to meet their requirements, even in the spring and summer, explaining the reduced performance of the calves. Similar results were found by Restle et al. (2004), who evaluated the performance of calves kept near the mother in a native pasture and observed an ADG of 479 and 425 g for Charolais and Nellore calves, respectively. Early weaning is an important tool for livestock production systems, and Vaz et al. (2011) suggested that early weaning benefits the cow through weight gain and improved body condition, allowing for better reproductive indexes. However, this advantage should not be offset by poor feeding in the post-weaning period.

The genetic group of the cow influenced (P<0.05) (Table 2) the ADG of calves only until 21 days of age, and from 42 to 63 days of age. Pure Nellore calves were lighter than crossbred calves until 21 days of age, but presented a similar weight to pure Charolais calves. From 42 to 63 days of age, pure Charolais calves showed a lower ADG, but similar to pure Nellore and Charolais crossbred cows. Crossbred animals are known to be superior to purebreds due to the effect of maternal heterosis, which is 100% in the F1 generation (OLIVEIRA et al., 2007; RESTLE et al., 2009).

From 63 days of age, the ADG of the calves decreased progressively until one year of age for all the genetic groups evaluated (P>0.05). This reduction resulted from these animals being maintained in a native pasture infested with annoni grass and without receiving any extra nutrients. However, there was no weight loss during the autumn/winter period, while other authors (MOOJEN; MARASCHIN, 2002) have reported losses of 150 to 250 g day^{-1} in native pastures without supplementation.

As shown in Table 3, the weights of all the calves were influenced (P<0.05) by genetic group.

Crossbred calves were the heaviest until one year of age, and the weights of pure Charolais and crossbred calves were similar at birth and at 21, 150, and 210 days of age, corroborating the findings of Oliveira et al. (2007). The superiority of crossbred calves compared to purebreds is well established (CUNDIFF et al., 1974; RESTLE et al., 2005; OLIVEIRA et al., 2007) and results from the effect of heterosis on milk production, which leads to a better performance of their offspring at weaning. Moreover, the high weight of pure Charolais calves is inherent to the characteristics of the breed, which has a large size, and shows high rates of weight gain and considerable muscle mass (MENEZES; RESTLE, 2005).

Table 2. Means for the average daily weight gain (ADG), in grams, of calves according to the genetic group of the cows.

Variables**	Breed predominance*				CV (%)***
	N	CH	PN	CHP	
ADGbirth-21d	746c	839bc	1015a	939ab	12.24
ADG21-42d	667a	619a	786a	680a	11.33
ADG42-63d	754ab	601b	809a	675ab	8.22
ADG63d-5m	479a	760a	676a	760a	18.86
ADG5-7m	153a	373a	353a	338a	19.10
ADG7-12m	72a	12a	83a	65	49.95

*N - pure Nellore animals; CH - pure Charolais animals; NP - animals with Nellore predominance; CHP - animals with Charolais predominance; **ADGbirth-21d: average daily weight gain from birth to 21 days of age; ADG21-42d: average daily weight gain from 21 to 42 days of age; ADG42-63d: average daily weight gain from 42 to 63 days of age; ADG63d-5m: average daily weight gain from 63 days to 5 months of age; ADG5-7m: average daily weight gain from 5 to 7 months of age; ADG7-12m: average daily weight gain from 7 to 12 months of age; ***CV: coefficient of variation of the data; [a,b]Means in the same row, followed by different letters, differ (*P*<0.05) by Tukey's test.

Table 3. Live weight (kg) of calves from birth to one year of age according to the genetic and age groups of the cows.

	Age of the calf** (days)						
	WB	21	42	63	150	210	365
Genetic group*							
N	28.1b	45.5b	59.4c	75.6b	120.6b	134.1b	146.5b
CH	33.1a	50.5ab	63.7bc	76.7b	136.9ab	152.9a	158.2b
NP	36.3a	55.1a	71.4a	88.2a	154.5a	173.7a	186.9a
CHP	36.1a	55.4a	70.0ab	86.5a	149.6a	170.1a	184.8a
Age of the cow							
Primiparous	32.4b	48.4b	61.3c	75.0b	143.0a	162.2a	179.8a
Young	34.5ab	52.4b	67.7b	84.1a	144.6a	163.9a	176.6a
Adult	36.5a	57.9a	74.1a	91.8a	146.7a	163.9a	171.6a
CV (%)***	7.9	6.2	6.3	4.8	7.3	7.4	7.9

*N - pure Nellore animals; CH - pure Charolais animals; NP - animals with Nellore predominance; CHP - animals with Charolais predominance; **WB: weight at birth; ***CV: coefficient of variation of the data; [a,b]Means followed by different letters in the same column differ significantly (*P*<0.05) for the factors evaluated by Tukey's test.

The age group of the cow influenced ($P<0.05$) the weight of the calves until 63 days of age (Table 3). Adult cows produced calves that were heavier from birth to weaning compared to primiparous cows, whereas the offspring of young and adult cows showed a similar performance at birth and 63 days of age. The performance was intermediate for the other age groups. The differences in weight reflect the lower ADG (Table 1). Cerdótes et al. (2004a) found that calves from primiparous cows (3 years of age) were the lightest, followed by calves from old cows (> 9 years of age), which showed a similar performance to calves born to young (4-5 years old) and adult (6-8 years of age) cows. Similar results were found in our study.

Milk production was not affected by the genetic group ($P>0.05$) (Table 4), with an average production of 5.94 L day^{-1}. However, comparing the age groups of the cows, adult cows produced more milk (6.64 L day^{-1}) than primiparous cows (5.12 L day^{-1}), and a similar amount to young cows (6.04 L day^{-1}). Besides the requirements for maintenance and production, primiparous cows also require nutrients for growth, explaining the lower milk production compared to young and adult cows that have already reached physiological maturity (CERDÓTES et al., 2004b). Restle et al. (2003) also confirmed that adult cows maintained on improved cultivated pasture produced more milk than young and old cows (5.61 versus 5.00 and 3.77 L day^{-1}, respectively).

Table 4. Milk production (kg day^{-1}), net energy for maintenance of calves estimated by the NRC (1984), available energy in the milk, and NE_g balance according to the genetic and age groups of the cows.

	Milk production of the cows	Net energy requirements (Mcal)		Net energy for gain available in the milk	NEB_g*
		For maintenance	For gain	Mcal	
Genetic group**					
N	5.38a	1.617c	0.703b	3.92a	3.19a
CH	5.88a	1.738bc	0.692b	4.14a	3.46a
NP	6.45a	1.930a	0.987a	4.50a	3.50a
CHP	6.05a	1.851ab	0.844ab	4.11a	3.29a
Age of the cow					
Primiparous	5.12b	1.655b	0.636c	3.46b	2.79a
Young	6.04ab	1.765b	0.804b	4.30ab	3.50a
Adult	6.64a	1.972a	1.005a	4.61a	3.59a
CV (%)***	22.39	16.07	25.44	25.67	32.65a

*NEB_g: net energy balance for gain (Mcal day^{-1}); **N - pure Nellore animals; CH - pure Charolais animals; NP - animals with Nellore predominance; CHP - animals with Charolais predominance; ***Coefficient of variation of the data; [a,b]Means followed by different letters in the same column differ significantly ($P<0.05$) for the factors evaluated by Tukey's test.

The NE_m and NE_g of calves until weaning estimated by the NRC (1996) equations were influenced ($P<0.05$) by the genetic group of the cows (Table 4). The highest NE_m and NE_g requirements were for crossbred and pure Charolais calves, the latter being similar to Nellore calves. This superiority of crossbred calves may have been due to their higher body weight (Table 3), since they were heavier than Nellore calves. Crossbred animals accrue 100% maternal heterosis, resulting in higher birth weight, higher milk production by the mothers, and a higher survival rate (OLIVEIRA et al., 2007; RESTLE et al., 2009). In addition, animals with a higher body weight show increased organ and viscera development that require increased metabolic activity, resulting in increased nutritional requirements for maintenance (NRC, 1996). In contrast, the Nellore breed presents lower gastrointestinal tract and internal organ weights compared to bulls and crossbreds (PACHECO et al., 2005; KUSS et al., 2007), explaining why they require approximately 10% less energy for maintenance than bulls (NRC, 1996).

The NE_g available in the milk was not affected (P>0.05) by the genetic group of the cows (Table 4) and presented positive values throughout the lactation period. According to Pimentel et al. (2006), the availability of NE_g in the milk remains positive until the fourth month of lactation, which agrees with our study since milk production was measured until day 63 of lactation. The NE balance for gain was positive, indicating that enough energy was available to meet the maintenance requirements, as well as to promote the gain of the calves. The lack of a significant difference in energy availability of the milk for the different genetic groups is likely due to similar milk production, which can influence the energy available in the milk.

Conclusion

The weight gain of calves was influenced by the age of the cows until weaning. The pre-weaning and post-weaning weights of calves were affected by the genetic group of the cows. Adult and young cows produced heavier calves in the pre-weaning period than primiparous cows.

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